# Analysis of Alternatives: Comparison of Techniques

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# Agenda

- Review Basic Principles
- Introduce Alternative Techniques
- Make Some Comparisons
- Discuss Case Studies
- Discussion / Q&A

# Basic Elements

- Supports a decision
- Competing alternatives
- Commonly applied criteria
- Scored values on criteria
- Relative importance of criteria
- Conclusive comparison

**Alternatives for Decision X**

|  | Alt. #1 | Alt. #2 | Alt. #3 |
|---|---|---|---|
| Criteria A (20%) | ~~~ | ~~ | ~~~ |
| Criteria B (30%) | ~ | ~~~ | ~~~ |
| Criteria C (10%) | ~~ | ~ | ~~~ |
| Criteria D (40%) | ~~ | ~~ | ~ |
| Total | 86% | 81% | 95% |

# Simple Example

- ✓ Decision to be made
- ✓ Competing alternatives
- ✓ Common criteria
- ✓ Scored values
- ✓ Relative importance
- ✓ Conclusive comparison

**Passenger Car Selection**

| | Jetson's Hova-Disk | Flinstone's Rolla-Rock |
|---|---|---|
| Speed (60%) | 9 / 10 pts | 3 / 10 pts |
| Ease of Use (40%) | 8 / 10 pts | 9 / 10 pts |
| | | |
| Summary | B+ | F |

# Common Problems

- **Decision**
  - Decision to be made is ambiguous. No decision to be made – e.g. considering 'solutions' in search of a problem.
- **Alternatives**
  - Single option evaluation – no alternatives considered. Alternatives aren't comparable. Alternatives aren't representative of what is available.
- **Criteria**
  - Criteria don't apply, or weren't applied, to all alternatives. Overlapping or redundant criteria. Criteria incomplete relative to characteristics of alternatives.
- **Scoring**
  - Confusion about score values – e.g., Is a 70 above average or a 'C'? Descriptions used instead of evaluations. Relies on individual preference. Scores don't add up.
- **Importance**
  - Relative importance of criteria not considered. Relative importance used isn't meaningful – e.g. not considered legitimate by stakeholders .
- **Conclusion**
  - Conclusion not provided. "Conclusions" aren't actually conclusive – e.g. if totals are same are alternatives comparable or is a 2$^{nd}$ round of analysis required? Conclusion inconsistent with analysis.

# Technique: Criteria are all Benefits

| | Hova-Disk | Rolla-Rock |
|---|---|---|
| Speed | High | Low |
| Fuel Used | High | Low |

| | Hova-Disk | Rolla-Rock |
|---|---|---|
| Speed | High | Low |
| Fuel Economy | Low | High |

# Technique: Cost as Separate Line

May Not Be Negotiable

|       | A1      | A2      | A3      |
|-------|---------|---------|---------|
| C1    | ~~      | ~       | ~~      |
| C2    | ~       | ~~      | ~~~     |
| C3    | ~~      | ~       | ~       |
| C4    | ~~      | ~~      | ~~      |
| Total | 10 pts  | 30 pts  | 20 pts  |

| Cost | $10m | $50m | $15m |
|------|------|------|------|

Might Be Negotiable

Total Score

High Scoring Alternatives

Good Value Alternatives

Low Cost Alternatives

Cost
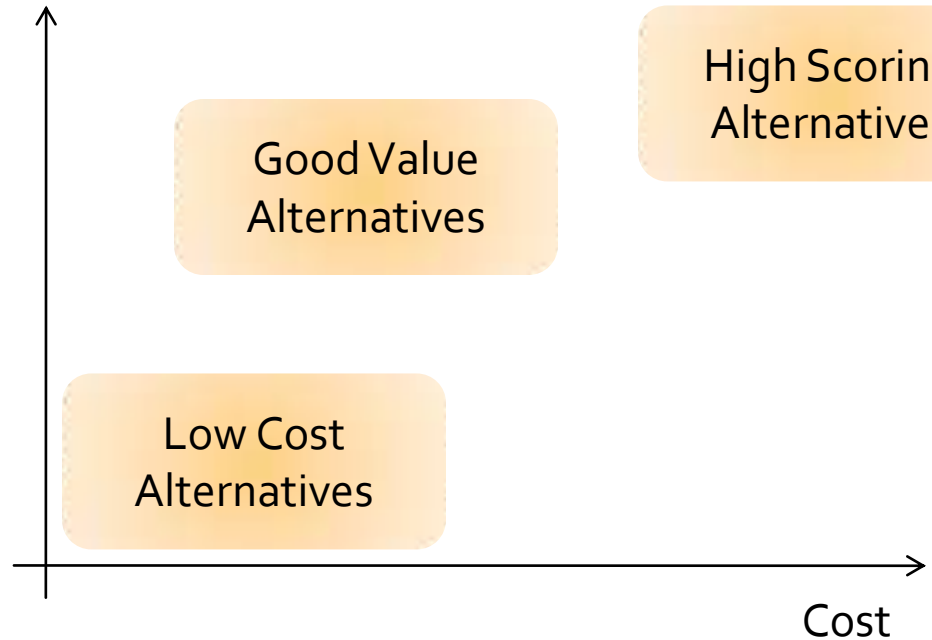
# Challenge: Hard to Score Evaluations

## Server System Selection

| | A1 | A2 | A3 |
|---|---|---|---|
| Throughput (transactions/sec) | 22ktps | 7ktps | 13ktps |
| Easy to Program | 🔴 | 🟢 | 🟡 |
| Computing Power (TFLOPS) | 36 | 7 | 11 |
| Vendor Reputation | Good | Poor | Fair |
| Availability (% on annual basis) | 99 | 99.99 | 99.9 |
| | | | |
| Cost | $$$ | $ | $$ |

An alternative approach for analysis of alternatives…

…is to use pair-wise logical comparisons instead of scores.

# Basic Elements Still Apply

- Applicable decision
- Competing alternatives
- Common criteria
- ~~Scored values~~
  *Logical comparisons*
- Relative importance
- Conclusive comparison

**Alternatives for Decision X**

| | Alt. #1 | Alt. #2 | Alt. #3 |
|---|---|---|---|
| Criteria A | | | |
| Criteria B | | | |
| Criteria C | | | |
| Criteria D | | | |
| Total | ~~ | ~ | ~~~ |

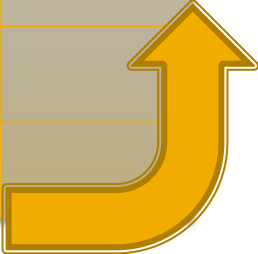# Logical Comparisons - Simple Example

- Decision is *Passenger Car Selection*
- Competing alternatives
  - Jetson Corp. *Hova-Disk*
  - Flinstone Inc. *Rolla-Rock*
- Common criteria
  - Speed
  - Ease of Use
- Logical Comparisons
  - With respect to Speed, Hova-Disk™ is better than Rolla-Rock ™
  - With respect to Ease of Use, Rolla Rock ™ is better than Hova-Disk ™
- Relative importance
  - Speed is more important than Ease of Use
- Conclusion
  - Each of the alternatives is better at one of the criteria. However, because Hova-Disk™ is better at the criteria that is more important, that is the better alternative overall

# Analysis Based on Comparisons
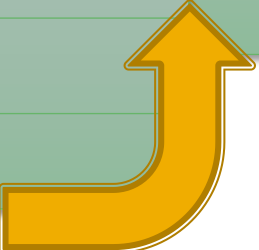
**Decision to be Made**

## Compare Importance of Criteria
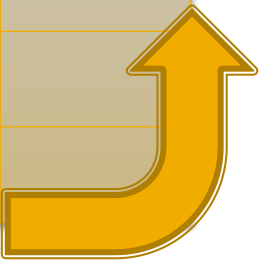
|       | $C_1$ | $C_2$ | $C_3$ |
|-------|-------|-------|-------|
| $C_1$ |       |       |       |
| $C_2$ | >     |       |       |
| $C_3$ | >     | =     |       |

## Compare Alternatives for each Criteria

**$C_3$:**

| | $A_1$ | $A_2$ | $A_3$ |
|---|---|---|---|
| $A_1$ | | | |

**$C_2$:**

| | $A_1$ | $A_2$ | $A_3$ |
|---|---|---|---|
| $A_1$ | | | |

**$C_1$:**

|       | $A_1$ | $A_2$ | $A_3$ |
|-------|-------|-------|-------|
| $A_1$ |       |       |       |
| $A_2$ | >     |       |       |
| $A_3$ | >     | >     |       |

# Comparison Tables - Criteria

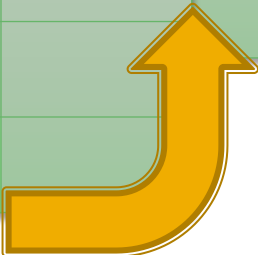|      | C1 | C2 | C3 |
|------|----|----|----|
| C1   |    |    |    |
| C2   | >  |    |    |
| C3   | >  | =  |    |

Translation:
*Criteria 2 is more important than Criteria 1.*
*Criteria 3 is also more important than Criteria 1.*
*Criteria 3 is equal in importance to Criteria 2.*

# Comparison Tables - Alternatives

| C3: | A1 | A2 | A3 |
|---|---|---|---|
| A1 | | | |

| C2: | A1 | A2 | A3 |
|---|---|---|---|
| A1 | | | |

| C1: | A1 | A2 | A3 |
|---|---|---|---|
| A1 | | | |
| A2 | > | | |
| A3 | > | > | |

Translation:
*With respect to Criteria 1*
  *Alternative 2 is better than Alternative 1*
  *Alternative 3 is better than Alternative 1*
  *Alternative 3 is better than Alternative 2*
*With respect to Criteria 2...*

# Logical Comparison Scenarios

- One is better at more important criteria
  - Criteria 1 > Criteria 2
  - Criteria 1: Alt. #1 > Alt. #2
  - Criteria 2: Alt. #1 < Alt. #2
  - Conclude: Alt. #1 is better
- Logical deadlock
  - Criteria 1 = Criteria 2
  - Criteria 1: Alt. #1 > Alt. #2
  - Criteria 2: Alt. #1 < Alt. #2
  - Conclude: Alternatives are comparable

- One is better but on criteria that are less important
  - Criteria 1 > Criteria 2
  - Criteria 1: Alt. #1 = Alt. #2
  - Criteria 2: Alt. #1 < Alt. #2
  - Conclude: Alt. #2 is (slightly) better
- One is better because of a scale in comparison
  - Criteria 1 = Criteria 2
  - Criteria 1: Alt. #1 > Alt. #2
  - Criteria 2: Alt. #1 << Alt. #2
  - Conclude: Alt. #2 is better

# Laws of Logic Apply



- No 'circular' logic errors
  - Criteria 1 more important than Criteria 2.
  - Criteria 2 more important than Criteria 3.
  - Criteria 3 more important than Criteria 1. *D'oh!*

- Reasoning must be complete
  - Criteria 1 more important than Criteria 2
  - Alternative 1 better than Alternative 2 with respect to Criteria 2
  - Conclusion: Alternative 1 is better. *D'oh!*

# Comparison of AoA Alternatives

|  | Scored Values | Logical Comparisons |
|---|---|---|
| Good for range of decisions | Yes | Yes |
| Allows analysis to be transparent | Yes | Yes |
| Can be used for large programs, complex decisions, high-value systems, etc. | Yes | Yes |
| Support sensitivity analysis | Yes | Yes |
| Commonly used and widely understood | Yes | No |
| Easy to compute with common hardware and software | Yes | No |
| Works well when using interviews | Fair | Yes |
| Well suited to qualitative business decisions or 'political' decisions | No | Yes |
| Easily uses samples or probabilities | Fair | Fair |

But, what about a different class of alternatives analysis?

What if you are trying to decide if something is "good" or "bad" based upon probabilities and prior experience?

Or, what if the alternatives being considered are different systems for picking out "good" things from "bad" things... and sometimes they make mistakes?
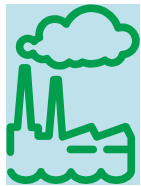
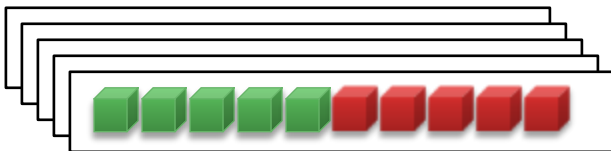# Alternatives Based on Probability and Experience (Scenario #1)
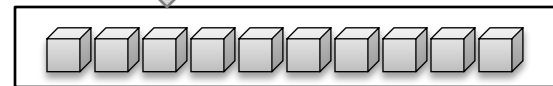
**Jetson Corp.**
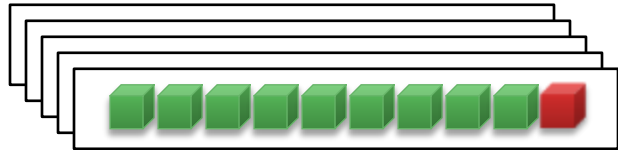
5 boxes of 10 items each
9 of 10 item are "good", 1 of 10 are "bad"

**Flintstone Inc**

5 boxes of 10 items each
5 of 10 items are "good", 5 of 10 are "bad"

Inventory

- Applicable decision
- Competing alternatives
- Common criteria
- *Statistical analysis*
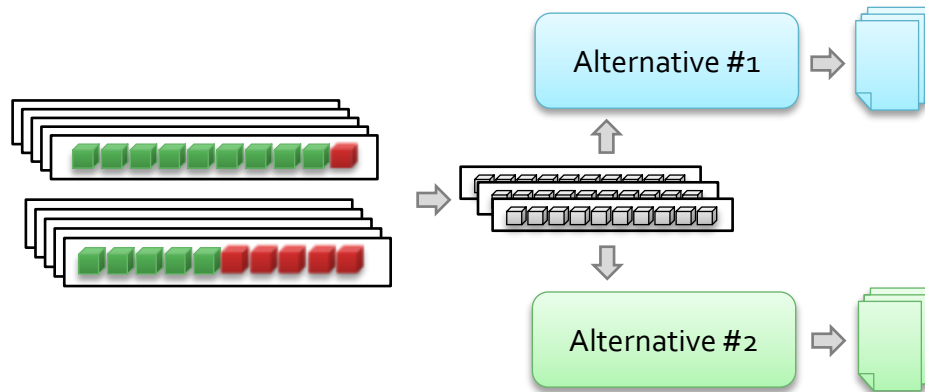- Relative importance
- Conclusive comparison

Is the box pulled from inventory a "good" box or "bad" box?
If the first item inspected is "bad", is that just "bad" item in a "good" box from a "bad" box?
Should I test a 2nd item in the box?  If the 2nd item is "bad", do I test any more items?
Is my conclusion different if I test two "bad" items versus two "good" items?

# Alternatives Based on Probability and Experience (Scenario #2)

- Applicable decision
- Competing alternatives
- Common criteria
- *Statistical analysis*
- Relative importance
- Conclusive comparison

Alternative #1

Alternative #2

Decision: Which alternative is better at sorting out "good" and "bad" boxes?

Alternatives:  Alternative #1 versus Alternative #2... versus random guessing.

Criteria: Comparison of outputs by alternatives to known inputs

Analysis: How often each alternative correctly (or mistakenly) identifies a "good" box as a "bad" box.... and vice versa.

Importance: More important to catch all "bad" boxes. Okay to falsely call some "good" boxes as "bad" boxes.  [Alternatively....]

Conclusion: .... [See "chainsaws" problem for sample using only add, subtract, multiply and divide.]

# Comparison of AoA Alternatives

| | Scored Values | Logical Comparisons | Probabilities + Experience |
|---|---|---|---|
| Good for range of decisions | Yes | Yes | Fair |
| Allows analysis to be transparent | Yes | Yes | Yes |
| Support sensitivity analysis | Yes | Yes | Yes |
| Commonly used and widely understood | Yes | No | No |
| Easy to compute with common hardware and software | Yes | No | Yes |
| Well suited to qualitative business decisions | No | Yes | No |
| Good fit for data with samples, trends or probabilities | Fair | Fair | Yes |

| Not Negotiable | A1 | A2 | A3 |
|---|---|---|---|
| C1 | ~~ | ~ | ~~ |
| C2 | ~ | ~~ | ~~~ |
| C3 | ~~ | ~ | ~ |
| C4 | ~~ | ~~ | ~~ |
| Total | 10 pts | 30 pts | 20 pts |

Remember this?

What if this isn't true? What if the characteristics of the system, or its parts, are negotiable…. but within certain boundaries?
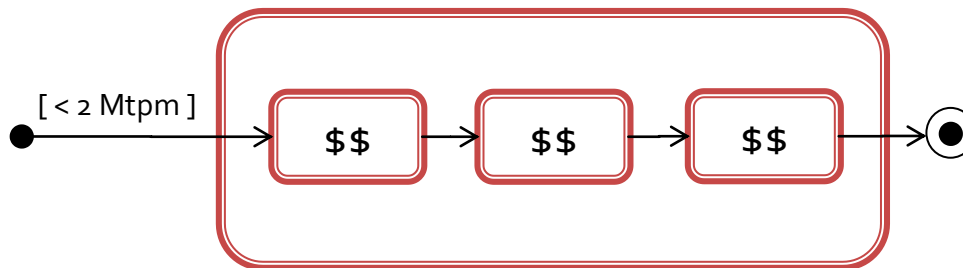
Then we may have an analysis of alternatives that can be pursued as a constraint satisfaction problem.
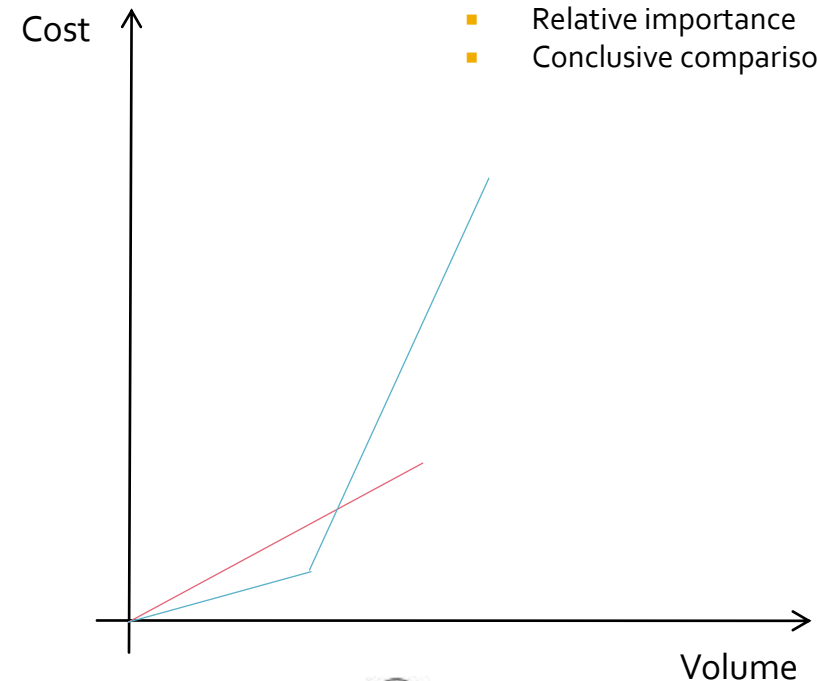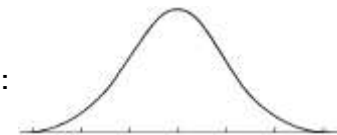
# Constraint Sample

## Alternative #1

[ < 3 Mtpm ]

[ < 1 Mtpm ]

$

$

$

$$$$

[ > 1 Mtpm ]

## Alternative #2

[ < 2 Mtpm ]

$$

$$

$$
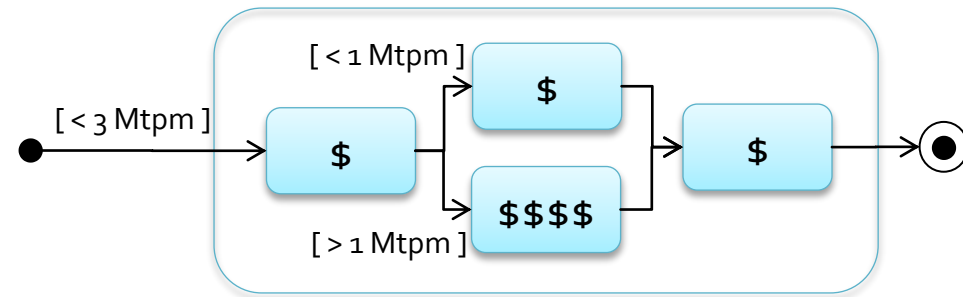
- Applicable decision
- Competing alternatives
- Common criteria
- *Throughput analysis*
- Relative importance
- Conclusive comparison

Cost

Volume

Usage Pattern:

See: J. Pang, Two Shirts Problem.

# Comparison of AoA Alternatives

| | Scored Values | Logical Comparisons | Probabilities + Experience | Constraint Analysis |
|---|---|---|---|---|
| Good for range of decisions | Yes | Yes | Fair | Yes |
| Allows analysis to be transparent | Yes | Yes | Yes | Yes |
| Support sensitivity analysis | Yes | Yes | Yes | Yes |
| Commonly used and widely understood | Yes | No | No | No |
| Easy to compute with common HW and SW | Yes | No | Yes | No |
| Well suited to qualitative business decisions | No | Yes | No | Yes |
| Good fit for data with samples or probabilities | Fair | Fair | Yes | Yes |
| Works well with scenarios | No | Fair | Yes | Yes |

# Public Case Studies

- ✳ Boeing 777 Sub-system Selections
- Basis for DoD 5000.2 Instructions
- Consumer and Enterprise Product Evaluations
- Air Force KC-135 Recapitalization (RAND)
- Treasury Inter-agency Agreement Guide
- 2008, IBM-UK IT Energy Efficiency Study
- MITRE, NOAA FY'08 Observing Systems Investment Analysis
- MITRE, Applying ROI Analysis to Investment Management Process, 2002
- IRS Business Modernization Report (2000)
- TIGTA, *Business Cases for IT Projects Need Improvement*, 2004

- IBM AS/400 Quality Improvement
- U.S. ACDA Arms Control Negotiations  (60's and 70's)
- 1986 South Africa Conflict Resolution Strategy
- 2003 Study of U.S. Engagement Strategy for Iraq
- MITRE, Risk to Mission Assessment Process (DHS), 2009
- ✳ COTS product source selections
- Spam filtering systems
- Case management systems
- ✳ Identity verification systems

- ✳ ...and others

# Q&A, Discussion, etc.