Cost and Performance Trades and Cost-Benefits Analysis

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Icebreaker

A cost analyst finds an interesting CER in a cost estimating textbook and wants to use it, but is concerned whether it was derived from real data. Of the 1000 raw data dollar figures, 200 begin with the digit 1 and only 75 begin with a 9. If the analyst expected about 100 should start with each digit, the probability that the data is real is extremely small.

Should the analyst be concerned?

Hint: What happens if the numbers are converted to a different currency?

Agenda

- Introduction and Disclaimers
- Types of Trades Analysis
- Cost-Benefits Analyses (C-BAs) and Trades Analyses
- Trades Analysis
- Trades Analysis Characteristics
- Example with Weight Constraint
- Conclusion

Introduction

Cost and performance trades are becoming more important in DoD Acquisition. These trades are being done earlier in Acquisition cycle at multiple points. The C-BA is one of the forums where these trades are addressed.

The Army is conducting C-BAs for all requirements that result in a new demand for resources. This paper is intended to discuss how the C-BA applies Trades Analysis. Additionally, it discusses how the C-BA techniques can be used to facilitate Trades Analysis during other cost analyses.

The term “Trades Analysis” refers to cost and performance trades, including risk and schedule as performance attributes.

Disclaimers

- All figures and numbers are notional.
- All sources and references are public.
- The views in this presentation do not necessarily represent the views of the Army, DoD or the U.S. Government.
- No government resources were used in the production of this presentation, except as required for review of the final product.
- This presentation is intended to promote awareness of useful ideas and topics in Cost Analysis. Each Trades Analysis is different.

Types of Trades Analysis: Definition

A Trades Analysis redefines a product in order to improve the product value.

- Usually the goal is to improve cost effectiveness, so Trades Analysis is done in conjunction with a cost estimate.
- The most common components of value are cost, risk, performance and schedule.
- The end state is a new or restated product definition.
- Trades Analysis is an iterative process among multiple stakeholders.
- Interactive cost estimation is important.

Types of Trades Analysis: Army

The Army routinely conducts Trades Analysis based on:

- New information from development.
- Changes in capability needs.
- Results of Request for Proposal.
- Feedback during the Contracting process.
- Updates during the ordinary Systems Engineering process.
- Changes in budget and risk.

Types of Trades Analysis: Army

The Army specifically conducts Trades Analysis through:

- Analysis of Alternatives (AoA).
- Requirements Analysis.
- C-BA.
- Cost as an Independent Variable (CAIV).

Source: TRADOC Regulation 71-20

Types of Trades Analysis: Industry

Industry conducts Trades Analysis based on:

- Changes to business strategy.
- Buy vs. build decisions.
- Product Systems Engineering.
- Market dynamics.
- Feedback from the Contracting process.
- Subcontractor relationships.
- Competition.

Trades Analysis: Workshops

Trades workshops are interactive, iterative and responsive. The cost analyst is only one stakeholder. Cost estimating techniques for workshops tend to be:

- Preplanned.
- Parametric.
- Parametric at the subcomponent level.
- May require WBS redesign.
- The scope, number and magnitude of the trades may limit the use of parametric cost estimating techniques.

C-BA: Definition

A C-BA is a comparison of multiple alternative Courses of Action (COAs).

- A COA is a means of accomplishing the goal.
- A C-BA compares cost and benefit of each COA.
- It provides the logical reasoning that supports decision making.
- It includes a documented cost estimate for each alternative.
- It includes a thorough sensitivity analysis.

Source: U.S. Army Cost Benefit Analysis Guide

C-BAs: Trades Analysis

A C-BA addresses trades:

- Implicitly through the iterative redefinition of COAs and the scope of the C-BA.
- Through sensitivity analysis.
- Explicitly by discussing trades, especially among cost drivers, that can be made near the recommended COA.

It is important to note here that a COA is more than a piece of equipment. It includes the entire Life Cycle Cost. Crew, training, risk and schedule are important considerations.

C-BAs: COAs

In this example, 5 COAs address 5 attributes:

	COA 1	COA 2	COA 3	COA 4	COA 5
Speed	T	T	T	T	T
Weight	T	T	< T	T	T
Range	T	< T	T	> T	>> T
Schedule	T	< T	< T	T	T
Risk	Medium	Low	Low	Medium	High

Note: T is a hypothetical value. A < or > indicates worse or better than T. It is difficult to isolate attributes in the main C-BA analysis.

C-BAs: Sensitivity Analysis

The C-BA include a sensitivity analysis:

	Recommendation
Recommendation	COA 2
Reduce importance of weight by 50%	COA 2
Double importance of weight	COA 2
Increase quantity 100%	COA 2
Decrease quantity 43%	COA 1
Actual cost of COA 1 is 10% lower than estimate	COA 1
Risk is number one factor	COA 1

Note: Sensitivity analysis is similar to Trades Analysis.

C-BAs: Requirements Documents

The Army uses Requirements Documents to describe what, why, when, who and where a new capability is needed.

- Each one is accompanied by a C-BA.
- They do not presuppose a solution.
- Capability is defined in terms of performance attributes.
- Rationale behind the attributes and their desired values is explained.
- Attributes partially define tradespace boundaries and are partially prioritized.

C-BAs: Requirements Documents

C-BAs that accompany Requirements Documents have COAs that tend to be differentiated by:

- Whether or not development is required.
- Performance attributes that have the most impact on effectiveness (especially potential trades).
- Different classes of solutions rather than different solutions within a class.
- Quantity, risk and schedule.

C-BAs: C-BAs and Trades Analysis

An appropriately framed C-BA provides a framework for Trades Analysis.

- COAs are efficient points in the tradespace.
- COAs provide a rough outline of the tradespace in relation to cost and/or effectiveness drivers.
- The end state of a C-BA is a recommended COA and cost estimate, but it allows for other decisions.
- COAs should provide insight into key cost drivers.

Trades Analysis: Parametric Approach

The parametric approach models cost near the starting point estimate in order to facilitate cost responses to trades.

- Difficult to account for second order effects.
- Difficult to trade beyond the range of the parametrics.
- The parametric approach fundamentally uses the marginal contributions of the attributes to product/subcomponent cost.
- Difficult to get sufficient data.

	Speed	Weight	Range	Schedule	Risk
Frame	.3	.9	0	.3	0
Wheels	.7	.8	0	.1	0
Drivetrain	.7	.8	0	.1	0
Accessories	-.3	.6	0	0	0
Integration	0	0	0	.7	.8

Note: These marginal values change after the first trade.

Trades Analysis Characteristics

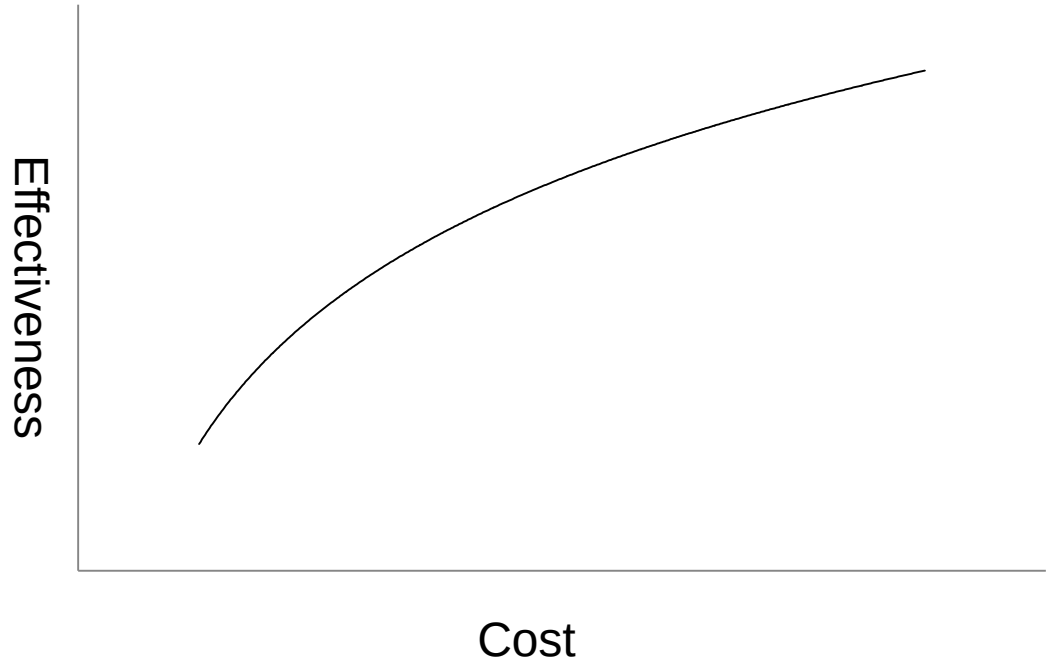
Trades Analysis performed in interactive workshops is:

- Extremely sensitive to a commonly understood clearly defined starting point.
- An inherently non-linear (combinatorial) problem at the holistic level.
- Sensitive to the order the trades are made.

Because of these factors, the individual trades can produce counterintuitive results and the cost estimate needs to be frequently reassessed. Engineering-based cost estimates are usually unsuccessful.

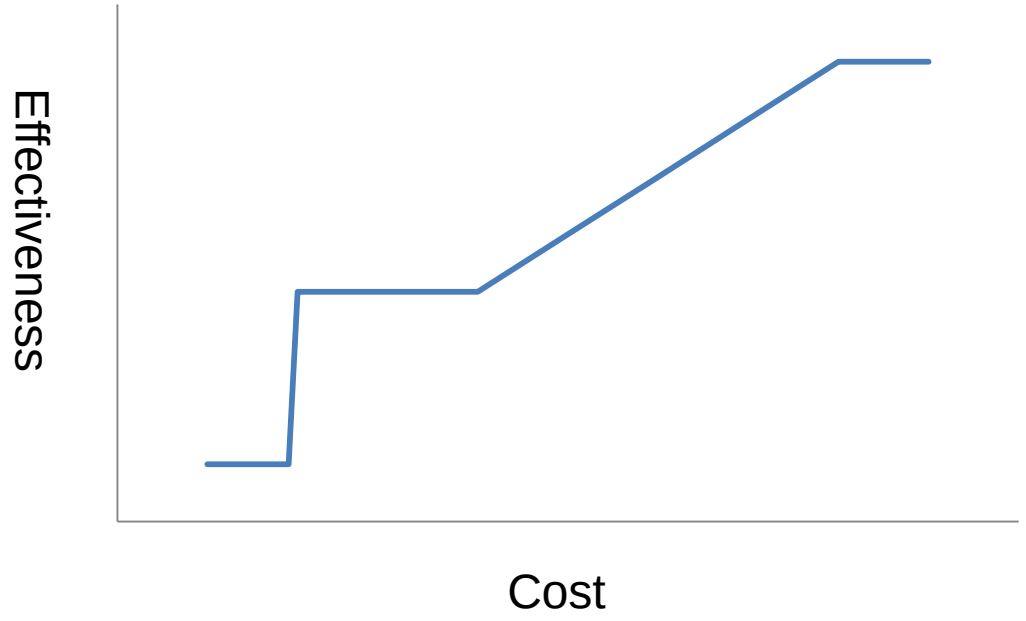
Trades Analysis Characteristics: Concavity

Cost – Effectiveness curves are increasing and concave down (diminishing returns):



Trades Analysis Characteristics: Groups

- Attributes are interrelated.
- Past trades matter.
- A trade may be free or nearly free.



Note: The chart shows a sequence of several trades.

Trades Analysis Characteristics: Groups

As a consequence, it's useful to know how the attributes are related (parametrics).

	Attr 1	Attr 2	Attr 3	Attr 4
Attr 1	1	.7	.3	.9
Attr 2	.7	1	-.3	.3
Attr 3	.3	-.3	1	0
Attr 4	.9	.3	0	1

Note: Include risk. This is really only a correlation matrix.

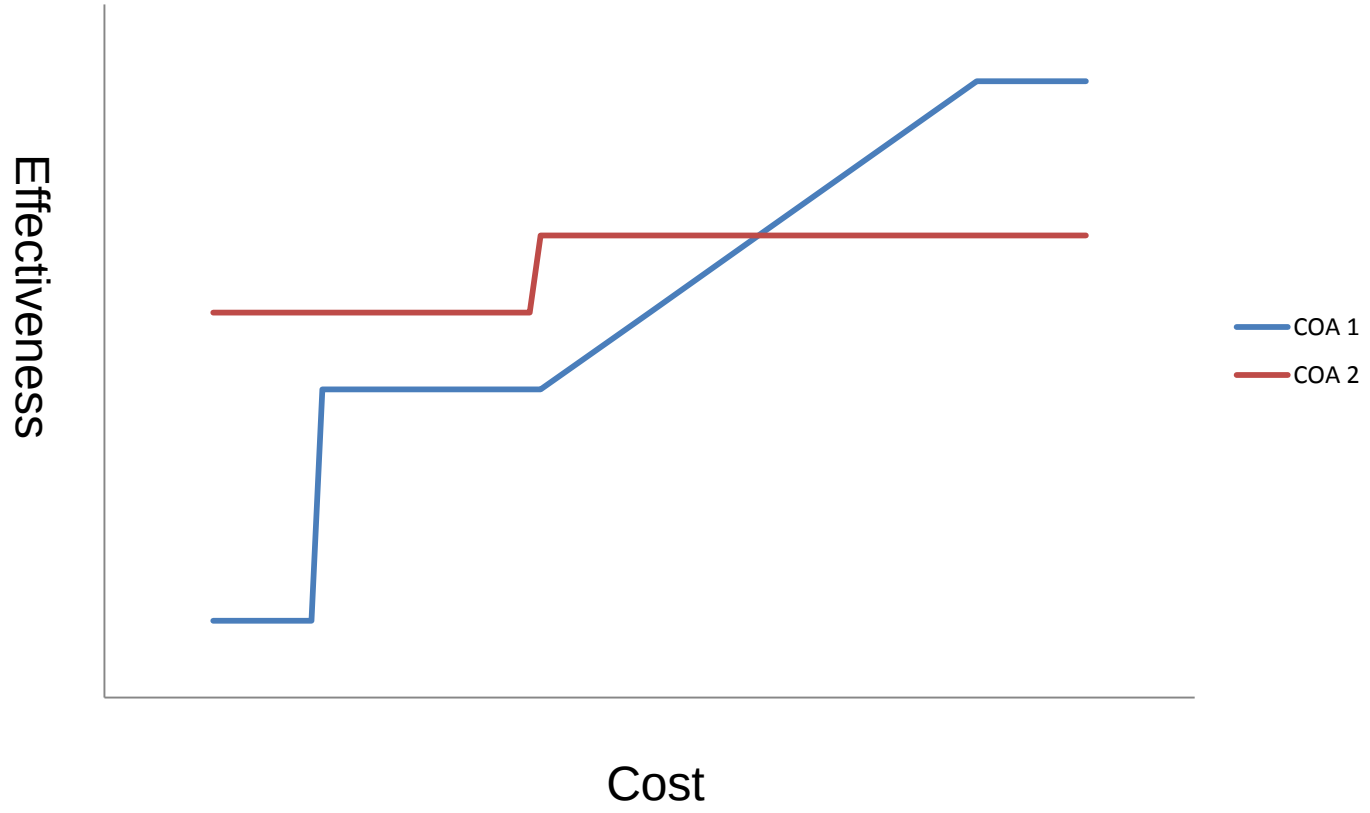
Trades Analysis Characteristics: Groups

Groupings are tracked using graphs, spreadsheets and narratives.

Attributes 6, 7 and 8 must all be traded away in order for the trades to generate cost savings.

Trades Analysis: Tipping Points

Trades Analyses have “tipping points”.



Note: The chart shows a sequence of several trades.

Trades Analysis: Tipping Points

- Tipping point ideas should come from the C-BA sensitivity analysis.
- Tipping points deal with holistic properties of the object, rather than a collection of small trades.
- Tipping points cause significant changes in the product definition and require revisiting the basis of the cost estimate.

Trades Analysis: Tradespace Currency

Requirements that are non-tradeable often result in a new “currency” for the analysis.

- The first currency is cost. However, without affordability targets, cost may not be a tradespace currency.
- The Trades Analysis can use one or more currencies.
- Tradespace currencies arise from non-tradeable requirements.
- Operations Research tells us when a constraint eliminates otherwise feasible points, the remaining solutions are heavily influenced by the constraint.

Example: Introduction

I claim this next example is interesting because it demonstrates tradespace currencies.

Within a class of similar material solutions, weight almost always is the number one most significant variable in a cost estimate. The example demonstrates this.

The example also demonstrates the need to reassess the estimate after trades. It demonstrates how C-BA-like techniques can facilitate Trades Analysis.

Example: Definition

I want to estimate a road racing bicycle that:

- Must be less than 15 pounds.
- Must have a three year warrantee.
- Should include accessories including headlight and race computer that weigh 2 pounds.
- Should have run-flat tires.
- Must have my name engraved into the frame.
- Should be carbon fiber or titanium frame.
- Permits my best race performance.

Example: Cost

	Cost ($)	Weight (lbs)
Frame	3,000	4
Wheels/Tires	3,000	3
Brakes	1,000	1
Drivetrain	1,000	3
Accessories	500	2
Integration	300	0
Total	8,800	15

Note: In this example, runflat tires were not included. Only one vendor was considered. I would finish the race in three hours. Only the purchasing cost was considered in this estimate.

Example: Trade Accessories

Cost estimates with and without the accessories:

With accessories(Alt A)

	Cost	Weight
Frame	3,000	4
Wheels/Tires	3,000	3
Brakes	1,000	1
Drive	1,000	3
Accessories	500	2
Integration	300	0
Total	8,800	15

Without accessories(Alt B)

	Cost	Weight
Frame	1,000	5
Wheels/Tires	2,000	3.5
Brakes	850	1.2
Drive	800	3.3
Accessories	0	0
Integration	250	0
Total	4,900	15

Example: Rebalancing

The example demonstrates:

- The need to rebalance among subcomponents after significant trades.
- Reducing weight in one subcomponent, allows others to increase. Operations Research (Linear programming) can tell us which ones.
- A trade of a $500 component resulted in a $4,000 decrease in total cost.
- Usefulness of “anchoring” estimates.

Example: Tipping Points

The example demonstrates:

- Trading accessories resulted in a tipping point.
- The real COAs are two customized high performance bikes (one 13 pound and the other 15 pound).
- The C-BA should tell me several things, such as a 3 hour 1 minute finish time is acceptable.

Example: Affordability

The example also demonstrates:

- Affordability must be addressed early.
- Other COAs should be considered, such as renting.
- One of the requirements should have been that the cost is under $1,000.

Example: New Product Definition

The new product definition is a road racing bicycle that:

- Must be less than 15 pounds.
- Must have a three year warrantee.
- Must have my name engraved into the frame.
- Would like carbon fiber or titanium frame.
- Costs less than $1,000.

Conclusion

- Trades Analysis requires planning of the Cost Estimate with consideration of the cost and effectiveness drivers.
- Each Trades Analysis is different and requires a customized approach.
- The C-BA technique provides a framework for Trades Analysis by using “anchoring” efficient-point COAs.
- Trades Analysis is integral to the C-BA.
- A C-BA is (should be) a Trades Analysis.

Questions