2015 ICEAA Conference & Training

Workshop Practitioner Track
CEA 02 - Technical Baselines

Jason Dechoretz
Jdechoretz@mcri.com

Sam Toas
Samuel.Toas@ngc.com

Paul Tetrault
paul.tetrault@mda.mil

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Introduction

- Course objective is to answer:
  - What is a technical baseline?
  - Why is the technical baseline important?
  - How is a technical baseline created?
  - How do we Assess the reasonableness of a proposed baseline
  - How is a technical baseline used to create a credible estimate?

What is a Technical Baseline?

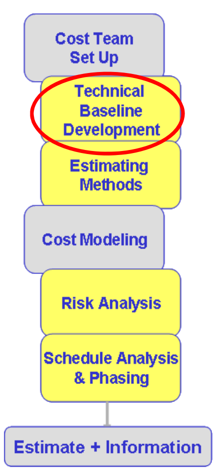
- Working definition:
  - Provides clear definition of the project's scope and the selected technical approach
  - Captures the results of the engineering effort which converted the functional objectives and requirements of the project into clear technical specifications
  - Contains significant technical milestones such as completion of scope required to meet performance objectives and/or stakeholder commitments
- Working COST definition:
  - A description of a program in sufficient detail to enable a credible cost estimate

What is a Technical Baseline? (2)

- For major Programs (e.g., ACAT I) …
  - Cost Analysis Requirements Description (CARD)
  - Intelligence Capability Baseline Description (ICBD)
  - NASA's Cost Analysis Data Requirements (CADRe)
  - Homeland Security's Cost Estimating Baseline Document (CEBD)
- At minimum it will include…
  - Program description (including performance requirements & a *DoD MIL-STD compliant* WBS)
  - Resource listing (hardware, software, personnel, etc.)
  - Operational concept depiction
  - External dependency explanation
  - Acquisition milestone identification

CARD Outline is an Ideal Starting Point for Creating a Technical Baseline

Generic Cost Estimating Process
Highlights Tech Baseline Assessment



- Establishment of realistic Technical Baseline is most critical part of the estimating process
- Historical cost growth studies of DoD systems have concluded that much of the cost growth in a program is due to initial design being inadequate to meet intended requirements
- Technical assessment of the baseline is often overlooked in the estimating process
- Independent assessment of estimating inputs can uncover risks in the Point Design

Tech Baseline: Common Standards

- CARD is required for DoD ACAT I MDAP (Programs at MS B, MS C, and FRP and MAIS (for MS B EA, FRP EA)
  - Instructions for format and content provided in DoD 5000.4M (released in 1992, updated in 2007 for CSDR)
  - CARD is generated by the Program Office, reviewed by Service cost center, and deemed "cost-able" by OSD CAPE
  - Service cost centers typically require CARDs for ACAT II Programs for CCAs (AFI 65-508, SECNAVINST 5000.2B, Army Cost Manual)
- ICBD is required for Programs undergoing Independent Cost Estimate by Intelligence Community CAIG
  - Required for all Major Systems by IC Policy Guidance (ICPG) 105.1
  - Guidance document released Sept 2002 and updated in 2011
  - ICBD is generated by the Programs Office

Common Standards (2)

- NASA Procedural Requirement (NPR) 7120.5 requires technical baseline for Non-Advocate Reviews (NARs)
  - Guidance document (rev. E) released Aug 2012
  - Development Process
    - Program Manager is responsible for providing required data
    - NASA Cost Analysis Division prepares and delivers draft CADRe 60 days after data collection
    - Program Manager approves final CADRe
    - CADRe entered into Once NASA Cost Engineering (ONCE)
- No specific format used by FAA
  - Program requirements document drafted for Joint Resource Council 2a (JRC-2a) review and finalized for JRC-2b
  - Developed by system engineering and Program offices

Common Standards (3)

- Conceptual Design Report used for major DOE Programs (DOE Estimating Guide 413.3-2; Feb 2011)
  - Developed for CD-1: Clear and concise description of the alternatives Scope required to satisfy the Program mission requirements;
    - Project feasibility;
    - Attainment of specified performance levels (KPPs);
    - Assessment of project risks and identification of appropriate risk handling strategies;
    - Reliable cost and schedule range estimates for the alternatives considered;
    - Project criteria and design parameters;
    - Impact on the site Sustainability Plan; and
    - Identification of requirements and features.
  - Updated and converted into the Program Execution Plan (PEP)

Common Standards (4)

- Department of Homeland Security uses Cost Estimating Baseline Document (CEBD) for its Programs
  - Required by DHS Acquisition Instruction #102-02-001 (Oct 2011) for all DHS Level 1 (LLC > $1B) and 2 (LLC >$300M) programs, recommended for DHS Level 3
  - Overview
    - Single document provides a common definition of the Program from which all Life Cycle Cost Estimates (LCCEs) are developed
    - Program Office generates the CEBD, Program Manager approves it (180 days prior to MS), and Homeland Security Program Accountability and Risk Management (PARM) Cost Estimating Center of Excellence reviews it (within 20 days of receipt), PM signs final CEBD (90 day prior to MS)
    - Must contain information on all life cycle phases and elements as well as incremental and spiral development plans, and identify levels of risk for them

DoD CARD

- Acquisition Program office prepares CARD
  - Describes main features of Program
  - Used as basis for cost estimating
  - Provided to OSD CAPE (formerly the CAIG), Defense Acquisition Board for review
  - *Updated* throughout acquisition process, level of detail depends on Program maturity
    - Frequently just used to support Program Milestones
    - Does not serve as historical record of Program
  - Included as documentation in Program Office Estimate (POE) and Component Cost Analysis (CCA) estimates

DoD CARD Outline

- System Technical Description
  - Key Performance Parameters (KPPs)
  - Physical and functional design
- Work Breakdown Structure (WBS)
- Predecessor System Description
  - Reasons for replacement
- Staffing Requirements
  - Number, grade, skill sets of personnel
- Risk
  - Drivers, planned mitigations
- Operational Concept
  - How and where operated
- Deployment [plans]
- Logistics Support Concept
  - Maintenance and sparing plan
- Training
  - User and maintenance training
- Acquisition Schedule
- Acquisition Strategy
  - Contracting plan
  - Development approach
- System Test and Evaluation (ST&E)
  - Number, type of tests
  - Availability of test resources
- Environmental Impact Analysis
- Track to Prior CARD

Why Should An Organization Have A Common Standard?

- Similarities of the common standards
  - Collection of all the data necessary to complete a LCCE
    - Technical description
    - Programmatic information
    - Schedule details
  - Snapshot of the Program
- Purpose is to improve the quality of the cost estimate
  - Accuracy: reflects Program requirements
  - Comprehensiveness: describes the Program work scope
  - Replicability and Auditability: system specification is completed
  - Traceability: WBS is defined, source documents identified, and legacy Program described

What If A Common Standard Were Not Required?

- Phew! That sounds like a lot of work and we don't have a lot of time. Let's just go estimate…
  - Not so fast!
  - Your estimate still needs to be based on a system description
- What is the minimum?
  - Program description (including performance requirements & defined WBS)
  - Acquisition milestone identification
  - Resource listing (hardware, software, personnel, etc.)
  - Operational concept depiction
  - External dependency explanation

Minimum Information Required
For Program Description

- Listing of KPPs
  - What are they?
  - How will they be achieved?
- Block diagram of system/Program
  - Identify preferred configuration if alternatives are still being evaluated
  - Describe major elements
  - Define interrelationships of major elements
- Reliability projections
- Security requirements
- WBS with definitions

Minimum Information Required
for Resource Listing

- Description of subsystems and components
  - Physical configuration (weight, material type, SLOC, language type)
  - Performance characteristics (power, processing speed, maximum number of simultaneous users)
  - Operational characteristics (design life)
  - Limitations (operating temperature, vibration)
  - Expected condition: developed, COTS, GFI
- Testing facilities and equipment

Minimum Information Required
For Other Categories

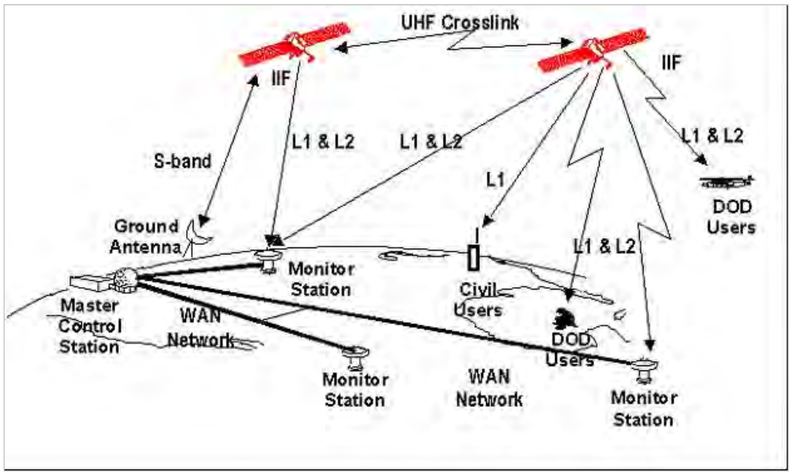
- Operational Concept
  - Program management plans
  - Operating locations (geographical and/or host Programs)
  - Manpower requirements (quantity, skill sets, grades)
- External Dependency Explanation
  - Technology transfers
  - Information (data) flow
  - Physical integration
- Acquisition Milestone Identification
  - Development events (Preliminary Design Review, Critical Design Review, etc.)
  - Fielding events (Initial Operational Capability, Full Operational Capability)

Data Collection For Technical Baseline –
Examples Of Official Data Documents

- Capability Development Description (CDD)
  - Was: Operational Requirements Document (ORD)
- System Engineering Plan (SEP)
  - Was: System Engineering Management Plan (SEMP)
- Test & Evaluation Management Plan (TEMP)
- Contract & Proposals
- Integrated Master Plan/Schedule (IMP/IMS)
- Program Review Briefings
- Acquisition Decision Memorandum (ADM)
- Acquisition Program Baseline (APM)
- CCDR Database, consisting of …
  - Historical CARDs, ORDs, TEMPs
  - System descriptions

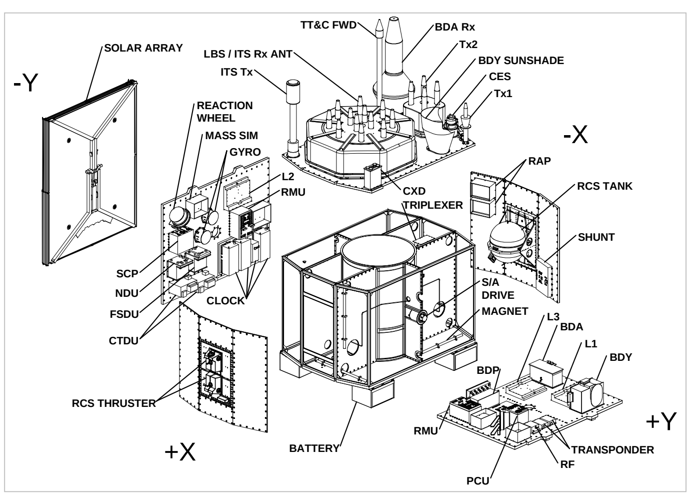
Data Collection For A Technical Baseline –
Examples From Official Data Documents

GPS Architecture Concept



Diagrams (2)

GPS Satellite Schematic



Description of Hardware

- Why show different types of weight?
- Which one to use for a cost estimate?
- Are any of these weight estimates correct?

Subsystem/Components *Satellite Notional Weights*	Baseline Weight, lbs	New Architecture		
		Weight, lbs	Design Margin Weight, lbs	Total w/ Margin, lbs
Spacecraft Processor (SCP)	30.4	31.4	0.0	31.0
Telemetry Tracking and Control (TT&C)	92.2	98.3	5.9	104.2
ADCS	93.9	100.1	0.8	100.9
Reaction Control System (RCS)	94.4	126.1	5.4	131.5
Electrical Power (EPS)	642.9	780	130	910
Thermal Control (TCS)	77.8	80.3	11.6	91.9

Data Collection For Technical Baseline – Subject Matter Experts (SMEs)

- Who are they?
  - Program manager(s)
  - System engineers
  - Program control or finance analysts
  - Test & evaluation analysts
  - Logistics analysts
- Will they just give me what I need?
  - No!
  - You must prepare a read ahead package
    - Introductory memo that defines purpose and required data
    - Partially completed interview form using available documented data
    - Letter of support from Program management
    - Suggest that support staff and contractors (as appropriate) participate

Questions to Ask the Experts

- "I found this architecture block diagram in the PDR briefings. Does it still represent the objective system?"
  - "These are portions you are responsible for, right?
  - "Do you have a detailed description already prepared that even a cost analyst can understand?"
- "I know we have not completed the development of this Program yet, but logistics is important to consider at the beginning of the project."
  - "What type and quantity of spares will be required?"
  - "Will there be a dedicated depot?"
- "The data mining CSCI is described in the software architecture document, but no size is provided. How many lines of code do you think will be required?"
  - "What is conservative number?"
  - "What is a more optimistic number?"
  - "Did you derive this information from past experience?"

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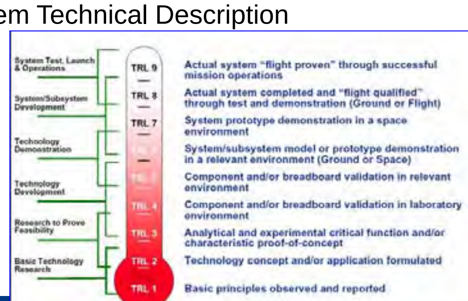
Example of a Specific Question to Ask the Experts

- Can you rate the maturity level of the system/subsystem/component? Please use these levels.
  - While initially defined by NASA, they have been successfully used outside of NASA for a wide variety of aircraft, armored, electronic, and ship systems
  - If you are using another system/subsystem/component as a proxy for the assessment please describe that item for me
  - Include this in the System Technical Description



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Packaging the Technical Baseline

- Cross reference vs. stand-alone document
  - Cross reference
    - Pro: Quicker and easier to build
    - Con: Suffers from configuration control limitations and is harder to use
  - Stand-alone
    - Pro: Meets CARD/ICBD/CEBD/CADRe requirement
    - Pro: Serves as both a historical record and a living document
    - Con: Can represent a very large file!
- For the Technical Baseline document (as for all other documents), always formalize its date and version number

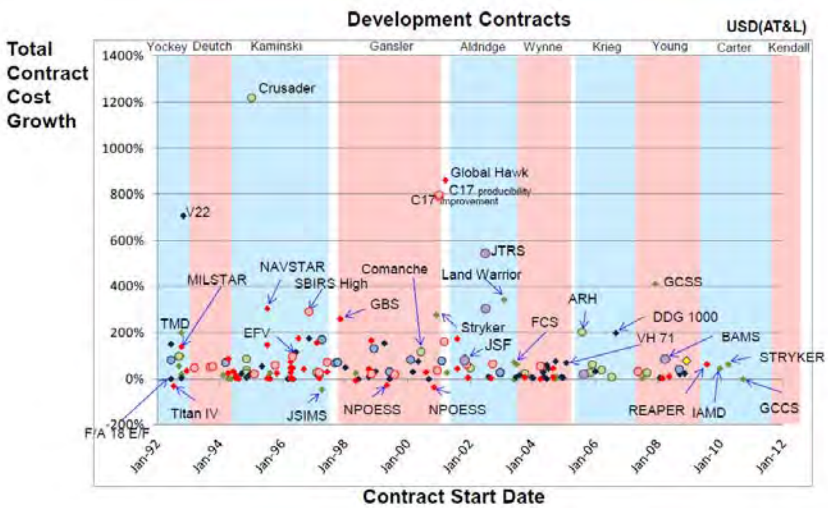
How Long Should It Take To Develop?

- Like everything in cost analysis, it depends!
- How much of the required data are readily available?
  - Existing documents (electronic vs. hardcopy)
  - Outdated, but still relevant, technical baseline
  - Availability and willingness of SMEs to participate
- When will key program events occur to generate any missing necessary data?
  - Preliminary design review or Critical Design Review
  - Contract award

If a Formal Technical Baseline Is Required (CARD, ICBD, CEBD), Do Not Forget Mandatory Lead Times!

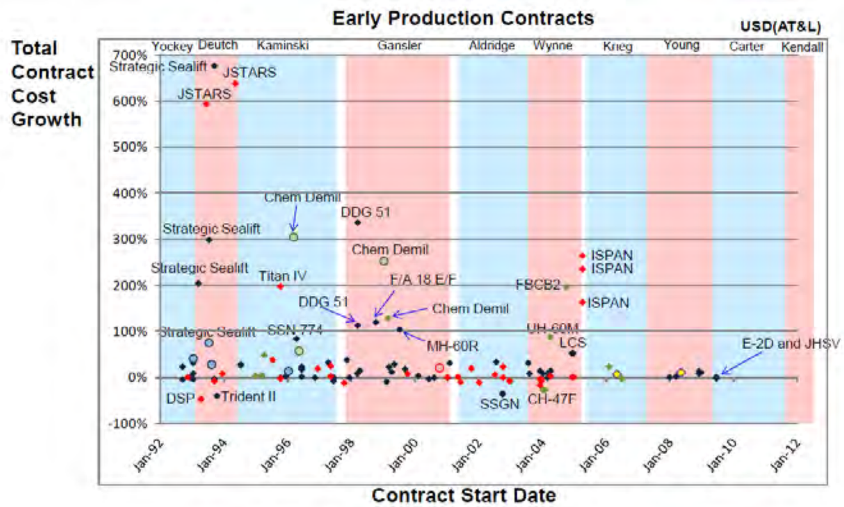
TECHNICAL BASELINE ASSESSMENTS

DoD Cost Growth
Development Contracts



Source: 2013 Annual Report - Performance of Defense Acquisition System.
http://www.defense.gov/pubs/PerformanceoftheDefenseAcquisitionSystem-2013AnnualReport.pdf

DoD Cost Growth
Production Contracts

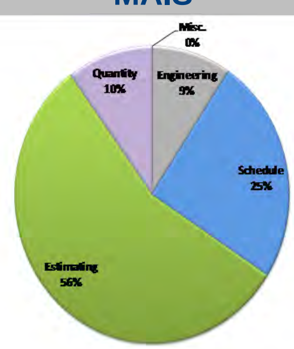


Source: 2013 Annual Report - Performance of Defense Acquisition System.
http://www.defense.gov/pubs/PerformanceoftheDefenseAcquisitionSystem-2013AnnualReport.pdf

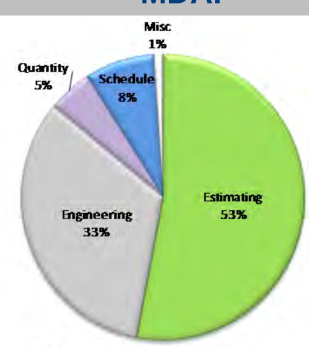
Contributors to Cost Growth
DoD Systems

40-45% of Cost Growth is attributed to Technical Baseline*

MAIS



MDAP



"Straight SAR" Data

MDAP Source: "Current Issues in Air Force Acquisition Cost Analysis ", Richard Hartley, 28 May 2009
MAIS Source: "Building CERs and SERs for Enterprise Resource Planning", Wilson Rosa, 9 June 2011
*Technical Baseline = engineering, quantity, and schedule

PARCA Root Cause Analysis – Summary

Table 2-3. PARCA Root Causes Analyses (Statutory and Discretionary; 2010–2012).

	Dominant
10 of 18 (56%)	Poor management performance • Systems engineering • Contractual incentives • Risk management • Situational awareness
5 of 18 (28%)	Baseline cost and schedule estimates • Framing assumptions
4 of 18 (22%)	Change in procurement quantity
	Infrequent
1 of 18	Immature technology, excessive manufacturing, or integration risk
2 of 18	Unrealistic performance expectations
1 of 18	Unanticipated design, engineering, manufacturing or technology issues
None	Funding inadequacy or instability

PARCA Root Cause Analysis
Management effectiveness

Poor Management Effectiveness. The broad category of *poor management effectiveness* was a root cause in just over half of the cases. Problem areas included:

- **Poor systems engineering to translate user requirements into testable specifications.** This includes the flow down of requirements, interface/environmental management, and management of holistic performance attributes such as reliability or weight. These largely are systems engineering functions.
- **Ineffective use of contractual incentives.** This includes whether the acquisition strategy selected satisfies the conditions necessary for its success, whether it is consistent with corporate environment (including long- and short-term objectives), whether it is aligned with program goals, whether there are perverse effects, and whether it was enforced.
- **Poor risk management.** This includes the identification, quantification, evaluation, and mitigation of risks.
- **Poor situational awareness.** Deficiencies have been identified in program office, contractor, and oversight awareness, and the timeliness and effectiveness of responses, related to the cost, schedule, and technical performance of DoD programs.

PARCA Root Cause Analysis
Baseline Estimates

Baseline Cost and Schedule Estimates. Baseline cost and schedule estimates were unrealistic in just over one-fourth of the cases. The primary underlying reason was invalid framing assumptions (Arena et al., 2012; Bliss, 2012b). Framing assumptions are any explicit or implicit assumptions central in shaping cost, schedule, and/or technical performance expectations. A prototypical example of a framing assumption was the original space shuttle processing concept of minimal preparation of the orbiter between launches whereas the actual processing involved extensive facilities and refurbishment (e.g., individual testing of each heat tile). Below are illustrative examples of framing assumptions that may be made on defense systems:

- The design is very similar to the prototype or demonstration design.
- Modular construction will result in significant cost savings.
- Arbitrating joint requirements will be straightforward.
- The satellite bus will have substantial commercial market for the duration of program.

Key responsibility of a cost estimator is to verify the inputs!

PARCA Root Cause Analysis
Infrequent Root Causes

Currently Infrequent Root Causes

Although often cited as common acquisition problems, the following were each found in only one case each (to date):

- Immature technology; excessive manufacturing risk; or excessive integration risk.
- Unrealistic performance expectations.
- Unanticipated design, engineering, manufacturing or technology issues.

Baseline Assumptions are Improving

Why Perform the Technical Baseline Assessment?

- The Technical Baseline Assessment ensures the estimating inputs are realistic "in family" and informs the risk process
- The Point Estimate of the most likely baseline serves as the reference point on which the cost risk analysis is anchored
- It is imperative that we complete reliable cost estimates and this starts with an accurate and reliable baseline

- Questions you should ask yourself
  - Is the SLOC input reasonable given system requirements?
  - Is the mass / power input reasonable given the stated performance?
  - Is the heritage assumption reasonable given current system design and analogy definition?
  - Is the Schedule reasonable as compared to analogous systems?

TECHNICAL BASELINE ASSESSMENT: SOFTWARE

Software Code Growth

- Software Baselines grow
- Many studies performed by various organizations
  - USAF/ASC – 100% growth circa 1996
  - OSD CAIG – 43% growth from government size estimate
  - NCAD – 22% growth
  - CAIG – CEC study 64% growth
  - NASA study post CDR – 40% growth
  - CAIG Crusader report – 74% growth
  - IDA analysis – 43% growth

Source: "Calibrating Software Code Growth", M.Popp, 2006 DoDCAS

Technical and Programmatic Baseline

Software Assessment Checklist

1. Is the baseline sizing input to meet objective requirements reasonable when compared to historical benchmarks?
   - ❑ Is the baseline software size (i.e., SLOC) reasonable
   - ❑ Is the baseline size reported by CSCIs
   - ❑ Is the baseline size allocated by deliverables (e.g. builds, increments)
   - ❑ Are CSCIs reported by size type: new, modified, reused, generated, COTS
2. Has growth been applied to account for anticipated downstream changes?
   - ❑ Has growth been added to baseline size; does it make sense; has it been derived from analogous programs
3. Is baseline heritage reasonable compared to legacy systems and current state of technology?
   - ❑ Is the software reuse plan realistic; has reuse source been identified along with actual code count; has it been validated by qualified expert
   - ❑ Does the re-design scope (DM%, CM%, IM%) for reuse code make sense; when independently estimated or compared to historic benchmark?
4. Has the complexity and integration risks been reasonably determined?
   - ❑ Are software and hardware interdependencies planned in a logical manner?
   - ❑ Has the complexity been determined for each CSCI
5. Is the planned schedule consistent with analogous programs and does this schedule account for normal schedule challenges?

1. Is the baseline size reasonable; when compared to historic benchmarks

- How We Do It
  - Compare Baseline Size to Historic Benchmarks
  - Historic Benchmark must have similar attributes:
    - Same Operating Environment (e.g. aircraft)
    - Same Mission (e.g. Fire Control)
    - Same Productivity Type (e.g. sensor control and processing)
  - If Baseline is within Historic Benchmarks then it is deemed reasonable… Else, select the most analogous or mean value from dataset as your new Baseline…
- Example
  - The following example shows how to select appropriate benchmarks to assess reasonableness

Example (page 1 of 3)

- Background
  - You are asked to assess the software baseline size for an aircraft subsystem
  - The software characteristics are as follows:
    - Baseline Size: 235,000 SLOC
    - Platform: Manned Aerial Vehicle
    - Subsystem: Avionics
    - Sub-subsystem: Communication/Identification
    - Productivity Type: sensor control and procession
    - Technology: Active Electronically Scanned Array

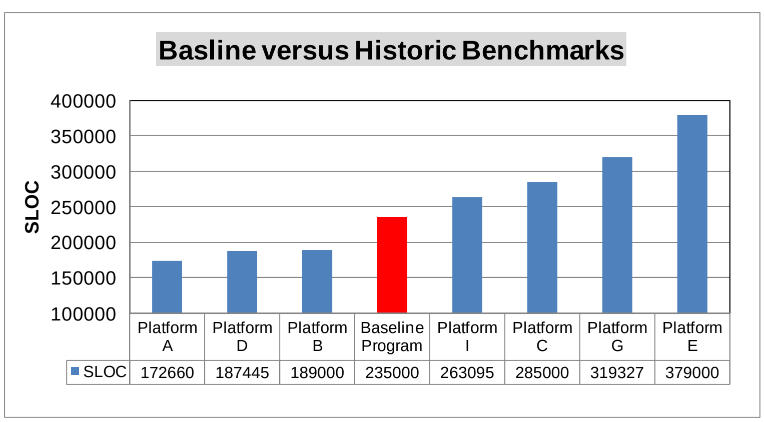
Example (page 2 of 3)

- Process
  - Select Historic Benchmarks with similar attributes.
  - As shown in Column 8, the seven Platforms labeled
  - "Very High" were chosen on the basis of same mission, same type, and same technology

Platform	Radar	Operating Environment	Mission	Type	Technology	SLOC	Similarity
Platform A	Radar 1	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	AESA	172660	Very High
Platform B	Radar 2	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	AESA	189000	Very High
Platform C	Radar 3	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	AESA	285000	Very High
Platform D	Radar 4	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	AESA	187445	Very High
Platform E	Radar 5	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	AESA	379000	Very High
Platform F	Radar 6	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	OTHER	196000	High
Platform G	Radar 7	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	AESA	319327	Very High
Platform H	Radar 8	Manned Aerial Vehicle	Suveillance	Sensor Control & Processing	OTHER	800000	Low
Platform I	Radar 9	Manned Aerial Vehicle	Fire Control	Sensor Control & Processing	AESA	263095	Very High
Platform J	Radar 10	Manned Aerial Vehicle	Suveillance	Sensor Control & Processing	OTHER	585536	Low
Platform K	Radar 11	Manned Aerial Vehicle	Suveillance	Sensor Control & Processing	OTHER	347808	Low
Platform L	Radar 12	Manned Aerial Vehicle	Suveillance	Sensor Control & Processing	OTHER	535000	Low

Example (page 3 of 3)

- Result
  - As shown below, the Baseline Size is within Historic Benchmarks. Thus, it is reasonable…



TECHNICAL BASELINE ASSESSMENT: MASS & HERITAGE

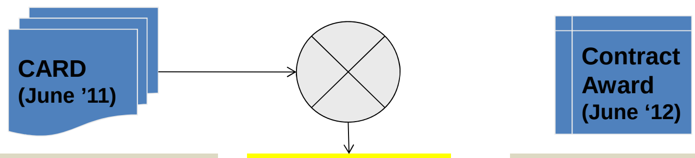
Geared towards Satellite estimate, but applicable to any mass driven cost estimates

Technical and Programmatic Baseline

Hardware Assessment Checklist

1. Is the baseline sizing input to meet objective requirements reasonable when compared to historical benchmarks?
   - ❑ Size, weight, and power parameters consistent with historical norms?
2. Has growth been applied to account for anticipated downstream changes?
   - ❑ Weight and/or power growth been accounted for in the baseline assessment?
3. Is the baseline heritage input reasonable compared to legacy systems and current state of technology?
   - ❑ Technology Readiness (TRL) and manufacturing readiness (MRL) levels consistent with industry benchmarks?
   - ❑ Heritage assessment considers Engineering Models, Design Reviews, Test Equipment, Supplier readiness, etc.?
4. Has the complexity and integration risks been reasonably determined at various levels of the system?
   - ❑ Program risk assessment (e.g., risk register, risk cube) identify end item, subsystem, and system complexity / integration risks?
   - ❑ Complexity and integration risks consistent with assessment of heritage?
5. Is the planned schedule consistent with analogous programs and does this schedule account for normal schedule challenges?

Technical Baseline Assessment
Notional Example - FireSat



GRA (pre source selection)
- 1000 W (EOL)
- 800 lbs.
- < 10% New

Govt Assessment
- 1100 W (EOL)
- 1200 lbs.
- 60% New

Proposed Solution
- 1150 W (EOL)
- 1100 lbs.
- 30% New

- Govt initially assessed FireSat CARD (pre KDP-B)
  - Concluded Mass was too optimistic for mission type
  - Concluded Heritage was too optimistic
- Without Tech assessment we would have under-estimated the Program cost

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Tech Baseline –
Assessment of Bus Mass

Step 1: Compare FireSat to Analogous Systems and/or Parametric Sizing results

- FireSat EPS similar to IceSat (GaAs array, 28% efficiency, NiH batteries)
- FireSat EOL Power 25% higher than IceSat EOL

Subsystem Mass Comparison	ICESAT CARD	FIRESAT CARD
Bus	**472**	**435**
Structue and Thermal	180	177
Electrical Power	220	170
Attitude Determination Control	21	29
Propulsion	23	28
Telemetry, Tracking, and Control	28	31
Payload	**104**	**117**
Total Space Vehicle	**575**	**552**
EOL Power	**800**	**1,000**

IceSat and FireSat are notional designs

Can FireSat Bus Weigh Less and Still Provide 25% More Power?

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Tech Baseline – Assessment of Bus Mass

Step 2: Adjust mass to be "in family" with analogous data

- Consider orbit, design life, power requirements, technology etc.
- Scale IceSat mass to derive FireSat mass for the Power Subsystem accounting for satellite geometry

	ICESAT CARD	FIRESAT Adjusted
EOL (Watts)	800	1100
EPS Mass (all lbs)	**220**	**274**
Battery	48	66
Solar Array	54	74
Wire harness[1]	91	106
Power Cond & Reg[2]	27	27

1. Harness scaled from square root of power ratio
2. Power conditioning and regulation not scaled

Based on historical data EPS Mass - expected to be 274# vs. CARD mass of 170#

Re-sizing Power Subsystem impacts other subsystems and heritage

Tech Baseline – Assessment of Bus Mass

Step 3: Resize remainder of satellite consistent with engineering relationships to account for derivative impacts

- Payload was adequately sized
- TT&C / C&DH – no change
- More Power = more heat = more thermal control
- More EPS, TC Mass = additional Attitude Control
- More EPS, TC, ACS Mass = more propulsion
- All changes above = more Structure

	FIRESAT CARD	FIRESAT Adjusted
Space Vehicle Total	552	725
Payload Total	117	117
Bus Total	435	608
EPS	170	274
TT&C	31	31
Structure/Thermal	177	234
ADACS	29	35
Propulsion	28	35

Modeling Relationships among Subsystem Mass ensures Design Closes

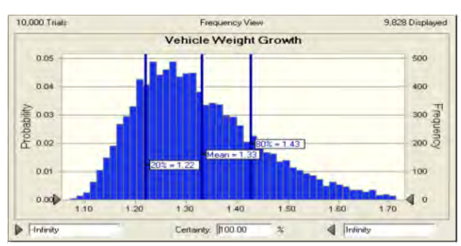
Tech Baseline –
Assessment of Bus Mass

Step 4: Consider Weight growth to account for Program Changes

- Is this example we only corrected the Power Subsystem using historical data
- Other subsystems may still require growth on-top of adjustments made to close design
- The space community has developed models which can size the entire bus based on historical data (minimizes reliance on weight growth)
  - Refer "Creating Tech Baselines for Point Estimates" SCEA 2008

Causes of Mass Changes
Satellite Programs

- Satellite mass grows on average ~33%
- Mass growth (or decrease) occurs for a number of reasons
  - Better Definition
  - Overlooked components
  - Measured vs. Estimated
  - Redesign
  - Updated mass analysis
  - Reduction initiatives
  - Vendor Swap
  - Out of Scope Changes



Our job is not to reduce mass growth but to model what we feel will be the final mass of the system – accounts for changes from the basic SOW

Tech Baseline – Assessment of Bus Mass

Step 5: Cross check the end results with a comparison of mass fractions

Bus Mass Ratios	Program A	Program B	ICESAT	FIRESAT (Adj)
Structure / Thermal	42%	33%	38%	35%
EPS	34%	37%	47%	46%
ADCS	10%	6%	5%	5%
Propulsion	11%	14%	5%	9%
TT&C / C&DH	3%	10%	6%	5%
PL to Bus ratio	21%	42%	35%	32%
STR/TCS to PL Ratio	201%	80%	109%	107%

Mass Fraction analysis ensures nothing went "out of family"

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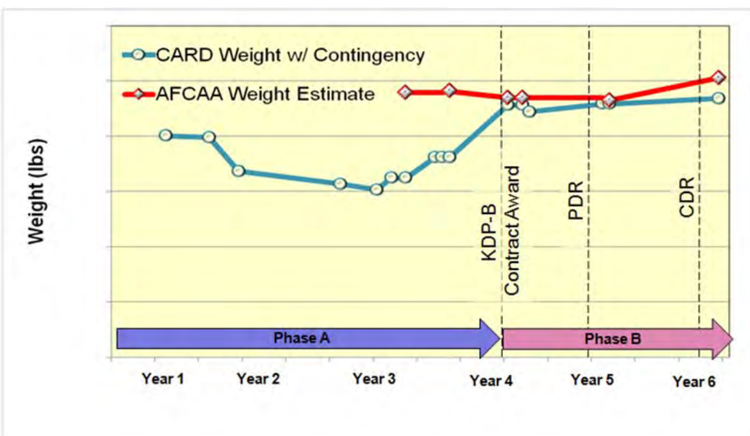
Historical Mass Estimates (Actual Results)



Mass grew over time to match Govt mass estimate

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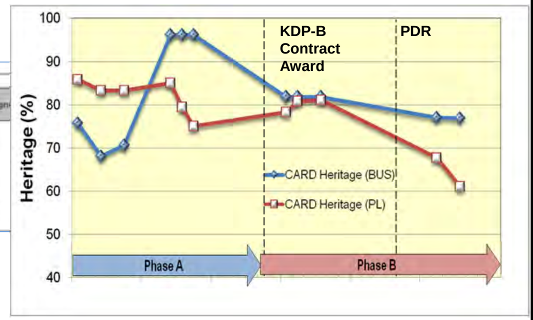
Tech Baseline – Heritage Assessment

Rigorous process to assess heritage claims

- Provides consistent evaluation of New Design at the box level
- Provides for "intelligent" dialogue with SPO / Contractor Engineers
- Frequently influences the SPO position

y or n	Factor to consider in addressing %New
y	System specification complete, system design review (SDR) complete
y	System requirements flow down through work breakdown structure (systems engineering begin…
y	System interface requirements known
y	Hardware requirements analysis complete - includes embedded software
y	Draft design drawings (mechanical / electrical) are complete to PDR maturity
[illegible]	Engineering Model (EDM) required to verify design meets functional requirements
[illegible]	Test procedures understood, Test Plan complete
[illegible]	Tooling in place to support build and test of ProtoQual and EDM
[illegible]	Design drawings (mechanical / electrical) are complete to CDR maturity
[illegible]	Test equipment / software in place to support unit level Proto-Qual and Acceptance testing
[illegible]	Manufacturing process controls / configuration management program in place
[illegible]	Component parts qualification completed OR comp qualification testing not required
[illegible]	Unit level qualification testing completed OR ProtoQual / acceptance testing required



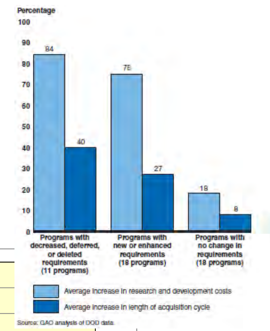
Initial Claims of High Heritage were not Realized

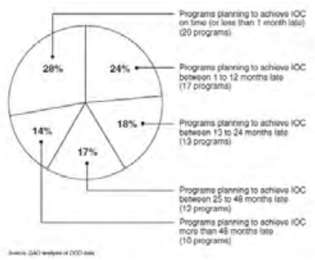
TECHNICAL BASELINE ASSESSMENT: SCHEDULE

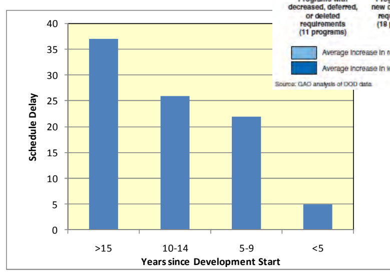
Schedule Growth History

GAO Conclusions

- Average Schedule Growth on Weapons Programs is approx 2 years (2008 data)
- Average Schedule across portfolio growth is increasing
- Direct correlation between schedule growth and requirements change (even decrease)







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Schedule Growth Assessment

Causes for Schedule Growth

- Requirements Change (add extra signal)
- Technical Issues (part failure during vibration test)
- Programmatic Issues (funding delay)
- Uncontrollable (launch vehicle manifest changes)

Realism Assessment

- Range of approaches to complete schedule realism assessment
  - Top level parametric of overall expected schedule duration
  - Buildup, risk adjusted IMS analysis

Our job is not to reduce schedule growth but to model what we feel will be the final (actual) schedule

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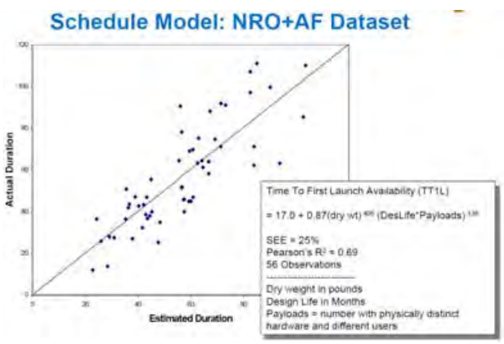
Example
Satellite SER

- Within oversight agencies (e.g. AFCAA and NRO CAIG) a top level Schedule Estimating Relationship is completed
  - Uses similar drivers as satellite CERs (Weight, design life, # of payloads, etc)
- Historically based SER can be used to assess reasonableness of schedule input
- Relationship can also be calibrated for analogous systems (e.g. navigation Programs)
- Output of SER is used to adjust LOE type elements as well as correctly phase expenditures



Graphic Source: "Time Phasing Methods and Metrics", E.Burgess. 2004 DODCAS

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Summary

- What is a technical baseline?
  - Collection of all the data necessary to complete the LCCE
    - Technical description
    - Programmatic information
    - Schedule details
  - Snapshot of the Program
- Why is the technical baseline important?
  - Help achieve qualities of a good cost estimate: accuracy, comprehensiveness, replicability & auditability, and traceability
- How is a technical baseline created?
  - Data extracted from published data and subject matter expert interviews
- How is tech baseline used to create credible estimate?
  - Primary source of inputs required by estimating methods

A <u>realistic</u> Technical Baseline Estimate is key to completing a reliable cost estimate

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Acronyms

ACAT = Acquisition Category
ADM = Acquisition Decision Memorandum
APM = Acquisition Program Baseline
CADRe = Cost Analysis Data Requirement
CAIG = Cost Analysis Improvement Group
CAPE = Cost Analysis and Program Evaluation
CARD = Cost Analysis Requirements Description
CCA = Component Cost Analysis
CCDR = Contractor Cost Data Report
CEBD = Cost Estimating Baseline Document
CDD = Capability Development Document
CER = Cost-Estimating Relationship
COTS = Commercial Off the Shelf
CSCI = Computer Software Configuration Item
CSDR = Cost and Software Data Report
DoD = Department of Defense
DoE = Department of Energy
EA = Economic Analysis
FAA = Federal Aviation Administration
FRP = Full Rate Production
GFI = Government-Furnished Information
IATD = Investment Analysis Technical Description
ICBD = Intelligence Capability Baseline Description
IMP = Integrated Master Plan
IMS = Integration Master Schedule
JRC = Joint Resource Council
KPP = Key Performance Parameter
LCCE = Life Cycle Cost Estimate
MAIS = Major Automated Information System
MDAP = Major Defense Acquisition Program
MS = Milestone
NASA = National Aeronautical and Space Administration
NAR = Non-Advocate Review
NPR = NASA Procedural Requirement
ORD = Operational Requirements Document
PDM = Program Decision Memorandum
POM = Program Objective Memorandum
SEMP = System Engineering Management Plan
SEP = System Engineering Plan
SLOC = Source Lines of Code
SME = Subject Matter Expert
SoS = Systems of Systems
ST&E = System Test and Evaluation
TEMP = Test and Evaluation Management Plan
TRL = Technology Readiness Level
WBS = Work Breakdown Structure