



NORTHROP GRUMMAN DEFINING THE FUTURE
Mission Systems

October 2003

Costing COTS Integration

18th International Forum on COCOMO
and Software Cost Modeling/
LA SPIN Meeting

Los Angeles

Linda Brooks



Objective

Provide a roadmap for doing an estimate for a Commercial Off-the-Shelf (COTS) software intensive system development

Defining characteristics of COTS:

- **Source code not available**
- **Future evolution of product not controlled by system developer**

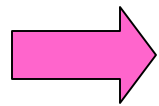


Topics

- **Challenges of Estimating COTS Integration**
- **Components of an Estimate**
- **COTS Integration Software Estimating Methods**
- **Avoiding Common COTS Estimation Pitfalls**
- **Validation Example**
- **Summary**



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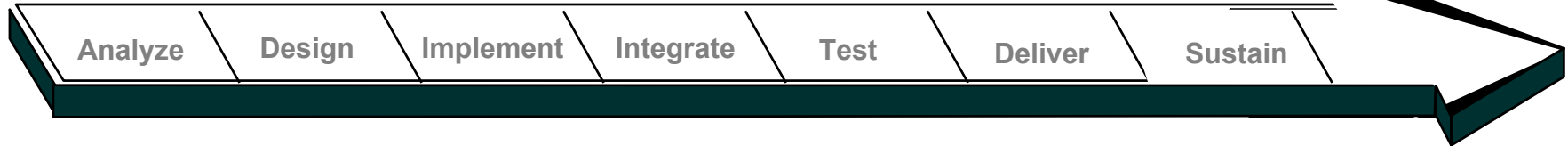


Challenges of Estimating COTS

- **Sizing**
- **Productivity (size/effort)**
- **Limited availability of historical data and seasoned parametric models**
- **Non-separable effort in development**
- **Activities, life cycle phases and risks substantially different than new development**
- **COTS integration typically underestimated**



COTS vs. Custom

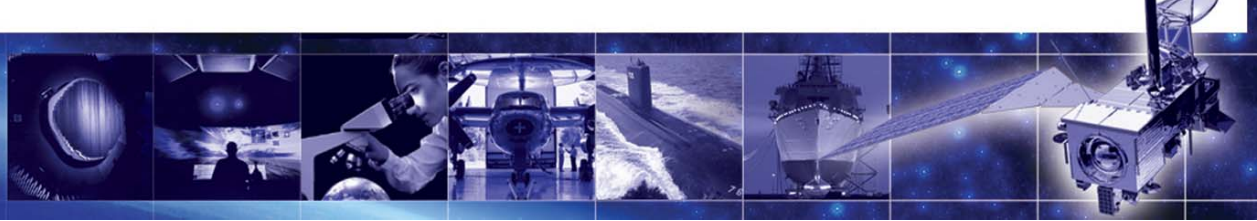


Cost Factor *	COTS	Custom
Marketing research	\$\$\$	\$
Selection Analysis	\$\$\$	\$
Design/Tailoring	\$	\$\$\$
Implementation	\$	\$\$\$
Interfaces/Integration	\$\$\$	\$\$
Security	???	???
Licenses	\$\$\$	\$
Technical support	\$\$	\$\$
Testing	\$\$	\$\$\$
System Cut-Over	\$\$\$	\$\$
Training	\$\$	\$\$
Upgrades	\$\$	\$
Replacement	\$	\$\$

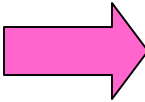
Most factors are project dependent

*** Cost of COTS versus Custom development needs to be evaluated across life-cycle**

Source: The MITRE Corporation. Used with permission.

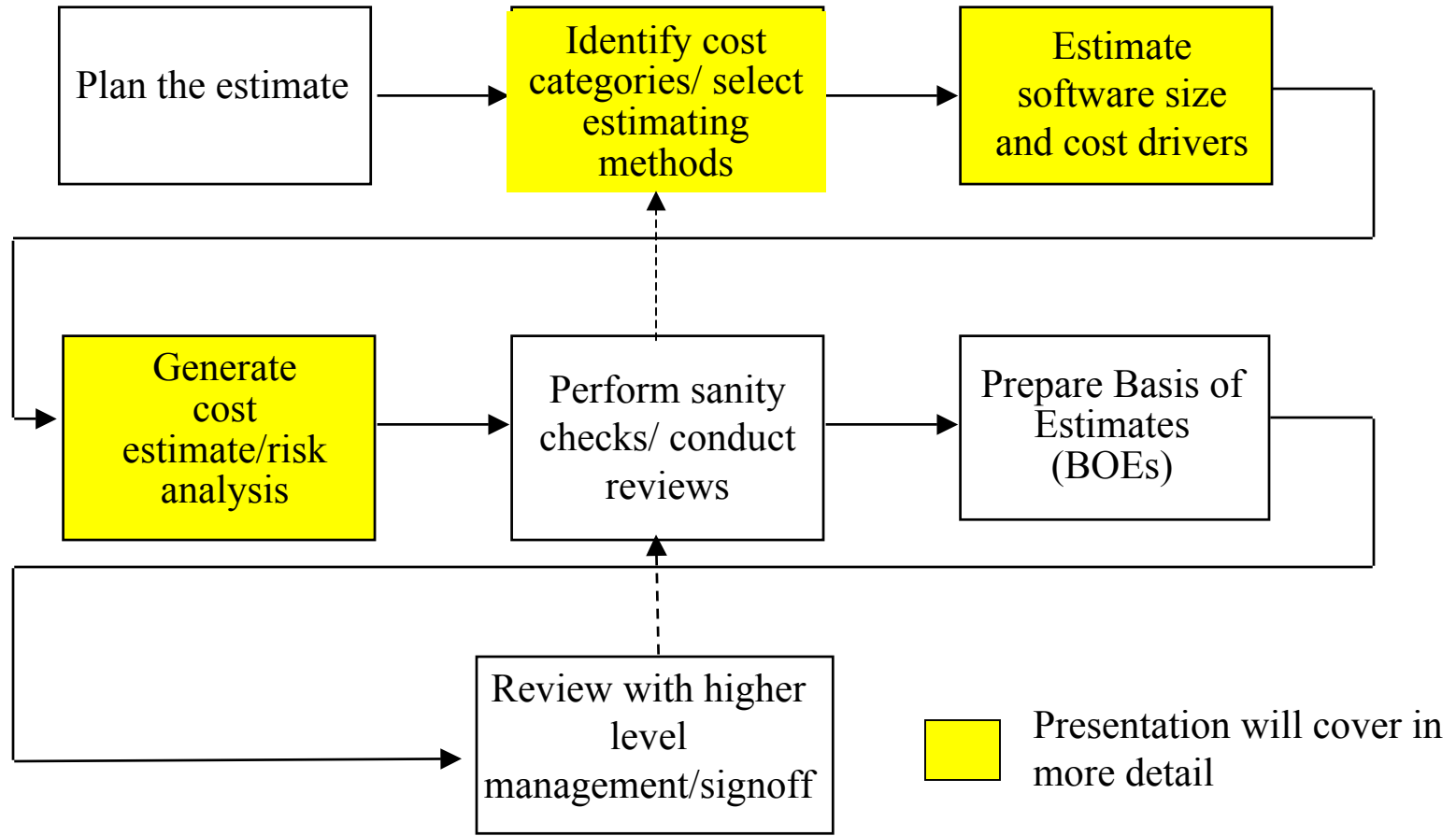


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Sample Cost Estimation Process Flow





Basic Cost Estimation Methods

- **Direct comparison to historical data**
- **Adapted Comparison**
- **Cost Estimation Relationships (CERs) and standards**
- **Bottoms Up (engineering judgment based on detailed plan)**
- **Parametric cost model (preferably calibrated to org historical data)**
- **Level of effort (LOE)**
- **Quote for services or material to be purchased (COTS, Government-Off-the-Shelf [GOTS], NDI, etc.)**



Estimate Software Size and Cost Drivers

- Identify and document software components to the lowest level possible
- Identify components expected to be satisfied by
 - Developed software
 - New software to be written
 - Adapted Software
 - Commercial off-the-shelf (COTS) software
 - Includes COTS, GOTS, and NDI (Non-Developmental Items) where no source code is available
- Size each developed component and identify cost drivers*
- Identify COTS size and cost drivers*
- Identify size/cost driver ranges if appropriate (for risk analysis)

* Can use definitions from selected parametric cost model



Risk Analysis

- Identify the the cost and risk drivers and quantify their impact
- Use cost categories, activities, cost driver settings, lessons learned from this briefing or other sources to trigger identification of risks
- Ideally develop at least three estimates (both cost and schedule)
 - Best, worst, and expected baseline cases
- Monte-Carlo techniques can provide more sophisticated risk analysis



Components of a Complete Estimate

- **Ground rules, assumptions**
- **Definitions & quantification of terms**
- **What the estimate includes (WBS Element, WBS Dictionary)**
- **Estimate of size, other cost drivers**
- **Required resources (labor hours)**
- **End products (Software, Specs, Manuals, etc.)**
- **Estimated schedule**
- **Estimated costs (labor and non-labor)**
- **Basis of Estimate (BOE)**
- **Risk Assessment**





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S/W Development Phase Activities: Custom & COTS

REQUIREMENTS	DESIGN	IMPLEMENTATION	ACCEPTANCE & DEPLOYMENT	SUSTAINMENT
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Custom Development Activities

<ul style="list-style-type: none"> •Planning •System Reqs •Architecture •Concept of Ops •SW Reqs 	<ul style="list-style-type: none"> •Preliminary Design •Detailed Design 	<ul style="list-style-type: none"> •Code & Unit Test •Component Test •System Test 	<ul style="list-style-type: none"> •Acceptance Test •Site Installation •Site Activation 	<ul style="list-style-type: none"> •Operations •Maintenance •Enhancements
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COTS Specific Activities

<ul style="list-style-type: none"> •COTS Approach (Reqs Negotiation) •COTS Component Identification •COTS Assessment/Selection •Prototyping 	<ul style="list-style-type: none"> •Glue Code Development •Tailoring/Configuring •COTS Integration & Test •Component refresh 	<ul style="list-style-type: none"> •Component Refresh •Maintenance
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COTS Software Integration Activities (1 of 2)

- **Assessment (*COCOTS*)**
 - **Research and evaluation of COTS products to select products to be used, 2 parts:**
 - **Initial filtering of products**
 - **Detailed assessment and evaluation**
- **Cognition (*SEER-SEM*)**
 - **Understanding the functionality of the COTS software so as to have insight into, knowledge of, and comprehension of the receiving system/software in order to integrate it with the system or with other COTS components**

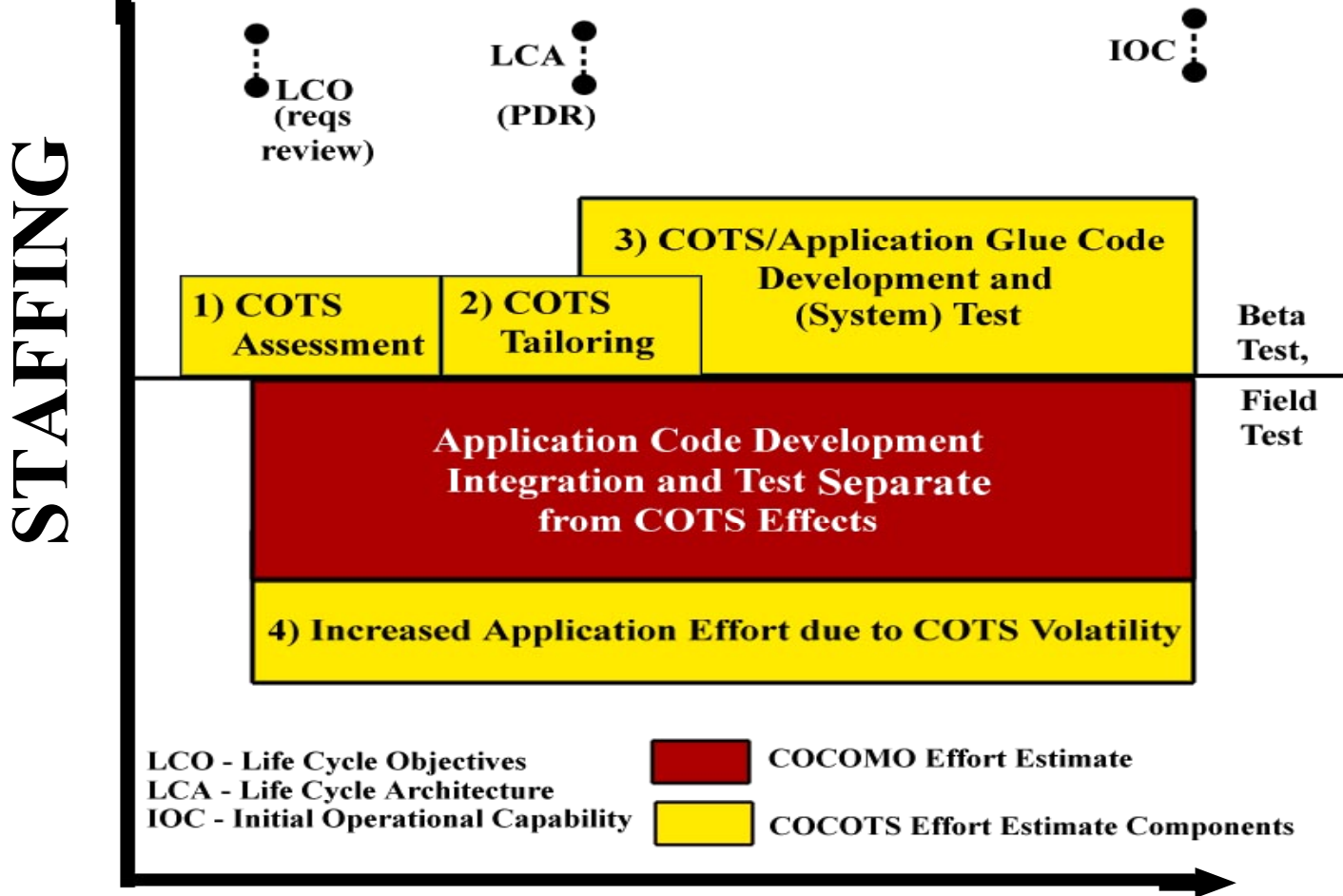


COTS Software Integration Activities (2 of 2)

- Tailoring (*COCOTS*)
 - Customization of the product for its intended use
 - Provides required functionality missing in the COTS product, or
 - Isolates users and/or developed software from unrequired/undesired capabilities or overly complex interfaces (e.g, “wrappers”)
- “Glue” code (*COCOTS*)
 - Developed software that
 - Facilitates data or information exchange between the COTS component and the system or other COTS components into which it is being integrated
 - Connects or “hooks” the COTS component into the system or to other COTS components but does not necessarily enable data exchange



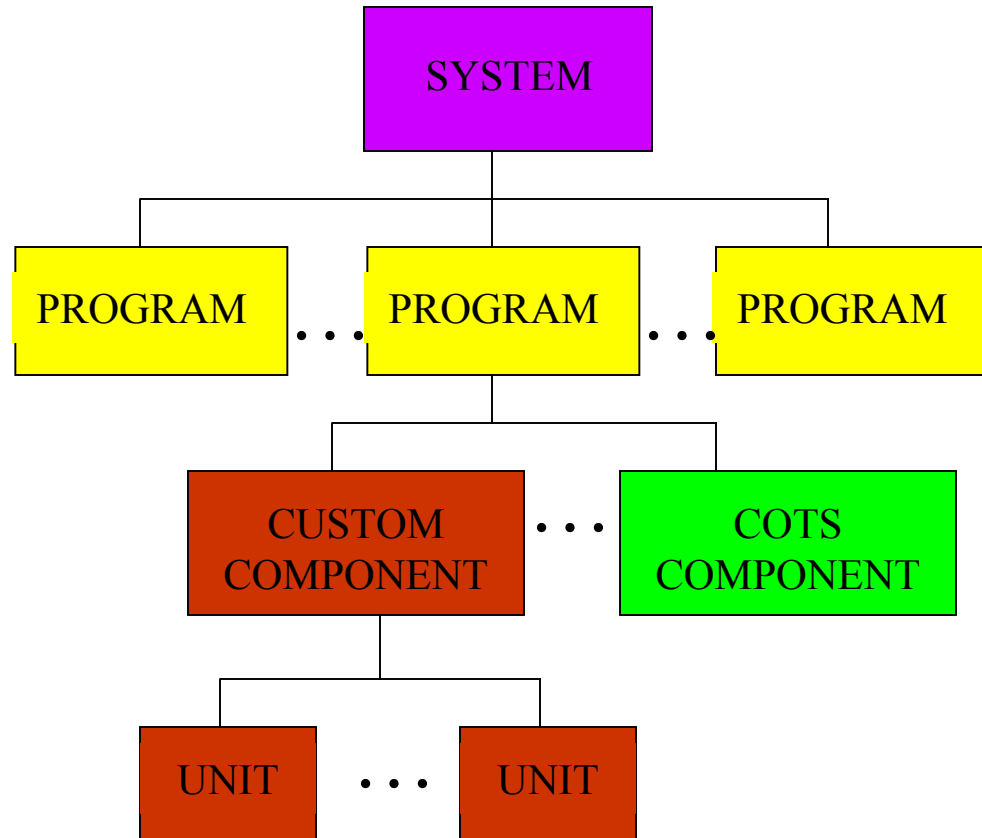
COCOTS/COCOMO Costing View





SEER-SEM COTS Costing View

- Summary level, define overall system characteristics
- Define overall program/CSCI characteristics, sums both custom and COTS components
- Custom software component
 - New, reused, modified software – SLOC, FP, Proxy sizing
 - COTS glue code
 - COTS Tailoring scripts, DDL, etc.
- COTS Software Component
 - COTS functional sizing
 - COTS specific cost drivers
 - COTS Cognition
 - License/Maintenance Fees





SEER-SEM COTS Component Sizing

IFPUG function point (FP) compatible sizing

- **Quick Size - Computes sizes based on selection from COTS application list and % usage parameter**
- **Feature Sizing - FPs translated to terminology related to common COTS features**
- **Object Sizing – FPs translated to object related terminology**



Candidate COTS Integration Estimation Methods

Overall Method #	Specific Method	Integration Method								
		NEW	ADAPTED	GLUE	ASSESSMNT	TAILORING	COGNITION	VOLATILITY	INTEGRATION	SYSTEM I & T
1	SEER-SEM	✓	✓	✓	✗ ^C	✓	✓ ^C	✓ ^C	✓ ^C	✓
2	COCOMO II	✓	✓							✓
	COCOTS			✓	✓	✓	✗	✓	✗	
3	Parametric Model	✓	✓	✓	✓	✓			✓	✓
	Non-Model Estimate				✓	✓	✓	✓	✓	

Custom Code
 COTS
 Custom/COTS
 C SEER COTS Unit
✓ Normally Included
 ✗ May Be Underestimated



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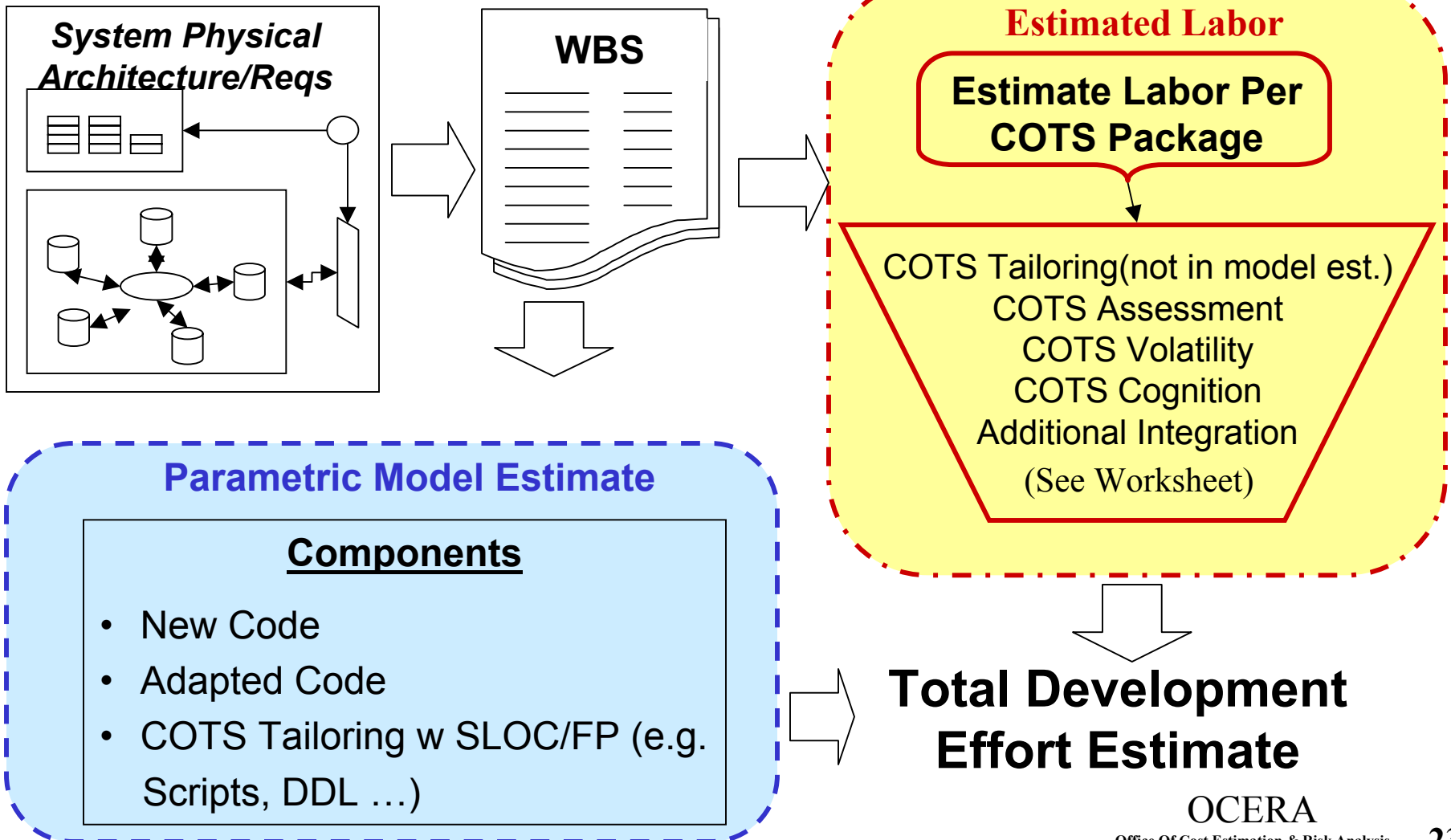
COTS Tasks Typically Overlooked or Underestimated

- **Systems and software engineering**
- **Hands-on prototyping**
- **Integrated system training and documentation**
- **Acquisition of COTS software in-depth knowledge**
 - -e.g., mentors, toolsmiths, vendor support
- **Component and system performance tests**
- **Components and system regression tests with each upgrade**
- **Related software changes to support COTS software upgrades**
 - **Glue code, database changes, configuration files**
 - **Developer/operator training needed for COTS upgrades**

Source: The Aerospace Corporation. Used with permission



COTS Software Development Cost Estimation Method - 3



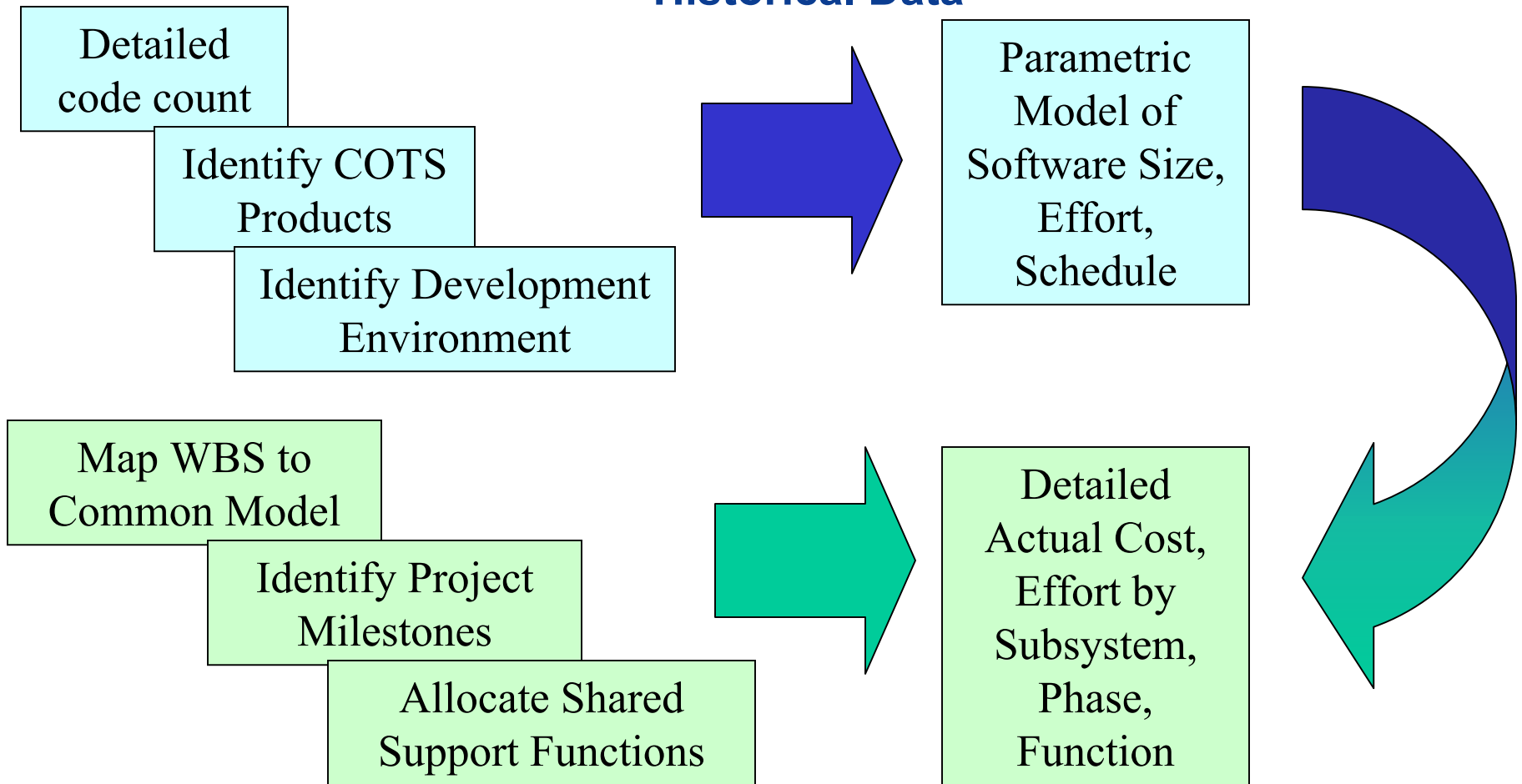


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Standard Process for Performing a Parametric Validation of Historical Data





Example of SEER-SEM Validation

- **Successful calibration of SEER-SEM to Mission Systems COTS intensive completed project**
- **Used SEER COTS Components with SEER quick sizing to model COTS elements**
- **Used developed S/W components with SLOC counts for 4GL tailoring scripts and DDL**
- **Matched total actuals to within 7% of SEER estimate**
 - **Included both COTS and non-COTS development labor**
 - **With adjustments came within 2%**
- **Provides confidence in method for future COTS estimates for similar COTS intensive developments**

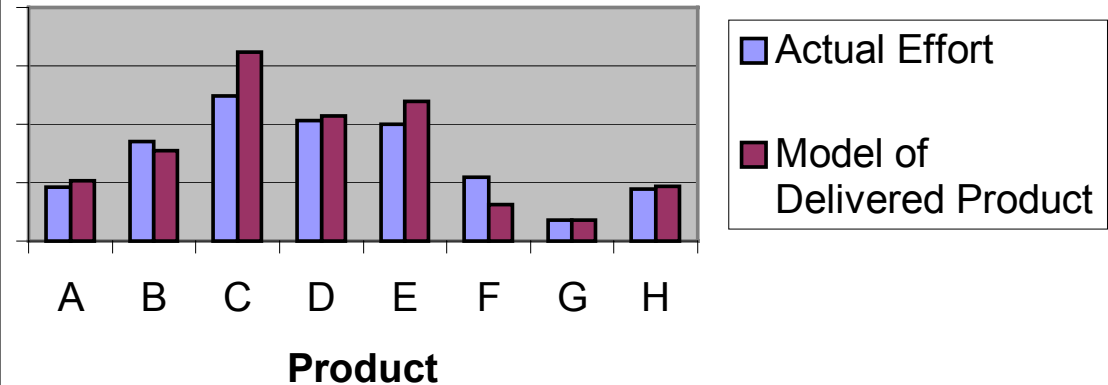


A calibrated model provides:

- Validation of provided data
- Basis of estimate for future enhancements

Product	% Diff
A	12%
B	-9%
C	31%
D	4%
E	20%
F	-43%
G	0%
H	6%
Total	7%

Actual Vs Model of Delivered Software

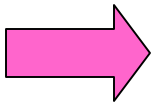


- Product F was forced to restart with alternate COTS product 28% into the schedule.
- Product C was severely constrained by staffing problems.
- Difference <2% with these corrections



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Summary

- **There are lessons learned from using and integrating COTS software applications, use them**
- **The necessary components of a complete estimate are always required, even with estimating for COTS usage**
- **Use cost drivers and sizing inputs from parametric models (such as SEER SEM or COCOTS) to derive your COTS integration estimate**
- **Cross check estimates by using results from two estimating methods**
- **Calibrate your estimating models and methodologies with historical data**
- **Evaluate the cost of COTS versus custom development across the life-cycle**
- **Identify the the cost and risk drivers and quantify their impact**
- **Revise estimates as you obtain more or better information**



References

- **SEER SEM™ Estimating Model, Galorath, Inc.,**
http://galorath.com/tools_soft.shtm
- **Software Cost Estimation With COCOMO II, Barry Boehm et al,**
Prentice Hall, 2000
- **COCOTS Estimating Model, USC Center for Software Engineering,** <http://sunset.usc.edu/research/COCOTS/>
- **Kathy Bradford, Lessons Learned in Estimating the Software Cost of a Ground Station with COTS Integration, GSAW2001,**
<http://sunset.usc.edu/gsaw>
- **IFPUG Counting Practices Manual 4.1, <http://www.ifpug.org>**



Acronym List

- **BOM – Bill of Materials**
- **CER – Cost Estimating Relationship**
- **CM – Configuration Management**
- **COCOMO – COConstructive COSt MOdel**
- **COCOTS – COntstructive COTS**
- **COTS – Commercial Off-the-Shelf**
- **DDL – Data Definition Language**
- **FP – Function Points**
- **GFE – Government Furnished Equipment**
- **GOTS – Government Off-the-Shelf**
- **GSAW – Ground System Architectures Workshop**
- **GUI – Graphical User Interface**
- **H/W – Hardware**
- **IFPUG – International Function Point Users Group**
- **LOE – Level of Effort**
- **NDI – Non-Developmental Item**
- **NGMS – Northrop Grumman Mission Systems**
- **OCE – Office of Cost Estimation**
- **QA – Quality Assurance**
- **SEER-SEM™ – System Evaluation and Estimation of Resources - Software Estimation Model**
- **S/W – Software**
- **USC – University of Southern California**
- **WBS – Work Breakdown Structure**
- **4GL – Fourth Generation Language**