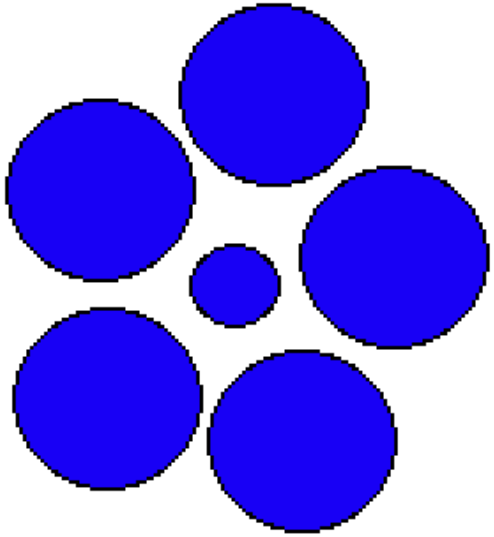
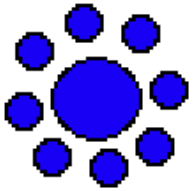
Decision Support for Leaders

Level III – DoD FM Certification

Defense Resources Management Institute
Naval Postgraduate School
Monterey, California

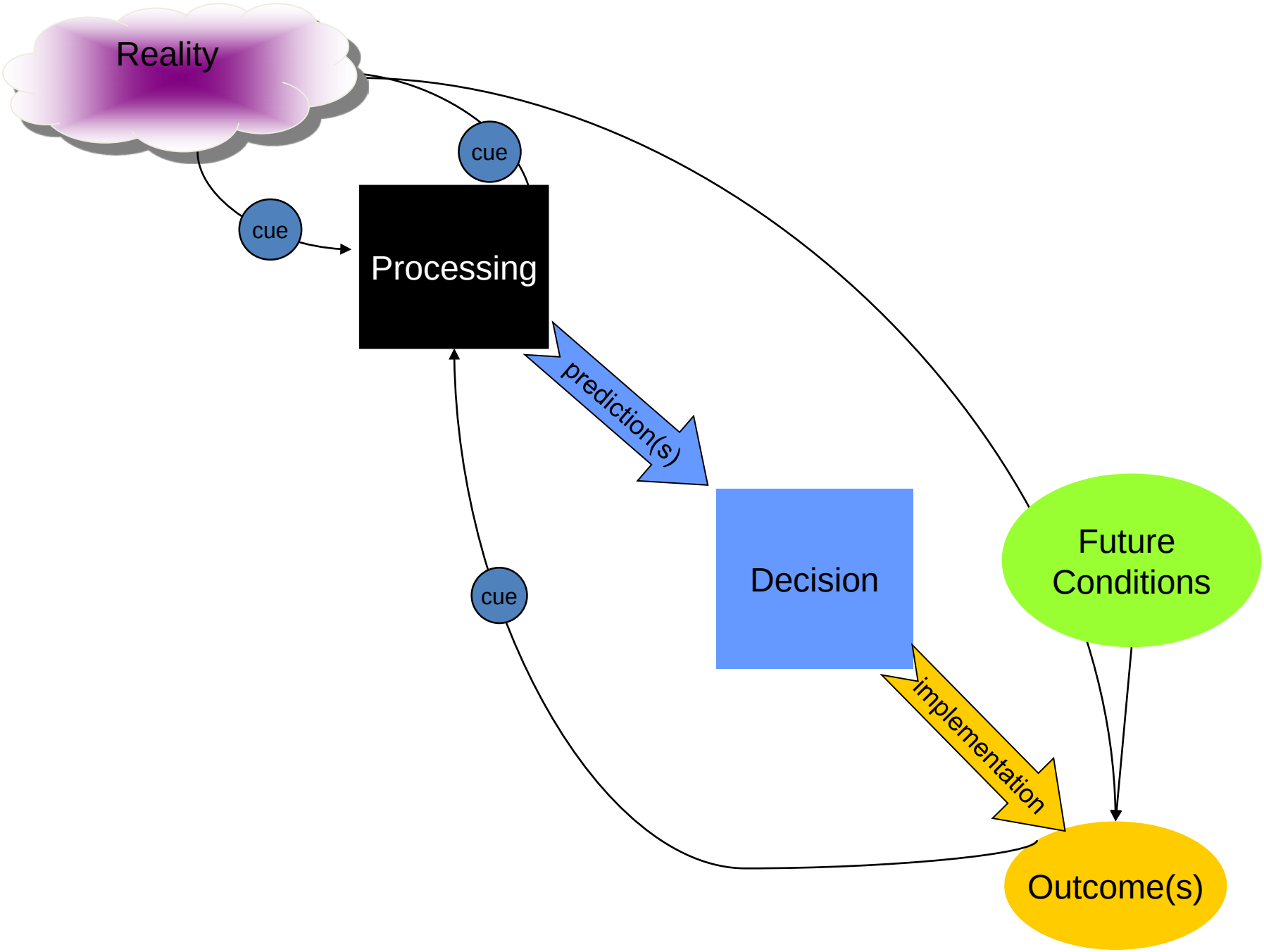
Why Decision Support?





Definitions of terms

- assessment – the output of an estimation or evaluation process (prediction)
- cues – items of information used as inputs to the assessment process (predictors)
- validity – strength of the relationship between a cue and event being assessed
- bias – a tendency to systematic error (i.e. the same type of error is reproduced)


Reality
cue
cue
Processing
prediction(s)
Decision
cue
Future
Conditions
implementation
Outcome(s)

Predictive accuracy

Definition: long-run average match between assessment and reality (e.g. between prediction and predicted event)

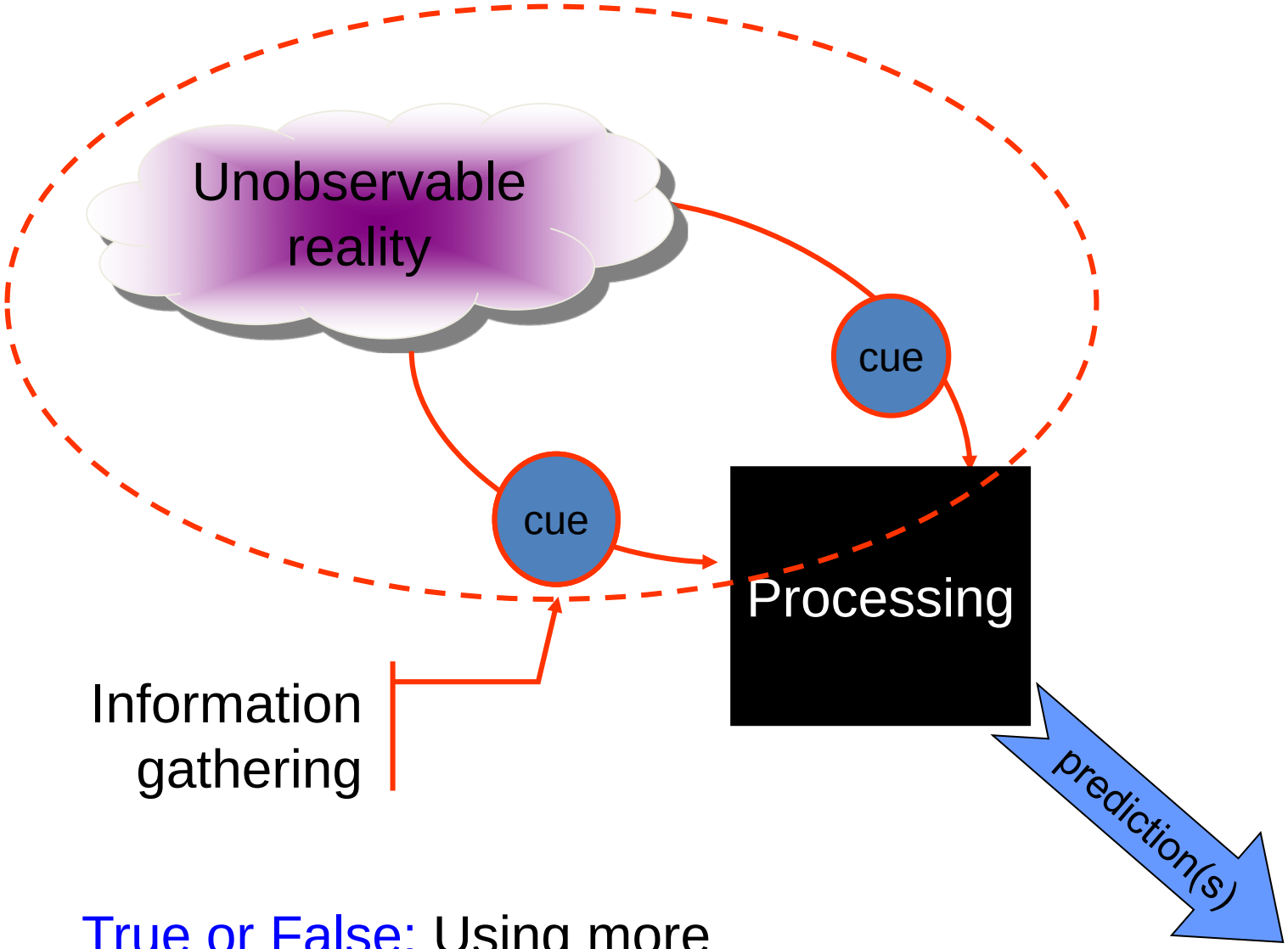
Depends on:

- inherent predictability of the event
- cues used to make the prediction
- processing of the cues

Problems in <u>any</u> of these three areas reduce predictive accuracy.

Inherent Predictability

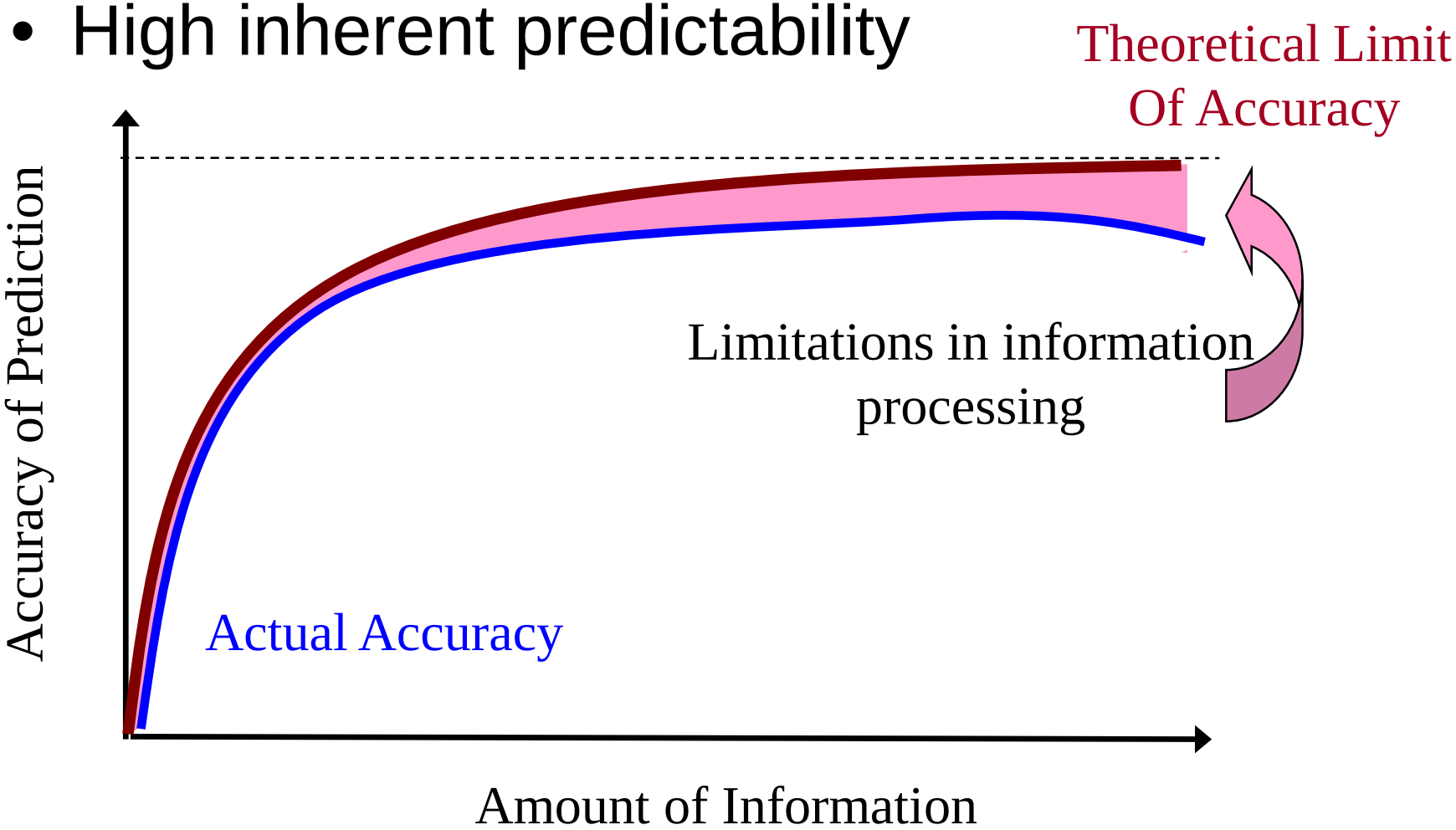
- We cannot increase inherent predictability – this is why we use the word “inherent”.
- Inherent predictability imposes an upper bound on (long-run) accuracy of predictions.
- **The lower the inherent predictability the worse experts do at information gathering and processing.**



True or False: Using more information always makes predictions (or decisions) better.

Amount of info. vs. Accuracy

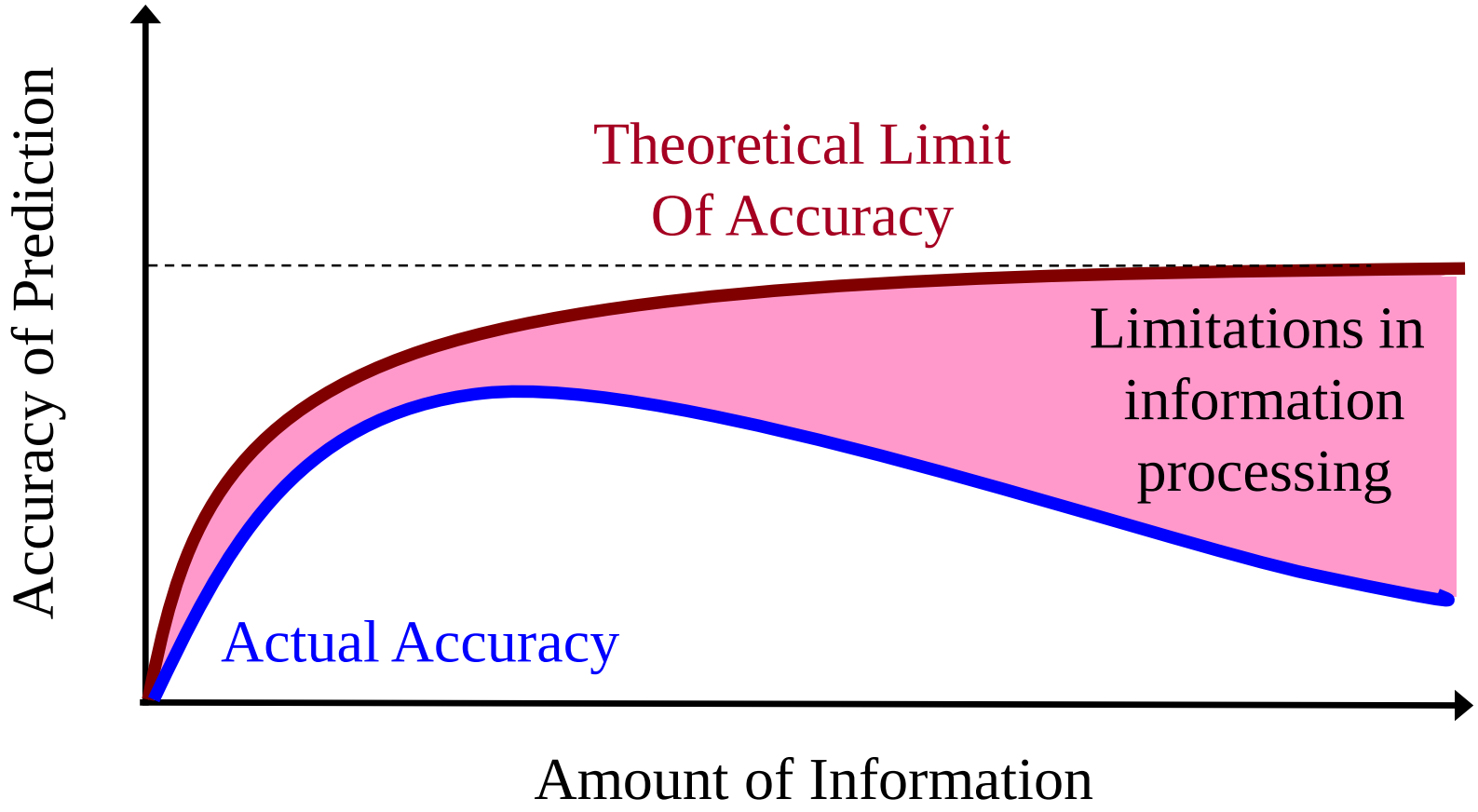
- High inherent predictability



Adapted from TR Stewart, "The human forecaster: Components of judgmental skill" Jan.2007

Amount of info. vs. Accuracy

- Low inherent predictability



Adapted from TR Stewart, "The human forecaster: Components of judgmental skill" Jan.2007

Example: Heart patient triage

Decision: whether to send patient home, for observation, or check them into the hospital

Information available:

- Family history
- Medical history (diabetes, heart disease, etc.)
- Electro cardiogram (ECG) results
- Blood pressure, fever, pulse, weight, lung function, etc.
- Age, gender, race

Example: Heart patient triage

Statistical model based on four cues:

- Systolic blood pressure
- ECG results (4 parameters)
- Sound of fluid in lungs
- Chest pain

Cues <u>not</u> necesary: diastolic blood pressure, age, diabetes, prior heart disease,…and <u>everything else</u>.

Example: Heart patient triage

	Judgment	Model
of patients with heart complications* how many were hospitalized	89%	94%
of patients who were hospitalized, how many who had complications	29%	36%

* severe complications within 72 hours.

Reilly, B.M., Evans, A.T., Schaider, J.J., and Wang, Y. (2002) “Triage of patients with chest pain in the emergency department: A comparative study of physicians’ decisions”. Journal of the American Medical Association 112:95-103.

Pitfalls in information-gathering

- Collection of <u>too many cues</u>
- Inconsistent use of cues (changing cues)
- Use of non-valid cues
- Error (variability) in assessing cues
- Perceptual biases in collection and assessment of cues, including
  - Optimism
  - Confirmation bias

Definitions of terms

- Heuristic – a simple procedure for seeking a solution or making a decision

  Often called a “rule of thumb”

- Judgmental heuristic – a mental rule of thumb, which allows us to make a judgment quickly
- Bias – a tendency to systematic error (i.e. the same type of error is reproduced)

Exercise

Which kills more people in the US:

A. Shark attacks; or
B. Falling airplane parts

Which kills more people in the US:

A. Firearm Assault
B. Falling

Availability

Heuristic: events that are easy to imagine are more likely.

Bias: events that are recent, emotionally charged, or vivid are believed to be more likely than they really are.

Exercise

Which is more likely to have been generated by a fair coin?

- HTHTTH
- HHHTTT

Representativeness

Heuristic: things that resemble each other must be related.

Bias: events that are representative of their class seem more likely than they really are.

Exercise

Which would you rather have:

1. A lottery ticket with a one in a thousand (0.1%) chance of winning a million dollars, or
2. The opportunity to flip ten coins. If all are heads, you win $1M.

Issues in Probabilities

Heuristic: multiple events lead to greater likelihood.

Bias: overestimating conjunctive probabilities (the probability of Event A AND Event B).

Exercise

Bill is 34 years old. He is intelligent but unimaginative. In school, he was strong in mathematics, but weak in social studies and humanities.

Which is more likely?

A. Bill is an accountant.

B. Bill plays jazz as a hobby.

C. Bill is an accountant who plays jazz as a hobby.

Reproduced from Tversky and Kahneman (1984)

Framing effect

Losses and gains are viewed differently.

Anchoring

Heuristic: start with a baseline estimate (‘anchor’) and adjust relative to this starting point.

Exercise

- For each of the following ten items, provide a low and high estimate such that you are 90 percent sure the correct answer falls between the two.
- The range (between high and low) should be neither too narrow (i.e., overconfident) not too wide (i.e., underconfident).

Exercise

Adapted from Russo and Shoemaker

Exercise

- If you are well calibrated, how many will you get wrong (i.e. true value is outside your estimates)?
- Is it an advantage to know a lot about these items?

Answers

Overconfidence

Bias: humans are generally more confident in

- their relative abilities,
- future prospects, and
- judgments

than they should be.

Improving Intuition

“Experience is inevitable;
Learning is not.”

Paul J. H. Shoemaker

Which of the following factors improve intuitive judgment?

- ☒ Complex decision context
- ☑ Highly predictable environment
- ☒ More information
- ☒ Confidence
- ☒ Experience
- ☑ Feedback
- ☐ Hearing this lecture

How to increase accuracy In repeated intuitive predictions

Systematize information gathering

- Choose cues systematically
- Use a small set of cues
- Test cues for validity
- Standardize the assessment of cues
- Provide systems (e.g. a checklist) for collection and use of cues
- Separate assessment of cues from prediction process
- Design systems to present cues to experts in most intuitive form

How to increase accuracy In repeated intuitive predictions

Create conditions for learning

- Systematic information gathering
- Task training: letting person making prediction know how valid cues are, how predictable context is
- Outcome feedback: measuring how well predictions match reality, and providing feedback

How to reduce errors In one-time intuitive predictions

- Seek disconfirming evidence
- Require verbal justification of a prediction
- Combine <u>independent</u> judgments from more than one expert
- Break complex tasks into smaller pieces

How to reduce errors

Use formal models and analysis whenever appropriate (often!).

Analysis vs. intuition

Pros of Analysis

- More consistent
- More accurate*
- Can be automated
- Endures as personnel change
- Transparent

Cons of intuition

- Inconsistent
- Less accurate*
- Can be slower (reinventing the wheel)
- Expertise linked to the expert
- Harder to justify to others

* In many, many situations, even when experts do not believe this is possible.

Analysis vs. intuition

Cons of Analysis

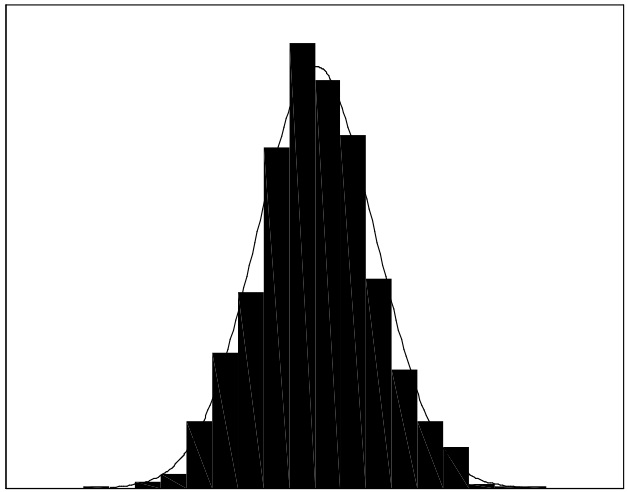
- Some human perceptions cannot be reproduced
- Errors, though rarer, can be extreme
- Slower in a one-time decision
- Experts lose sense of control
- Transparent

Pros of Intuition

- Very good at certain kinds of pattern recognition
- Can be faster, especially in a one-time decision
- Experts feel more in control
- Not transparent

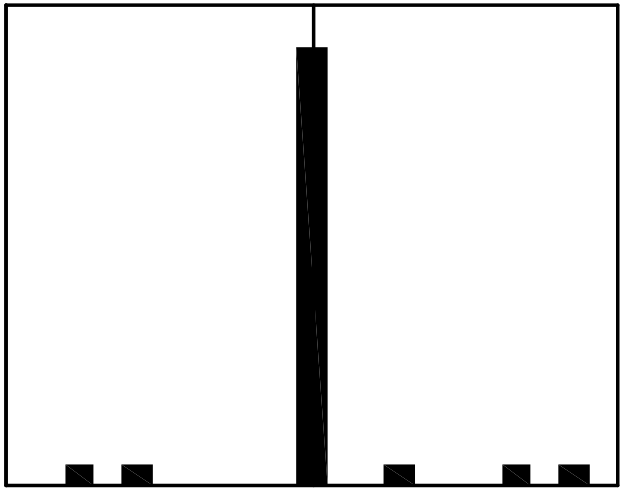
Distribution of Errors in Intuitive and Analytic Processes

Distribution of errors for intuitive process



Intuitive judgment

Distribution of errors for analytic process



Analytic judgment

Based on Hammond, K. R., 1996. Adapted from TR Stewart, "Intuition and Analysis - Detail" Jan.2007

Decision Support Systems

Human beings are vulnerable to errors.

What can we do about it?

- Be aware of these errors, and use techniques to combat them
- Monitor expert performance and find ways to support and enhance intuition.
- Systematize collection and use of information.
- Create conditions for learning with task training and feedback.
- When possible, use models and expert systems.

Decision Environment

Before

Informing a choice among alternatives

- acquisition
- policy
- program
- process

After

Determining how well a chosen option is working

- acquisition
- policy
- program
- process

Analyses / Methodologies

Cross - Cutting
At the START

Before
Informing a choice among alternatives

After
Determining how well a chosen option is working

Cross – Cutting
At the END

Cross Cutting Analyses/Methodologies At the start

Analysis

Elements of Analysis

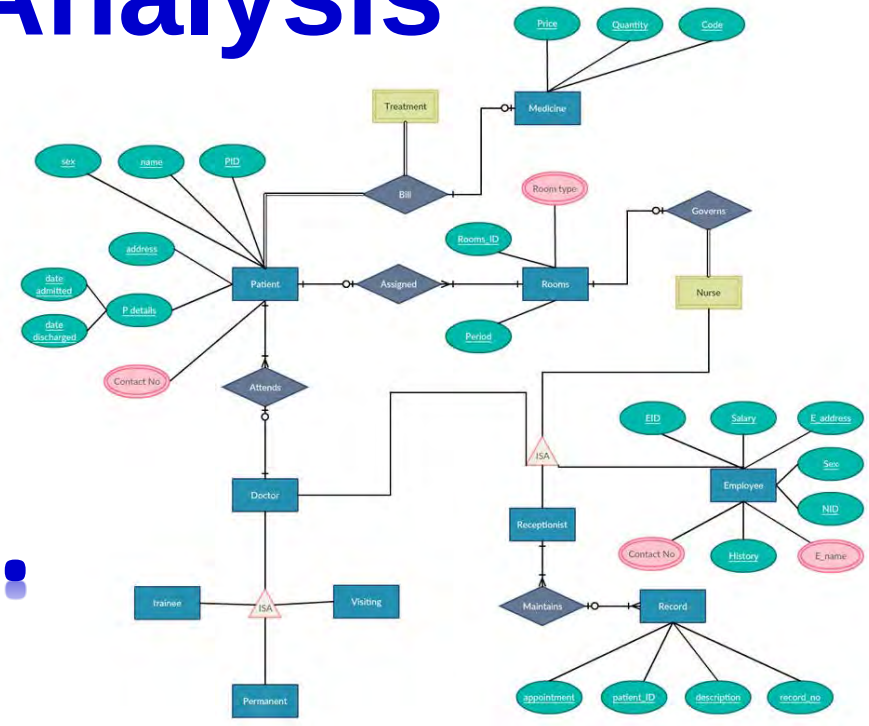
GOAL(S)	**What is to be achieved** **Why are does the question exist**
OBJECTIVE(S)	**How do you plan to achieve the goal(s)** **By what means?**
ALTERNATIVE(S)	**The courses of action; the potential solutions/policies/options we could choose**
MODEL(S)	**The means by which we estimate, measure, or evaluate the consequences of an alternative**
PREFERENCE(S)	**Rules for ranking the alternatives**

Formulation

- What is the **REAL** problem?
- What is the **RIGHT** question to ask?
- What is **RELEVANT** to consider?
  - What scope? Wide? Narrow?
  - What do we include?
  - What are the boundaries?

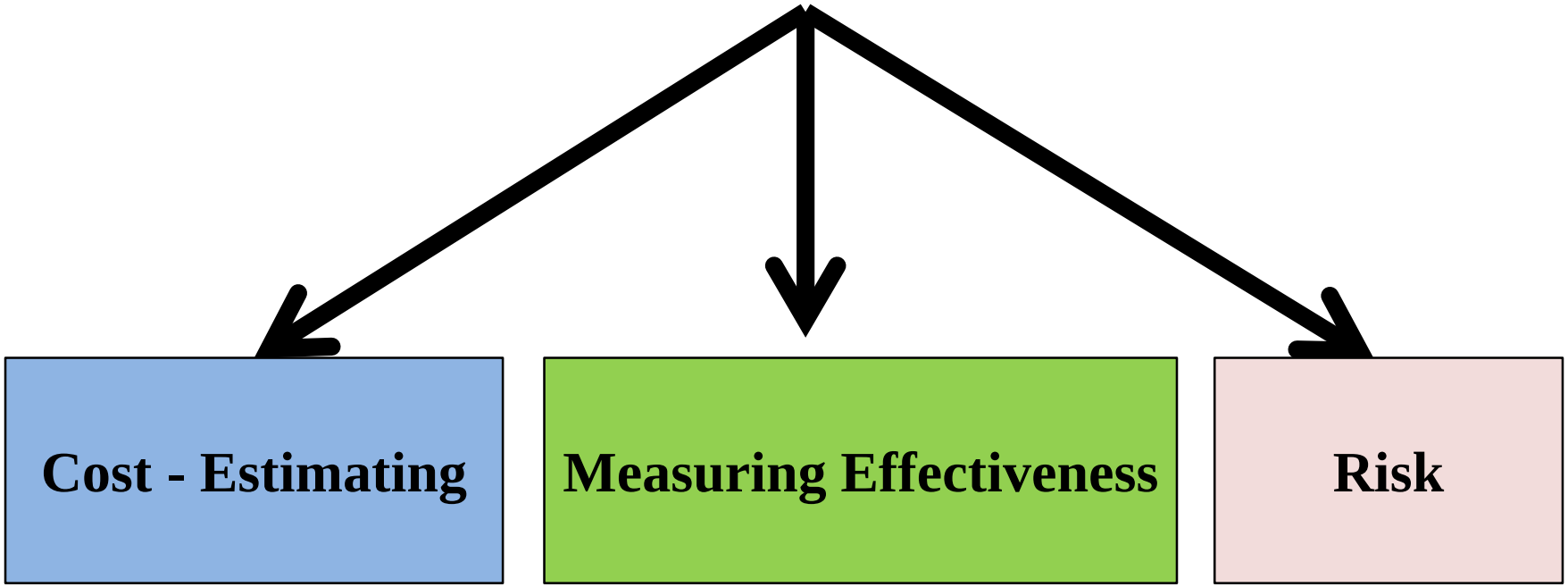
Systems Analysis

Vs.



Pre-Decision Analysis

- The analysis you conduct to help you make choices among alternative courses of action



Decisions in Defense Sector

When you or other officials make a decision in the defense sector, what are your objectives?

- Max. readiness
- Min. cost
- Max. security
- Max. capabilities
- Min. number of deaths
- Max. skills
- Max. flexibility

Choose the Best Alternative

Choose the alternative that minimizes cost and maximizes effectiveness and minimizes risk

How can I know the cost of alternatives beforehand?

How can I combine all my objectives into one measure of effectiveness?

What should I do if one alternative is the cheapest and another alternative is the most effective?

What if something doesn't go as expected, did I still make a good choice?

What can go wrong and does my choice minimize either the probability or the consequences of this uncertainty?

Buzzword Bingo

Analysis of Alternatives

Cost Estimating

Benefits/ Effectiveness

Risk

Schedule

Acquisition focus

Sensitivity

Analysis of Alternatives

- …an analytical comparison of the operational effectiveness, suitability, and life cycle cost …of alternatives that …satisfy … capability needs…

  (Defense Acquisition Guidebook) &(A5R Guidebook)

- …assesses potential materiel solutions that could satisfy validated capability requirement(s) …. and supports a decision on the most cost effective solution to meeting the validated capability requirement(s). (DoDI 5000.02)

Cost Estimating

Lease vs.
Buy Analysis

Benefits/
Effectiveness

Risk

Assumes equal effectiveness

Cost Estimating

Affordability Analysis

Benefits/ Effectiveness

Risk

Portfolio

Scope

Management

Affordability Analysis

- The purpose of Affordability Analysis is to avoid starting or continuing programs that cannot be produced and supported within reasonable expectations for future budgets. Affordability constraints …will be used to ensure capability requirements prioritization and cost tradeoffs occur as early as possible and throughout the program's life cycle (DoDI 5000.02)

Affordability Analysis

- Affordability analysis …necessitates …ongoing communication …on the cost and risk implications of capability requirements.

(DoDI 5000.02)

Affordability vs. Cost Estimating

Affordability Analysis ≠ **Cost Estimates**

Management Decision > Best Estimate of Actual Costs

NOT

"Affordable"

"Affordable"

Cost Estimating

Robust Decision Analysis

Benefits/ Effectiveness

Risk

Need to define "robust"

Cost is secondary

Cost Estimating

Business Case Analysis

Benefits/ Effectiveness

Risk

Policies, Processes, and acquisitions

Enterprise

Sensitivity

Business Case Analysis

- a structured methodology …that aids decision making by identifying and comparing alternatives by examining the mission and business impacts (both financial and non-financial), risks, and sensitivities.

Business Case Analysis

- Other names for a BCA
  - Economic Analysis,
  - Cost-Benefit Analysis, and
  - Benefit-Cost Analysis.
- Broadly speaking, a BCA is any documented, objective, value analysis exploring costs, benefits, and risks.

(BCA Guidebook 2014)

Cost Estimating

Cost Benefit Analysis

Benefits/ Effectiveness

Risk

Benefits are measured in monetary terms

Sensitivity

Sources

- Analysis of Alternatives
  - http://www.acqnotes.com/wp-content/uploads/2014/09/Analysis-of-Alternative-AoA-Handbook-July-2016.pdf
- Affordability Analysis
  - https://www.dau.mil/guidebooks/Shared%20Documents%20HTML/DoDI%205000.02.aspx#toc231
- Business Case Analysis
  - https://www.dau.mil/guidebooks/Shared%20Documents%20HTML/BCA%20Guidebook%202014.aspx

Cost Estimation

Cost Concepts

- Opportunity Costs – what else could you be doing with these funds
  - Sometimes a LOT
  - Sometimes nothing

- Should drive your decision

Total Cost of Alternative

- All relevant costs of the system
- Over the lifecycle of the system
- Based on expected operating conditions

Having accurate and revealing cost information is critical for decision making.
Understanding cost behavior is the key to useful cost analysis.

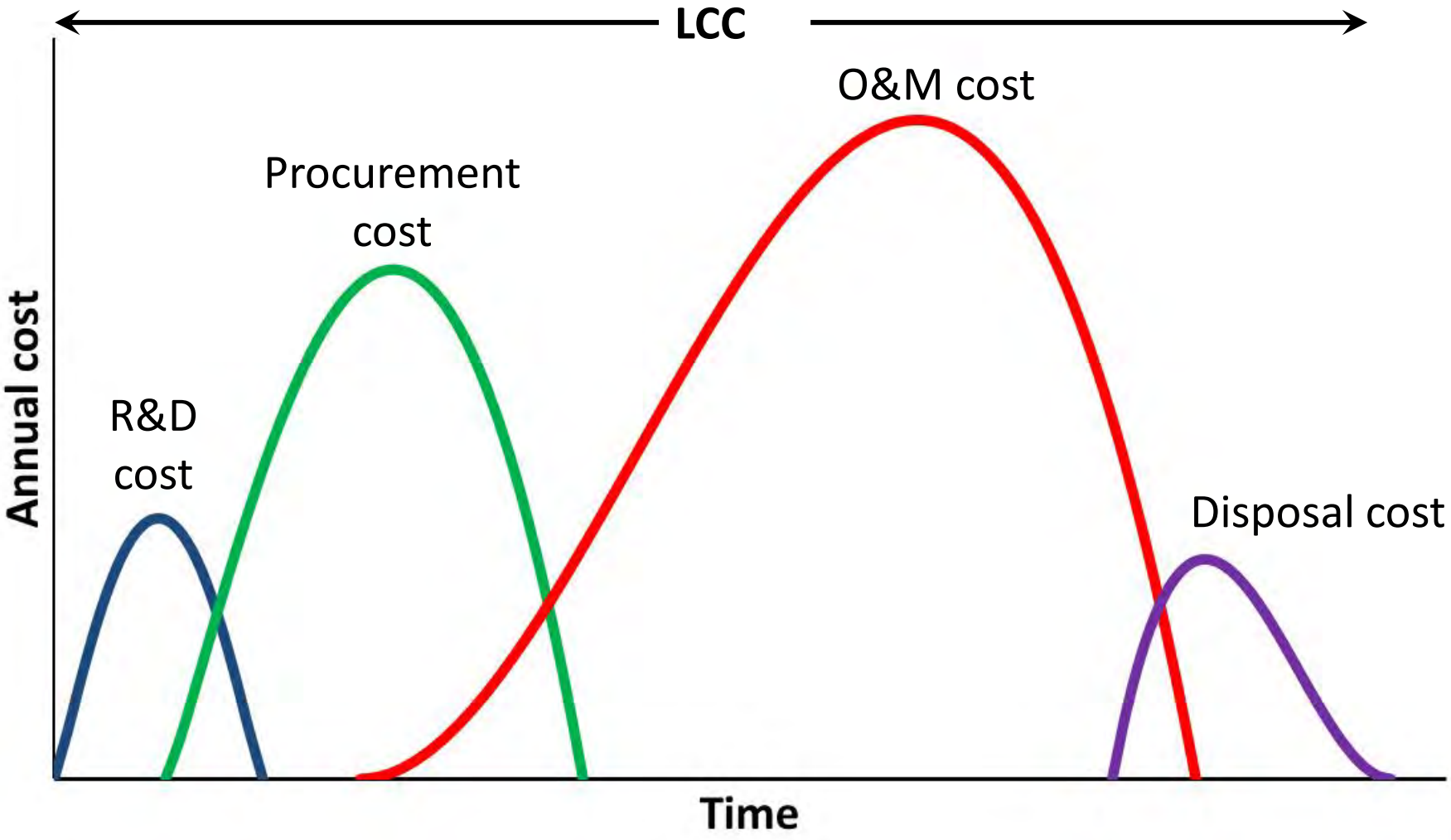
Relevant Costs

- Directly attributable to the system
  - Look at all the appropriations categories
  - Personnel
  - Military Construction
  - Disposal
- Dependent on the decision
  - All choices incur same costs – can drop
  - Need to include in budget though!!

Life Cycle Costing

- Life cycle phases
  - Costs in each phase
- Recurring costs
  - smaller, but many, many instances
  - Easy to overlook
- Non-recurring costs
  - usually larger
  - easy to “see”
- Relevant

Cost over Time



Present Value Analysis

- Time value of money
  - Discounting
  - Present Value Analysis
- Mandated by OMB A-94
  - https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A94/a094.pdf
  - https://www.gpo.gov/fdsys/granule/FR-2018-02-08/2018-02520
- Used **ONLY** pre-decision analysis
- Not used in budgeting

Avoid Surprises

- ~2010 T-6 Texan II took over for T-34 as the primary Navy **flight trainer**
  - Group buy with the Air Force
  - Air Force had fielded it for years
- Provides examples of life cycle costing issues and second and third order effects

Unexpected Cost

- Navy was told that the planes needed to be parked under shelters to avoid heat damaging the flight computers
  - Decided this was a “luxury” – fine during winter
  - A closed cockpit canopy on a 90 degree day can get the temps in the cockpit to be anywhere from 300-400 degrees.
  - Started loosing computers (and planes)
- Cost
  - Shelters built later at additional expense
  - Had to pay for new computers in damaged planes
  - Availability ??

Runway Issues (Pt 1)

- Aircraft required MINIMUM 6,000 ft runways
  - Longer in <u>hot</u> or <u>wet</u> conditions
  - No issue for Air Force (they had 10,000 ft)
- Many NAVY runways ~3,000 – 4,000 ft
  - Acquire land
  - Lengthen runways
  - Built to “minimum” requirements
  - Unexpected cost

Cost Estimating

- Lots of different ways to do this
  - Direct assessment
  - Handbook/catalog
  - Vendor quote
  - Analogy
  - Regression
  - Resource requirements
  - Actual costs

Effectiveness Analysis

Effectiveness Analysis

- What is the benefit of the decision
  - $$$
  - More flight hours
  - Mission readiness
  - Healthier soldiers
- Benefits to whom (which stakeholders)
- How are you going to measure / quantify these benefits

Effectiveness Analysis

- Why quantify?
  - Many potential ways to generate benefit
  - Very rare that they all produce the same benefits at the exact same levels
  - Each alternative costs money
  - How do you decide between them
- Lots of different ways to do this

Cost-Benefit Analysis (CBA)

A systematic quantitative method of assessing the desirability of government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects.

The standard criterion for deciding whether a project can be justified on economic grounds is *net present value*

OMB Circular A-94

The CBA Cook Book

1. Convert all costs and benefits into monetary values
2. Calculate NPV of costs and benefits
3. Subtract costs from benefits

People do CBA Intuitively

NREL National Renewable Energy Laboratory

A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

Innovation for Our Energy Future

Cost-Benefit Analysis of Plug-In Hybrid Electric Vehicle Technology

A. Simpson

Presented at the 22nd International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exhibition (EVS-22)
Yokohama, Japan
October 23–28, 2006

Conference Paper
NREL/CP-540-40485
November 2006

NREL is operated by Midwest Research Institute • Battelle Contract No. DE-AC36-99-GO10337

CBA Can Be Tougher For Groups Especially for BIG Groups!

Problems in Estimating Benefits and Costs?

- It is hard to place a value on many things such as air and water quality, scenic views, historical landmarks, endangered species, etc.
- How do we get around this?
- That is **THE** issue

CBA vs. CEA

- CBA is what you use when costs and benefits of alternatives of proposals can be measured using a single metric (often money, time, or lives, but typically money)

- CEA is what you use when you do not or cannot measure all of the costs or benefits using a single metric

Cost-Effectiveness Analysis

- Requires measurable costs
- Requires measurable benefits
  - Hard question
  - How to quantify benefits so that they are comparable across alternatives (choices)
  - Based on decision makers' preferences
  - Frequently based on multiple objectives

Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA)

- CBA and CEA are often presented as competing approaches to decision making
- UNTRUE!
- They are actually points on a spectrum of a single approach to decision making…

An Integrated Approach

- Use monetary values for everything that comes measured in money
- Estimate monetary values for everything that such values can meaningfully be estimated
- Use CEA if there are a lot of things that matter that cannot be estimated in monetary terms

The CBA Eight-Step Process

ODASA Cost & Economics

Using analysis to make the case for a project or proposal:
Weighing the total expected costs against the total expected benefits over the near, far, and lifecycle timeframes from an ***Army enterprise*** perspective.

COSTS

- The total of quantifiable and non-quantifiable costs
- Quantifiable costs
  - Direct
  - Indirect
  - Initial/Start up
  - Sustainment
  - Procurement
  - Salary and Benefits
- Non Quantifiable costs
  - Life/Safety/Health
  - Perception/Image
  - Opportunity
  - Risk/Uncertainty
  - Political

1. **Define the Problem/Opportunity**
2. **Define the Scope; Formulate Facts and Assumptions**
3. **Define Alternatives**
4. **Develop Cost Estimate for Each Alternative**
5. **Identify Quantifiable and Non- Quantifiable Benefits**
6. **Define Alternative Selection Criteria**
7. **Compare Alternatives**
8. **Report Results and Recommendations**

BENEFITS

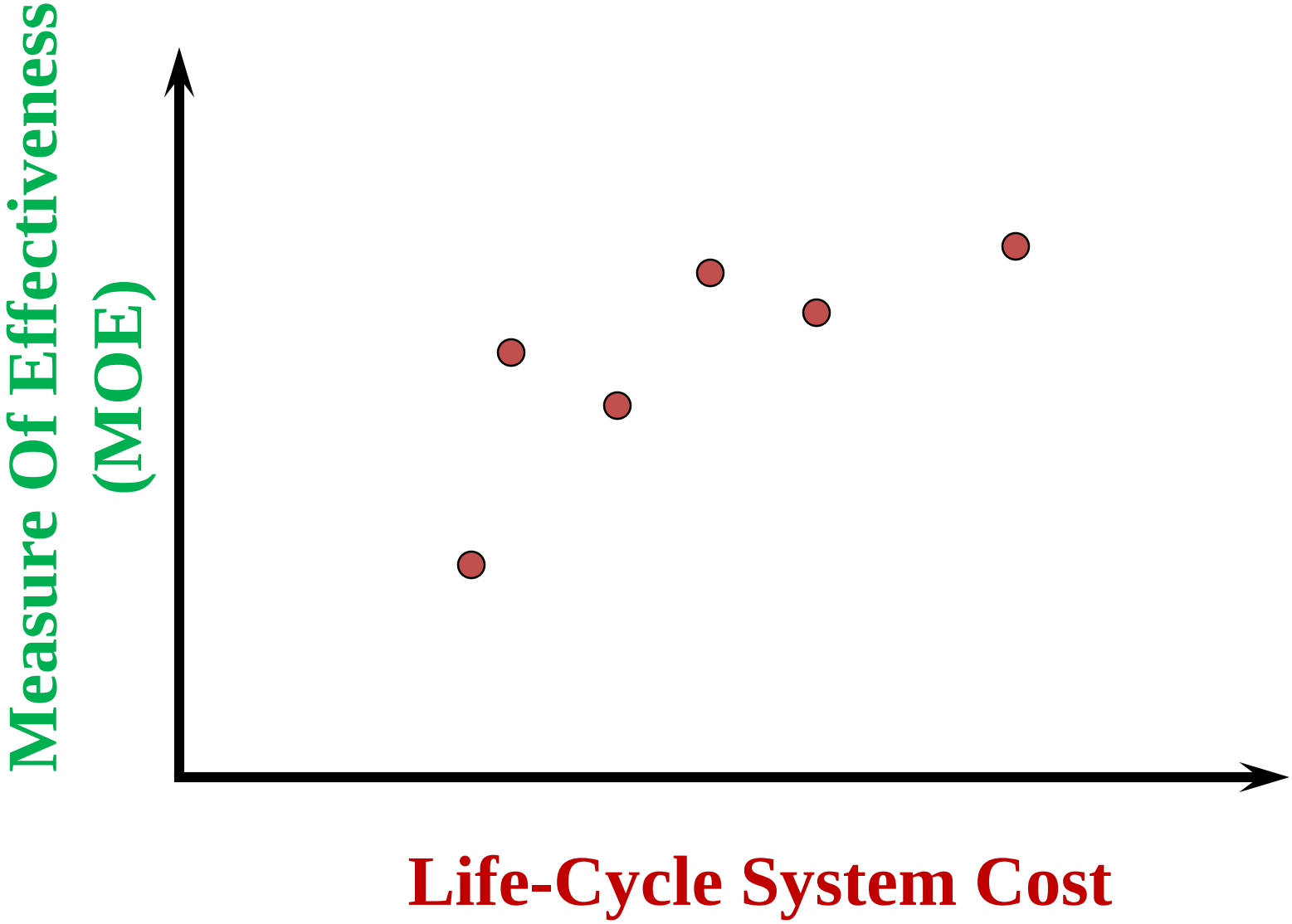
- The total of quantifiable and non-quantifiable benefits
- Quantifiable benefits
  - Cost savings and avoidances
  - Increased productivity
  - Reduced processing time
  - Reduced error rates
  - Increase in capacity
- Non-quantifiable benefits
  - Better Information for decision making
  - Easier to use or access
  - Increase in choice or options
  - Reduced redundancy
  - Achievement of organizational goals/objectives

BENEFITS MUST BALANCE OR OUTWEIGH COSTS AND REQUIRED TRADE-OFFS

Multi Criteria Decision Making

- Framework that is useful when there are several non-monetary objectives
- Measures the extent to which an alternative helps to pursue objectives
- Takes into account relative importance of each objective
- Relies on the decision maker's preferences
  - **Different people may determine that the same alternative has different levels of effectiveness**

Cost-Effectiveness



“Optimal” Solution

- Eliminate dominate options
- Marginal Assessment

- Cost-effectiveness ratios
  - Optimal solution ***IF PERFECTLY DIVISIBLE***
  - Defense has very, very little that is “divisible”
  - 50% of an aircraft carrier does **NOT** provide 50% of the benefits of the aircraft carrier

Portfolio: Definition

A collection of projects, programs, systems, activities, or assets, which may be selected for implementation and which have in common

- a locus of decision;
- a resource base; and/or
- a purpose

NOTE: The term “resource allocation” may also be used to describe this kind of analysis

Constraints

Resource constraints

- Budget
- Personnel
- Time
- Number of overall elements

Requirements

- Critical capabilities

Compatibilities

- Incompatibilities

  if A selected, C is disallowed

- Conditional requirements

  if A is selected, B is required

Divisibility

Can you partially fund elements?

- If **yes**, then you can get part of the benefits by spending part of the money*
- If **no**, you must completely fund the element to see any benefits

We assume elements are defined such that you must fully fund an element to get its benefit.

*If elements are divisible, you can re-define elements in minimally fundable increments…plus some constraints this will yield an equivalent problem with non-divisible elements

Measure of Portfolio Value

- Value of the portfolio
  - A function of the collection of elements selected
- Cost does not affect value
  - Captured as a constraint
  - Portfolio cost is sum of costs of selected elements

Does Value Add?

Quantity vs Quality

- Do you buy one of the best or many of the not quite as good?
- Lancaster model – quantity has a quality all of its own
- How to capture the trade-off between quantity you can purchase within a budget and the quality of the systems purchased

Value of Portfolio

- You can have both complementarities (bonuses) and substitution effects (penalties) in the same portfolio.
- Example: Air and space systems
  - Bonuses for selecting control systems and weapons systems that work together
  - Penalties for selecting multiple launch systems, especially those that can launch the same platforms

Value of Portfolio

Portfolio level objectives - Additional objectives that describe desirability of the portfolio itself

e.g. a “good” portfolio

- Covers the widest range of the population or communities (function of selected elements)
- Has the lowest overall risk
- Lift capacity
- Detection capability

Solution Technique: Integer Programming

What is Affordability?

“Affordability is the ability to allocate resources out of a future total budget projection to individual activities. It is determined by Component leadership given priorities, values, and total resource limitations against all competing fiscal demands on the Component.” Defense Acquisition Guidebook

How do you know you got it wrong?

- Coast Guard's new Offshore Patrol Cutter
  - Acquisition needs at over $2 billion per year
  - President's budget requested $1.2 billion
- Will strain funding for other programs
  - Delayed new acquisitions
  - Is facing a gap in the capability provided by its Medium Endurance Cutters, which are slated to reach the end of their service lives before all the OPCs are operational.
- "Lacks a long-term plan to set forth affordable priorities"

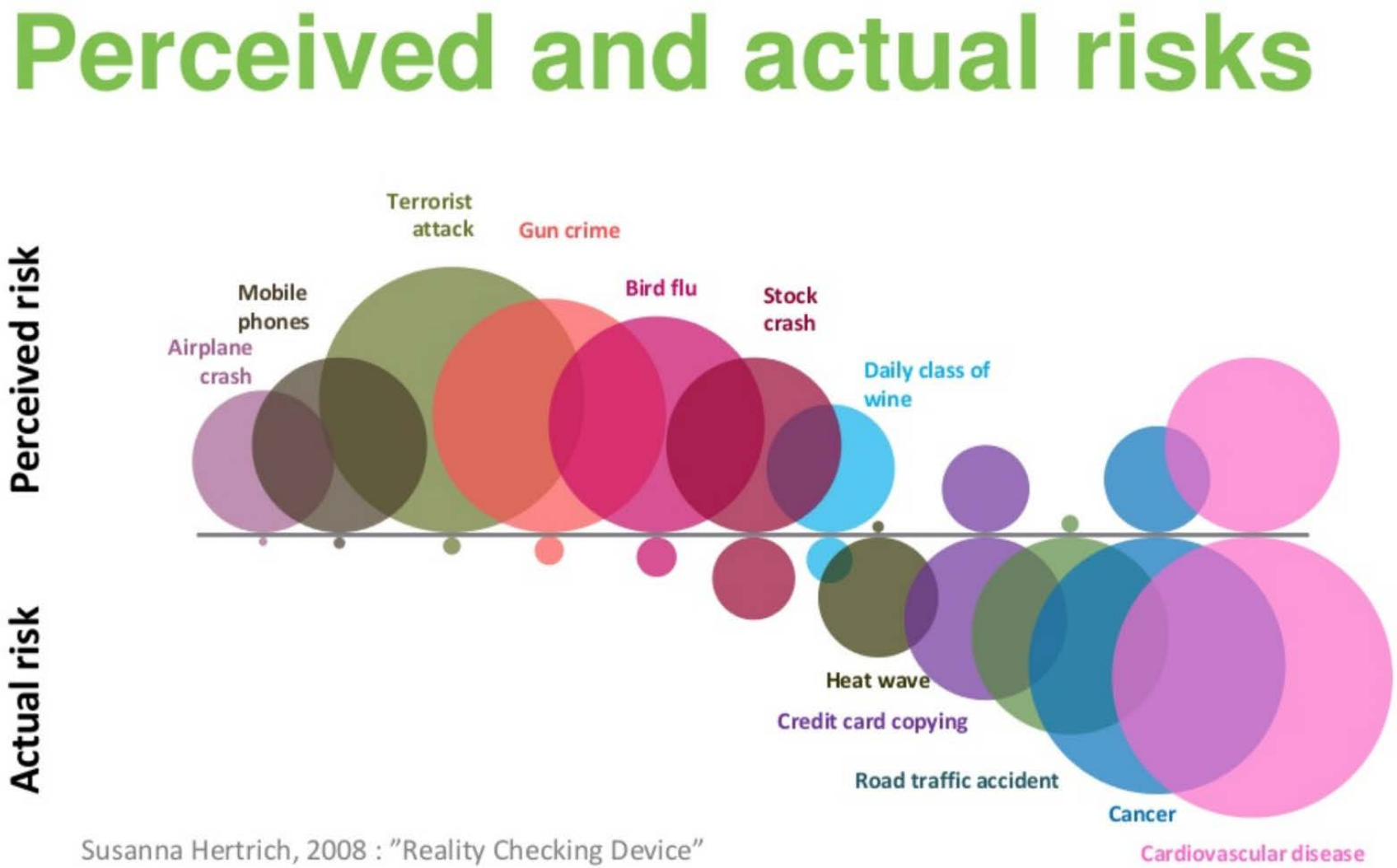
https://www.gao.gov/products/GAO-17-654T

Risk Analysis

“Risky” Decisions

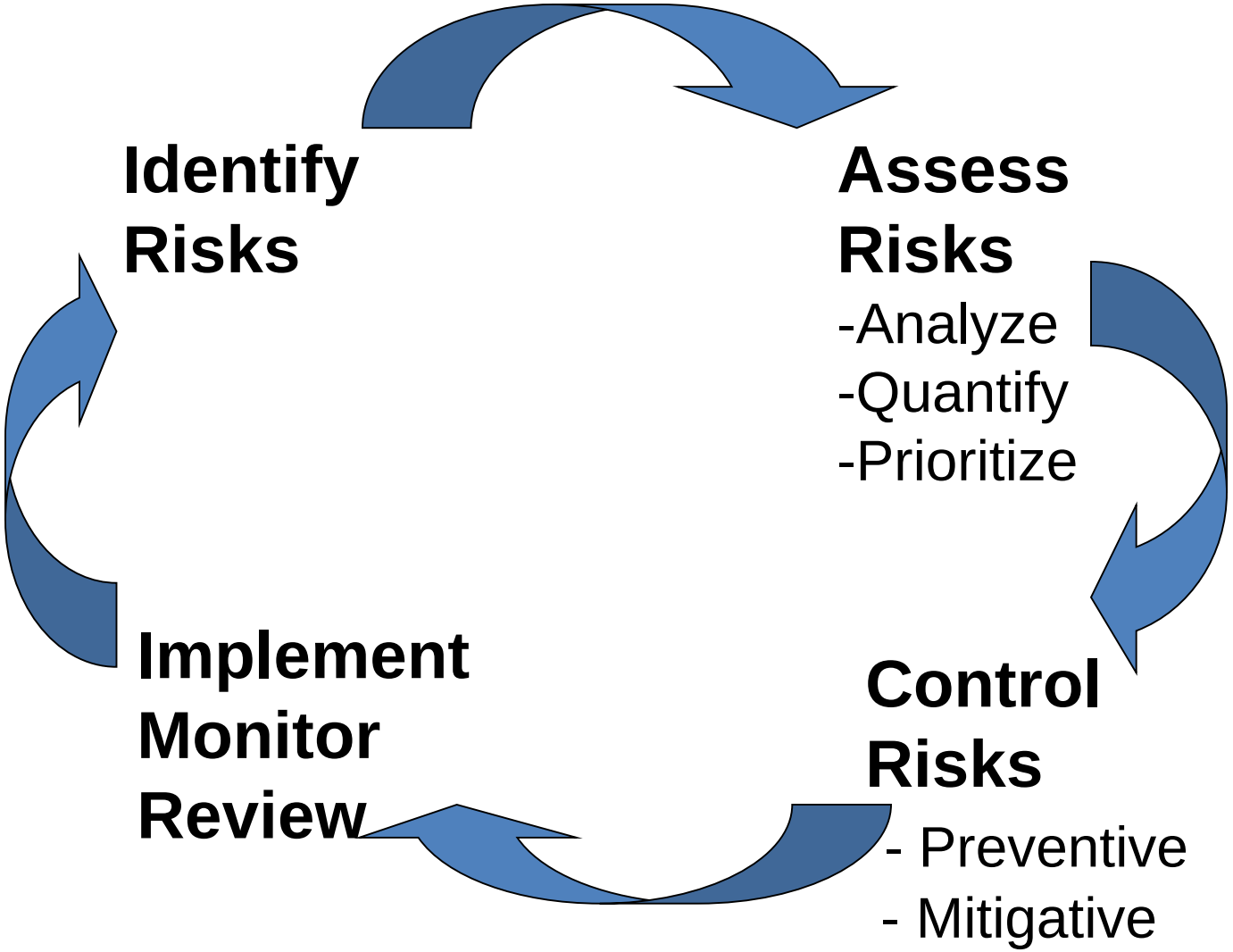
- What makes a decision “risky”?
  - Something can go wrong
  - Dangerous environment
  - Uncertainty
  - Probability of failure
  - High stakes (consequences)

People are bad at Estimating Risk



Susanna Hertrich, 2008 : "Reality Checking Device"

Risk Management Process



Why “Easy” Approaches Go Awry

Example 1: Choice by Priority

Example 2: Choice by Rank and Weight

TSA Screening Example

Alternative	TSA operational costs ($B)	Average passenger wait time (minutes)	Annual chance of a successful terrorist attack in the U.S. (%)
A	3	29	4
B	6	8	1
C	13	32	0.5

Imagine that TSA is considering the above alternatives for airport security, and it is basing its decision on operational costs, average passenger wait time, and the probability of a successful terrorist attack per year.

Idea 1: Prioritizing Objectives

Alternative	TSA operational costs ($B)	Average passenger wait time (minutes)	Annual chance of a successful terrorist attack in the U.S. (%)
A	3	29	4
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What if?

Idea 1: Prioritizing Objectives

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C	13	**90**	0.5

Idea 2: Rank and weight

Alternative	TSA operational costs ($B)	Average passenger wait time (minutes)	Annual chance of a successful terrorist attack in the U.S. (%)
A	3	29	4
B	6	8	1
C	13	32	0.5
Weights	0	0.1	0.9

Idea 2: Rank and weight

Alternative	TSA operational costs (RANK)	Average passenger wait time (RANK)	Annual chance of a successful terrorist attack in the U.S. (RANK)	Score
A	1	2	3	2.9
B	2	1	2	1.9
C	3	3	1	1.2
Weights	0	0.1	0.9	

Lower is better

breakeven at ⅓ wait time ⅔ attack probability

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breakeven at wait time ⅔ attack probability

Flexibility and Risk

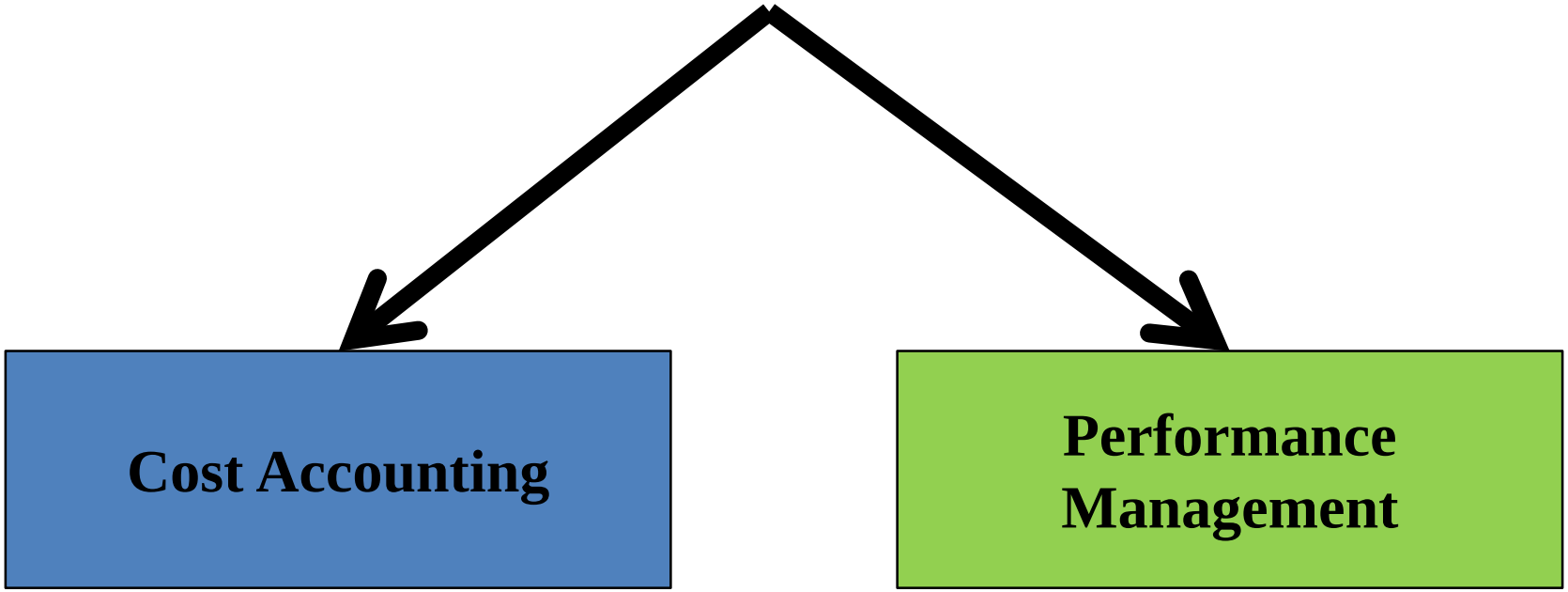
High Uncertainty	High Risk	Flexible Strategy
Low Uncertainty	Focused Strategy	Wasted Flexibility
	No Options	*Options*

Adapted from "Real Options 2", presentation by R. de Neufville, J. Clark, and F.R. Field for Engineering Systems Analysis for Design *course, Massachusetts Institute of Technology*

Post Decision

Post-Decision Analysis

- The analysis you conduct to see how well you are doing



Cost Accounting

- What does it actually cost
- Who is incurring the costs
- Who is receiving the benefits
- Are there secondary costs

- Lots of different methodologies

Tracing Costs from Expenditures to Products

- Cost *accumulated* by “responsibility center”
  - A component of a reporting unit or organization
  - Responsible for carrying out a mission, conducting a major activity, producing a product or providing services
- Cost *allocated* to “cost objects”
  - The outputs of a responsibility center
  - Indirect costs are spread over multiple Cost Objects.

Accumulation of Expenditures

- Job Order
  - Costs are recorded for each unique job, product, batch or service separately
  - Used for products, projects or assignments that differ in duration, complexity or resource requirements
- Process
  - Cost are recorded and accumulated by process (one or more activities)
  - Used for continuous flow production of homogeneous units undergoing identical procedures

Allocation of Expenditures
Direct Tracing

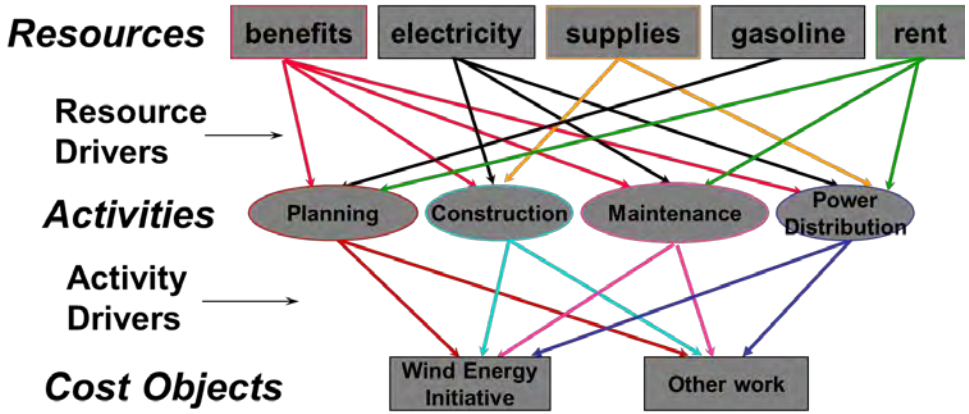
- Observation, counting and recording of resources consumed by cost objects (outputs)
- Cause-and-Effect relationship
- Most accurate
- Most expensive and difficult
  - Relatively easy for direct costs
  - Data must exist
  - Very difficulty for indirect (overhead) costs

Allocation of Expenditure
Single-step Allocation

- Costs allocated to units based on a <u>single cost driver</u> (usually volume, labor hours, machine hours or direct materials, square meters)
- Least accurate
  - Often the allocation base (cost driver) has little relation to the consumption of resources
- Least expensive and easiest

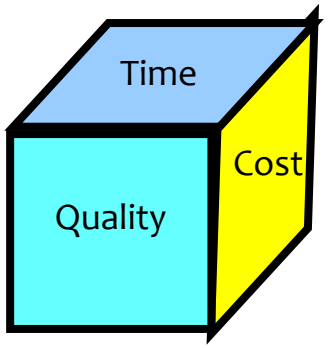
Tracing of Expenditures to Outputs Activity Based Costing

- Traces cost of resources to *activities* using *resource drivers*, then cost of activities to products using *activity drivers*
- Minimizes cost distortion
- Requires more effort and expense



Performance Management

- Mandated by a series of laws
  - Government Performance and Results Act of 1993 (Public Law 103-62)
  - GPRA Modernization Act of 2010 (Public Law 111-352)
- Designed to help manage cost, time, risk, and effectiveness challenges



Performance Management

- Focuses on:
  - Improving effectiveness, focusing on how well desired outcomes are achieved;
  - Improving efficiency, focusing on how well the costs of producing services and goods are managed; and
  - Improving accountability, focusing on bringing together budgets and performance measures

Performance Management

- Requires **“properly”** setting/measuring progress against performance targets
  - Measuring the right things
  - Construct bounded targets (restrictions on possible negative incentives for behavior)

Cross Cutting Analyses/Methodologies At the end

Sensitivity vs. Robustness

- **Sensitivity analysis**: explores how variation in parameters affects which alternative is the best; choice of alternative is **sensitive** if small or likely changes in parameter values change the choice of best alternative

- **Robustness**: an alternative is **robust** if it is good (i.e. effective and/or cost-effective) under many or most possible or likely future conditions

Assessment Techniques

- One-way sensitivity analyses
  - Range of variance (BOP)
  - Best, worst, most likely
  - Analysis at each level
- Two-way analyses
- Multivariate analysis
  - Simulation techniques

Example

Suppose that the commander has three different options for weatherizing the buildings on base.

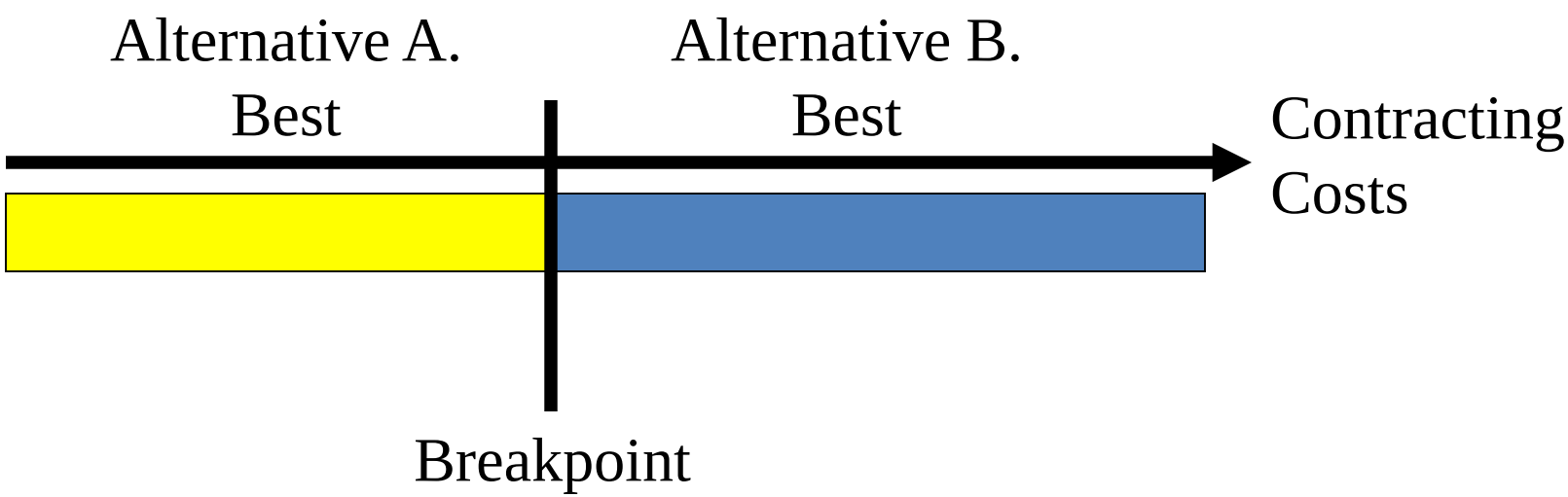
- Alternative A – Hire an outside contractor
- Alternative B – Have the work done by existing maintenance workers on base
- Alternative C – Combination of contract labor and existing forces

Example (cont)

- In conducting a cost estimation, total costs have been shown to depend on a variety of cost components including
  - Contracting costs
  - Management costs
  - Labor costs
  - Materials costs
  - Equipment costs

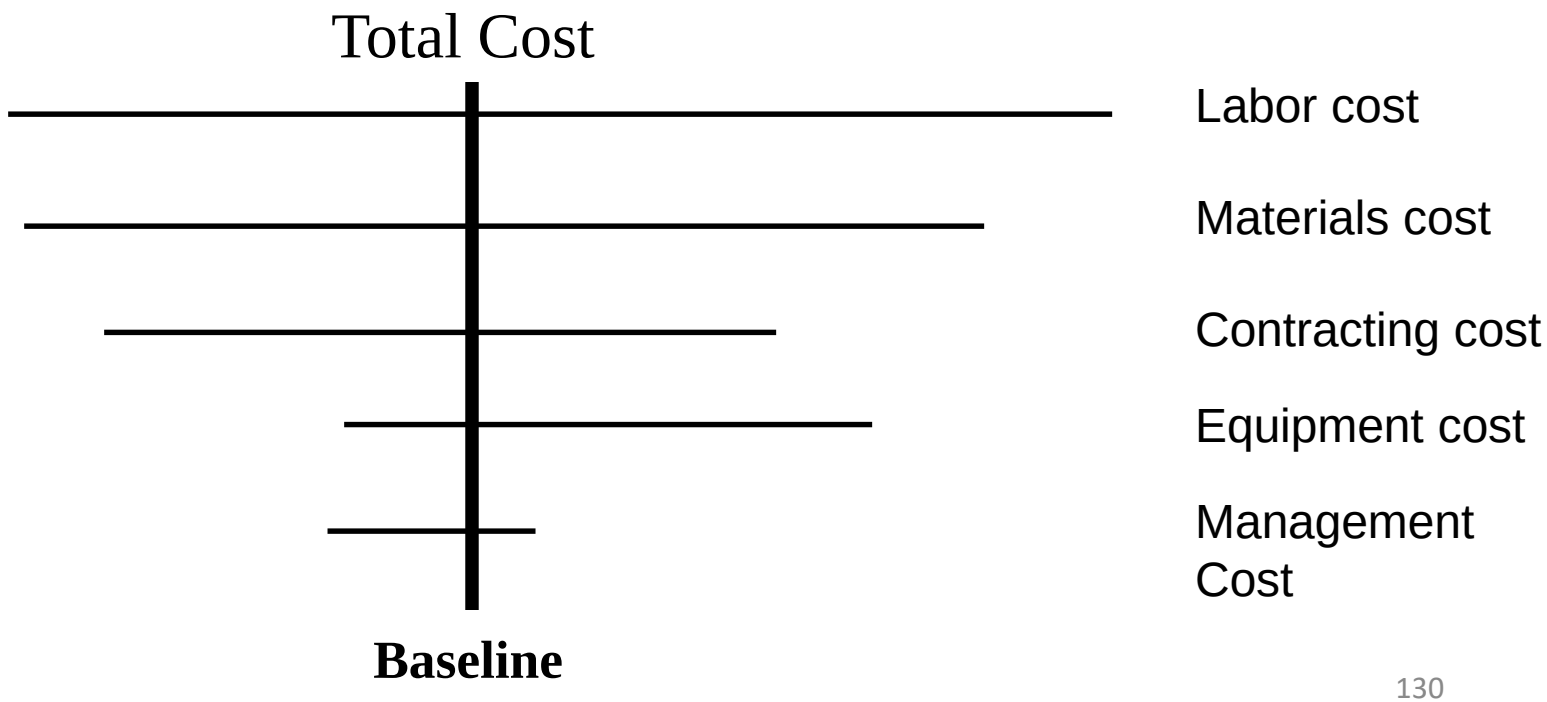
Assessment Techniques

- One-Way sensitivity analysis
  - Where on the line is the breakpoint?



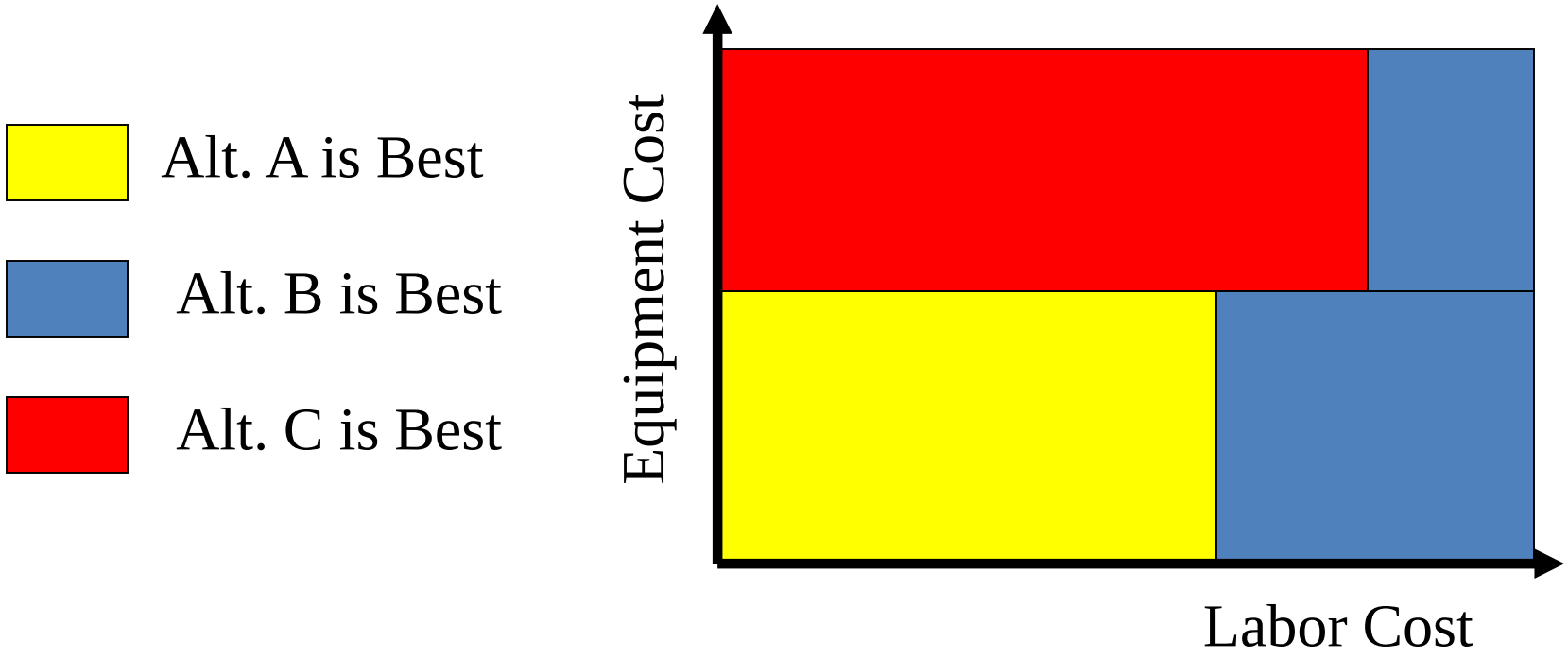
Tornado Diagrams

- Comparison of one-way sensitivity analyses
  - Let each component range from worst to best, all others held constant. Keep track of total value.
  - Which attributes contributes most to variance?



Assessment Techniques

- Two-Way sensitivity analysis
  - Where in the graph are the changes?



Important Questions Answered by Sensitivity Analysis

- Where should you spend more time and effort reducing uncertainty
- How much variation can happen before we change our choice?
- Which variables are most important to your decisions?

Scenario Analysis

- Variation in the components is dependent on the scenario (operational conditions)
- Developing future alternatives
- Uncertain future conditions

Looking for robustness across different scenarios

Secondary (+) Consequences

- Combination scenario analysis and systems analysis
  - Scope
  - Often "***Unintended***" consequences
  - Never hard **AFTER** the fact - very hard to determine at the outset
- Requires thought
- Worth the effort !!

Runway Issues (Pt 2)

- Recall: T-6 Texan II, aircraft used for <u>training</u> pilots
  - Found themselves with “book minimum” runways not sufficient in hot or wet conditions
  - Throughput of student flights fell to less than 50% of prior norms
  - Massive training delays
  - Affecting pilot pipeline

Runway Issues (Pt 2)

- Work around(s)
  - Keep airfields with longest runways open nights and weekends
    - Additional cost (triple overtime)
    - Contractor eventually couldn’t do it
    - Dramatic increase in O&M costs
  - Fly out of Pensacola International Airport
    - Additional costs in ramp fees
    - Costs to students/instructors drive 30 miles each way
    - (Indirect) Political capital

Decision Environment

Before

Informing a choice among alternatives

- acquisition
- policy
- program
- process

After

Determining how well a chosen option is working

- acquisition
- policy
- program
- process

Analyses / Methodologies

Cross - Cutting
At the START

Before
Informing a choice among alternatives

After
Determining how well a chosen option is working

Cross – Cutting
At the END