Cost Estimating

SEAPOWER THROUGH ENGINEERING

TOPIC LEARNING OBJECTIVES

Upon successful completion of this topic, the student will be able to:

1. Recognize the scope and purpose of Life-Cycle Cost Estimates (LCCEs).
2. Given a cost breakdown, determine Development Cost, Sailaway Cost, Weapon System Cost, Procurement Cost, Acquisition Cost, and Life-Cycle Cost.
3. Recognize the impact and interrelationship of logistics support and life-cycle cost.
4. Identify the four basic cost-estimating techniques.
5. Identify the strengths and limitations of the four basic cost estimating techniques and where each roughly fits in the life-cycle.
6. Select an appropriate method to estimate the cost of an acquisition program.
7. Identify terms associated with Acquisition Program Cost Estimates, including Program Office Estimate (POE), Component Cost Estimate (CCE), Independent Cost Estimate (ICE), Cost Analysis Requirements Description (CARD), Cost Assessment and Program Evaluation (CAPE).
8. Recognize the steps and review authority in the cost estimating review process for both Major Defense Acquisition Programs (MDAP) and Major Automated Information Systems (MAIS).
9. Identify where and when learning curve theory is applied.
10. Identify the concept of escalation in submitting program and budget documents.
11. Identify the definitions of Will Cost, Should Cost, and Should Cost management initiatives.

STUDENT PREPARATION

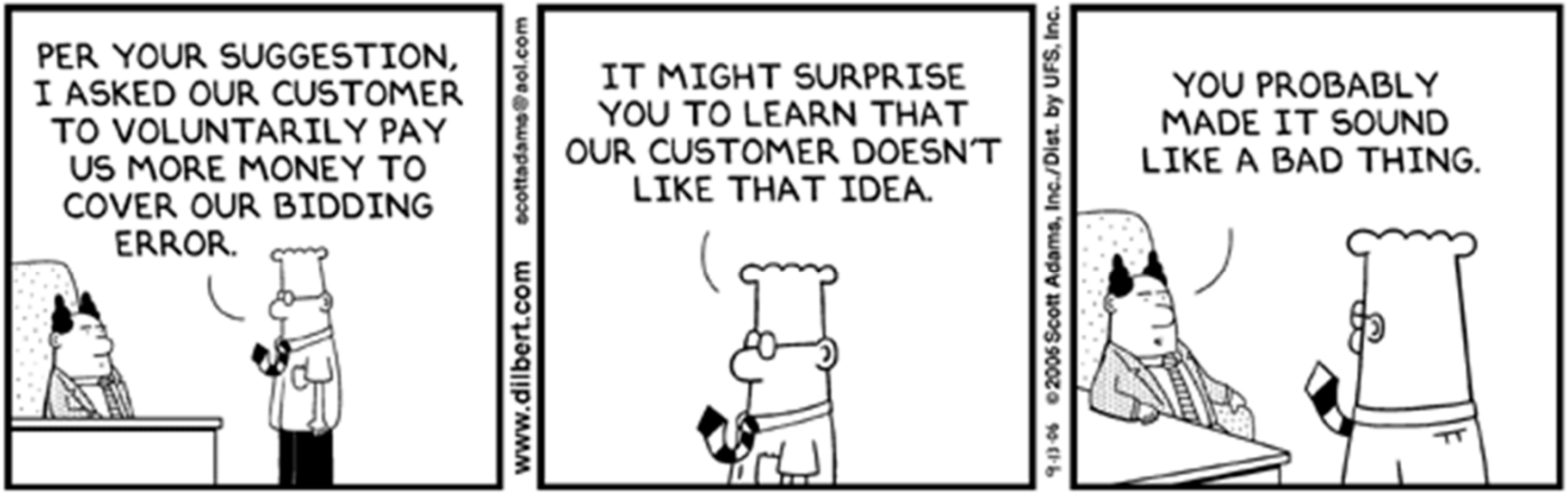
Student Support Material

1. DAU Cost Estimating Methods video: https://media.dau.edu/media/Cost+Estimating+Methods/0_943h37ey
2. Acquisition Note: Cost Estimating Overview: https://acqnotes.com/acqnote/tasks/cost-estimating-overview
3. OSD Inflation and Escalation Best Practices Glossary https://cade.osd.mil/content/cade/files/csdr/guidance/OSDCAPEEscalationHandbook2021.pdf
4. US Bureau of Labor Statistics data demonstrating escalation and inflation over time https://www.bls.gov/charts/consumer-price-index/consumer-price-index-average-price-data.htm
5. Naval Center for Cost Analysis https://www.ncca.navy.mil/references.cfm
6. DAU PMT 0160 Cost Estimating
7. DAU CLB 025 Total Ownership Cost

Primary References

1. SECNAV 7110.12
2. DODI 5000.73 Cost Analysis Guidance and Procedures https://cade.osd.mil/policy/csdr-timeline
3. Implementation of Will-Cost & Should Cost Management https://www.acq.osd.mil/fo/docs/USD(ATL)_Memorandum_on_Implementation_of_Will-Cost_and_Should-Cost_Management_042211.pdf

Why do cost estimating?



Overview

- Life-cycle cost
- Cost estimating methodology
  - Analogy
  - Parametric
  - Engineering
  - Actuals
- Cost estimating products and players
- Learning curves
- Escalation
- Will Cost Should Cost

Life-Cycle Cost

- Life-Cycle Cost (LCC) can be defined as the ***total cost to the Government of a program over its full life (cradle to grave)***
- Program Life-Cycle Cost Estimates (LCCE) are important because:
  - They form the basis of program budgets and are also critical in the day-to-day management of a program
  - Current acquisition regulations require programs to maintain a program cost estimate
  - They support headquarters-directed analyses, to defend program budget requirements, or to choose between potential Contractors in source selection

LCC Includes
Research & Development
Testing
Production
Facilities
Operations & Maintenance
Personnel
Environmental Compliance
Disposal

Life-Cycle Cost (LCC) Groupings

- LCCs can be presented in three ways depending on how the program's major stakeholders prefer to see them grouped

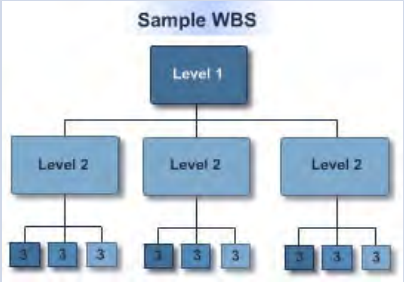
Congress, Budgeteers

Appropriation Categories

- Research, Development, Test and Evaluation (RDT&E)
- Procurement (OPN, WPN, SCN, etc.)
- Operations and Maintenance (O&M)
- Military Construction (MILCON)
- Military Personnel (MILPERS)

Program Office

Work Breakdown Structure



1.10	Data
1.10.1	Technical Publications
1.10.2	Engineering Data
1.10.3	Management Data
1.10.4	Support Data
1.10.5	Data Depository

Decision Makers, OSD CAPE

Life-cycle Cost Categories

- Research & Development (R&D)
- Investment
- Operating and Support (O&S)
- Disposal

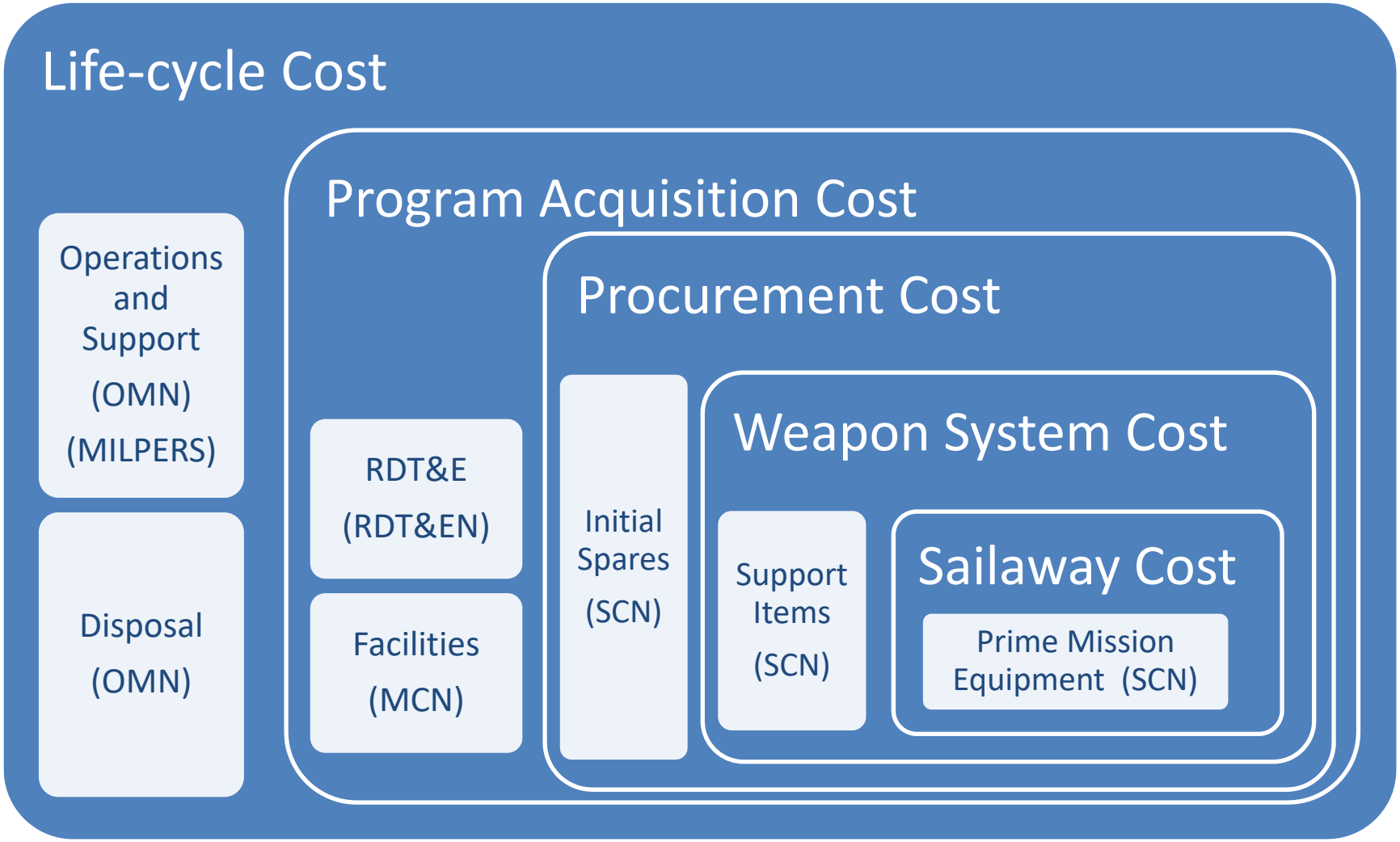
Life-Cycle Cost Composition

- LCC includes standard cost definitions at multiple levels, so it is clear exactly what the scope a cost includes:
  - Flyaway/Sailaway/Rollaway cost
    - The cost of procuring only the prime mission equipment (for example, an aircraft, ship, or tank)
  - Weapon system cost
    - Covers the cost of procuring the prime mission equipment and all its support items required to deliver a complete, functioning weapon system (e.g., technical manuals, test equipment, etc.)
  - Procurement cost
    - Total cost to procure the system: prime mission equipment, support items and initial spares required to stock the supply system when the system is fielded
  - Program acquisition cost
    - All costs associated with developing, procuring, and housing a weapon system, including any facilities (for maintenance, training, etc.)

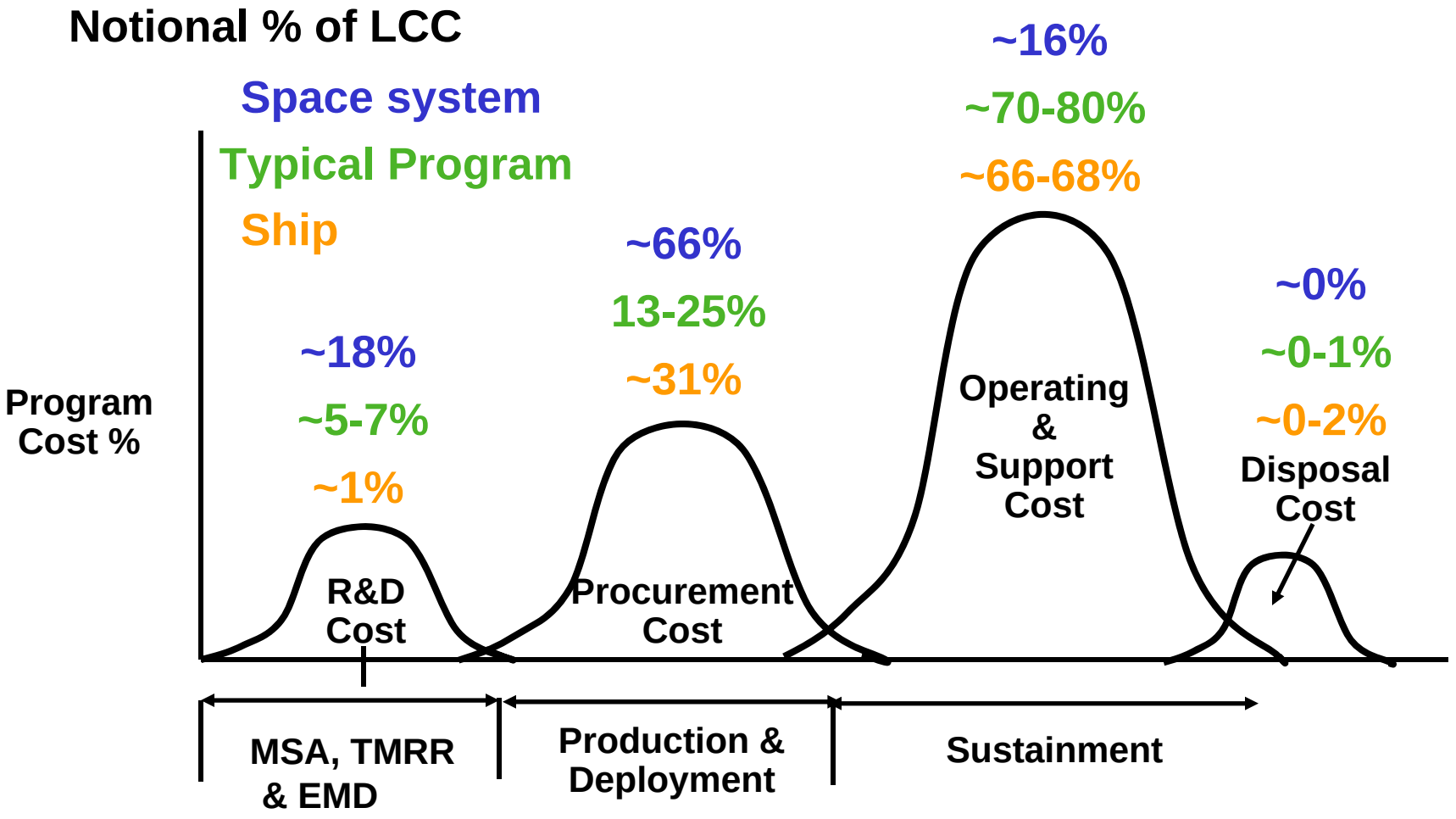
Life-Cycle Cost Composition cont.

- Life-Cycle Cost includes standard cost definitions at multiple levels, so it is clear exactly what the scope a cost includes:
  - Operating and support cost
    - All costs for personnel, equipment, and supplies associated with operating, modifying, maintaining, and supporting a weapon system in the DoD inventory
  - Disposal cost
    - Cost of demilitarizing and/or disposing of the system after the end of its useful life

Life-Cycle Cost Composition



Life-Cycle Cost Composition



O&S is the largest component of the LCC for most programs; ***about 2/3***

Total Ownership Cost (TOC)

- Comprised of:
  - Costs to research, develop, acquire, own, operate, and dispose of weapon and support systems, other equipment, and real property
  - Costs to recruit, train, retain, separate, and otherwise support military and civilian personnel
  - All other costs of business operations of the DoD
- TOC includes all elements of LCC ***plus*** total supporting infrastructure that plans, manages, and executes that weapons system program over its full life which can come from other programs
  - TOC also includes the cost of requirements for common support items and systems that are incurred because of introduction of that weapons system
- Acquisition program managers are responsible for supporting the reduction of DoD TOC through the continuous reduction of LCC for their systems
  - DoD TOC reduction efforts are being implemented by all DoD Components

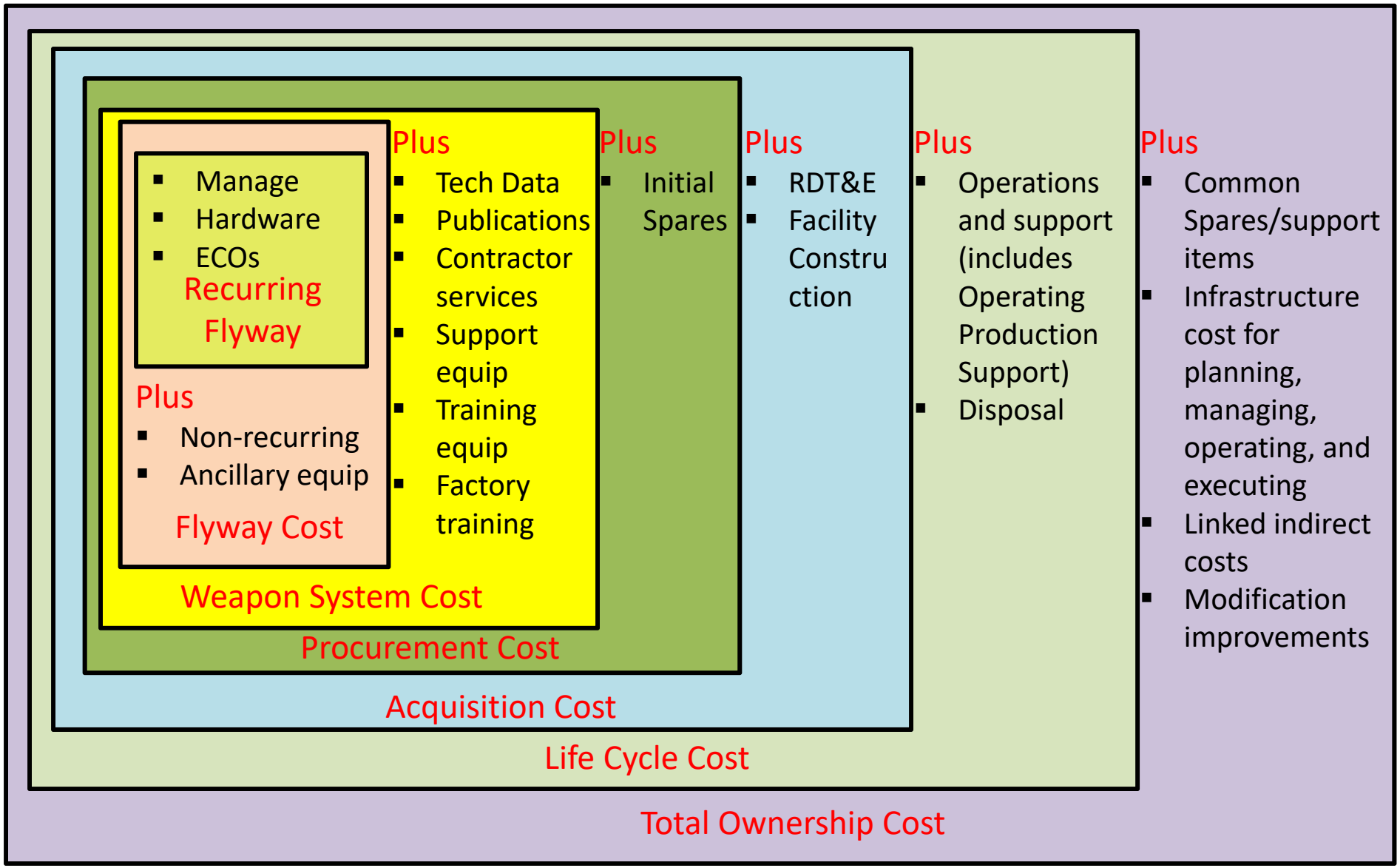
TOC = LCC + distributed indirect costs to other programs/organizations

TOC versus LCC

- Total Ownership Cost:
  - Includes LCC
  - Includes common spares/ support systems costs, infra-structure cost for planning, managing, operating, and executing
  - Includes additional indirect costs not covered in LCC
  - Seeks to allocate as many indirect costs to program as practicable, with a focus on variable indirect costs

- Life-Cycle Cost:
  - Is a subset of TOC
  - Includes R&D, Investment, O&S, and Disposal
  - Includes acquisition direct cost
  - Includes direct costs associated with a program
  - Includes obvious indirect costs linked to a program
  - Traditionally excluded most of the infrastructure costs needed to support a program

TOC versus LCC



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Analogy Method

- One-to-one comparison with existing, similar systems or subsystems
- Subjective technical assessment
  - Similarities and differences
  - Cost drivers
  - Inflation
- Used very early - initial estimate
- Advantages
  - Inexpensive, easily changed
  - Can be based on experience
- Disadvantages
  - High level estimates
  - Highly subjective (especially if no truly similar program exists) and highly uncertain

Attribute	Old System	New System
Engine:	F-100	F-200
Thrust:	12,000 lbs	16,000 lbs
Cost:	$5.2M	?

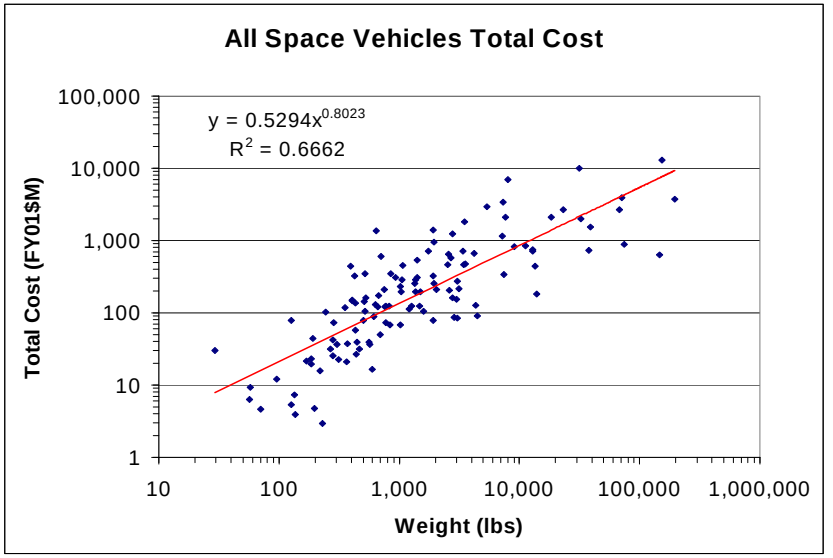
Q: What is the unit cost of the F-200?

A: $5.2M * (16,000/12,000) = $6.9M

An adjusted analogy is, by definition, estimating outside the range of data

Parametric Method

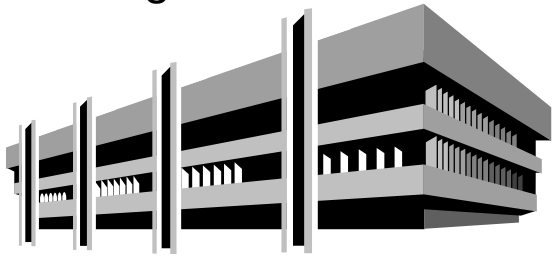
- Cost estimating relationships between performance parameters (e.g., speed, thrust, weight, electronics)
- Uses ***statistical*** techniques (linear regression)
- Quality of database is critical
  - Like technologies and homogeneous breakdowns
- Used early - advanced development
- Advantages
  - Multitude of quantitative measurements
  - Inexpensive
  - Easily changed
- Disadvantages
  - Moderately subjective; relies on quality of the database



Engineering Cost Office

Parametric Method
Cost Estimating Relationships (CER)

Building Construction

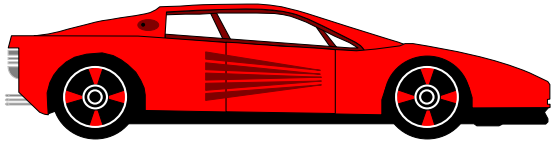


Cost is a function of:

CER VARIABLES

- Floor Space
- Numbers of Floors
- Schedule

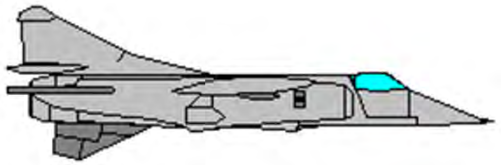
Passenger Car



Cost is a function of:

- Type, e.g., Sedan, SUV
- Doors
- Passenger Seating
- Cylinders/Horsepower

Aircraft



Cost is a function of:

- Empty Weight
- Speed
- Useful Load
- Wing Area
- Power
- Range
- Schedule

Engineering Method

- Also referred to as Bottom-up estimate
- ***Detailed work breakdown structure required***
  - Lowest level of definable work
  - All components & activities
- Used in development & production:
  - In mid to late development (engineering development)
  - Most powerful during production
- Advantages
  - Limited subjectivity (more detailed)
  - Reduced uncertainty (more accurate)
- Disadvantages
  - Expensive
  - Time consuming
  - Detailed specifications required

Labor Type	WBS	Labor Category	Rate	Hours	Cost	Subtotal
Program Management	1	Z2	$146.89	1500	$220,335	
	1	N3	$146.00	750	$109,500	
	1	N2	$120.34	125	$15,043	
	1	N1	$101.23	125	$12,654	
	1	A3	$192.74	500	$96,370	
	1	B3	$196.82	1000	$196,820	$650,721
Housing	2.1	B2	$160.44	750	$120,330	
	2.1	B1	$137.82	500	$68,910	$189,240
Interface	2.2	B2	$160.44	500	$80,220	
	2.2	C2	$143.74	500	$71,870	$152,090
Cards	2.3	B3	$196.82	500	$98,410	
	2.3	B1	$137.82	125	$17,228	$115,638
Software	2.4	A2	$157.63	500	$78,815	
	2.4	A1	$137.89	125	$17,236	$96,051
Integrated Logistics Support (ILS)	3	C3	$176.03	500	$88,015	$88,015
Test	4	C2	$143.74	125	$17,986	$17,968
Quality	5	C2	$143.74	125	$17,986	$17,968
Production Engineering	6	C3	$176.03	250	$44,008	$44,008
					Total:	$1,371,698

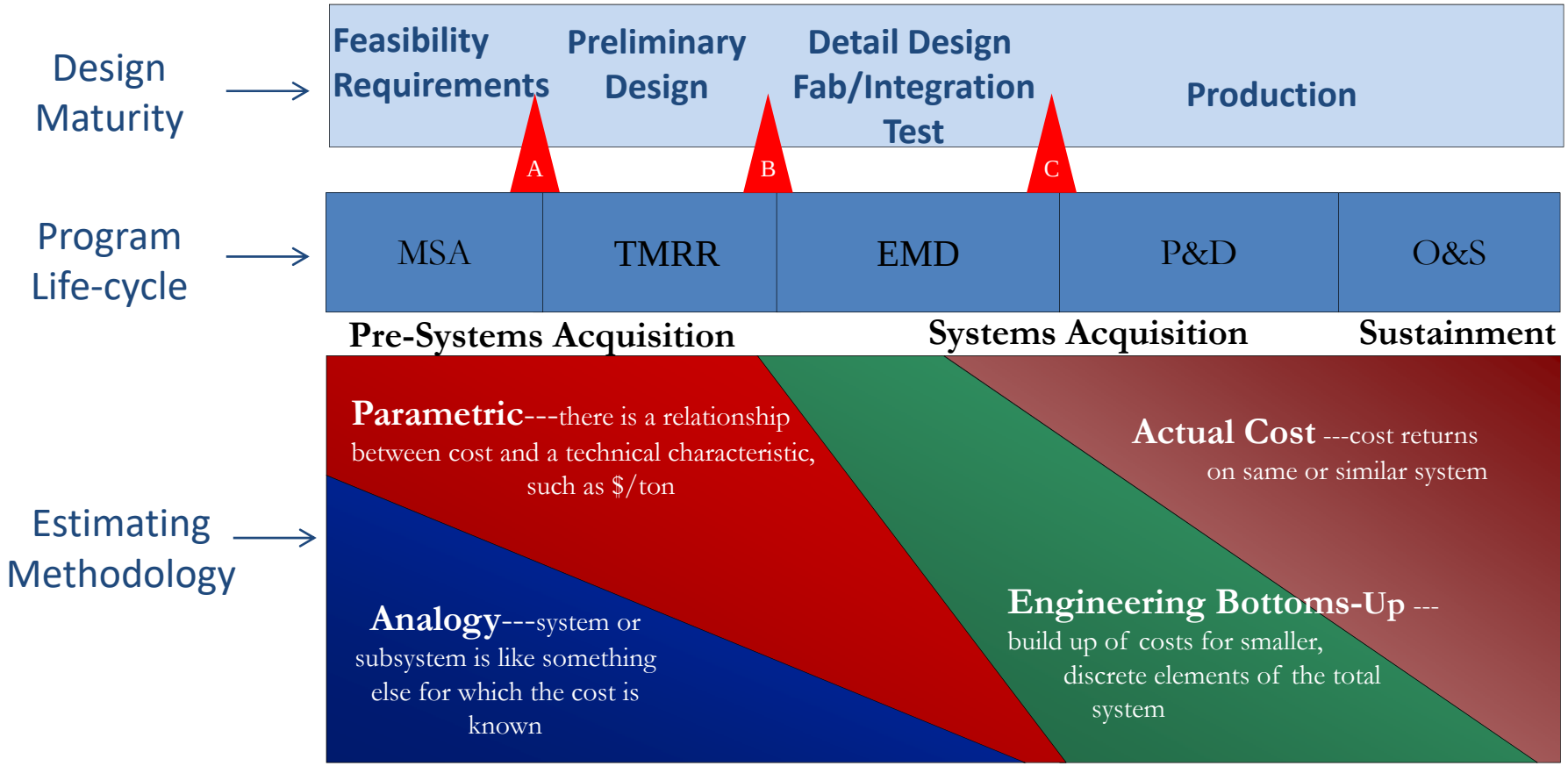
Extrapolation from Actuals

- Compares cost of previous units of the same system to extrapolate future costs
  - Subjective technical assessment of similarities and differences of prototype units, early engineering development hardware, and early production hardware and actual production models
- Stage in acquisition process impacts accuracy
  - Prototype vs production model
  - Manufacturing and assembly methods
- Used in development & production
  - Engineering development
  - Most powerful during production
- Advantages
  - Less subjectivity
  - Most accurate cost estimating method
- Disadvantages
  - Unavailable early in development

Application:
Building a Swimming Pool

- Analogy
  - Ask friends and neighbors what they paid for their pools
  - Adjust for security fence, deck, diving board, heater, filter, etc.
- Parametric
  - Collect and analyze price lists, price surveys
  - Use regular analysis to calculate cost per square foot factor, based on historical price data for options
- Engineering
  - Work with building material suppliers, general contractor to generate a detailed estimate
    - Bill of Materials (BOM), labor rates, permits, and inspections
- Actuals
  - If you were building a housing development with multiple pools, the costs of those constructed later could be extrapolated from those constructed earlier

Cost Estimating Methods Appropriate to Acquisition Phases



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Cost Estimating Products and Players

Player	Product
Program Management Office (PMO) and/or affiliated SYSCOM (e.g., NAVSEA, NAVAIR, NAVWAR)	Cost Analysis Requirements Description (CARD) Economic Analysis (EA) Program Office Estimate (POE)
Component Cost Agency (e.g., Naval Center for Cost Analysis (NCAA), Air Force Cost Analysis Agency (AFCAA))	Independent Cost Estimate (ICE) Component Cost Estimate (CCE) Component Cost Position (CCP)
Director of Cost Analysis and Program Evaluation (OSD CAPE)	Independent Cost Estimate (ICE)

Cost Estimating Players

- Program Management Office (PMO)
  - Responsible for defining the program and developing and/or maintaining the CARD and POE
- Component Cost Agency
  - Lead organization for cost analysis and cost estimating actions (NCAA for Navy)
  - Is the component's financial management chain of command to maintain independence from the acquisition decision chain
  - Prepares a CCE for ACAT IC and ACAT ID programs
    - CCE may serve as an ICE, if so designated
- Office of Cost Assessment and Program Evaluation (CAPE)
  - Conducts or approves an ICE for ACAT ID and ACAT IC programs
    - Often has representative on ACAT I Defense Acquisition Boards
  - Plays essential role throughout PPBE process including program reviews
  - Director, CAPE is an independent advisor to SECDEF
    - Extremely influential, but no direct authority or line of responsibility

Cost Estimating Products

- Cost Analysis Requirements Description (CARD)
  - Developed by the Program Office to support cost estimates
    - Includes a description of features pertinent to costing the system
    - Quantitative descriptions of technical, physical, programmatic, and performance characteristics
  - Requirements are specified in DoD Manual 5000.04 (series)
  - Updated for all milestone reviews

- Component Cost Estimate (CCE)
  - Developed by the Component Cost Agency using input from the POE
  - Provided to the MDA at all milestones
  - Reviewed by CAPE for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) programs

Cost Estimating Products

- Program Office Estimate (POE)
  - Developed by the respective SYSCOM cost analysis organization on behalf of the PMO
  - A cost estimate of all resources and associated cost elements required to develop, produce, deploy, sustain, and dispose system over its entire life-cycle
  - Reflects the information provided in the approved program CARD
- Component Cost Position (CCP)
  - The outcome of the reconciliation between the CCE and the POE
  - Serves as the official cost position from the component (except for DON)
    - For the DON, the POE serves as the official cost position, in the absence of a CCP
  - Components must fund a program to this level across the FYDP in order to satisfy the DoD full funding policy and other statutory and regulatory requirements

Cost Estimating Products and Players

- Independent Cost Estimate (ICE)
  - A LCCE that is conducted independently of the PMO or defense agency by an outside organization
  - Statutory requirement for ACAT I programs
  - Typically, performed by SCA for ACAT IC and IB programs and by OSD CAPE for ACAT ID programs before entry into the TMRR, EMD, and PD phases
- Economic Analysis (EA)
  - Evaluates the relative economic (financial) costs of different technical alternatives, design solutions, and/or acquisition strategies, and provides the means for identifying and documenting their costs
  - Developed by PMO for Major Automated Information Systems (MAIS) programs as required by statute

Typical CARD Elements

- System description
- System WBS
- Detailed technical and physical description
- Subsystem descriptions, as appropriate
- Technology maturity levels of critical components
- System quality factors
- Reliability/Maintainability/Availability
- PM's assessment of program risk and risk mitigation measures
- System operational concept
- Organizational/unit structure
- Basing and deployment description (peacetime, contingency, and wartime)
- System support concept
- System logistics concept
- Hardware maintenance and support concept
- Software support concept
- System training concept
- Time-phased system quantity requirements
- System manpower requirements
- System activity rates (OPTEMPO or similar information)
- System milestone schedule
- Acquisition plan or strategy

Summary of Cost Analysis review process

Event	Date
• Cost Assessment Review Kick-off Meeting • Draft Cost Analysis Requirements Description (CARD) Delivered by DoD Component	180 days before Overarching Integrated Product Team (OIPT) meeting

• Cost Assessment Briefs Preliminary Independent Life-Cycle Cost Estimate (LCCE) to Program Manager (PM)
  • Draft Documentation of DoD Component Cost Estimate Delivered by DoD Component
  • Final CARD Delivered by DoD Component
	45 days before OIPT meeting

• Cost Assessment Review Meeting
  • PM Representative Briefs Program Defined in CARD, and Program Office Cost Estimate
  • DoD Component Representative Briefs Component Cost Position, if applicable
  • Cost Assessment Briefs Final Estimate of Independent LCCE to PM
	21 days before OIPT meeting

• Final Documentation of DoD Component Cost Estimate Delivered by DoD Component	10 days before OIPT meeting
• OSD Cost Assessment Report Delivered to OIPT Members	3 days before OIPT meeting

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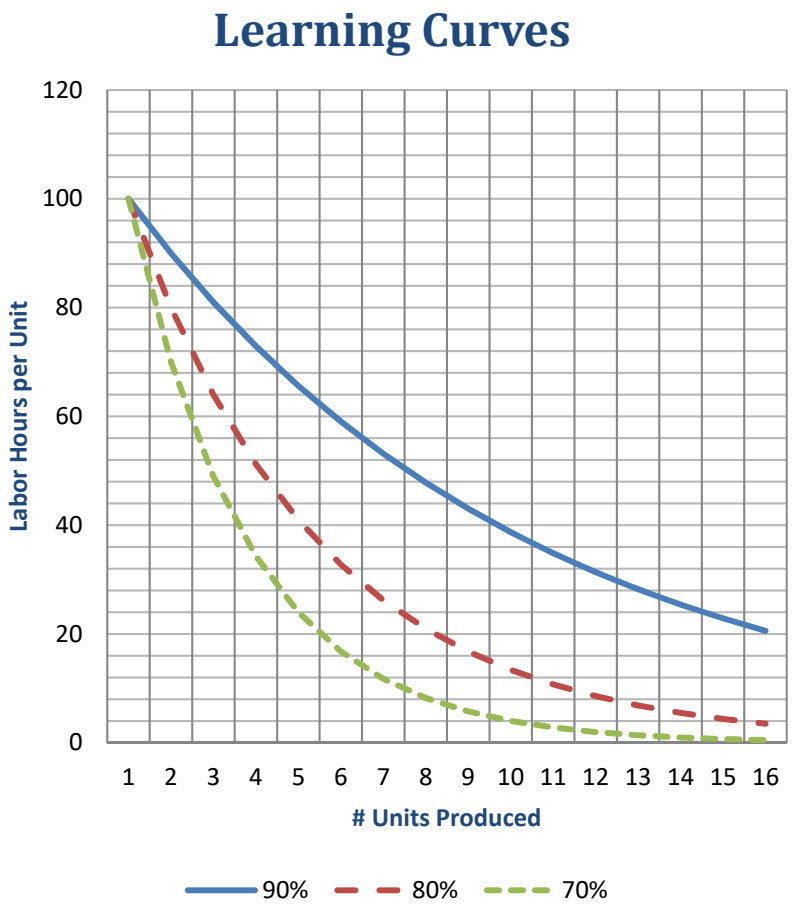
Learning Curve Theory

- As the quantity produced of a product doubles, the per unit production hours expended in producing the product will decrease at a fixed rate or constant percentage
- Reasons that improvement occurs
  - Worker experience
  - Uninterrupted production
  - Consistent design
  - Tooling improvements
  - Emphasis on productivity
- ***Apply to production labor only***
  - A 90% learning curve means that the labor hours to produce the fourth unit are only 90% of those required to produce the second unit (10% decrease)



Learning curves apply to labor only for repeatable processes

Learning Curve - Computing

UNIT	DIRECT LABOR HOURS
1.....	200
2.....	____
3	169
4.....	____
5	157
6	152
7	149
8.....	_
9	143
10	141

90 % LEARNING CURVE

$$Y_x = Kx^{\log_2 b}$$ [2]

where

- K is the number of direct labour hours to produce the first unit
- Y_x is the number of direct labour hours to produce the **xth** unit
- x is the unit number
- b is the learning percentage

Note: Change to Workforce or Design will cause a setback to learning

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Escalation Concept

- Escalation is accounting for inflation and outlay rates for submitting budget estimates
  - ***Inflation*** - general price level increases over time
  - ***Outlay rates*** - not all dollars are expended in the budget year
- Allows for the conversion between constant year and then-year dollars
  - Constant-Year (Base-Year) Dollars
    - Tied to specific year
    - Used for cost estimates so apples can be compared to apples
  - Then-Year Dollars
    - Budget requests are made in then-year (the budget year) dollars because that is when the costs are realized
    - Escalation is applied to base-year dollars to compute the then-year dollars
- OSD provides annual inflation and outlay rates

Escalation Terms

- Raw (Compound) Index
  - Simple annual compounding of inflation rates
- Weighted (Composite) Index
  - Combines inflation (compound index) with outlay rates
  - Unique for each appropriation
  - Used to turn constant dollars (cost estimate) into current-year dollars (budget estimate)
- OSD provides annual inflation rates and outlay rates
  - Services compute raw and composite indices to use for budget estimates

SCN = Shipbuilding & Conversion, Navy (1611)					
NAVY	Base Year = 2010				26-Mar-18
Fiscal Year	Inflation Rate %	Raw Index	Weighted Index	Budget Year Index	Budget Year Inflation Rate %
2008	2.40%	0.9774	1.0091	0.9680	1.61%
2009	1.50%	0.9921	1.0238	0.9821	1.45%
2010	0.80%	1.0000	1.0425	1.0000	1.83%
2011	2.00%	1.0200	1.0636	1.0203	2.03%
2012	1.80%	1.0384	1.0791	1.0352	1.46%
2013	1.50%	1.0539	1.0942	1.0497	1.40%
2014	1.50%	1.0697	1.1101	1.0648	1.44%
2015	1.10%	1.0815	1.1288	1.0828	1.69%
2016	1.20%	1.0945	1.1483	1.1015	1.73%
2017	1.70%	1.1131	1.1690	1.1214	1.80%
2018	1.60%	1.1309	1.1910	1.1425	1.88%
2019	1.70%	1.1501	1.2143	1.1649	1.96%
2020	1.90%	1.1720	1.2386	1.1881	1.99%
2021	2.00%	1.1954	1.2633	1.2118	2.00%
2022	2.00%	1.2193	1.2886	1.2361	2.00%
2023	2.00%	1.2437	1.3144	1.2608	2.00%

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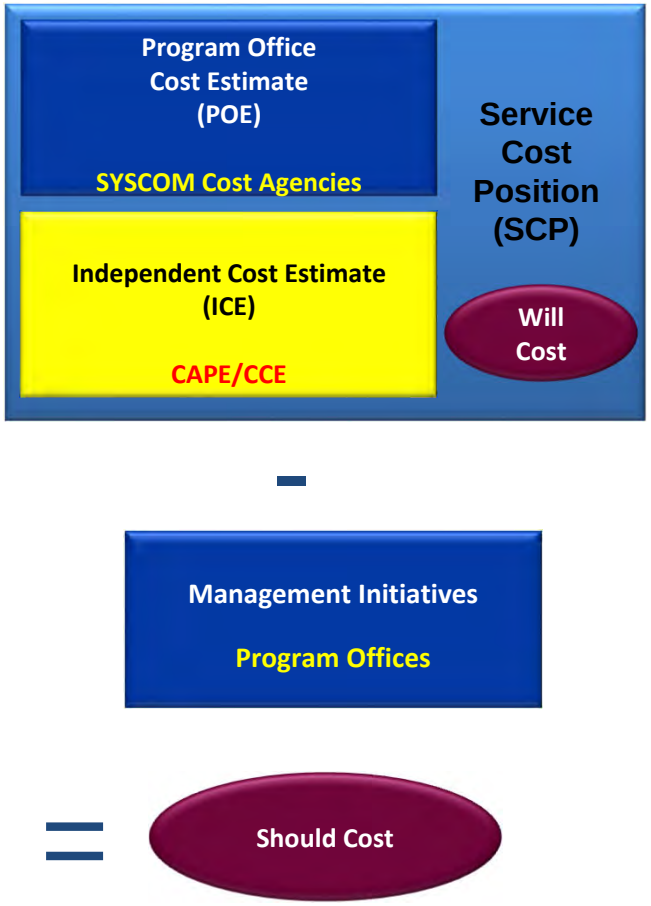
Will Cost/Should Cost

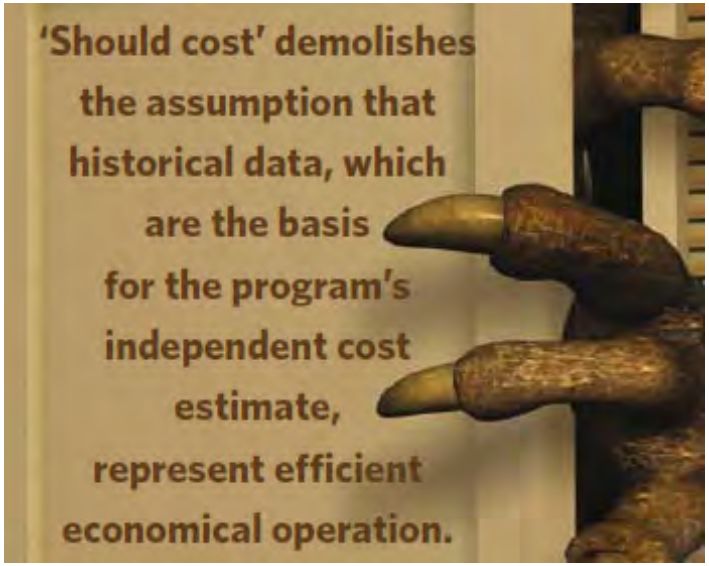
- Will Cost: Your ***funded-to level*** or what the program will cost without implementing additional cost saving management initiatives
- Should Cost: The ***desired cost*** of the program after realizing cost savings due to successful implementation of management initiatives
- Every identified "should cost" savings opportunity must be tied to a specific engineering or business change that can be quantified and tracked



Will Cost - Management Initiatives = Should Cost

Will Cost/Should Cost

- Should cost management opportunities
  - Learning curve improvements
  - Process improvements
  - Changes in contracting
  - Competition
  - Incentives
  - Government Furnished Equipment (GFE)



- What not to include in a should cost target
  - Straight percentage reductions
  - Large investments with no near-term cost recovery

Summary

- (TRUE/FALSE) Life-Cycle Cost (LCC) is the Acquisition Cost + O&S + disposal cost

- Which cost estimating technique would work best:
  - Very early in life-cycle for an initial estimate and there was a similar program in the past
  - Working on preliminary design. High-level technical and performance parameters are known and there are applicable known cost estimating relationships
  - Detailed design is complete and a detailed WBS is available
  - Getting ready to start the 2nd production run

Summary

- (TRUE/FALSE) Assuming a 90% learning curve, material cost for the 8th unit should be 90% of the material cost of the 4th unit

- What 2 factors need to be considered to adjust constant year dollars to then-year dollars?