Raytheon

Customer Success Is Our Mission

Weapon Design Tradeoff: Using Life Cycle Costs

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Weapon Design Tradeoff . . .
Using Life Cycle Costs

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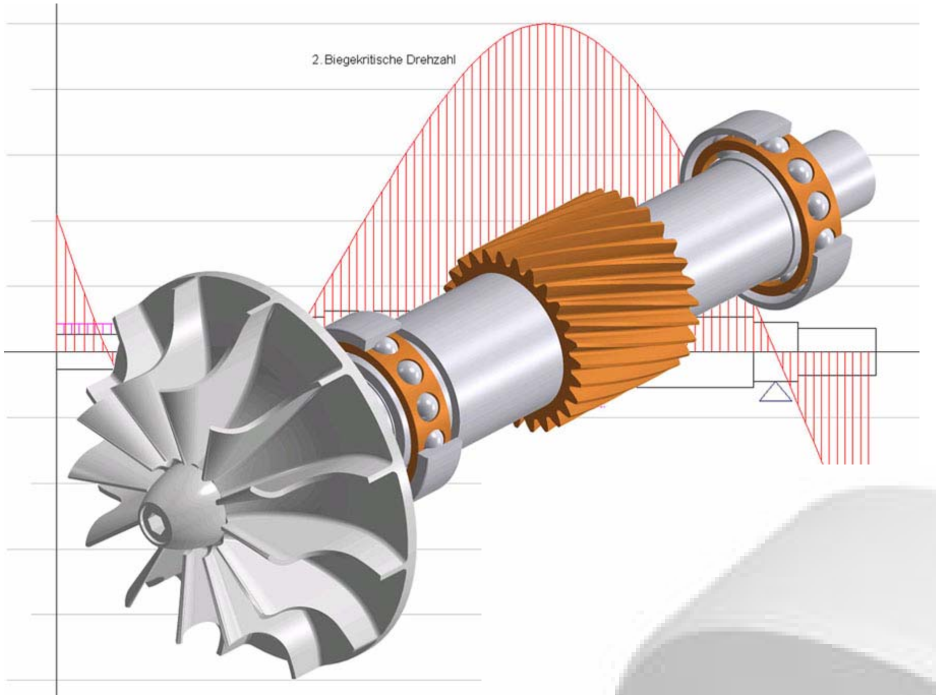
Space and Airborne Systems



LCC: What is it?

Definition:

MIL-HDBK-259 (Navy) gives a comprehensive (if long winded) expanded definition:

"LCC is the sum total of the direct, indirect, recurring, non-recurring, and other related costs incurred, or estimated to be incurred in the design, research and development (R&D), investment, operation, maintenance, and support of a product over its life cycle, i.e. its anticipated useful life span. It is the total cost of the R&D, investment, O&S and, where applicable, disposal phases of the life cycle."

- **More simply: LCC is the total cost to the customer for a program over its full life.**
  - Includes all costs directly and indirectly attributable to the program.

"Cradle to Grave"

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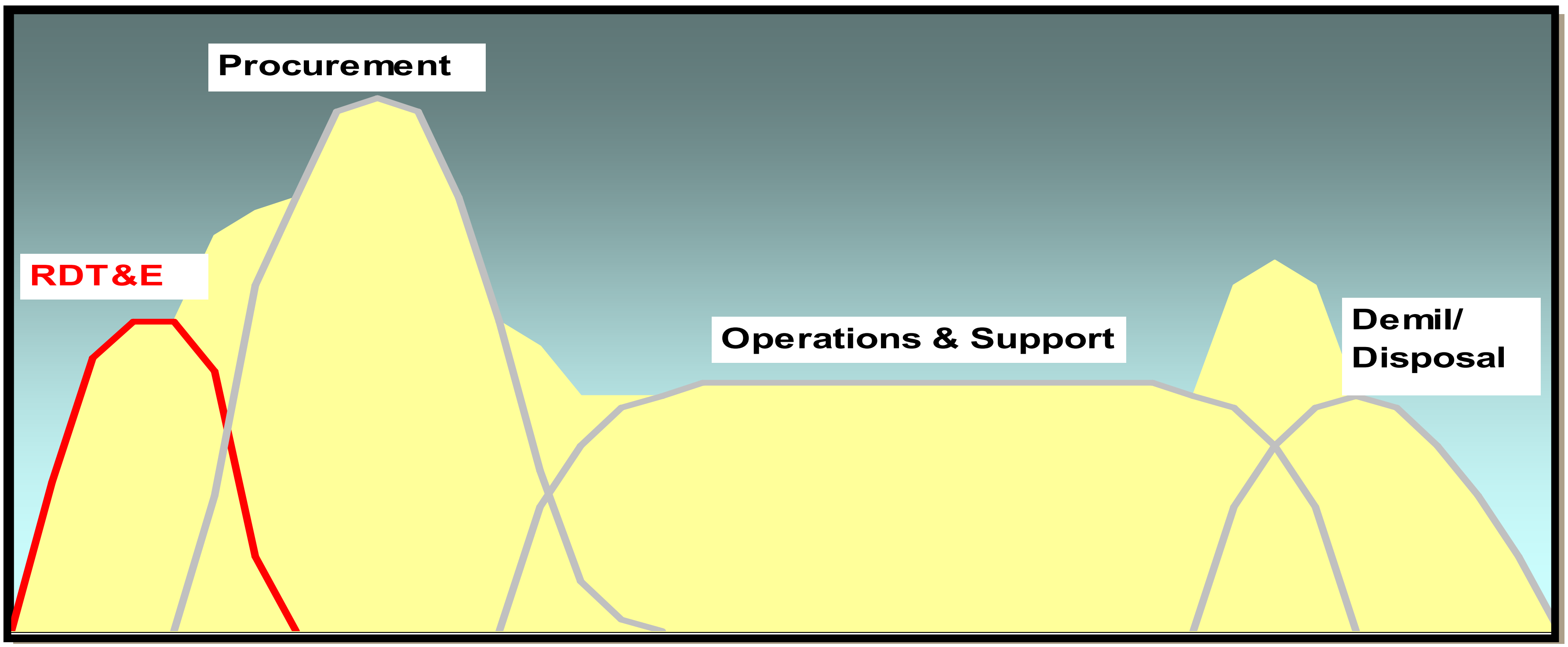
The Phases of the Life Cycle

LCC = RDT&E $ + Procurement $ + O&S $ (+ Disposal $)

- Phase 1: Research, Development, Test, Evaluation (RDT&E)
- Phase 2: Procurement (or Acquisition)
- Phase 3: Operations and Support (O&S)
- Phase 4: Disposal (Sometimes a subset of O&S)



LCC: Why do we use it?

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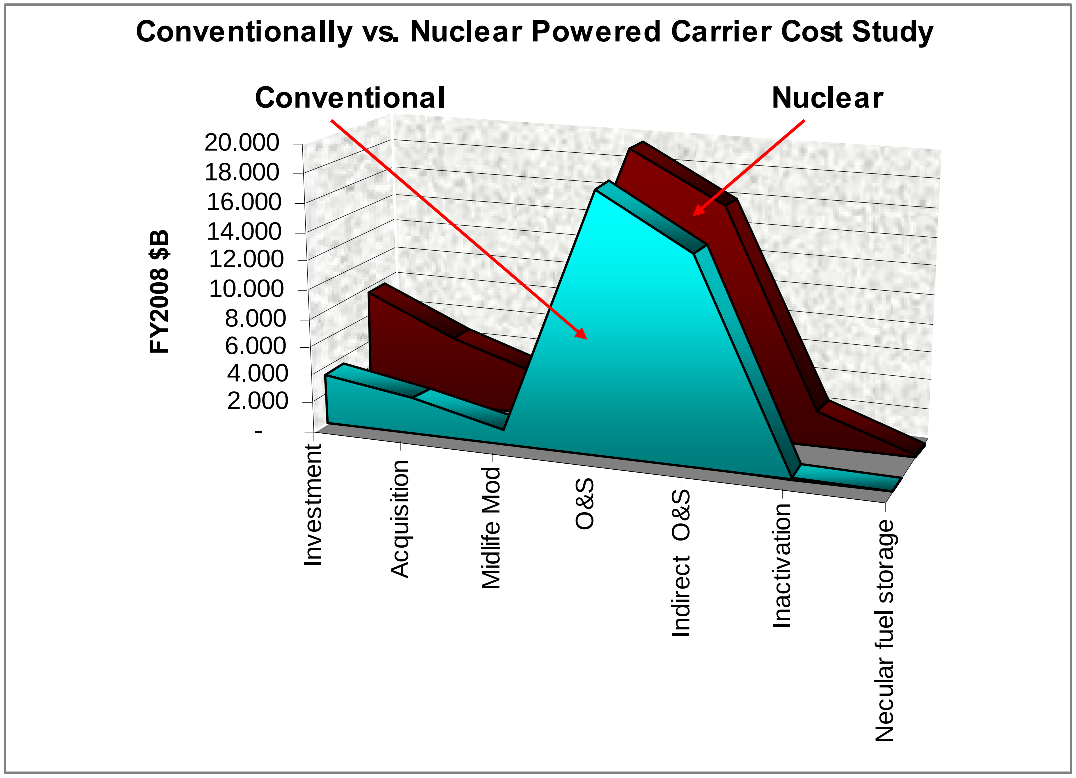
By ignoring O&S and disposal costs what are you missing?

System	% of LCC
Missile ("Wooden Round")	
• RDTE	11%
• Production/Acquisition	77%
• O&S	12%
Ship (Average)	
• RDTE	3%
• Production/Acquisition	37%
• O&S	60%
Aircraft (F-16)	
• RDTE	2%
• Production/Acquisition	20%
• O&S	78%
Ground Vehicle (M-2 Bradley)	
• RDTE	2%
• Production/Acquisition	14%
• O&S	84%

- **Early design efforts determine LCC.**
- **By the time requirements are set over 80% of LCC is committed by design decisions.**
- **By the time the design is final approximately 90% of LCC is committed!!!!**
- **Clearly the time to evaluate LCC is EARLY!!**

LCC: How do we use it?

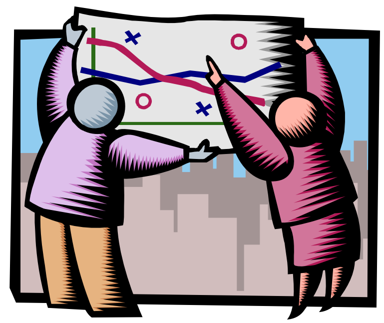
- **Option evaluation**
  - – LCC allows the evaluation of competing system proposals on the basis of total ownership cost.
- **Improved Awareness:**
  - – LCC allows management and stakeholders a broader and more accurate assessment of cost drivers.
  - – May be a first glimpse of the total cost of ownership.
  - – Facilitates the appropriate focus of resources to where they are needed.



Source: Analyses by the Naval Sea Systems Command and the Center for Naval Analysis GAO/NSIAD-98-1

LCC: How do we use it?

- **Improved forecasting and budgeting**
  - – Understanding LCC allows more effective budgeting of future funds such as O&S costs and disposal costs.
  - – Helps prevents budgeting surprises!



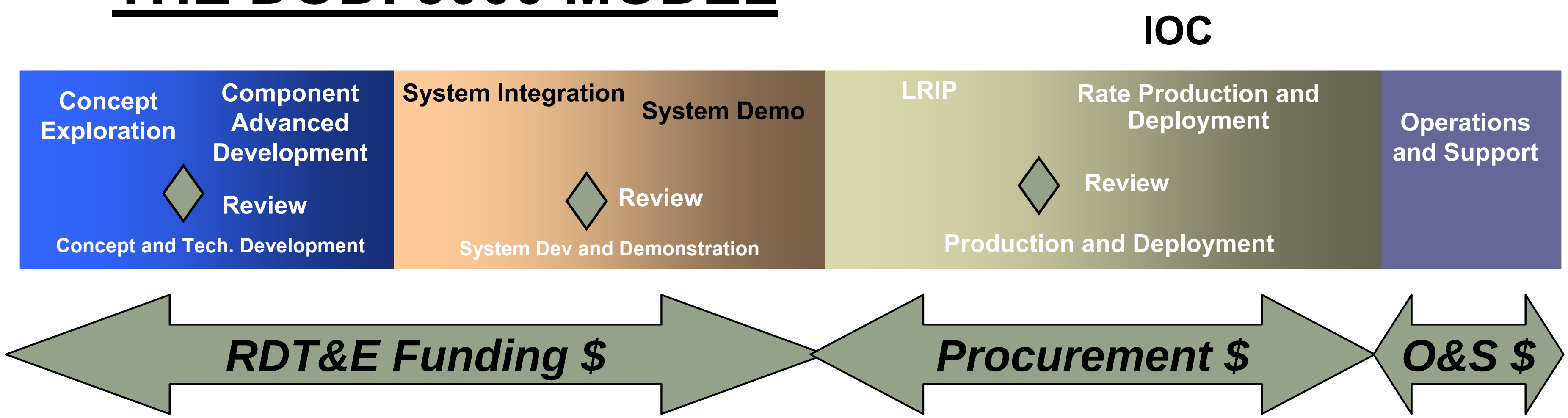
- **Cost Strategy Support**
  - – LCC perspective maximizes the benefit of applying strategies.
    - Cost as an Independent Variable (CAIV)
    - Design to Cost (DTC)
    - Reduced Total Ownership Cost (R-TOC)

Aircraft Procurement and O&S Costs		
ATTACK	UFAC	DoD Reimb
A-10A	10.7	$3,815
BOMBER		
B001B	254.7	$22,928
B002A	1,041.1	$13,294
B052H	55.4	$13,347
FIGHTER		
F015A/B	29.0	$11,220
F015C/D	31.0	$11,705
F015E	32.3	$11,781
F016A/B	15.2	$5,428
F016C/D	19.5	$4,935
F022A	95.1	$2,462
TANKER		
KC010A	79.8	$9,114
KC135R	17.7	$4,896
RECON/EW		
E003A	121.2	$8,375
E004B	96.3	$49,330
E008C	251.5	$4,037
EC130E	28.0	$2,985
EC135C	41.1	$3,106
CARGO/TRANSPORT		
C005A	119.3	$14,885
C005B	156.8	$10,849
C009A	16.5	$6,256
C009C	21.8	$5,775
C012A/C/J	3.8	$1,911
C020A/B/C	30.5	$3,952
C021A	3.4	$1,523
C130E	12.4	$3,830
C130H	29.2	$3,952
C130J	64.0	$2,536
C141B	43.9	$6,969
HELICOPTER		
HH060D/E	14.1	$3,443
UH001N	2.6	$1,063
TRAINER		
T037A/B/C	1.0	$398
T038A	3.9	$1,353
T041A/C/D	0.1	$11
T043A	21.4	$3,476

UFAC = Unit Fly Away Cost FY 05 $M
oD Reimb= flying hour reimbursement rate

LCC – Phasing and Funding

THE DODI 5000 MODEL



051 Funds (DOD TOA)

Military Personnel
O&M
Procurement
RDT&E ←
Military Construction
Family Housing
R&M Funds
Defense Wide Contingency
Offsetting Receipts
Trust Funds
Inter-fund Transactions

Total Research, Development, Test & Evaluation

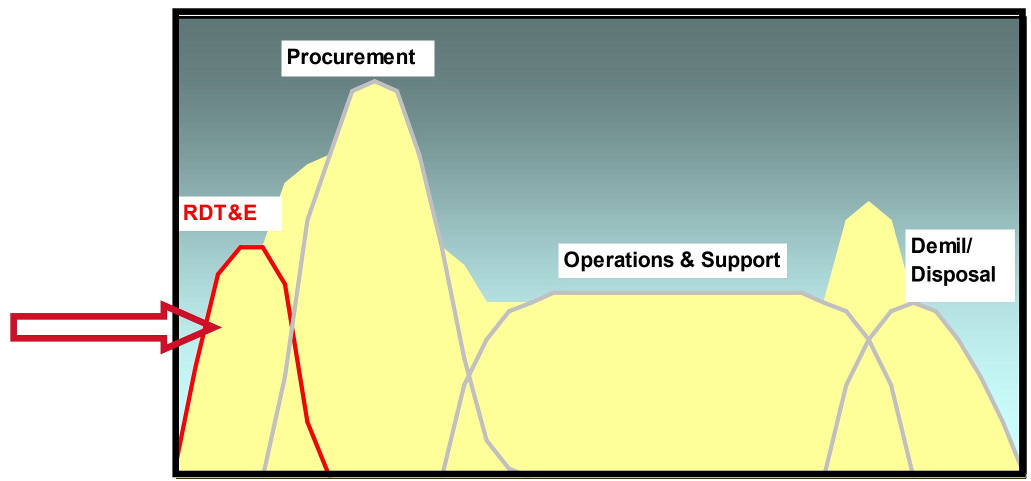
6.1 Basic Research
6.2 Applied Research
6.3 Advanced Technology Development
6.3 Advanced Component Development & Prototypes
6.4 System Development & Demonstration
6.4 RDT&E Management Support Operational Systems Development

Phase 1: RDT&E

RDT&E $ = Σ (RDT&E Program Element $)

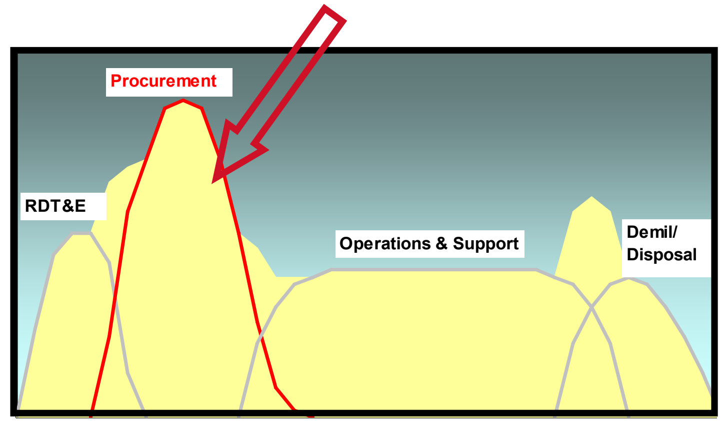
- RDT&E consists of development costs incurred from the beginning of concept through the end of development. It may include Low Rate Initial Production (LRIP) if funded with RDT&E Dollars.

- Typical cost elements include:
  – Prime Mission equipment
  – Design/Development Engineering
  – Systems Eng/Program Management
  – Data Management
  – Special Tooling and Test Equipment
  – Peculiar support equipment
  – ILS
  – Training
  – Test and Evaluation



Phase 2: Procurement

Procurement $ = Σ (LRIP, Production and Fielding Program Element $)



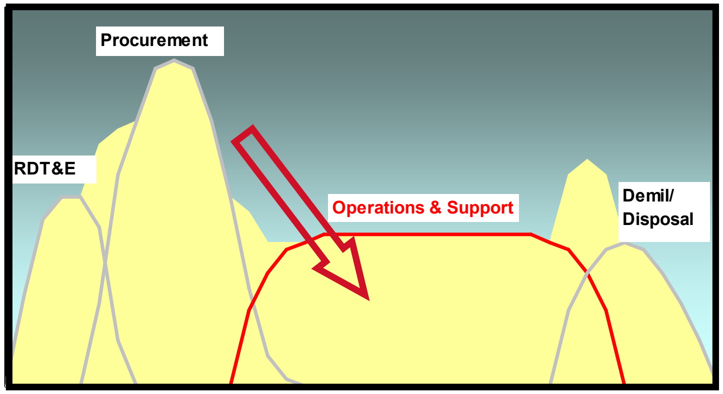
- Procurement consists of production and deployment / fielding costs from LRIP through completion of FRP and fielding.

- Typical cost elements include:
  - Prime Mission equipment
  - Integration, Assembly, and Test
  - Special tooling and Test Equipment
  - Systems Eng/Program management
  - Lot Acceptance Testing
  - Peculiar Support Equipment
  - 1st Destination Transportation
  - Initial Spares
  - Warranty
  - Container

Phase 3: O&S

O&S $ = Σ (O&S and Disposal Program Element $)

- Operating and Support costs include all costs of sustaining the system through the end of system operation. It includes all costs of operating and maintaining the system.
- Typical cost elements include:
  - Operator Training
  - Maintainer Training
  - O-level Maintenance
  - I-level Maintenance
  - Depot level maintenance
  - Support Equipment repair
  - Repair Transportation
  - Inventory management
  - Replenishment Spares
  - Mission Support
  - Software upgrades
  - Tech Manual Updates
  - Mission Programming



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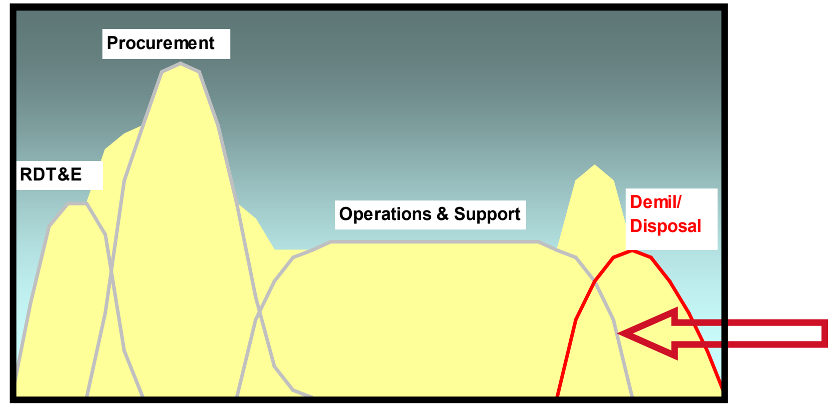
Phase 4: Disposal

- Demil/Disposal costs include all costs associated with demilitarization and disposal of the system at the end of it's useful life. These costs can be significant and should be considered early in the life cycle.
- Typical cost elements include:
  - Disassembly
  - Hazardous Material Disposal
  - Material Processing
  - Transportation
  - Documentation
  - Regulatory Compliance
- Some cost may be recouped through salvage value



Introduction to Cost Engineering Budgeting

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- "Colors" of money:
  - Nothing to do with the new currency issues.
  - DoD/Industry slang for budget/appropriations categories.
    - Each service has its own nomenclature for the various "colors."
    - Some further subdivision possible.

	Army	Air Force	Navy
Development	2040 / RDT&E	3600 / RDT&E	1318 / RDT&E
Procurement	2035 / Ammo / MIPA	3020 Missile Procurement	1507 / WPN
Operations & Support	2020 / OMA	3400 Operations and Maintenance	1804 / O&M

DoD Appropriations by Title, including Supplementals

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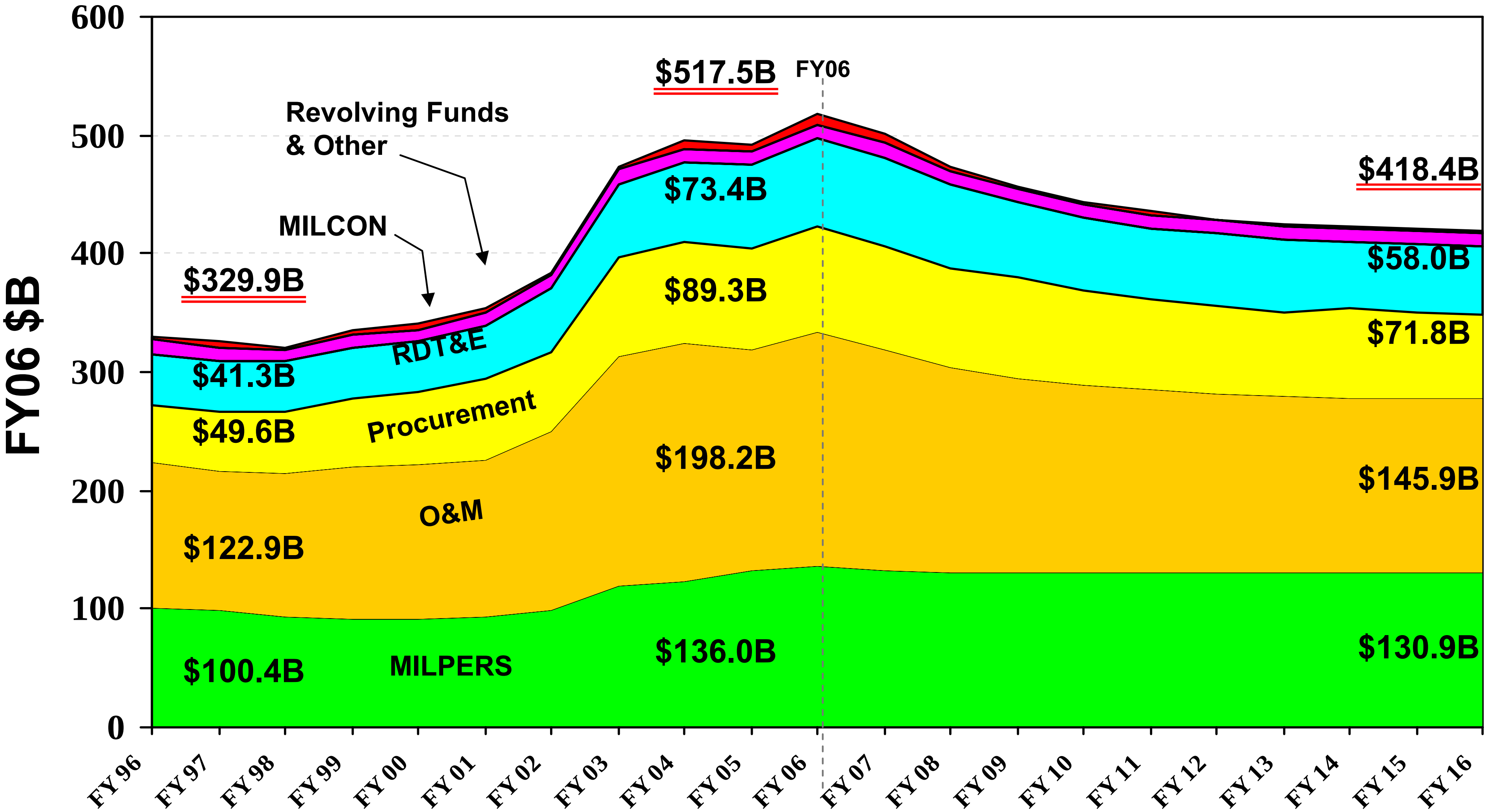
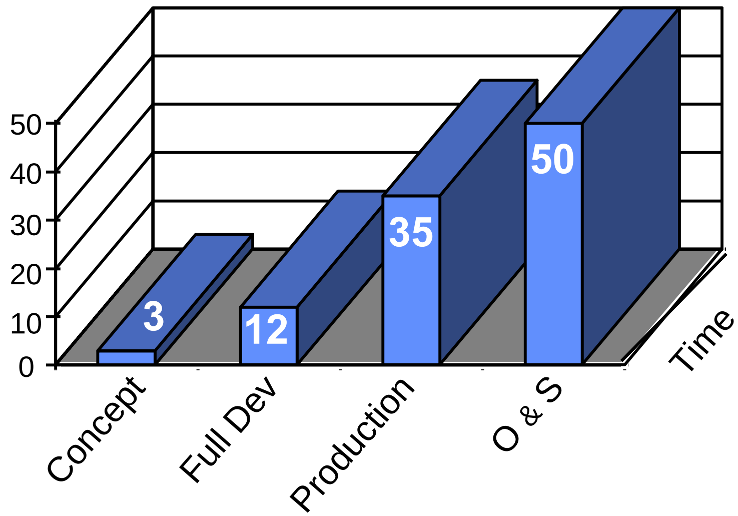
From GEIA 2006 Vision Conference

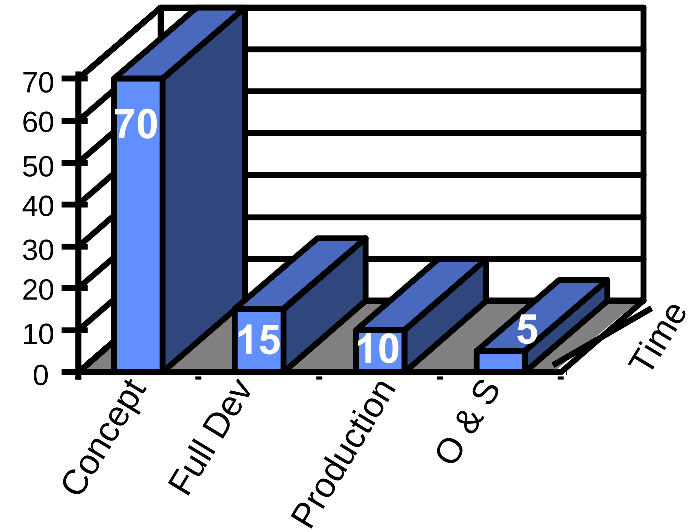


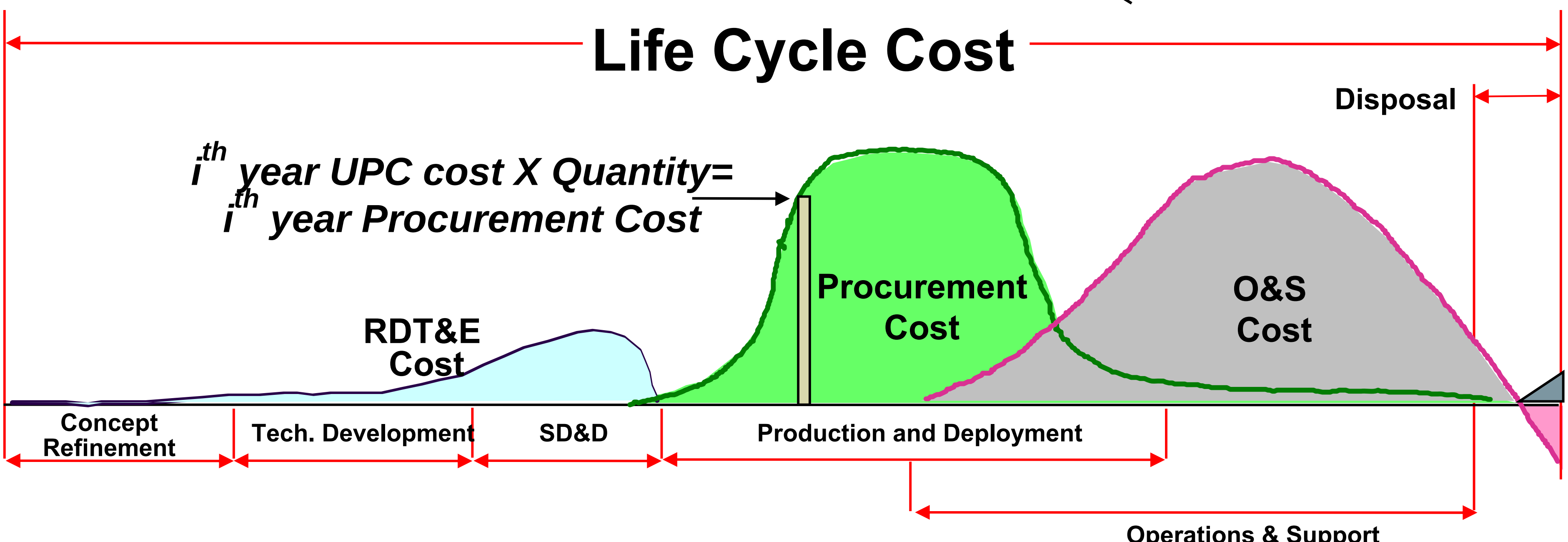
Trade Space Window Of Opportunity

Life Cycle Cost Spent (%)

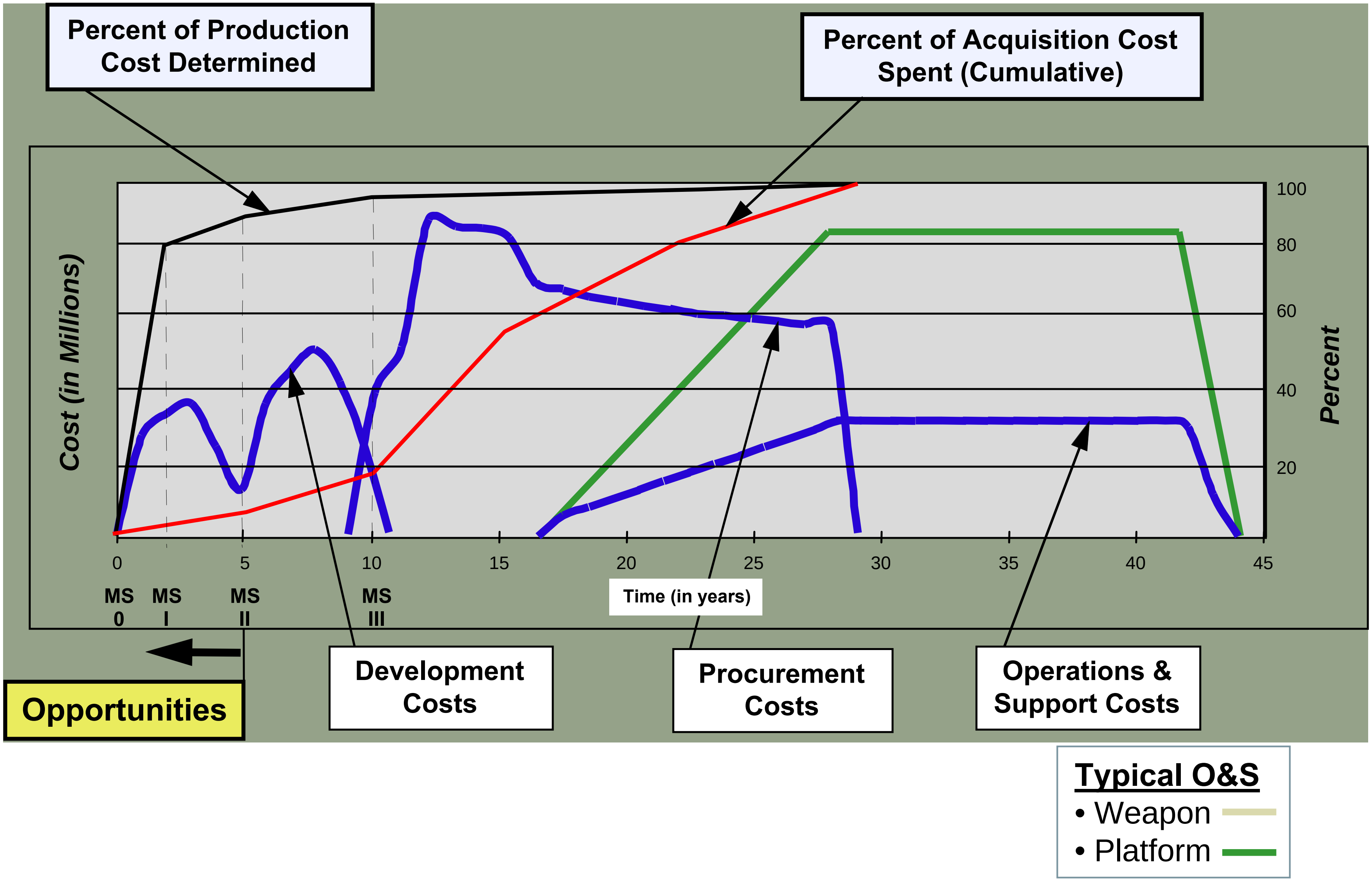


Impact On Life Cycle Cost (%)





Missile Cost History



DoD Budgets on a Yearly Basis but Plans on a 5 / 6 Year Cycle

"HOW" Design to LCC IS UTILIZED

1. **Determine the *customer concerns* and understand those concerns**
   - Explicit – States cost goals or operating budgets
   - Implicit – Customer desire to reduce operational staffing
   - Next Phase – Contract contains a limited budget / funding
   - Unit Production – Average unit production cost (AUPC) goals
   - Total Ownership Costs (TOC) – Reduced total ownership costs (RTOC)
   - Life Cycle Costs (LCC) – must be some determine percent (normally 30%) less than the replacement system
2. **Determine how the *competition impacts* affordability**
   - Marketing determines cost time to WIN the contract
   - Existing inventory items with potential modification costs
3. **Set *design goals* (including system cost goals and targets)**
   - Top level system or architecture
   - Subsystems
   - All phases
4. **Understand system *requirements vs. system affordability***
   - Perform economic analysis
   - Establish a cost as an independent variable, design to life cycle costs or design to cost program
5. ***Review* the present estimates against goals often and *react* appropriately and expediently**

Planning the Analysis

- Identify ground rules and assumptions
  - Any assumptions that will bound, constrain, or otherwise impact the analysis.
    - ✓ Life cycle/ horizon
    - ✓ Base year dollars
    - ✓ Production units
    - ✓ Schedule
    - ✓ Performance constraints

- Identify ground rules and assumptions – cont.
  - Estimate resources required and reporting schedule

SOURCE DATA				
Acquisition Scenario				From ASP Study (Can also Use Therm
Development (EMD)	See Cost Distribution Model)			Enter total anticipated production qua
Total ADM Protype Quantity	1.5	3		= Years in ADM Phase
Total SDD Protype Quantity	4	4		= Years in SDD Phase
SDD Production Occurs From	2007	2011	4	
Production				
Total Production Quantity	344			Enter total anticipated production qua
Production Occurs From	2012	2027	15	Years over which
Production Rate (Yearly even)	22.93			Average Quantity Built Each Year
O&S				Used Therman's model to calculate thi
Years Operational	10			Estimated Fielded (Operational) Years
Years from Production to IOC	2			Must be 1 or greater! Includes 1st yea
Net Years of O&S Costs	26		0.692	= Cost factor for e
Fielding	2.5%			Used Therman's model to calculate thi
Annual Sustainment (O&S)	9.0%			Used Therman's model to calculate thi
Economics				
Constant Year Dollars	2002			Model is built using 2002 dollars
Overhead rates (Composite)	50%			Used to calculate all non HW direct co
Learning Curve				
Labor	0.90	-0.152003093		
Commerical Items (diodes)	0.92	-0.120294234		Also used in Cost Distribution model
Material & Purchased Parts	0.95	-0.074000581		
Production Parts	0.89	-0.168122759		

Planning the Analysis

- Determine the life cycle
  - System service life: Useful life of the system depends on what the system is.

    (i.e. aircraft – 25 years, ship – 50 years, missile – 20 years, bridge – 100 years, etc.)
  - Planning Horizon: Period of time over which all costs are estimated.
  - May not coincide or may change over time.

Planning the Analysis

- Cost element structure (CES)
  - Estimating LCC requires breaking down the system into its cost elements and time phasing them.
    - There is no standard CES for all LCC applications due to the tremendous variation in systems and programs (aircraft, missiles, electronics, ships, infrastructure, etc)
    - The CES may be imposed as a requirement
    - The level of CES detail will depend on the system as well as the purpose of the analysis. Consider:

      Estimation methodology

      Significant cost generating components.

      Support philosophy

Cost Element Structure

1.000 RTDT&E Funded Elements

Concept & Tech Development
1.010 Development Engineering & Planning
1.020 Producibility Engineering & Planning
1.030 Development Tooling
1.040 Prototype Manufacturing
1.050 System Engineering/Program Management
1.051 Project Management Administration
1.052 Other
1.060 System Test and Evaluation
1.070 Training
1.080 Data
1.090 Support Equipment
1.091 Peculiar
1.092 Common
1.100 Development Facilities
1.110 Other RDT&E

System Dev & Demonstration
1.010 Development Engineering & Planning
1.020 Producibility Engineering & Planning
1.030 Development Tooling
1.040 Prototype Manufacturing
1.050 System Engineering/Program Management
1.051 Project Management Administration
1.052 Other
1.060 System Test and Evaluation
1.061 System Demo
1.070 Training
1.080 Data
1.090 Support Equipment
1.091 Peculiar
1.092 Common
1.100 Development Facilities
1.110 Other RDT&E

2.000 Procurem... Production...
2.010 NonRecurring...
2.011 Initial Product...
2.012 Production Ba...
2.013 Other NonRec...
2.020 Recurring Pro...
LRIP Producti...
2.021 Manufacturing...
2.022 Recurring Eng...
2.023 Sustaining To...
2.024 Quality Contr...
2.025 Other Recurri...
Rate Producti...
2.021 Manufacturing...
2.022 Recurring Eng...
2.023 Sustaining To...
2.024 Quality Contr...
2.025 Other Recurri...
2.030 Engineering C...
2.040 System Engin...
2.041 Project Manag...
2.042 Other
2.050 System Test a...
2.060 Training
2.070 Data
2.080 Support Equip...
2.081 Peculiar
2.082 Common
2.090 Operational/S...
2.100 Fielding
2.101 Initial Depot-L...
2.102 Initial Consum...
2.103 Initial Support Equipment
2.104 Transportation (Equipment to Unit)
2.105 New Equipment Training
2.106 Contractor Logistics Support
2.110 Training Ammunition/Missiles
2.120 War Reserve Ammunition/Missiles
2.130 Modifications
2.140 Other Procurement

3.000 Military Constru...
3.010 Development Construct...
3.020 Production Construction...
3.030 Operational/Site Activat...
3.040 Other Military Construct...

4.000 Military Personn...
4.010 Crew
4.020 Maintenance
4.030 System-Specific Suppo...
4.040 System Engineering/Pr...
4.041 Project management Ad...
4.042 Other
4.050 Replacement Personnel...
4.051 Training
4.052 Permant Change of Sta...
4.060 Other Military Personne...

5.000 Operations and...
5.010 Field Maintenance Civili...
5.020 System Specific Base C...
5.030 Replensihment Depot L...
5.040 Replenishment Consum...
5.050 Petroleum, Oil, and Lub...
5.060 End Item Supply and M...
5.061 Overhaul
5.062 Integrated Materiel Man...
5.063 Supply Depot Support
5.064 Industrial Readiness
5.065 Demilitarization
5.070 Transportation
5.080 Software
5.090 System Test and Evalua...
5.100 System Engineering/Pr...
5.101 Project management Ad...
5.102 Other
5.110 Training
5.120 Other O&M

6.000 Defence Business Operations Fund Elements
6.010 Class 1X War Reserve
6.020 Other DBOF

Select / Develop the Model

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- Some general guidelines
  - Should be responsive to changes in design and operational scenarios.
  - It should clearly incorporate all major cost drivers.
  - Include clear documentation
  - User friendly and should not require special programming support.
  - Allow for adjustment of inflation, discounting, and learning curve where appropriate.
  - Be able to compare and contrast alternatives
  - Identify areas of uncertainty
  - Support sensitivity analysis

HEL Weapon Cost Model - BETA #3 Release Of 5/29/02 - GLS (545-6104)

Notes: User input Cells are in Blue.
Red idenotes key areas

Yearly diode buy Quantity: see N4

SOURCE DATA			
Acquisition Scenario			From ASP Study (Can also Use Therman's model
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	Specifications	Terminology	Unit Cost ($ K)	Factors	
HMMWV Laser WS Concept Unit Production Cost			4,583.47		
Platform (HMMWV) and Shelter			125.94		At 200 Units
HMMWV		From VMADS Study	97.05		101.03
Roof/Structure		From VMADS Study	9.30		9.68
Gyro Support		From VMADS Study	4.65		4.84
Structure IA&T		From VMADS Study	9.99		10.40
HEL Weapon			3,937.22		
Laser Subsystem			1,792.7		
Laser Diodes	15	KW Laser Energy Output	952.0	63.46	AUPC for array - $
2 Watt Diode Cost $	$1,190.00	Est. Unit Cost in low quantity		$153.50	Unit cost (from intel
Adaptive Optics - beam shaping	13.0	cm -Edge Size for Mirror	377.77		Note; this Length is hard wir
Laser Cavity	Missing (In Adaptive Optics?)		Missing		
Laser Materials (GGG Heat Capacity Ma	13.0	cm -Edge Size for Material	83.71		
Mirors	3	Number	26.99	8.0	Weight Each in LBS
PFM Cards	$10.50	$K for first unit card (T1)	319.79	108	Number of Cards ((
Inter-Cavity Beam Control	Missing (In Adaptive Optics?)		Missing		
Structure - Laser & associated assembli	200.0	Lbs - Assume Steel Rails	32.44		
Diode Current Regulator	Missing (In PFM Cards?)		Missing		
Beam Control Subsystem			1,648.22		
EO Laser Tracker	344	ATFLIR - Learning to Qty	1,088.79		
Tracker	90%	% ATFLIR Cost	826.41		
Illuminator - 30W	35%	% ATFLIR Cost	126.65		
Power	75%	% ATFLIR Cost	12.80		
Video	75%	% ATFLIR Cost	85.98		
Structure	25%	% ATFLIR Cost	36.95		
Telescope	Missing (In Mirrors?)		Missing		
Beam Steering	Missing (In Mirrors?)		Missing		
Main Beam Director	5	Number or Mirrors	181.65	15.0	Edge in cm Mirrors
Adaptive Optics	1	Number or Mirrors	377.77	13.0	cm -Edge Size for M
Beam Clean-up	Missing (In Adaptive Optics?)		Missing		
Power Subsystem	346.42	KW Power to Generate	338.99	280	KW Power VMADS
System Power Generator				4.33%	Efficiency - Input po
Intermediate Power Storage					
Power Processing Unit				75%	Battery Recharge fa
Power Controller Unit				1	0=Lead Acid, 1=Adv
Battery Subsystem (Advanced)	346	KW Stored Energy	211.58	23.09	Scalling Factor to a
Power Conditioning	31%	VMADS % from 100 KW	104.69		Scaled from VMAD
Coll. Supply	*0%*	*VMADS % from 100 KW*	-		*Scaled from VMAD*
Gun Assy	*0%*	*VMADS % from 100 KW*	-		*Scaled from VMAD*
Source Supply	31%	VMADS % from 100 KW	9.35		Scaled from VMAD
Structure	31%	VMADS % from 100 KW	6.35		Scaled from VMAD
Electronics	31%	VMADS % from 100 KW	0.11		Scaled from VMAD
Power Conditioning IA&T	31%	VMADS % from 100 KW	6.92		Scaled from VMAD
Thermal Subsystem	224.89	KW Power to Dissipate	157.35	100	KW Power VMADS

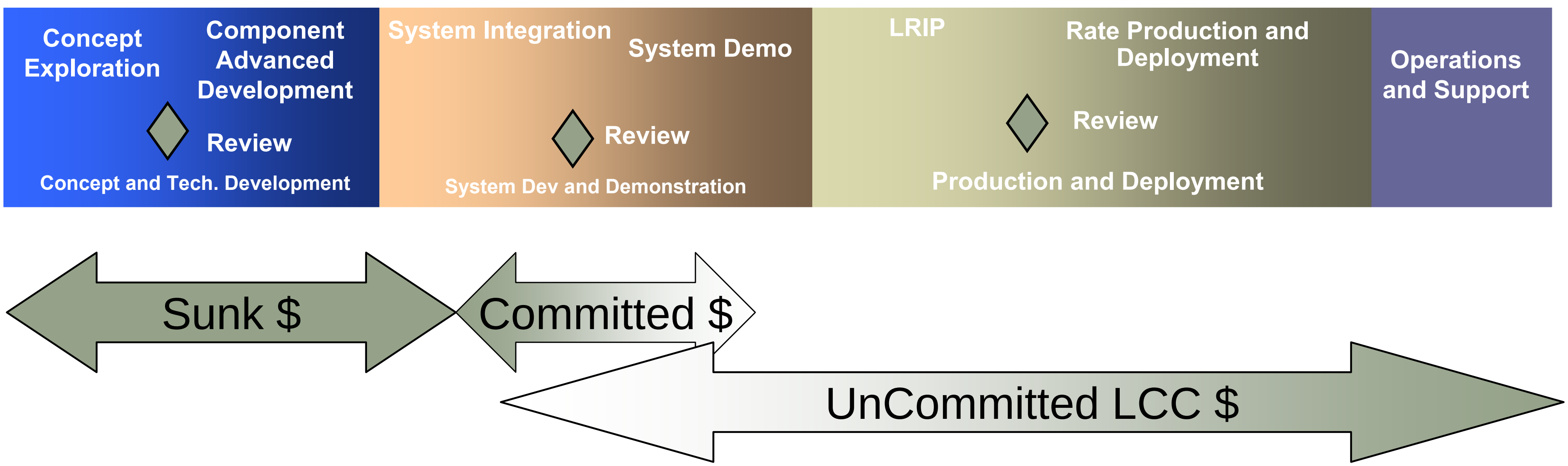
LCC vs. Sunk Cost

LCC = RDT&E $ + Procurement $ + O&S $

Sunk costs are cost already spent

Committed costs are contracted for costs not yet spent (Sunk) - Where in the cost to cancel equals or exceeds the cost to continue the effort.

Therefore, early in SDD, the LCC_a still subject to design trades is:



LCC_a is the LCC still available or subject to be traded

LCC_a = RDT&E $ (Uncommitted SDD $) + Procurement $ + O&S $

where uncommitted SDD $ = RDT&E $ - (Sunk $ + Committed RDT&E $)

LCC_a Trade Space vs. Sunk Cost

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Design Trades are only conducted for costs which you can influence!

Possible Cost ($) Trade Spaces Are:

1. Minimizing: Total LCC_a (LCC = $RDT\&E_a$ + $Procurement_a$ + $O\&S_a$)
2. Minimizing: $RDT\&E_a$ vs. $PROC_a$ vs. $O\&S_a$ (vs. $Disposal_a$)
3. Separate Individual Pots of Money. E.g. $RDT\&E_a$ vs. RDT&E Goal, $PROC_a$ vs. PROC Goal, and $O\&S_a$ vs. O&S Goal

Note: $Disposal_a$ is assumed to be included within $O\&S_a$

REMEMBER – Frequently there are Technological Answers, Budgetary Answers and Political Answers and usually they are NOT THE SAME.

OR: LCC Metric = RDT&E * (RDT&E Politics Value)
+ Procurement * (Procurement Politics Value)
+ O&S * (O&S Politics Value)

Sunk Costs are Cost already Spent plus Committed Costs.
Committed Costs are Contracted for Tasks/Costs which are not yet fully Spent (Where in the Cost to Cancel Equals or Exceeds the Cost to Continue the Effort). Therefore, Early in SDD, the LCCa Still Subject to Design Trades is:

LCCa = RDT&E $ (Uncommitted SDD $) + Procurement $ + O&S $
where Uncommitted SDD $ = RDT&E $ - (Sunk $ + Committed RDT&E $)

TRADE SPACE MATRIX – Cost Metric

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Optional Cost Factors

COST Metric	AUPC			
COST GOAL	Threshold	Goal	Current	Current/Goal
Cost-System				
Sub-System				
Sub-System				
Sub-System				
Sub-System				
Sub-System				
Sub-System				

AUPC (average unit procurement cost or average unit production cost)

COST Metric	RDT&E				Procurement				O&S (+ Personnel and Disposal)			
COST GOAL	Threshold	Goal	Current	Current/Goal	Threshold	Goal	Current	Current/Goal	Threshold	Goal	Current	Current/Goal
Cost-System												
Sub-System												
Sub-System												
Sub-System												
Sub-System												
Sub-System												
Sub-System												

LCC (by Phase: RDT&E $, Proc. $, O&S $)

COST Metric	LCC			
COST GOAL	Threshold	Goal	Current	Current/Goal
Cost-System				
Sub-System				
Sub-System				
Sub-System				
Sub-System				
Sub-System				
Sub-System				

LCC (Total $)

COST Metric	O&S (+ Personnel and Disposal)
COST GOAL	Unique Personnel Req. or Disposal Issues
Cost-System	
Sub-System	
Sub-System	
Sub-System	
Sub-System	
Sub-System	
Sub-System	

O&S, Disposal and Personnel

Politically Correct Answer?

Selection of the "Best Value" Alternative

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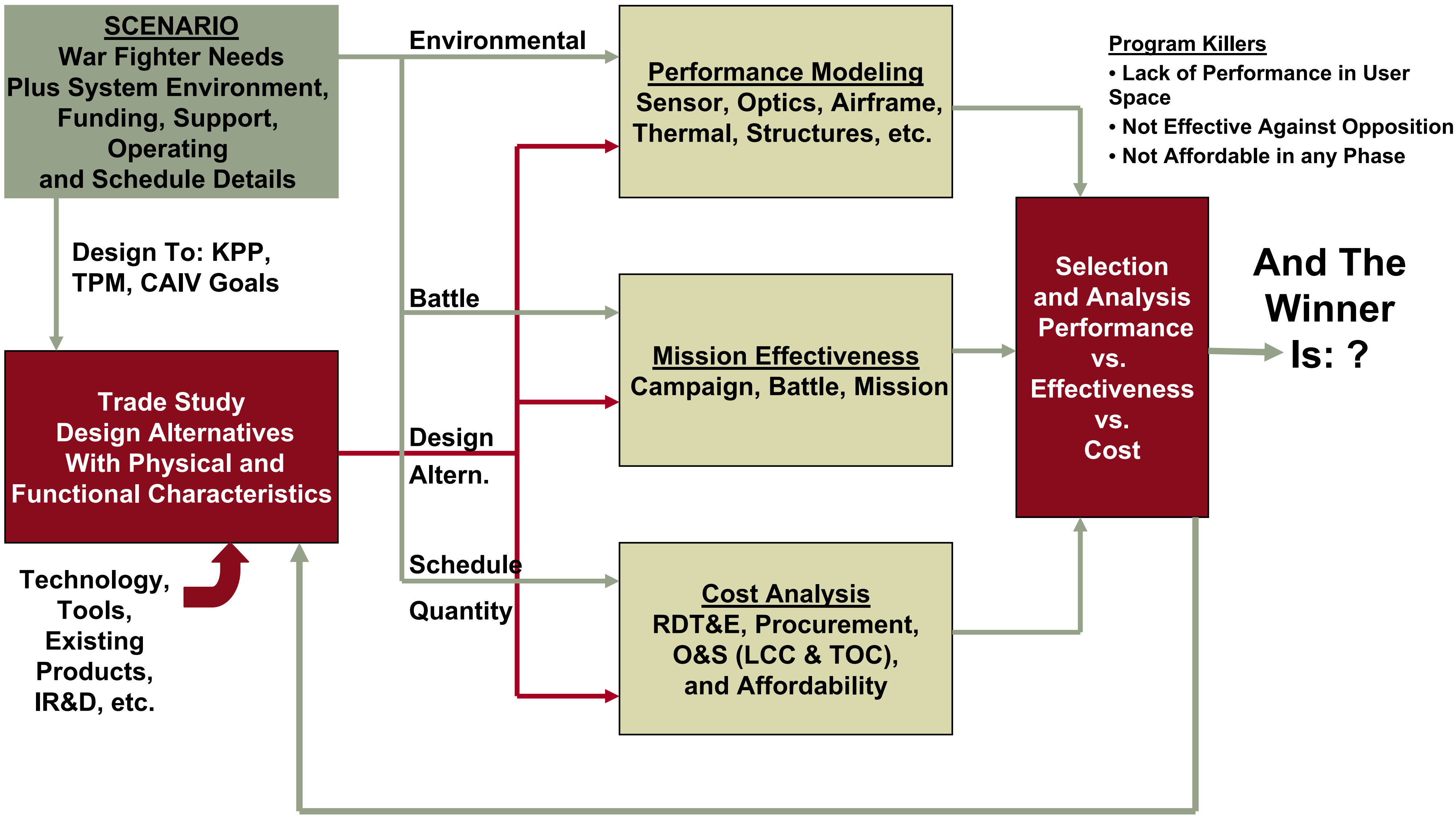
Trade Off DECISION POINT



"TRY AGAIN" (New Alternative or Adjust Existing Alternative) with Suggestions

Software is included in the "Best Value" Alternative

DECISION POINT

Trade Study Design Alternatives With Physical and Functional Characteristics

Technology, Tools, Existing Products, IR&D, etc.

Missile Alternative

- Physical and Functional Characteristics
  - Size, Weight, Speed, Range, Payload, etc.
  - Functions Performed (Search, Ballistic Load, etc.)
    - Hardware Resident
      - Seeker Head
      - Propulsion, Warhead, etc.
    - Software Resident
      - Target ID, Tracker, etc.
    - HW/SW Combined
      - Position in Space (IMU and GPS)

Software Issues

- **Functions Performed**
  - **Lines of code**
  - **Interfaces**
- **Coding Group Capabilities**
- **Environment**
- **Schedule**
- **Existing (mod/reuse/etc)**

Software Alternatives. . . Consider the Life Cycle

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Software DECISION POINT

HW vs. SW Trades

NEW SW Development

- Requirements (11%)
- Design (14%)
- Code (24%)
- Test (27%)
  - Function / Integ / Sim
  - SW in the Loop
  - HW in the Loop
  - Flight Tests (AD, SD)
  - Quality
- Documentation (10%)
- Installation (1%)
- Management (13%)

Enhancement and or Maintenance

Enhancement and or Maintenance

Enhancement and or Maintenance

SW does not age! However, as HW, processes, situations and people change, enhancements (and maintenance) are required. These can either be planned for as a continuous maintenance contract or in separate modification / upgrade contracts. Funding can be through O&S or RDT&E Funds.

SW LCC $s

- RDT&E – Large
- Procurement - ≈ Zero
- O&S – 50-75% of LCC
- Disposal - ≈ Zero

(avg. Dev to Supt = 47-53%)

LCC Sensitivity Analysis
Look for the Cost Driver(s)

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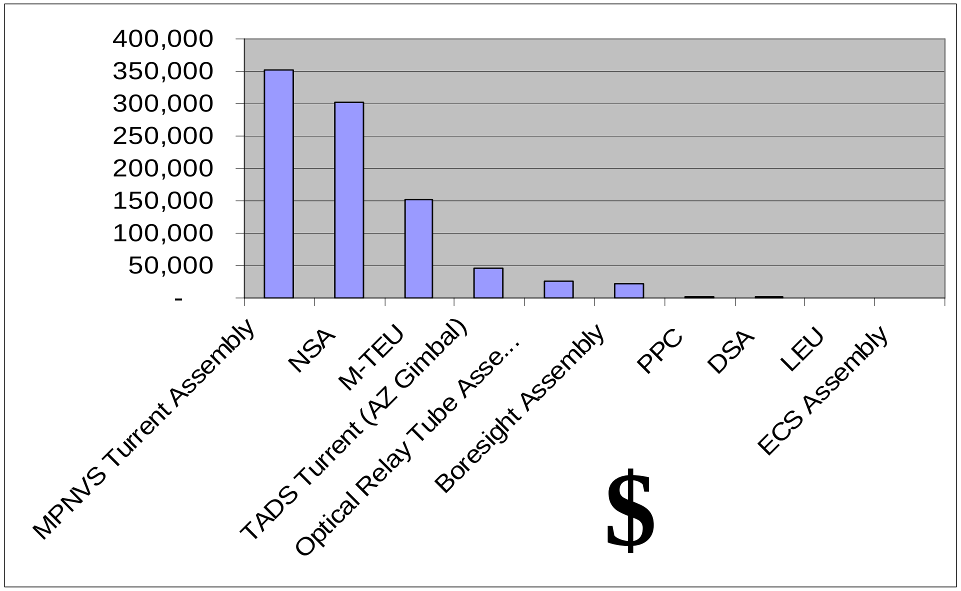
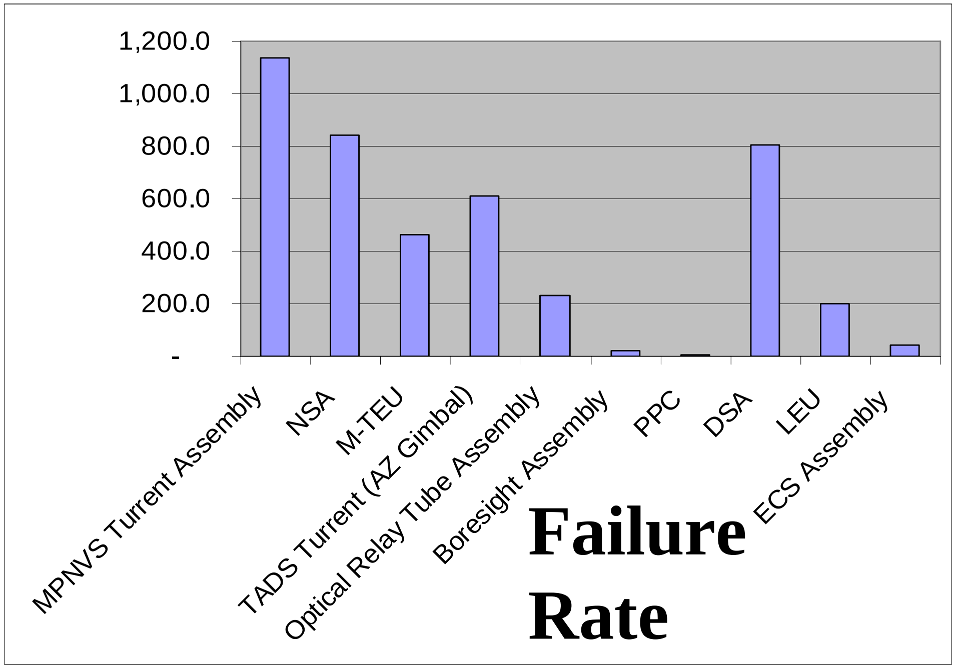
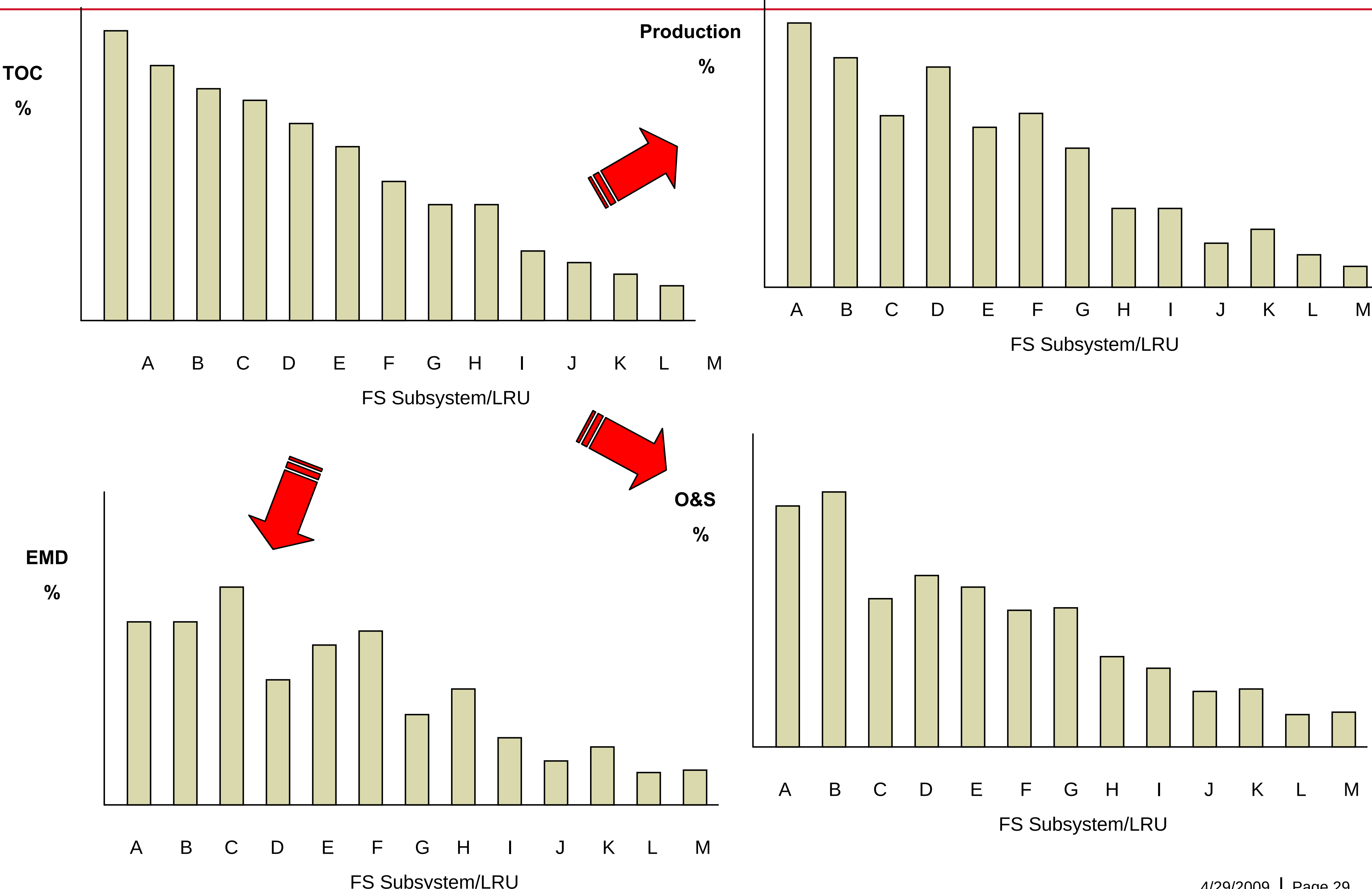
- Sensitivity analysis is useful for performing what-if analysis, determining how sensitive the point estimate is to changes in the cost drivers, and developing ranges of potential costs.
  - *The example shown is for project FS and is a pareto of its LRU estimated failure rates and their effect upon the project LCC estimate*
  - *Note that while the over all LRU failure rate may be a significant driver for the systems maintenance costs and therefore its LCC estimate, this is not true for every LRU.*
- A drawback of sensitivity analysis is that it looks only at the effects of changing one parameter at a time.
- In reality, many parameters could change at the same time.
- Therefore, in addition to a sensitivity analysis, an uncertainty analysis should be performed to capture the cumulative effect of additional risks.

(From GAO Cost Guide, Chapter 14)





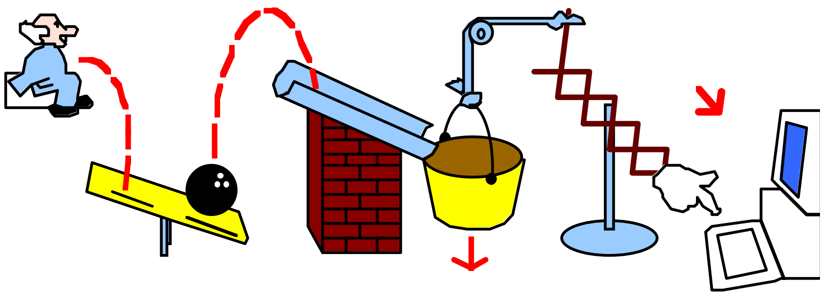
Sensitivity Analysis for Project FS Pareto – TOC/LCC $ and Phased $



Cost Risk and Uncertainty

- Cost risk and uncertainty refer to the fact that because a cost estimate is a forecast, there is always a chance that the actual cost will differ from the estimate.
  - lack of knowledge about the future
  - the error resulting from historical data inconsistencies, assumptions, cost estimating equations, and factors that were used to develop the estimate
  - biases get into estimating program costs and developing program schedules.
    - biases may be cognitive—often based on estimators' inexperience
    - or motivational where management intentionally reduces the estimate and/or shortens the schedule to make the project look good to stakeholders.
  - Recognizing the potential for error and deciding how best to quantify it is the purpose of risk and uncertainty analysis.

From GAO Cost Guide, Chapter 14



"You can start with erroneous assumptions, then use impeccable logic to arrive at the grand fallacy"
Darrell Gieseking

Risk and Uncertainty

- Risk is the chance of loss or injury. In a situation that includes favorable and unfavorable events, risk is the probability an unfavorable event occurs.
- Uncertainty is the indefiniteness about the outcome of a situation. It is assessed in cost estimate models for the purpose of estimating the risk (probability) that a specific funding level will be exceeded.

- For management to make good decisions, the program estimate must reflect the degree of uncertainty, so that a level of confidence can be given about the estimate.
- Having a range of costs around a point estimate is more useful to decision makers, because it conveys the level of confidence in achieving the most likely cost and also provides information regarding cost, schedule, and technical risks
- Point estimates are more uncertain at the beginning of a program, because less is known about its detailed requirements and opportunity for change is greater. In addition, early in a program's life cycle, only general statements can be made. As a program matures, general statements translate into clearer and more refined requirements that reduce the unknowns. However, more refined requirements often translate into additional costs, causing the distribution of potential costs to move further to the right.

From GAO Cost Guide, Chapter 14

The S Curve
(or cumulative probability curve)

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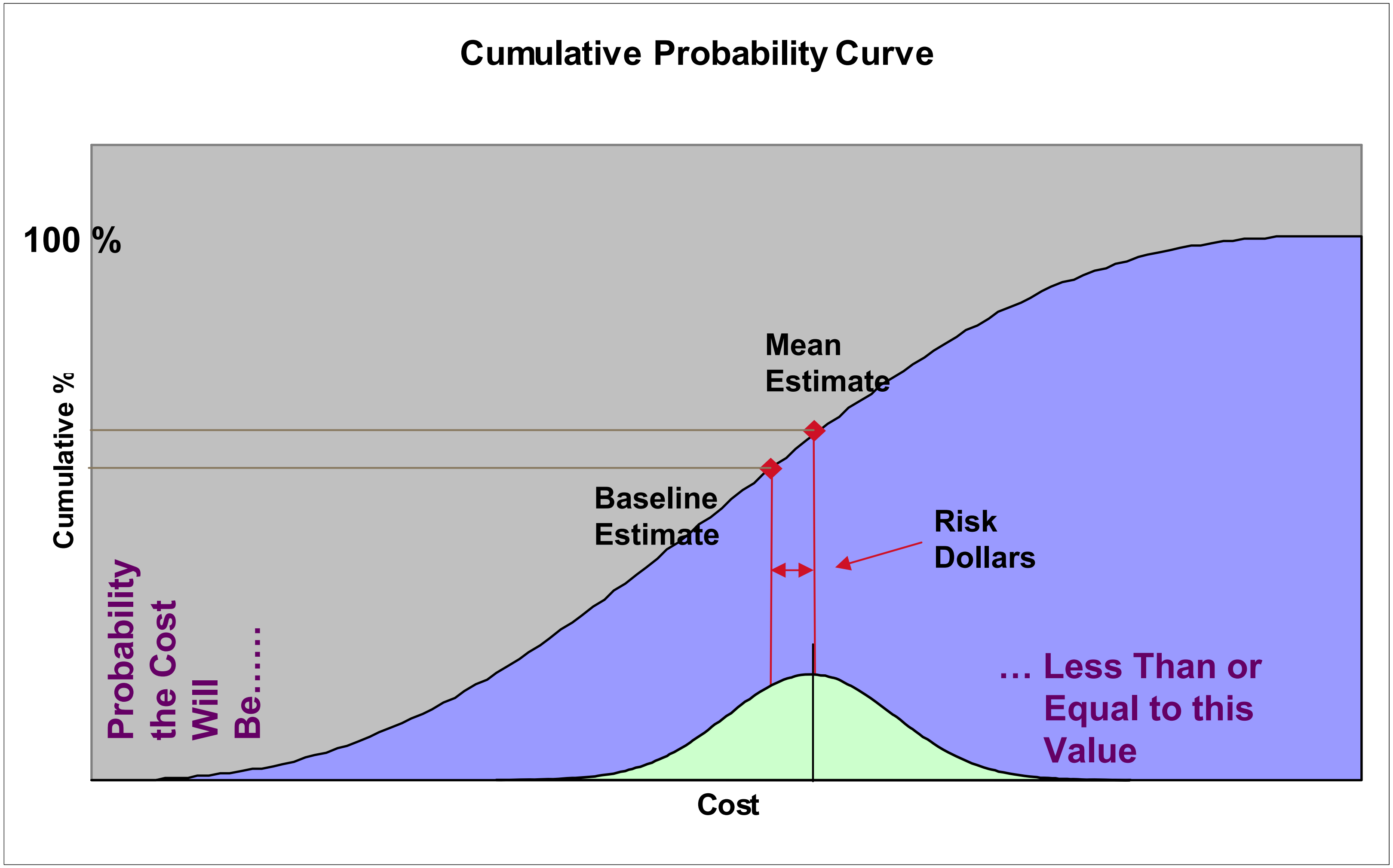
- Cost estimates should be based upon variables that are specified with realistic ranges for all inputs.
- Consider far future events as having potentially a greater risk – technology, or environment changes may not be known



Estimates Must Contain Ranges

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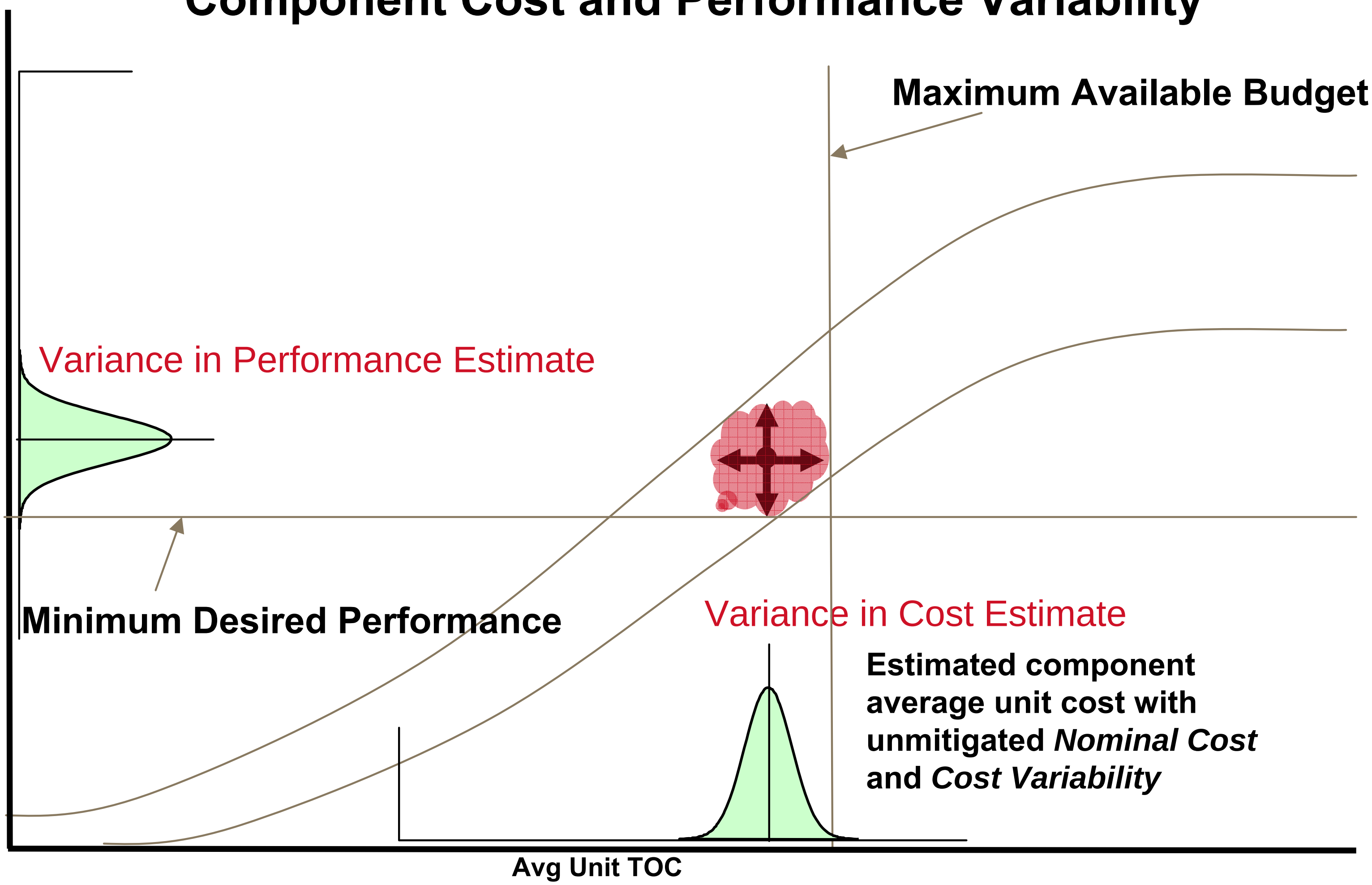
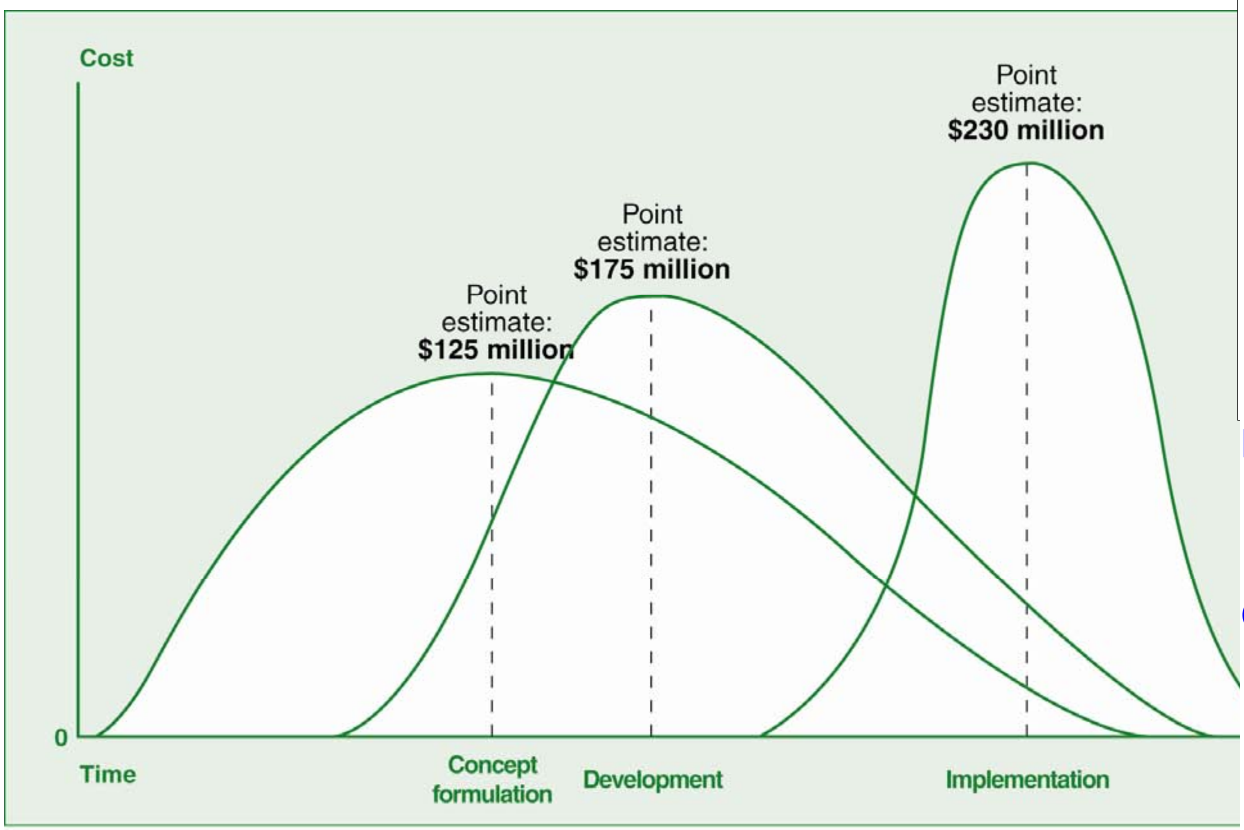
It's amazing the estimates we generate on tasks we really don't yet understand………
but each side wants cost/schedule/ earned value containment (Greg Shelton, RTN Ret.)

Component Cost and Performance Variability



Cost Risk and Uncertainty (2)

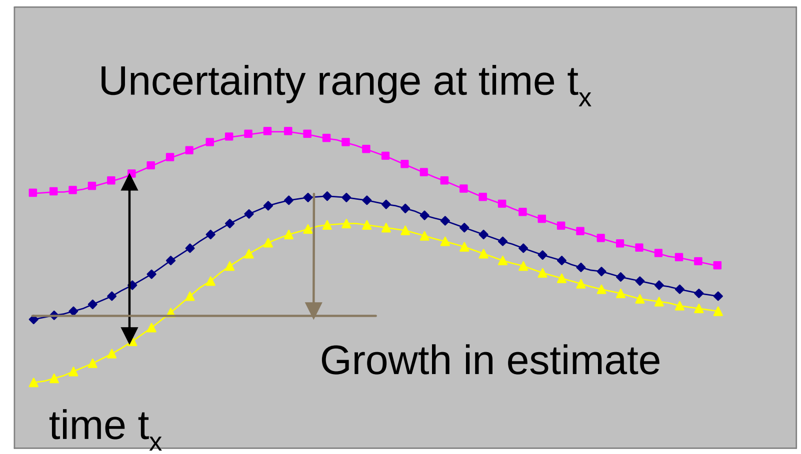
- DOD specifically directs that uncertainty be identified and quantified.
- The Clinger-Cohen Act requires agencies to assess and manage the risks of major information systems, including the application of the risk adjusted return on investment criterion in deciding whether to undertake particular investments.



Source: GAO.

From GAO Cost Guide, Chapter 14, Figure 15: Changes in Cost Uncertainty across the Acquisition Life Cycle

Estimate Uncertainty Through Development



Estimate Uncertainty decreases as knowledge increases over time. E.g width of uncertainty range decreases.

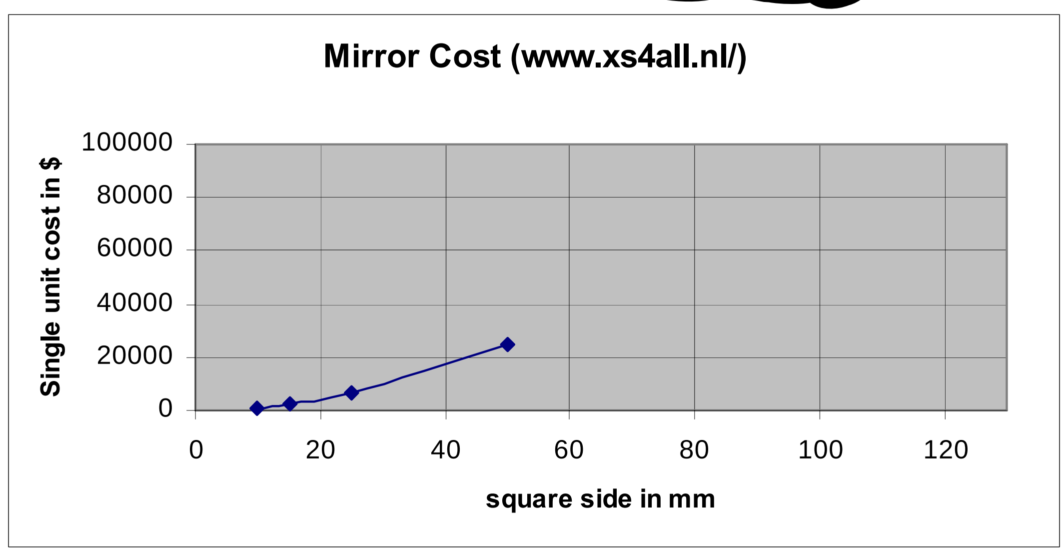
Growth in estimate occur due to increased knowledge and new requirements. Later reductions in growth are possible if cost management techniques are aggressively employed early on in the program life.

Document and Review Results

- **Review Results**
  - Ground Rules and Assumptions
  - Modeled System
  - Overall LCC
  - Cost Drivers
  - Spikes
  - Measure of Effectiveness
  - Program Risks and Uncertainties

- **Document**
  - If no one can figure out what you did, how you did it, and why you did it ----- It doesn't count!!

  *(Hard truth: The program may last longer than you)



Summary

- **LCC is the total cost to the customer for a program over its full life.**
  - Cost, including LCC is an engineering design parameter.
    - Total cost impact, not just initial near-term cost, must be considered
    - Each Phase (Color of Money) estimate is important!
  - Early estimates are just estimates! Look at the risks and uncertainty within those estimates. Be prepared for and manage growth.

- **More and more customers (especially government) are emphasizing and requiring an LCC perspective.**
  - Early design efforts determine LCC. Don't wait!!!!