



## Defense Acquisition in Transition

6<sup>TH</sup> ANNUAL ACQUISITION RESEARCH SYMPOSIUM

# The Economic Evaluation of Alternatives (EEoA)

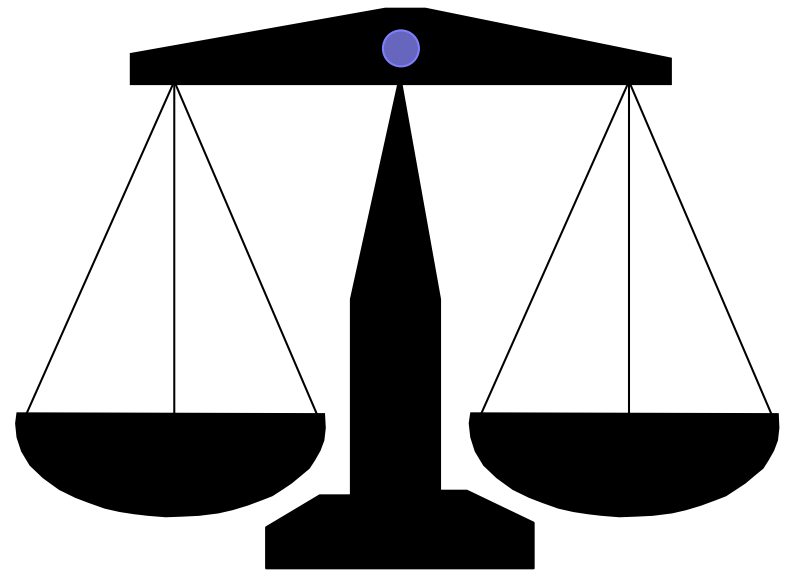
Dr. Francois Melese, Professor of Economics  
Defense Resources Management Institute (DRMI),  
Naval Postgraduate School

# Analysis of Alternatives (AoA)

[www.deskbook.osd.mil](http://www.deskbook.osd.mil)

“An AoA is an analytical  
**Comparison** of the  
operational  
***Effectiveness***,  
suitability, and  
***Life-Cycle Cost*** of  
**Alternatives** that satisfy  
established  
**Capability** needs.”

Defense Acquisition GuideBook Section 3.3)



# Source Selection

- “Source selection” is the decision process used in competitive, negotiated, contracting to select the proposal that offers the **Best Value** to the government.”
- In the UK => “Best value” = “Value for Money”
- In the US => “In different types of acquisitions, the relative importance of cost or price may vary...”  
[www.arnet.gov](http://www.arnet.gov) FAR 15.101
- “This process permits ***tradeoffs among cost/price and non-cost factors*** and allows the Government to accept other than the lowest priced proposal.”

[www.arnet.gov](http://www.arnet.gov) FAR 15.101-1(2)c

# Analysis of Alternatives (AoA)

- **Decision Sciences (MCDM) Approach:**

- Objective: Given Alternatives, Select one that Maximizes **Best Value** =  $V(\text{MOE}, \text{COST})$

$$= w1 * \text{MOE} - w2 * \text{COST}$$

- “In the literature the terms multi-attribute decision making (MADM), multi-criteria decision making (MCDM), and multi-objective decision making (MODM) are used almost interchangeably.”  
S. French (1986) Decision Theory, p.105

- **(MOE) Build Effectiveness model** (non-cost factors: Performance=quality, schedule, etc.)

- Analytical Hierarchy

- **(COST) Build Cost model** (costs/prices)

- Estimate total system life cycle costs (total ownership costs)

# Evaluation of Alternatives (EEOA)

- **Economics Approach:**

- Objective: Select Alternative that  
**Maximizes MOE = Utility = U(non-cost factors),**  
**Subject to AFFORDABILITY (Funding/Budget) constraint**

- **(MOE) Build Effectiveness model** (non-cost factors: Performance = quality, schedule, etc.)

- Analytical Hierarchy

- **(COST) Build Cost model** (costs/prices)

- Estimate total system life cycle costs (total ownership costs)

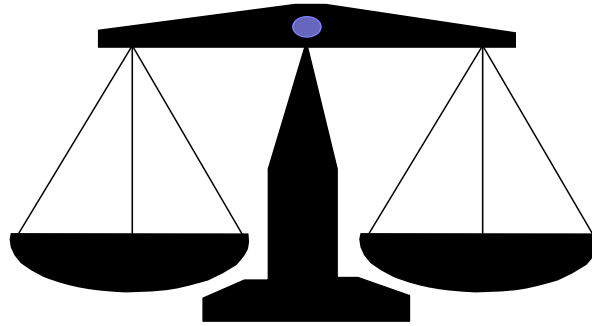
- **(FUNDING) Estimate budget authority** (constraint)

- Construct Alternatives
- In the Spirit of: Cost as an Independent Variable (CAIV) and Target Costing

# **Economic Evaluation of Alternatives (EEoA)**

## **Approaches: Six Ways to Structure an EoA**

- Build Alternatives: “Intra-Program Analysis”
  1. **Fixed Budget Approach**
  2. **Fixed Effectiveness Approach**
  3. **Expansion Path Approach** (Construct alternatives as Cost-Output/Effectiveness “Response Functions”)
- Modify Existing Alternatives: “Level the Playing Field”
  4. **Modified Budget Approach: GOTO 1.**
  5. **Modified Effectiveness Approach: GOTO 2.**
- Cannot Modify Existing Alternatives: “Inter-Program Analysis”
  6. **Opportunity Cost/Benefit Approach**



## Analysis of Alternatives

“[The] two basic conceptual approaches for making comparisons in systems analysis [are]:

1. the fixed budget approach, and
2. the fixed effectiveness approach.”

Fisher, 1970 (p. 78)

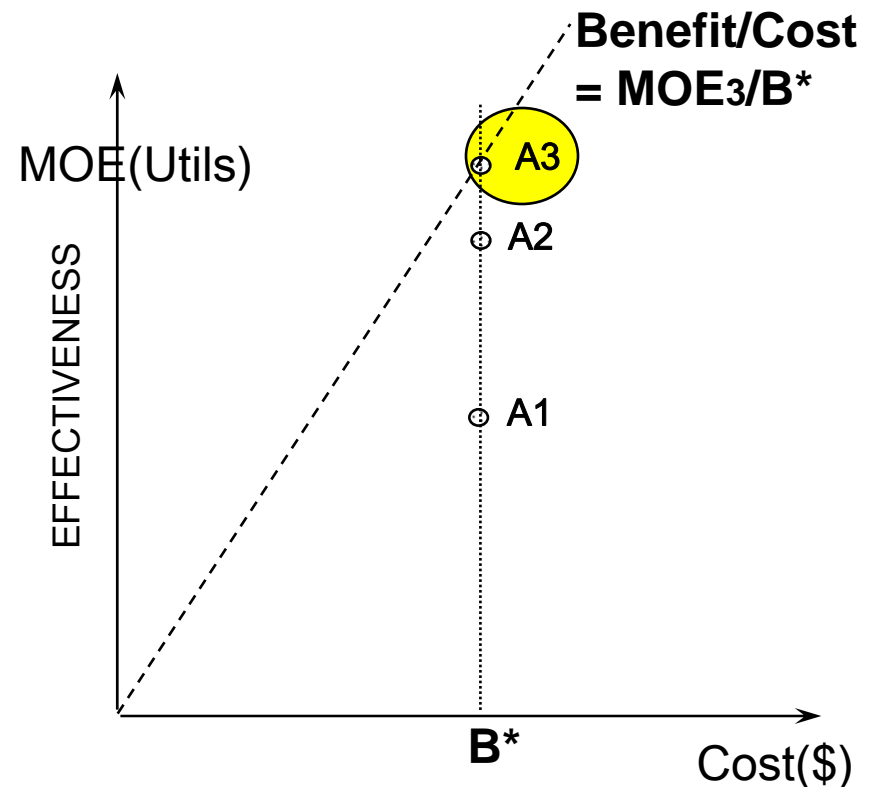
# Cost-Effectiveness EEOA

## Build Alternatives

### 1. Fixed Budget Approach

Maximize Effectiveness subject to Budget Constraint  
*(construct alternatives for given budget)*

Can we get more bang for the same bucks?



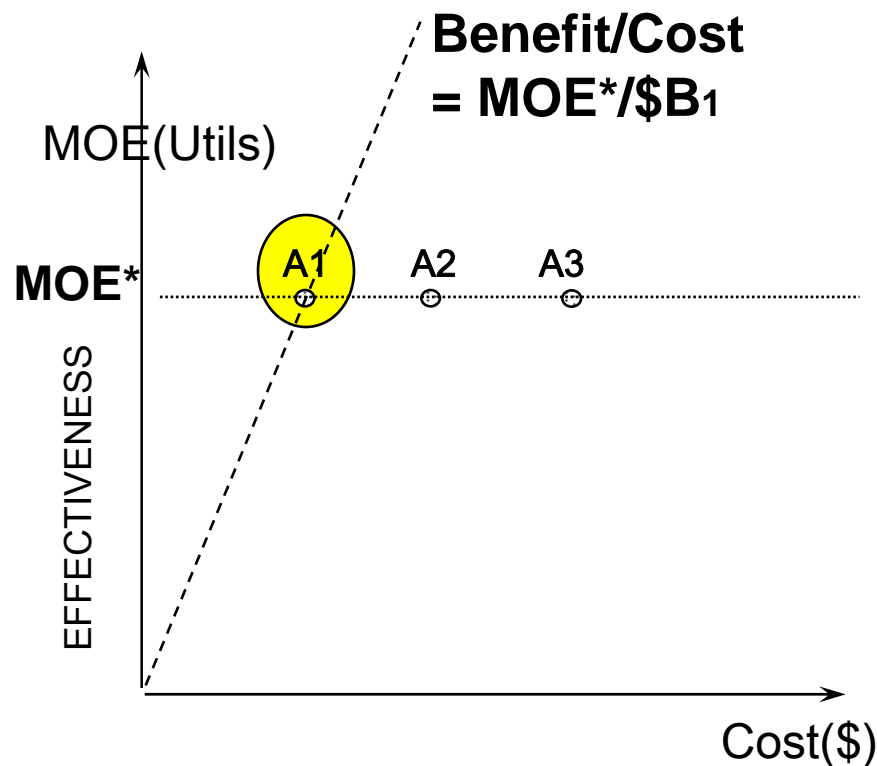


# Cost-Effectiveness EEOA

## Build Alternatives

### 2. Fixed Effectiveness Approach

Dual: Minimize Costs subject to Effectiveness Constraint  
(*construct alternatives for given MOE*)



Can we spend less bucks for the same bang?

# AoA

- “Typically, the ***last*** analytical section of the AoA plan deals with the planned approach for the cost-effectiveness comparisons of the study alternatives.”

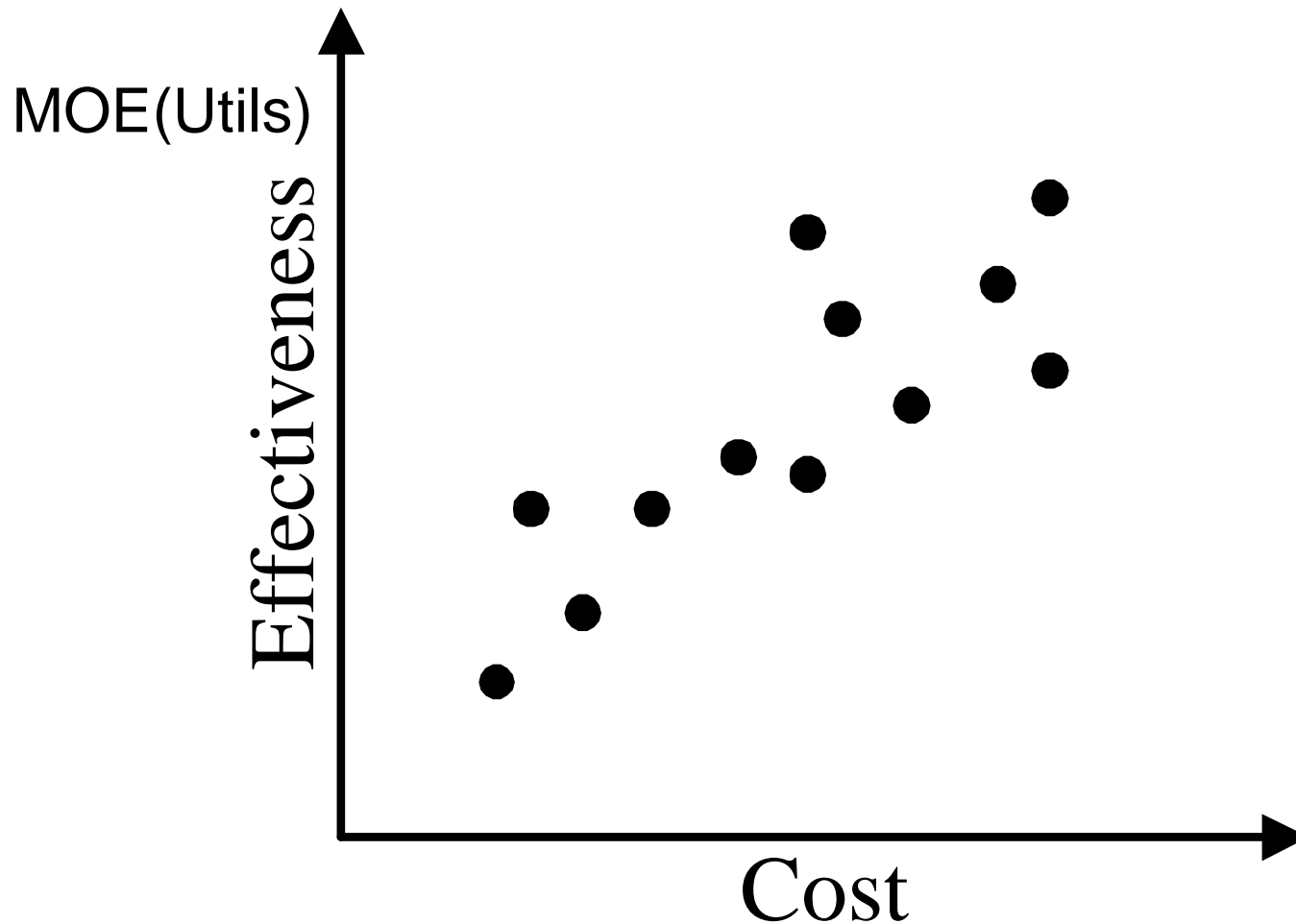
## **THIS IS FIRST STEP OF Economic Evaluation of Alternatives**

- “Cost effectiveness comparisons in theory would be simplified if...all the alternatives have equal effectiveness (the best alternative is the one with the lowest cost) or equal cost (the best alternative is the one with the greatest effectiveness).”
- “In actual practice, the ideal of equal effectiveness or equal cost alternatives is difficult...to achieve...”
- “A common...comparison is a *scatter plot of effectiveness versus cost.*”

# Decision Sciences Approach

Identify “Efficient Set”

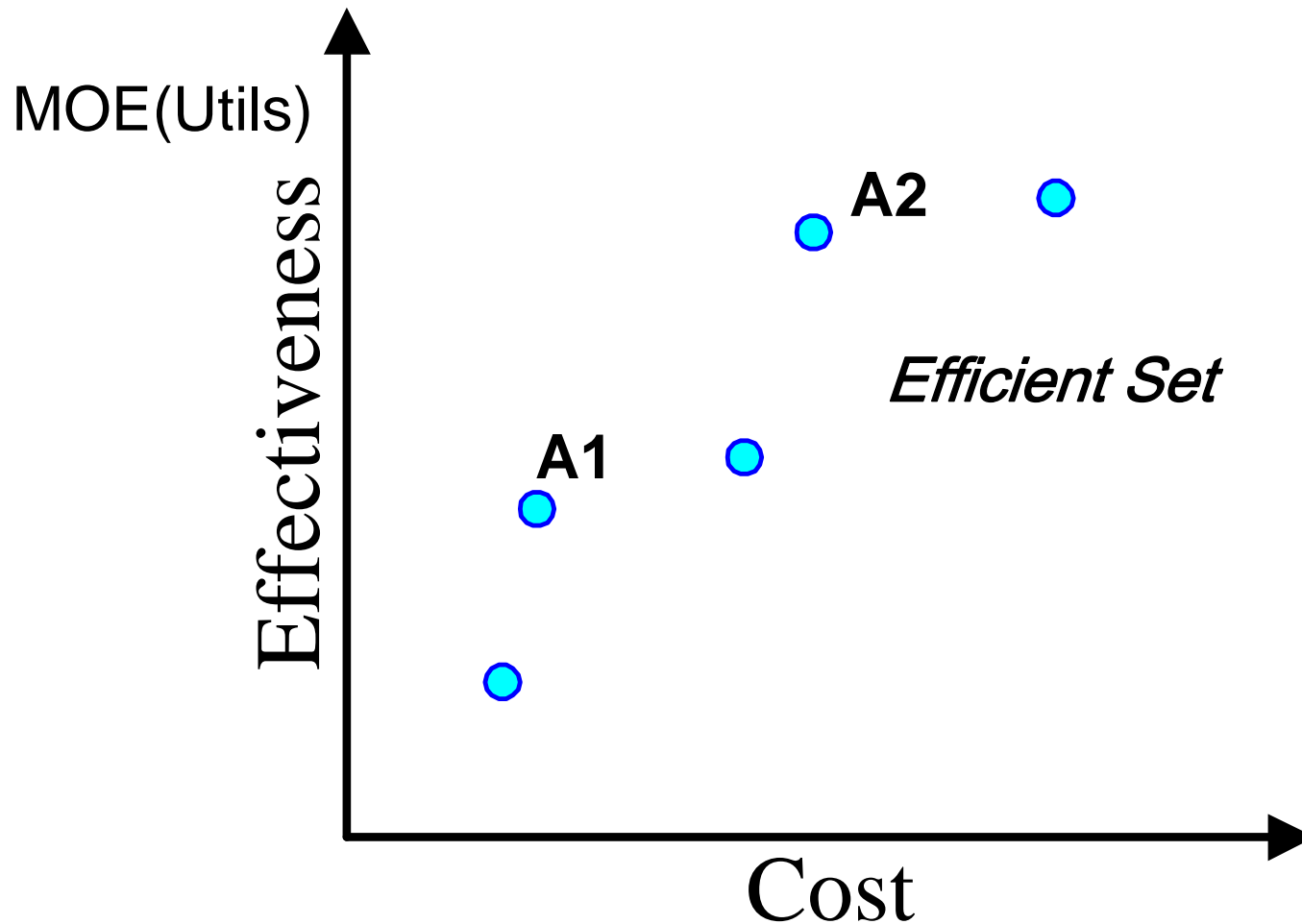
Weed out dominated alternatives



# Decision Sciences Approach

Those remaining form an efficient set.

Which Alternative is the Best?



# Source Selection

- “The solicitation shall state whether all evaluation factors other than cost/price, when combined [MOE], are significantly more important than, approximately equal to, or significantly less important than cost/price.”

[www.arnet.gov](http://www.arnet.gov) FAR 15.101-1(2)

- “[A]gencies must: a) identify the specific weight given to each evaluation factor..., and b) **make the specific weight for cost or price at least equal to all other evaluation factors** combined...”

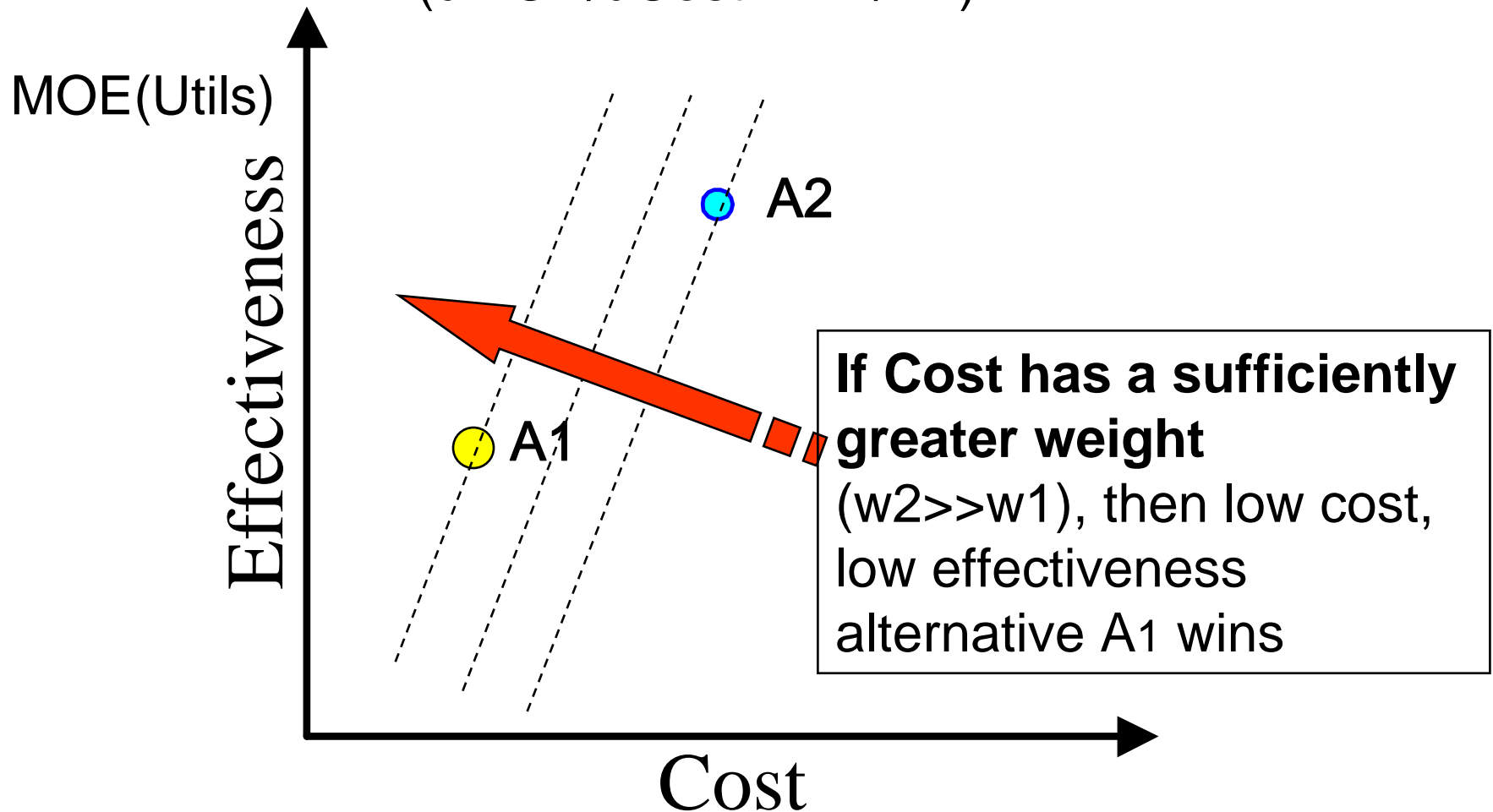
# So Which Alternative is “Best”?

## Decision Sciences Approach

$$\text{Max } V = V(\text{MOE}, \text{Cost}) = w_1 * \text{MOE} - w_2 * \text{Cost}$$

**Ask Decision Maker What is More Important: MOE or Cost?**

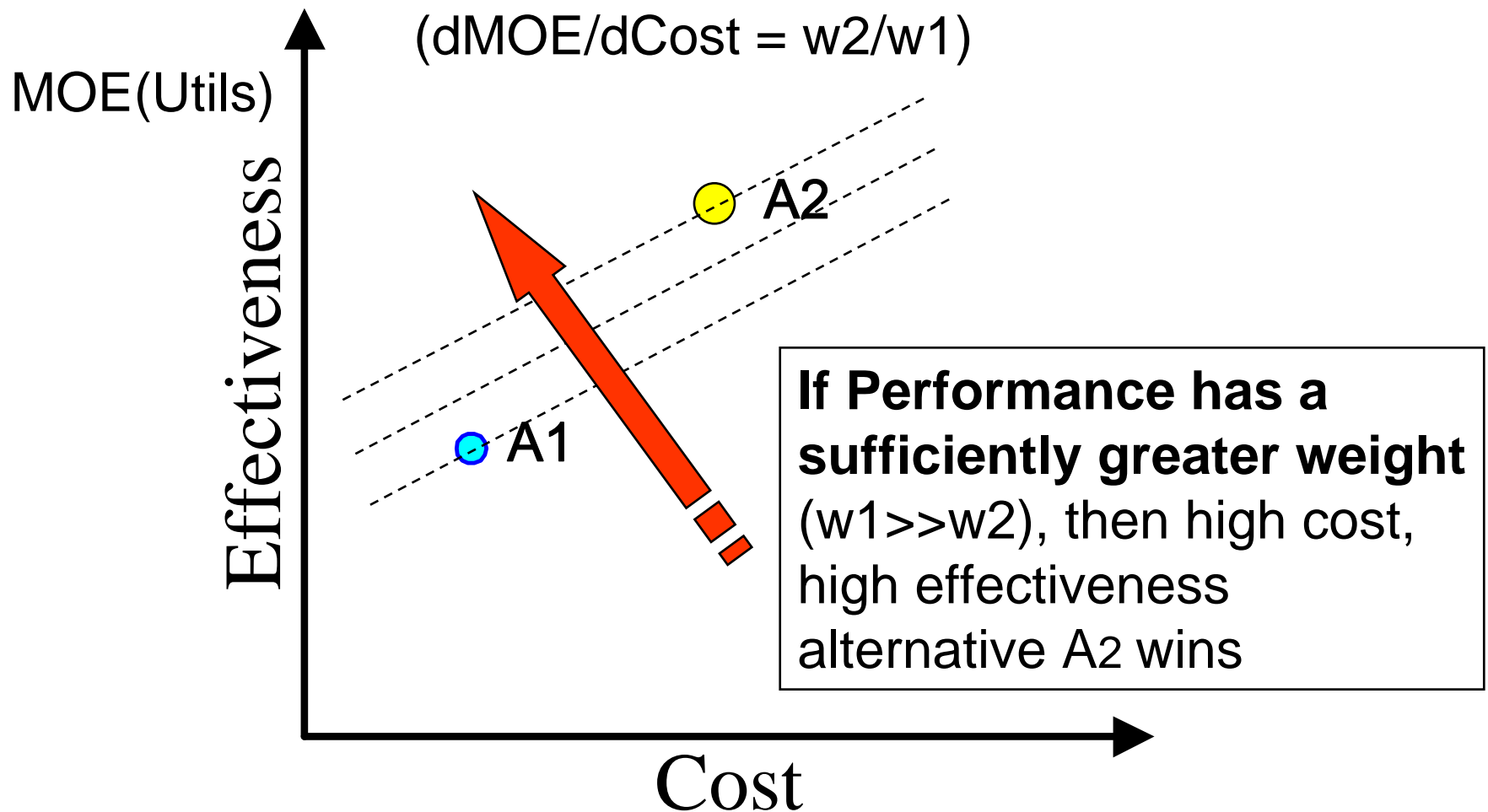
$$(d\text{MOE}/d\text{Cost} = w_2/w_1)$$



# Which Alternative is “Best”?

## Decision Sciences Approach

$$\text{Max } V = V(\text{MOE}, \text{Cost}) = w_1 * \text{MOE} - w_2 * \text{Cost}$$



# “Most Common Critical Mistake”

“One mistake is very commonly made in constructing value models...illustrated in the context of...air pollution...[i.e. reducing pollutant concentrations]

***I personally do not want some administrator to give two minutes of thought to the matter and state that [reducing] pollutant concentrations [is] three times as important as cost.”***

DECISION SCIENCES EXPERT

R. Keeney (1994) “Using Values in Operations Research,” Ops. Research 42/5 p.797



## Question: How does Decision Maker (DM) decide relative weights to assign to MOE & COSTS? What does this mean?

---

- Economist's Hypothesis:
  - If DM cares about COSTS (i.e. places any weight on cost) it is because there is a budget constraint or opportunity cost of obtaining funds to pay for the extra MOE in this program.
  - Otherwise “Go for the Gusto (greatest MOE)!”
  - Decision Sciences (AoA) approach addresses this indirectly:  
Typical Objectives Hierarchy includes both Max MOE & Min Costs =>  
$$\text{Max } V = V(\text{MOE}, \text{Cost}) = w_1 * \text{MOE} - w_2 * \text{Cost}$$
  - One ubiquitous source of confusion is the attempt to maximize gain while minimizing cost...if a person approaches a problem with the intention of using such a [decision] criterion, he is confused to begin with...” (p.167)

Hitch C. & R. McKean 1967 “The Economics of Defense in the Nuclear Age” Harvard University Press, Cambridge, Mass.

# EEoA Proposal: Three-Step Optimization

“Tell them WHAT you want and roughly what you can afford, then let them figure out HOW to do it.”

## I) First Stage: (CAIV)

- DoD provides notional budget guidance (B) to alternative vendors for the program. DoD searches for the optimum product (Procurement) and/or service (R&D; O&M) package it can obtain at that price, B. DoD also reveals optimistic, most likely, and pessimistic budget guidance.
- DoD defines the set of characteristics/attributes it values and this is known to vendors, but DoD's precise Utility Function over those characteristics is unknown to vendors.

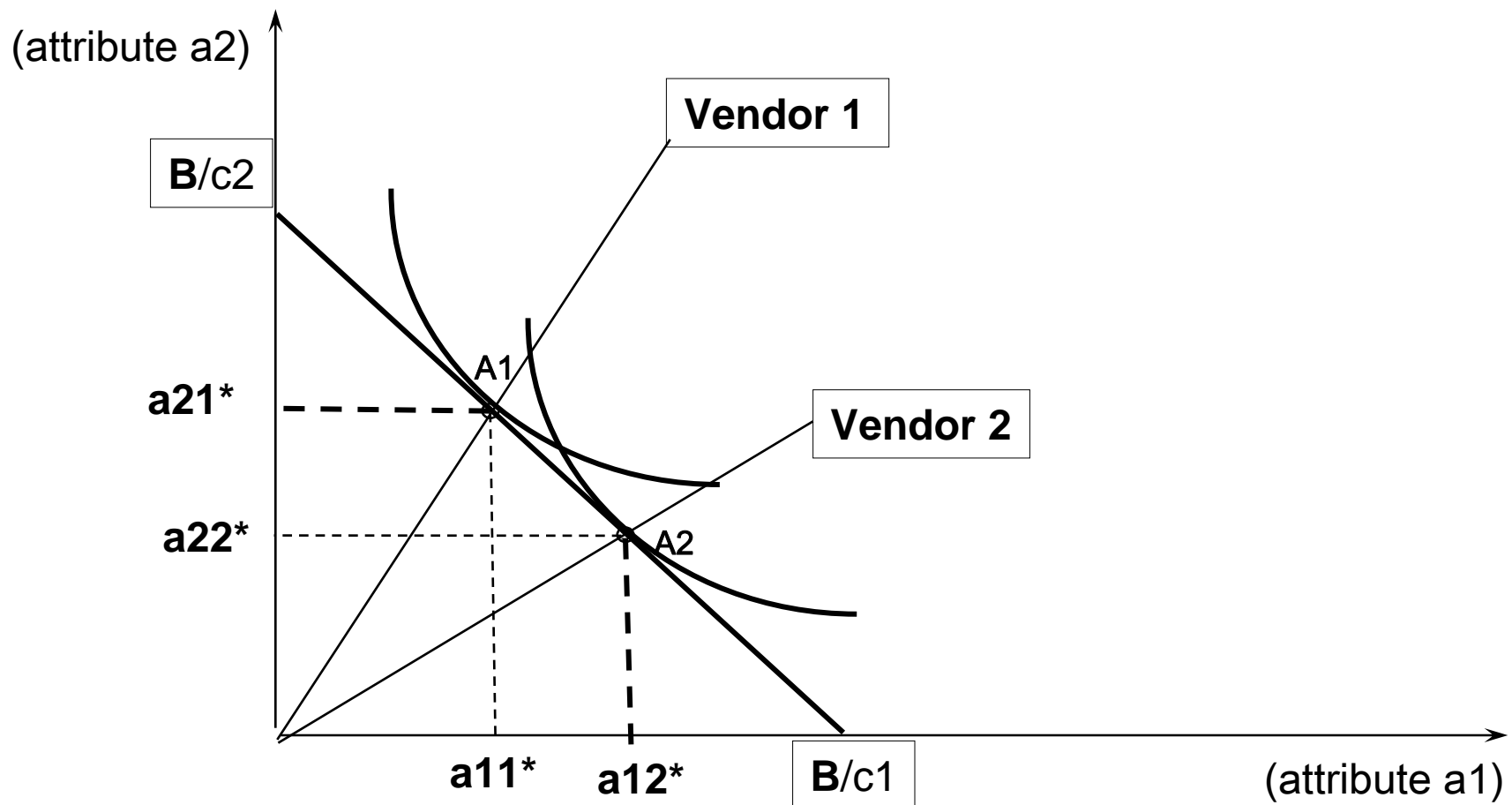
## II) Second Stage: (Target Costing)

- Vendors have different costs and production functions for generating products or services (defined as bundles of characteristics).
- Each vendor maximizes its output offer (an optimal mix of the desired characteristics) subject to their particular budget constraint (which includes DoD's budget guidance and the vendor's individual costs to produce a unit of each characteristic).
- This is the product and/or service package (output) a particular vendor is able to propose for each possible budget (B), given their production function (technical production possibilities) and their costs of generating those characteristics.

- III) Third Stage: With the latest budget forecast, DoD selects among optimized characteristic bundles proposed by each vendor, the bundle/alternative (system) that maximizes DoD's Utility Function.

# EEoA: Vendor Expansion Paths with same Costs

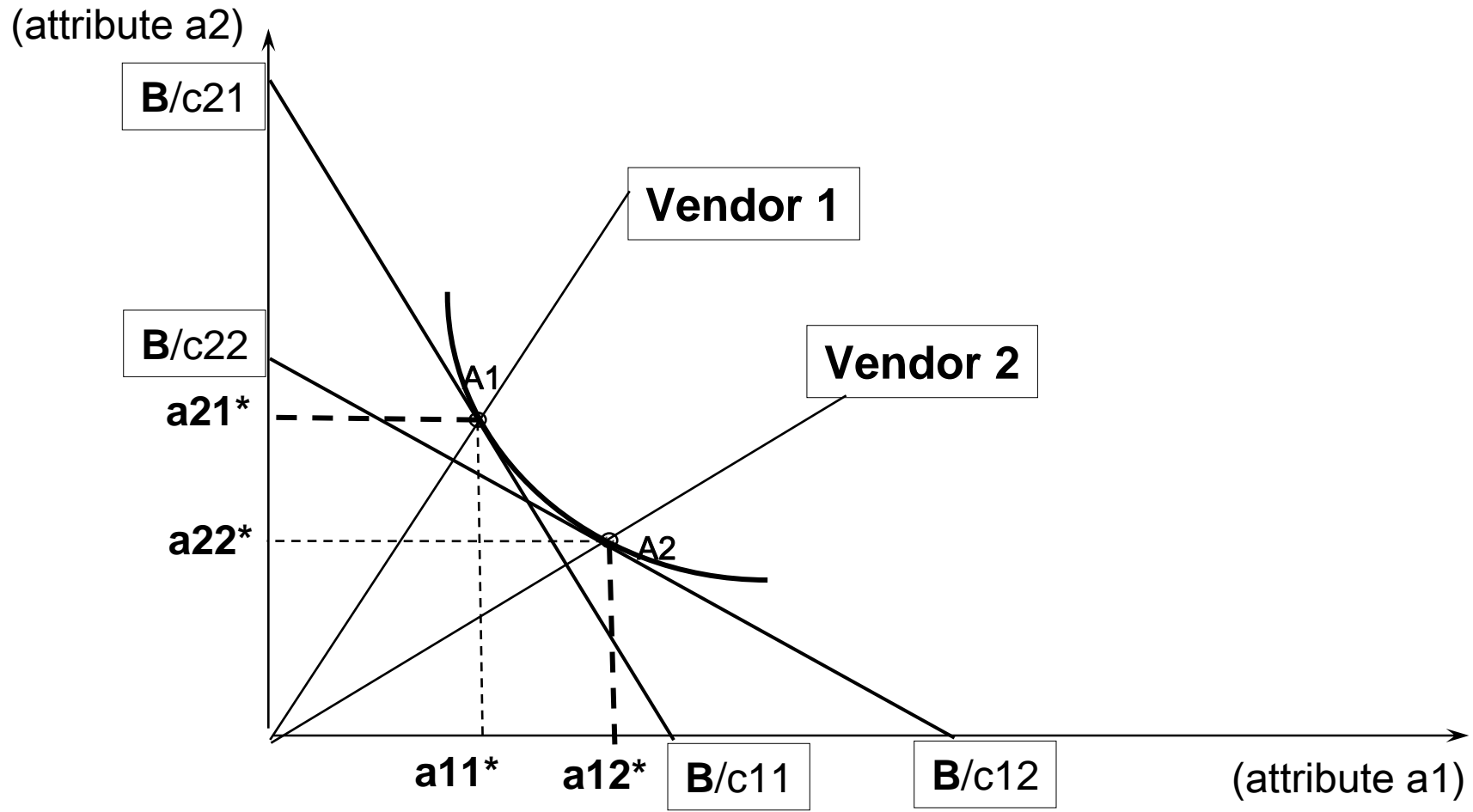
Maximize Attribute Bundle subject to Budget Constraint  
(Assumption: Two Vendors & Two Attributes)



$$\text{Vendors' budget constraint: } TC = c_1 a_1 + c_2 a_2 = B \Rightarrow a_2 = B/c_2 - (c_1/c_2) a_1$$

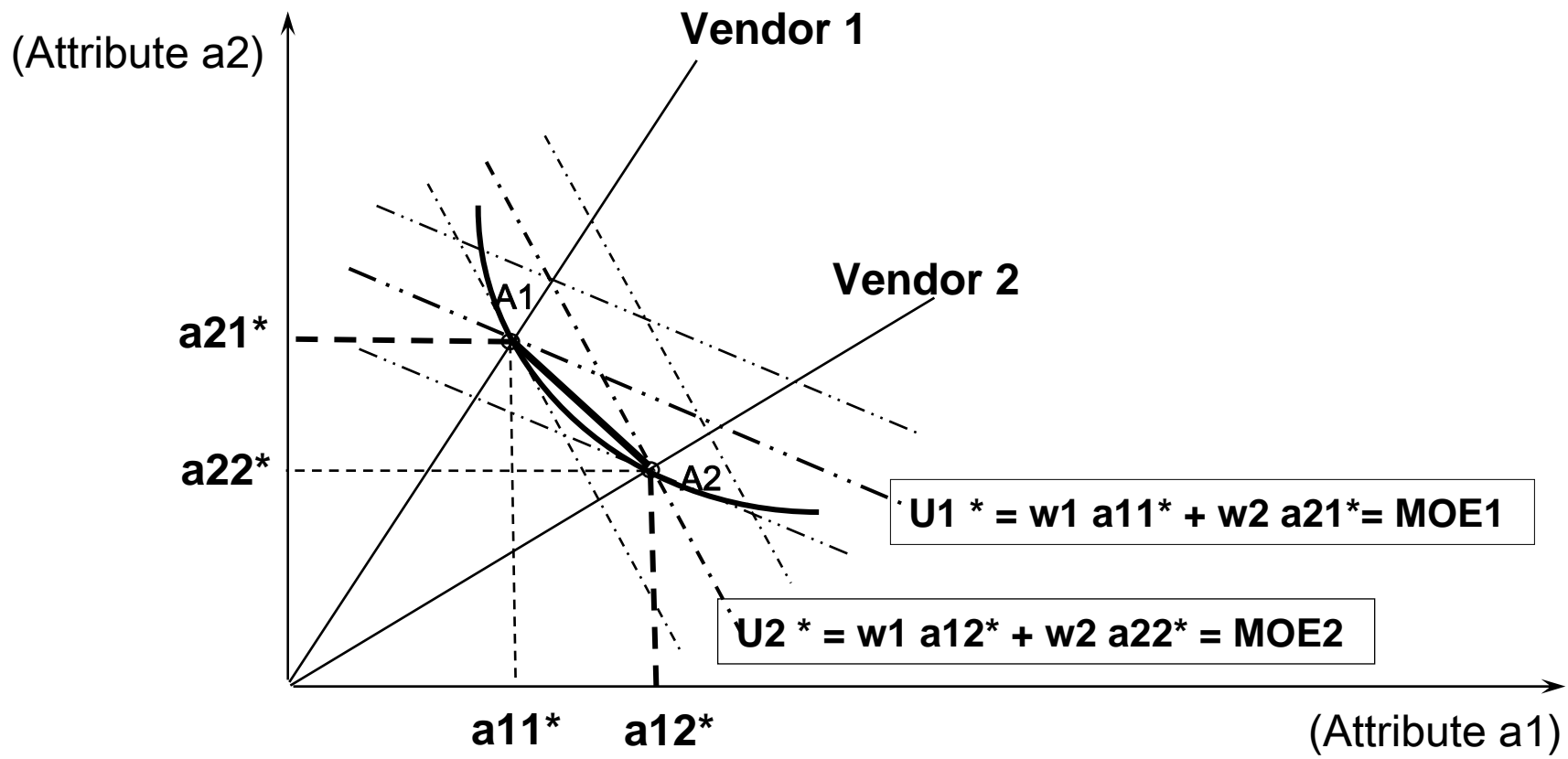
# EEoA: Vendor Expansion Paths with same Technology

Maximize Attribute Bundle subject to Budget Constraint



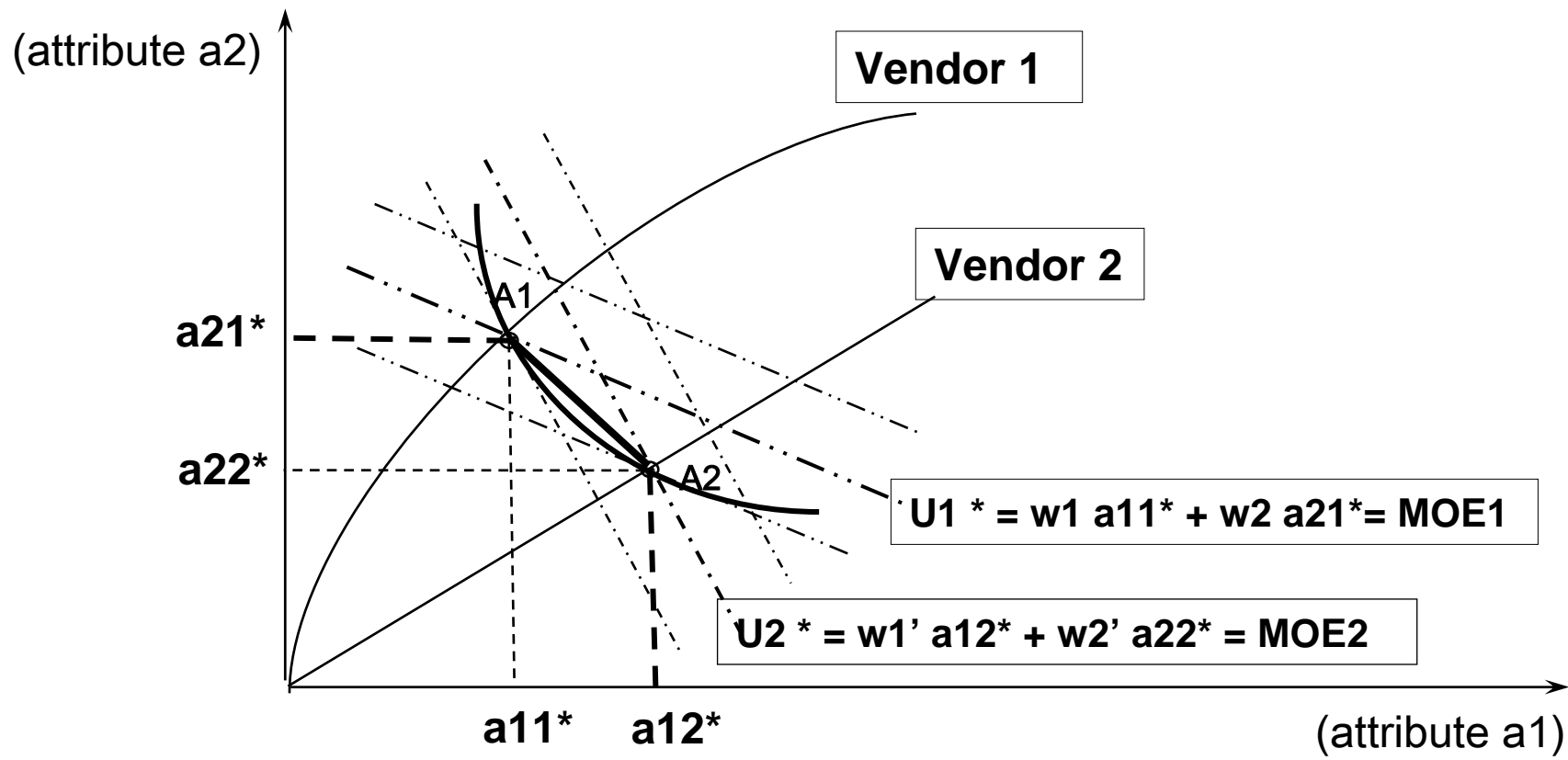
# EEoA: Procurement Agency Choice

Maximize Utility subject to Budget Authority Constraint



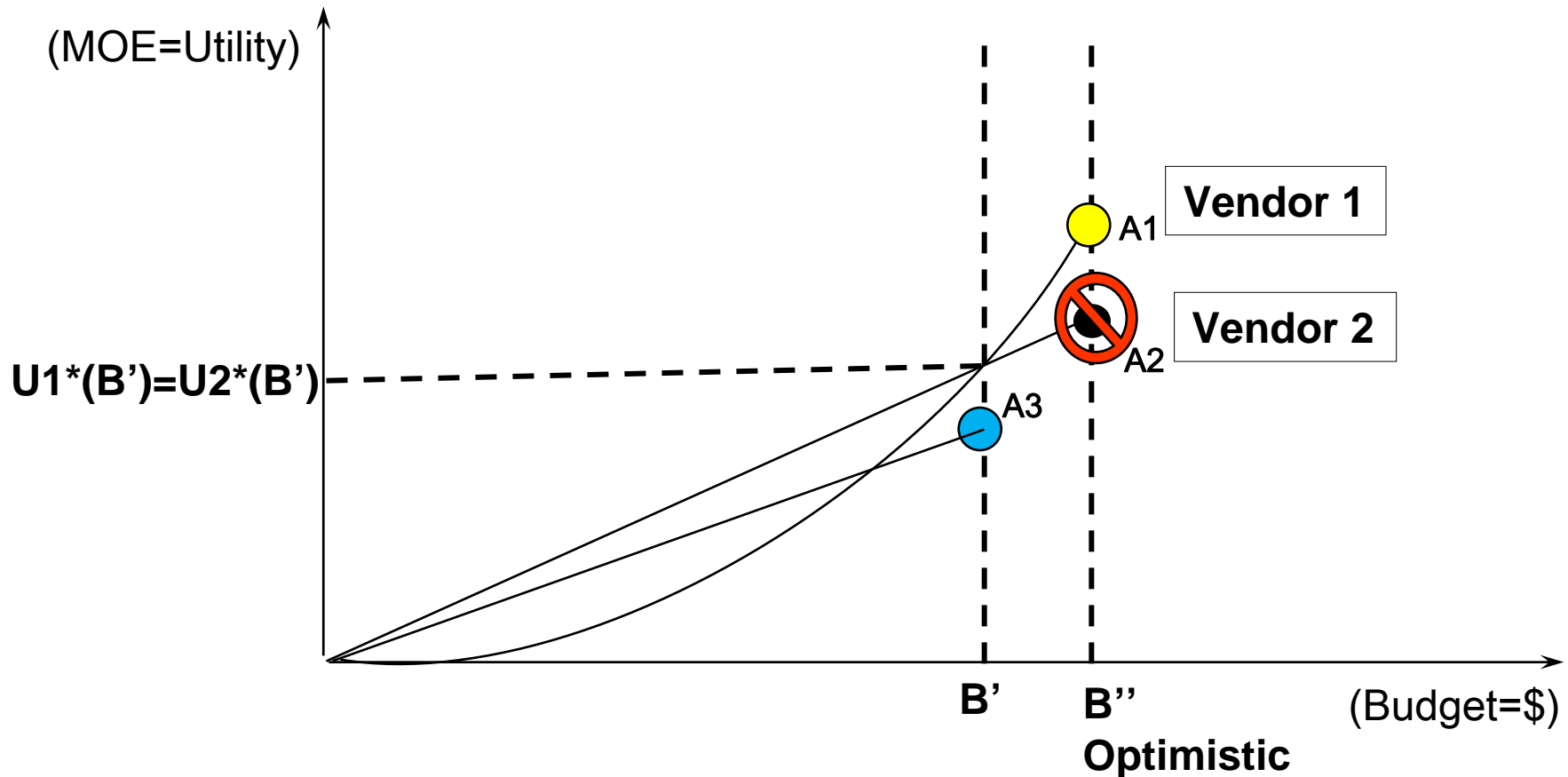
# EEoA: Procurement Agency Choice

Maximize Utility subject to Budget Authority Constraint



# Economic Evaluation of Alternatives

Cost-Effectiveness (Budget-Utility) Analysis  
Vendor Response Functions (Not Points)



# What if we cannot build Alternatives? (Alternatives have already been identified)

- “In many cases, there will be a **minimum set of alternatives required** by the initial analysis guidance.”
- In most AoAs,...comparisons involve **alternatives that have both different effectiveness and cost**, which leads to the *question of how to judge when additional effectiveness is worth additional cost.*

(Defense Acquisition GuideBook Section 3.3  
[www.deskbook.osd.mil](http://www.deskbook.osd.mil))

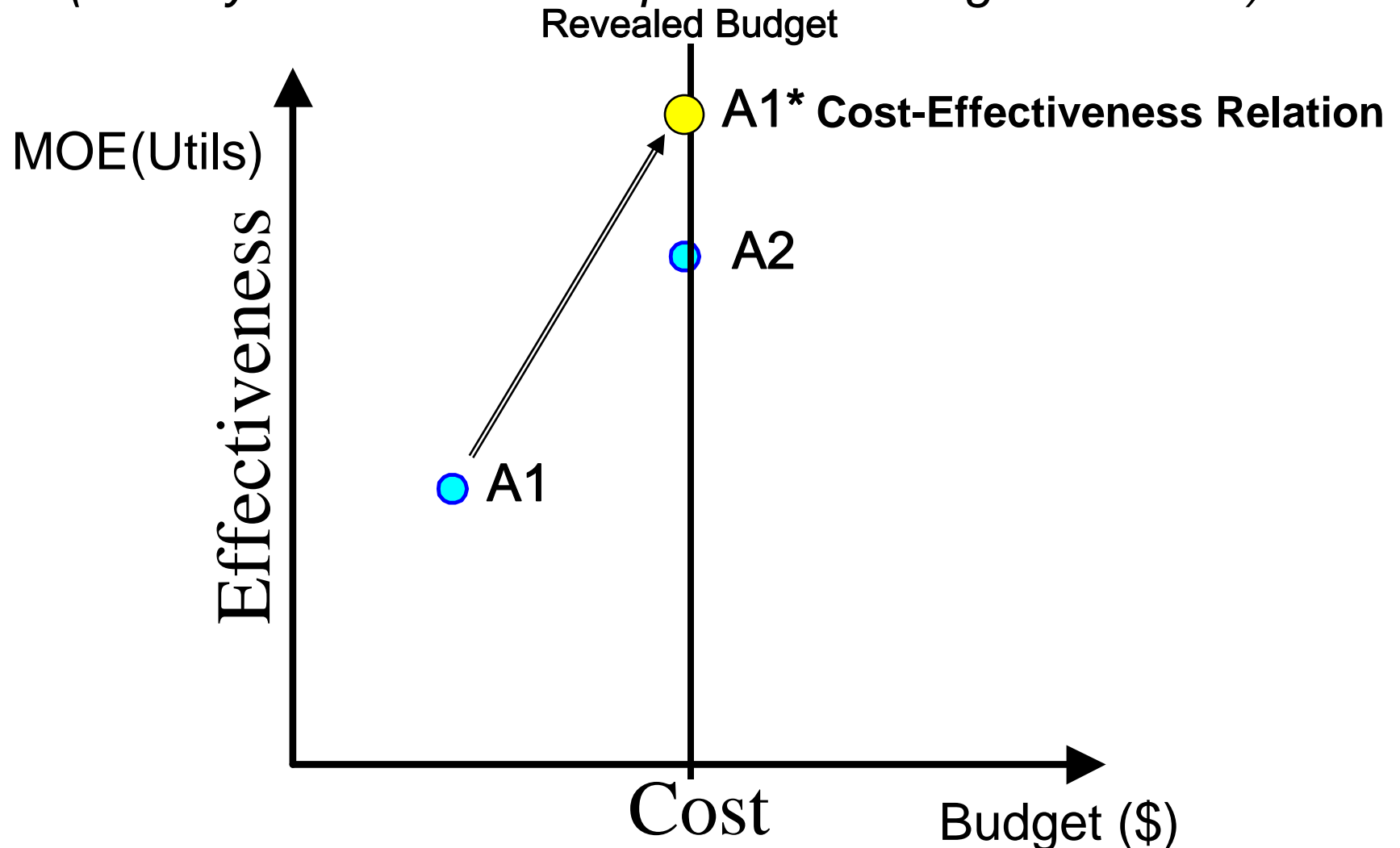


# EOA: “LEVEL THE PLAYING FIELD”

## 4. Modified Budget Approach (GOTO 1 & 3)

Modify alternatives to equalize budget

*(Identify vendor MOE responses to budget increase)*

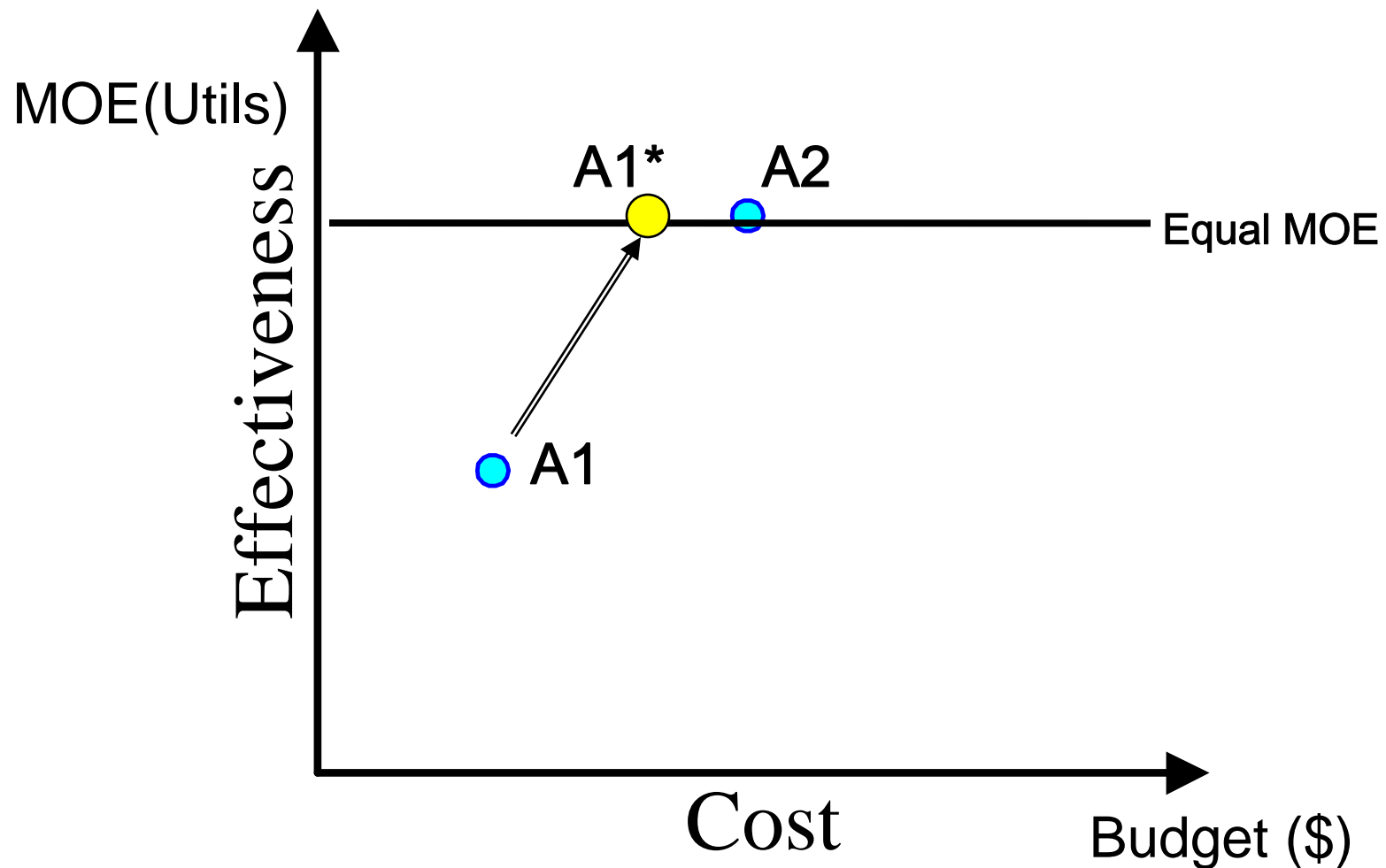


# EOA: “LEVEL THE PLAYING FIELD”

## 5. Modified Effectiveness Approach (GOTO 2 & 3)

Modify alternatives to equalize MOE

*(Identify vendor COST responses to higher MOE requirement)*



## **6. Opportunity Cost Approach (INTER-PROGRAM Analysis)**

- **What if**
  - **We Cannot Modify alternatives to obtain response functions?**

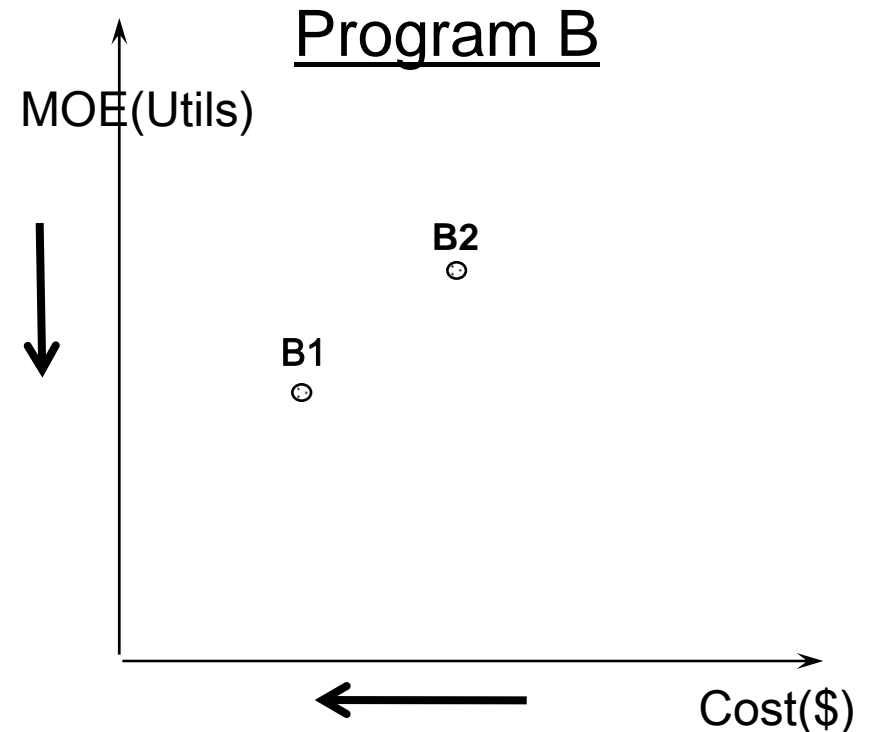
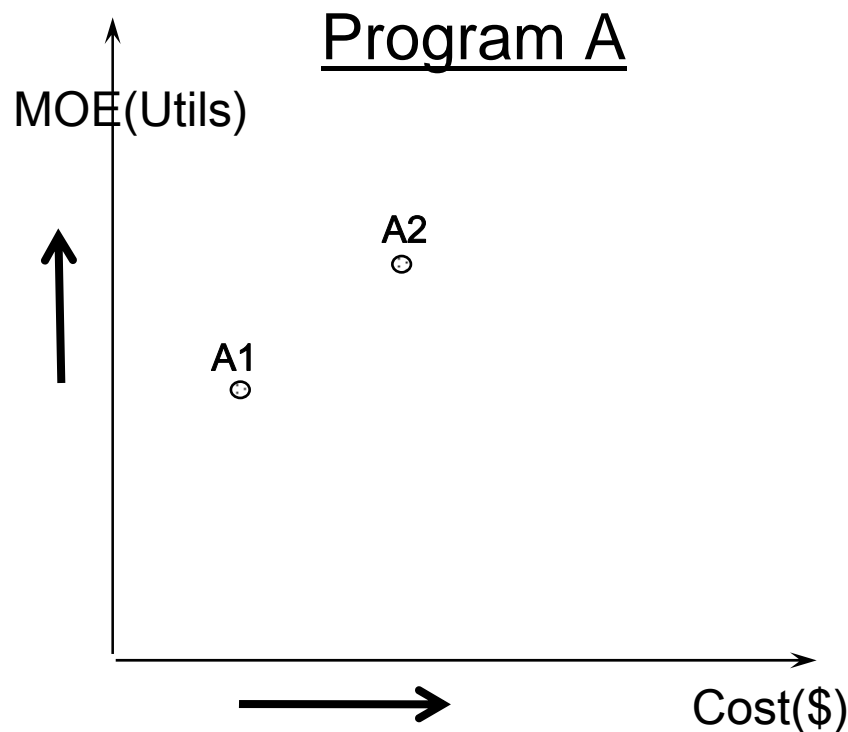
**and**

  - **We don't know or cannot assume a given Budget or desired MOE.**
- Then some alternatives (bundles) cost more but offer more effectiveness, while others cost less and offer less effectiveness (“efficient set”).

# 6. Opportunity Cost Approach (INTER-PROGRAM Marginal Analysis)

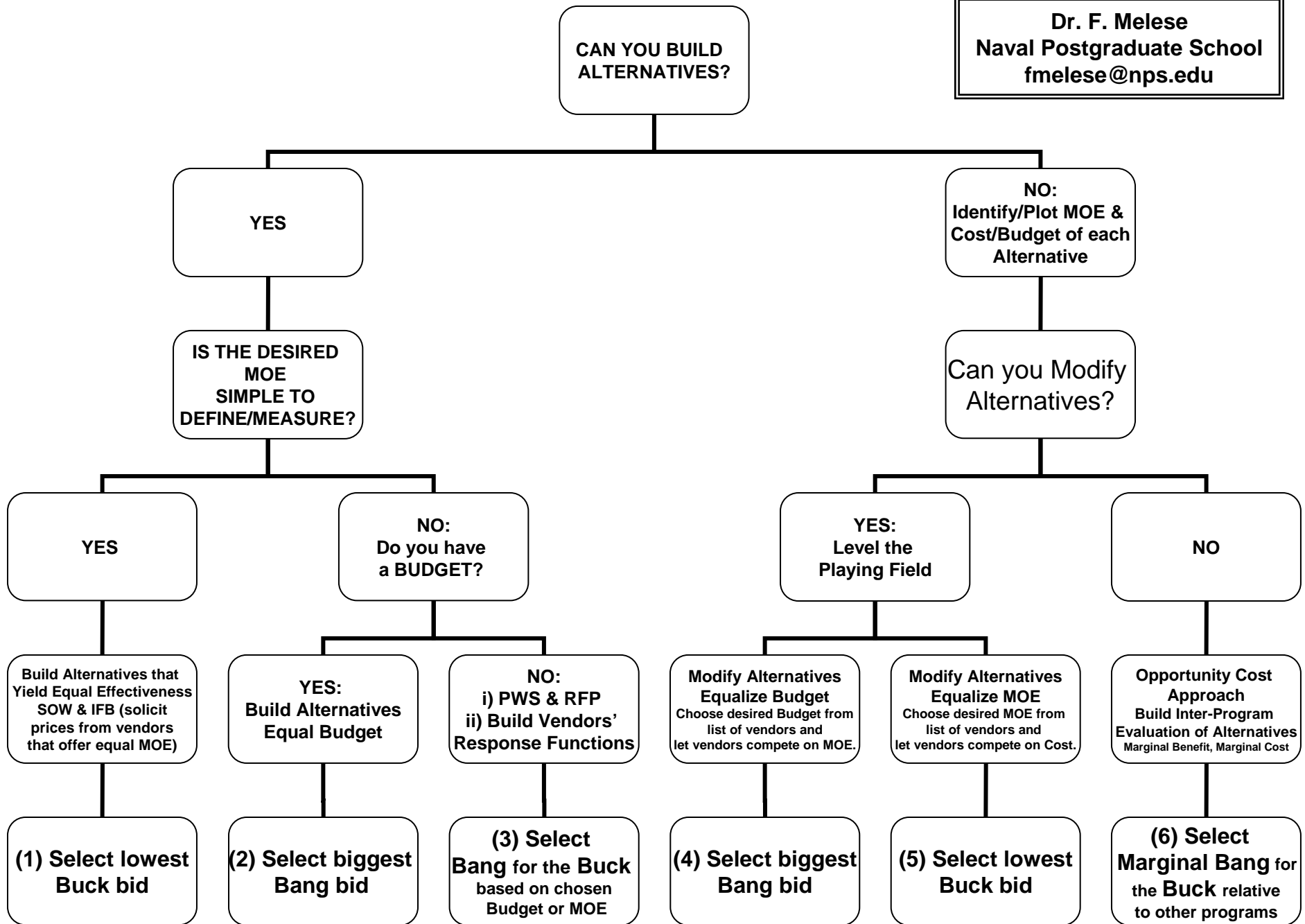
A) Question: Where is the extra money coming from if I buy the high cost alternative?

B) Question: Where is the extra money going if I buy the low cost alternative?



# Decision Map to Structure an Economic Evaluation of Alternatives (EEoA)

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**Enjoy your stay in Monterey!**



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[www.nps.navy.mil/drmi](http://www.nps.navy.mil/drmi)

# **Evaluation of Alternatives (EEoA) Proposal:**

## **Six Ways to Structure an EEoA**

- Build Alternatives: “Intra-Program Analysis”
  1. **Fixed Budget Approach**
  2. **Fixed Effectiveness Approach**
  3. **Expansion Path Approach** (Construct alternatives as Cost-Output/Effectiveness Relations or “Response Functions”)
- Modify Existing Alternatives: “Level the Playing Field”
  4. **Modified Budget Approach: GOTO 1.**
  5. **Modified Effectiveness Approach: GOTO 2.**
- Cannot Modify Existing Alternatives: “Inter-Program Analysis”
  6. **Opportunity Cost/Benefit Approach**

# Economics EOA Approach

- Evaluation of Alternatives (EOA):
  - “[A] criterion in which the budget or level of effectiveness is specified has the virtue of being aboveboard.” (p. 167)  
[EoA approaches 1. and 2.]
  - “The test of ***maximum effectiveness for a given budget*** seems much less likely to mislead the unwary...”(p.167)
  - “As a starter,... ***several budget sizes can be assumed.***
    - If the same [alternative] is preferred for all...budgets, that system is dominant.
    - If the same [alternative] is not dominant, the use of several...budgets is nevertheless an essential step, because it provides vital information to the decision maker.” (p.176)

Hitch C. & R. McKean 1967 “The Economics of Defense in the Nuclear Age” Harvard University Press, Cambridge, Mass.



# AoA

## *[Marine Corps Systems Command PA&E Methodology]*

- Statement of **requirements**
  - Mission Needs Statement (“Customer”), Subject Matter Expert input, etc.
- Development of **alternatives**
  - Complete and exhaustive; Think broadly
  - Multi-step approach; eliminate no alternative before its time
  - “Do nothing” is an alternative!
- Evaluation of **effectiveness** of alternatives (**Modeling & Simulation**)
  - Performance (MOP): inherent characteristic of alternative
  - Effectiveness (MOE): contribution of alternative to overall mission
- Estimation of “rough order of magnitude” **life-cycle costs**
- **Integration** of results
  - Equal effectiveness
    - Set a threshold for a given level of effectiveness
    - Buy enough systems to achieve; compare costs
  - Equal cost
    - Set a fixed expenditure rate
    - Compare effectiveness with equal-cost alternatives
- Conclusions and **recommendations**

***Economic EoA Approach**  
First Structure the Source  
Selection Decision and  
Identify Budgets To Build  
Alternatives*

# DoD Outsourcing Examples

- Materiel management
  - Distribution
  - Inventory control
  - Disposal
- Base commercial activities
  - Facilities maintenance
  - Food services
  - Vehicle maintenance
- Depot maintenance
- Finance & accounting
  - Purchasing & Travel (credit) cards
  - Debt & claims management
  - Administrative support
- Training
  - Simulators
  - Distance Learning
- Information Technology
  - Computer equipment, maintenance & repair
  - Communication equipment, maintenance & repair
  - Software development
  - Internet services

## Summary: Six Approaches to AoA

- Can Construct alternatives:
  1. **Fixed Budget Approach** (Construct alternatives with equal budget):
    - Objective: Maximize Effectiveness
  2. **Fixed Effectiveness Approach** (Construct alternatives with equal effectiveness):
    - Objective: Minimize Costs
  3. **Expansion Path Approach** (Construct alternatives as Cost-Output/Effectiveness Relations): Sensitivity Analysis
- Can Modify pre-determined alternatives: “Level the Playing Field”
  4. **Modified Budget Approach** (Identify high/low cost alternative as “revealed” budget constraint and adjust others accordingly)
    - Objective: Maximize Effectiveness (GOTO 1 & 3)
  5. **Modified Effectiveness Approach** (Identify effectiveness of an alternative as “revealed” objective and adjust others accordingly)
    - Objective: Minimize Costs (GOTO 2 & 3)
- Cannot Construct or Modify alternatives:
  6. **Opportunity Cost/Benefit Approach**: (Inter-program analysis)

## To generate MOE:

**Identify: decision scenario, relevant players  
“decision makers” (DM), and time frame**

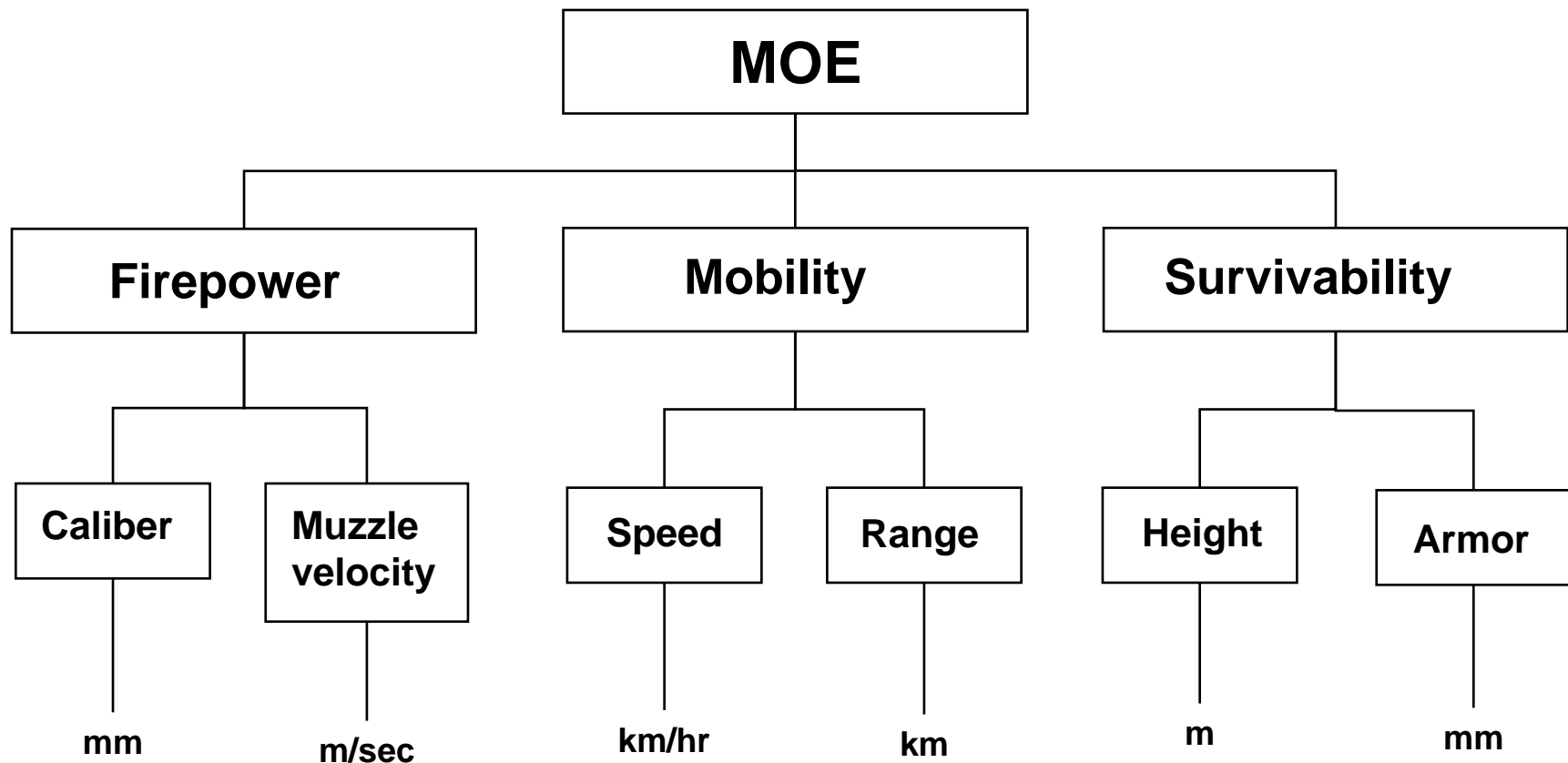
- Identify relevant players: DM
  - Users
  - Evaluators
  - “Political” Stakeholders
  - Payers **\$\$** (Cost as an Independent Variable—CAIV )
- “Top-down” approach to assist DM to describe components of **MOE** (utility) function
  - Saaty’s (1977) Analytic Hierarchy Process (AHP)
    - Proceed from general criteria to measurable attributes

# Example: MOE

What Capabilities do DM's want/need?

(Given Scenario, Players, and Time Frame, Identify desired Attribute Mix)

MOE = f(Firepower, Mobility, Survivability)



**MOE = f(F(Cal, Muzz); M(Speed, Range); S(Height, Armor))**

# DoD Outsourcing Goals

## 1. Cut Costs:

- Competition increases productivity and cuts costs.
- Leverage economies of scale & scope, learning curves, and specialized human capital and technology investments.

## 2. Boost Performance/Effectiveness:

- Continuous improvement of product and service quality, schedules, and responsiveness to military demands.

## 3. Focus on Core Competencies:

- Focus scarce DoD resources and defense management attention on core competencies.
- Provide oversight and monitoring of service and supply contracts, and preserve option of future competitions.

# Federal Outsourcing Guidance

- Office of Management & Budget (**OMB Circular A-76**)
- Federal Acquisition Streamlining Act (PL 103-355)
- Federal Acquisition Reform Act (PL 104-106)
- Information Technology Management Reform Act (PL 104-106)
- Federal Activities Inventory Reform Act (PL 105-270)
- Federal Acquisition Regulations (FAR/DFAR 5000.1&2)

# OMB Circular A-76

- “Mandates...the government obtain commercially available goods and services from the private sector when it makes economic sense to do so.”
- “[R]equires...structured process for [evaluating] the most efficient and cost-effective method of performance for commercial activities...”

## Four Steps:

1. Develop Statement of Work (SOW) or Performance Work Statement (PWS) to define desired performance/effectiveness (and a Quality Assurance Surveillance Plan—MOE)
2. Construct Most Efficient Organization (MEO) for in-house competitor
3. Issue Invitation for Bid (IFB) for well-defined, routine commercial activities; or Request for Proposal (RFP) for less well-defined, more complex activities
4. **Source Selection: Compare bids or proposals—“least cost” for IFB; “BEST VALUE” for RFP**



# Federal Activities Competed Most Frequently in FY 2004-5

<b>Activity</b>	<b>FTE</b>	<b>%</b>
<b>Maintenance/property mgmt</b>	<b>5,459</b>	<b>29</b>
<b>Logistics</b>	<b>4,435</b>	<b>23</b>
<b>Information technology</b>	<b>3,262</b>	<b>17</b>
<b>HR/personnel mgmt</b>	<b>1,378</b>	<b>7</b>
<b>Finance &amp; accounting</b>	<b>1,178</b>	<b>6</b>
<b>Administrative support</b>	<b>1,078</b>	<b>6</b>
<b>Other</b>	<b>2,316</b>	<b>12</b>

# Examples: Outsourcing Travel

## (2005 Vendor Sales to the Federal Government)

<u>Airlines</u>	2005 (\$mil)	Market share
United	\$846	25%
Delta	\$718	21%
American	\$491	14.4%

<u>Hotels</u>	2005 (\$mil)	Market share
Marriot	\$146	7.3%
Holiday Inn	\$141	7.0%
Residence Inn	\$125	6.3%

<u>Cars</u>	2005 (\$mil)	Market share
Hertz	\$76	20.2%
Enterprise	\$56	15%
Avis	\$54	14.3%

<u>Gov't Executive</u> 8/15/06 pp.66-8	2004	2005
Defense	\$8.9bil	\$10.9bil
Homeland Security	\$849mil	\$940mil

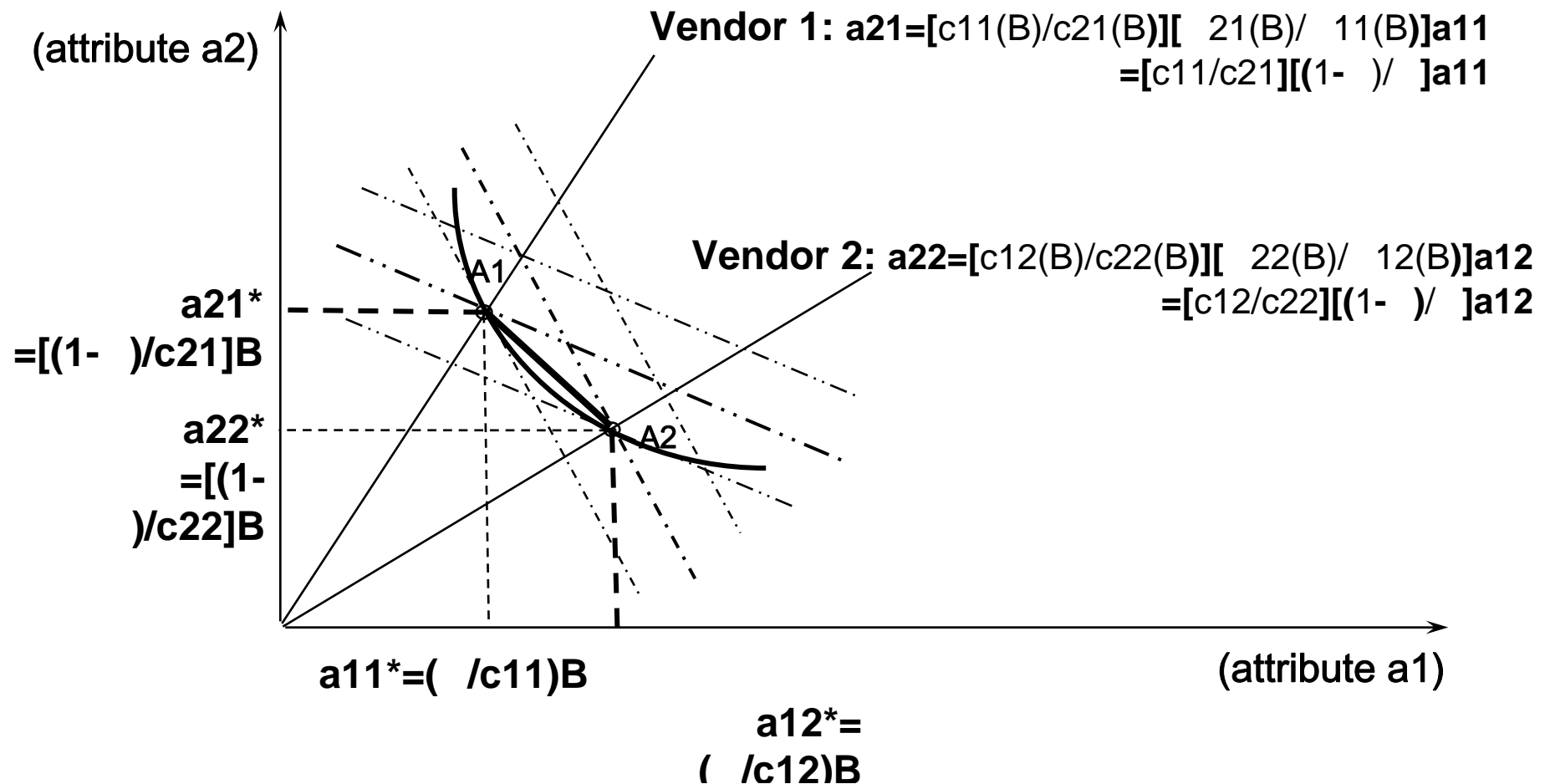
# Outsourcing Lessons Learned

1. Use performance-based contracting
  - Do not list tasks [mix of inputs], but state results sought or problems to be solved [desired attributes/characteristics of outputs/outcomes]
  - Tell them **WHAT** you want...**not HOW** to do it.
  
2. Choose contractors according to **BEST VALUE**
  - Source Selection: Trade off performance and price instead of simply awarding to the lowest bidder.

# EEoA: Vendor Expansion Paths

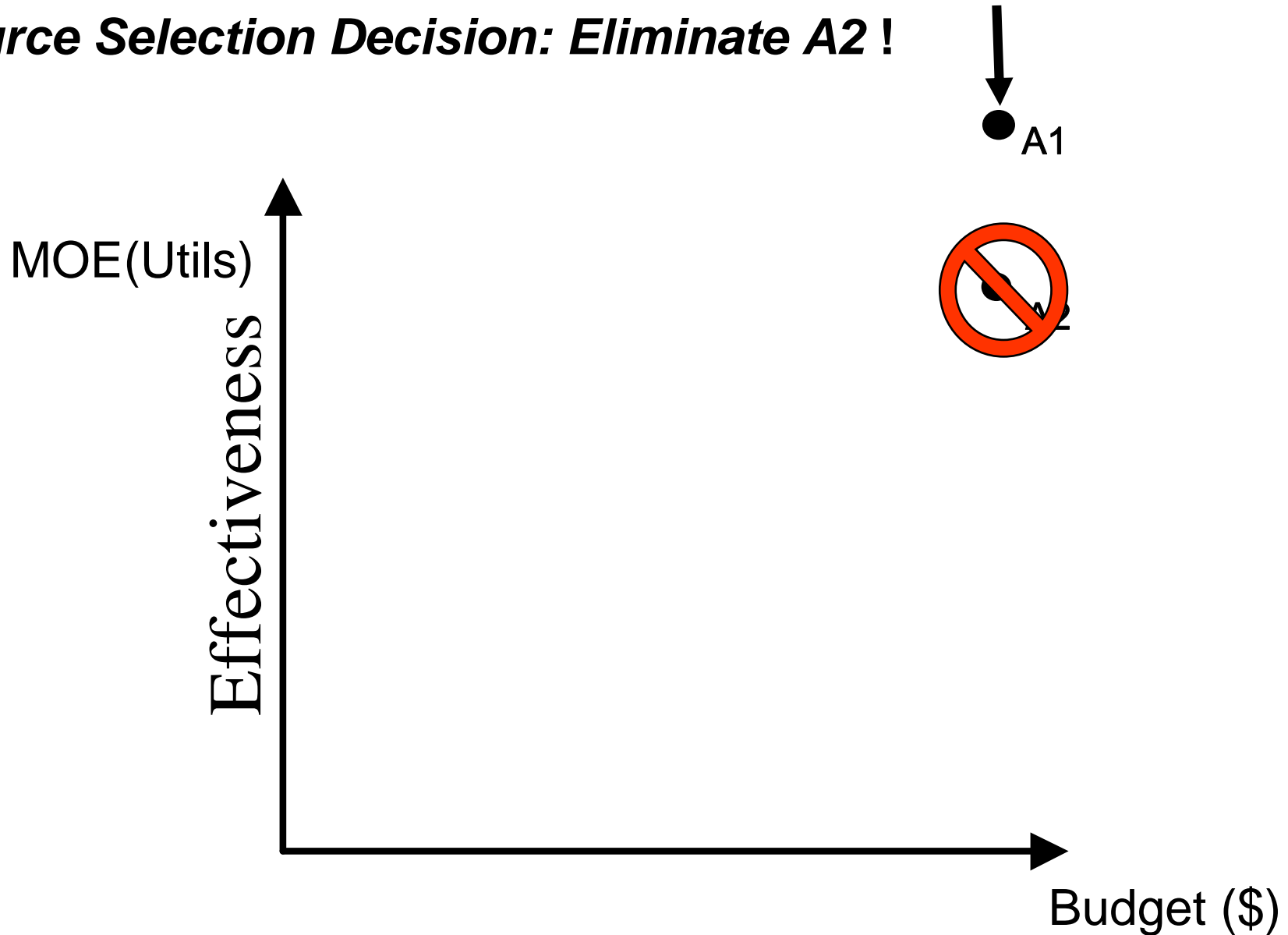
Maximize Attribute Bundle subject to Budget Constraint

(Assumptions for Illustration: Identical, constant, technology (i.e.  $\alpha_{11} = \alpha_{12} = \alpha_1$  and  $\alpha_{21} = \alpha_{22} = \alpha_2$ ), constant returns to scale (i.e. CRTS  $\Rightarrow \alpha_1 + \alpha_2 = 1$ , or if  $\alpha_1 = \alpha$  then  $\alpha_2 = 1 - \alpha$ ), constant attribute costs, and  $c_{11}/c_{21} > c_{12}/c_{22}$  or  $c_{11}/c_{12} > c_{21}/c_{22}$ , so slope of vendor1 expansion path is steeper than vendor 2.



**DECISION SCIENCES APPROACH: Exogenous Alternatives**  
**Example of “SUPERIOR (Dominant) SOLUTION”**

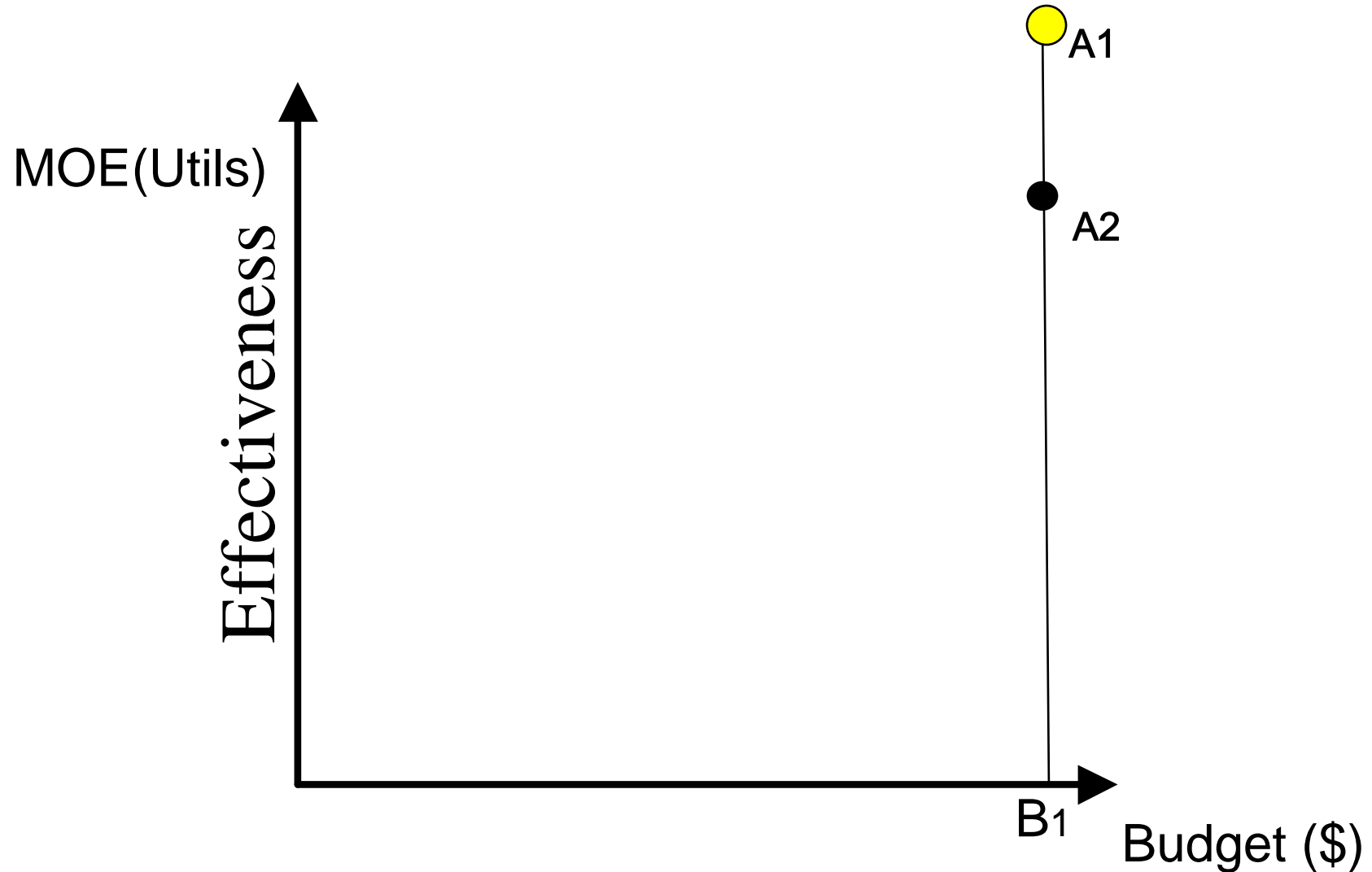
***Source Selection Decision: Eliminate A2 !***



**ECONOMIC APPROACH:** Evaluation of Alternatives (“Engel Curves”)

**3. Expansion Path (Response Function) Approach**

***Do not eliminate A2 prematurely: Explore impact of budget cuts (Identify vendor responses)***

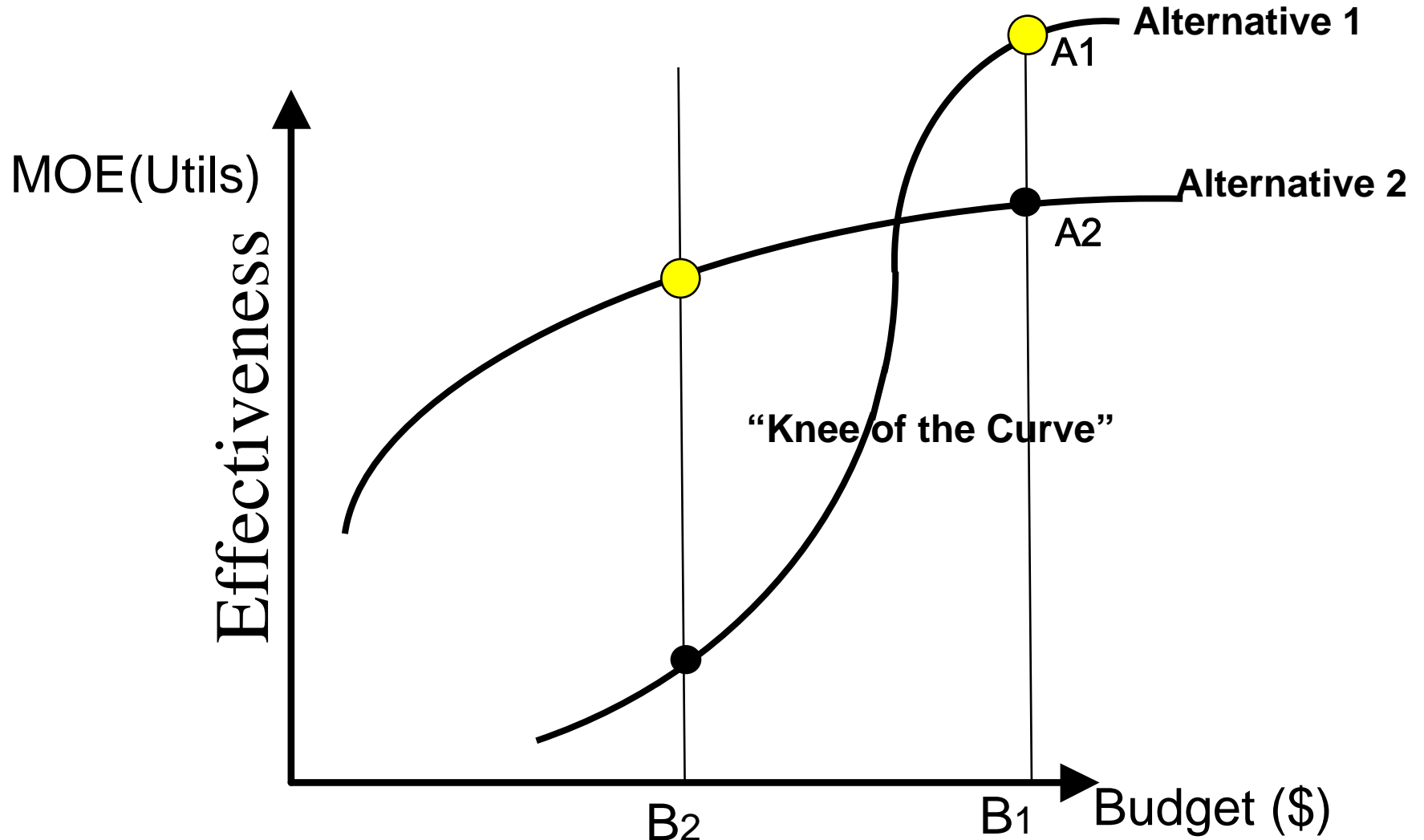


**ECONOMIC APPROACH:** Endogenous Alternatives (“Engel Curves”)

**3. Expansion Path (Response Function) Approach**

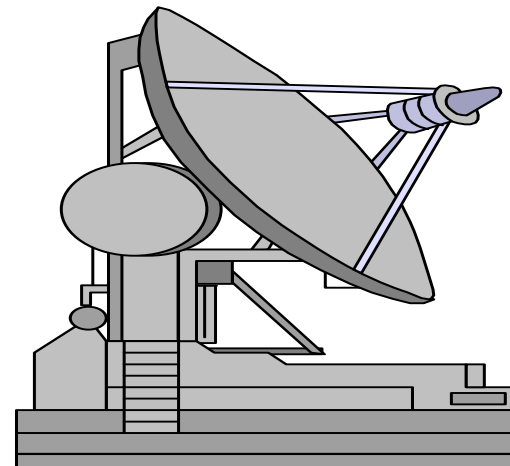
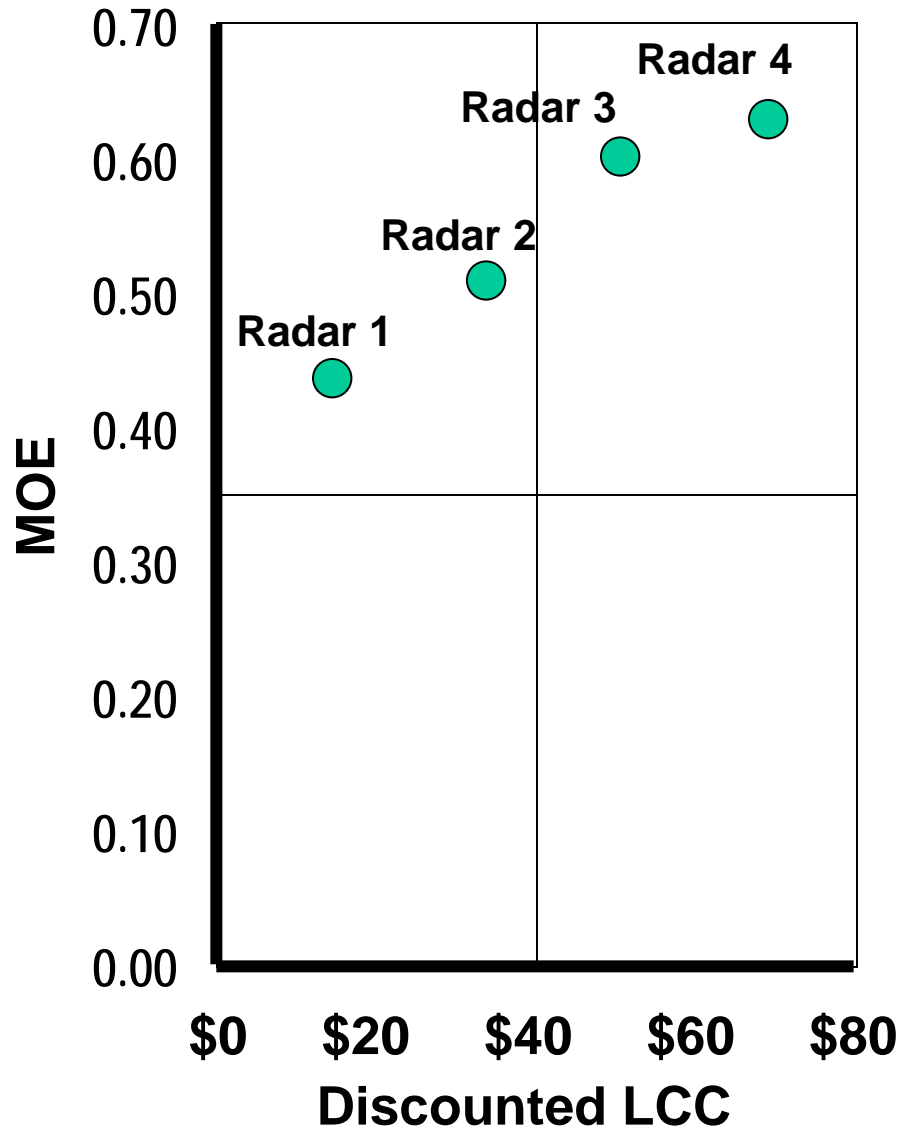
**(Alternatives are Cost-Effectiveness Relations, not Points)**

*Explore impact of budget cuts (Identify vendor responses)*



**Source Selection Decision: A2 for pessimistic budget; A1 for optimistic budget**

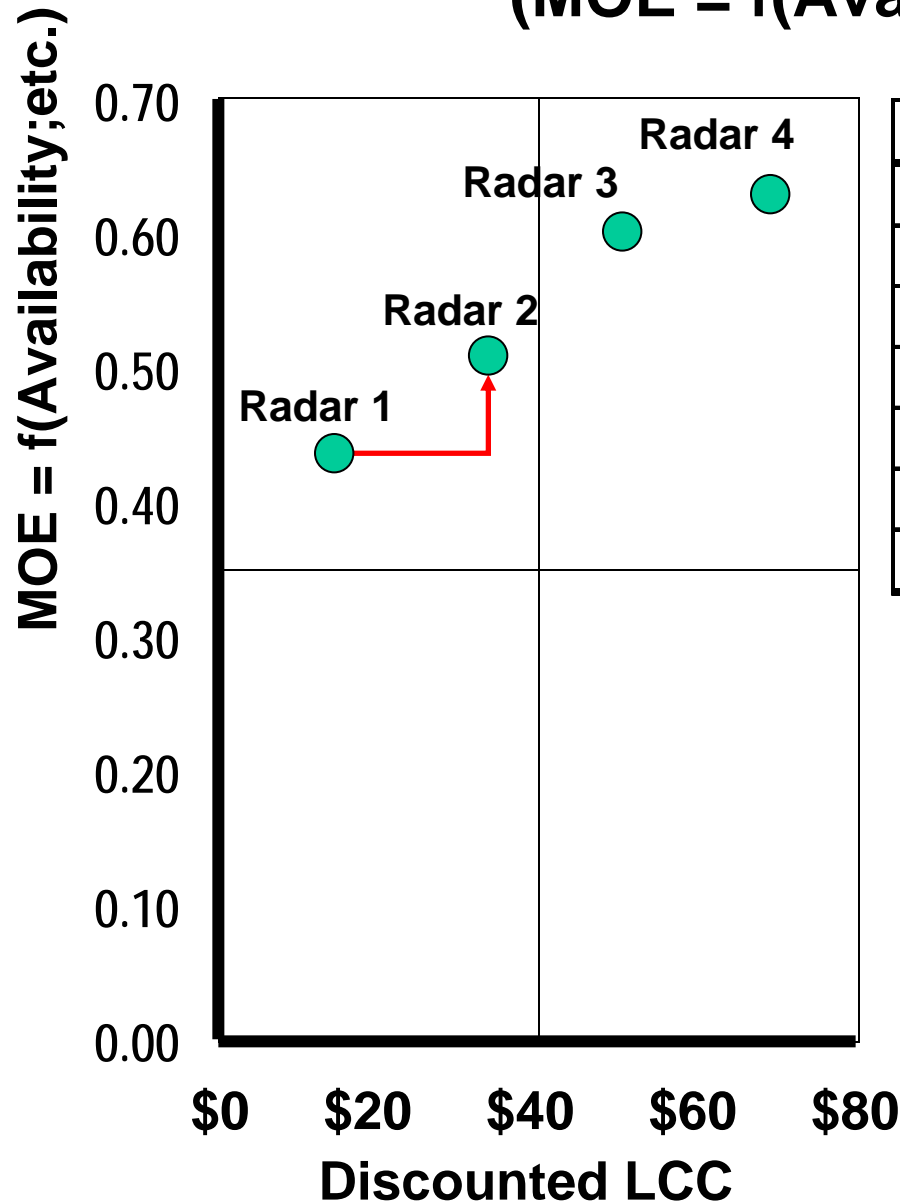
# Example: Evaluate Alternative Radar Maintenance Packages





# Which is “Best Value?” Radar 1 or 2?

(MOE = f(Availability;etc.))



Attributes	Radar 1	Radar 2	Change
Availability	0.8	0.9	0.1
<b>COST</b>	\$14.00	\$35.00	\$21.00

Is it worth \$21mil over the life of the system to obtain the extra Availability MOE?

**Relative to what?**

## Source Selection

“One straightforward method for combining cost and effectiveness involves constructing a ratio.” (p.6-3)

“The methods we choose for combining effectiveness [and] cost...depend upon the nature of the problem.  
**We can fix either cost or effectiveness.**”

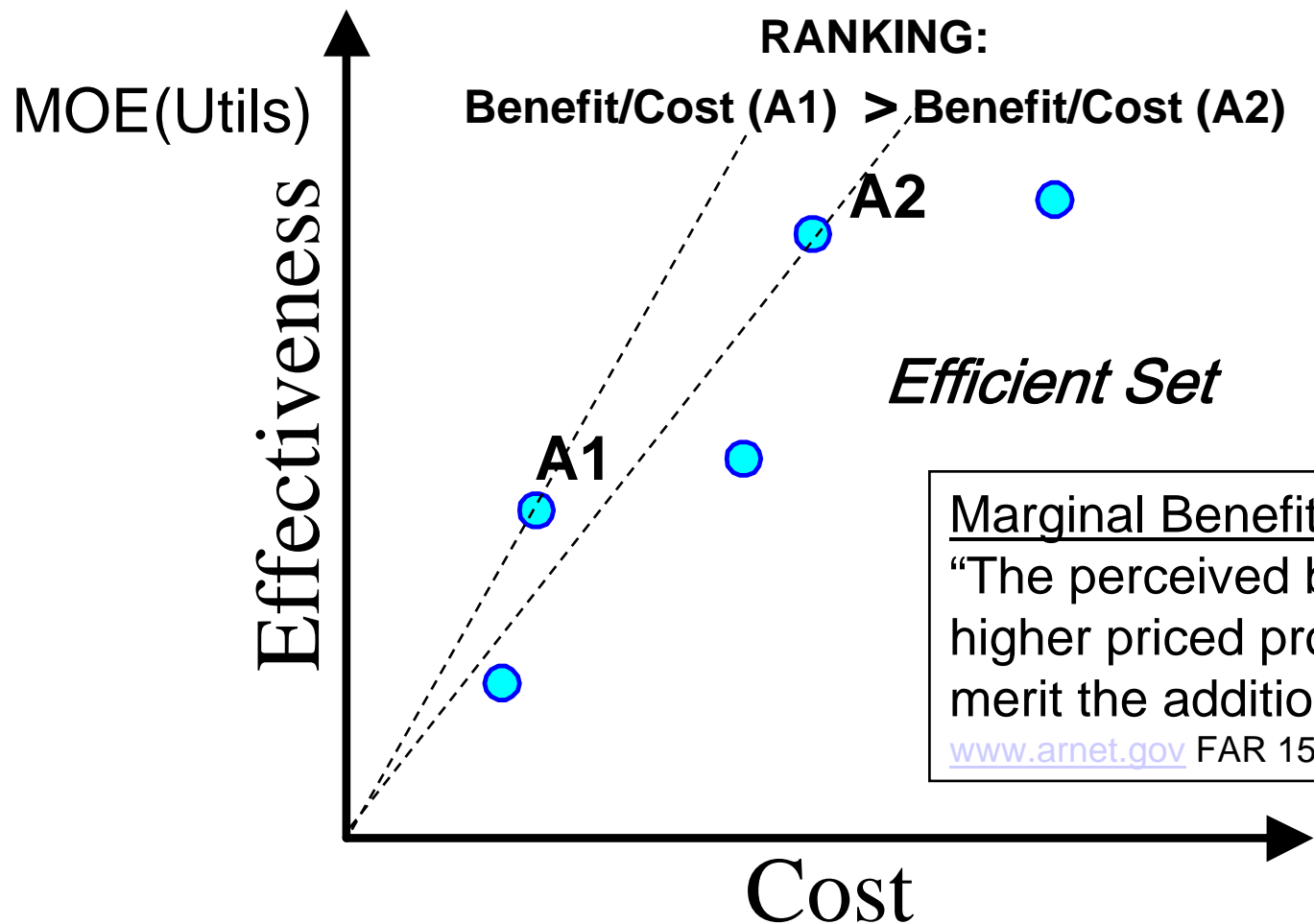
“**If neither can be fixed...we can establish a cost/effectiveness ratio...**” (p.6-10)

C. Murray, Editor (2002) Executive Decision Making, National Security Decision Making Dept., U.S. Naval War College ([www.nwc.navy.mil/nsdm/sndmedm2.htm](http://www.nwc.navy.mil/nsdm/sndmedm2.htm)) 6<sup>th</sup> Edition

**Danger in applying  
Bang/Buck or Buck/Bang  
Ratios to rank alternatives**

Is A1 really superior to A2 ?

LESSON: **DANGER** in using Benefit/Cost (Bang/Buck) or Cost/Benefit (Buck/Bang) ratios without anchoring Budget or MOE



Marginal Benefit/Marginal Cost

“The perceived benefits of the higher priced proposal shall merit the additional cost...”

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