Multi-attribute Decision Analysis

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Agenda

- What is Multi-attribute Decision Analysis and when should it be used?
  - Two slides from Frank Koch provide the context for this discussion
  - Definition and distinctions
- Common mistakes dealing with multi-attribute
  - Noted by Ralph Keeney
  - Additional mistakes
- Proposed protocol for correctly facilitating and completing multi-attribute DA
- Case Studies
  - Personal
  - Business
- Summary, References, and Appendix

The Big Picture [from Frank Koch][1]

Framing

Analyzing

Descriptive

Normative

How people make decisions

"How people *should* make decisions"

Normative Decision Making[1]

Descriptive	Normative
How people make decisions	"How people *should* make decisions"
Ranking/Weighting AHP Throwing Bones Reading Entrails	Math

What is (and is not) Multi-attribute Decision Analysis?

- Financial measures-of-value (e.g. expected NPV, DPI) are not sufficient for some decisions, which leads to *multi-attribute* analysis...

- Multi-attribute Decision Analysis is appropriately considering non-financial objectives and their associated trade-offs, which leads to clarity for the decision maker.
  - Keeney refers to this as "Making Value Trade-offs"[2]

- Multi-attribute Analysis is *not*:
  - Multi-attribute Utility Theory (MAUT)
  - Analytical Hierarchy Process (AHP) [see Koch][1]
  - Ranking and Weighting
  - Throwing Bones
  - Reading Entrails

When Should Multi-attribute Analysis be Used… (and When Should it not be Used)?

Multi-attribute may not needed for strategic decisions, e.g.

- Project go/no go decisions
  - Capital expenditure authorization
  - Development phase gate decisions
- Technically driven decisions:
  - Product development and launch
  - Field development
  - Well scheduling
- Multi-attribute may not needed for some tactical decisions:
  - Choosing the low bid among multiple proposals

Multi-attribute *is* needed when subjective non-financial objectives and/or criteria are important.

These can be relatively tactical but real-life decisions:

- Buying a car
- Buying a house
- Choosing a college
- Selecting a site for a new facility
- Choosing a proposal when low bid is not sufficient
- Grading eMBA presentations

Keeney's "Common Mistakes" and Recommendations[2]

Common Mistakes

1. Not understanding the decision context
2. Not having measures for consequences
3. Using inadequate measures
4. Not knowing what the measures represent
5. Making trade-offs involving means objectives [instead of fundamental]
6. Using willingness to swap as a value trade-off
7. Trying to calculate correct value trade-offs
8. Assessing value trade-offs independent of the range of consequences
9. Not having value trade-offs depend on where you start
10. Providing conservative value trade-offs

Making Good Value Trade-offs

1. Frame the decision appropriately
2. Structure the value trade-off problem
3. Determine pairs of consequences that are indifferent
4. Revise value trade-offs as appropriate to assure reasonableness

Common Mistakes
To Avoid Destroying Clarity, DO NOT:

- Use unnecessary and complex weighting and scoring schemes (AHP, swing weights, MAUT):
  - "Black Box" analytical complexity
  - Confuses complexity with correct analysis
  - Loses sight of the Big Picture
- Confound cost with other value measures (AHP).
- Confuse independent and dependent variables:
  - The independent attribute (cost) should <u>always</u> be on the *x-axis* (the decision maker *decides* how much to spend).
- Weight and score attributes which should be treated as conforming / non-conforming attributes (e.g. safety performance).
- Ask the wrong questions:
  - "Which is more important to you – Cost or Quality?"

How does Multi-attribute Fit into the Decision Analysis Process?

Typical DA Frame:
- Problem Statement
- Issue Raising
- Situation Analysis
- Stakeholder Analysis
- Objectives Hierarchy
- Decision Hierarchy
- Decision Tree
- Strategy Table
- Influence Diagram

Typical DA Analysis:
- Financial Model
- Risk and Uncertainty Assessment
- Tornado
- Cumulative Probability
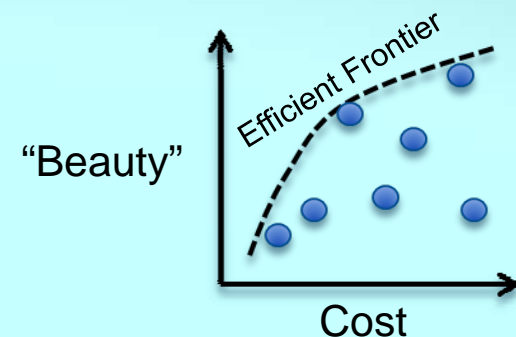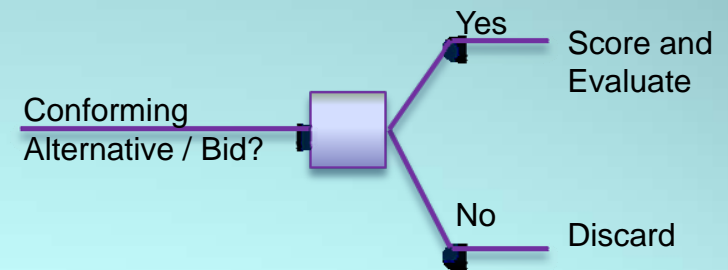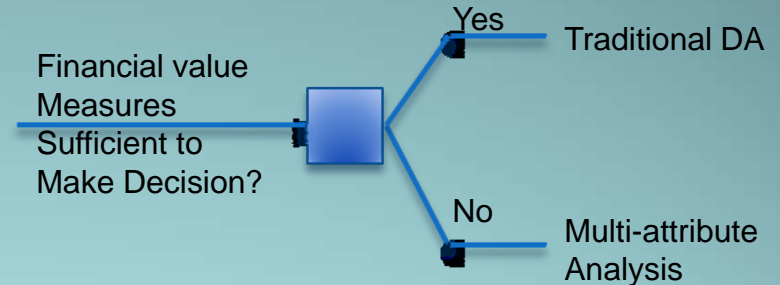- VOI / VOC
- Implementation

Multi-attribute Analysis:
- Additional Attributes
- Attribute Scoring
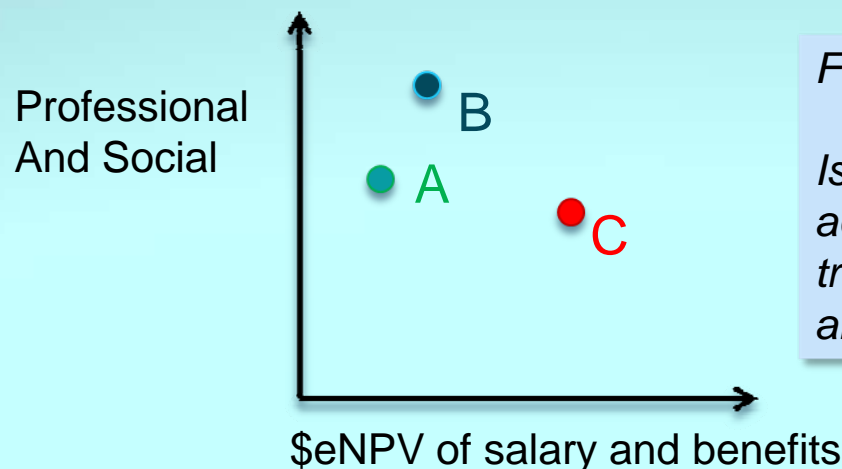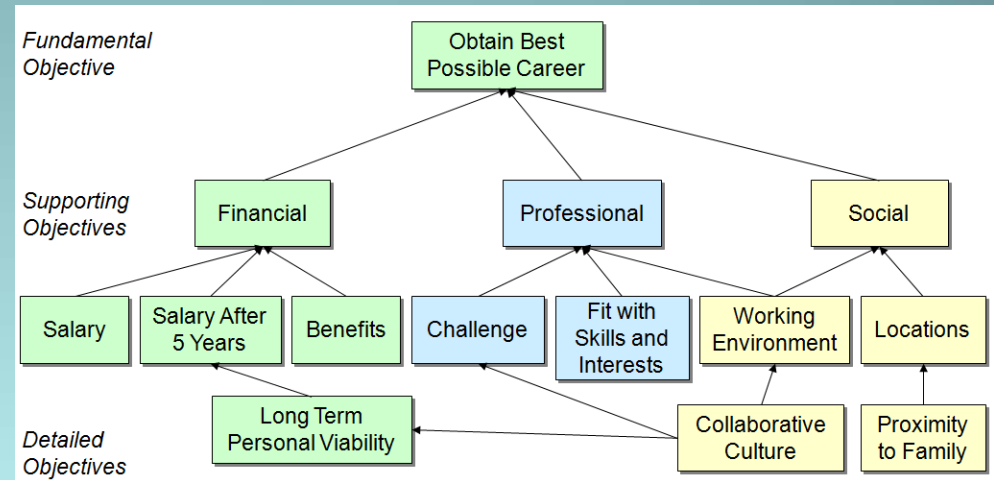- Subjective versus Quantitative: Trade-offs

Proposed Protocol: To add Clarity: ("Keep It Simple")

1. Determine whether Financial value measures (NPV, DPI) are sufficient to make the decision(s)
   - Purchasing decision: Can you live with accepting the low bid?
2. Complete the financial analysis so that costs and associated uncertainties are sufficiently understood
3. Score the alternatives relative to the subjective Fundamental Objectives
   - Discard non-conforming alternatives / bids / proposals
4. Plot Beauty versus Cost to show the trade-offs between alternatives
5. Develop the story to accompany the graph

Financial value Measures Sufficient to Make Decision?
Yes — Traditional DA
No — Multi-attribute Analysis

Conforming Alternative / Bid?
Yes — Score and Evaluate
No — Discard

Efficient Frontier
"Beauty"
Cost

Case #1: Choosing Among Job Opportunities Which Job Would You Choose?

Cumulative Probability graph — Job A, Job B, Job C plotted against Measure of value (NPV, 5 year time horizon) ->

Objectives hierarchy:
- Fundamental Objective: Obtain Best Possible Career
- Supporting Objectives: Financial, Professional, Social
- Detailed Objectives: Salary, Salary After 5 Years, Benefits, Challenge, Fit with Skills and Interests, Working Environment, Locations, Long Term Personal Viability, Collaborative Culture, Proximity to Family

Professional And Social (vertical axis)

$eNPV of salary and benefits (horizontal axis)

Points: B, A, C

Fundamental Question:

Is the potential financial advantage of Job C worth trading off the Professional and Social objectives?

Case #2: Retirement [Frank Koch][1]

- Frank has previously reported how he:
  - Framed his retirement decision
  - Completed the analysis and made the decision(s)
- Financial (cost): cost of living, taxes, cost of housing
- Subjective attributes ("Net Present Happiness"): "must understand your [and your spouse's] Objectives Hierarchy"[5]
  - Discarded non-conforming alternatives
  - Balanced trade-offs between remaining alternatives and cost
  - Understood alternatives of subjective ambivalence and used this as negotiation strategy (reverse auction)

State	City	Setting	Home	Convertible
Texas	Corvallis	Development	Keep	Frank gets one
Oregon	Eugene	Coastal	Buy New	Frank doesn't
	Coos Bay	Woods	Build New	
	Houston		Buy Old	

Case #3: Mid-life Crisis New Car[3]
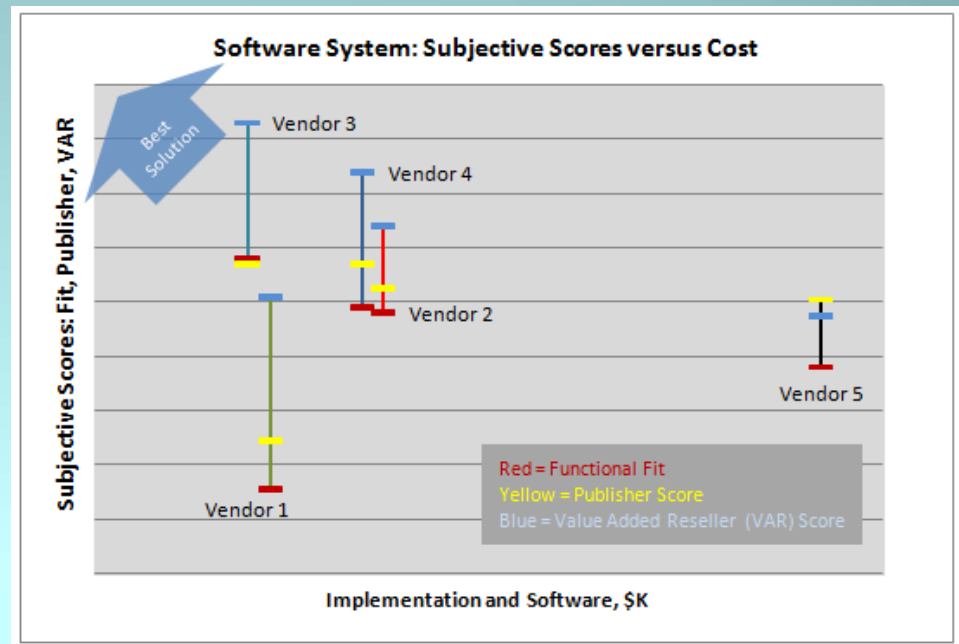## *Which car would you purchase?*

- Financial measure: List price
- Subjective attributes: "Fun"
  - Horsepower
  - Handling
  - "Green" (i.e. mpg)
  - Aesthetic appeal

| Make/ Model	2010 Chevrolet Corvette Grand Sport	2011 Ford Shelby GT500
List price	$54,770	$48,645
Curb weight	3360 lb	3820 lb
Engine, transmission	6.2-liter V-8, 6-sp manual	5.4-liter supercharged V-8, 6-sp manual
Horsepower, bhp	436 @ 5900	550 @ 6200
Torque, lb-ft	428 @ 4600	510 @ 4250
0-60 mph	4.1 sec	4.4 sec
0-100 mph	9.2 sec	9.2 sec
0-1320 ft (1/4 mile)	12.4 sec @ 116.5 mph	12.6 sec @ 118.9 mph
Top speed	190 mph*	155 mph*
Braking, 60-0 mph	112 ft	117 ft
Braking, 80-0 mph	197 ft	197 ft
Lateral accel (200-ft skidpad)	0.96g	1.00g
Speed thru 700-ft slalom	70.7 mph	69.6 mph
EPA city/highway	16/26 mpg	15/23 mpg

Case #4: Which Software System to Buy *(adapted from a real case; sometimes you get lucky)*

- Based on proposals generated from a detailed RFP, five conforming proposals were "short listed."

- Subjective criteria included:
  - Functional Fit
  - Publisher (financial stability, experience, depth)
  - Value-added Reseller (VAR) (financial stability, experience, depth)

Software System: Subjective Scores versus Cost

Best Solution

Vendor 3
Vendor 4
Vendor 2
Vendor 5
Vendor 1

Subjective Scores: Fit, Publisher, VAR

Red = Functional Fit
Yellow = Publisher Score
Blue = Value Added Reseller (VAR) Score

Implementation and Software, $K

Case #5: Choosing an Office Suite
(adapted from a another lucky case)

- Stand-alone, fully functioning office space needed
  - 8,500 ft2 +/-, downtown Houston, 3Q 2008
- Subjective criteria (attributes):
  - Location (relative to services, bus lines, HOU150, etc.)
  - State of build-out
  - Time frame (lease term, availability)
- Shortlisted 4 properties after looking at over 30.
- The property with the highest qualitative score was also the least expensive, which is unusual.
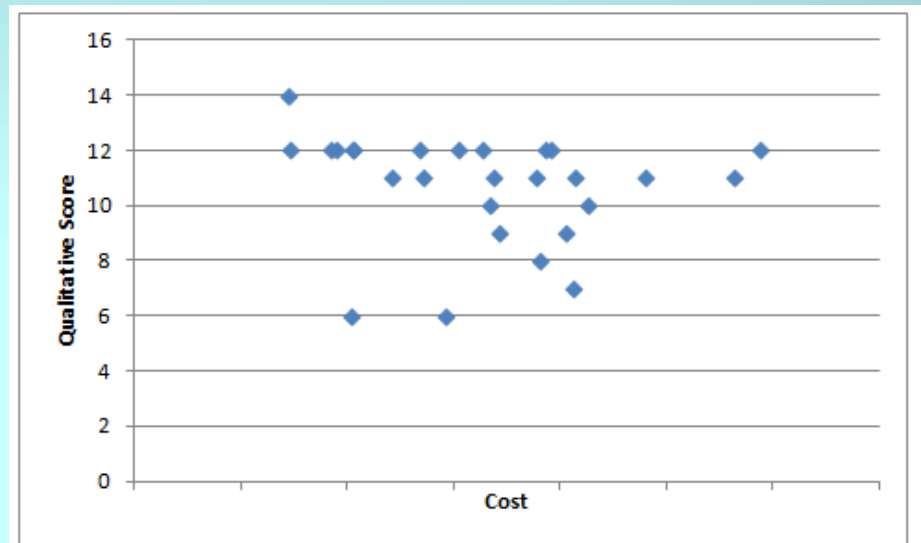
Case #6: Scoring Executive MBA Presentations

- Teams have ½ hour to present their Projects to a mock Decision Review Board.
- The instructor facilitates the DRB to score each team relative to subjective criteria:[4]
  - Discovery / Problem Understanding
  - Correct Frame
  - Logical and Consistent Analysis
  - Clear Presentation of Insights
  - Team Cohesiveness
  - Oral Presentation Skills.
- A scale of 0 to 7 is used, where 0 is "confused," 1 is "close to correct," and 7 is "perfect."
- Individual DRB members score each presentation separately and then reach consensus via discussion.
  - Logical breakpoints between grades become apparent.

Summary:
Keep Multi-attribute Decision Analysis Simple!

1. Are financial value measures sufficient to make the decision?
2. Complete financial analysis.
3. Score the non-financial objectives.
   - Eliminate non-conforming alternatives / proposals / bids.
4. Plot "Beauty" versus "Cost."
   - Examine and discuss trade-offs.
5. Develop and present The Story.

References

1. Koch, Frank, several presentations and several personal conversations, 2008-2011.

2. Keeney, Ralph L., "Common Mistakes in Making Value Trade-offs" Operations Research Vol. 50, No. 6.

3. Data and photographs from Road and Track, September 8, 2010.
   (http://www.roadandtrack.com/tests/comparison/2010-chevrolet-corvette-grand-sport-vs.-2011-ford-shelby-gt500)

4. Skinner, David, personal conversation, April 2, 2011.

5. Koch, Frank, personal conversation, 2011.