Improving Software Cost and Schedule Estimating Within the FAA

Federal Aviation Administration

2009 Joint International Annual Conference

Society of Parametric Analysts (ISPA) /

Society of Cost Estimating & Analysis (SCEA)

William Barfield

BAE SYSTEMS

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- Background
- The Problem
- FAA Progress to Date
- Next Steps
- Questions, Comments

FAA Mission

- **Provide the safest, most efficient aerospace system in the world**
- **Major FAA roles:**
  - Developing and operating a system of air traffic control and navigation for both civil and military aircraft
  - Regulating civil aviation to promote safety
  - Researching and developing the National Airspace System and civil aeronautics
  - **See also** ***http://www.faa.gov/about/mission/***

Air Traffic Organization (ATO)

Finance Services (AJF)

- Provides business consulting, products and services that promote the achievement of ATO performance goals, cost efficient operations, and FAA leadership in global aviation

Investment Planning & Analysis (IP&A)

- Ensures that new, proposed, and existing National Airspace System (NAS) investments meet established business case and economic criteria, including schedule and risk assessments
- Validates the business justification of NAS programs
- Ensures business case and investment analysis policies, procedures, standards and training are established and maintained and utilized

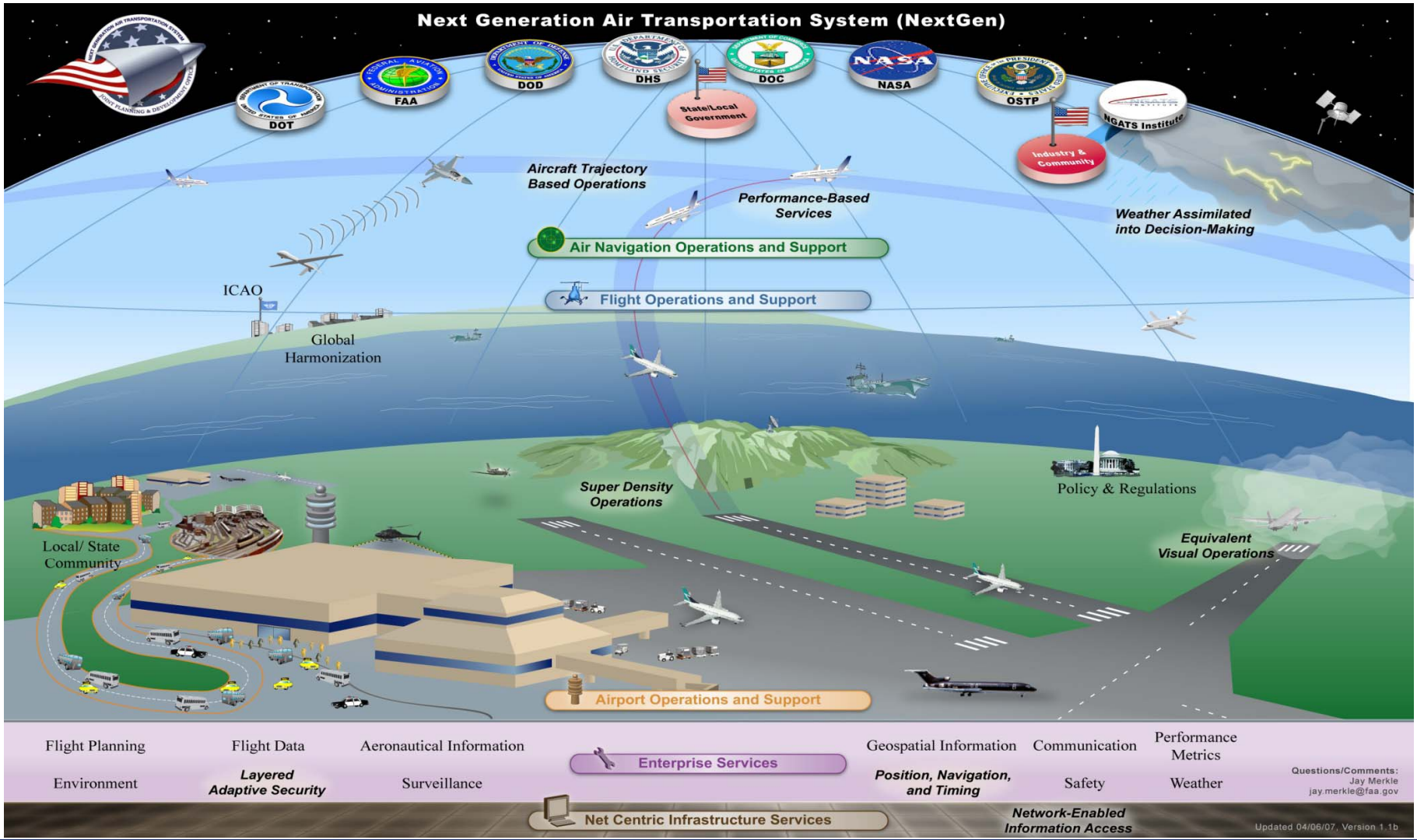
SETA-II

- BAE Systems is Prime Contractor with several subcontractors
- Contract - Provide a variety of systems engineering, project management, and information technology support services to the FAA Air Traffic Organization
- Subtask - Provide expertise and objective business case analysis for FAA investment decisions that support the optimal evolution of the National Airspace System (NAS)
- Focus - Develop products to support the definition, development, and implementation of Next Generation Air Transportation System (NextGen) as required to meet increasing air traffic demands

NextGen

- Existing NAS architecture is approaching its limit to accommodate significant growth in air traffic
- NextGen will implement re-engineer concepts, systems, technologies, roles and responsibilities for guiding the nation's air traffic system
- NextGen will address existing and evolving Safety, Environment, and Security requirements
- Reference
  - http://nextgen.faa.gov/
  - http://www.faa.gov/regulations.policies/reauthorization/

NextGen Overview



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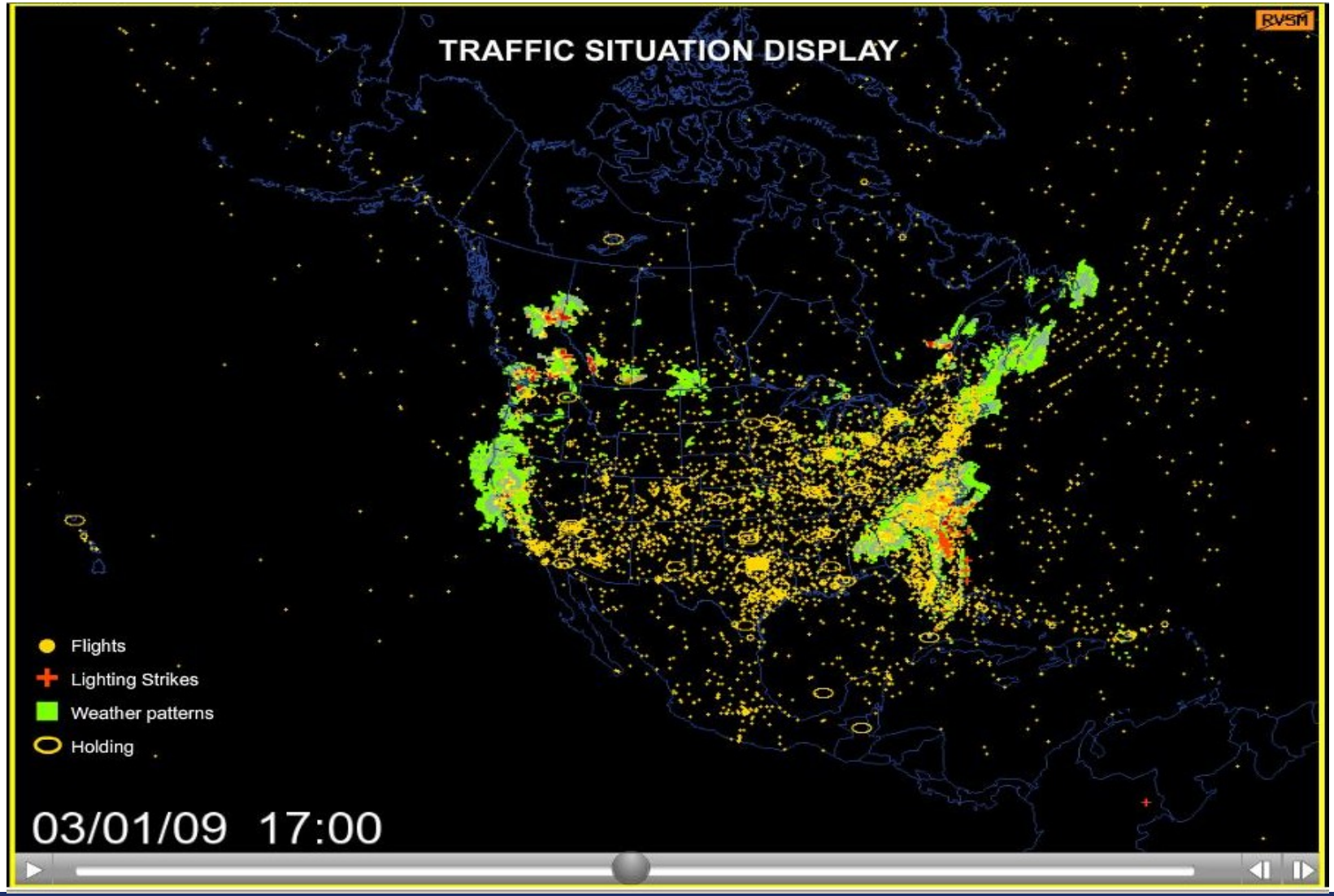
The Problem


TRAFFIC SITUATION DISPLAY
RVSM
Flights
Lighting Strikes
Weather patterns
Holding
03/01/09 17:00

The Problem

- **AJF recognizes the need to improve software cost and schedule estimating policies, procedures, standards and training**
- **Upcoming demands on AJF IP&A require near-term analysis of several NextGen-related programs involving significant software development and maintenance effort**
- **Therefore IP&A established Software Working Group to:**
  1. **Update En-Route Automation Modernization (ERAM) 2003 SEER-SEM cost estimate & compare to 2009 actuals; use as basis for a future calibrated FAA SEER cost model**
  2. **Develop Software Development Cost Estimating Relationships (CERs)**
  3. **Develop FAA Software Cost Estimating Guide**
  4. **Expand/Validate Pocket Estimating Guide (PEG) that provides 24 cost factors to support the development of Life Cycle Cost Estimates (LCCEs) early in a program's life cycle**

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Status of Tasks 1 and 2

1. **ERAM SEER Estimate Update:**
   - **ERAM actuals data collected**
   - **2003 SEER cost model verified**
   - **Analyzing actuals and their most efficient use to validate of predicted costs**
   - **No results yet to report**

2. **SW Development CERs**
   - **Identified data sources**
   - **Collected and normalized data**
   - **Received EVM data on four major programs**
   - **Developed candidate independent variables and hypotheses of their relationships to dependent variables**
   - **Developed the Beta distribution**

Status of Tasks 3 and 4

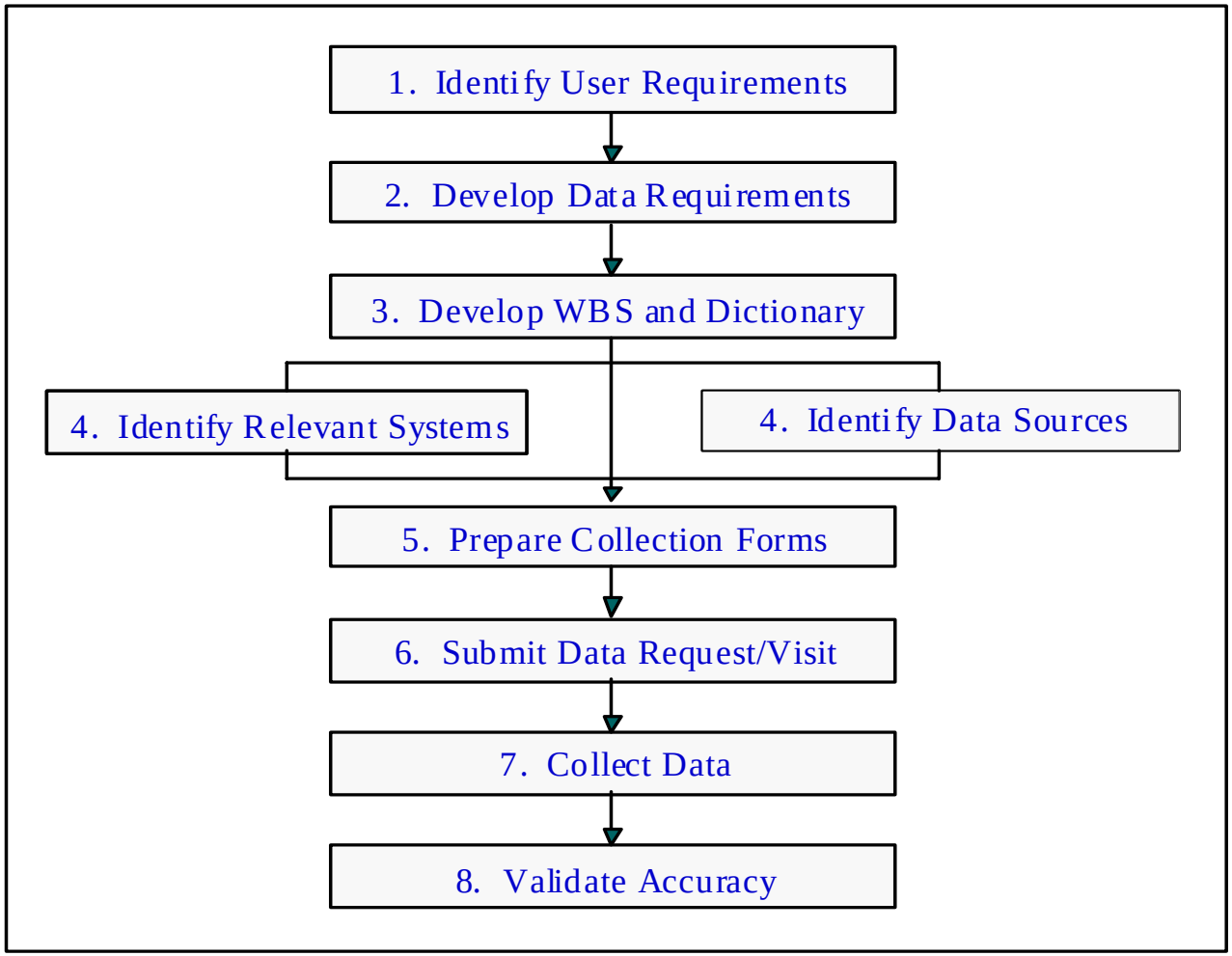
3. SW Cost Estimating Guide

- Identified and reviewing six other related cost guides
  1. *Refining Software Development Estimating Techniques*, FAA, Jan. 03
  2. *The Morass of Software Costing*, Stephen A. Book, MCR, LLC. Nov. 01
  3. *Software Cost and Productivity Model*, The Aerospace Corporation, March 2004
  4. *Cost Estimating Relationships (CERs) For Software Development*, Space And Missile Systems Center, Air Force Materiel Command, May 1996
  5. *Software Assessments, Benchmarks, and Best Practices*, Capers Jones
  6. *Function Point Analysis: Measurement Practices for Successful Software Projects*, Garmus and Herron, 2001
- Summarizing independent and dependent variables in each guide

4. Expand/Validate PEG

- Identified data sources
- Collected and normalized data
- Received EVM data on four major programs
- Developed draft Systems Engineering CER

All Tasks: Data Collection Process



All Tasks: Data Sources

1. Resource Planning Documents (RPDs) - provides cost data by WBS and FY as well as detailed technical and programmatic data
2. Earned Value Management (EVM) – reported by Program Offices
3. Joint Resources Council/Chief Information Officer – a compilation of Program information
4. AJF/IP&A Internal – corporate history of investment analysis information archived on Knowledge Sharing Network
5. CM Document Control Center – FAA Program configuration management archive
6. RIMS/Mathtech - database of final life cycle cost estimates
7. FAA Contracts Office – source of contracts and modifications
8. Exhibit 300s – from Dept of Transportation and Program Offices

Tasks 2 and 4: Initial Targeted Programs for Data

1. Airport Surface Detection Equipment - Model X (ASDE-X)
2. ATC Beacon Interrogator (ATCBI)
3. Advanced Technologies & Oceanic Procedures (ATOP)
4. En Route Automation Management (ERAM)
5. Standard Terminal Automation Replacement System (STARS)

Tasks 2 and 4: EVM Data

- Making great progress on collecting EVM Data due to recent FAA AMS changes
  1. **DTFAWA**
  2. **SASO**
  3. **SBS**
  4. **ASWON**
- Data provided in responses to technical and programmatic questions has been difficult to normalize
- This study is first analysis of the new actual performance data from EVM data that the FAA has begun collecting

Tasks 2 and 4: Data Criteria

- **Candidate independent variables**
  - **Program Office size (FTEs)**
  - **Systems Engineering size (FTEs)**
  - **Duration between IARD and FID**
  - **Duration between FID and Initial Fielding**
  - **Service Areas (7 in FAA)**
- **Conduct data Normalization to ensure that data set consistent with and comparable to other data**
  - **Cost Units**
  - **Sizing Units**
  - **Key Groupings**
  - **Technology Maturity**
- **Construct models**
  - **Excel: to support data analysis**
  - **Access: to support analogies**
- **A program's data will be used if the program was at least 70% complete and its overall CPI and SPI were each 1.00 +/-10 %.**

Tasks 2 and 4: CER Development Approach

- Develop scatter plots of the data to determine outliers, relationships, and trends.
- Determine dependent variables
  - Software cost
  - Software schedule
- Determine candidate independent variables
  - Identify variables that can reasonably be estimated early in program life cycle
  - Avoid using SLOC to estimate cost & schedule
  - Use of REES to calibrate the early-estimated variables to actual SLOC
  - Results from correlating domains (7), PM Staff Size, Decision Duration
- Develop hypotheses relating independent to dependent variables
- Transform data to enable development of non-linear CERs.
- Calculate descriptive statistics to characterize and describe the data
- Calculate the mean, standard deviation, and coefficient of variation
- Evaluate residuals and outliers
- Document the results

Tasks 2 and 4:
Some Statistical Analysis Tools for Future Use

Statistics Tool	Version	Strengths					Source
		Excel compatible	Graphing function	Non-Linear Regression	Hypothesis Testing	Cluster analysis	
Microsoft Excel	2003	X	X	X			http://office.microsoft.com/en-us/excel/default.aspx
EZ Analyze	3.0	X	X	X			http://www.ezanalyze.com/products.htm
KADDStat	5	X	X	X	X	X	http://he-cda.wiley.com/WileyCDA/HigherEdTitle/productCd-0471239836.html
MACANOVA	5.05	X	X		X		http://en.freestatistics.info/stat.php
MICROSIRIS	9.2	X	X		X	X	http://en.freestatistics.info/stat.php
OpenStat	1.27.08	X	X	X	X		http://www.statpages.org/miller/openstat/
Decision Visualizer	1.0		X		X		http://www.brightstat.com/

Findings - Task 3:
Software Guide Update (in progress)

	Varibles Used in Other Guides					
	A	B	C	D	E	F
Dependent Variables						
DV1						
DV2						
DV3						
DV4						
DV5						
DV6						
DV7						
DV8						
DV9						
DV10						
Independent Variables						
IV1						
IV2						
IV3						
IV4						
IV5						
IV6						
IV7						
IV8						
IV9						
IV10						

A. ***Refining Software Development Estimating Techniques***, **FAA, Jan. 03**

B. ***The Morass of Software Costing***, **Stephen A. Book, MCR, LLC. Nov. 01**

C. ***Software Cost and Productivity Model***, **The Aerospace Corporation, March 2004**

D. ***CERs For Software Development***, **Space And Missile Systems Center Air Force Materiel Command, May 1996**

E. ***Software Assessments, Benchmarks, and Best Practices***, **Capers Jones**

F. ***Function Point Analysis: Measurement Practices for Successful Software Projects***, **Garmus and Herron**

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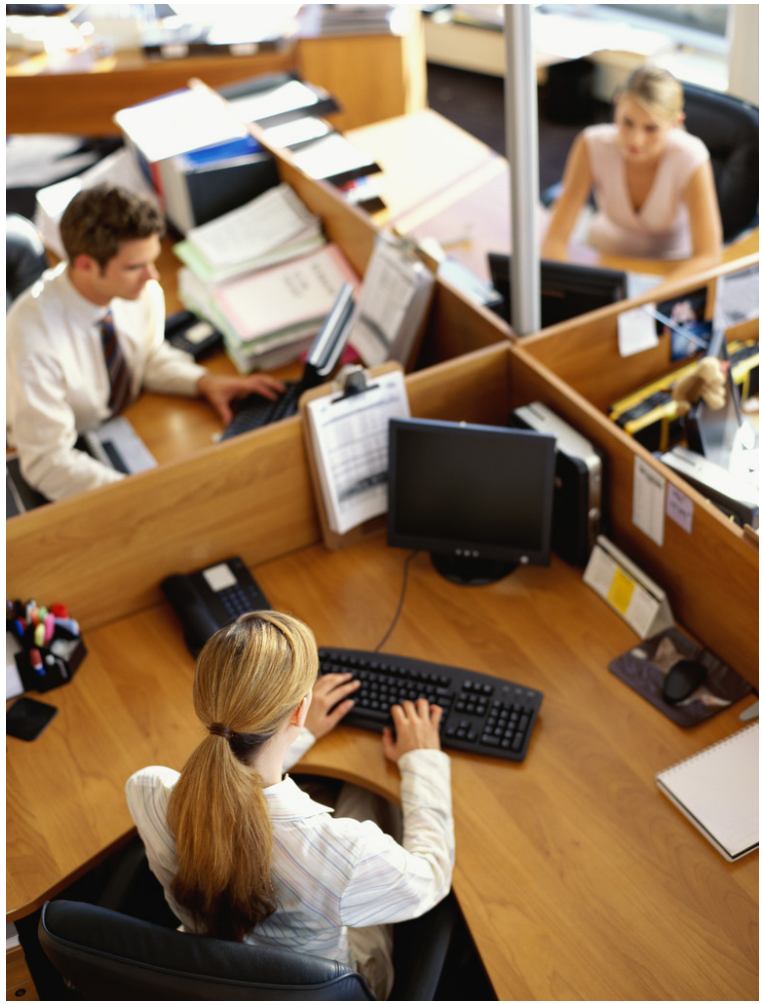

Next Steps

- Maintain and expand existing data base
- Develop statistical relationships for other dependent variables (WBS Elements)
- Refine existing statistical relationships
- Develop spreadsheet implementation of CERs and Cost Factors

- Acknowledgements
  - Scott M. Allard MCR
  - Gia Grady FAA
  - Stacey Appel FAA
  - Al Clark Galorath
  - Michael Paul Cobec Consulting

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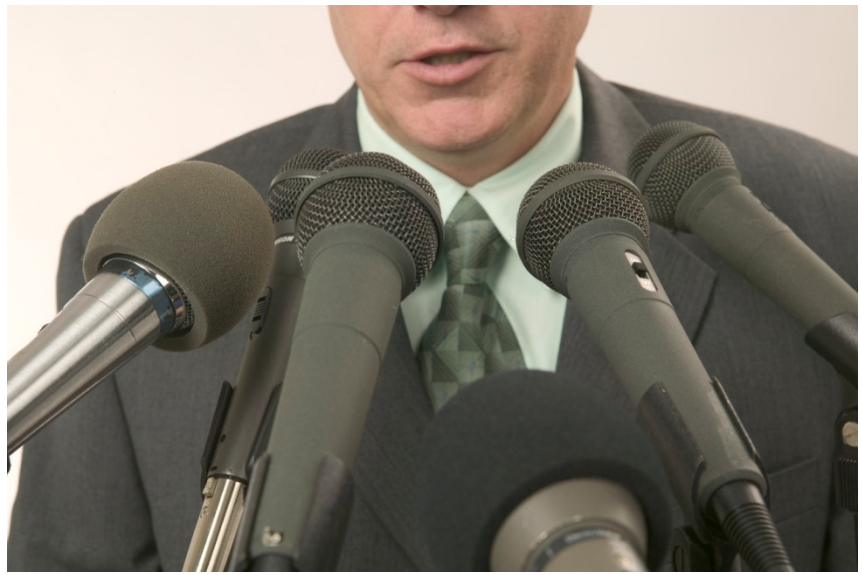

Backup - FAA Terms

1.	AJF	Senior Vice President, Finance
2.	ATO	Air Traffic Organization
3.	CER	Cost Estimate Relationship
4.	CM	Configuration Management
5.	DCC	FAA Configuration Management Document Control Center
6.	EVM	Earned Value Management
7.	Ex 300	OMB Exhibit 300
8.	FID	JRC milestone Final Investment Decision
9.	IARD	JRC milestone Investment Analysis / Readiness Decision
10.	ICAO	International Civil Aviation Organization
11.	IID	JRC milestone Initial Investment Decision
12.	IP&A	AJF Investment Planning & Analysis Branch
13.	JRC	Joint Resources Council
14.	NextGen	Next Generation Air Traffic Control System
15.	NAS	National Airspace System, (FAA Activities that support Operational Air Traffic Services)
16.	RIMS	Resources Information Management System
17.	RPD	Resources Planning Document
18.	SETA-II	Systems Engineering and Technical Assistance (contract)

Backup - FAA Programs

1.	ADS-B	Automatic Dependent Surveillance-Broadcast
2.	ASDE-X	Airport Surface Detection Equipment - Model X
3.	ASKME	Aviation Safety Knowledge Management Environment
4.	ASR-8	Airport Surveillance Radar Model 8
5.	ASR-11	Airport Surveillance Radar Model 11
6.	ASWON	Aviation Surface Weather Observation Network
7.	ATC-BI-6	Air Traffic Control Beacon Interrogator Model 6
8.	CARTS	Common ARTS (Automated Radar Terminal System)
9.	CATMT	Collaborative Air Traffic Management Technologies
10.	CIWS	Corridor Integrated Weather System
11.	ERAM	En Route Automation Modernization
12.	IFPA	Instrument Flight Procedures Automation
13.	ITWS	Integrated Terminal Weather System
14.	NNEW	NextGen Network-Enabled Weather
15.	SASO	System Approach for Safety Oversight
16.	SBS	Surveillance and Broadcast Services
17.	STARS	Standard Terminal Automation Replacement System
18.	TFM	Traffic Flow Management
19.	TMA	Traffic Management Advisor (now CTAS-En Route)
20.	URET	User Request Evaluation Tool
21.	WAAS	Wide Area Augmentation System
22.	WARP	Weather and Radar Processor (ARTCC)