

SAR Data Analysis, CV Benchmarks, and the Updated NCCA S-Curve Tool



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Benjamin F. Breaux, Naval Center for Cost Analysis (NCCA)

Richard C. Lee, Peter J. Braxton, Kevin M. Cincotta, Brian J. Flynn, Technomics, Inc.

Abstract

To support the development of better probabilistic cost estimates, the Naval Center for Cost Analysis (NCCA) has championed the development of the S-Curve Tool, which was well received at both the 44th Annual Department of Defense Cost Analysis Symposium (ADoDCAS) in February, 2011, and the joint Society of Cost Estimating and Analysis (SCEA) / International Society of Parametric Analysts (ISPA) conference in June, 2011. This paper presents ongoing research to support both continued improvement of the S-Curve Tool and greater understanding of the nature of cost growth for major acquisition programs; its mean value (risk) and variability (uncertainty); and the components thereof. The refinement of historical benchmarks presented in the previous paper on analysis of Selected Acquisition Report (SAR) Summaries for Department of the Navy (DON) programs, including cost growth factors (CGFs) and coefficients of variation (CVs), enables more realistic estimates and supports better decision-making.

This paper presents the results of extensive data collection, validation, normalization, and analysis using cost variance data from SARs across all Services DoD components. By shifting from the SAR Summaries to the SARs themselves, the authors were able to decompose the previous data, which were at the level of total Acquisition cost with Quantity and Economic adjustments only, into appropriation types – Research, Development, Test, and Evaluation (RDT&E), Procurement, Military Construction (MILCON), and (Acquisition-phase) Operating and Support (O&S) – and all seven SAR Cost Variance categories. We identified and quantified two additional categories, Baseline Adjustments (identified elsewhere in the SAR) and Inter-Phase growth, which occurs when the initial Baseline Estimate of one phase does not match the final Current Estimate of the previous phase. We identified several distinct validation steps to ensure the soundness of the data, and used those steps to identify and resolve any apparent anomalies. In addition to significantly improving the granularity of the data, we more than tripled the number of data points by incorporating Army, Air Force, and DoD-level SAR programs. The data, comprising more than 400 milestone estimates from more than 300 programs, are stored in a Microsoft Access-based relational database in 3rd normal form. This allows thousands of query types (based on any combination of Service, phase, appropriation type, program year, milestone, etc.) to be run quickly without any manual manipulation of data, and ensures referential integrity by storing all data in only one place.

We re-tested previous hypotheses regarding historical cost growth and variability, including tests for differences in CGFs and CVs by commodity, era, and milestone, and examined more closely the decomposition of CGF and CV by Cost Variance category, beyond just the previous Quantity and Economic (Then Year vs. Base Year) adjustments. We also revisited the comparison of the two primary CV data analysis approaches, the CV of CGFs presented in (1) and the size-effect maximum-likelihood estimation (MLE) regression approach presented in (3). For the latter, we introduce standardized residuals based on the heteroscedastic variance model to enable additional hypothesis testing.

The paper includes a brief demonstration of the use of the new expanded benchmarks within the updated S-Curve Tool.

Problem Statement

- Growing realization in defense cost community that commonly estimated S-curves are sometimes too narrow and risk analysis is incomplete
 - OSD CAPE, and others, cite cases where actual acquisition costs fall at the 99th+ percentile
 - For MDAPS
 - On S-curves estimated years previously
 - Anecdotal evidence that CV estimates greater than 10% difficult to achieve, in too many cases
 - Experts have seen values of under 10% at MS A, and values of ½ of 1% at roughly half way through production
- Lack of definition of CVs
 - Quantity and inflation as exogenous or random
- Inconsistency in CV estimation between and within organizations
- Guidelines on risk analysis
 - NCCA leading a DON cost-community effort
 - CV Tool and benchmark values will contribute to solution

Inaccurately steep S-curves can lead to an underestimation of the mean, misallocation of scarce defense resources, and failure to understand program risk

Objective

- The objective of the study is to provide historical benchmarks to cost estimates (S-Curves)
- This will be accomplished through the analysis of cost growth factors (CGFs) and coefficients of variation (CVs) through the SARs
- NCCA S-Curve Tool has been built in efforts to easily and efficiently compare cost estimates

Work In Progress

- At “press time,” data validation and analysis were still underway
- We anticipate significant updates to the presentation prior to the conference



The “historical” icon indicates results published in 2011



The “under construction” icon indicates preliminary results based on the new database

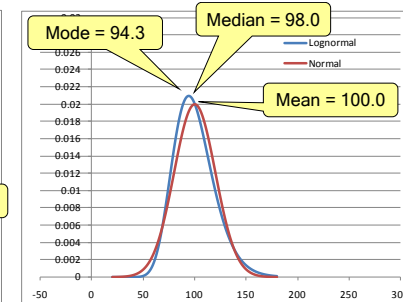
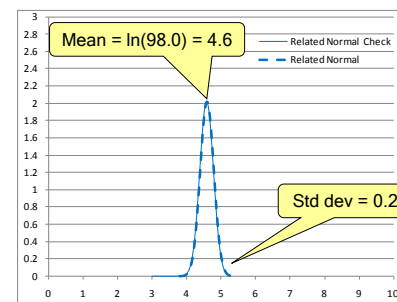
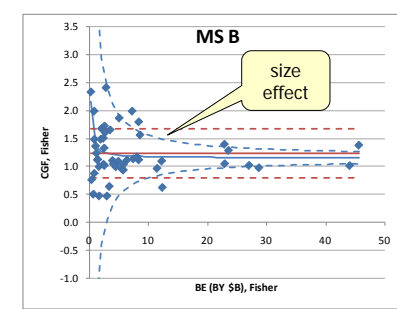
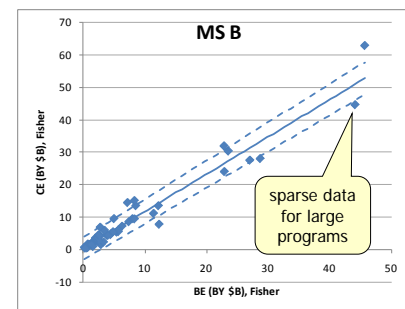
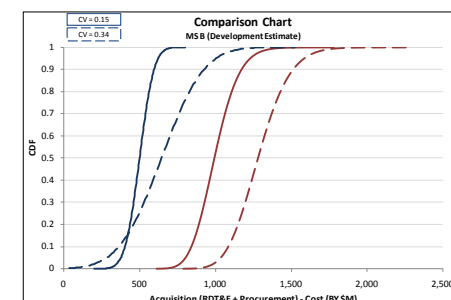
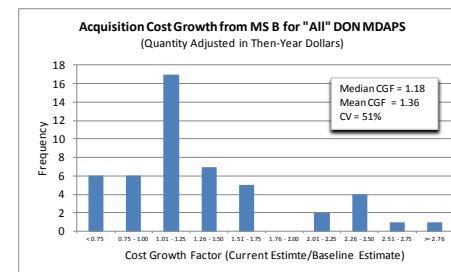
- To request the latest version of the presentation, please email lead author Richard Lee
– Rlee@technomics.net

Outline

- SAR Growth Papers
- SAR Data Collection
 - SAR Data expansion
 - Added Army, AF, DoD programs
 - Broken out by Appropriation Type and Cost Growth Category
- SAR Data Analysis
 - Analysis of \$ Growth, CGFs, CVs, and correlations
 - Hypothesis tests for conjectures
 - Size Effect via Maximum Likelihood Estimator (MLE)
Regression
- Update to the NCCA S-Curve Tool
 - S-Curve Tool and Documentation posted to NCCA Tools page

SAR Growth Papers

- “Development and Application of CV Benchmarks,” Brian Flynn, Paul Garvey, Peter Braxton, Richard Lee, DoDCAS, 2011
- “Testing S-Curves for Reasonableness: The NCCA S-Curve Tool,” Coleman, Braxton, Lee, Flynn (Hampton Roads SCEA Chapter, DoDCAS 2011, SCEA/ISPA 2011)
- “The Perils of Portability: CGFs and CVs,” Braxton, Lee, Cincotta, Smuck, Guild, Coleman, Flynn (SCEA/ISPA 2011)*
 *Pleasant surprises while developing S-Curve Tool
- “Probability Distributions for Risk Analysis,” Braxton (SCEA/ISPA 2011)



SAR Growth Papers

- “CV Benchmarks and the NCCA S-Curve Tool: An Update” Poster Presentation, Braxton, Lee, Cincotta, Flynn, Breaux (DoDCAS 2012)*

CV Benchmarks and the NCCA S-Curve Tool: An Update
 45th Annual Department of Defense Cost Analysis Symposium (ADoDCAS)
 February 14-17, 2012
 Peter Braxton, Richard Lee, Kevin Cincotta, Brian Flynn, Ben Breaux

Problem Statement

- Growing realization in defense cost community that correctly estimated S-curves are as critical as metrics and risk analysis techniques
- Inaccurately steep S-curves can lead to an underestimation of the mean and higher percentiles, misallocation of funds elsewhere, and failure to understand program risk
- Inconsistency in coefficient of variation (CV) estimation between and within organizations

Objective

- Leverage Dr. Flynn's historical analysis of SAR for DoD programs to develop a tool that will allow practitioners to easily and quickly:
 - Compare their estimate S-curves to historical CIA and cost growth factors (CGF) benchmarking
 - Compare two different estimates (Scenario A)
 - Generate graphics for applications (Presentation)

NCCA S-Curve Tool

- Compatible with:
 - Empirical methods such as Monte Carlo risk analysis
 - Parametric methods such as enhanced scenario-based historical (ESB)
- Publicly available on NCCA website: <http://www.ncca.navy.mil/look/look.cfm>

Usage

- New Center for Cost Analysis (NCCA) ICs and cost assessments
- Comparisons with historical CIA and CGF estimates
- ICs via NATO Alliance Ground Surveillance (AGS) System
- Global Hawk (GHW)
- DoD Acquisition is still required for cost risk analysis
- S-Curve tool for graphics and data analysis

Results

- ICs via Joint Strike Fighter (JSF) Presentation to Deputy Secretary
- Defense Integrated Information Management System
- ISPA analysis for cost risk analysis
- Virginia Coast Submarine (VCS)
- Method estimate of completion
- Department of Homeland Security (DHS)
- Standard for cost analysis

Data Collection

Analysis was also provided by OASD/CD for data collection efforts

Program	Start	End	Start	End	Start	End
AGS	2005	2015	2005	2015	2005	2015
GHW	2005	2015	2005	2015	2005	2015
JSF	2005	2015	2005	2015	2005	2015
VCS	2005	2015	2005	2015	2005	2015

Data Validation

- Perform deep-dive reviews of the accuracy and completeness of each program
- Correct transcription errors (i.e., OCF and manual data entry)
 - Update user error application type
 - Update user error configuration
 - Remove obsolete data to clean up the summary sheet
- Detect and correct mislabeled transition disconnects
- Reporting points such as baseline labeling and year of usage
- Baseline Estimate is the first data point Estimate in the last DoD SAR
- Simple algorithm, under development to make algorithms based on history such as benchmark of base cost and degree of growth rates
- Database update in progress and not yet complete

Data Storage and Access

- Return whether database developed (27 normal form)
- Stores all raw, validated data (updates to be tied to DAU/IS)
- Program, Service, appropriation tags, baseline estimates, current estimates, values for all SAR software packages
- Strives to establish a standard database for CV calculations

Road Ahead

- Continue to develop and analyze programmatic programs
- Perform data analysis (e.g., exploratory plots, testing, etc.)
- Document analysis and develop database user's guide
- Release new version of NCCA S-Curve Tool with updates to historical benchmarks

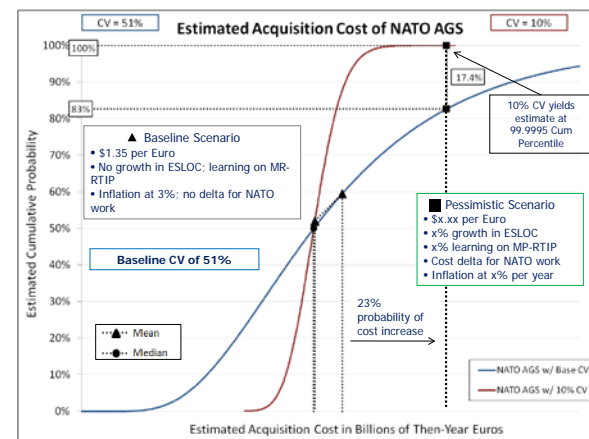
Presentations

- "Development and Application of CV Benchmarking"
 - With Dr. Paul Garvey (DoDCAS 2012)
 - With Richard Mark, Director, AFCEA, May 2011
 - DoD Cost Estimating Directorate Group, May 2011
 - ISPA, London, May 2011
 - Australian Cost PPT at NARS, May 2011
 - ISPA Global Community, NATO/ISPA, June 2011
- "The DoD S-Curve Tool"
 - DoDCAS 2012
 - ISPA Hampton Roads, Feb 2012
 - ISPA June 2012
 - "Part of Feasibility"
 - ISPA June 2012
 - ISPA June 2012
 - "Probability Distributions for Risk Analysis"
 - ISPA June 2012

- “SAR Data Analysis, CV Benchmarks, and the Updated NCCA S-Curve Tool” Braxton, Lee, Cincotta, Flynn, Breaux (ISPA/SCEA, Brussels, Belgium, 14-16 May 2012)*

* Unpleasant surprises while developing SAR database

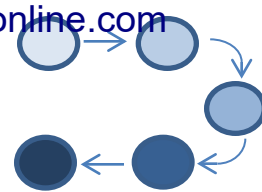
- “Enhanced Scenario-Based Method for Cost Risk Analysis: Theory, Application, and Implementation” Braxton, Flynn, Garvey, Lee (SCEA/ISPA 2012)



What is a SAR?

- System Acquisition Reports (SARs) report the status of total program cost, schedule, and performance for major defense acquisition programs (MDAP)
- The SAR for the quarter ending December 31 is the annual SAR and is mandatory for all ACAT I programs
- Quarterly SARs for the quarters ending March 31, June 30, and September 30 are reported on an “exception basis”
 - One of the exceptions is a Milestone B or Milestone C approval within the reportable quarter (will revisit this later in the presentation)

Data Collection Outline



Data was extracted and validated from SAR Summary Sheets to identify last SAR for a given milestone (effort funded by ODASA-CE)

1

2

Individual SARs were obtained from DAMIR

3

Cost Variance Tables were extracted from individual SARs

	Change Summary Then Year SM			
	RD&E	Proc	MILCON	Total
SAR Production Estimate	-4210.0	-17421.4	107.7	-21739.1
Previous Changes				
Economic	-122.5	+404.0	+3.5	+285.0
Quantity	0.0	-15562.9	0.0	-15562.9
Schedule	-25.3	+6354.0	0.0	+6328.7
Engineering	+161.3	0.0	0.0	+161.3
Estimating	-317.3	-823.3	-83.9	-1156.7
Other	0.0	0.0	0.0	0.0
Support	+54.6	-804.0	0.0	-749.4
SubTotal	+436.0	-8665.5	-80.4	-8329.9
Current Changes				
Economic	-0.9	-50.5	--	-51.4
Quantity	--	--	--	--
Schedule	--	--	--	--
Engineering	--	--	--	--
Estimating	+1.5	-207.4	--	-205.9
Other	--	--	--	--
Support	--	-15.4	--	-15.4
SubTotal	-0.6	-253.3	--	-252.7
Total Changes	+435.6	-8928.8	-80.4	-8573.6
Current Estimate	-4645.5	-18422.5	27.3	-23040.7

Prepared data were stored in relational database (MS Access)



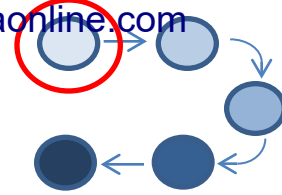
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Several validation steps were taken to understand the raw data and address anomalies

	RD&E	Proc	MILCON	Total
SAR Baseline (Dev Est)	1139.2	6954.1	--	8093.3
Previous Changes				
Economic	-12.0	-393.8	--	-405.8
Quantity	--	+356.5	--	+356.5
Schedule	--	+127.6	--	+127.6
Engineering	--	+80.2	--	+80.2
Estimating	-20.9	-490.2	--	-511.1
Other	--	--	--	--
Support	--	+95.1	--	+95.1
SubTotal	-32.9	-1314.4	--	-1347.3
Current Changes				
Economic	+14	+19.7	--	+33.7
Quantity	--	--	--	--
Schedule	--	+19.5	--	+19.5
Engineering	--	--	--	--
Estimating	+541.3	+1993.3	--	+2534.6
Other	--	--	--	--
Support	--	+141.0	--	+141.0
SubTotal	+542.7	+2174.4	--	+2717.1
Total Changes	+509.8	-3299.4	--	-2789.6
CE - Cost Variance	1649.0	10244.1	--	11893.1
CE - Cost & Funding	1649.0	10244.1	--	11893.1

4

SAR Summary Tables



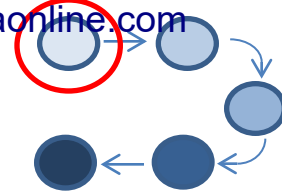
- SAR Summary Tables can be found through the following link:

<http://www.acq.osd.mil/ara/am/sar>

- Unlike the SARs themselves, SAR Summary Tables are publicly available
- Through funding from ODASA-CE, December SAR Summary Sheets were collected and validated from 1986 to 2010*
 - Program Acquisition Cost Summary
 - Cost Categories (\$BY and \$TY)
 - Programs are organized by Service
 - Does NOT split cost by appropriation
- Examples of the SAR Summary Sheets used for this analysis may be found in Backup

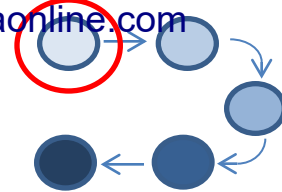
*December 2011 SARs were just released at “press time”

SAR Summary Tables



- Extracted SAR Summary Sheets from PDF to Excel
- Validated and corrected transcription errors (shown in detail on next slide)
 - **Validation A:** Sum of Baseline Estimates (BE) and all changes to date are equal to Current Estimates (CE)
 - Applies to \$BY, \$TY, and Quantity columns
 - **Validation B:** Sum of Cost Categories are equal to Total Changes
 - Applies to \$TY and \$BY Cost Categories, and also to changes for “This Qtr” and “To Date” columns
 - **Validation C:** Total Changes in Program Acquisition Cost Summary table are equal to Total Changes in Cost Category tables
 - Applies to both \$TY and \$BY
- Improved program metadata
 - Populated data with PNO, since program names often change over time (e.g., DD 21 → DD(X) → DDG 1000)
 - Verified Milestone/Phase in SARs against Baseline Type (e.g., DE/PdE)

SAR Summary Tables



Program Acquisition Cost Summary (Dollars in Millions) As of December 31, 2010														
Program	Base Year	Baseline Type	Baseline Estimate			Changes To Date			Current Estimate			% Change To Date Adjusted for Qty		
			Base-Year Dollars	Then-Year Dollars	Quantity	Base-Year Dollars	Then-Year Dollars	Quantity	Base-Year Dollars	Then-Year Dollars	Quantity	Base-Year Dollars	Then-Year Dollars	

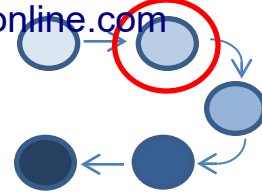
Validation A: Baseline Estimate + Changes To Date = Current Estimate

Validation C: Changes To Date = Total Changes

Distribution of Cost Changes (Base-Year Dollars in Millions) As of December 31, 2010														
Program	Base Year	Cost Changes Between the Baseline and Current Estimate												
		Quantity		Schedule		Engineering		Estimating		Other		Support		Total
		This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr

Validation B: Sum of all Cost Changes = Total Changes

Distribution of Cost Changes (Then-Year Dollars in Millions) As of December 31, 2010																
Program	Cost Changes Between the Baseline and Current Estimate															
	Economic		Quantity		Schedule		Engineering		Estimating		Other		Support		Total	
	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date



SAR Summary Tables

- Used SAR Summary Sheets to identify final SAR for a given milestone estimate
 - Final SAR is sufficient, as it contains Baseline Estimate

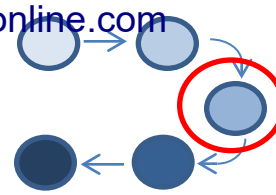
Program Metadata					Baseline Estimate			Changes To Date			Current Estimate			% Change To Date Adjusted for Qty			
Date	Service	Program	BY	Baseline	PNO	Unique ID	BY \$	TY\$	Qty	BY \$	TY\$	Qty	BY \$	TY\$	Qty	BY \$	TY\$
12/31/10	Army	AB3A REMANUFACTURE	2010	DE	202	202_DE	7,064.40	8,093.90	602	3,388.10	3,799.20	37	10,452.50	11,893.10	639	43.9	40.1
12/31/10	Army	AB3B NEW BUILD	2010	PdE	437	437_PdE	2,307.00	2,510.40	56	-150.4	-157.7	1	2,156.60	2,352.70	57	-8.3	-8.1
12/31/10	Army	ATIRCM-CMWS: QRC	2003	PdE	219A	219A_PdE	894.8	1,054.40	0	6	-47.8	83	900.8	1,006.60	83	-16.3	-25.9
12/31/10	Army	ATIRCM-CMWS	2003	PdE	219B	219B_PdE	1,900.90	2,186.20	2,668	1,260.50	1,421.60	-648	3,161.40	3,607.80	2,020	38.8	30.1
12/31/10	Army	ICH (CH-47F)	2005	PdE	278	278_PdE	10,614.80	12,147.40	512	2,088.30	2,291.10	20	12,703.10	14,438.50	532	15.1	14.1
12/31/10	Army	EXCALIBUR	2007	PdE	366	366_PdE	2,264.60	2,518.70	30,388	-580	-808.1	-22,914	1,684.60	1,710.60	7,474	6	0.7
12/31/10	Army	FBCB2	2005	PdE	294	294_PdE	1,579.90	1,556.70	22,248	2,059.70	2,260.90	67,820	3,639.60	3,817.60	90,068	20.9	20.9
12/31/10	Army	FMTV	1996	PdE	746	746_PdE	11,594.20	18,921.30	85,488	3,842.40	-189.9	2,351	15,436.60	18,731.40	87,839	28	-2
12/31/10	Army	GMLRS	2003	PdE	260	260_PdE	9,780.20	11,848.90	140,239	-4,902.80	-5,824.50	-96,357	4,877.40	6,024.40	43,882	21.8	93.3
12/31/10	Army	HIMARS	2003	PdE	367	367_PdE	3,711.60	4,388.40	894	-1,929.20	-2,375.10	-513	1,782.40	2,013.30	381	-11.8	-2.1
12/31/10	Army	IAMD	2009	DE	205	205_DE	4,856.60	5,791.60	296	483.1	528.8	0	5,339.70	6,320.40	296	9.9	9.1
12/31/10	Army	INCREMENT 1 E-IBCT	2010	PdE	432	432_PdE	3,149.50	3,284.00	9	-1,906.00	-2,014.40	-6	1,243.50	1,269.60	3	-18.3	-19.9
12/31/10	Army	ILENS	2005	DE	372	372_DE	5,850.00	7,151.00	16	1,046.00	1,386.90	0	6,896.00	8,537.90	16	17.9	19.7

PNO and Unique ID were added to the SAR Summary Sheets, and the latter was used to create the Excel Pivot Table shown below

Row Labels	Dec-86	Dec-87	Dec-88	Dec-89	Dec-90	Dec-91	Dec-92	Dec-93	Dec-94	Dec-95	Dec-96	Dec-97	Dec-98	Dec-99	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-09	Dec-10	Grand Total	
100_PE					1	1	1	1	1															5	
101_DE												1	1	1	1	1	1	1	1	1	1				10
101_PdE																						1	1		2
106_DE	1	1	1	1	1	1	1																		6
107_DE	1																								1
108_DE	1	1	1	1	1	1	1	1	1																8
115_DE	1	1	1	1	1	1	1	1																	7
116_DE	1	1	1	1	1	1	1	1	1																9

Final SAR for milestone estimate

SAR Cost Variance Tables



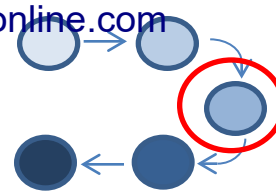
- Cost Variance tables were extracted in TY\$ and BY\$ from individual SARs to provide cost growth by both **Appropriation Type** and **Cost Category**

Summary Then Year \$M				
	RDT&E	Proc	MILCON	Total
SAR Baseline (Prod Est)	5574.0	36063.3	--	41637.3
Previous Changes				
Economic	-23.7	+37.7	--	+14.0
Quantity	--	+6367.3	--	+6367.3
Schedule	--	+1125.9	--	+1125.9
Engineering	--	+258.3	--	+258.3
Estimating	+7.3	-643.1	--	-635.8
Other	--	--	--	--
Support	--	+2213.2	--	+2213.2
Subtotal	-16.4	+9359.3	--	+9342.9
Current Changes				
Economic	--	+132.9	--	+132.9
Quantity	--	+575.3	--	+575.3
Schedule	--	-16.5	--	-16.5
Engineering	--	--	--	--
Estimating	--	-656.3	--	-656.3
Other	--	--	--	--
Support	--	-16.9	--	-16.9
Subtotal	--	+18.5	--	+18.5
Total Changes	-16.4	+9377.8	--	+9361.4
CE - Cost Variance	5557.6	45441.1	--	50998.7
CE - Cost & Funding	5557.6	45441.1	--	50998.7

Summary Base Year 2000 \$M				
	RDT&E	Proc	MILCON	Total
SAR Baseline (Prod Est)	5889.4	32995.3	--	38884.7
Previous Changes				
Economic	--	--	--	--
Quantity	--	+4990.1	--	+4990.1
Schedule	--	+990.1	--	+990.1
Engineering	--	+227.2	--	+227.2
Estimating	+5.8	-441.6	--	-435.8
Other	--	--	--	--
Support	--	+1980.9	--	+1980.9
Subtotal	+5.8	+7746.7	--	+7752.5
Current Changes				
Economic	--	--	--	--
Quantity	--	+431.8	--	+431.8
Schedule	--	+8.0	--	+8.0
Engineering	--	--	--	--
Estimating	--	-512.1	--	-512.1
Other	--	--	--	--
Support	--	-12.0	--	-12.0
Subtotal	--	-84.3	--	-84.3
Total Changes	+5.8	+7662.4	--	+7668.2
CE - Cost Variance	5895.2	40657.7	--	46552.9
CE - Cost & Funding	5895.2	40657.7	--	46552.9

- Cost Variance Tables occasionally reported data by Subprograms
 - Our fundamental “data points” are Subprograms, not Programs
 - Assignment of PNOs with letter to denote Subprogram

SAR Cost Variance Tables



Cost Category	Definition
Economic	A change that is solely due to price-level changes in the economy
Quantity	A cost variance that is due to a change in the number of units of an end item of equipment
Schedule	Costs resulting from a change in a procurement or delivery schedule, completion date, or intermediate milestone for development or production
Engineering	Cost increases or decreases that are due to an alteration in the physical or functional characteristics of a system or item delivered
Estimating	Changes that are due solely to the correction of previous estimating errors or to refinements of a current estimate
Other	Cost variances that are due to unforeseeable events not covered in any other category (e.g., natural disaster, strike)
Support	Any change in cost, regardless of reason, associated with support equipment for the major hardware item (defined as any WBS element not included in flyaway, rollaway, or sailaway costs)
Baseline Adjustment	Adjustments to the baseline estimate
InterPhase	Correction of milestone transition disconnects (will be explained later in the presentation)

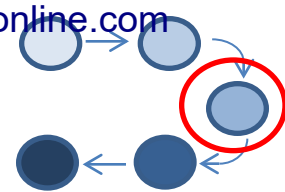
Seven "standard" categories shown in SAR*

*DoD 7000.3-G

Reported occasionally

Calculated value

Data Collection Approach

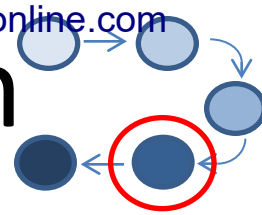


- Identified in-house data
 - Leveraged existing SAR holdings
 - Additional SARs requested from DAMIR
- Expanded on last year’s data set, both in the number of data points and in the level of detail

Element	Last Year	This Year
Source	SAR Summary Sheets	Individual SARs
Service	DON MDAPs	All Services & DOD
Appropriation	Total Program Acq Cost	RDT&E, Proc, MILCON, O&M
Milestone	A, B, and C	A, B, and C
Cost Variance Categories	Qty Only	9 Cost Categories
Number of Programs	83	312
Number of Estimates	100	406

Numbers may change depending on current V&V efforts.





Data Verification & Validation

- Correct transcription errors (i.e., OCR and manual data entry)
 - #1: Validate sums across appropriation types (shown in red)*
 - #2: Validate sums across cost categories (shown in blue)**
 - #3: Reconcile totals from SARs to totals from SAR Summary Sheets (shown in green)

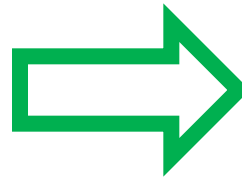
*Previous Validations A/C
 **Previous Validation B

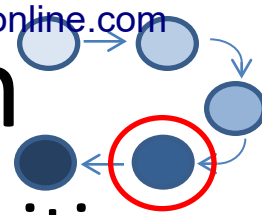
Distribution of Cost Changes (Then-Year Dollars in Millions)
 As of December 31, 2010

Program	Cost Changes Between the Baseline and Current Estimate														Total	
	Economic		Quantity		Schedule		Engineering		Estimating		Other		Support			
	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date
Army Subtotal:																
AB3A REMANUFACTURE	21.1	-384.7	-	395.5	19.9	147.5	-	-	2,534.6	2,593.9	-	-	-	-	1	1
AB3B NEW BUILD	4.1	4.1	49.7	49.7	2.8	2.8	-	-	-344.6	-344.6	-	-	-	-	1	1
ATIRCM/CMWS - ATIRCM QRC	-	25.4	-	303.3	-	-866.9	-	179.7	-27.5	304.0	-	-	-	-	-	-

	Summary Then Year \$M			
	RDT&E	Proc	MIL CON	Total
SAR Baseline (Dev Est)	1139.2	6954.7	--	8093.9
Previous Changes				
Economic	-12.0	-393.8	--	-405.8
Quantity	--	+395.5	--	+395.5
Schedule	--	+127.6	--	+127.6
Engineering	--	--	--	--
Estimating	-20.9	+80.2	--	+59.3
Other	--	--	--	--
Support	--	+905.1	--	+905.1
Subtotal	-32.9	+1114.6	--	+1081.7
Current Changes				
Economic	+1.4	+19.7	--	+21.1
Quantity	--	--	--	--
Schedule	--	+19.9	--	+19.9
Engineering	--	--	--	--
Estimating	+541.3	+1993.3	--	+2534.6
Other	--	--	--	--
Support	--	+141.9	--	+141.9
Subtotal	+542.7	+2174.8	--	+2717.5
Total Changes	+509.8	+3289.4	--	+3799.2
CE - Cost Variance	1649.0	10244.1	--	11893.1
CE - Cost & Funding	1649.0	10244.1	--	11893.1

The "To Date" column in the SAR Summary Sheets is equal to the sum of "Previous Changes" and "Current Changes" in the SARs



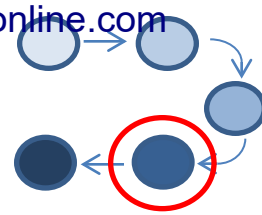


Data Verification & Validation

- #4/#5: Detect and correct milestone transition disconnects
 - Baseline Estimate in the current milestone SAR ≠ Current Estimate in the previous milestone SAR
 - Developed “InterPhase” category to capture changes (split by appropriation)
 - Example shown below, Total InterPhase for DE = 28.7 (11,424.7 – 11,396)

Change Summary Then-Year \$M					
	RDT&E	Proc	MILCON	O&M	Total
SAR Development Estimate	548.7	5087.7	0.0	0.0	5636.4
Previous Changes					
Economic	-24.6	-450.8	--	--	-475.4
Quantity	+153.0	+988.2	--	--	+1141.2
Schedule	--	+198.0	--	--	+198.0
Engineering	+226.0	+780.6	--	--	+1006.6
Estimating	+402.4	+2569.4	--	--	+2971.8
Other	--	--	--	--	--
Support	+70.2	+638.9	--	--	+709.1
Subtotal	+827.0	+4724.3	0.0	0.0	+5551.3
Current Changes					
Economic	+3.4	+144.8	--	--	+148.2
Quantity	--	--	--	--	--
Schedule	--	-8.2	--	--	-8.2
Engineering	--	--	--	--	--
Estimating	-0.3	-6.9	--	--	-7.2
Other	--	--	--	--	--
Support	--	+75.5	--	--	+75.5
Subtotal	+3.1	+205.2	0.0	0.0	+208.3
Total Changes	+830.1	+4929.5	0.0	0.0	+5759.6
Current Estimate	1378.8	10017.2	0.0	0.0	11396.0

Summary Then Year \$M				
	RDT&E	Proc	MILCON	Total
SAR Baseline (Prod Est)	1375.7	10049.0	--	11424.7
Previous Changes				
Economic	-10.1	-164.0	--	-174.1
Quantity	--	+1385.4	--	+1385.4
Schedule	--	+100.7	--	+100.7
Engineering	+188.7	+46.9	--	+235.6
Estimating	+113.5	+123.6	--	+1352.1
Other	--	--	--	--
Support	--	-83.4	--	-83.4
Subtotal	+292.1	+2524.2	--	+2816.3
Current Changes				
Economic	-0.2	-12.2	--	-12.0
Quantity	--	--	--	--
Schedule	--	+9.2	--	+9.2
Engineering	+17.0	+0.3	--	+17.3
Estimating	-4.2	+76.8	--	+72.6
Other	--	--	--	--
Support	--	+71.8	--	+71.8
Subtotal	+13.0	+145.9	--	+158.9
Total Changes	+305.1	+2670.1	--	+2975.2
CE - Cost Variance	1680.8	12719.1	--	14399.9
CE - Cost & Funding	1680.8	12719.1	--	14399.9



InterPhase Growth Example

- SSN21 and ANBSY2 (PNO 258)

1988 SAR

1999 SAR

a. Summary — (Current (Then-Year) Dollars in Millions)

	RDT&E	PROC	MILCON	TOTAL
Development Estimate	1912.6	1962.4	0.0	3875.0
Previous Changes:				
Economic	-44.8	-253.0	-	-297.8
Quantity	-	+5080.8	-	+5080.8
Schedule	-	-	-	-
Engineering	-	-	-	-
Estimating	+314.3	+42.7	-	+357.0
Other	-	-	-	-
Support (OF/PD)	-	+237.7	-	+237.7
Subtotal	269.5	5108.2	0.0	5377.7
Current Changes:				
Economic	+11.1	+3.8	-	+14.9
Quantity	-	+8670.0	-	+8670.0
Schedule	-	-	-	-
Engineering	-	-	-	-
Estimating	+253.9	+195.1	+107.7	+556.7
Other	-	-	-	-
Support (OF/PD)	-	+389.0	-	+389.0
Subtotal	265.0	9257.9	107.7	9630.6
Total Changes	534.5	14366.1	107.7	15008.3
Current/Prod. Estimate	2447.1	16328.5	107.7	18883.3

Change Summary Then-Year \$M				
	RDT&E	Proc	MILCON	Total
SAR Production Estimate	4210.0	17421.4	107.7	21739.1
Previous Changes				
Economic	-122.5	+404.0	+3.5	+285.0
Quantity	0.0	-15562.8	0.0	-15562.8
Schedule	+25.3	+6354.0	0.0	+6379.3
Engineering	+161.3	0.0	0.0	+161.3
Estimating	+317.3	+923.3	-83.9	+1156.7
Other	0.0	0.0	0.0	0.0
Support	+54.6	-804.0	0.0	-749.4
Subtotal	+436.0	-8685.5	-80.4	-8329.9
Current Changes				
Economic	-0.9	-30.5	-	-31.4
Quantity	-	-	-	-
Schedule	-	-	-	-
Engineering	-	-	-	-
Estimating	+1.5	-207.4	-	-205.9
Other	-	-	-	-
Support	-	-15.4	-	-15.4
Subtotal	+0.6	-253.3	-	-252.7
Total Changes	+436.6	-8938.8	-80.4	-8582.6
Current Estimate	4646.6	8482.6	27.3	13156.5

DE Only*		
BE (DE)	CE (DE)	CGF
3,875.0	18,883.3	4.87

InterPhase*		
CE (DE)	BE (PdE)	CGF
18,883.3	21739.1	1.15

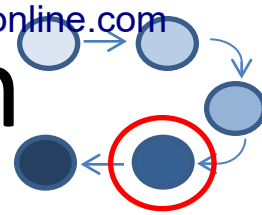
PdE Only		
BE (PdE)	CE (PdE)	CGF
21739.1	13156.5	0.61

BE = Baseline Estimate
 CE = Current Estimate
 *Calculations aren't shown in current version of database

DE to end		
BE (DE)	CE (PdE)	CGF
3,875.0	13,156.5	3.40

CGF Calculation
 (DE Only*) · (InterPhase*) · (PdE Only) = (DE to end)
 4.87 · 1.15 · 0.61 = 3.40

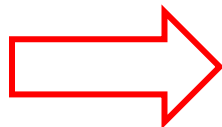
Data Verification & Validation



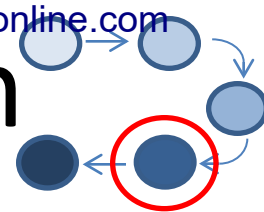
- Additional verification & validation (V&V) efforts
 - Development of “Scripts” to handle certain cases
 - Contacted SMEs for further understanding of programs
 - Investigation of quarterly SARs in efforts to reduce programs with “InterPhase” growth

- Used SAR Summary Sheets for further V&V
 - Identified programs with different baseline estimates (\$TY) in the same milestone
 - Captured additional programs w/ Subprograms and/or Baseline Adjustments

Example:
JTUAV
(PNO:514)



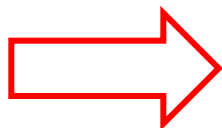
Subprogram title in Cost Variance Tables	MS	1992	1993	1994	1995
Close Range	DE	1017.8			
Short Range	DE	1661.4			
Medium Range	DE	2756.9			
Maneuver	DE			1017.8	
JTUAV Hunter/Shipboard	DE			1661.4	
TOTAL		5436.1		2679.2	



Data Verification & Validation

- Identified programs with the same baseline estimate (\$TY) for different milestones
 - Unusual cases since PdE occurred before DE

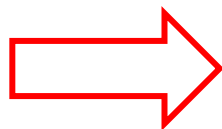
Example:
CG-47
(PNO:159)



Date	1986	1987	1988	1989	1990	1991	1992
MS (Shown in SAR)	PdE	PdE	PdE	DE	DE	DE	DE
Baseline Estimate (\$TY)	14,083.5	14,083.5	14,083.5	14,083.5	14,083.5	14,083.5	14,083.5
Current Estimate (\$TY)	24,869.2	24,277	24,070.9	23,491.1	23,315.9	23,294.1	23,276.9
Base Year of \$BY	1978	1978	1978	1978	1978	1978	1978

- Was really a Development Estimate (DE) all along
 - Most ship programs do not have a Milestone C

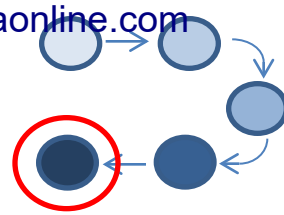
Example:
WGS
(PNO:326)



Date	2001	2002	2003	2004	2005	2006	2007	2009	2010
MS (Shown in SAR)	PdE	PdE	PdE	PdE	PdE	PdE	PdE	PdE	DE (PdE)
Baseline Estimate (\$TY)	1042.5	1042.5	1042.5	1042.5	1042.5	1042.5	1042.5	1042.5	1042.5
Current Estimate (\$TY)	876.9	1544.1	1555.8	1837.4	1979.2	1943.8	1950.5	3441.7	3510.7
Base Year of \$BY	2001	2001	2001	2001	2001	2001	2001	2001	2010

- Was really a Production Estimate (PdE) all along
 - Program restructure pending

Data Storage and Access



- Robust relational database developed (3rd normal form)
- Stores all raw, validated data (annual updates to be tied to DAMIR)
- Strives to establish a standard database for CV calculations

Filters *:
Commodity: Aircraft, Electronics, Gun, Missile, Satellite, Ship, Submarine, Torpedo, Vehicle
Estimate Type (Milestone): DE (MS B)
Base Year (>=):
Lead Service:
Program Name (includes):
Appropriation Type(s): RDT&E, Procurement, MILCON, O&M
 Completed Programs Only
 Joint Programs Only
 Cancelled Programs Only

Adjustments:
Adjust for: Economic, Quantity, Schedule, Engineering, Estimating, Other, Support, Baseline Adjustment, InterPhase

Data & Calculations:
 View Data
View Stats: Use TY Dollars

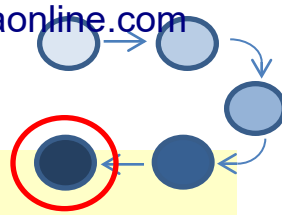
Utilities:
 Reset Form
 Exit Database

*Note: Each of these selections are filters. To query all data within a particular dimension, leave the corresponding object blank. For example, to query all years, do not enter a value in the "Initial Base Year" dropdown.

Filter by Service, Appropriation, and Adjustments

Additional features added to database this year

Data Storage and Access



Filters *:

Commodity:

Adjustments:

Adjust for:

Estimate Type (Milestone):
 Base Year (>=):
 Lead Service:
 Program Name (includes):
 Appropriation Type(s):

- Completed Programs Only
- Joint Programs Only
- Cancelled Programs Only

Data & Calculations:

View Data
 View Stats: Use TY Dollars

- ### Utilities:
- Reset Form
 - Exit Database

Last Year's Output

μ	σ	CV	Median	n
1.36	0.69	0.51	1.18	50

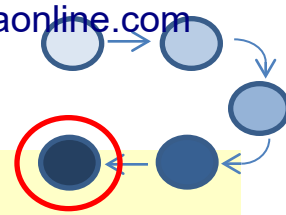
This Year's Output

μ	σ	CV	Median	n
1.34	0.83	0.62	1.10	65

* Note: Each of these selections are filters. To query all data within a particular dimension, leave the corresponding object blank. For example, to query all years, do not enter a value in the "Initial Base Year" dropdown.



Data Storage and Access



Filters*:

Commodity:

Aircraft
Electronics

Adjustments:

Adjust for: Economic
Quantity

Estimate Type (Milestone):

Base Year (>=):

Lead Service:

Program Name (includes):

Appropriation Type(s):

- Completed Programs Only
- Joint Programs Only
- Cancelled Programs Only

Data & Calculations:

View Data

View Stats:

Utilities:

Reset Form

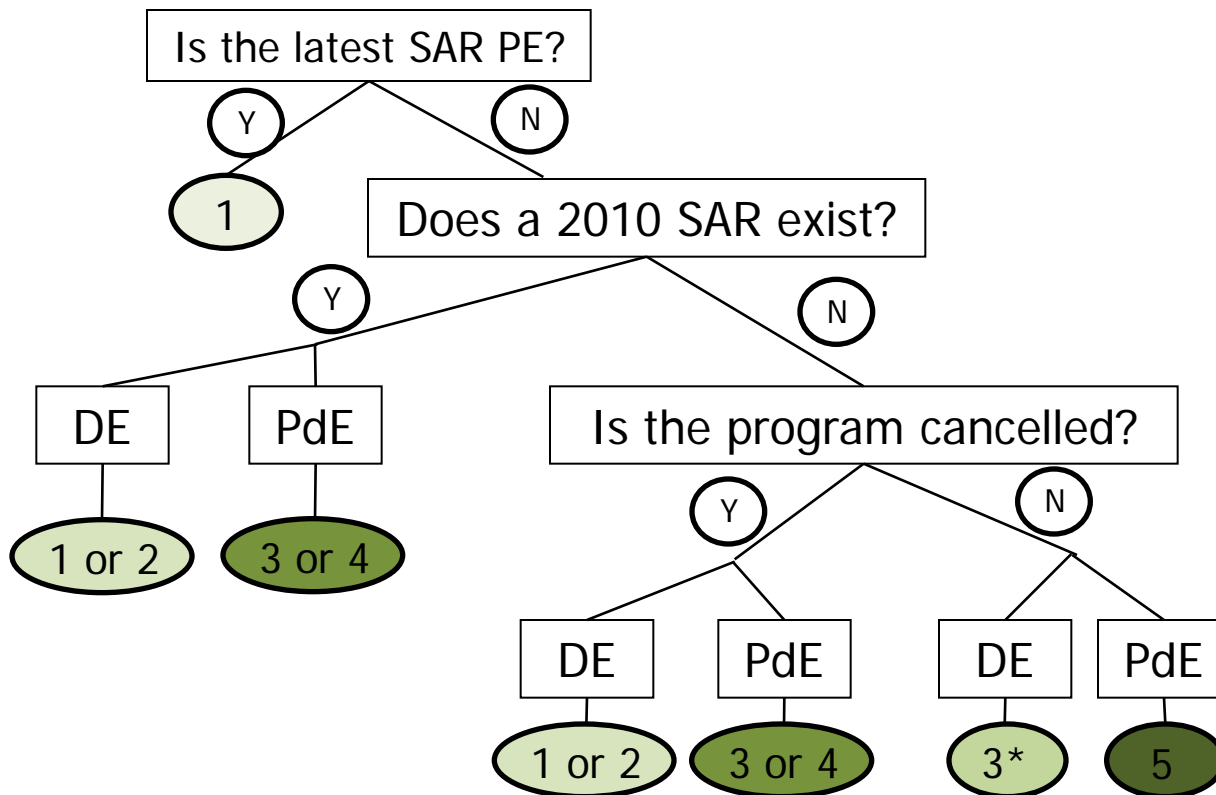
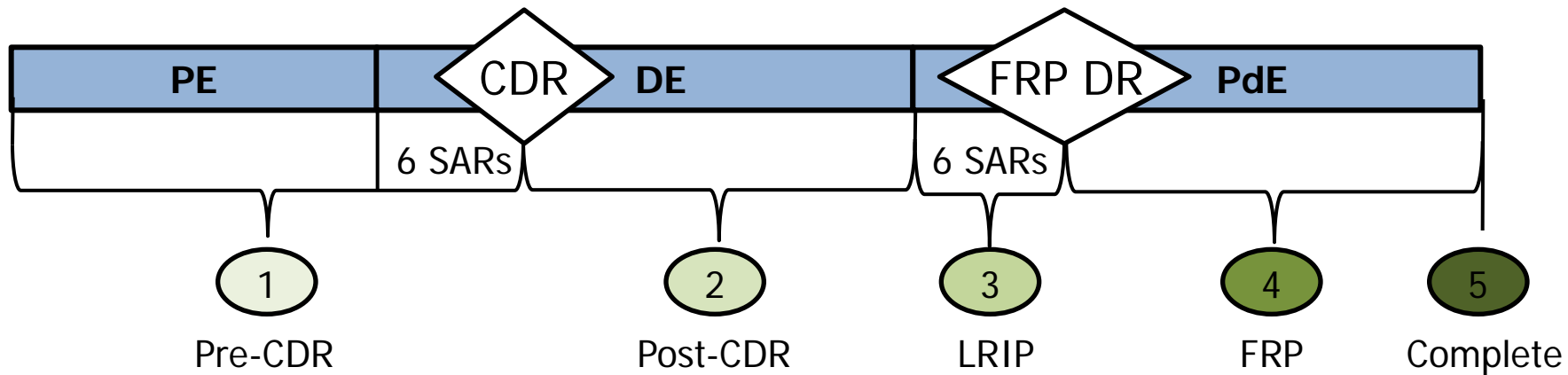
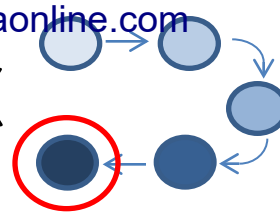
Exit Database

Program	SumOfBaseYear\$Initial	SumOfThenYear\$Initial	SumOfBaseYear\$Growth	SumOfThenYear\$Growth	SumOfBaseYear\$Current	SumOfThenYear\$Current	SumOfBYAdjustme	SumOfTYAdj
Advanced Amphibious Assault Ve	\$8,493.2	\$8,725.2	(\$5,050.6)	(\$5,395.6)	\$3,442.6	\$3,329.6	(\$6,386.4)	\$7,967.
Advanced Deployable System (AD	\$1,337.0	\$1,431.7	(\$784.9)	(\$902.9)	\$552.1	\$528.8	(\$465.3)	\$566.
Advanced Seal Delivery System (A	\$1,837.9	\$1,969.3	(\$1,094.8)	(\$1,231.6)	\$743.1	\$737.7	(\$1,115.1)	(\$1,298.
AGM-88A/B/C High-Speed Anti-Ra	\$1,681.8	\$2,409.9	\$1,378.9	\$3,813.3	\$3,060.7	\$6,223.2	\$456.5	\$914.
AGM-88E Advanced Anti-Radiation	\$1,339.8	\$1,510.9	\$252.4	\$397.8	\$1,592.2	\$1,908.7	\$44.0	\$59.
AIM-9X Air-to-Air Missile Upgrade	\$2,464.0	\$3,232.9	\$475.3	\$521.7	\$2,939.3	\$3,754.6	\$25.8	\$39.
Airborne Self Protection Jammer (\$227.7	\$236.4	\$305.0	\$300.0	\$326.4	\$332.7	\$536.4	\$0.
AN/BSY-1 Submarine Advanced Co	\$2,972.4	\$3,827.6	(\$1,628.4)	(\$2,321.1)	\$1,344.0	\$1,506.5	(\$57.0)	(\$62.
AV-8B Harrier II Close-Air-Support	\$5,740.6	\$9,125.5	(\$766.8)	(\$407.1)	\$4,973.8	\$8,718.4	(\$544.2)	(\$1,389.
CG 47 AEGIS Cruiser (Ticonderoga	\$9,013.7	\$14,083.5	\$0.0	\$0.0	\$9,013.7	\$14,083.5	\$5,491.4	\$11,739.
CH-53E Super Stallion / MH-53E Se	\$464.4	\$78.4	\$1,328.1	\$4,273.3	\$1,792.5	\$4,851.7	\$969.8	\$2,780.
CH-53K Heavy Lift Replacement (H	\$14,980.9	\$18,766.3	\$5,322.7	\$6,978.5	\$20,303.6	\$25,744.8	\$2,326.4	\$3,108.
CH-60S / MH-60S Fleet Combat Bus	\$2,769.0	\$3,154.0	\$3,874.7	\$4,790.4	\$6,643.7	\$7,944.4	\$1,499.7	\$1,926.
COBRA JUDY Replacement (CJR)	\$1,365.0	\$1,464.0	\$162.6	\$250.2	\$1,527.6	\$1,714.2	\$0.0	\$0.
Cooperative Engagement Capabili	\$2,441.6	\$2,573.1	\$1,875.1	\$2,063.5	\$4,316.7	\$4,636.6	\$108.2	\$244.
CV Helo (SH-60F) Seahawk Carrier	\$2,559.0	\$3,076.2	(\$940.5)	(\$1,250.9)	\$1,618.5	\$1,825.3	(\$931.4)	(\$1,287.
CVN 21 / CVN(X) / CVN 78 Nuclear	\$28,701.2	\$36,082.1	(\$1,275.2)	\$4,213.2	\$27,426.0	\$40,295.3	\$0.0	\$0.
CVN 71 Theodore Roosevelt (Nimi	\$1,808.3	\$2,420.6	\$86.9	\$120.5	\$1,895.2	\$2,541.1	\$0.0	\$0.
CVN 72 Abraham Lincoln / CVN 73	\$5,265.5	\$7,418.9	(\$34.8)	(\$1,262.7)	\$5,230.7	\$6,156.2	\$0.0	\$0.
CVN 74 John C. Stennis / CVN 75 H	\$5,911.0	\$6,966.0	\$616.2	\$56.3	\$6,527.2	\$7,022.3	\$0.0	\$0.
DD 21 / DD(X) / DDG 1000 Guided M	\$31,547.9	\$36,296.3	(\$13,130.9)	(\$15,404.9)	\$18,417.0	\$20,891.4	(\$14,646.0)	(\$19,092.
DDG 51 Guided Missile Destroyer	\$13,595.5	\$18,479.6	\$46,569.4	\$69,937.0	\$60,164.9	\$88,416.6	\$34,827.1	\$54,612.
E-2D Advanced Hawkeye	\$14,250.5	\$14,982.0	\$2,889.8	\$3,475.9	\$17,140.3	\$18,457.9	(\$0.1)	\$0.
E-6A TACAMO Airborne Strategic C	\$1,584.7	\$2,251.7	\$36.8	(\$88.3)	\$1,621.5	\$2,163.4	\$41.1	\$61.
EA-18G Growler Airborne Electron	\$7,662.6	\$8,421.6	\$2,078.9	\$2,783.4	\$9,741.5	\$11,205.0	\$1,167.6	\$1,384.
Extended Range Munition (ERM)	\$1,242.7	\$1,478.0	\$44.8	\$43.4	\$1,287.5	\$1,521.4	\$0.0	\$0.
F/A-18 A/B/C/D Hornet Naval Atta	\$8,016.6	\$12,875.3	\$5,949.8	\$23,908.1	\$13,966.4	\$36,783.4	\$1,116.9	\$333.
F/A-18 E/F Super Hornet Naval Str	\$66,010.7	\$94,583.0	(\$19,373.5)	(\$43,602.8)	\$46,637.2	\$50,980.2	(\$13,245.5)	(\$25,527.
F/A-18E/F AESA / Active Electroni	\$1,899.8	\$525.2	\$56.1	\$54.7	\$1,955.9	\$579.9	\$0.0	\$0.
F-14D Tomcat All Weather Carrier-	\$16,647.0	\$19,219.8	(\$10,539.8)	(\$12,721.6)	\$6,107.2	\$6,498.2	(\$2,975.3)	(\$3,394.
FFG 7 (Oliver Hazard Perry Class)	\$2,620.4	\$3,244.5	\$1,733.2	\$6,203.4	\$4,353.6	\$9,447.9	\$104.4	\$307.
Fixed Distributed System (FDS) Ar	\$5,190.5	\$7,847.3	(\$4,094.8)	(\$6,583.8)	\$1,095.7	\$1,263.5	(\$3,047.3)	(\$4,827.
H-1 Upgrades (4BW/4BN) United S	\$3,449.1	\$3,547.5	\$8,499.1	\$9,171.4	\$11,948.2	\$12,718.9	\$0.0	\$0.
Harpoon Anti-Ship Weapon (A/R/I	\$795.0	\$1,031.8	\$736.3	\$2,713.2	\$1,531.3	\$3,745.0	(\$35.1)	(\$132.
High Frequency Anti-Jam (HFAJ)	\$3,366.8	\$4,540.3	(\$3,256.6)	(\$4,430.5)	\$110.2	\$109.8	(\$3,256.6)	(\$4,430.
Integrated Defensive Electronic C	\$660.7	\$746.1	\$121.0	\$117.1	\$781.7	\$863.2	\$59.5	\$69.
Joint High-Speed Vessel (JHSV)	\$3,460.0	\$3,892.3	\$35.9	\$45.7	\$3,495.9	\$3,938.0	\$0.0	\$0.
Joint Precision Approach and Land	\$963.2	\$1,031.9	(\$27.6)	(\$47.6)	\$935.6	\$984.3	\$0.9	\$1.
Joint Standoff Weapon (JSOW) Ba	\$1,885.8	\$2,969.2	(\$388.0)	(\$1,069.3)	\$1,497.8	\$1,899.9	(\$1,082.0)	(\$1,616.
Joint Standoff Weapon (JSOW) Ba	\$3,360.9	\$6,307.2	(\$1,168.7)	(\$2,894.0)	\$2,192.2	\$3,413.2	\$901.5	\$1,522.

Fisher Use TY Dollars 1.34 0.83 0.62 1.10 65

* Note: Each of these selections are filters. To query all data within a particular dimension, leave the corresponding object blank. For example, to query all years, do not enter a value in the "Initial Base Year" dropdown.

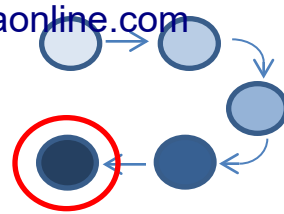
Completeness Degree Index



- Philosophy is to include *all* available SARs in database and use queries to produce desired subsets for analysis

*Exception for completed Production programs without MS C (e.g., Ships)

Business Rules in Database



- For Procurement or Total Acquisition
 - Include 4s and 5s only
 - Unless “Completed Programs” box checked, in which case 5s only
- For RDT&E
 - Include 2s through 5s, inclusive
 - Unless “Completed Programs” box checked, in which case 3s through 5s only

CGF is Invariant with Base Year

- CGF is invariant with Base Year

- Addition of BY12 should not necessitate new CGFs, since the CGFs based on BY12 would be mathematically identical to those based on BY

$$CGF (BY) = \frac{CE (BY)}{BE (BY)} = \frac{CE (BY) \cdot i}{BE (BY) \cdot i} = \frac{CE (BY12)}{BE (BY12)} = CGF (BY12)$$

where CE = Current Estimate, BE = Baseline Estimate, BY = Base Year,
 i = escalation index from BY to BY12

- Example calculation shown for DDG-51 at MS C for Procurement



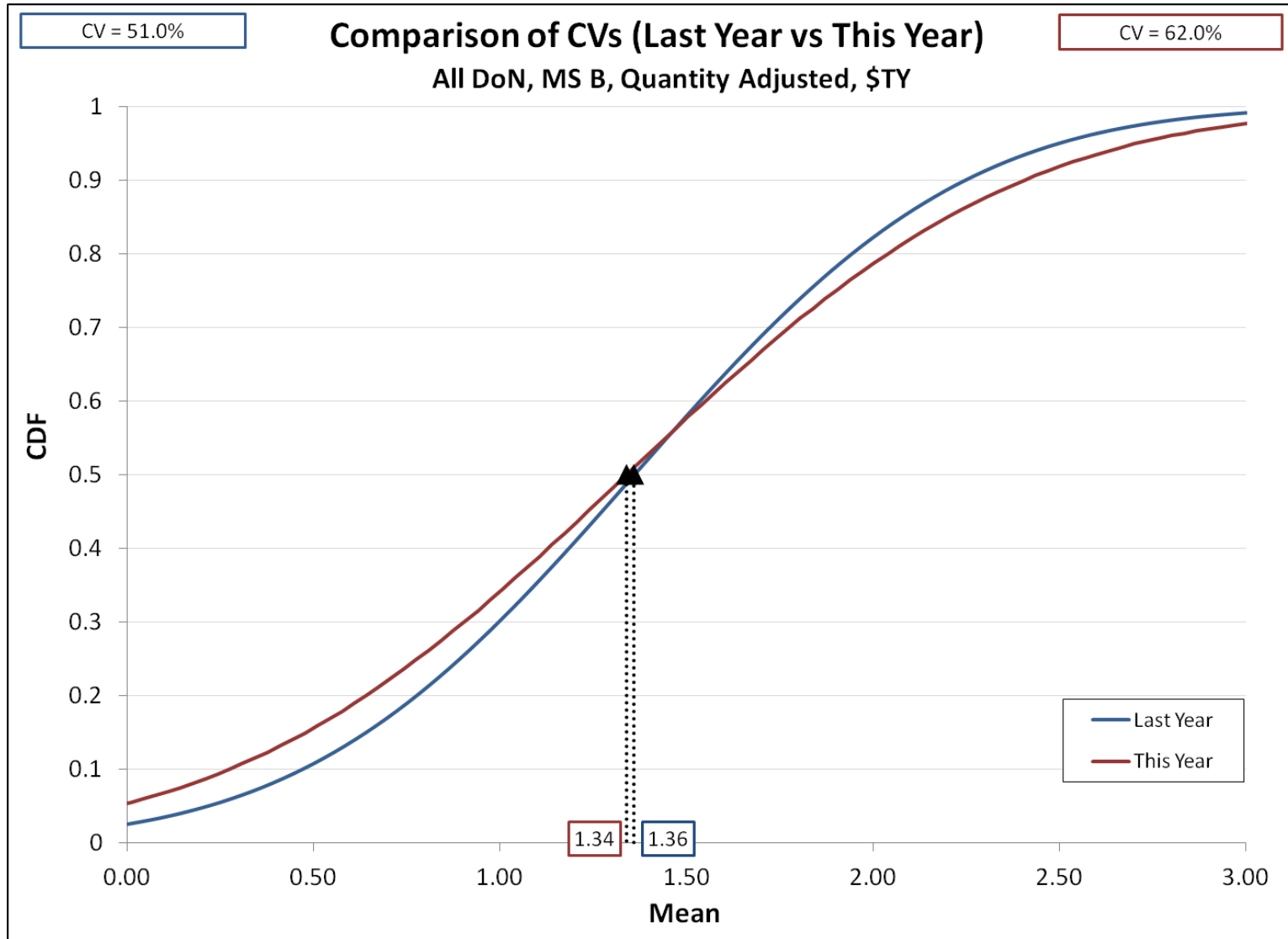
$$CGF (BY1987) = \frac{CE (BY1987)}{BE (BY1987)} = \frac{57,095.5}{15,948.3} = 3.58$$

$$i = \frac{Raw\ Index\ (2012)^*}{Raw\ Index\ (1987)^*} = \frac{1.0394}{0.6076} = 1.71$$

$$CGF (BY12) = \frac{CE (BY1987) \cdot i}{BE (BY1987) \cdot i} = \frac{57,095.5 \cdot 1.71}{15,948.3 \cdot 1.71} = \frac{97,633.3}{27,271.6} = 3.58$$

*Based on BY2010 Shipbuilding & Conversion, Navy (SCN) inflation table

Self-Benchmark via S-Curve Tool



Total Number of Estimates

Total # of Estimates	PE	DE	PdE	
25	25			
38	19			
12	6		6	
36	12			
130		130		
90		45		
75			75	
Total # of Estimates	406	62	206	138

Total Number of Programs
(sum of grey cells)

312



SAR Data Analysis

- Quantity-adjustments:
 - Laspeyres, Paasche, and Fisher $\$$ and indices
- Standard deviations and percentiles
 - Standard deviation vs. CV vs. (median-based) pseudo-CV
 - Empirical percentile of 1.0 CGF vs. implied percentile given CV and CGF
- CGF and CV derivations
 - CV of CGFs
 - Confidence intervals for CV (normal or lognormal assumption)
 - CV of Cost and CE vs. BE graphs
 - White test for heteroskedastic error terms
 - MLE regressions, error functional forms, and the size effect
 - CV of MLE regression vs. CV at \bar{x}
 - Normalized deviations and correction for size effect

SAR Data Hypothesis Testing

- Program Maturity
 - CGFs and CVs decline throughout Acquisition process (i.e., MS A to B to C)
- Platform Homogeneity
 - CGFs and CVs equivalent for aircraft, ships, and other platform types
- Service Homogeneity*
 - CGFs and CVs equivalent for three services, DoD
- Adjustment Decline
 - CGFs and CVs decrease when adjusted for changes in quantity and inflation
- Invariance of Secular Trend
 - CVs steady long-term

Quantity Adjustments

- Quantity viewed as either:
 - Random (no adjustment); or
 - Exogenous (adjustment)
- Three possible quantity adjustments:

Method	Description	Baseline \$	Current \$	CGF
Laspeyres	Adjust current estimate to reflect baseline quantities	BE	$CE - Q\Delta$	$\frac{CE - Q\Delta}{BE}$
Paasche	Adjust baseline estimate to reflect current quantities	$BE + Q\Delta$	CE	$\frac{CE}{BE + Q\Delta}$
Fisher	“Split the difference” between baseline and current quantities	$\sqrt{BE \cdot (BE + Q\Delta)}$	$\sqrt{(CE - Q\Delta) \cdot CE}$	$\sqrt{\frac{(CE - Q\Delta) \cdot CE}{BE \cdot (BE + Q\Delta)}}$

“Development and Application of CV Benchmarks,” Brian Flynn, Paul Garvey, Peter Braxton, Richard Lee, DoDCAS, 2011.

Geometric mean is used for multiplicative comparisons

Cost Growth Calculations

Example: CG-47 Class (MS B)



- Baseline Estimate (BE) of 1978
 - 16 ships at \$9.01B (BY\$) and \$14.08B (TY\$)
- Current Estimate (CE) of 1992
 - 27 ships at \$14.11B (BY\$) and \$23.28B (TY\$)
 - Deltas in BY\$
 - \$5.10B total & \$5.49B quantity
 - Deltas in TY\$
 - \$9.20B total & \$11.74B quantity

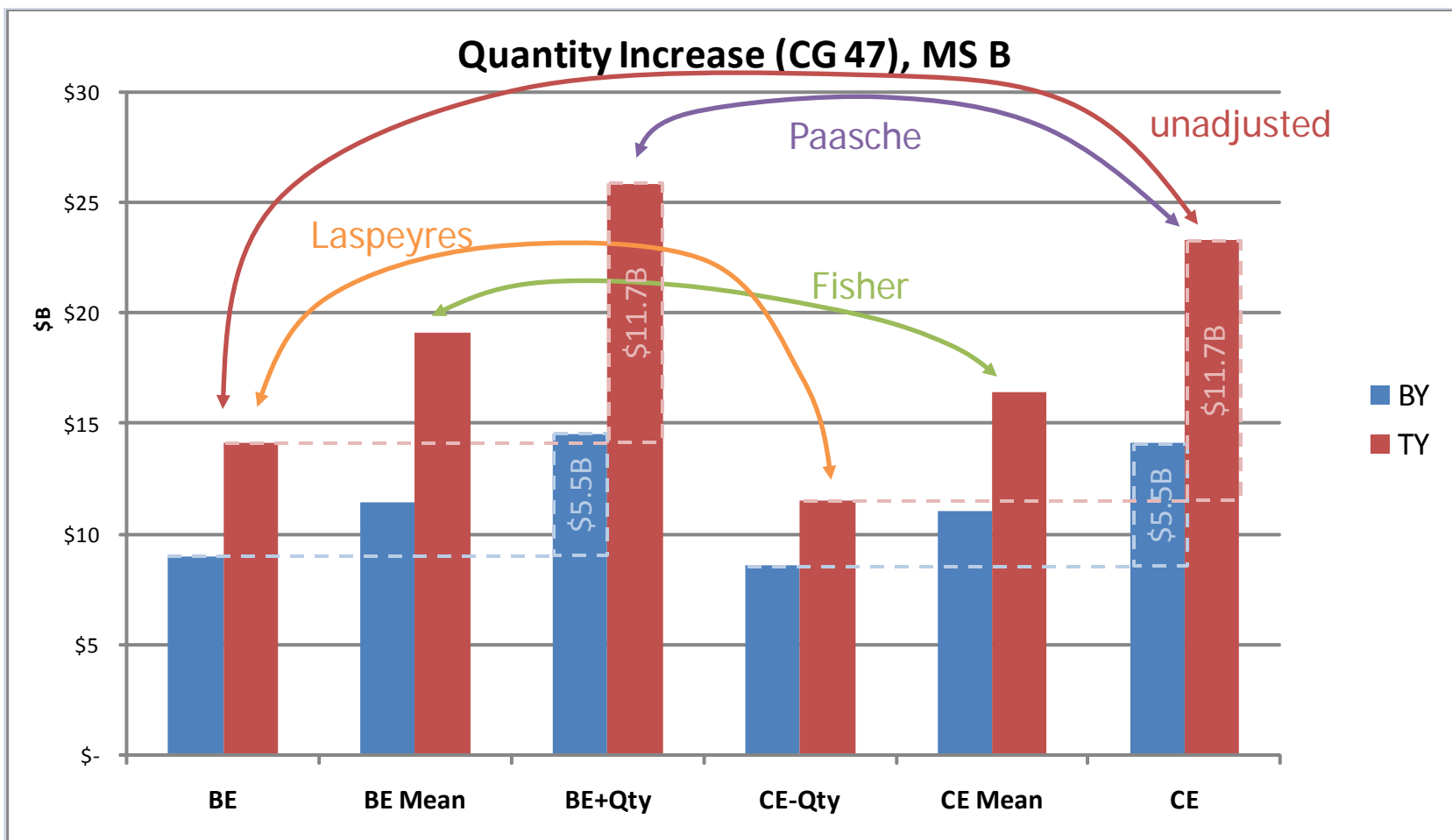
Paasche

Cost Growth Factors

- Unadjusted for quantity Δ
 - Then-year dollars
 - $\$23.28B / \$14.08B = 1.65$
 - Base-year dollars
 - $\$14.11B / \$9.01B = 1.57$
- Adjusted for quantity Δ , using OSD methodology
 - Then-year dollars
 - $\$23.28B / (\$14.08B + \underline{\$11.74B}) = 0.90$
 - Base-year dollars
 - $\$14,11B / (\$9.01B + \underline{\$5.49B}) = 0.97$

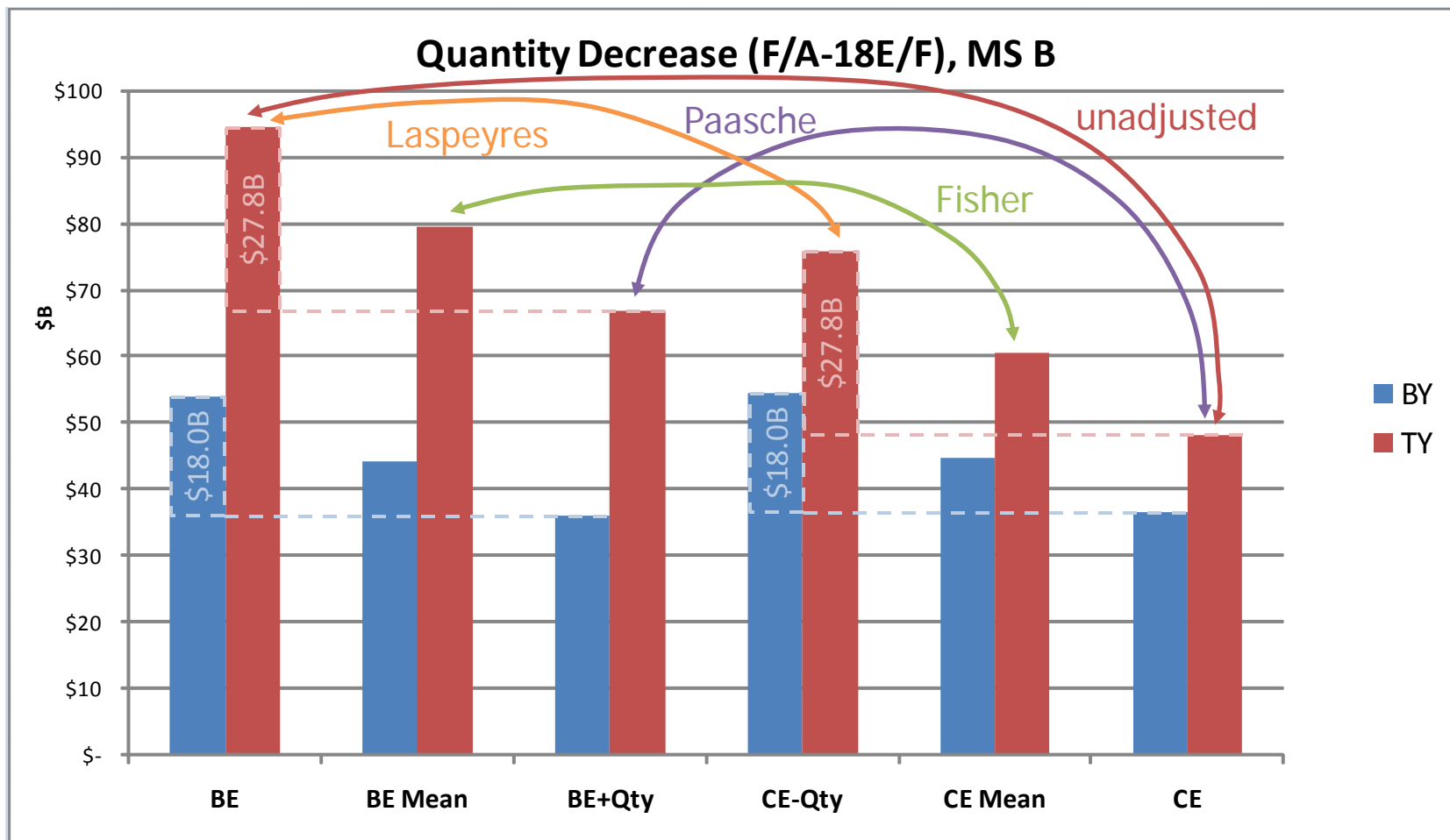
“Development and Application of CV Benchmarks,” Brian Flynn, Paul Garvey, Peter Braxton, Richard Lee, DoDCAS, 2011.

CGF Calculations Illustrated



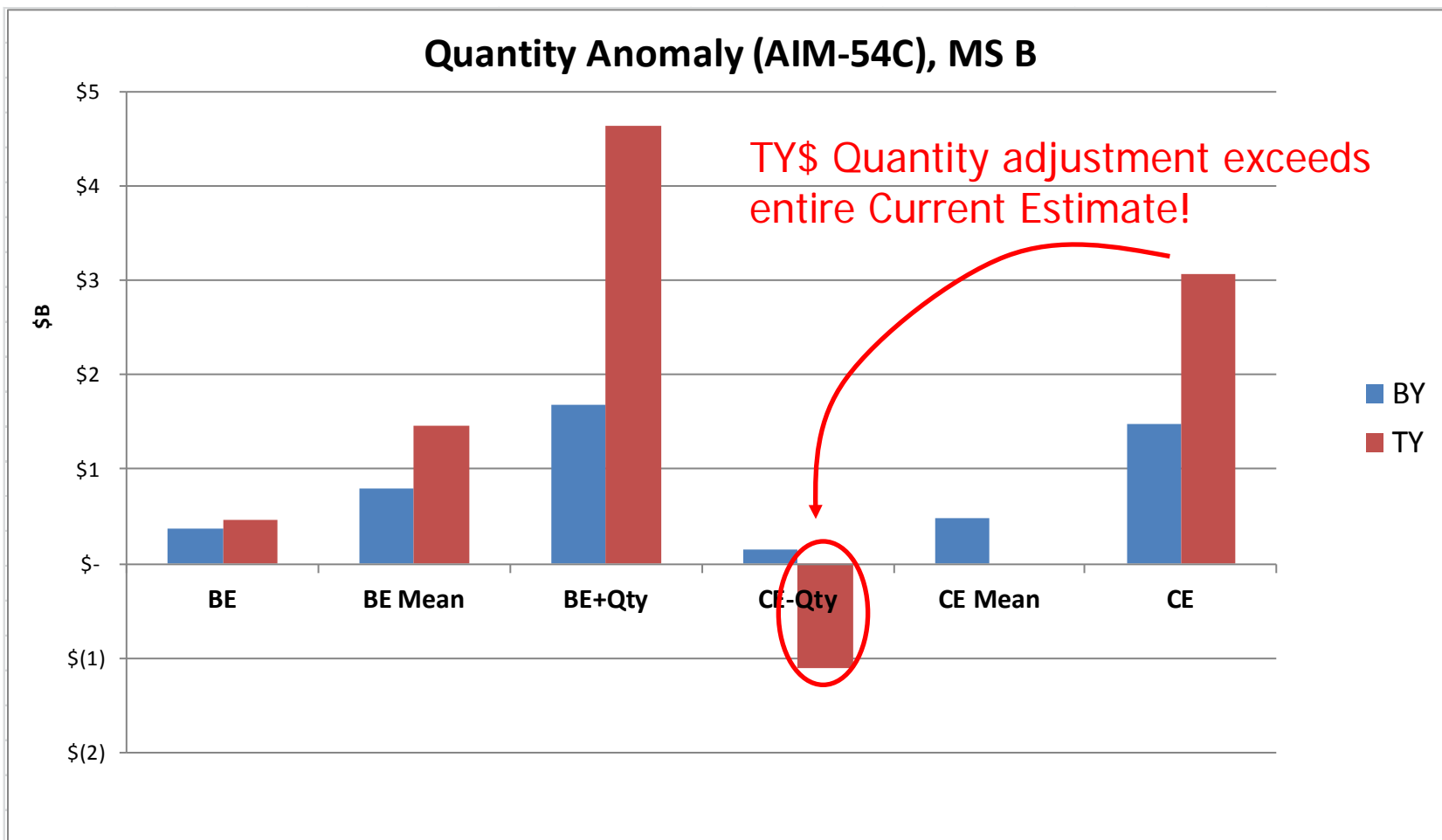
CG 47	BE	BE Mean	BE+Qty	CE-Qty	CE Mean	CE	Qty
BY	\$ 9,013.7	\$ 11,434.4	\$ 14,505.1	\$ 8,620.2	\$ 11,029.3	\$ 14,111.6	\$ 5,491.4
TY	\$ 14,083.5	\$ 19,070.2	\$ 25,822.5	\$ 11,537.9	\$ 16,388.0	\$ 23,276.9	\$ 11,739.0
BY	1.57			0.96	0.96	0.97	
TY	1.65			0.82	0.86	0.90	
	unadjusted			Laspeyres	Fisher	Paasche	
Qty	16		27	16		27	11

CGF Calculations Illustrated



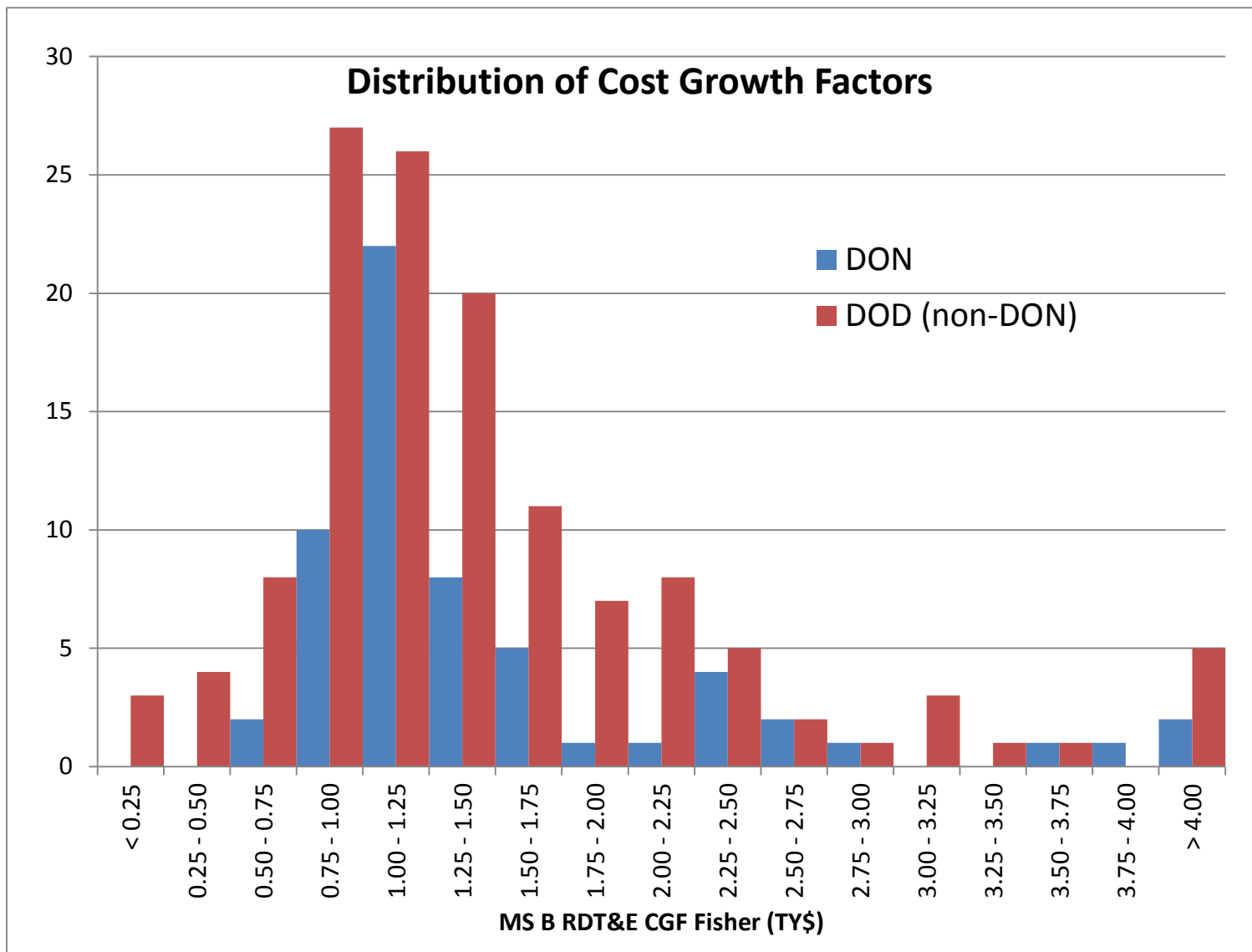
F/A-18E/F	BE	BE Mean	BE+Qty	CE-Qty	CE Mean	CE	Qty
BY	\$ 53,959.6	\$ 44,068.9	\$ 35,991.1	\$ 54,538.2	\$ 44,659.2	\$ 36,569.7	\$ (17,968.5)
TY	\$ 94,583.0	\$ 79,503.6	\$ 66,828.2	\$ 75,846.2	\$ 60,394.9	\$ 48,091.4	\$ (27,754.8)
BY	0.68			1.01	1.01	1.02	
TY	0.51			0.80	0.76	0.72	
	unadjusted			Laspeyres	Fisher	Paasche	
Qty	1000		515	1000		515	-485

Quantity Anomaly Illustrated

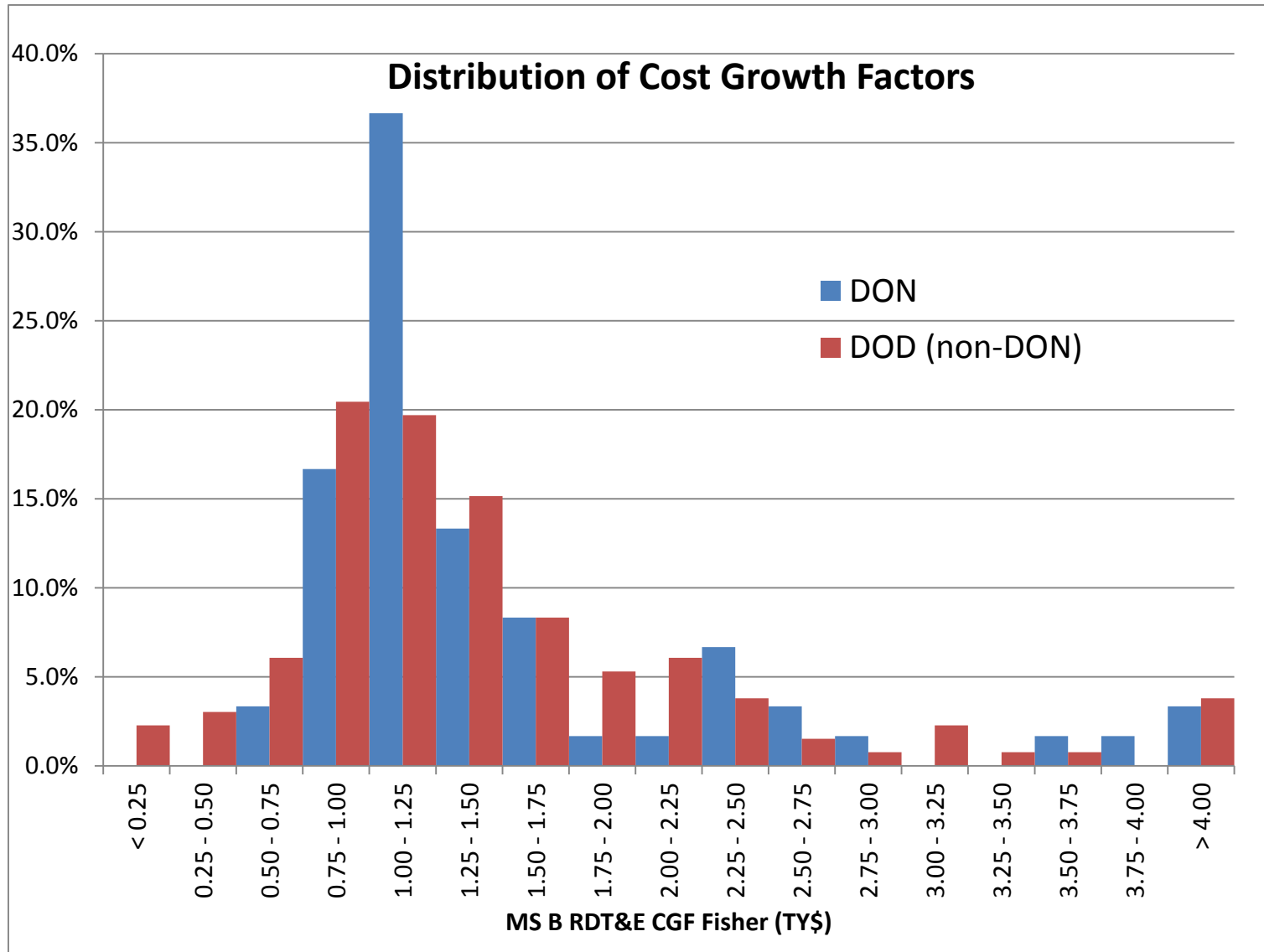


AIM-54C	BE	BE Mean	BE+Qty	CE-Qty	CE Mean	CE	Qty
BY	\$ 372.0	\$ 792.9	\$ 1,690.2	\$ 158.1	\$ 483.1	\$ 1,476.3	\$ 1,318.2
TY	\$ 464.3	\$ 1,466.8	\$ 4,633.6	\$ (1,096.2)	#NUM!	\$ 3,073.1	\$ 4,169.3
BY	3.97			0.43	0.61	0.87	
TY	6.62			-2.36	#NUM!	0.66	
	unadjusted			Laspeyres	Fisher	Paasche	
Qty	735		2528	735		2528	1793

Data Analysis Example



Data Analysis Example

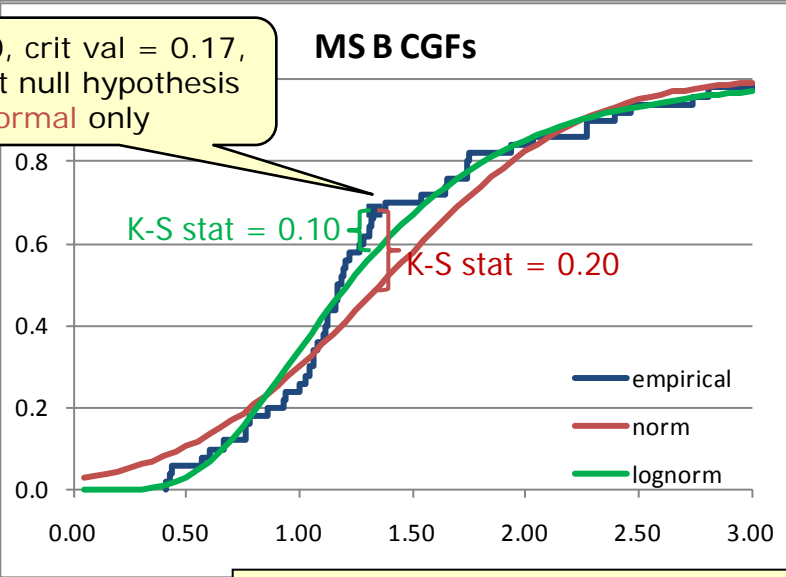


S-Curve vs. Stair Step

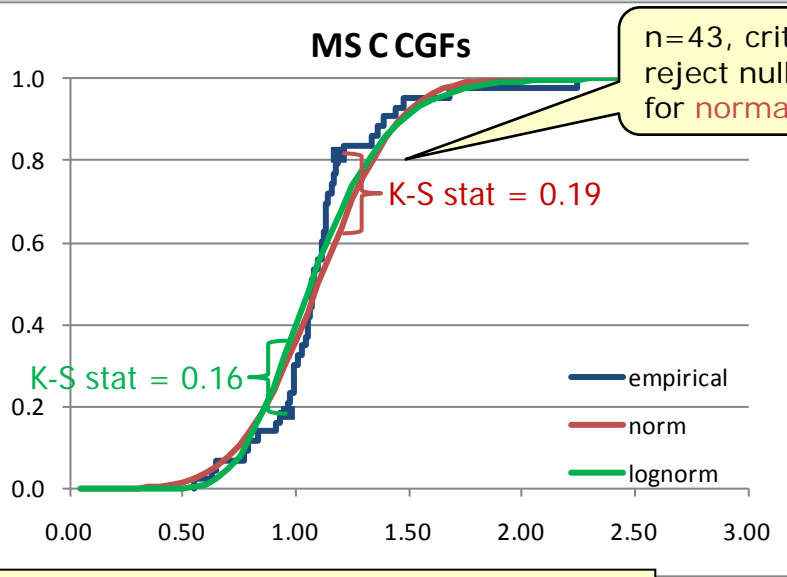
- The aforementioned methods preserve the “shape” of the baseline distribution and ignore the “shape” of historical (cross-program) risk
- Parametric approach
 - Normal or lognormal distribution with historical CV
 - Distributions diverge as CV increases
- Non-parametric approach
 - Empirical distribution of CGFs (non-parametric)
 - Does not circumvent that distribution of CGFs may not be the right thing to look at in the first place
- Comparison graphs for MS B (CV = 51%) and MS C (CV = 26%), TY\$ Fisher

For $\alpha=0.10$, $n>40$,
K-S critical value is approx.⁸ $\frac{1.22}{\sqrt{n + \sqrt{n/10}}}$

$n=50$, crit val = 0.17,
reject null hypothesis
for **normal** only



$n=43$, crit val = 0.18,
reject null hypothesis
for **normal** only



8. *Practical Nonparametric Statistics* (3rd ed.), W.J. Conover, John Wiley and Sons, Inc., 1999.
Table A13 Quantiles of the Kolmogorov Test Statistic.



CV of Cost – Theoretical Framework

- Some mental models are not very satisfying, as they fly in the face of historical data
 - Variation in cost cannot be a fixed percent, because the well-established “size effect” says that **larger programs** have a **smaller *percent* variation**
 - Variation in cost cannot be a fixed dollar value, because clearly **larger programs** have a **larger *dollar-value* variation**
- Thus we need a model that will accommodate both these observations, which bring us to... [drum roll]
 - Current Estimate is a linear function of Baseline Estimate with a heteroskedastic error term
 - Variance increases linearly with program size (BE\$)
- We explore this model using the DON SAR data themselves

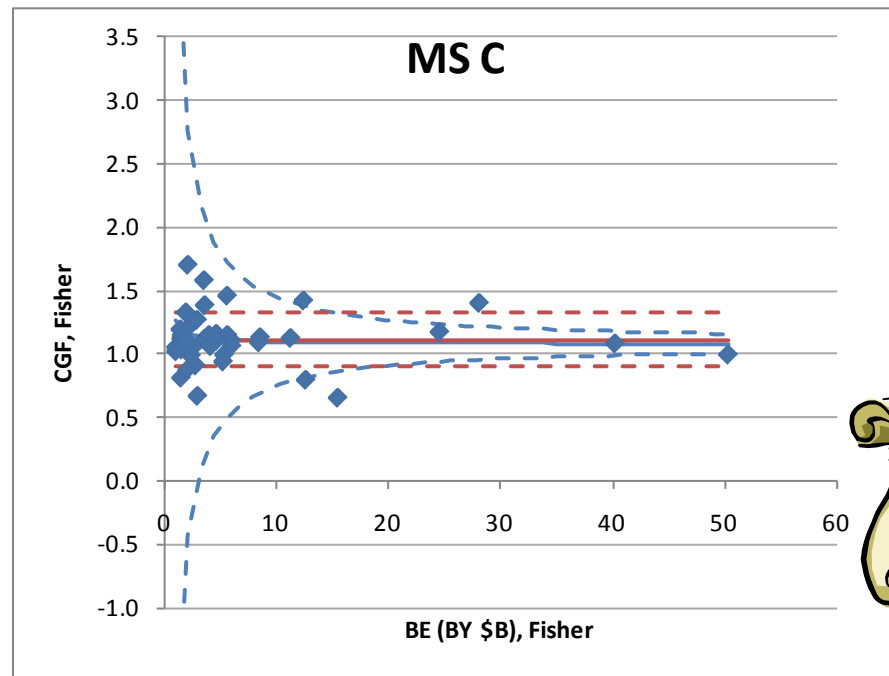
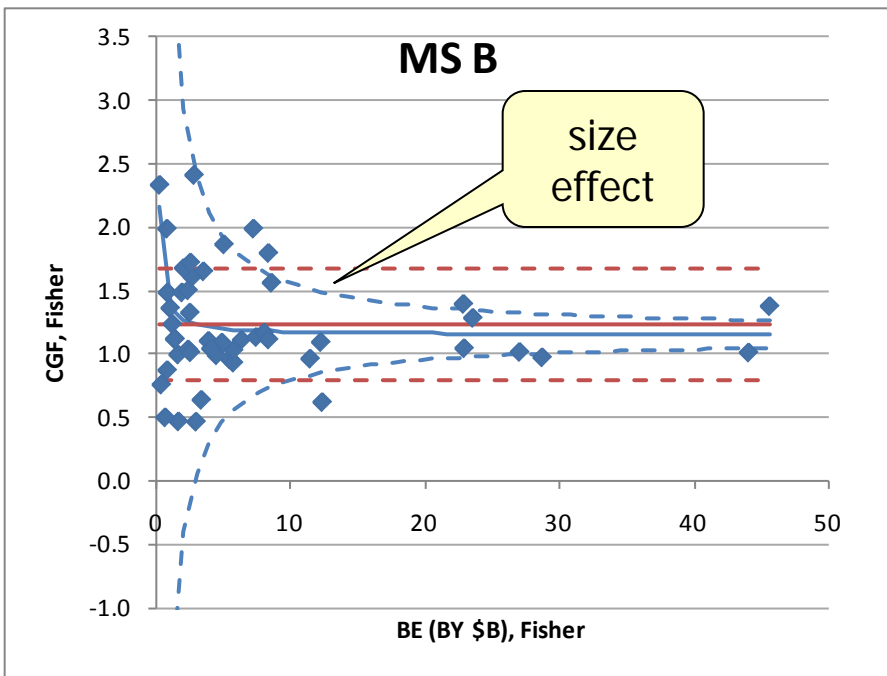
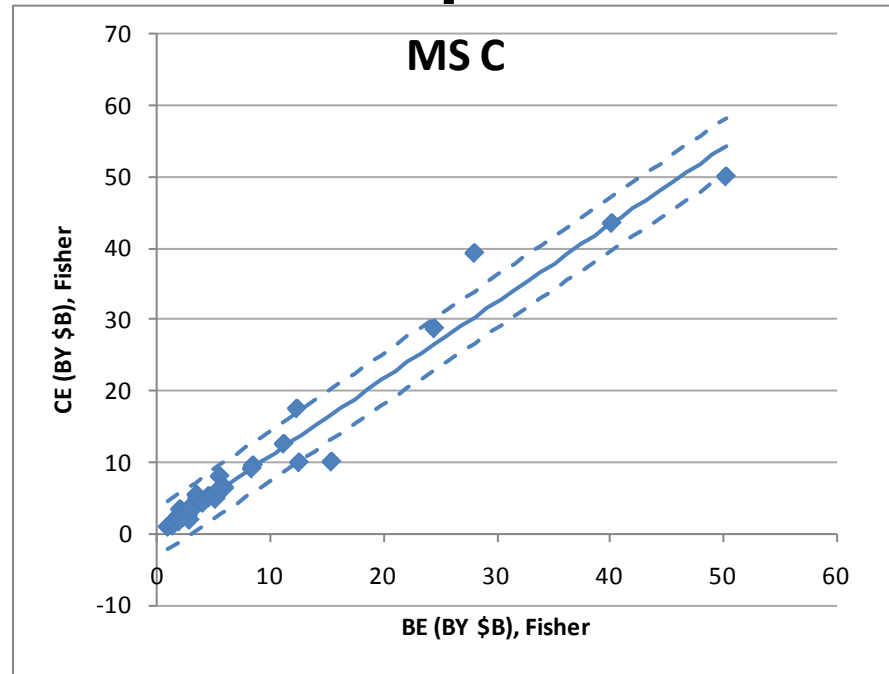
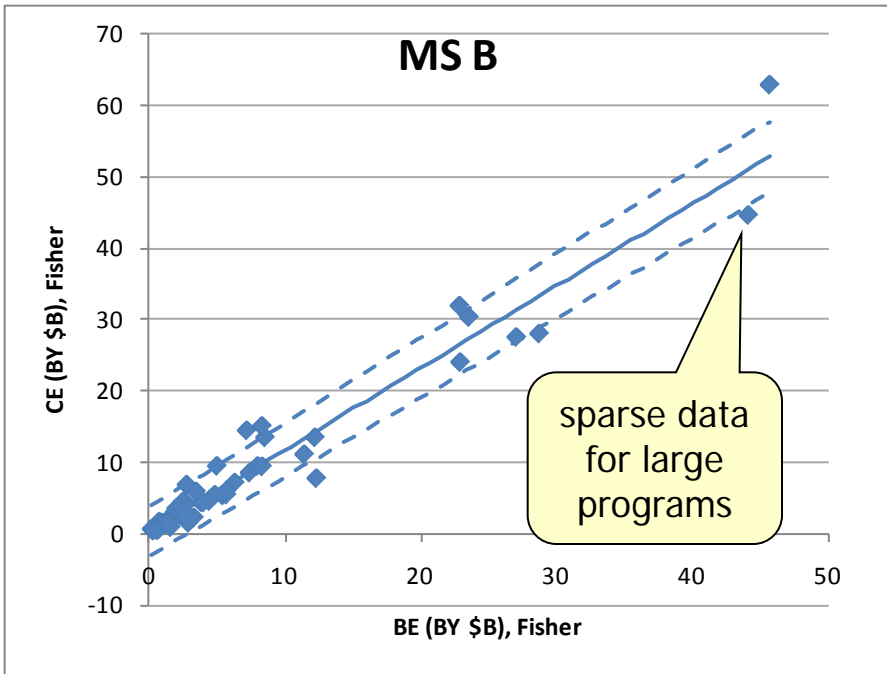


CV of Cost – SAR Data

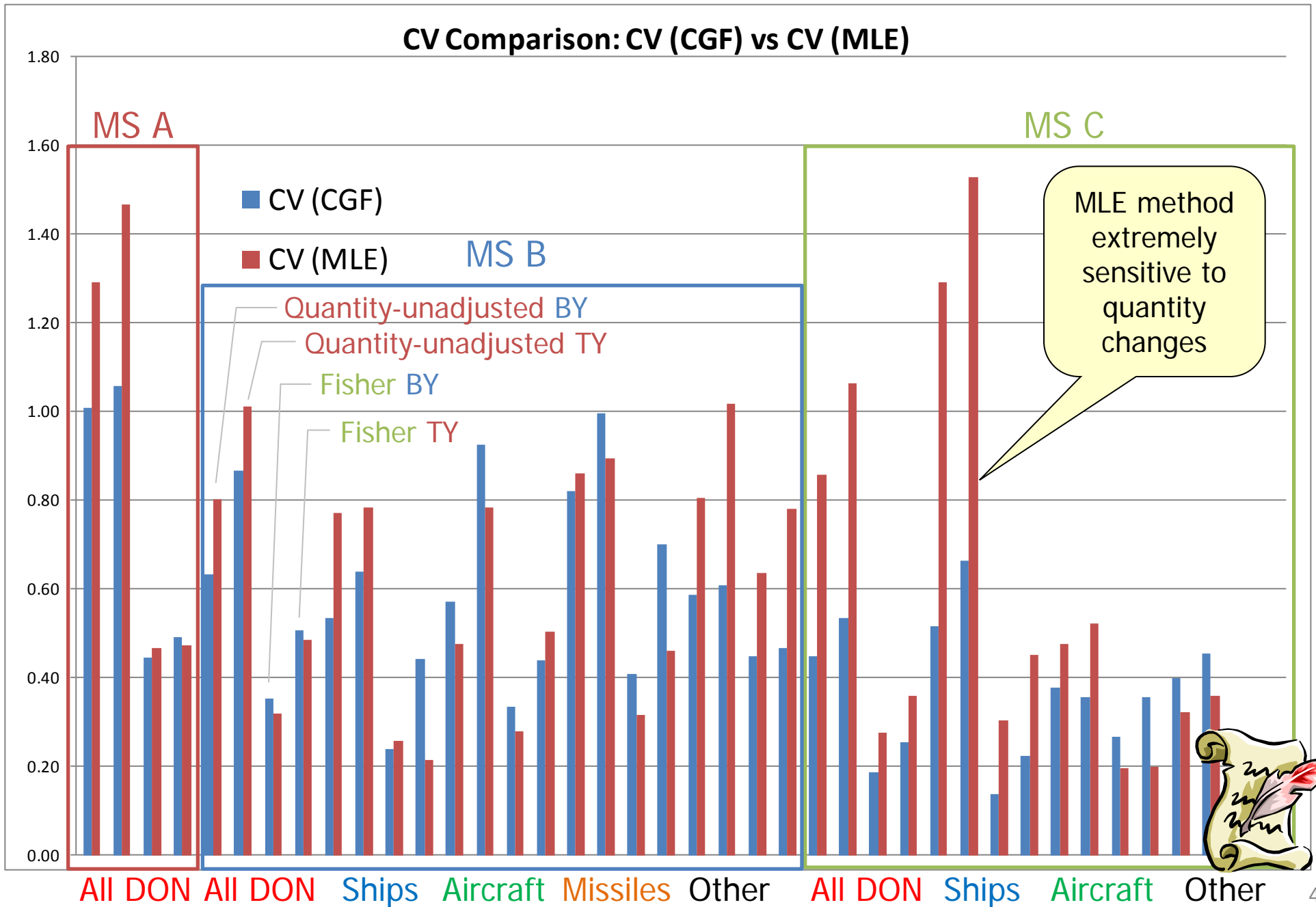
- White test conducted
 - Reject null hypothesis of homoskedastic error terms at $\alpha = 0.10$
- Maximum Likelihood Estimation (MLE) regressions
 - Error functional forms tried:
 1. $\sigma^2 = kx$, error bands tight for small programs (shrink to zero)
 2. $\sigma^2 = kx^2$, error bands are linear, too wide for large programs, constant CV regardless of program size
 3. $\sigma^2 = k_0 + k_1x$, error bands “just right,” models prevalent size effect reasonably, greater \$ errors but smaller % errors for larger programs
 - Currently prefer #1 for the extra degree of freedom and fact that regression is highly insensitive to constant term in #3
- Because this method uses dollars and not (unitless) quotients, it is somewhat problematic with TY\$
 - Even BY\$ need to be normalized to a common BY!



CV of Cost – Scatterplots



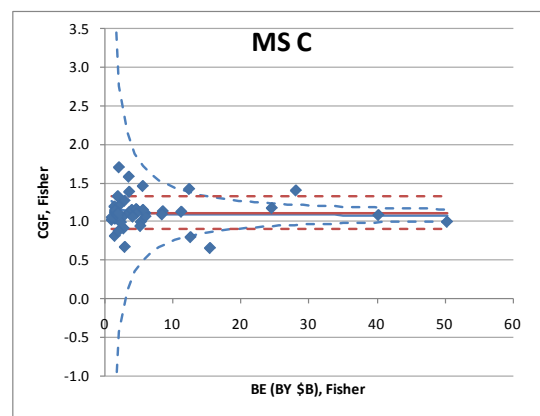
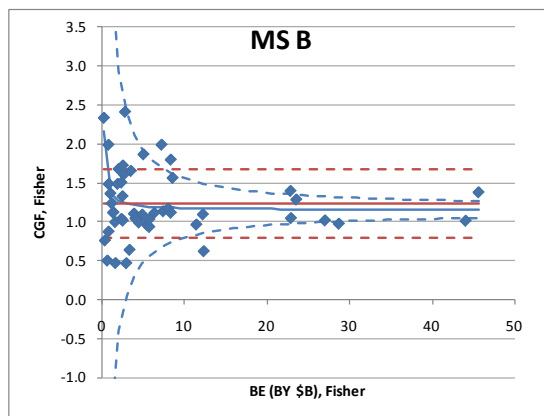
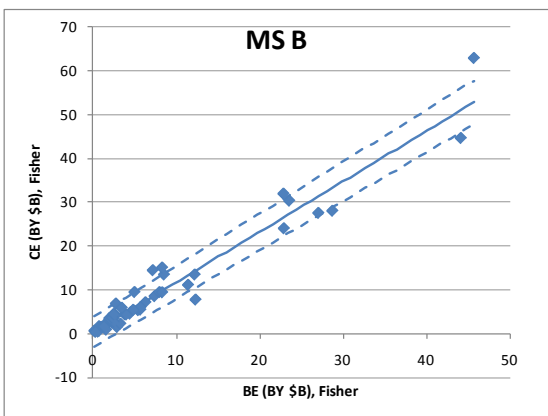
CV Comparison – CGF vs. MLE



CV Methods Summary

			CGFs			MLE		
			small (MIDS-LVT)	medium (EA-18G)	large (DDG 51)	small (MIDS-LVT)	medium (EA-18G)	large (DDG 51)
MS B	BY	CGF	1.23	1.23	1.23	1.35	1.18	1.16
		CV	35.4%	35.4%	35.4%	290.8%	44.8%	18.3%
	TY	CGF	1.36	1.36	1.36	1.80	1.21	1.13
		CV	50.6%	50.6%	50.6%	255.8%	56.6%	26.5%
MSC	BY	CGF	1.11	1.11	1.11	1.17	1.10	1.09
		CV	18.8%	18.8%	18.8%	182.4%	41.5%	13.1%
	TY	CGF	1.10	1.10	1.10	1.05	1.11	1.12
		CV	25.5%	25.5%	25.5%	170.6%	43.6%	14.0%

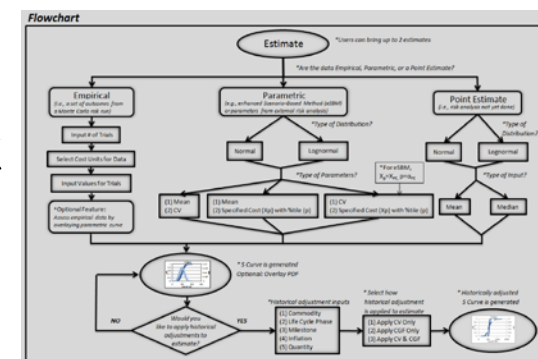
Need to examine extremes of size effect



NCCA S-Curve Tool

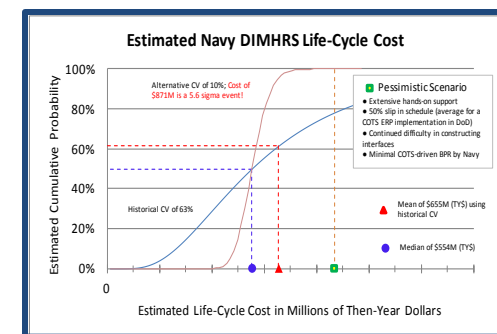
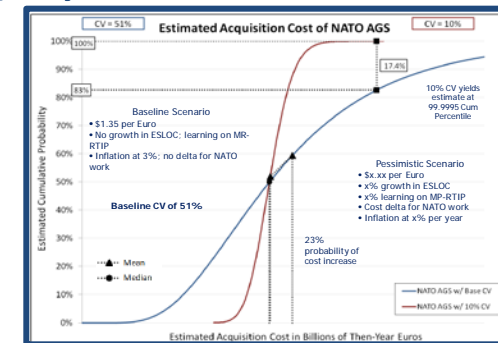
- With the help of the NCCA S-Curve Tool, practitioners can easily and clearly:
 - Compare their estimate (S-curve!) to history in coefficient of variation (CV) and cost growth factor (CGF) [Benchmarking]
 - Compare two different estimates [Reconciliation]
 - Generate graphics for decision briefs
- Compatible with both:
 - Empirical methods such as Monte Carlo risk analyses
 - Parametric methods such as enhanced Scenario-Based Method (eSBM)
- For more information, visit the following link

<http://www.ncca.navy.mil/tools/tools.cfm>



S-Curve Tool Users

- Naval Center for Cost Analysis (NCCA) ICEs and cost assessments
 - Comparisons with historical CVs and SYSCOM estimates
- ICE on NATO Alliance Ground Surveillance (AGS) System
 - Global Hawk Block 40
 - Dr. Paul Garvey's eSBM employed for cost risk analysis
 - S-Curve tool for graphics and what-if drills
- Canada
 - ICE on Joint Strike Fighter (JSF)
 - Presentation to Deputy Ministers
- Defense Integrated Military Human Resources System
 - eSBM employed for cost risk analysis
- Virginia Class Submarines (VCS)
 - Manhour estimates at completion
- Department of Homeland Security (DHS)
 - Standard for cost analyses



S-Curve Tool Updates

- NCCA S-Curve Tool Beta v3.0 is publicly available tool on NCCA's website
- Listed below are the updates from Beta v2.0 to Beta v3.0
 - Benchmarks now available for RDT&E and Procurement (vice Total Acquisition)
 - Benchmarks now available for all DoD (vice DON)
 - Broader range of commodity-specific benchmarks now available
 - Indicators for number of data points and unusual values in data set for each benchmark

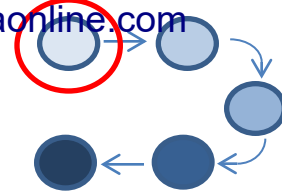


Future Research

- Update database for December 2011 SARs
- Investigate correlation amongst Cost Growth Category and relate decomposition to Root Cause Analysis (RCA)
- Investigate applicability of MOEs and MARs for development of CV benchmarks for MAIS programs

BACKUP

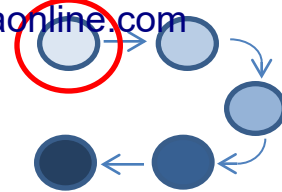
SAR Summary Sheets



Program Acquisition Cost Summary (Dollars in Millions)													
As of December 31, 2010													
Program	Base Year	Baseline Type	Baseline Estimate			Changes To Date			Current Estimate			% Change To Date Adjusted for Qty	
			Base-Year Dollars	Then-Year Dollars	Quantity	Base-Year Dollars	Then-Year Dollars	Quantity	Base-Year Dollars	Then-Year Dollars	Quantity	Base-Year Dollars	Then-Year Dollars
Army:													
AB3A REMANUFACTURE	2010	DE/PdE	7,064.4	8,093.9	602	3,388.1	3,799.2	37	10,452.5	11,893.1	639	43.9	40.1
AB3B NEW BUILD	2010	PdE	2,307.0	2,510.4	56	-150.4	-157.7	1	2,156.6	2,352.7	57	8.3	8.1
ATIRCM/CMWS - ATIRCM QRC	2003	PdE/DE	894.8	1,054.4	-	6.0	-47.8	83	900.8	1,006.6	-	-	-
ATIRCM/CMWS - CMWS	2003	PdE	1,900.9	2,186.2	2,668	1,260.5	1,421.6	-648	3,161.4	3,607.8	-	-	-
CH-47F	2005	PdE	10,614.8	12,147.4	512	2,088.3	2,291.1	20	12,703.1	14,438.5	-	-	-
EXCALIBUR	2007	PdE	2,264.6	2,518.7	30,388	-580.0	-808.1	-22,914	1,684.6	1,710.6	-	-	-
FBCB2	2005	PdE	1,579.9	1,556.7	22,248	2,059.7	2,260.9	67,820	3,639.6	3,817.6	9	-	-
FMTV	1996	PdE	11,594.2	18,921.3	85,488	3,842.4	-189.9	2,351	15,436.6	18,731.4	8	-	-
GMLRS/GMLRS AW	2003	PdE	9,780.2	11,848.9	140,239	-4,902.8	-5,824.5	-96,357	4,877.4	6,024.4	4	-	-
HIMARS	2003	PdE	3,711.6	4,388.4	894	-1,929.2	-2,375.1	-513	1,782.4	2,013.3	691	11.8	2.1
IAMD	2009	DE	4,856.6	5,791.6	296	483.1	528.8	-	5,339.7	6,320.4	296	9.9	9.1
INCREMENT 1 E-IBCT	2010	PdE	3,149.5	3,284.0	9	-1,906.0	-2,014.4	-6	1,243.5	1,269.6	3	-18.3	-19.5
JLENS	2005	DE	5,850.0	7,151.0	16	1,046.0	1,386.9	-	6,896.0	8,537.9	16	17.9	19.4
LONGBOW APACHE	1996	PdE	5,690.6	7,027.8	758	5,684.5	6,122.1	-1	11,375.1	13,149.9	757	80.6	69.7
LUH	2006	PdE	1,638.3	1,883.0	322	170.9	123.5	23	1,809.2	2,006.5	345	3.5	-0.8
MQ-1C UAS GRAY EAGLE	2010	DE/PdE	4,923.6	5,220.8	13	98.6	41.7	18	5,022.2	5,262.5	31	8.4	5.6
PATRIOT PAC-3	2002	PdE	9,084.0	9,205.6	1,159	513.4	796.3	51	9,597.4	10,002.1	1,210	2.0	4.1
PATRIOT/MEADS CAP - FIRE UNIT	2004	DE	16,530.5	21,839.4	48	-13,651.0	-18,535.9	-48	2,879.5	3,303.5	-	-62.4	-64.4
PATRIOT/MEADS CAP - MISSILE	2004	DE	6,220.9	8,056.0	1,528	555.3	1,203.8	-	6,776.2	9,259.8	1,528	8.9	14.9
STRYKER	2004	PdE	8,276.9	8,534.7	2,096	7,271.8	8,548.7	2,139	15,548.7	17,083.4	4,235	13.0	14.3
UH-60M BLACK HAWK	2005	PdE	16,801.7	20,847.1	1,235	5,286.9	6,493.4	140	22,088.6	27,340.5	1,375	15.5	13.3
WIN-T INCREMENT 1	2007	PdE	3,798.0	3,879.7	1,677	388.1	423.4	183	4,186.1	4,303.1	1,860	4.0	4.5
WIN-T INCREMENT 2	2010	PdE	4,686.0	4,996.9	2,216	1,206.3	1,355.6	630	5,892.3	6,352.5	2,846	5.9	6.2
WIN-T INCREMENT 3	2009	DE	15,807.9	18,813.2	3,482	-2,410.9	-2,757.3	-275	13,397.0	16,055.9	3,207	-11.9	-11.1
Subtotal			159,026.9	191,757.3		9,819.6	4,086.3		168,846.5	195,843.6		10.7	8.5
Navy:													
AGM-88E AARGM	2003	PdE	1,528.5	1,861.4	1,919	63.7	47.3	-	1,592.2	1,908.7	1,919	4.2	2.5
AIM-9X	1997	PdE	2,464.0	3,232.9	10,049	475.3	521.7	93	2,939.3	3,754.6	10,142	18.7	15.4
CEC	2002	PdE	4,123.3	4,310.7	272	193.4	325.9	-1	4,316.7	4,636.6	271	9.5	13.8
CH-53K	2006	DE	14,980.9	18,766.3	156	5,322.7	6,978.5	44	20,303.6	25,744.8	200	17.3	17.7
COBRA JUDY REPLACEMENT	2003	DE	1,365.0	1,464.0	1	162.6	250.2	-	1,527.6	1,714.2	1	11.9	17.1
CVN 78 CLASS	2000	DE	28,701.2	36,082.1	3	-1,275.2	4,213.2	-	27,426.0	40,295.3	3	-4.4	11.7
DDG 1000	2005	DE	31,547.9	36,296.3	10	-13,130.9	-15,404.9	-7	18,417.0	20,891.4	3	9.0	21.4
DDG 51	1987	PdE	16,953.7	20,117.5	23	43,211.2	68,299.1	52	60,164.9	88,416.6	75	24.3	25.2

Program Acquisition Cost Summary

SAR Summary Sheets

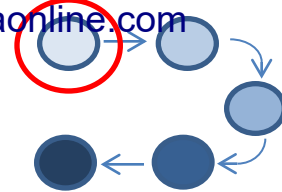


Distribution of Cost Changes (Base-Year Dollars in Millions)
As of December 31, 2010

		Cost Changes Between the Baseline and Current Estimate													
Program	Base Year	Quantity		Schedule		Engineering		Estimating		Other		Support		Total	
		This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date
Army:															
AB3A REMANUFACTURE	2010	-	201.6	-	0.9	-	-	2,161.7	2,222.3	-	-	127.8	963.3	2,289.5	3,388.1
AB3B NEW BUILD	2010	44.0	44.0	-	-	-	-	-312.2	-312.2	-	-	117.8	117.8	-150.4	-150.4
ATIRCM/CMWS - ATIRCM	2003	-	180.9	-	-593.7	-	138.9	-22.9	289.5	-	-	-	-	-	-
ATIRCM/CMWS - CMWS	2003	-	376.7	-	-99.2	-	635.0	91.1	295.9	-	-	0.5	-	-	-
CH-47F	2005	121.0	417.0	-4.1	-8.3	176.9	177.4	340.2	1,463.6	-	-	-	-	16.8	-
EXCALIBUR	2007	37.2	-674.7	-2.6	48.9	-	-	73.9	47.2	-	-	-	-	0.1	-
FBCB2	2005	-	1,431.3	-	-44.7	-	185.4	-10.3	186.9	-	-	-	-	-14.6	-
FMTV	1996	559.2	462.0	-134.4	-91.6	241.9	2,471.1	-1,756.0	1,204.4	-	-	-120.9	-203.5	-1,210.2	3,842.4
GMLRS/GMLRS AW	2003	-	-5,775.3	-	224.1	-	8.5	-21.6	632.6	-	-	0.1	7.3	-21.5	-4,902.8
HIMARS	2003	-	-1,689.8	-	-16.6	-	35.5	-25.5	-169.3	-	-	1.8	-89.0	-23.7	-1,929.2
IAMD	2009	-	-	-	-	-	-	481.3	481.3	-	-	1.8	1.8	483.1	483.1
INCREMENT 1 E-IBCT	2010	-788.1	-788.1	-	-	-	-	-680.8	-899.2	-	-	-332.6	-280.7	-1,799.5	-1,906.0
JLENS	2005	-	-	90.7	278.2	77.9	77.9	-104.5	316.1	-	-	259.4	643.8	323.5	1,046.0
LONGBOW APACHE	1996	4.9	608.7	0.1	5.6	8.5	2,915.5	22.9	1,703.8	-	-	-0.1	452.9	36.3	5,684.5
LUH	2006	-	110.5	1.5	31.5	-	74.4	-1.5	-77.9	-	-	0.9	32.4	0.9	170.9
MQ-1C UAS GRAY EAGLE	2010	-238.9	-238.9	-210.4	-210.4	401.4	401.4	214.3	214.3	-	-	-67.8	-67.8	98.6	98.6
PATRIOT PAC-3	2002	322.2	325.5	38.4	83.2	-	-	182.0	104.7	-	-	-	-	540.6	513.4
PATRIOT/MEADS CAP - FIRE UNIT	2004	-8,875.5	-8,875.5	-148.0	-148.0	-	-	-1,795.6	-2,447.3	-	-	-2,343.2	-2,180.2	-13,162.3	-13,651.0
PATRIOT/MEADS CAP - MISSILE	2004	-	-	-	-	-	-	121.7	546.4	-	-	2.7	8.9	124.4	555.3
STRYKER	2004	588.7	5,484.2	-16.4	-81.8	10.7	2,292.0	990.4	-1,513.3	-	-	-21.5	1,090.7	1,551.9	7,271.8
UH-60M BLACK HAWK	2005	2,330.0	2,330.0	10.4	146.6	-74.2	538.8	103.2	1,722.6	-	-	178.8	548.9	2,548.2	5,286.9
WIN-T INCREMENT 1	2007	114.3	227.8	-	-	-	-	-124.7	-185.4	-	-	418.0	345.7	407.6	388.1
WIN-T INCREMENT 2	2010	879.1	879.1	-	-	-	-	-78.7	-75.0	-	-	405.1	402.2	1,205.5	1,206.3
WIN-T INCREMENT 3	2009	-	-596.5	-0.5	-0.5	-	-1,741.2	92.6	-127.0	-	-	20.1	54.3	112.2	-2,410.9
Subtotal		-4,899.9	-5,559.5	-377.3	-475.8	843.1	8,210.6	-59.0	5,685.0	-	-	-1,349.0	2,229.4	-5,842.1	9,819.6
Navy:															
AGM-88E AARGM	2003	-	-	-	-	19.3	19.3	7.2	44.1	-	-	15.6	0.3	42.1	63.7
AIM-9X	1997	-	12.9	-	64.3	84.9	297.5	-1.2	307.5	-	-	-0.8	-206.9	83.1	475.3
CEC	2002	-71.3	-181.1	-3.1	-36.9	16.4	261.0	139.5	237.9	-	-	-23.5	-87.5	58.0	193.4
CH-53K	2006	-	2,326.4	48.8	848.0	-	-	116.9	1,333.0	-	-	22.2	815.3	187.9	5,322.7
COBRA JUDY REPLACEMENT	2003	-	-	-	30.0	-	-	1.3	132.6	-	-	-	-	1.3	162.6
CVN 78 CLASS	2000	-	-	-	120.2	-	-888.9	-588.7	-706.5	-	-	-	-	-588.7	-1,275.2
DDG 1000	2005	-	-14,646.0	-	63.8	-	15.9	769.5	1,435.4	-	-	-	-	769.5	-13,130.9
DDG 51	1987	2,060.0	31,444.9	86.4	363.8	1,326.5	3,342.9	100.3	8,059.6	-	-	-	-	3,573.2	43,211.2

Cost Categories (\$BY)

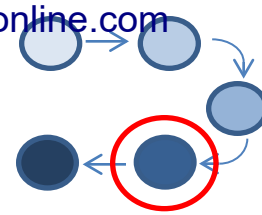
SAR Summary Sheets



Distribution of Cost Changes (Then-Year Dollars in Millions)
As of December 31, 2010

Program	Cost Changes Between the Baseline and Current Estimate															
	Economic		Quantity		Schedule		Engineering		Estimating		Other		Support		Total	
	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date	This Qtr	To Date
Army Subtotal:																
AB3A REMANUFACTURE	21.1	-384.7	-	395.5	19.9	147.5	-	-	2,534.6	2,593.9	-	-	141.9	1,047.0	2,717.5	3,799.2
AB3B NEW BUILD	4.1	4.1	49.7	49.7	2.8	2.8	-	-	-344.6	-344.6	-	-	130.3	130.3	-157.7	-157.7
ATIRCM/CMWS - ATIRCM QRC	-	25.4	-	303.3	-	-866.9	-	179.7	-27.5	304.0	-	-	-	-	-	-
ATIRCM/CMWS - CMWS	-0.1	124.5	-	587.1	-	-424.3	-	704.0	128.1	386.6	-	-	-	-	-	-
CH-47F	1.0	-147.8	154.4	502.9	-18.5	-285.6	217.5	218.0	425.8	1,969.3	-	-	-	-	-	-
EXCALIBUR	-0.9	-80.3	38.5	-819.2	-3.4	47.9	-	-	73.9	44.9	-	-	-	-	-	-
FBCB2	-0.3	14.7	-	1,600.7	-	-120.2	-	198.4	-12.1	226.7	-	-	-	-	-	-
FMTV	-13.2	-2,797.1	786.5	188.7	-518.0	-2,203.8	340.4	3,388.0	-2,332.4	1,623.1	-	-	-	-	-	-
GMLRS/GMLRS AW	-8.1	494.7	-	-8,732.6	0.4	1,279.5	-	10.8	-26.7	1,115.1	-	-	-0.1	8.0	-34.5	-5,824.5
HIMARS	-0.6	229.3	-	-2,332.3	-	-17.3	-	39.6	-32.1	-150.6	-	-	2.2	-143.8	-30.5	-2,375.1
IAMD	-10.0	-10.0	-	-	-	-	-	-	537.3	537.3	-	-	1.5	1.5	528.8	528.8
INCREMENT 1 E-IBCT	4.3	-8.7	-829.8	-829.8	-	-	-	-	-713.3	-875.9	-	-	-358.3	-300.0	-1,897.1	-2,014.4
JLENS	-11.5	-138.9	-	-	184.9	507.0	99.7	99.7	-144.6	398.4	-	-	345.6	520.7	474.1	1,386.9
LONGBOW APACHE	-1.5	-270.2	6.4	721.4	-0.3	24.1	11.1	3,601.4	29.7	1,558.8	-	-	-	486.6	45.4	6,122.1
LUH	-0.1	-60.3	-	139.3	3.8	-2.8	-	84.9	-2.0	-82.7	-	-	1.2	35.1	2.9	123.5
MQ-1C UAS GRAY EAGLE	2.9	2.9	-289.8	-289.8	-242.2	-242.2	433.0	433.0	215.5	215.5	-	-	-77.7	-77.7	41.7	41.7
PATRIOT PAC-3	5.6	165.4	398.4	405.3	42.8	86.2	-	-	229.2	139.4	-	-	-	-	676.0	796.3
PATRIOT/MEADS CAP - FIRE UNIT	-38.7	-91.9	-12,555.5	-12,555.5	-491.3	-86.5	-	-	-2,226.4	-2,759.9	-	-	-3,349.9	-3,042.1	-18,661.8	-18,535.9
PATRIOT/MEADS CAP - MISSILE	-16.5	-21.9	-	-	271.5	538.9	-	-	117.8	630.7	-	-	25.0	56.1	397.8	1,203.8
STRYKER	-2.2	124.8	707.8	6,413.9	-30.8	-310.4	20.9	2,669.7	1,201.5	-1,413.4	-	-	-9.8	1,064.1	1,887.4	8,548.7
UH-60M BLACK HAWK	7.1	-706.0	3,291.3	3,291.3	67.2	400.3	-83.7	655.1	140.5	2,147.1	-	-	236.4	705.6	3,658.8	6,493.4
WIN-T INCREMENT 1	-0.4	-26.3	119.5	238.0	-0.2	-0.7	-	-	-129.9	-193.0	-	-	479.1	405.4	468.1	423.4
WIN-T INCREMENT 2	-3.1	-3.1	983.4	983.4	-13.2	-13.2	-	-	-78.8	-75.0	-	-	466.5	463.5	1,354.8	1,355.6
WIN-T INCREMENT 3	-27.7	-247.1	-	-761.0	-4.0	334.1	-	-2,056.7	113.3	-156.5	-	-	10.6	129.9	92.2	-2,757.3
Subtotal	-88.8	-3,798.5	-7,139.2	-10,499.7	-728.6	-1,205.6	1,038.9	10,225.6	-323.2	7,839.2	-	-	-2,107.8	1,525.3	-9,348.7	4,086.3
Navy Subtotal:																
AGM-88E AARGM	-1.9	-42.8	-	-	5.3	5.3	22.8	22.8	10.5	63.6	-	-	20.3	-1.6	57.0	47.3
AIM-9X	-12.7	-293.3	-	19.5	-0.8	306.2	109.3	375.9	-7.3	400.3	-	-	-0.7	-286.9	87.8	521.7
CEC	0.3	53.7	-77.6	-234.7	-7.3	27.6	19.8	274.3	177.8	177.3	-	-	-21.5	27.7	91.5	325.9
CH-53K	-38.6	-738.5	-	3,108.9	71.8	1,889.8	-	-	155.9	1,456.1	-	-	29.6	1,262.2	218.7	6,978.5
COBRA JUDY REPLACEMENT	-0.2	51.2	-	-	-	36.3	-	-	1.7	162.7	-	-	-	-	1.5	250.2
CVN 78 CLASS	599.0	4,782.2	-	-	-	839.5	-	-963.6	-849.2	-444.9	-	-	-	-	-250.2	4,213.2
DDG 1000	132.1	1,500.2	-	-19,092.9	-	57.7	-	66.2	987.9	2,063.9	-	-	-	-	1,120.0	-15,404.9
DDG 51	363.9	-4,999.8	4,376.1	50,515.6	155.2	1,510.3	2,697.0	5,981.2	416.7	15,291.8	-	-	-	-	8,008.9	68,299.1

Cost Categories
(\$TY)

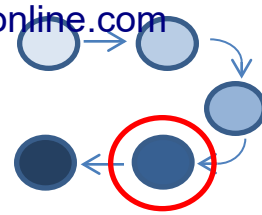


V&V Due Diligence

- Twin goals:
 - Get the data “as good as we can”
 - Go in “eyes wide open” as to the limitations of the data as “the best we have”
- Leverage in-house expertise
 - Primarily Dr. Brian Flynn, DON programs
- Provide data transparency...
 - ...to the appropriate audience
- Acknowledge inherent noise in the data (“measurement error”) without being nonchalant
 - Prego = “It’s in there”
- “Draw the line” and proceed with data analysis at the appropriate time

Pee Wee
Herman’s Law
of Visibility

Coleman’s Law
of Avoidable
Errors



Variation in Risk Analysis

- Example of different results with essentially the same data

v1.1

Historical Cost Growth

Source	Raw Average			\$ Wtd Average			During Prod	
	Tot	R&D	Prod	Tot	R&D	Prod	N	Prod
RAND 93:	1.30			1.20	1.25	1.18	100+	1.02
CAIG 91:	1.33	1.40	1.25	1.21	1.24	1.19	27	
TASC 94:		1.49	1.54				20+	
TASC 96:		1.43	1.55		1.21	1.35	14	0.99
Christensen 99:				1.09	1.14			1.06

MSIII

This chart presents data from different eras and different database subsets
The message it conveys is a general similarity, not precise equality

1. All data are from DoDSARs, under generally the same rules and procedures, except for Christensen
2. Christensen data is EVM Data, which includes re-baselining, and is contract only, vice program
3. This cost growth data includes growth due to "Cost Estimating Errors"
4. RAND Data and CAIG Data are from MS I, TASC data is from MSII

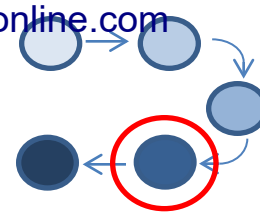
SCEA **CEBoK**
Unit III - Module 9
NEW!
97

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*CEBoK Module 9 - Risk

- Benefits of an "open-source" data approach?
 - A la Mike Popp's SRDR eRoom postings

WGS Example



- Identified data anomaly
- Identified coordinating SME
- Inputs from those with direct knowledge of program
- Interpretation of inputs

Peter,

See below.

Greg Hogan
(202)210-5693 or (703)609-9134
Gregory.Hogan@pentagon.af.mil

-----Original Message-----

From: PRATER, MICHAEL D GS-15 USAF AFSPC AFSPC/FMS
[\[mailto:michael.prater.9@us.af.mil\]](mailto:michael.prater.9@us.af.mil)
Sent: Thursday, March 15, 2012 1:14 PM
To: HOGAN, GREGORY A EE-00 USAF U S AIR FORCE HQ/1500 W. Perimeter Road, Suite 3500, Joint Base Andrews, MD 20762
Cc: CIPRESSI, RONALD P GS-13 USAF AF COST ANALYSIS AGENCY/1500 W. Perimeter Road, Suite 3500, Joint Base Andrews, MD 20762
Subject: FW: EXTERNAL: SAR satellite oddities

Greg,

See response below. Please forward to Peter and/or Richard as appropriate. Let us know if you have any questions.

Thanks,
Mike

-----Original Message-----

From: Cipressi, Ronald P CIV USAF AFCAA/FM
[\[mailto:ronald.cipressi@pentagon.af.mil\]](mailto:ronald.cipressi@pentagon.af.mil)
Sent: Thursday, March 15, 2012 10:55 AM
To: PRATER, MICHAEL D GS-15 USAF AFSPC AFSPC/FMS
Cc: Rutledge, Gabriel CIV USAF AFCAA/FMR
Subject: RE: EXTERNAL: SAR satellite oddities

Mike,

I did some research on the v-drive and spoke to Gabe about this. Here is what Gabe and I came up with.

Yes, three Block I satellites, SV1-3, were produced and launched in the timeframe cited.

Gabe pulled the 12/31/10 SAR and we compared it to the 12/31/09 version. Due to the Nunn-McCurdy (NM) certification Acquisition Decision Memorandum (ADM) for WGS dated June 01, 2010, the program was restructured to account for the

Historical Factors Table

1	2	3	4	A	B	C	D	E	F	G	H	I	J
1	commodity	milestone	phase	quantity	inflation	CGF	CVact	CVest	percentile	Median			
82	DoN Acquisition	MS B (Development Estimate)	Acquisition	adj	BY\$	1.21	0.46	55.6%					1.06
83	DoN Acquisition	MS B (Development Estimate)	Acquisition	adj	TY\$	1.34	0.63	83.9%					1.09
84	DoN Acquisition	MS B (Development Estimate)	Acquisition	not adj	BY\$	1.38	0.70	96.6%					1.05
85	DoN Acquisition	MS B (Development Estimate)	Acquisition	not adj	TY\$	1.65	0.93	153.6%					1.10
86	DoN Acquisition	MS B (Development Estimate)	RDT&E	adj	BY\$	1.48	0.78	115.0%					1.13
87	DoN Acquisition	MS B (Development Estimate)	RDT&E	adj	TY\$	1.60	0.85	136.0%					1.17
88	DoN Acquisition	MS B (Development Estimate)	RDT&E	not adj	BY\$	1.47	0.79	116.9%					1.13
89	DoN Acquisition	MS B (Development Estimate)	RDT&E	not adj	TY\$	1.60	0.86	138.0%					1.16
90	DoN Acquisition	MS B (Development Estimate)	Procurement	adj	BY\$	1.16	0.61	70.9%					1.03
91	DoN Acquisition	MS B (Development Estimate)	Procurement	adj	TY\$	1.52	1.49	226.4%					1.08
92	DoN Acquisition	MS B (Development Estimate)	Procurement	not adj	BY\$	1.40	0.83	116.5%					1.05
93	DoN Acquisition	MS B (Development Estimate)	Procurement	not adj	TY\$	1.72	1.06	181.7%					1.11
94	DoN Acquisition	MS B (Development Estimate)	O&S	adj	BY\$								
95	DoN Acquisition	MS B (Development Estimate)	O&S	adj	TY\$								
96	DoN Acquisition	MS B (Development Estimate)	O&S	not adj	BY\$								
97	DoN Acquisition	MS B (Development Estimate)	O&S	not adj	TY\$								
98	DoN Acquisition	MS C (Production Estimate)	Acquisition	adj	BY\$	1.09	0.21	22.3%					1.06
99	DoN Acquisition	MS C (Production Estimate)	Acquisition	adj	TY\$	1.07	0.27	28.6%					1.05
100	DoN Acquisition	MS C (Production Estimate)	Acquisition	not adj	BY\$	1.11	0.46	50.9%					1.04
101	DoN Acquisition	MS C (Production Estimate)	Acquisition	not adj	TY\$	1.09	0.53	57.7%					1.03
102	DoN Acquisition	MS C (Production Estimate)	RDT&E	adj	BY\$	1.25	0.52	65.0%					1.07
103	DoN Acquisition	MS C (Production Estimate)	RDT&E	adj	TY\$	1.26	0.57	72.3%					1.07
104	DoN Acquisition	MS C (Production Estimate)	RDT&E	not adj	BY\$	1.27	0.54	68.1%					1.07
105	DoN Acquisition	MS C (Production Estimate)	RDT&E	not adj	TY\$	1.29	0.59	75.5%					1.07
106	DoN Acquisition	MS C (Production Estimate)	Procurement	adj	BY\$	1.10	0.28	31.0%					1.07
107	DoN Acquisition	MS C (Production Estimate)	Procurement	adj	TY\$	1.11	0.46	50.8%					1.04
108	DoN Acquisition	MS C (Production Estimate)	Procurement	not adj	BY\$	1.09	0.50	54.2%					1.04
109	DoN Acquisition	MS C (Production Estimate)	Procurement	not adj	TY\$	1.07	0.57	60.4%					1.02
110	DoN Acquisition	MS C (Production Estimate)	O&S	adj	BY\$								
111	DoN Acquisition	MS C (Production Estimate)	O&S	adj	TY\$								
112	DoN Acquisition	MS C (Production Estimate)	O&S	not adj	BY\$								
113	DoN Acquisition	MS C (Production Estimate)	O&S	not adj	TY\$								



List of Programs

List of Cancelled Programs

PNO	ProgramShortName
225	Peacekeeper
239	NPOESS
254	Comanche
263A	SRAM II
263B	SRAM T
267	Small ICBM
370	Joint Common Missile
371	ACS
381	ASDS
382	TSAT (Legacy)
392	VH-71
511	SLAT
700	ACM
708	ATM
715	ADATS (FAADS LOS-F-H)
743A	ASM – Block III
743B	ASM – CMV
743C	ASM – FIFV
743D	ASM – AFAS
743E	ASM – FARV-A
743F	ASM – LOSAT
752	NATO AAWS
760	AAAM

List of Programs with 2010 SAR

PNO	ProgramShortName
101	H-1 Upgrades
178	Trident II Missile
180	DDG 51
191	MH-60R
197	DDG 1000
212	V-22
223	CVN 78
282	MH-60S
289	Tactical Tomahawk
333a	LHA 6
334	P-8A
345	MUOS
364	E-2D AHE
365	CJR
368	AGM-88E AARGM
374	LCS
378	EA-18G
391	SM-6
515	EFV
516	SSN 774
542	LPD 17
549	F/A-18 E/F
582	CEC
592	T-AKE
766A	JSOW Baseline
766B	JSOW Unitary
202	AB3
437	AB3B New Build
261	AEHF
581	AIM-9X
185	AMRAAM
375	ASIP
224	B-2 EHF Increment 1
376	B-2 RMP

List of Programs with 2010 SAR

PNO	ProgramShortName
373	BAMS
362	BMDS
298	C-130 AMP
220	C-130J
273	C-5 AMP
327	C-5 RERP
278	CH-47F
390	CH-53K
243	Chem Demil-ACWA
285	Chem Demil-CMA
219B	CMWS
432	E-IBCT Incr 1
366	Excalibur
265	F-22
198	F-35
199	FAB-T
294	FBCB2
746	FMTV
237	GBS
252	Global Hawk
260C	GMLRS
292	GPS IIIA
420	Gray Eagle
257	HC/MC-130 Recap
367	HIMARS
205	IAMD
418A	IDECM BLK 2/3
418B	IDECM BLK 4
555B	JASSM Baseline
555C	JASSM ER
183	JCA
503	JDAM
247	JHSV

List of Programs with 2010 SAR

PNO	ProgramShortName
372	JLENS
238	JPALS
560	JPATS
421	JTRS AMF
360	JTRS GMR
385	JTRS HMS
284	JTRS NED
357	LAIRCM
831	Longbow Apache
182	LUH
293	MP-RTIP
353	MRAP
537	NAS
166C	NAVSTAR Mod Space & OCS
166D	NAVSTAR Mod User Equip
219C	NG ATIRCM
290	NMT
239	NPOESS
531A	Patriot MEADS CAP (Fire Unit)
531B	Patriot MEADS CAP (Missile Seg)
148B	Patriot PAC-3 (Missile Seg)
424	Reaper
286	RMS
210A	SBIRS High
328	SBSS B10
439	SDB II
299	Stryker
341	UH-60M
253	VTUAV
326	WGS
346	WIN-T Increment 1
349	WIN-T Increment 2
350	WIN-T Increment 3



Changes Since DoDCAS

	DoDCAS (February 14-17, 2012)	Current Progress (March 31, 2012)
# of Programs	305	312
# of Estimates	408	406

7 additional programs

Programs	PNO	Identified Subprograms	Additional Programs	Additional Estimates
ANSQQ-89	153	2 (Basic; Improved)	1	1
Tomahawk	154	2 (Tomahawk; TBIP)	1	1
UH-60 A/L Blackhawk	156	2 (UH-60A; UH-60L)	1	2
MCS	724	3 (Blocks I, II, III; Block IV; Block IV Software)	2	2
SADARM	735	3 (SADARM; 155mm Projectile; MLRS Rocket)	2	2

Name of Program	PNO	Discarded Estimate
CG-47*	159	PdE
C-130J	220	DE
VTUAV	253	DE
WGS*	326	PdE
SDB I	354	DE
CVN 72/73	161E	DE
CVN 74/75	161F	DE
NAVSTAR GPS Satellite	166A	DE
NAVSTAR GPS User Equipment	166B	DE
SM-2	234	DE

*Further explanations provided on slide 21

Deleted a total of 2 estimates (added 8 and discarded 10)