Cost-Benefit Analysis (CBA) Presentation

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March 5, 2014
Agenda

- Purpose
- Problem Statement
- Literature Review
- Opposing Reviews
- In What Ways Is a CBA Effective?
- Reliability and Accuracy
- Advantages and Disadvantages
- Lessons Learned
Define CBA and describe its proper use.

Explain how CBA can be effective during the early phase of a program life-cycle.

Identify opposing viewpoints.

Describe the value of CBA in the pursuit of programs and policies.

Identify CBA tools and techniques that ensure the accuracy and reliability of the outputs.

Describe a methodology that can be used to quantify the cost of benefits.

Discuss the accuracy and reliability of CBA and what other techniques are available to support decision making in the early phase of a program life-cycle.
Problem Statement

- CBA is controversial in governmental agencies because it is misunderstood by decision makers.
- Policy changes cannot be made solely based on CBA.
- CBA is not intended to be used as a tool to unduly influence political decisions.
- Some CBA elements cannot be accurately measured or quantified.
- CBA is not intended to satisfy all quantifiable needs; other measures besides CBA should be used to support investment decisions.
- Many studies argue that CBA is ineffective and often inappropriate in the areas of safety, health, and environmental regulations.
CBA is both a theory and a practice or a practice that is an applied theory.

- From a theoretical perspective, CBA is ideas, principles, and techniques that are applied to a subject, especially when the results of the CBA are seen as distinct from investment decisions (Makowsky & Wagner, 2009).
- For an economist, CBA is a mathematical tool used in decision making for determining if the perceived benefits outweigh expected costs and for extending that determination to the social welfare of a community (Makowsky & Wagner, 2003).

Today, CBA is used to systematically quantify the costs and benefits to evaluate alternatives prior to developing investment decisions (Makowsky & Wagner, 2009).
Benefits

- Identifies expected returns based on Net Present Value (NPV).
- Identifies the monetary value of the outcomes that are the goal of the investment (Makowsky & Wagner, 2009), expressing that value in discounted dollars, constant dollars, or economies of scale.
- Identifies the positive effects of an alternative.

Costs

- “Measure in terms of the monetary costs of resources required to implement a program” (Kornhauser, 2000, p.90).
- Non-recurring costs of resources expended to develop, implement, and maintain a program or to comply with government policy or requirements (Makowsky & Wagner, 2009).
Opposing Viewpoints

- Although CBA has been the preferred methodology for evaluating economic factors associated with regulations and investment decisions:
  - Kornhauser (2000) and Gillroy (1992) argue that CBA does not identify proposed measures of benefits or harms, such as death or accidents.
  - Kornhauser (2000) argues that the CBA does not quantify life, the environment, or any other rare product or service. Kornhauser (2000) noted that Adler and Posner (1999) adopted a similar approach by distinguishing CBA as a moral criterion versus a decision-making process.

- Kornhauser (2000) raises two concerns:
  - CBA inappropriately generates estimates for products and services.
  - CBA produces inconsistent valuations of life.

- Anderson (1993), Graham & Vaupel (1981), and others argue that CBA applies to economic policy, risk, or value but not to life.

- Kornhauser (2000) suggests that it is not appropriate to consider using a CBA when moral criteria are at stake.
In What Ways Is a CBA Effective?

- Provides increased understanding of the consequences of proposed public policies (Ergas, 2009).
- Must be understood and used as a means to augment policy in making the best decisions for the public (Ergas, 2009).
- Offers a well-established and tested approach, supported by substantial research, for identifying and assessing the physical impacts of different investment options in addition to estimating their economic value.
- Provides information on the monetary intensity of preferences as well as on individuals’ willingness to make the types of trade-offs implicit in many investment decisions (Makowsky & Wagner, 2009).
- Measures the benefits and the cost of the alternatives being analyzed.
- Helps achieve an agency’s mission, goals, or objectives.
### Comparison of Analysis Approaches

<table>
<thead>
<tr>
<th>Item #</th>
<th>Criteria</th>
<th>Alternative Analysis</th>
<th>AoA</th>
<th>BCA</th>
<th>CBA</th>
<th>IGCE</th>
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AoA – Analysis of Alternatives  
BCA – Business Case Analysis  
CBA – Cost/Benefit Analysis  
IGCE – Independent Government Cost Estimate
# Plan of Action & Milestones

<table>
<thead>
<tr>
<th>Phase</th>
<th>Planning</th>
<th>Data Collection</th>
<th>CBA Development</th>
<th>Decision Making</th>
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<tr>
<td>Duration (Typical)</td>
<td>6 weeks</td>
<td>4 weeks</td>
<td>8 to 12 weeks</td>
<td>4 to 6 weeks</td>
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## Resources
- **Project Team and Cost Analyst(s)**
  - Form a cross-functional team including cost analysts
  - Determine critical path, scope & schedule of initiative
  - Develop preliminary project plan, requirements, CONOPS, transition plan, & architecture
  - Create a preliminary cost model and identify major cost drivers
  - Develop a survey, data call template with data dictionary, which will be basis for a lifecycle cost model, cost recovery plan, and resourcing
  - Issue data call

- **Leadership**
  - Brief internal leadership & stakeholders for CBA approval
  - Submit the CBA package to Cost Agency for validation
  - Present the CBA to influence a decision

## Actions
- **Planning**
  - Develop a first iteration of the cost model using actual data points from any pilot sites
  - Complete draft requirements, CONOPS, transition plan, & architecture

- **Data Collection**
  - Clean & validate data received in response to the data call
  - Build and refine all documents and the cost model with actual, validated data
  - Complete CBA package
    - CBA Word document
    - CBA slide package
    - Lifecycle cost model
    - Requirements CONOPS
    - Transition plan
    - Architecture
    - Funding plan

- **CBA Development**
  - Issue data call

- **Decision Making**
  - Brief internal leadership & stakeholders for CBA approval
  - Submit the CBA package to Cost Agency for validation
  - Present the CBA to influence a decision
## Project Team Roles & Responsibilities

<table>
<thead>
<tr>
<th>Roles</th>
<th>Responsibilities</th>
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</table>
| Project Lead         | Maintain adherence to Statement of Work  
                        Serve as official voice of the contractor with the client                          |
| Client/Program Manager | Get stakeholder buy-in  
                           Provide guidance  
                           Ensure project coordination and collaboration across communities                |
| Task Lead            | Develop Work Plan  
                        Coordinate/facilitate meetings, etc. with client  
                        Serve as POC for team response to client  
                        Develop and maintain quality assurance plan  
                        Coordinate development of briefings/responses                                      |
| Cost Estimators      | Develop estimate  
                        Interact with client experts on specific work packages  
                        Develop and maintain estimate documentation  
                        Perform quality check on estimate                                                    |
| SMEs                 | Provide technical advice and/or input  
                        Review estimate and documentation                                                    |
CBA Best Practices

Challenges

- How do you go about taking economic considerations into account when designing or modifying a system architecture?
- How do you account for the costs involved?
- How do you characterize and compare the benefits that will accrue to various architectural strategies?
- How can costs and benefits be "traded off" against quality attributes or functionality?
- How can you characterize the uncertainties involved in your estimates?
- How do you develop the cost tool?
- How do you display the results?
Ground Rules & Assumptions

Scope

Technology

Costs & Benefits

Uncertainties

Resources

Processes

Schedule

Risks Assessment

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Gaps in Performance

Current State (Status Quo)

Desired State

Functionality Performance Gaps

Benefits and Needs
Needs to Requirements

- Infrastructure
- Processes
- Application Software
- System Software
- Computer Hardware
- End Users
Key Inputs

- CONOPS, Transition Plan & Cost from Program Team
- Business, Application/Technical Rationalization Assumptions from Program Team
- Hosting Rates from Service Provider
- Costing Assumptions
- As-Is Cost Estimate from Survey, Data Call & Industry data
- Benefits & Risk Analysis by the SMEs

CBA
# Cost Estimating Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Strength</th>
<th>Weakness</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analogy</td>
<td>Requires few data</td>
<td>Subjective adjustments</td>
<td>When few data are available</td>
</tr>
<tr>
<td></td>
<td>Based on actual data</td>
<td>Accuracy depends on similarity of items</td>
<td>ROM estimate</td>
</tr>
<tr>
<td></td>
<td>Reasonably quick</td>
<td>Difficult to assess effect of design change</td>
<td>Cross-check</td>
</tr>
<tr>
<td></td>
<td>Good audit trail</td>
<td>Blind to cost drivers</td>
<td></td>
</tr>
<tr>
<td>Industry product comparison</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Build-up</td>
<td>Easily auditable</td>
<td>Requires detailed design</td>
<td>Production estimating</td>
</tr>
<tr>
<td>Bottom-up</td>
<td>Sensitive to labor rates</td>
<td>Show and laborious</td>
<td>Software development</td>
</tr>
<tr>
<td></td>
<td>Time honored</td>
<td>Cumbersome</td>
<td>Negotiations</td>
</tr>
<tr>
<td>Parametric</td>
<td>Reasonably quick</td>
<td>Lacks detail</td>
<td>Budgetary estimates</td>
</tr>
<tr>
<td>Top-down</td>
<td>Encourages discipline</td>
<td>Model Investment</td>
<td>Design-to-cost trade studies</td>
</tr>
<tr>
<td></td>
<td>Good audit trail</td>
<td>Cultural barriers</td>
<td>Cross-check</td>
</tr>
<tr>
<td></td>
<td>Objective with little bias</td>
<td>Need to understand model's behavior</td>
<td>Baseline estimate</td>
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<tr>
<td></td>
<td>Cost driver visibility</td>
<td></td>
<td>Cost goal allocations</td>
</tr>
<tr>
<td></td>
<td>Incorporates real-world effects, (e.g. funding, technical, processes, resources)</td>
<td></td>
<td></td>
</tr>
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</table>
Costs Estimation Approach

Inputs

1.0 Data Collection
- CONOPS
- Transition plan
- Requirements
- Interviews/Data Call
- Project schedule
- Risk register
- Environmental factors
- Process assets
- Inventory of products/services
- Awarded contracts
- Budgets

For Each Alternative

1.1 Create WBS
1.2 Develop Schedule/Constraints
1.3 Identify Resources
1.4 Develop Tech. Architecture/Process Flows
1.5 Identified Risks
1.6 Enterprise Organization
1.7 Benefits

Technique

2.0 Cost Estimation Model

2.1 Calculate Calculations
- Estimate Baseline/Alternative Costs
- Estimate Benefits
- Calculate Financial Metrics

Outputs

3.0 Cost Model
- Cost-Benefit Analysis

Decision Makers

3.1 Cost-Benefit Analysis
- Cost/Benefit Analysis
- Alternative Comparison

Budget

3.2 Cost/Benefit Analysis
- Cost/Benefit Analysis
- Alternative Comparison

Program/Acquisition

3.3 Cost/Benefit Analysis
- Cost/Benefit Analysis
- Alternative Comparison

3.4 Cost/Benefit Analysis
- Cost/Benefit Analysis
- Alternative Comparison
Integrated Cost Estimation

Program Lifecycle
- Program Management
- Design Approach
- Development
- Integrate & Testing
- Documentation
- Deployment
- Installation
- Maintenance
- Refresh
- Retirement

Costs Element Structure

<table>
<thead>
<tr>
<th>Full CES #</th>
<th>Cost Element</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>UTS</td>
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<tr>
<td>1-10</td>
<td>Project Management</td>
</tr>
<tr>
<td>1-2005</td>
<td>Portfolio Investment</td>
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<tr>
<td>1-50</td>
<td>IT Systems Development and Operation</td>
</tr>
<tr>
<td>1-5001</td>
<td>IT Requirements Analysis</td>
</tr>
<tr>
<td>1-5002</td>
<td>IT Systems Analysis and Design</td>
</tr>
<tr>
<td>1-5003</td>
<td>IT System Development</td>
</tr>
<tr>
<td>1-5004</td>
<td>IT Testing</td>
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<td>1-5005</td>
<td>IT Implementation (Deployment)</td>
</tr>
<tr>
<td>1-5006</td>
<td>IT Maintenance (Operations)</td>
</tr>
<tr>
<td>1-5007</td>
<td>IT Disposition (Retirement)</td>
</tr>
<tr>
<td>1-5008</td>
<td>IT Contract Program Management</td>
</tr>
<tr>
<td>1-5009</td>
<td>Math Stat, Researcher, Subject Matter Programming</td>
</tr>
<tr>
<td>1-6001</td>
<td>IT Security</td>
</tr>
<tr>
<td>1-6002</td>
<td>Data Center Operations and Support</td>
</tr>
<tr>
<td>1-6003</td>
<td>Storage Area Network Services</td>
</tr>
<tr>
<td>1-6004</td>
<td>Telecommunications Support</td>
</tr>
<tr>
<td>1-6005</td>
<td>Desktop Services and Support</td>
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<td>1-6006</td>
<td>System Architecture</td>
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<tr>
<td>1-5001</td>
<td>IT Systems Development and Operation</td>
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<tr>
<td>1-5001-1</td>
<td>Government Labor</td>
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<td>1-5001-2</td>
<td>Contractor Labor</td>
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<td>Non-Labor</td>
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<tr>
<td>1-5001-3.1</td>
<td>Hardware</td>
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<tr>
<td>1-5001-3.2</td>
<td>Software</td>
</tr>
<tr>
<td>1-5001-3.3</td>
<td>Other</td>
</tr>
</tbody>
</table>

WBS, Costs Components & Approach

Figure 1: Project Work Plan

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Costs Estimation

- Create Work Breakdown structure.
- Assign labor rates and hours to each activity.
- Quantify recurring and non-recurring costs using constant dollars at today’s prices:
  - Labor
  - Hardware
  - Software
  - Infrastructure
  - Security
  - Etc.
- Isolate investment cost from steady state.
Benefits Estimation

- Use gap analysis to quantify benefits.
- Categorize quantifiable benefits using constant dollars at today’s prices:
  - Cost elimination (avoidance)
  - Improve operations effectiveness and utility
  - Reduction of resources
  - Measure and validate using hours, time, units, scales and/or dollars
- Accumulate benefits after implementing the investment.
Cost Estimate Process Flow

Input Parameters:
- Project Size
- Personnel
- Development Environment
- Project Complexity
- Constraints

Program Cost Model:

Output Parameters:
- Effort
- Cost
- Schedule
- Risk
- Maintenance
Program Cost Model

Accuracy and reliability is driven by program lifecycle phase
## Financial Calculations: Point Estimate

- Quantify costs using cost categories, time phases, and assumptions.
- Quantify benefits using time, money, improve utilization, and/or labor avoidance.

### Alternative 1

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Benefits</th>
<th>Total Project Costs</th>
<th>Net Benefits (Costs)</th>
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<tr>
<td>2002</td>
<td>0</td>
<td>-13,631</td>
<td>(13,631)</td>
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<tr>
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<td>32,542</td>
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<td>(28,434)</td>
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<tr>
<td>2004</td>
<td>55,265</td>
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<td>(19,056)</td>
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<tr>
<td>2005</td>
<td>56,829</td>
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<td>11,566</td>
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<tr>
<td>2006</td>
<td>73,757</td>
<td>-44,121</td>
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<td>2007</td>
<td>51,700</td>
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**Breakeven Year = 6**

Net Present Value= $233,003  
Return on Investment= 210%

### Alternative 2

<table>
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<th>Total Benefits</th>
<th>Total Project Costs</th>
<th>Net Benefits (Costs)</th>
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</thead>
<tbody>
<tr>
<td>2002</td>
<td>0</td>
<td>-6,816</td>
<td>(6,816)</td>
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<tr>
<td>2003</td>
<td>16,271</td>
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<td>2004</td>
<td>27,632</td>
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<td>2005</td>
<td>28,415</td>
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<td>2006</td>
<td>36,879</td>
<td>-22,061</td>
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<td>2007</td>
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<td>2008</td>
<td>44,910</td>
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<td>40,592</td>
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<td>39,105</td>
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<td>$298,188</td>
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**Breakeven Year = 6**

Net Present Value= $116,502  
Return on Investment= 210%

### Alternative 3

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<th>Total Project Costs</th>
<th>Net Benefits (Costs)</th>
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<td>(6,816)</td>
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<td>-35,028</td>
<td>43,730</td>
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<td>2008</td>
<td>112,276</td>
<td>-5,765</td>
<td>106,511</td>
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<td>101,481</td>
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<tr>
<td>Total</td>
<td>$595,810</td>
<td>-$283,652</td>
<td>$312,158</td>
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**Breakeven Year = 7**

Net Present Value= $223,884  
Return on Investment= 210%
Uncertainty Analysis: Ranges vs. Point Estimates

- Risk analysis is to compute the probability that the total life cycle cost of the program implementation will exceed an upper affordability limit
  - Investigate the relative impacts of cost drivers upon NPV and the break-even point.
  - Use Monte Carlo simulation of the cost model equations using triangular approximations for all random inputs.
  - Use regression and distribution analyses to examine affordability and rank the marginal impacts of cost drivers, by alternatives.
Expected Outcome

Executive Summary
1. Definition of the Problem/Opportunity
   a. Problem Statement
   b. Background
   c. Objective

2. Definition of Scope, Facts and Assumptions
   a. Scope
   b. Facts
   c. Assumptions
   d. Constraints

3. Definition of Alternatives
   a. Status Quo
   b. Alternative 1
   c. Alternative 2
   d. Alternative 3

4. Cost Estimates for Alternatives
   a. Status Quo
   b. Alternative 1
   c. Alternative 2
   d. Alternative 3

5. Quantifiable and Non-Quantifiable Benefits

6. Alternative Selection Criteria

7. Alternative Comparison
   a. Risk Assessment and Mitigation
   b. Second and Third Order Effects
   c. Compare Costs and Benefits
   d. Sensitivity Analysis
   e. Resourcing Considerations

8. Report Results and Recommendations
Persuade Policy / Investment Decisions from CBA Results
The main factor influencing cost estimates is accuracy in the early phase, with a weight of nearly 40 percent, when the amount of information available about the program is limited (Ciraci & Polat, 2009).

Accuracy is defined “as nearness to truth” (Serpell, 2004, p.159).

Reliability as a measurement refers to knowing how well the measuring instrument consistently measures the true value of the characteristic (Serpell, 2004).

– Flyvbjerg et al. (2003, 2005) studies report “inaccuracy in cost estimation from 20.4% to 44.7% depending on the type of [program]” (Li & Napier, 2010, p.95).

– Bruzelius et al. (2002) note that it has been “reported that overruns of 50% to 100% in fixed prices are common for major infrastructure [programs], and overruns above 100% are ‘not uncommon’, with the magnitude of cost overrun unchanged over the past 70 years” (Li & Napier, 2010, p.95).

– Serpell (2004) points out that conceptual cost estimates are critical inputs for decision making in the early phase of a program.
Advantages & Disadvantages

- **Advantage of the parametric/engineering model is that it:**
  - Tends to be more objective and assign a causal reason (i.e., *that* happened because of *this*).
  - Resources are suitable for assessing the differences between past and future programs and are especially useful for new or unique programs for which no historical precedent exists.

- **Disadvantage of this model is that:**
  - The prediction process requires that the data are already available; in practice, most organizations do not keep adequate estimating records.
  - Experts or consultants who use their knowledge and experience to estimate the cost of programs may or may not be reliable.
  - Decision makers with factual information about those affected by the policy must be convinced that CBA is a positive, effective, descriptive exercise that supports the mission, strategies, and goals of the federal agency.
Lessons Learned

- Programs may consider measuring accuracy and reliability using statistical analysis to determine the sampling errors and confidence intervals of a CBA.
- A quality cost model may weigh the expected accuracy and reliability of a cost estimate.
- Programs may focus on aligning cost to strategy, performance measures, outputs, and outcomes to help improve the accuracy and reliability of cost estimates.
- A qualitative model may be constructed using information from a conceptual cost estimate.
- The expected accuracy assessment and its associated reliability enable decision makers to analyze different possible alternatives (Serpell, 2004) knowing the level of validity in the data.
- All cost estimates should be auditable – data sources and traceability.
- All key decisions should be transparent and documented.
References


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