COTS Product Selection

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Why a Formal Process is Needed

- Selection is usually more complex than expected
- Many candidate products are often considered
- Consider other criteria besides product functions
- The decision needs to be justified.
The Basis and Origin of This Work

  - The original work that developed the major improvements over most other processes.

  - Inspired the original work
Related Selection Process Work


  - Maintained by the Systems Engineering Practice Office (SEPO)

How this Process Differs

- Two stages, suitable for a large number of products
- Initial stage of binary criteria for quick down-select
- Defined numerical evaluation values
- Defined two-level weight assignment to criteria.
Two Stage Selection Process

- Identify Requirements
- Define binary criteria
- Define quantitative criteria
- Assign weights to quantitative criteria
- Identify candidate products
- Evaluate products against binary criteria – Stage 1
- Down-select using binary criteria – Stage 1
- Evaluate products against quantitative criteria – Stage 2
- Compile results to identify selected product – Stage 2.
Selection Process Stages

1. Candidate Products
2. Down-Select
3. Selection Criteria
   - Binary Criteria
4. Short List
5. Stage 1
6. Quantitative Criteria
7. Stage 2
8. Weights for Criteria
9. Scale of Values
10. Evaluate Products
11. Product Scores*
12. Spreadsheet Of Products and Criteria
13. Selected Product

* Score each product on each quantitative criterion.
Identify Requirements

**Sources of requirements**
- Business goals
- Domain knowledge – Existing lists of requirements
- Stakeholders
- Organizational and operational environment – regulations or laws that apply

**Merge and structure requirements**
- Group into logical hierarchy
- Resolve redundancies and conflicts
- Link each to its source(s)
- Discuss to resolve ambiguities.
Define Binary Criteria

- Each criterion can be answered with Yes or No
  - Traceable to a requirement or otherwise justified
- These are absolute requirements
  - The product or vendor must meet the criterion
  - Any “NO” answer results in that product being rejected
  - A product with all “Yes” answers makes the short list
- Evaluate most using product literature
- Down-select prior to quantitative evaluation.
Define Quantitative Criteria

- Form criteria from requirements
  - Each criterion is an aggregate of several requirements
  - Easier to compare products to a small number of criteria
- Assign scale values that represent completeness
  - 4 = product fulfills the criterion completely or better
  - 1, 2, 3 describe parts of the criterion that are met and unmet
  - 0 = product does not address the criterion at all
- Define multiple-choice answers for each criterion
  - Each answer gets a value from 0 to 4
  - Not all values need be used for every criterion.
Quantitative Criteria Categories

- Use more than just product functions
- Some suggested criteria categories:
  - Functional
  - Human Interface
  - Performance
  - Business Continuity (explained below)
  - Life-Cycle Cost (explained below)
  - Third-Party Evaluations
  - Security.
Life Cycle Cost Category

- Product cost, relative to the other candidates
- Maintenance cost, relative to the other candidates
- Vendor’s viability and ability to support the product
- Product’s defect record
- Vendor’s willingness to enhance or customize
- Availability and cost of training
- Compatibility with existing platforms and products

Cost in money and in time.
Business Continuity Category

- Is vendor a reputable company?
- Is the vendor company stable and likely to remain so?
- Is the product at end-of-life and about to be replaced?

Will they be around to support the product as long as we need it?
## Example of Quantitative Criteria Scale Values

<table>
<thead>
<tr>
<th>Seq #</th>
<th>The product is capable of storing and presenting for display, print, and/or download all required record information</th>
<th>Source or justification</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>0</td>
<td>The product is missing a provision for key record information.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Most of the information and all key information can be stored, but some of the information is not easily accessed.</td>
<td>1</td>
<td>Most of the information and all key information can be stored, but some of the information is not easily accessed.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>All of the necessary information can be stored but some is not easily accessed, or some of the non-key information is not available.</td>
<td>2</td>
<td>All of the necessary information can be stored but some is not easily accessed, or some of the non-key information is not available.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>All of the necessary information can be stored, but some of the non-key information is not easily accessed.</td>
<td>3</td>
<td>All of the necessary information can be stored, but some of the non-key information is not easily accessed.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>The product fully complies.</td>
<td>4</td>
<td>The product fully complies.</td>
<td></td>
</tr>
</tbody>
</table>

**Functional**
Example of Quantitative Criteria Scale Values

<table>
<thead>
<tr>
<th>Seq #</th>
<th>It is easy to print or export a full set of documentation for a specified section.</th>
<th>Source or justification</th>
<th>0</th>
<th>The information is not available in coherent form.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>All information is available but requires several operations to retrieve several independent pieces.</td>
<td></td>
<td>4</td>
<td>The product fully complies.</td>
</tr>
</tbody>
</table>

**Functional**
Example of Quantitative Criteria Scale Values

<table>
<thead>
<tr>
<th>Seq #</th>
<th>The product offers context-sensitive help at the screen or menu level and the field level, in addition to overall guidance</th>
<th>Source or justification</th>
<th>0</th>
<th>There is no Help function.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The product includes instructional help for each screen, but it must be located within a common help file.</td>
<td></td>
<td>2</td>
<td>The product offers context-sensitive help for each screen, but not at the field level.</td>
</tr>
<tr>
<td>3</td>
<td>The product offers context-sensitive help for each screen, but not at the field level.</td>
<td></td>
<td>4</td>
<td>The product fully complies.</td>
</tr>
</tbody>
</table>

Human Interface
## Example of Quantitative Criteria Scale Values

<table>
<thead>
<tr>
<th>Seq #</th>
<th>Source or justification</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The product costs much more than its competitors</td>
<td>0</td>
<td>This is the least expensive of the products being considered.</td>
</tr>
<tr>
<td>1</td>
<td>Upper end of price range</td>
<td>1</td>
<td>Source or justification</td>
</tr>
<tr>
<td>2</td>
<td>Middle of the price range</td>
<td>2</td>
<td>Seq #</td>
</tr>
<tr>
<td>3</td>
<td>Lower end of price range</td>
<td>3</td>
<td>Seq #</td>
</tr>
<tr>
<td>4</td>
<td>The product costs much less than its competitors</td>
<td>4</td>
<td>Seq #</td>
</tr>
</tbody>
</table>

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### Software Life-Cycle Cost

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Example of Quantitative Criteria Scale Values

<table>
<thead>
<tr>
<th>Seq #</th>
<th>This is a solid, well-known company that has a deservedly good reputation and is doing well.</th>
<th>Source or justification</th>
<th>0</th>
<th>Company is defunct, or this is freeware with no support.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>Company is a start-up with no reputation, or this is open source with few interested supporters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>Company is not well known, or this is open source with a network of interested supporters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>Medium size company with an established reputation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>Blue chip company with a solid reputation and future</td>
</tr>
</tbody>
</table>

Business Continuity
Quantitative Criterion Weights

- Each criterion category gets a weight
  - Category weights are relative to other categories
- Criterion weights should be simple: 1 to 5
- Category weights and criterion weights can be adjusted independently of each other
- Can assign weights in parallel with product evaluations
- Preferable to have separate teams to:
  - assign weights
  - perform evaluations.
Criteria Weights—Definitions

- Category weights and criterion weights
  - Target_Weight: negotiated and assigned to a category
  - Assigned_Weight: negotiated for a criterion from 1 to 5
  - Category_Weight: calculated assuming Assigned Weights = 3
  - Final_Weight: based on Target_Weight and Assigned_Weights

- Allocate a category’s weights among its criteria.
  - For example, one algorithm is:
  - category_factor = Category_Weight / criterion_count
  - Final_Weight = Assigned_Weight + category_factor – 3
Assigning Criteria Category Weights – 1

- Each organization ranks categories independently
- Conference calls discuss and negotiate rankings
- Probe into reasons behind differences in ranking
- Get each group to understand other group’s reasons
- When all ranks are close, offer to split the difference
  - ranks of 3 and 5 become 4; ranks of 7 and 8 become 7.5
  - these are quasi_ranks – used to calculate Category_Weights
- Important to get buy-in from each group for the ranks.

Target_Weights assigned by consensus
Assigning Criteria Category Weights – 2

- Set Category Target_Weights
  - should total 1,000
  - needs a size factor based on number of categories
  - Target_Weight = size_factor * 1,000 / quasi-rank

- Example with 10 categories.
  - quasi_ranks: 2, 8, 10, 5.5, 2, 3, 5.5, 3, 8.5, 7.5
  - size_factor = 0.4 ➔ Target_Weight = 0.4 * 1,000 / quasi_rank
  - Target_Weights: 200, 50, 40, 73, 200, 133, 73, 133, 47, 53
  - Category_Weights total ≈ 1,000
Assigning Criteria Category Weights – 3

\[ C_i = \frac{T_i}{\sum_{i=1}^{m} T_i} \times 1000 \]

- \( C_i \) is Category Weight calculated for that category
- \( T_i \) is Target Weight negotiated for a category
- \( m \) is total number of categories
The algorithm evenly allocates weights within a category
- The middle Final_Weight values (3) for a category sum to Category_Weight ≈ Target_Weight
- Changing a Target_Weight recalculates all Final_Weights
- Changing an Assigned_Weight recalculates all Final_Weights.

<table>
<thead>
<tr>
<th>Criteria Category</th>
<th>Target Weight</th>
<th>Category Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queries</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Reporting</td>
<td>50</td>
<td>52</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>total</td>
<td>1002</td>
<td>1005</td>
</tr>
</tbody>
</table>
Allocate Weights Within a Category

\[ F_i = \frac{A_i}{\sum_{i=1}^{n} A_i} \times C_j \]

- \( F_i \): Final Weight of that criterion
- \( C_j \): Category Weight calculated for that category
- \( A_i \): Assigned Weight for a criterion
- \( n \): is number of criteria in this category
Identify Candidate Products

- Cast a wide net—there are probably more than you know
- Products are identified in parallel with criteria definition
- Collect enough information to locate the products again.
  - Product name
  - Vendor name
  - Website URL
Evaluate Products Against Binary Criteria

- For each product, address each criterion
- Done based on product literature without installing
- Group consensus might be used for each criterion
- If any response is “No”, the product is excluded
- Products with all “Yes” answers make the short list.
## Down-Select Using Binary Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Product A</th>
<th>Product B</th>
<th>Product C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product includes the required interfaces</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Product is available for MS Windows</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Requires all users to be authenticated</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Supports all Section 508 requirements</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Has a web based human interface</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In this example, only Product B goes on to the next stage.
Evaluate Products Against Quantitative Criteria

- Evaluate each product against each criterion
- Can be done by installing and testing each product
- Can ask vendors to answer with supporting evidence
  - Evaluators validate evidence to confirm it supports the answer
- Use spreadsheets to sum product scores
  - Use a spreadsheet for each category
  - Use a totaling spreadsheet
- Product with highest score is top choice.
Evaluate Against a Criterion Category

<table>
<thead>
<tr>
<th>#</th>
<th>Selection Criteria</th>
<th>Weight</th>
<th>Value</th>
<th>Score</th>
<th>Value</th>
<th>Score</th>
<th>Value</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Some criterion</td>
<td>7.00</td>
<td>2.50</td>
<td>17.50</td>
<td>4.00</td>
<td>28.00</td>
<td>4.00</td>
<td>28.00</td>
</tr>
<tr>
<td>2</td>
<td>Some criterion</td>
<td>6.67</td>
<td>3.25</td>
<td>21.67</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.33</td>
<td>1.75</td>
<td>12.83</td>
<td>4.00</td>
<td>29.33</td>
<td>3.00</td>
<td>22.00</td>
</tr>
<tr>
<td></td>
<td>Data Collection Score</td>
<td>559.00</td>
<td>809.00</td>
<td>775.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Final Weight for each criterion

weight * value = score

Category score for this product

Similar calculations are done for each category.
Evaluate Total Quantitative Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Total Score for Each Product</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Product A</td>
</tr>
<tr>
<td>Data Collection</td>
<td>599.00</td>
</tr>
<tr>
<td>Security</td>
<td>453.92</td>
</tr>
</tbody>
</table>

These numbers are links from the totals on the category sheets;

This line totals all of the category sheets.
Reviewing the Hard Parts

- Define the selection criteria from the requirements
- Define scale values for each quantitative criterion
- Getting agreement on weight assignments
- Performing the product evaluations
Conclusion

- All criteria can be considered
- The decision process is documented
- The final decision is fully justified
- New information is easily added to affect the decision.