



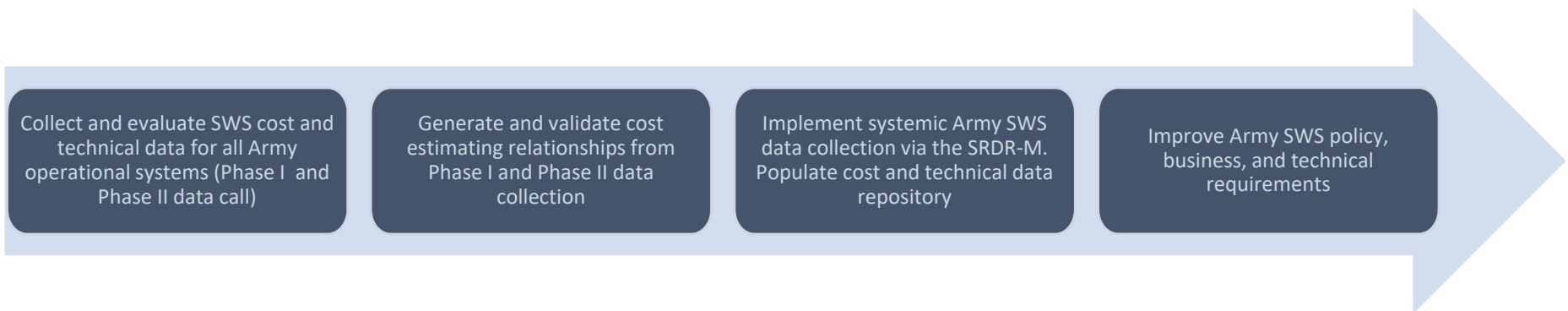
Using Army Software Sustainment Cost Estimating Results DASA-CE

Presented to
PSM
September 2018

SWM Initiative Objective and Strategy

Accurately estimate Army system software sustainment costs to:

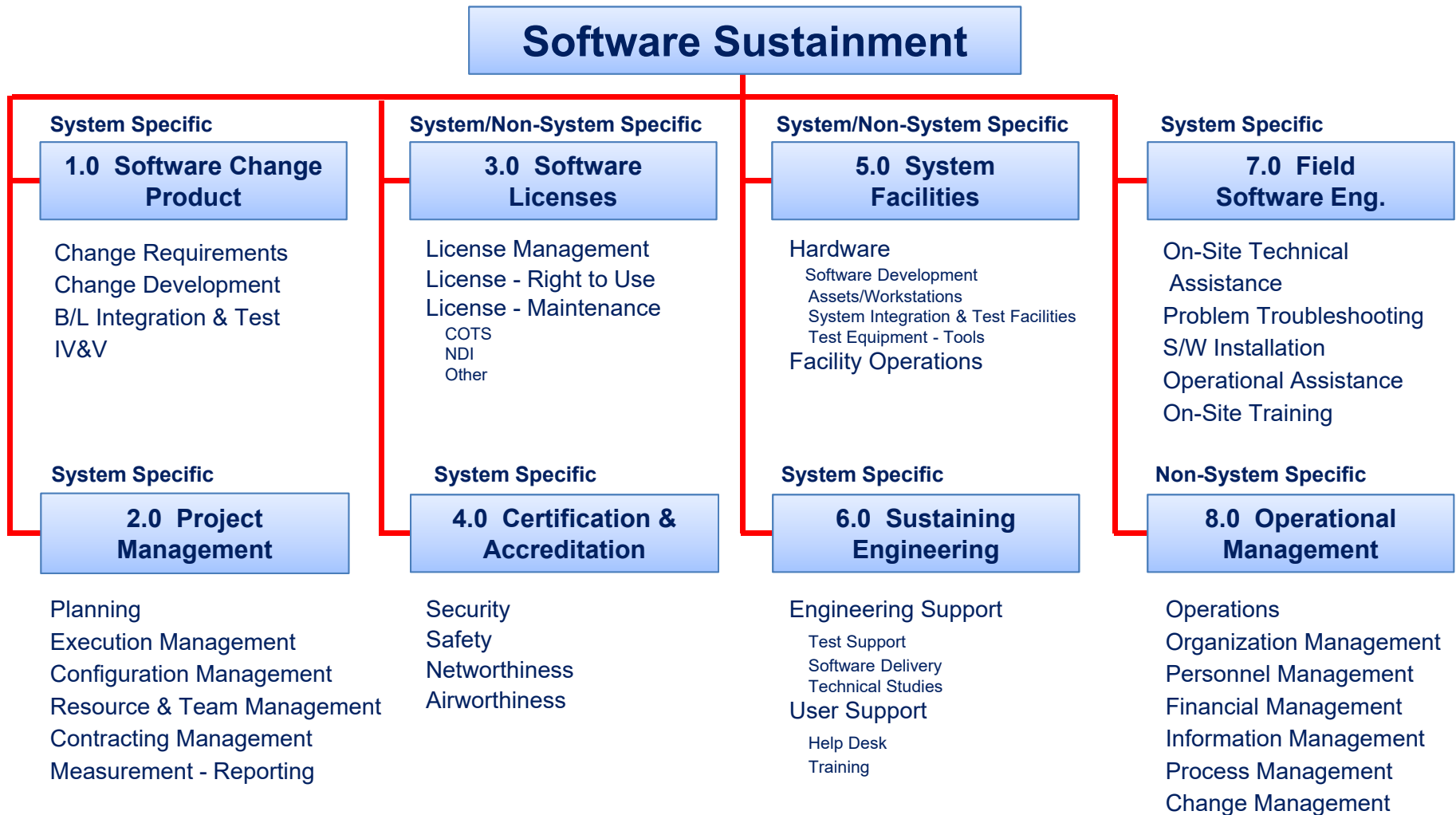
- Effectively project and justify software and system life cycle costs
- Objectively evaluate Army system software sustainment execution costs
- Inform and optimize the allocation of available sustainment resources across the Army



Effective software sustainment cost estimation is the basis for Army system software life cycle cost management



DASA-CE SWS WBS



Version 4.4d



UNCLASSIFIED

Data Demographics



192 Programs



1,041 Total Releases



3,434 Licenses



411K Data Fields

Real-Time

93

Engineering

47

AIS

39

Support

13

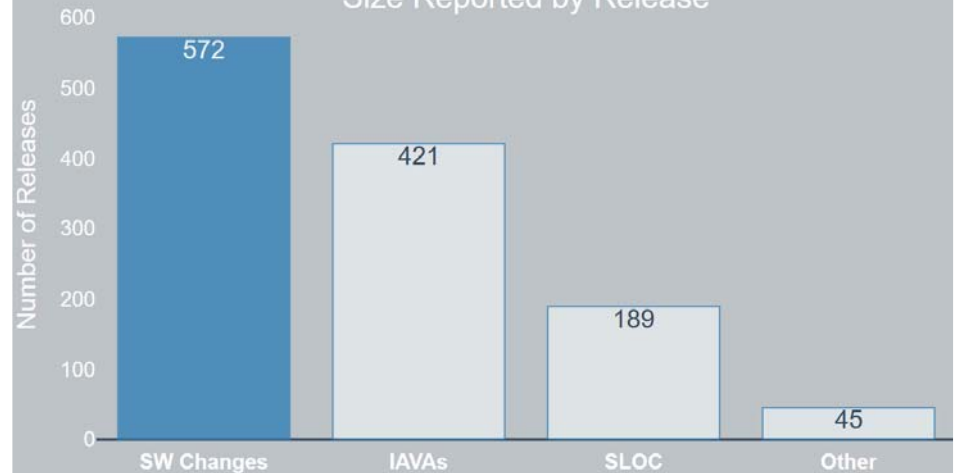
Release Types

Capability Releases 718

IAVA Releases 322

No Releases 1

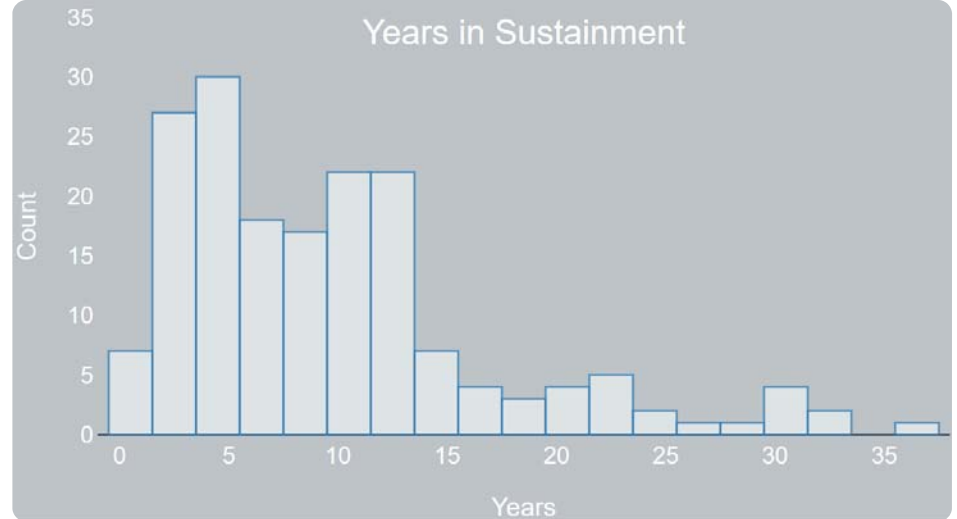
Size Reported by Release



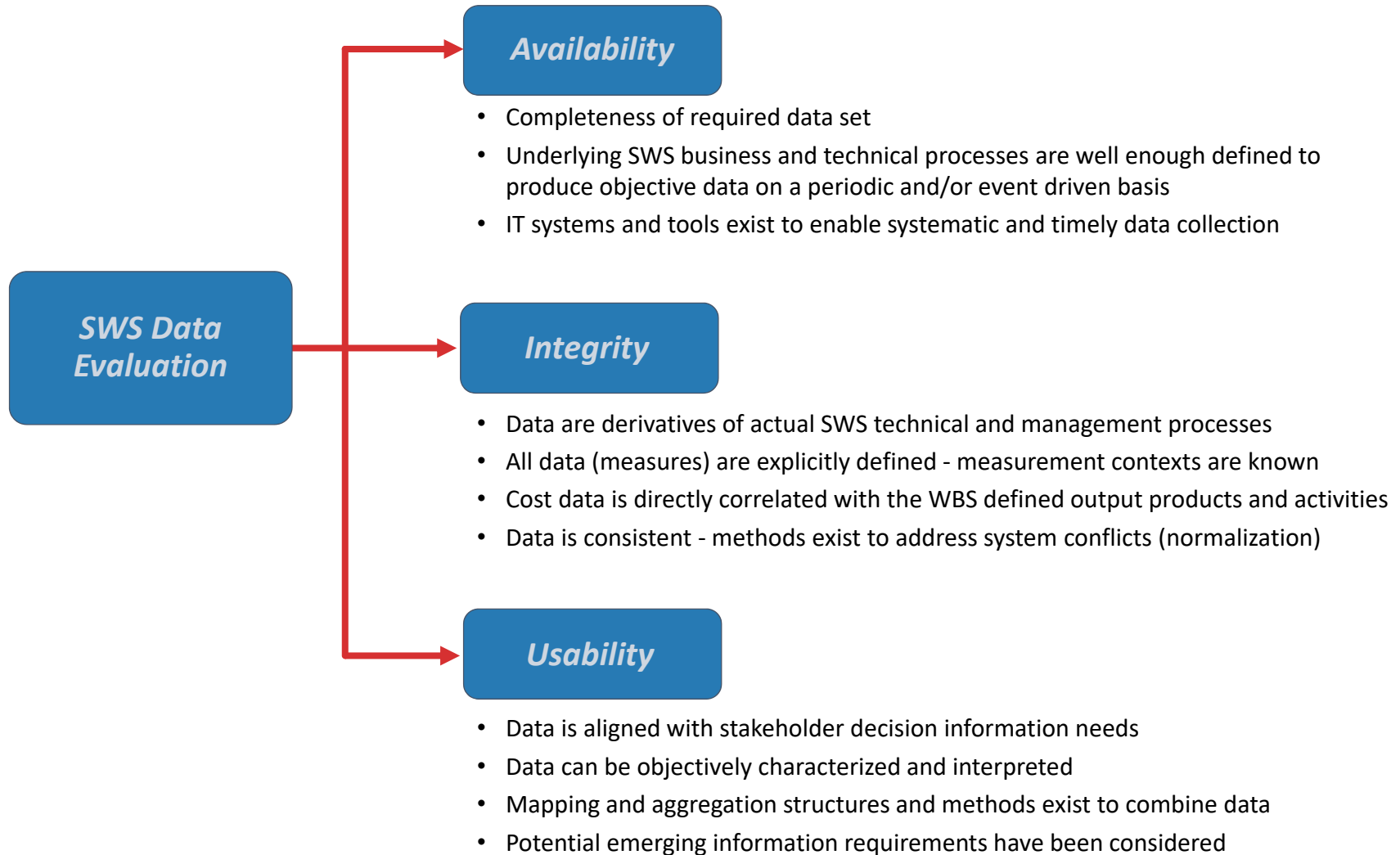
- Largest DoD Software Sustainment database
- Total Dollar Value Captured: \$3.1B
- Programs collected ranged from ACAT I to Non-Program of Records

* 6 DBS programs not listed above

Years in Sustainment



Software Sustainment Data Evaluation



Data Quality Evaluation

Annual Cost Level

Color	Definition	Value
R	Red indicates there is no planning or actual data reported	0
Y	Yellow indicates FTE or partial, actual data was reported	1
G	Green indicates that actual data was reported	2

System Level Annual											
Initial System Overall				Detailed System Assessment							
Rating	Definable Maint. Process	Total Program Effort/Cost	WBS 2-8	Change Product (WBS-1)	Project Mgmt (WBS-2)	License Mgmt (WBS-3)	C&A (WBS-4)	Facilities (WBS-5)	Sustaining Engineering (WBS-6)	Field S/W Engineering (WBS-7)	Operational Mgmt (WBS-8)
R	26	6	54	69	72	124	70	109	98	45	134
Y	81	33	100	78	28	18	49	19	18	11	9
G	76	153	38	45	92	41	63	44	72	47	49
N/A	10	0	0	0	0	9	10	20	4	89	0
Total	192	192	192	192	192	192	192	192	192	192	192

- Data was collected from 192 programs
 - 186 programs provided total system SWM costs (G, Y)
 - 6 programs could not provide even planned total cost
- A lot of programs could not articulate how much was spent for licenses or facilities, often because these are paid for by enterprise or overhead funds



Data Quality Evaluation

Capability Releases

Release Level (Capability Releases Only)										
Initial Release Overall			Detailed Release Assessment							
Rating	CER Usability	SER Usability	Schedule (WBS-1)	Effort (WBS-1)	Size: Requirements	Size: External Interfaces	Size: SLOC	Size: Non-SLOC	Size: SW Changes	IAVAs
R	273	222	78	204	392	454	306	0	177	552
Y	102	148	0	159	0	0	0	0	0	0
G	337	342	640	355	196	119	146	39	541	166
N/A	6	6	0	0	130	145	266	679	0	0
Total	718	718	718	718	718	718	718	718	718	718

- Data was collected from 718 capability releases
 - 439 releases had sufficient data to use in CER cost calculations (G, Y)
 - Size data was not always consistently tracked and generally was not mapped to resource (effort/cost) information
 - 541 releases tracked some sort of software change counts (defects, PTRs)
 - Many of the capability releases did not track the number of IAVAs addressed
 - Effort was often not tracked at the release level
 - Systems in different super-domains used different size measures
 - Software changes was the most commonly used size measure



Data Quality Evaluation

IAVA Only Releases

Release Level (IAVA Releases Only)										
Initial Release Overall			Detailed Release Assessment							
Rating	CER Usability	SER Usability	Schedule (WBS-1)	Effort (WBS-1)	Size: Req'ts	Size: External Interfaces	Size: SLOC	Size: Non-SLOC	Size: SW Changes	IAVAs
R	87	30	11	27	88	114	101	0	291	70
Y	141	162	0	163	0	0	0	0	0	0
G	94	130	311	132	40	11	7	0	31	252
N/A	0	0	0	0	194	197	214	322	0	0
Total	322	322	322	322	322	322	322	322	322	322

- Many programs reported IAVA only releases which are releases that address known cybersecurity vulnerabilities
- Data was collected from 322 IAVA only releases
 - 235 releases have sufficient data to use in CER cost calculations (G, Y)
 - Programs sized IAVA releases by the count of IAVAs information assurance vulnerability alerts



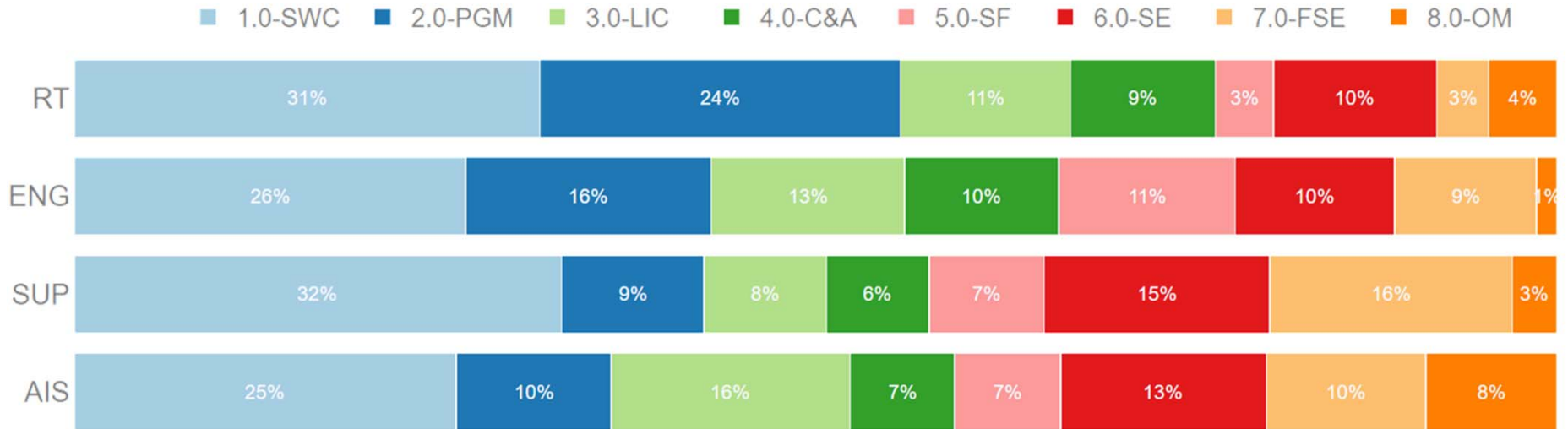
Super Domain Definitions

Real-Time	Engineering	Support	AIS
<p>Real-Time is the most constrained type of software. These are specific solutions limited by system characteristics such as memory size, performance, or battery life. These projects take the most time and effort due to constraints.</p>	<p>Engineering software operates under less severe constraints than real-time software. This software may take real-time software outputs and further process them to provide human consumable information or automated control of devices. Or the software may perform transformation and aggregation / distribution of data.</p>	<p>Support software assists with operator training and software testing. This software has few constraints.</p>	<p>Automated information system software provides information processing services to humans or software applications. These applications allow the designated authority to exercise control and have access to typical business / intelligence processes and other types of information access. These systems also includes software that facilitates the interface and control among multiple COTS / GOTS software applications.</p>
Application Domains	Application Domains	Application Domains	Application Domains
<p>Microcode & Firmware Signal Processing Vehicle Control/Vehicle Payload Other Real-Time Embedded Command & Control Communications</p>	<p>System Process Control Scientific and Simulation Test, Measurement, Diagnostic and Evaluation</p>	<p>Training Software Tools</p>	<p>Mission Planning Custom AIS Software Enterprise Service Systems Enterprise Information Systems</p>
Examples	Examples	Examples	Examples
<p>Field Programmable Gate Arrays, Flight Control, Missile Control, Radar Altimeter, Network Operations, Signal Electronics, Tracking Sensors, Encryption, Radio Networks, Propulsion</p>	<p>Operating Systems, Image processing, Simulation & Modeling, Test Equipment, File Management, Artificial Intelligence, Manufacturing Process Control</p>	<p>Computer Based Training, Compilers, Programming Aids, Code Generators, Assemblers, Courseware, Test case generation, Linker/loaders, Code Auditors</p>	<p>Scenario Generators, Target Planning, Enterprise Service Management, Enterprise Resource Planning, Transaction Processing, Data Warehousing, Financial Transactions</p>

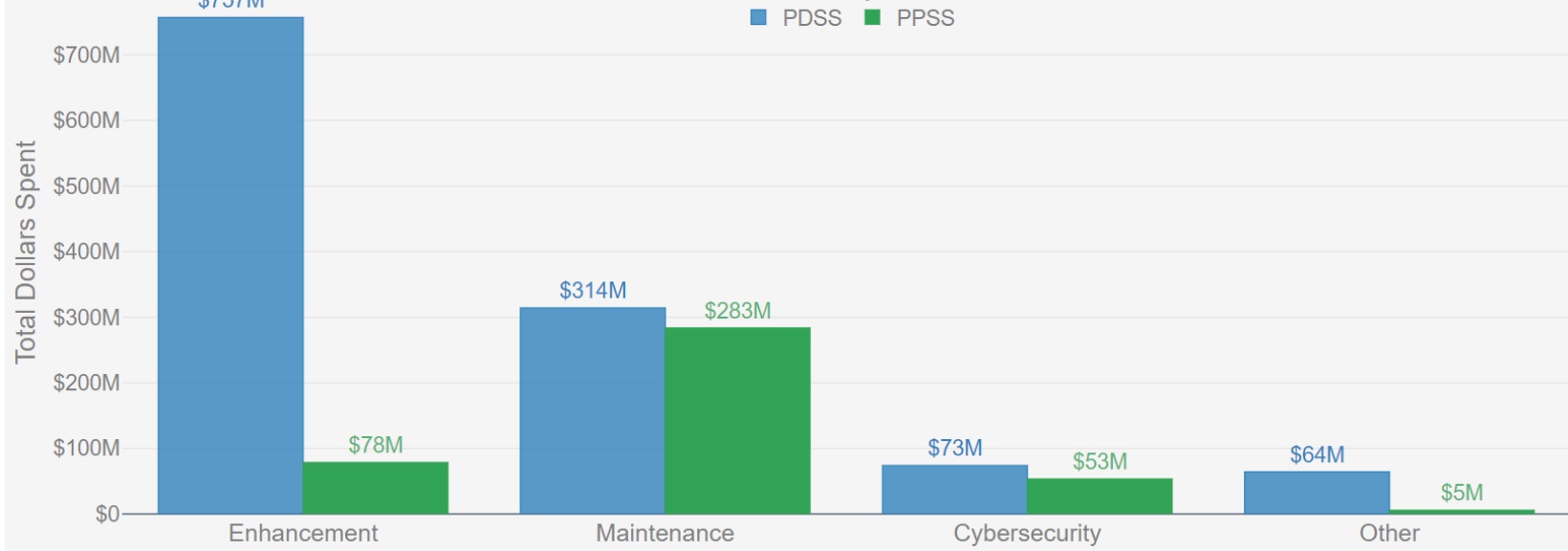


SWS Cost Allocation by WBS

Cost Allocation by Super Domain



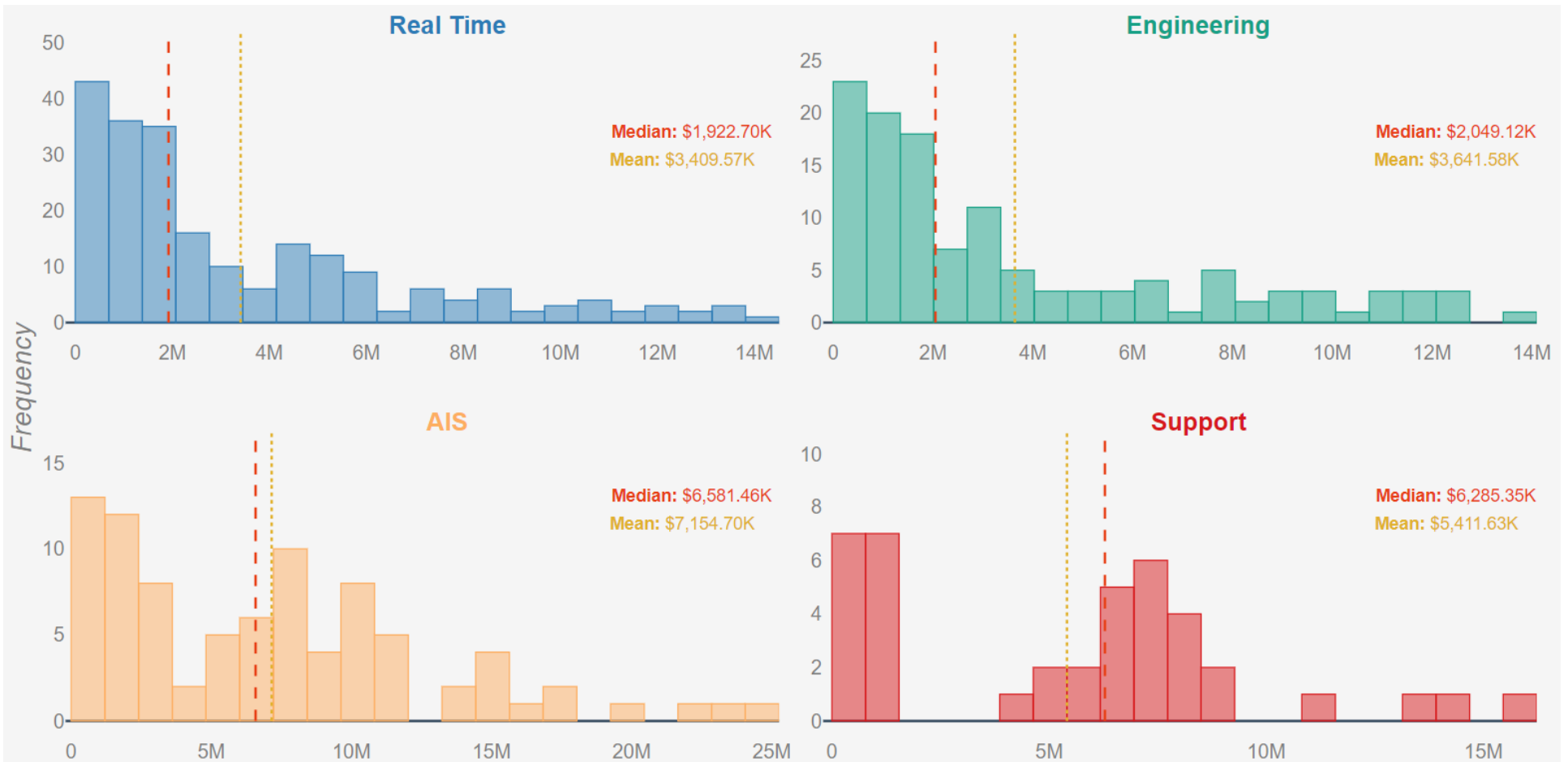
Total Release Cost by Characterization



Cost Distributions

SWS Total Annual Cost Distributions

Annual Cost by Super Domain

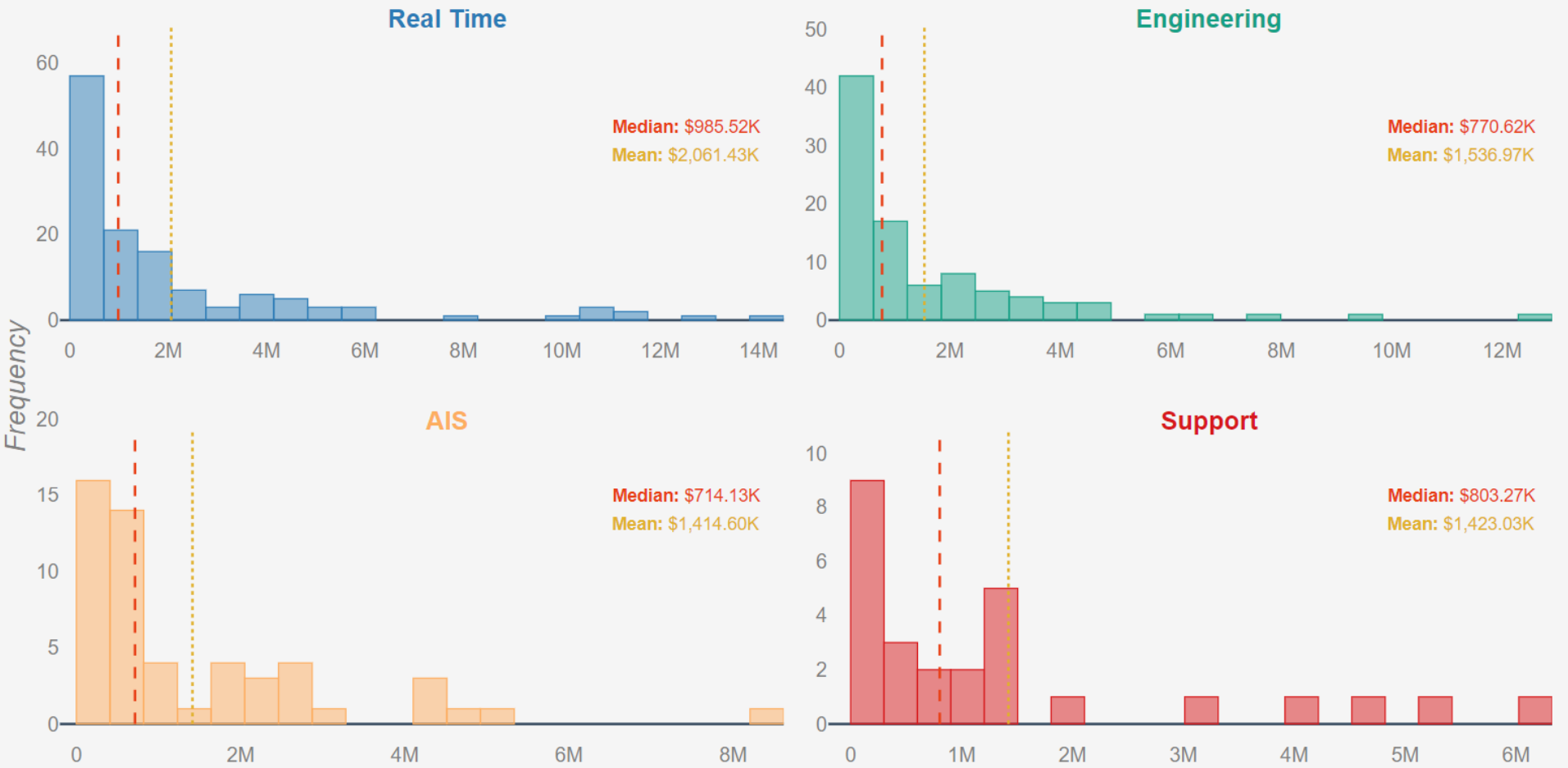


SD	Count	Min	25%	50%	75%	Max	Mean	St. Dev
RT	219	\$3,833	\$921,085	\$1,922,701	\$4,962,948	\$13,820,321	\$3,409,568	\$3,426,902
ENG	122	\$2,496	\$883,563	\$2,049,116	\$5,779,629	\$13,429,559	\$3,641,584	\$3,621,254
AIS	86	\$173,413	\$1,873,280	\$6,581,461	\$10,215,772	\$24,063,385	\$7,154,703	\$5,827,124
SUP	40	\$32,301	\$882,368	\$6,285,354	\$7,712,527	\$15,454,932	\$5,411,627	\$4,198,330



WBS 1.0 – Software Change Product

Annual Cost by Super Domain



SD	Count	Min	25%	50%	75%	Max	Mean	St. Dev
RT	130	\$97	\$236,253	\$985,524	\$2,459,095	\$13,820,321	\$2,061,429	\$2,928,788
ENG	93	\$2,496	\$170,815	\$770,619	\$2,103,549	\$12,293,399	\$1,536,970	\$2,105,995
AIS	53	\$4,978	\$368,106	\$714,129	\$2,054,633	\$8,206,612	\$1,414,603	\$1,640,786
SUP	27	\$31	\$194,516	\$803,269	\$1,497,107	\$6,024,926	\$1,423,032	\$1,735,959



Cost Estimating Relationships (CER) & Benchmarks

IAVA Releases

Data Preparation and Normalization

Data Preparation

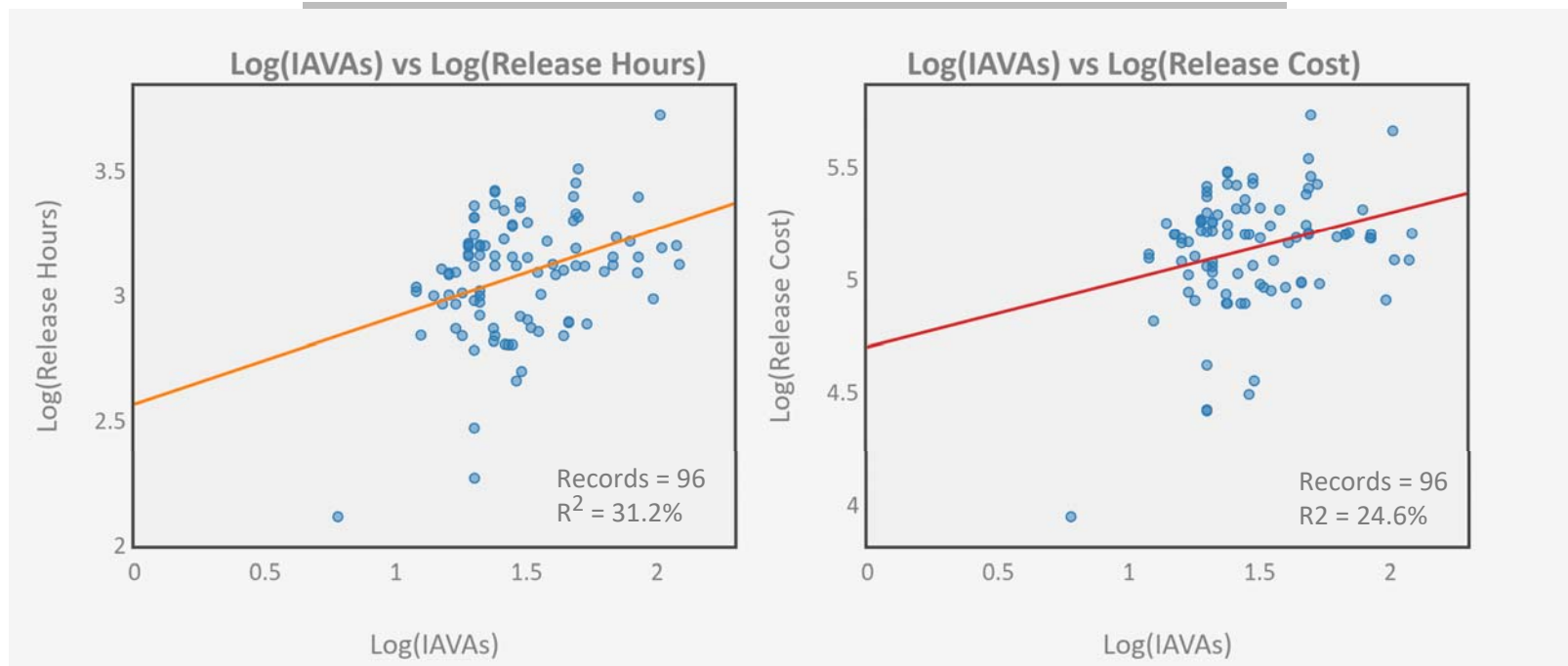
- IAVA Release data records (also called Observations)
- Removed records with:
 - There were no “DBS” Super Domain records
 - Hour data outliers or missing data: BO, CO, GO, and X, i.e. kept records with C, G & B
 - Records with no dependent variable e.g., IAVA counts
 - Upper & lower 10% of records (based on THrs/IAVA) were trimmed
 - However that data was not used because of the low record count and it did not improve results
- Aggregated records with repeating LOE effort data using averages (next slide)
- Data, both Dependent and Independent variables, are transformed using \log_{10}
 - Zeros were represented with 0.1

Dataset

- 224 Records total after removing Hrs outliers (GGO, CCO,BGO, BCO, BBO) & blanks
- 120 Records total after aggregating LOE records
- 96 Records total after trimming
 - Records sorted based on Unit Cost (Hrs/SC)
 - Top & Bottom 10% (12) records removed (trimmed)
- All quantitative variables were \log_{10} transformed
- All categorical variables were represented as dummy values (0,1)



IAVA CER Analysis

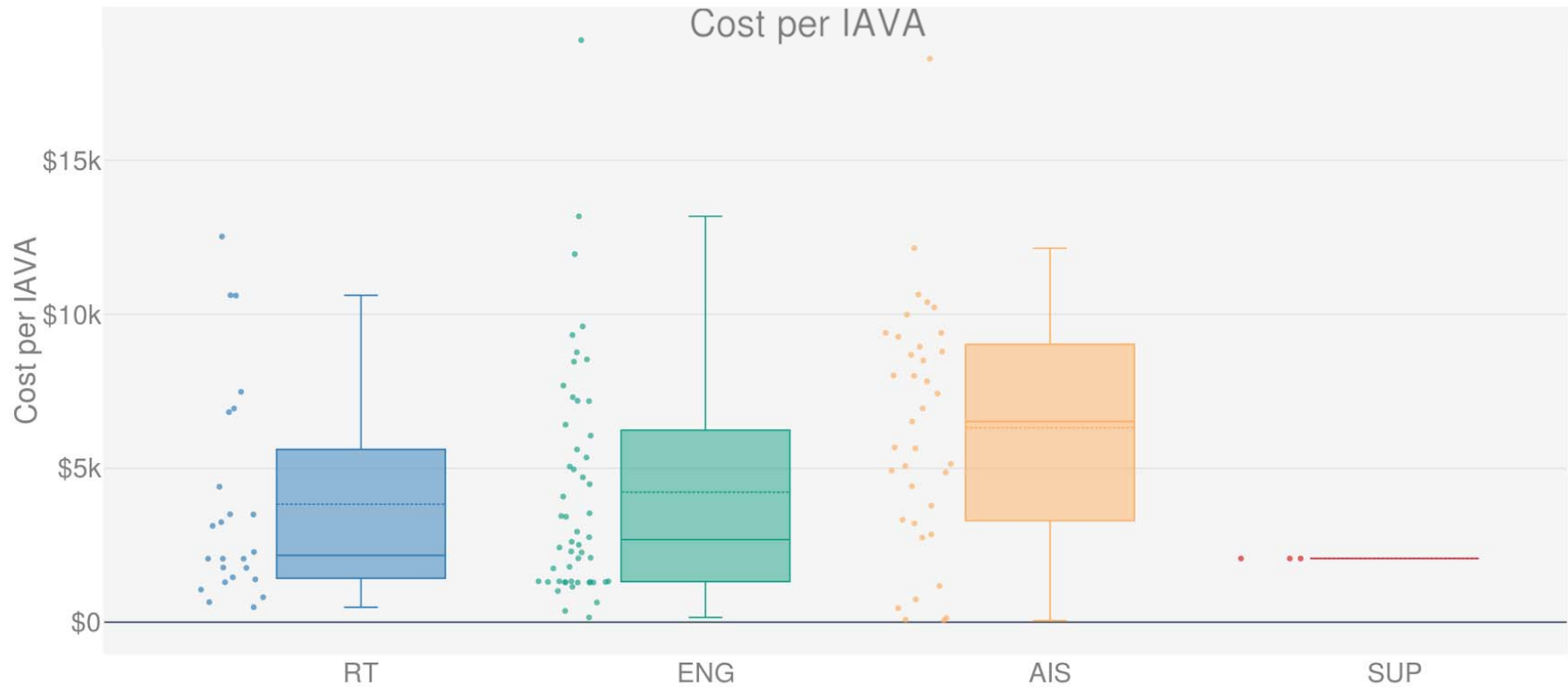


IAVA CER analysis failed to find a meaningful independent variable present in the data collected. It is recommended to use analogous programs or descriptive statistics to arrive at a more reliable estimate



Dollars per IAVA By Super Domain

IAVA Releases



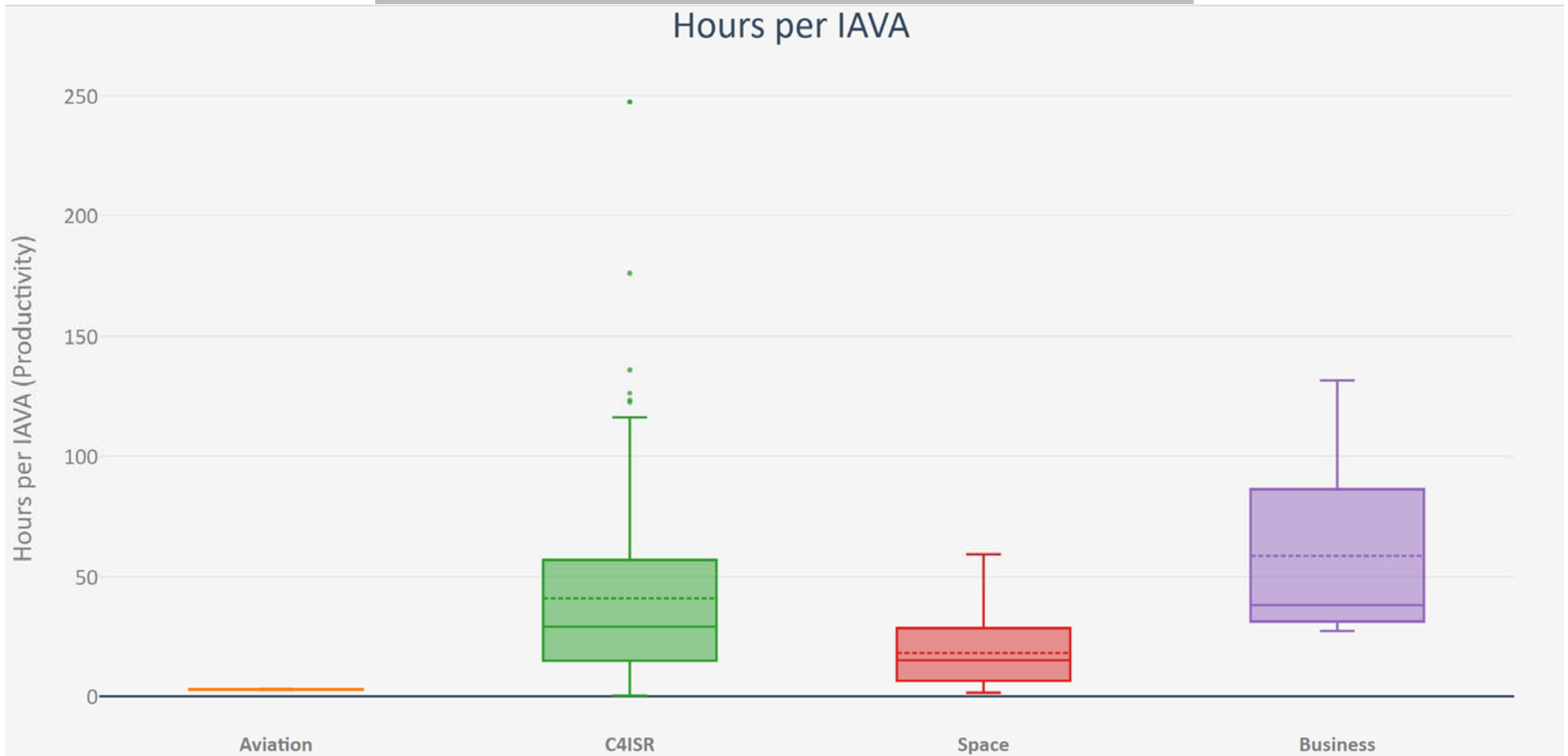
Super Domain	Count	Min	25%	50%	75%	Max	Mean	Std
RT	24	\$484	\$1,439	\$2,167	\$5,005	\$12,528	\$3,829	\$3,474
ENG	52	\$152	\$1,320	\$2,684	\$6,146	\$18,889	\$4,224	\$3,779
AIS	37	\$50	\$3,325	\$6,516	\$8,945	\$18,303	\$6,315	\$3,986
SUP	3	\$2,065	\$2,065	\$2,065	\$2,065	\$2,065	\$2,065	\$0

Cost per IAVA can be used to bound the number of IAVAs a program can expect to do given a fixed budget.



Hours per IAVA by Commodity

Hours per IAVA



Commodity	Count	Min	25%	50%	75%	Max	Mean	Std
Aviation	3	2	2	2	2	3	2	0
C4ISR	199	0	15	28	56	247	40	38
Space	22	1	6	15	27	59	18	13
Business	4	27	33	37	63	131	58	49



Capability CERs

Data Preparation

- Capability Release data
- Removed records with:
 - “DBS” super domain
 - Records where cost to effort (labor rate) was infeasible
 - Records with no dependent variable e.g., SW Change counts
- Data, both Dependent and Independent variables, are transformed using \log_{10}
- Records sorted based on Unit Cost (Hrs/SC)
- Top & Bottom 10% (33) records removed (trimmed)
- All categorical variables were represented as dummy values (0,1)



CER Results Summary Capability Releases

Conditions	Variable	Equation	# of Obs	Adj R ²	SEE (Hrs)	PRED(30)
Software Changes	SW Changes (single variable)	$Hours = 341 \times SC^{0.79}$	263	0.57	44,842	23.6%
Conditions	Variable	Equation	# of Obs	Adj R ²	SEE (Hrs)	PRED(30)
Software Changes & Super Domain (Categorical)	AIS	$Hours = 242 \times SC^{0.7341}$	263	0.62	39,330	20.2%
	ENG	$Hours = 386 \times SC^{0.7341}$				
	RT	$Hours = 736 \times SC^{0.7341}$				
	SUP	$Hours = 698 \times SC^{0.7341}$				
Conditions	Variable	Equation	# of Obs	Adj R ²	SEE (Hrs)	PRED(30)
Software Changes & Commodity	Aviation	$Hours = 1,452 \times SC^{0.66}$	263	0.68*	---	---
	Business	$Hours = 301 \times SC^{0.66}$				
	C4ISR	$Hours = 364 \times SC^{0.66}$				
	ChemBio	$Hours = 182 \times SC^{0.66}$				
	Fire	$Hours = 1,531 \times SC^{0.66}$				
	Missiles	$Hours = 1,114 \times SC^{0.66}$				
	Simulation	$Hours = 577 \times SC^{0.66}$				
	Space	$Hours = 1,005 \times SC^{0.66}$				
	Test	$Hours = 1,742 \times SC^{0.66}$				
Vehicles	$Hours = 425 \times SC^{0.66}$					
Conditions	Variable	Equation	# of Obs	Adj R ²	SEE (Hrs)	PRED(30)
Software Changes & Total Requirements	Total SRS Requirements	$Hours = 608 \times \frac{SC^{0.98}}{TotReqs^{0.21}}$	32	0.84	32,228	25.0%
Conditions	Variable	Equation	# of Obs	Adj R ²	SEE (Hrs)	PRED(30)
Software Changes & Requirements Implemented	Requirements Implemented	$Hours = 330 \times \frac{SC^{0.97}}{ReqsImp^{0.11}}$	65	0.74	63,904	23.1%

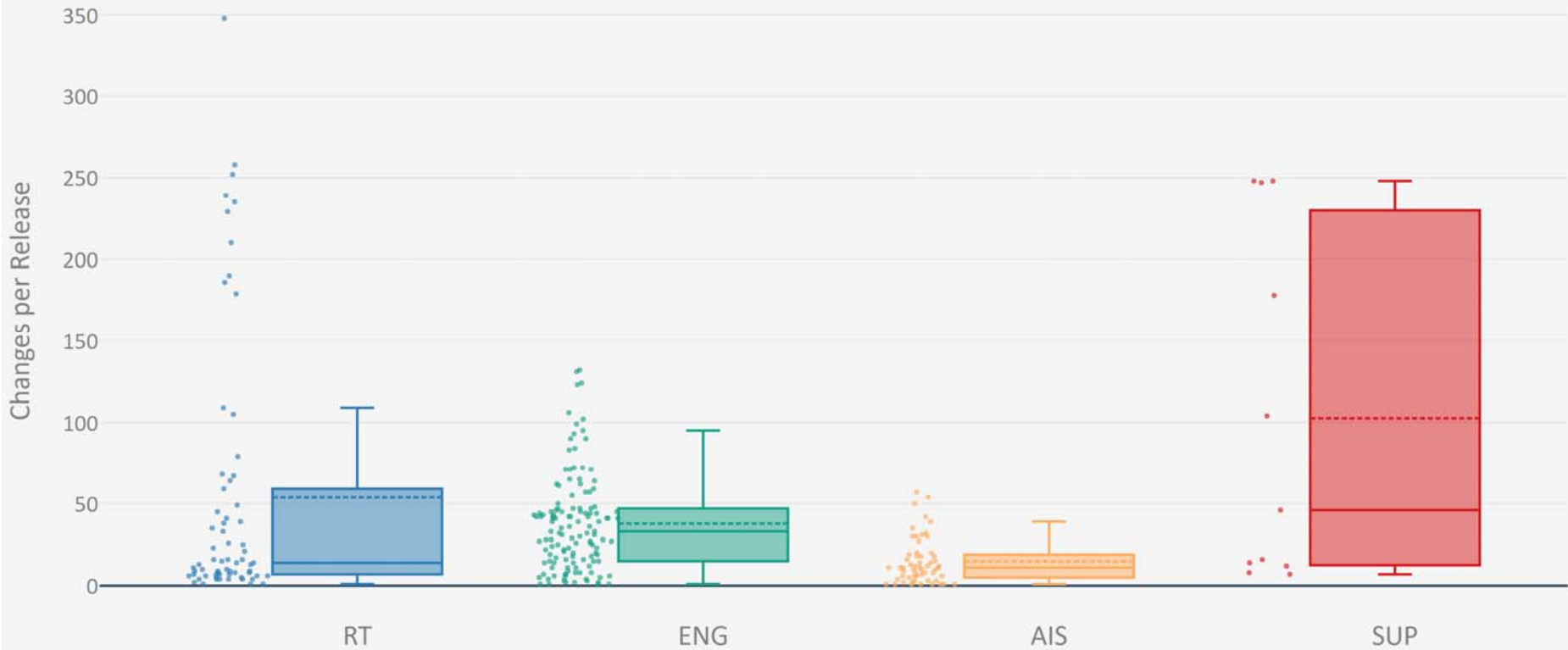
* 1 or more of the categorical variables resulted in a p-value > 0.05



Distribution of Software Changes

Capability Releases

Software Changes per Release



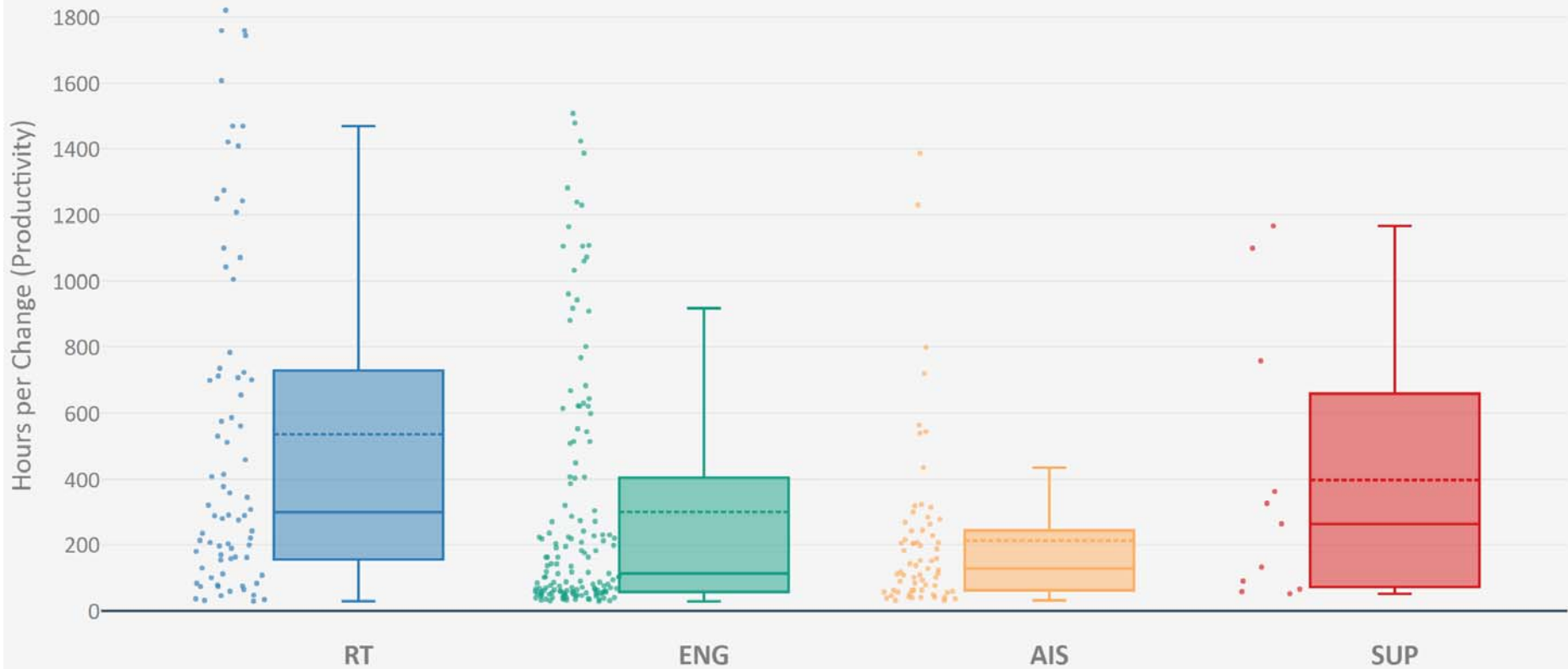
Super Domain	Count	Min	25%	50%	75%	Max	Mean	Std
RT	66	1	7	14	56	348	53	81
ENG	129	1	15	33	47	132	37	29
AIS	58	1	5	11	18	57	14	13
SUP	11	7	13	46	212	248	102	106

Number of SW Changes/Release can be used to size future releases when program specific data is unknown. The resulting size can be used with the associated cost benchmark or put into a CER.



Hours per SW Change by Super Domain Capability Releases

Hours per Software Change

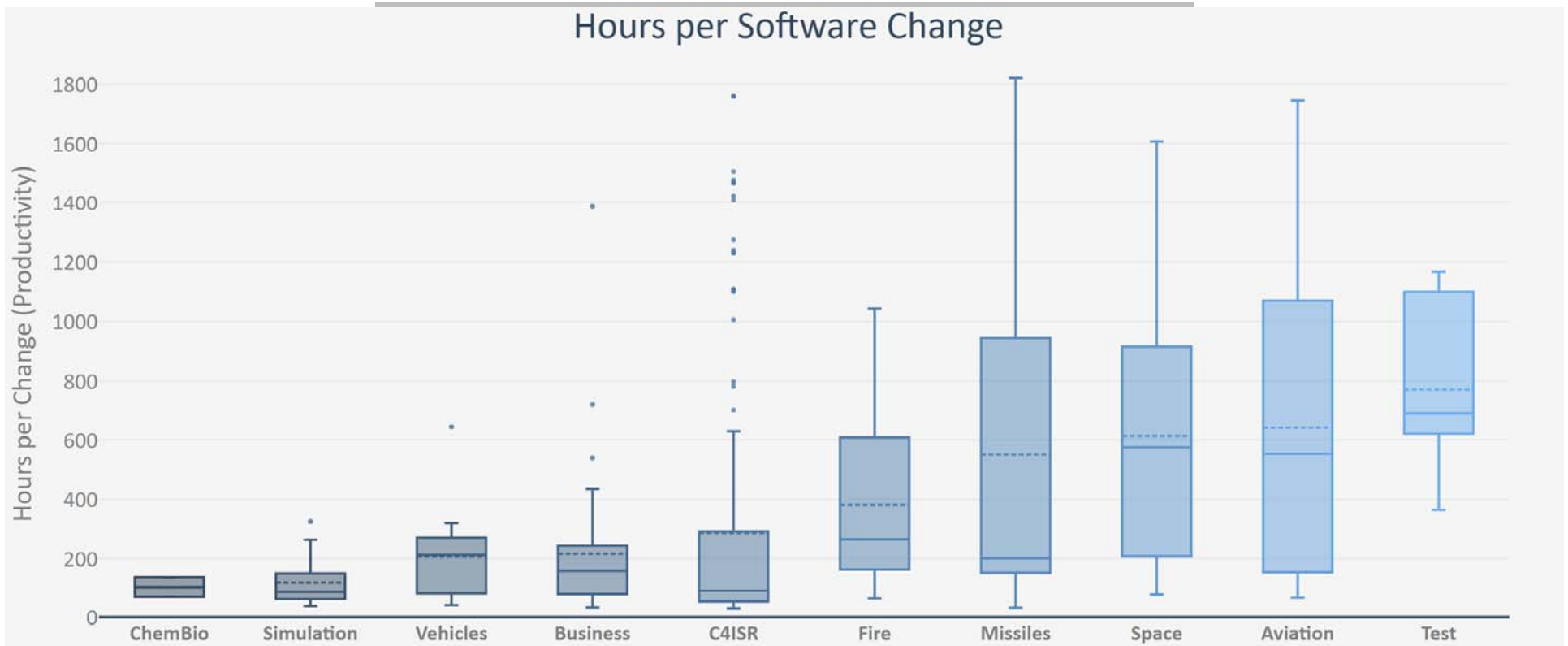


Super Domain	Count	Min	25%	50%	75%	Max	Mean	Std
RT	76	29	156	297	725	1,821	534	518
ENG	153	28	56	112	403	1,506	298	372
AIS	67	31	62	127	242	1,386	211	252
SUP	11	51	77	262	559	1,166	397	418



Hours per Software Change by Commodity

Capability Releases

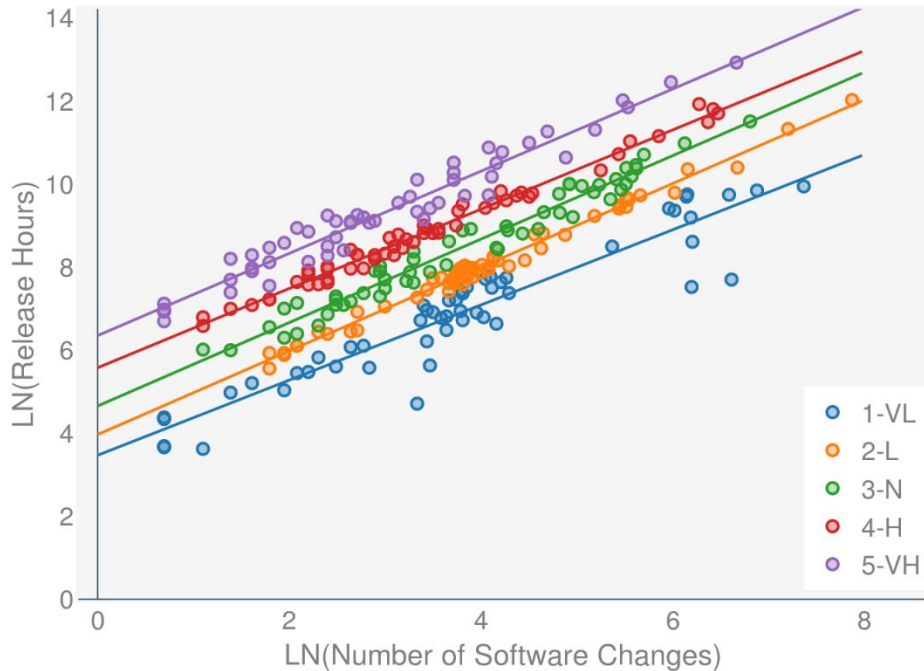


Commodity	Count	Min	25%	50%	75%	Max	Mean	Std
ChemBio	2	67	85	102	119	136	102	48
Simulation	17	36	60	83	135	324	118	82
Vehicles	14	40	88	211	258	642	206	154
Business	35	31	77	157	242	1,386	215	251
C4ISR	153	28	52	89	288	1,760	284	405
Fire	20	62	161	263	583	1,042	379	281
Missiles	18	31	153	200	899	1,821	549	544
Space	14	75	258	574	857	1,607	612	432
Aviation	28	64	170	552	1,051	1,745	639	499
Test	6	362	620	689	1,013	1,166	771	308

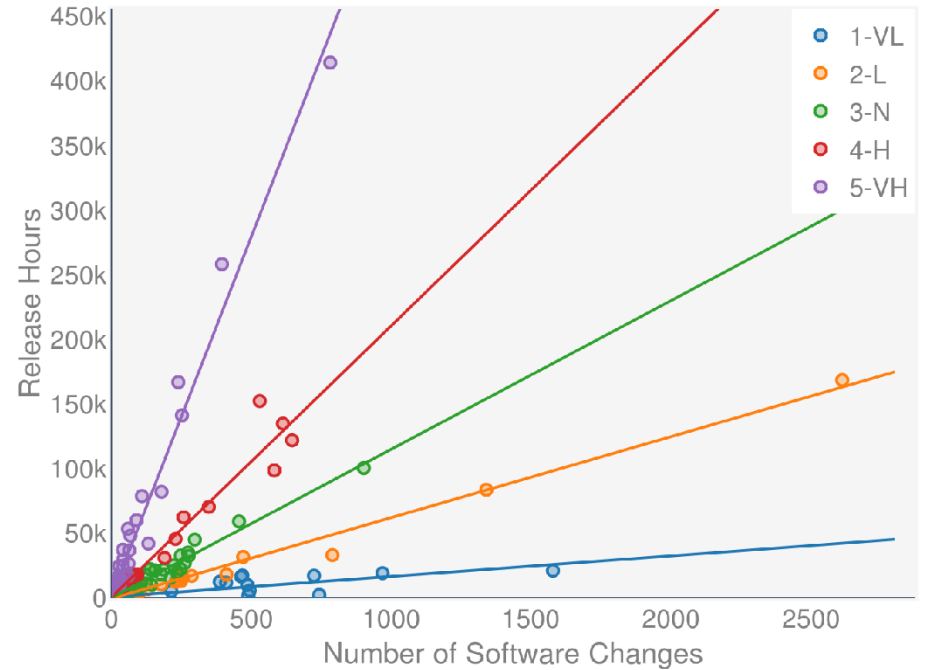


Unit Cost Grouping Levels: Hrs/SC

Release Hours vs Software Changes (Transformed-Space)



Release Hours vs Software Changes (Fit-Space)



Release Hrs per Software Change	1-VL (Count: 49)	2-L (Count: 46)	3-N (Count: 41)	4-H (Count: 48)	5-VH (Count: 39)
Mean	24.1	55.4	110.3	228.8	581.4
Median	23.6	56.3	107.2	219.6	568.5
Min Value	2.0	41.0	70.5	162.2	286.8
Max Value	40.1	69.5	161.8	324.3	961.3



Category Analysis Exploration

- ✓ Maintenance Organization (17)
 - Location of Maintenance Organization (11)
 - Commodities (10)
 - Super Domains (RT, ENG, SUP, AIS)
- ✓ Change types (Enhanced, Maintenance, Cybersecurity)
- ✓ Business models (Government, Contractor, Integrated)
 - Maintenance Phase (MS-C LRP, MS-C FRP, O&S)/Time in Phase
- ✓ ACAT Level
 - Number of Software variants
 - Number of Platform variants
 - Number of Users
 - Number of Licenses
- ✓ Number of Inter-Services Partners
 - Release/Total Cost

To determine which cost grouping (1-VL through 5-VH) a program will fall, a number of characteristics were examined for significance



Unit Cost Level One-Category Criteria

- Each slide presents Unit Cost levels by a category criteria
- There are two tables:
 - Top table are the counts of each Release’s Unit Cost at a level
 - Bottom table are the percentages of the counts
- The bottom table is examined for a “percentage” or “adjacent sum of percentages” greater than or equal to 50% (green highlight)
- For example, **Business Model**:

Release Unit Cost Level count by [Business Model](#)

Business Model	Count	1-VL	2-L	3-N	4-H	5-VH
Government	1	1				
Integrated	77	19	26	12	9	11
Contractor	142	25	18	31	35	33

Release Unit Cost Level count % by [Business Model](#)

Business Model	Count	1-VL	2-L	3-N	4-H	5-VH
Government	1	100.0%				
Integrated	77	24.7%	33.8%	15.6%	11.7%	14.3%
Contractor	142	17.6%	12.7%	21.8%	24.6%	23.2%



ACAT & Inter-Services

Release Unit Cost Level Count % by ACAT

ACAT	Count	1-VL	2-L	3-N	4-H	5-VH
ACAT I	38	5.3%	15.8%	26.3%	18.4%	34.2%
ACAT II	41	31.7%	4.9%	9.8%	24.4%	29.3%
ACAT III	101	24.8%	31.7%	16.8%	13.9%	12.9%
Non PoR	2			100.0%		

Release Unit Cost Level Count % by Inter-Service

Inter-Service	Count	1-VL	2-L	3-N	4-H	5-VH
Army Only	165	24.8%	23.0%	19.4%	18.2%	14.5%
2	11	9.1%	36.4%	9.1%	27.3%	18.2%
3	7			42.9%	14.3%	42.9%
4	7	14.3%		14.3%	28.6%	42.9%
5	33	6.1%	6.1%	24.2%	27.3%	36.4%



Super Domain

Release Unit Cost Level Count % by Super Domain

Super Domain	Count	1-VL	2-L	3-N	4-H	5-VH
Real Time	115	27.0%	28.7%	10.4%	18.3%	15.7%
Engineering	54	3.7%	13.0%	29.6%	27.8%	25.9%
AIS	49	18.4%	10.2%	34.7%	16.3%	20.4%
Support	6	50.0%			16.7%	33.3%

- Since the previous results were inconclusive, a more detailed analysis was conducted
 - Software changes were characterized based on contextual comments in the questionnaire and by Super Domain



Example of SW Change Descriptions

Automated Information Systems	1-VL	2-L	3-N	4-H	5-VH
Enhancement Changes					
Web platform; Heavy COTS (>=75)	X				
Web platform		X	X		
Web platform; 5 services			X	X	X
Web platform, Emergency release					X
Rewrite: Web platform; 5 services					X
Maintenance Changes					
Defect repair: Web platform	X				
Update, defect repair: Web platform	X				
Upgrade: Web platform; COTS upgrade	X	X			
Defect repair: Web platform; 5 services	X		X		
Update: Web platform	X		X		
Reconfiguration: Limited rel; 4 Services		X			
Update: Handheld device		X			
Update: 4 services			X		
Upgrade: Web platform			X		
Upgrade, rehost: Web platform; 5 services			X		
Update: Web platform; 5 services			X	X	
Rehost: Handheld device				X	
Rehost: Web platform; 5 services				X	
Upgrade: Web platform; 5 services				X	X
Cybersecurity Changes					
General		X			
Vulnerabilities: Web platform; 5 services		X			

Further investigation into release and defect description may lead to accurate stratification of release productivity that aligns with defined Unit Cost Levels



Lessons Learned/Next Steps



Software Sustainment Estimating Framework

1.0 Software Change Product		5.0 System Facilities	
Activities	IAVAs, SW Changes (defects/enhancements)	Activities	Lab infrastructure, Mgmt
Performing Org.	Contractor	Performing Org.	Government/Contractor/Outside Organization
Challenges	Use of inconsistent size measures; effort not generally tracked by release	Challenges	Facilities paid by various sources; inheriting hardware from other sources
2.0 Project Management		6.0 Sustaining Engineering	
Activities	CM, Execution, Project/Engineering Leads	Activities	Help Desk, Delivery/Installation, Test Support
Performing Org.	Government/Contractor	Performing Org.	Government/Contractor/Outside Organization
Challenges	Roles/Responsibilities spread throughout WBS; contractor generally paid by overhead	Challenges	Inconsistent/varying activities reported; category generally misunderstood
3.0 Software Licenses		7.0 Field Software Engineers	
Activities	License Cost	Activities	Field Maintenance, Installation, Troubleshooting
Performing Org.	Government/Contractor/Outside Organization (enterprise licenses)	Performing Org.	Government/Contractor/Outside Organization
Challenges	Payed for by multiple sources; licenses generally underreported; not always tracked	Challenges	Difficult to estimate required support; shared between multiple programs
4.0 Certification and Accreditation		8.0 Operational Management	
Activities	DIACAP/RMF, STIGs	Activities	Enterprise Management, Business Management
Performing Org.	Government/Outside Organization	Performing Org.	Government/PEO/Contractor
Challenges	Differs between types of C&A's, Difficult to track prep vs certification vs fixes post certification	Challenges	Generally treated as overhead, spread across programs



Core Truths of Cost Estimation

- No cost estimation decision is better than the data that supports it
- If you don't collect execution data, your cost estimate will be unreliable
- If you don't own the data, your cost estimate will likely be untrustworthy
- If your data is not related to actual performance, your cost data will be incomplete
- If you don't have a good software sustainment process, your cost data will be inconsistent
- If you don't compare planned to actual performance, you can't improve your cost estimates
- If no one asks for or uses the data, it will not exist
- If the quality of software sustainment data doesn't match that of acquisition development data, it will never be used by senior decision makers

Software is not static: it has to be continually monitored and updated to address cybersecurity issues, COTS changes, new/revised interfaces, changing platforms, platform capability shortfalls, new parameters, emerging threats, etc.



Importance of Data Collection

- Consistent and accurate technical/cost data allows for more meaningful CERs that are relevant to the changing environment of software sustainment
- Software sustainment data can be used to better inform design decisions and cost analysis
 - DASA-CE and the Army cost community are now able to develop cost products that use analogous program data and technical output to estimate software maintenance. This facilitates major milestone estimates, O&S cost targets, Operation Sustainment Reviews, and yearly POM reviews
 - Phase I dataset is hosted on CADE under “Library”



Implications

- The correlation between performance, sustainment practices, and budgeting remains elusive
- This is not likely to remain acceptable in the current environment of eliminating waste to pay for modernization
- Change is coming.....
 - There are already more demands for objective data across the services



Next Steps

- Additional analysis of data, including:
 - Refined CERs/SERs by appropriate categories (application domain, organization, operating environment, etc.)
 - Cost of impacts of DIACAP vs RMF
 - Cost of Cybersecurity
 - Release rhythm analysis
- Systemic data collection
 - The Software Resources Data Reporting for Maintenance (SRDR-M*) closely aligns to the DASA-CE SWM WBS and data requirements
 - Moving forward, the SRDR-M will be utilized to collect SWM data from a large number of programs across the Army
 - Ongoing analysis will be performed as data is made available through the SRDR-M
 - FY18 Execution data will be collected for OMA funded projects

*See <http://cade.osd.mil/policy/dids> for more information



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Backup

Model Evaluation Statistics

- Adjusted R² (R-sq Adj)
 - The R-sq Adj is a modified version of R-squared that has been adjusted for the number of predictors in the model.
 - The adjusted R-squared increases only if the new term improves the model more than would be expected by chance. It decreases when a predictor improves the model by less than expected by chance.
- Standard Error of the Estimate (SEE)
 - SEE indicates how wrong the regression model is on average using the units of the response variable. Smaller values are better because it indicates that the observations are closer to the fitted line. SEE is calculated:

$$\sqrt{\frac{\sum(Actual - Est)^2}{n - k}}$$

A =Actual Values

E = Estimated Values

N = Number of Observations

K = Number of terms in the model

- Prediction Level (PRED(X))
 - Percent of estimates (E) where the PREDiction is within X% (30% used) of actuals (A). PRED(X) answers how often the estimated effort falls within X% of the actual effort for a project. PRED(X) is calculated:

$$\left| \frac{(Actual - Est)}{Actual} \right|$$



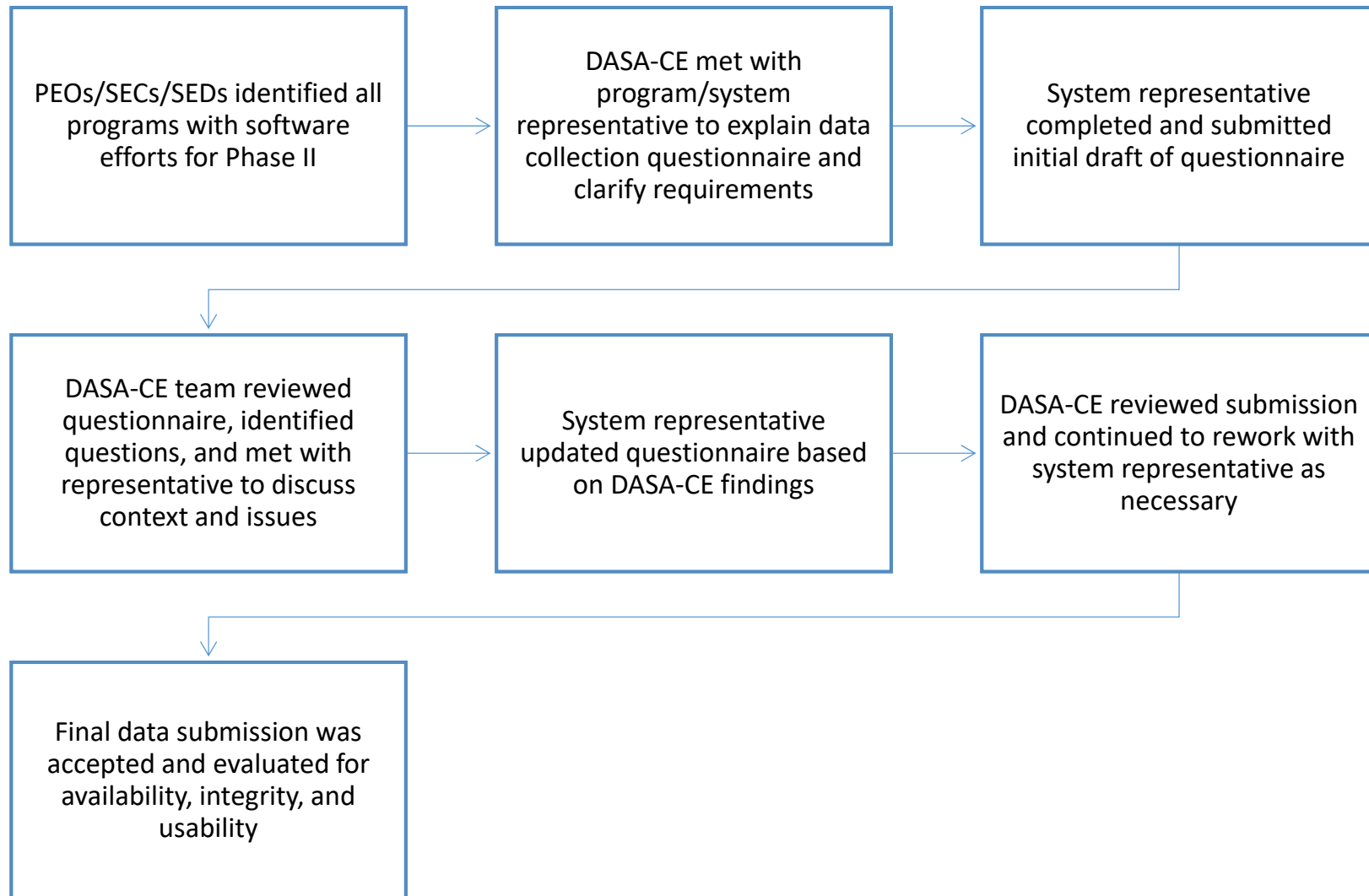
Army Software Maintenance Definition

For this effort, software maintenance is defined as:

- Software maintenance includes all software change activities and products associated with modifying a software system after EMD has completed and a software release has been provided to an external party
- The release is the primary SWM change product - a composite of one or more changes - it can be either a formal release or an engineering release
- SWM includes software enhancements and software corrections/adaptations
- SWM includes activities and change products funded by multiple funding sources
- Fixed and Variable costs accrued at both the system and organizational levels by both organic and contractor resources
- Software maintenance and software sustainment are considered to be synonymous



Data Collection Process



Data Fields in Questionnaire

System Level Context (1 of 3)

System Description	System Name
	System Description
	Services (Army, Navy, AF, etc)
	ACAT Level
Phase / Milestone	Current Phase
	Start Date of Phase
Context Information	# of Baselines
	# of Systems Fielded
	# of Variants
	# of Users
	Maintenance Activities Performed
	Maintenance Process
	Operational Tempo
	Software Process Maturity
Data Rights	Data Rights Type
	Data Rights Cost
	Data Rights Ownership
Organization Information	Analogous Systems
	Funding Appropriations Used
	Collection Date
	POC Information
	PEO & SEC
	Transition to SEC Date
	Developers & Current Maintainers



Data Fields in Questionnaire

System Level Annual (2 of 3)

WBS Element - Cost and Effort
System Total
Software Change Product (SW Releases)
Project Management
Software Licenses
Certification and Accreditation
System Facilities
Sustaining Engineering
Field SW Engineers
Operational Management
Labor Hours per Year & Labor Rate

License Questions
License Name
Company name
Quantity
Entitlement
Total Cost
Type
Duration
Award Date

- Programs were requested to report 3 years of cost and effort data broken out by the WBS as well as license information, certification frequency, and certification type (DIACAP, RMF, NSA, etc.)
- Data from government and contractor activities



Data Fields in Questionnaire

Software Release Level (3 of 3)

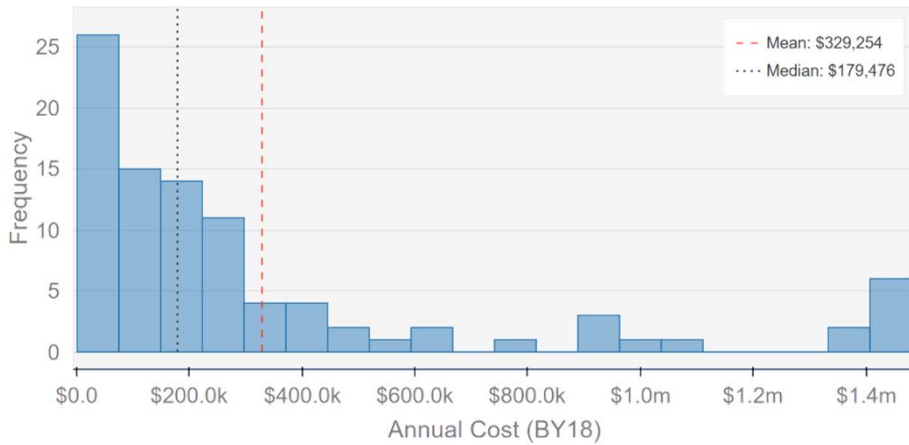
Report Context	Release Name	SLOC	Software Language
	Release Description		Baseline Code Count
Release Characterization	% Enhancements		New Code Count
	% Maintenance		Modified Code Count
	% Cybersecurity		Reuse Code Count
	% Other		Auto-Generated Code Count
	Release Status		Comments Count
Product and Maint. Description	SW Release Anomalies		Deleted Code Count
	Operating Environment		Delivered Code Count
	Manned vs Unmanned	Non-SLOC Sizing	Sizing Method
	Application Domain / Super Domain		Total Size
Release Schedule	Start Date		Count of Size Type
	End Date		Number Implemented
Release Effort & Cost	Government Cost & Hours	Software Changes	Total Number of Changes
	Contractor Cost & Hours		Priority 1
Requirements / Interface Size	Requirements /Interfaces Description		Priority 2
	Requirements at Release Start		Priority 3
	Requirements Affect in Release		Priority 4
	Total System Interfaces		Priority 5
	Interfaces Affected in Release	IAVAs	Number of Changes in Backlog
			Number of IAVAs Addressed



WBS 4.0 – Certification & Accreditation

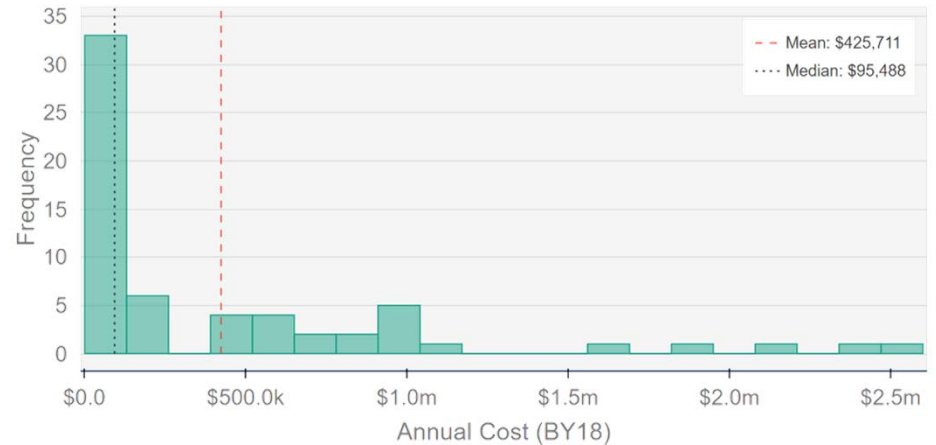
Annual Cost by Super Domain: All Years (FY13-FY17)

RT - C&A Total



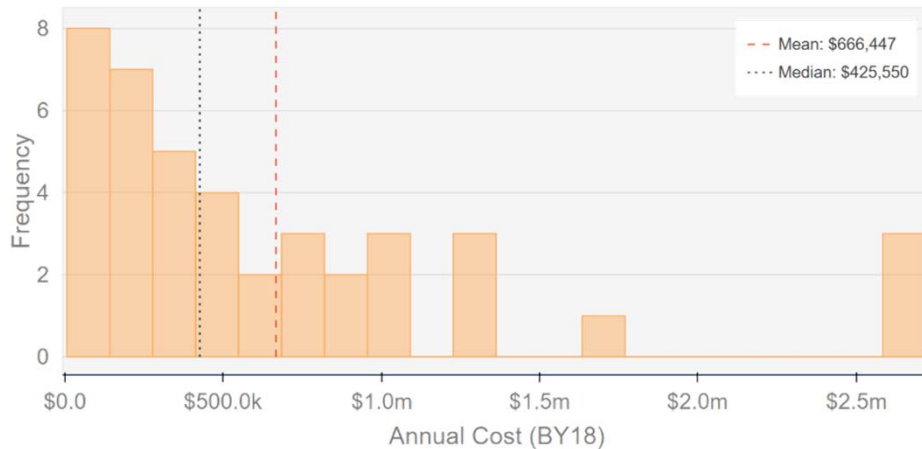
Count	Min	1st Quartile	Median	3rd Quartile	Max	Mean
93	\$1,589	\$74,148	\$179,476	\$368,363	\$1,481,020	\$329,254

ENG - C&A Total



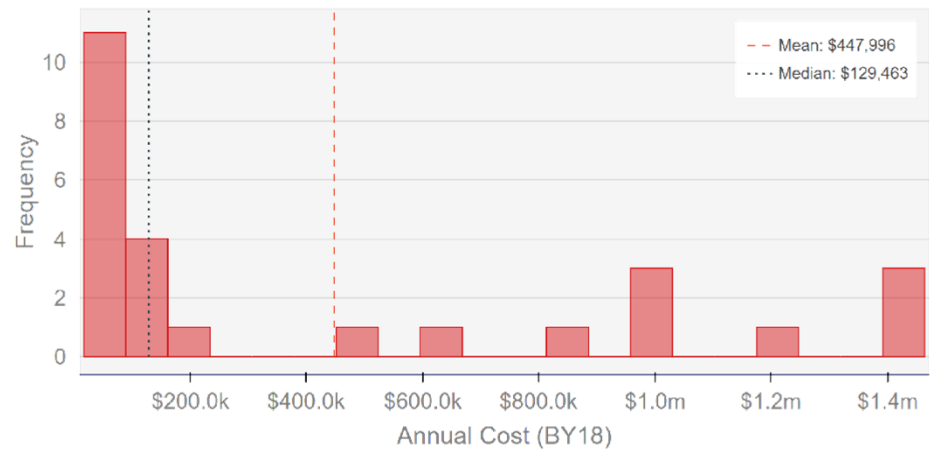
Count	Min	1st Quartile	Median	3rd Quartile	Max	Mean
62	\$3,070	\$36,196	\$95,488	\$569,705	\$2,600,117	\$425,711

AIS - C&A Total



Count	Min	1st Quartile	Median	3rd Quartile	Max	Mean
41	\$5,149	\$178,445	\$425,550	\$878,470	\$2,719,843	\$666,447

SUP - C&A Total



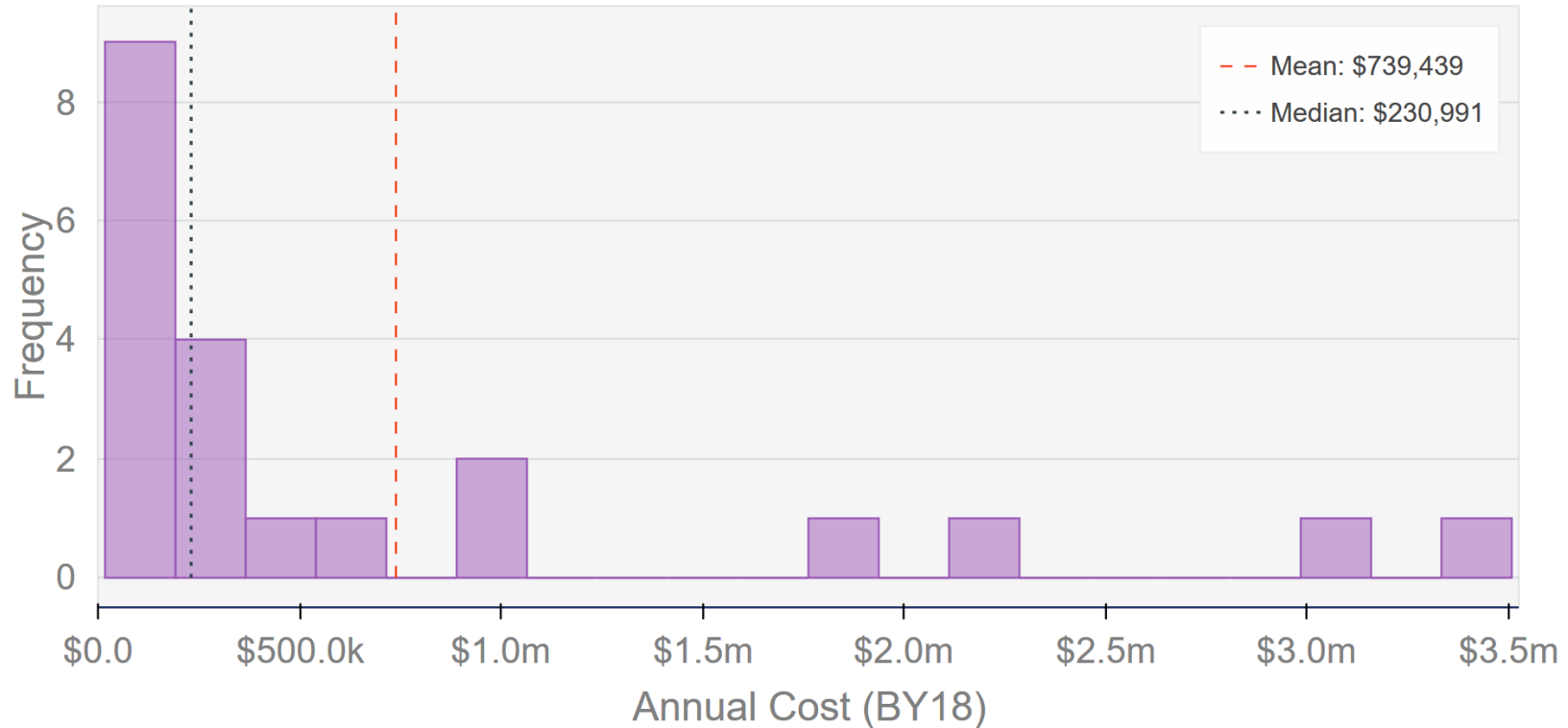
Count	Min	1st Quartile	Median	3rd Quartile	Max	Mean
26	\$17,262	\$42,449	\$129,463	\$940,186	\$1,463,958	\$447,996



WBS 4.0 – Certification & Accreditation

All Super Domains: FY16-FY17

Certification and Accreditation



Count	Min	1st Quartile	Median	3rd Quartile	Max	Mean
21	\$17,262	\$126,804	\$230,991	\$928,354	\$3,509,878	\$739,439

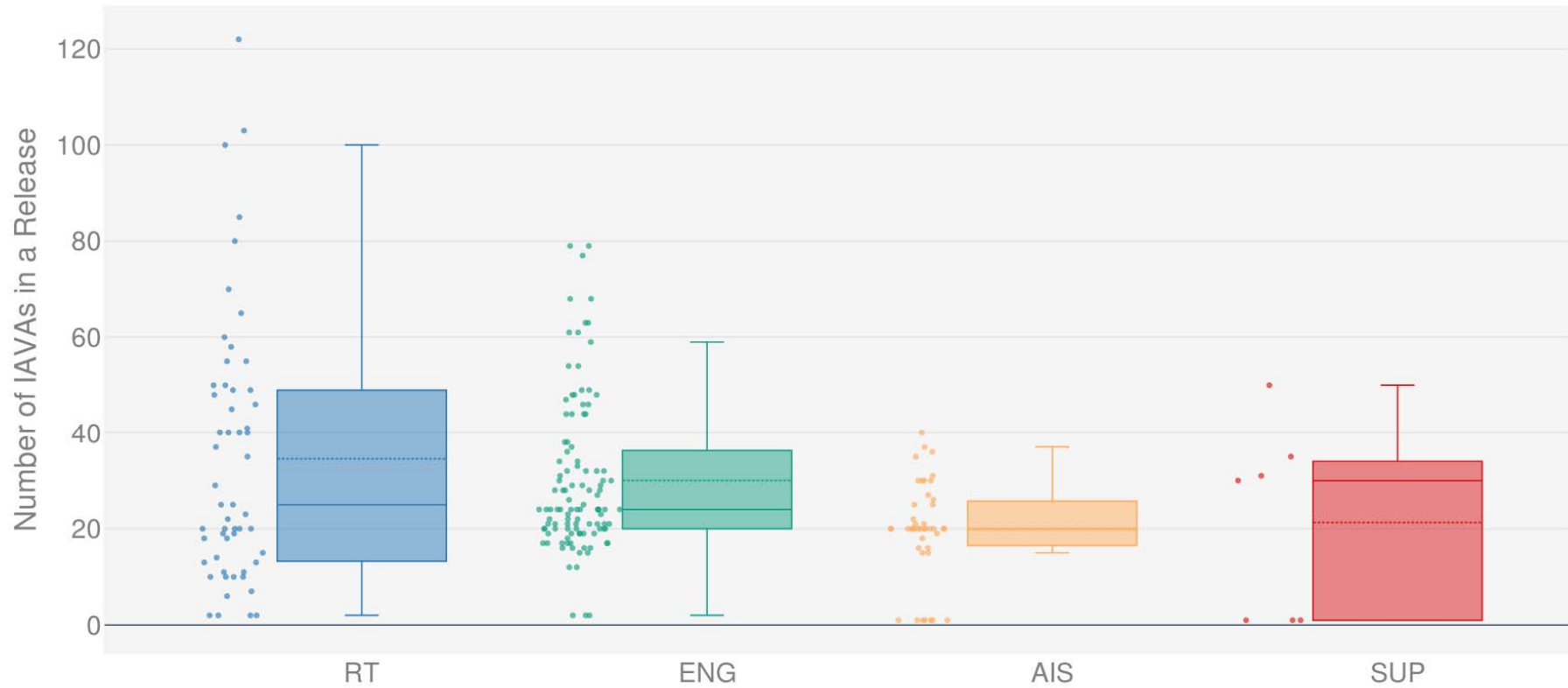
- Higher cost of C&A's in more recent years reflects the transition period of moving from DIACAP certification to Risk Management Framework (RMF) certification which generally requires more effort



Distribution of IAVAs

IAVA Releases

IAVAs per Release

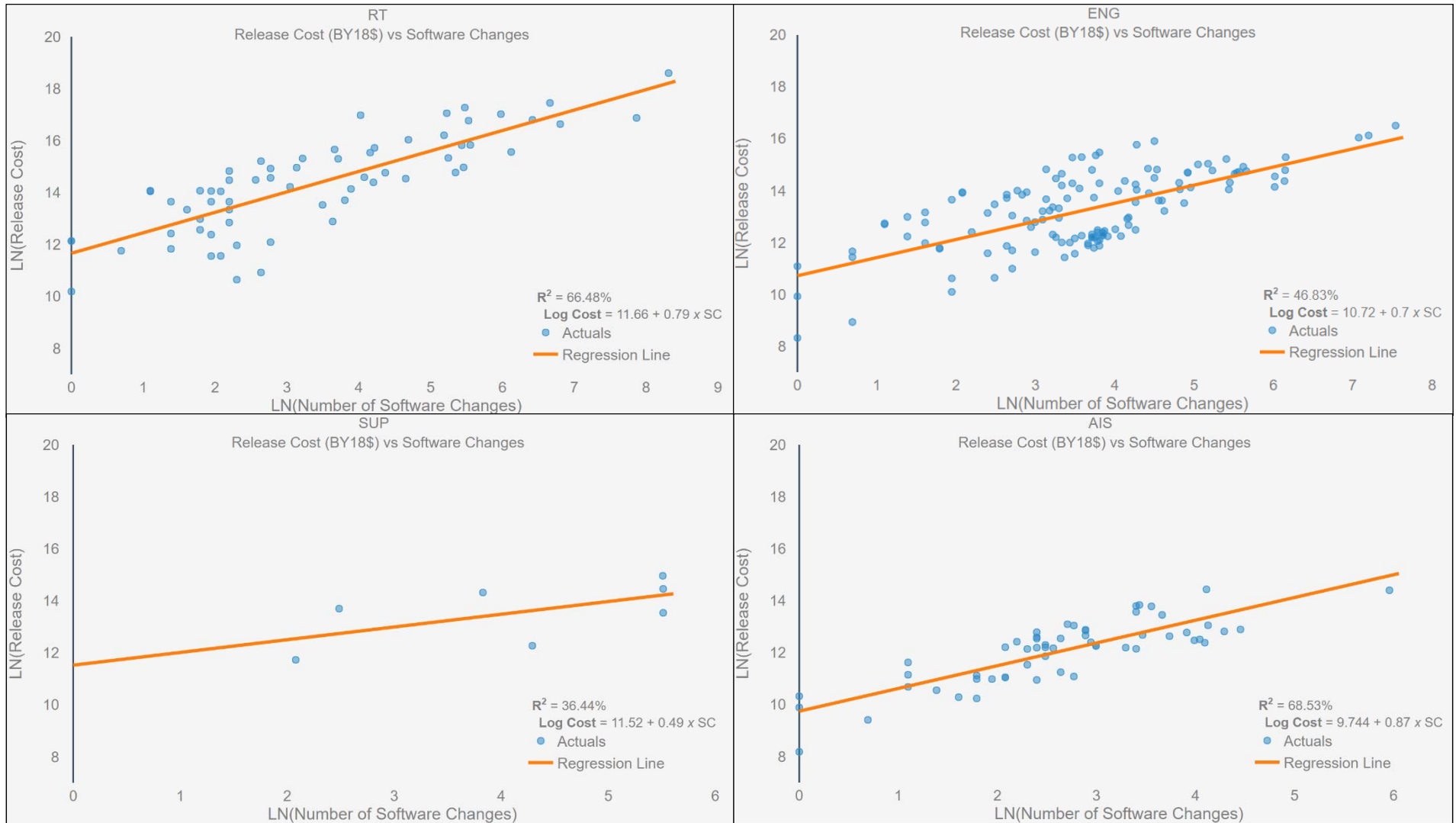


Super Domain	Count	Min	25%	50%	75%	Max	Mean	Std
RT	55	2	13	25	49	122	34	27
ENG	109	2	20	24	36	79	30	16
AIS	43	1	17	20	25	40	19	10
SUP	7	1	1	30	33	50	21	20



Release Cost vs Software Changes

By Super Domain



Lessons Learned

Data Collection and Normalization:

- Numerous iterations were required for every data submission (average 4 submissions/program) to ensure data was accurate
- Data cleansing and normalization consumed significantly more time than expected
- Automation/use of macros streamlined data quality checks and consolidation
- Lack of standardized naming conventions extended data merging effort

Data Analysis Findings:

- Need better measures of size (output) for software sustainment
- Cybersecurity releases for many Army programs are done very frequently (monthly/weekly)
- Release descriptions indicate that COTS changes and interfaces are a prominent cause of software changes
- “Percent Enhancement” of maintenance releases is a good predictor of Software Change Product

Observations Informed by Interviews:

- Many programs did not track actual costs in detail
- There is a lack of standardized processes across the SECs/PEOs
- Delayed retirement of legacy systems generates resource/overhead burden
- Multiple funding streams limit total system cost traceability

