



Affordability Measurement: Exploring Qualitative Approaches

(14939)

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Group*

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PSM Affordability Measurement Project



- ***Definition: Affordability measurement is the use of quantitative methods to provide insight into the effectiveness of affordability practices and/or the techniques used to perform affordability analysis.***
- ***Project Objective: Work collaboratively with the following industry teams***
 - ***INCOSE Affordability Working Group, Joe Bobinis (Lockheed Martin) Chair***
 - ***NDIA Affordability Working Group Frank Serna (Draper Laboratory), Chair***
 - ***MORS “Affordability Analysis: How Do We Do It?” Workshop, Kirk Michealson (Lockheed Martin), Chair – October 1-3, 2012***
to advance industry guidance for affordability measurement.
- ***Expected Output: White Paper providing measurement amplification to MORS, INCOSE and NDIA affordability work along with addressing other relevant affordability issues in measurement .***



This Presentation

- *Summarizes progress and intent of several industry affordability teams from a measurement perspective*
- *Discuss some aspects of affordability that may be better addressed qualitatively*



Affordability Measurement

- **Quantitative**

- *Indicators meant for use by higher level management both customer and supplier: perhaps think of this as what should be in an Affordability Analysis review package, or indicators tracked during TD and EMD that are associated with Full LCC*
- *Indicators meant for use by lower level management on the customer or supplier teams*
- *Low level nitty gritty analysis*

- **Qualitative**

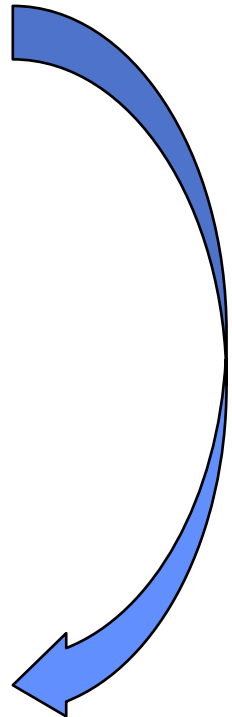
- *Subjectively evaluated criteria of what is required to manage Affordability effectively, or evaluate Affordability Analyses*



INCOSE Affordability WG

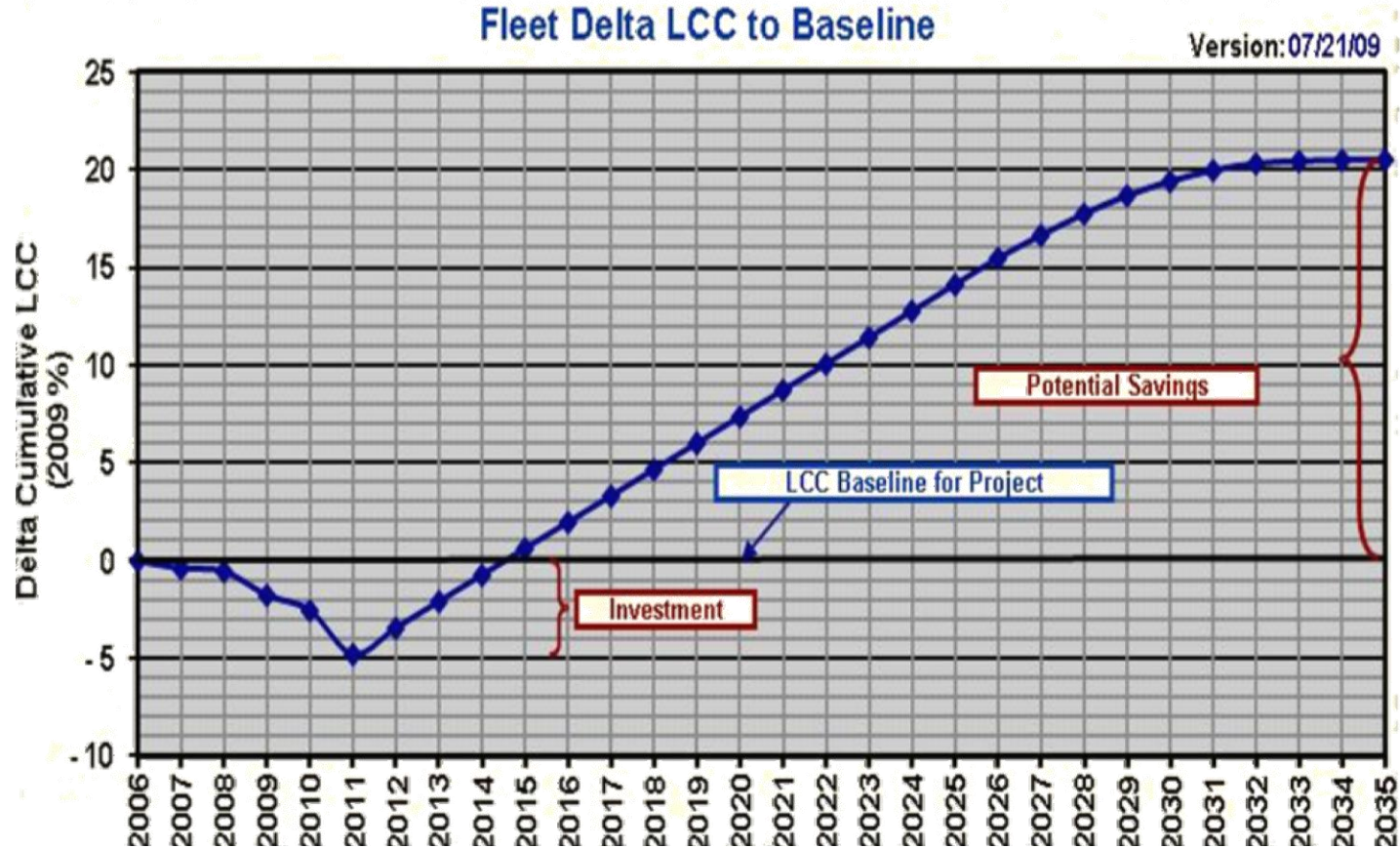
- ***White Paper drafts near completion***
 - ***Affordability: Cost Effective Capability***
 - ***The Role of Value Engineering In Affordability Analysis***
 - ***Affordability Specification***
- ***Two additional white papers planned***

Discusses a few quantitative indicators



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INCOSE: Cost Effective Capability

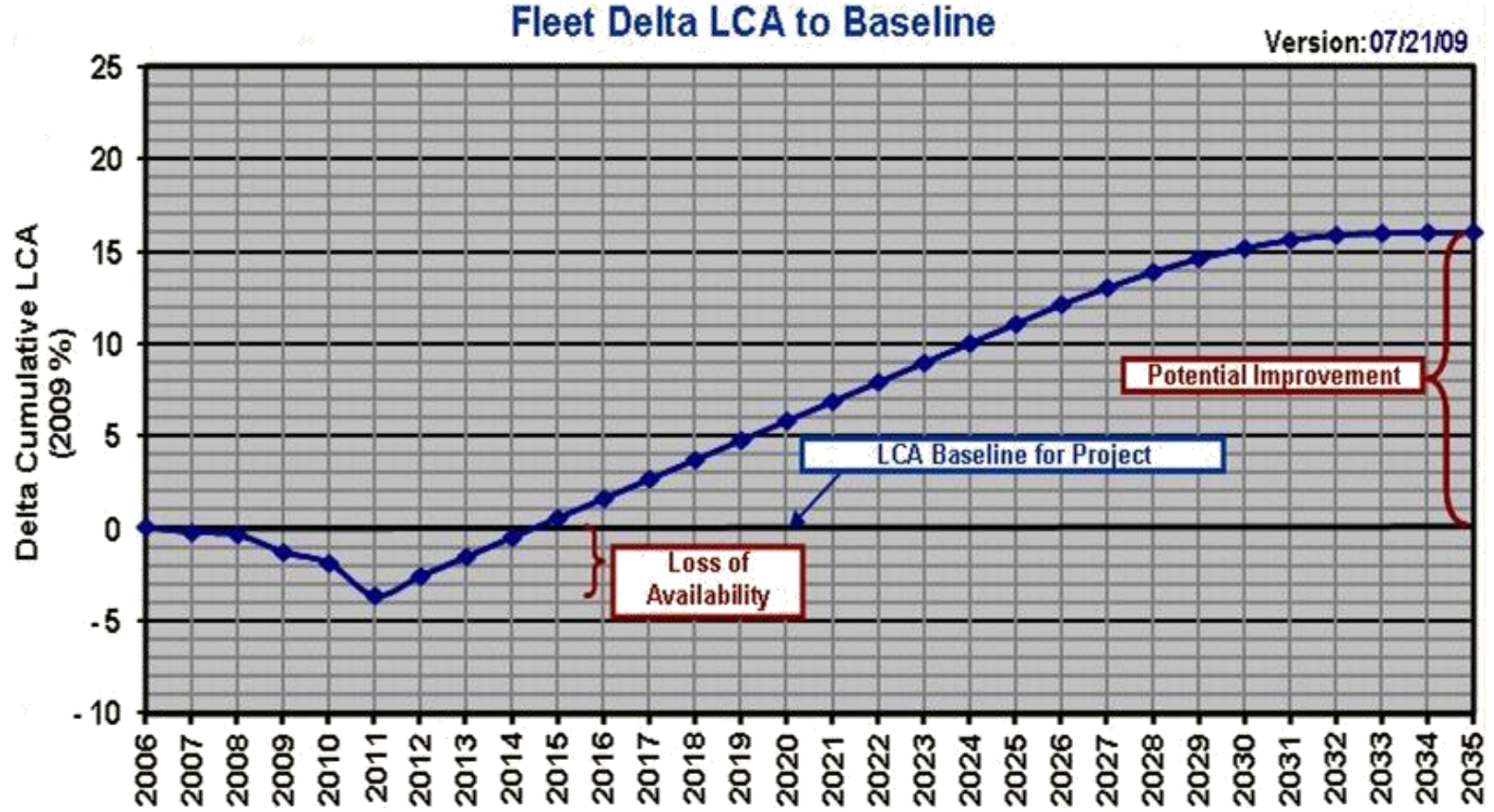


This chart indicates an investment during the 2009-11 timeframe. Costs are plotted comparing an investment opportunity, such as a modification, vs. the projected project baseline. Costs below the baseline indicate costs greater than the baseline – investment. Cost break-even occurs just prior to 2015 and cost savings increase thereafter. Costs are cumulative and the final cost at the end of the Life Cycle indicates the potential Delta Life Cycle Cost (DLCC) for the modification or improvement being analyzed – total Life-Cycle Savings



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INCOSE: Cost Effective Capability



In a similar manner, other KPPs can be calculated showing a return for an investment in time or materials. The Life-Cycle Availability for a given system yields a similar graph where time (Availability) is lost during the improvement activity – an investment in Availability is made and a return with a break-even point is established, just as with cost. This KPP also yields a delta at the end of the Life-Cycle – in this case a Delta Life-Cycle Availability (DLCA).

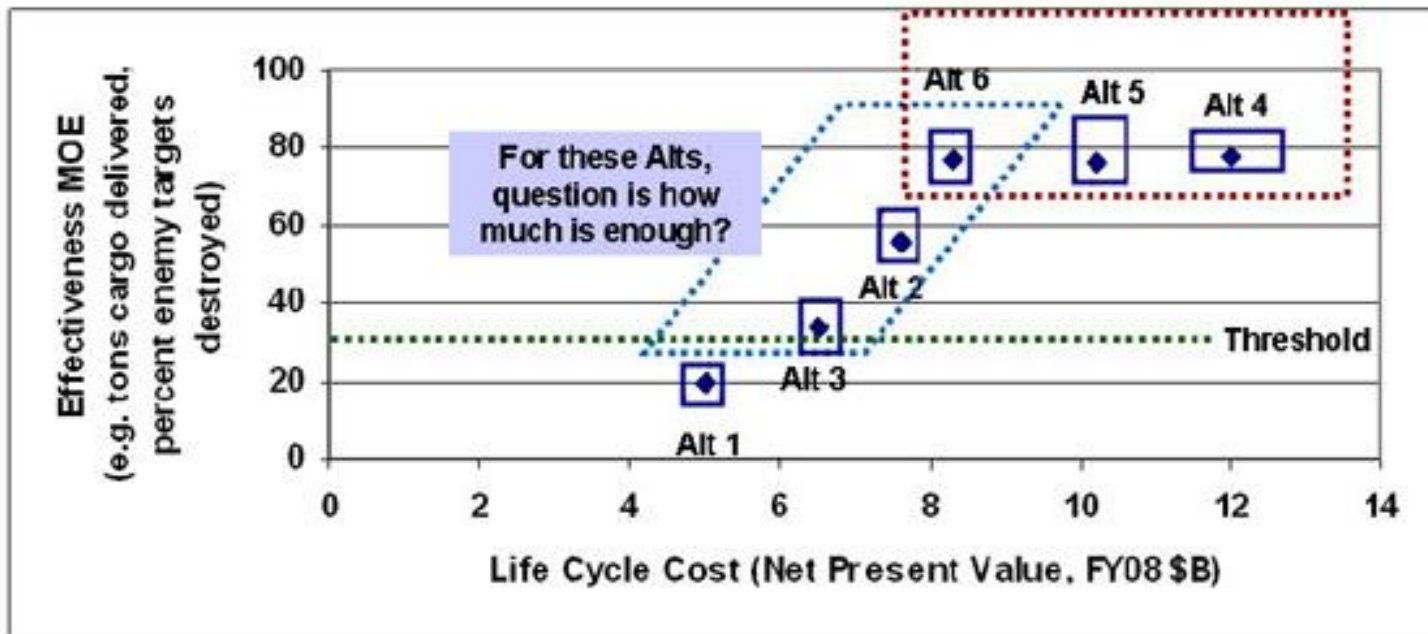
Practical Systems and Software Measurement Defense Acquisition Guidebook



Notional Cost-Effectiveness Analysis: Display of Results

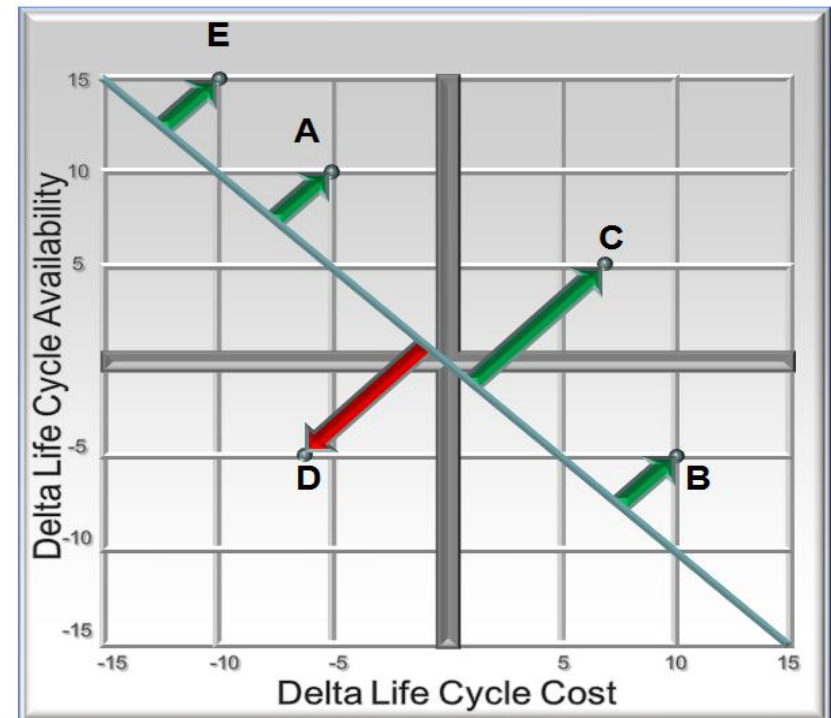
Rectangles indicate upper and lower bounds of sensitivity analyses (or bounds for distribution of results from stochastic models)

Alt 6 is more cost-effective than 5 or 4: at least as effective but at lower cost



INCOSE: Cost Effective Capability

In this figure, the normalized values of Availability and Cost are plotted. This represents five potential improvement projects. The best potential project is the point lying furthest from the diagonal, not the project with the highest Availability return or highest Cost savings. The angle of the diagonal represents the relative weights given to the KPPs. If KPPs are weighted equally, the diagonal lies at 45° to the axis.





NDIA Affordability WG

- *Completed work on policy recommendations*
- *Not active at the moment given the activities of other teams*
- *Has a notional idea on an Affordability Sensitivity Matrix: the sensitivity of capability excursions to changes in key performance parameters, cost and schedule:*

$$S_a = \frac{\Delta (CE_1, \dots, CE_m)}{\Delta (KPP_1, \dots, KPP_n, Cost, Sched)}$$

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PSM Workshop August 2012:

Affordability



- *For each performance parameter, Performance Parameter Values for each alternative vs. Life Cycle Cost of each alternative*
 - *Should show confidence intervals around parameter and cost*
 - *Should show current target for the performance parameter*
 - *Should show current Life Cycle Cost baseline*
 - *Should show Age of System at Retirement*
- *Decided more of a need for a qualitative measure of the value of an alternative than a qualitative measure of affordability management*
 - *Results would be represented by a spider chart with the spokes corresponding to the characteristics being evaluated*
- *Recognized the need for a mechanism to analyze cost and value results across multiple parameters*

Practical Systems and Software Measurement **MORS Affordability Workshop**



October 1-4

- **See Kurt Michaelson's presentation: 14588 - "MORS Affordability Analysis Workshop: Overall Workshop Results"**
- **WG3 Post Milestone A Information Needs**

Number Info Need Statement

1 insight into how well interfaces are defined

3 insight into the impact of mission requirements changes on Full LCC

Candidate Measure(s)

of interface issues

Extent or type of change;
Number of associated system requirements, architecture elements, model elements, system elements, operation procedures, maintenance procedures, training elements, etc. impacted in the system and enabling systems

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WG3 Post Milestone A Information Needs



Number	Info Need Statement	Candidate Measure(s)
6a	Insight into manufacturability, testability, of the solution	Manufacturability - MRL, Testability - Number of mission scenarios, paths, etc.
10	insight into sustainment supply chain performance, efficiency, & effectiveness	Past performance, System Availability and downtime, Time to repair/restore, Preventive Maint time, ...
11	insight into the cost distribution of each alternative relative to each other	Estimated cost per major life cycle phase
16	Mutiyear/contract alignment buy strategy impact on cost	Effective discount per part/unit
20	insight into design effectiveness for operations system, (including automation)	Number of operators needed to operation Availability of system for operations,

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WG3 Post Milestone A Information Needs

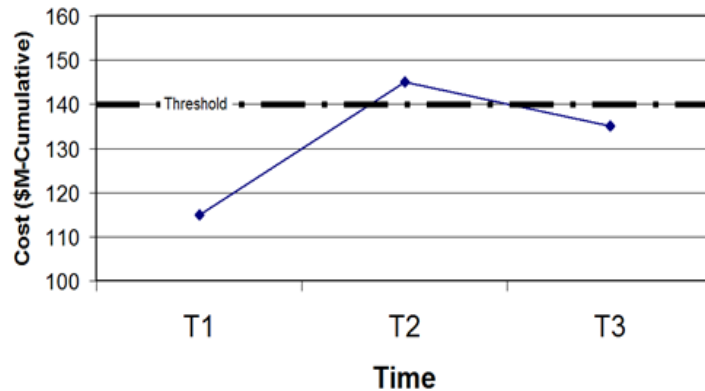


Number	Info Need Statement	Candidate Measure(s)
21	insight into material availability (obsolescence) throughout lifecycle	Number of suppliers, State of the Material Technology (TRL)
22	insight into material reliability throughout lifecycle	Number of failures, Timing of failures (Projected MTTF, MTBF)
24	insight into the sustainment cost per unit	Number of latent defects, MTTF/MTBF, Number of sustainment staff needed, Quantity of scheduled maintenance required, ...
24	insight into the production cost per unit	Material costs per BOM, Average waste, Effective Labor rate, Labor hours per unit, Idle time during production, ...



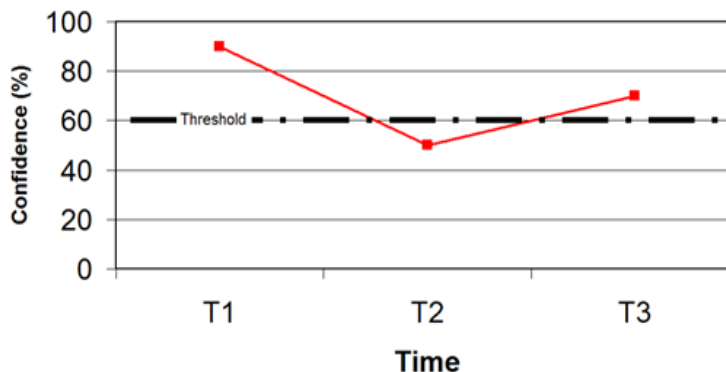
SELL: System Affordability Trends

Affordability - Cost Trend



Fixed Confidence

Affordability - Confidence Trend



Fixed Cost



Qualitative Approaches

- *As a substitute for any particular measure we've identified that is regarded as difficult to obtain or is just not quantitatively measureable*
- *For evaluating an organization's readiness to do affordability well*
- *For assessing some aspects that affect Full LCC*
- *For providing a "value" dimension*

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Q vs. Q Pros and Cons



Quantitative	Qualitative
Narrow perspective: more often used doing “fine,” or “detailed” modeling	Broad perspective: more often used in “macro” modeling
Objective: less dependence on subject matter experts once rules for determining a value is established	Subjective: needs availability of the right subject matter experts
Too often difficult to obtain/ not typically available	Usually easy to establish
Usage is straightforward	Usually require a lot of “setup” when several qualitative factors are used together
Interval or ratio measures	Nominal or ordinal measures
Used when a good understanding of the phenomenon of interest has been obtained; specific	Frequently used early in the game and helps figure out the path to quantitative measures; exploratory

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Organizational Affordability

Readiness



- *Based on the belief that good processes executed in a disciplined fashion results in good Affordability Analysis*
- *Determine the Attributes that are essential and criteria for each attribute that can be used to permit ranking in an ordinal fashion*

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- ***Understanding the Customer/User***
- ***PTW Process and Technical Approach***
- ***Requirements Flexibility***
- ***KPPs and Requirements***
- ***Cost of Requirements***
- ***Cost Drivers***
- ***Cost Targets***
- ***Architecture and Cost Baselines***
- ***Subcontractor Involvement***
- ***Rewards***
- ***Continuous Cost Reduction***
- ***Life Cycle Costs and the Trade Process***
- ***Cost Database and Its Usage***
- ***Parametric Cost Models***
- ***Constraint /Risk Identification and Management***
- ***Integrated Tools***
- ***Trade Study Levels***
- ***Selection and Optimization***
- ***Cost Reviews***
- ***Affordability Measures***



Life Cycle Costs and the Trade Process

Title	Level 1	Level 2	Level 3	Level 4	Level 5
Life Cycle Costs and the Trade Process	Ad hoc trade studies are performed but there is neither a standard process nor a method of assigning responsibility.	A process for performing trade studies is standardized and documented at the program level. Trade studies are conducted on a program-by-program basis. Responsibility is assigned and studies are managed at the program level.	A standardized trade study process is defined and managed at the enterprise level. The standardized process can be tailored from the enterprise set of standard practices for each program under guidelines specified within the process. Deviations beyond those allowed by tailoring guidelines are documented, justified, reviewed and approved.	Measures are assigned to the standardized trade study process such that adherence to the enterprise process is measured. Measures can consist of the number of trade studies performed on a program, the number of options considered in each trade, cost avoidance realized resulting from each trade, cost performance index (CPI) and schedule performance index (SPI) trend analysis, etc. Programs are quantitatively measured and statistics are logged for program design/cost/schedule influence.	Standard procedure for trade study management is in place and expected to be followed. Cost-performance trade study approach is part of the design process training. Standard trade study formats, derived from standard procedure, are followed within each program. Oversight of the trade study process is assigned at the enterprise level, along with the keeping measures for all programs. The measures are analyzed at the enterprise level, and fed back to the programs for optimization of the trade study process. An enterprise repository of trade study findings is available for the benefit of all programs.



Cranfield Affordability Index (C-AI)*

$$\frac{\text{Ability to Pay}}{\text{Life Cycle Cost}} \times \text{Spend Shortfall Adjustment} \times \text{Affordability Factor Adjustment}$$

Spend Shortfall Adjustment (SSA): over a life of n years, in some m of those years the ability to pay may be less than the costs incurred and billed. For these years only the SSA is

$$\left(1 - \frac{1}{n} \sum_{i=1}^n \frac{(C_i - S_i)}{S_i}\right)$$

n is the total number of years in which cost has exceeded spending

i is a year where cost exceeds the spending ability of the customer

C_i is the cost in the i th year

S_i is the spending ability in the i th year

Affordability Factors Adjustment $\sum_{i=1}^m w_i AF_i$

m is the number of factors
 AF_i is the i th Affordability Factor

*See references [1], [2] and [3]
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C-AI Affordability Factors

Affordability Factor	Weight
World Economic Climate	.09
Legislation	.11
Quality	.10
Supplier Chain	.12
Requirement Changes	.13
Global Competition	.09
Performance Related Measure	.12
Political Climate	.13
Unknown	.11

- *Determine a set of criteria spread across an ordinal goodness scale*
- *Determine a method for converting an ordinal value into an interval or ratio value to enable comparison/calculation across each affordability factor*
- *Score it*

Factors bolded are external to a program

Factors in blue were regarded as having the most effect

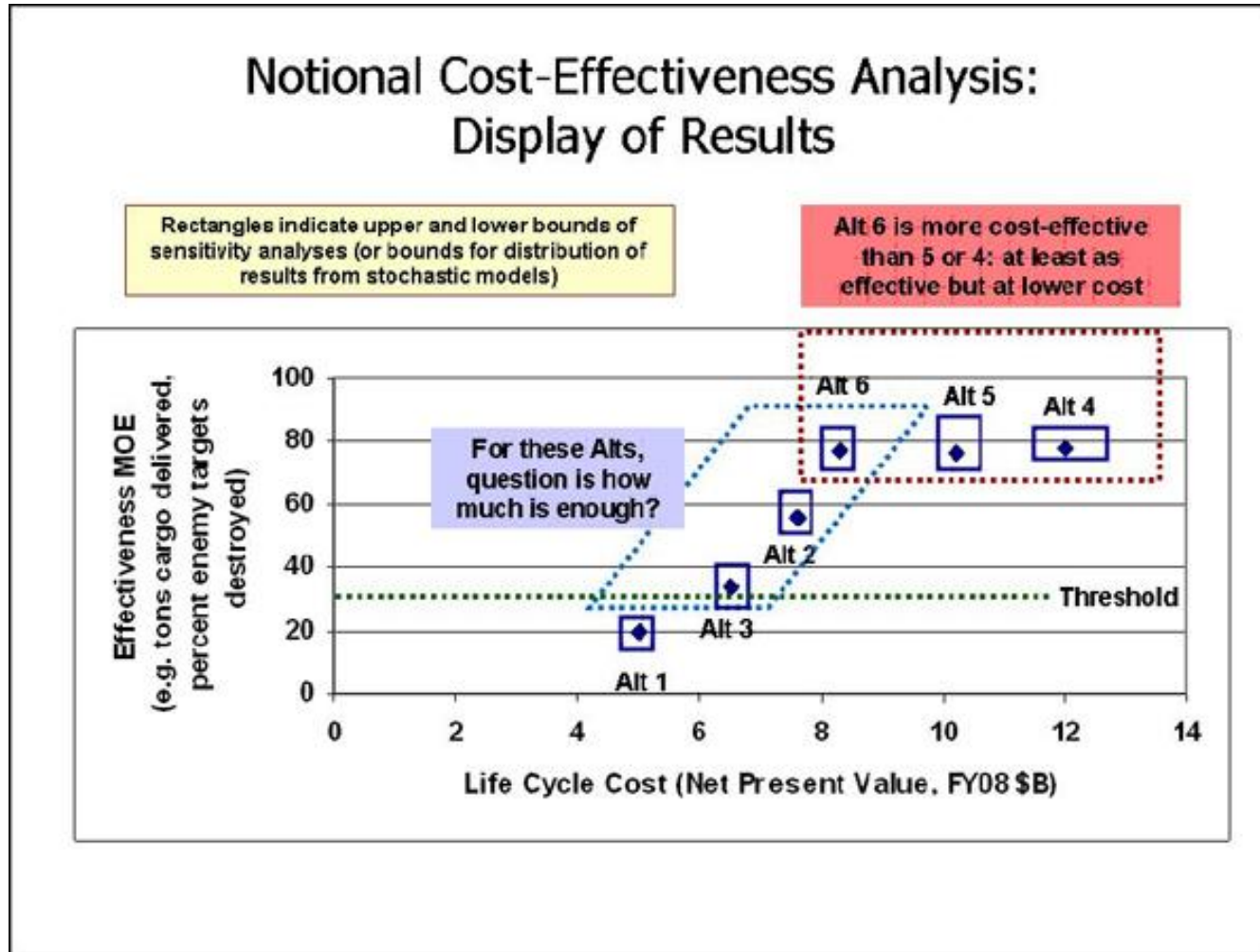


A Value Dimension

- ***Much of the discussion in the affordability space seems value neutral or***
- ***Tending to associate least cost alternative meeting KPP thresholds as best value***
- ***Value can often be a bit intangible***



Single Score for Multiple Factors



Source: [Defense Acquisition Guidebook \(DAG\) 3.3.3.7](#)

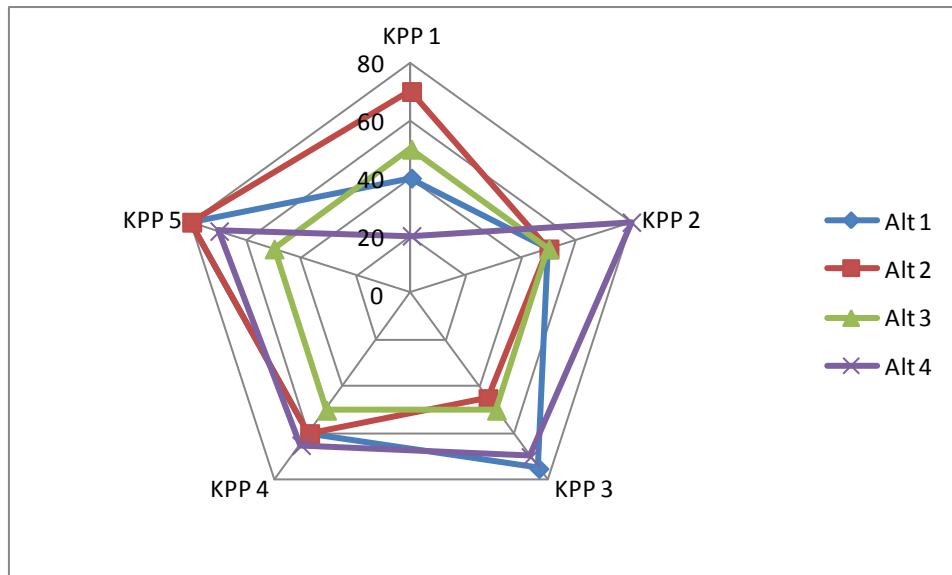
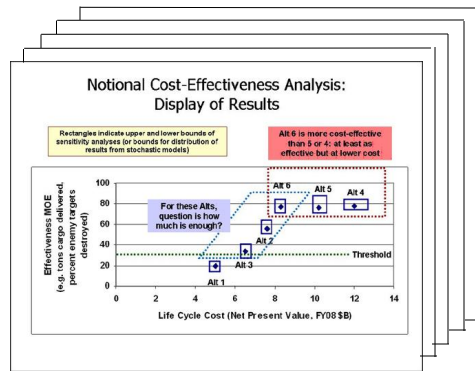
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Value of Multiple Quantitative Factors



Approach

Map each factor to a scale of 1 to 100 where the threshold that the factor must meet is mapped to 50. 1 is mapped to the lowest value to which any value is attached. 100 is mapped to the highest value to which any value is attached.



Score	KPP 1	KPP 2
1	10%	30%
50	30%	60%
100	60%	60%

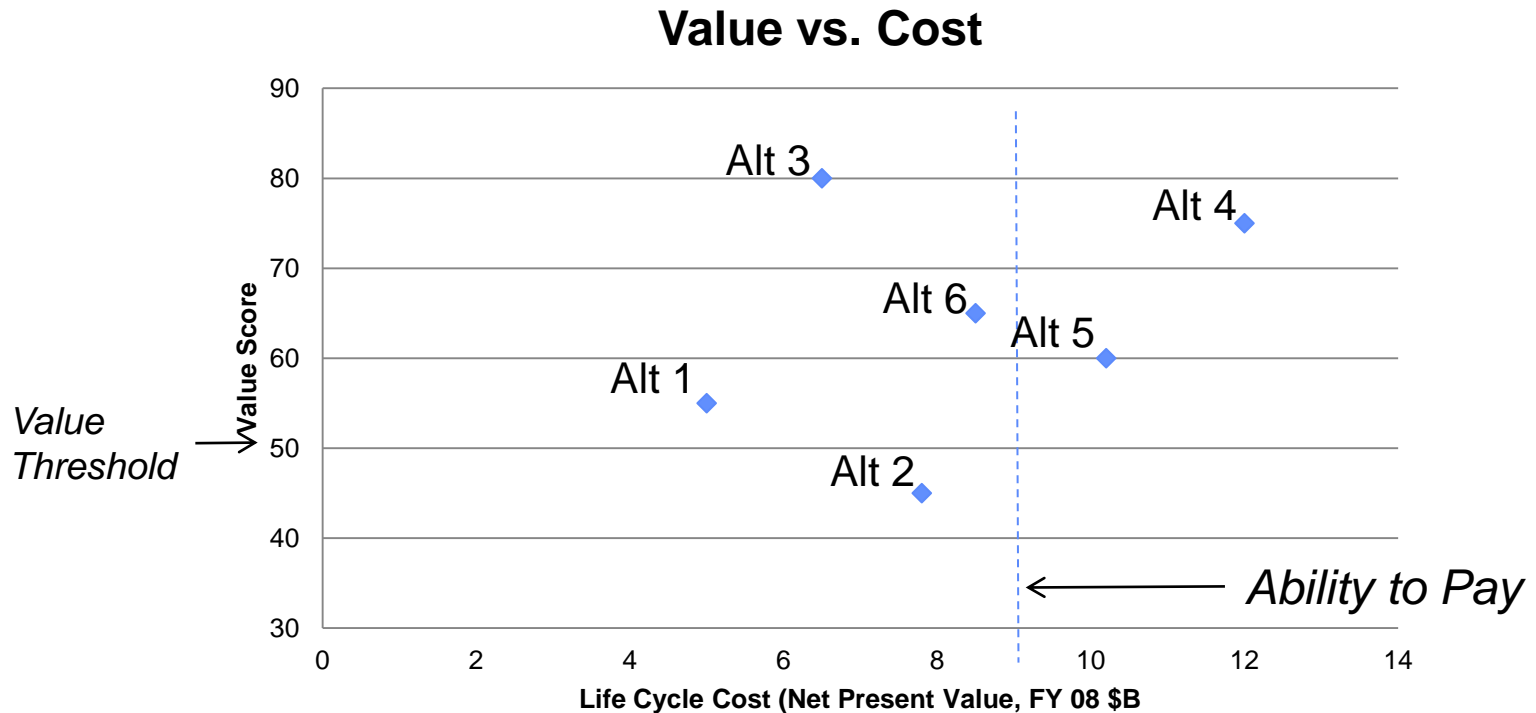
KPP 3 Weight

1	> 10000 lbs
50	8000 lbs
100	< 5000 lbs

Scores are somewhat subjectively driven

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Value Driven Analysis Based on KPPs



Can, of course, add additional criteria-based qualitative factors to the scoring



-ilities and Affordability

from PSM Workshops and INCOSE Affordability Working Group

- *Maintainability*
- *Supportability*
- *Reliability*
- *Stability*
- *Produceability*
 - *Manufacturability*
- *Upgradeability*
 - *Changeability*
 - *Versatility*
 - *Scalability*
 - *Modifiability*
- *Useability*
 - *Flexibility*
 - *Versatility*

Should definitions for an Affordability -ility set along with the determination of quantitative measures and qualitative approaches for the evaluation of each be pursued?



Way Forward

- *Indicators that should be tracked during TD and EMD that provide insight into Full Lifecycle Cost: work the results from the MORS Affordability Workshop*
- *What do you say about qualitative approaches:*
 - *Evaluating an organization's readiness to do affordability well*
 - *Assessing some macro aspects that affect Full LCC ala the Cranfield Affordability Index*
 - *Value points from the customer perspective*
 - *An Affordability –ility set*



References

- *Bankole, Roy, Shehab and Wardle. Affordability Assessment of Industrial Product-Service in the Aerospace Defence Industry. Proceedings of the 1st CIRP Industrial Product-Service Systems (IPS2) Conference, Crafield University, 1-2 April 2009.*
- *Bankole. Development of an affordability assessment framework for defence contracts at the bidding stage. PhD Dissertation. Cranfield University, Cranfield, UK, July 2011.*
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- *Defense Acquisition Guidebook (DAG)*