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The Trade Study Process

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MAKE OBJECTIVE AND DEFENSIBLE DECISIONS FOR YOUR ORGANIZATION

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Summary

Is your team facing a decision on which technology, product, or service to buy? After an organization makes the initial choice to invest in new or replacement technologies, a common follow on question is, "Which vendor-specific offering is best for us?" For investments of significant size, you need an objective process to maximize value. In this situation, a Trade Study will help you.

This paper defines a process to conduct Trade Studies. Properly conducted Trade Studies inform decisions by methodically framing the trade space and systematically evaluating alternatives. Objectivity throughout the process ensures that Trade Study recommendations are evidence-based and defensible, and can be used with confidence.

When to Conduct a Trade Study?

Trade Studies address situations where a set of comparable alternatives can be identified. A Trade Study is not needed in cases where alternatives are virtually identical (commodities); or in cases where alternatives are so disparate that objective comparison is not possible. **Table 1** provides some basic example situations.

Table 1. Should we do a Trade Study?

Situation	Should a Trade Study be conducted?
Choose among competing products or services	Yes. This is the classic situation where a Trade Study is appropriate (assuming the market is not commoditized).
Upgrade to new version of corporate human resources system	Maybe. In this case it would depend upon the time and resources required to upgrade and on whether there are new requirements. It may be a trivial decision, or it could be more complex and worthy of a Trade Study.
Choose between buying a ship or building a rocket	No. An Analysis of Alternatives (AoA) is more appropriate. In this case, the decision space is not bounded enough for a Trade Study.

It is important to distinguish Trade Studies from Analyses of Alternatives (AoAs). Trade Studies are used to inform decision making for bounded decisions. For example, a Trade Study can identify the best product to meet capability requirements. In contrast, the AoA is used for decision making in much broader situations, such as whether to

address capability needs through procurement of an existing commercial service or by building a completely new system. Additionally, some government organizations may use the term Alternatives Analysis (AA) instead of Trade Study. For the purposes of this paper, the reader can consider the two terms to be synonymous.

Trade Study Resources

A Trade Study team must be assembled by the sponsoring organization. The team may consist of a single type of experts for narrowly scoped trades, or it be may multidisciplinary for more complex trades. When assembling the team, other resources should be considered such as access to necessary test environments and data. In general the size of the team will be reflective of the size of the study; and the size of the study is typically directly related to the amount of funding at stake.

Trade Study Process

Readers are encouraged to follow the process described in this section, tailoring it as necessary. This process is elastic. It can be expanded to include additional detail and rigor to address more complex capabilities focused on evolving organizational risks and threats. Correspondingly, the process can be contracted in terms of time and resources for simpler studies.

Figure 1 shows the Trade Study process steps. Following these steps will lead to a defensible and objective Trade Study.

Subsequent sections provide guidance for each step. Each step is described generically and is based upon review of industry and academic trade study processes.

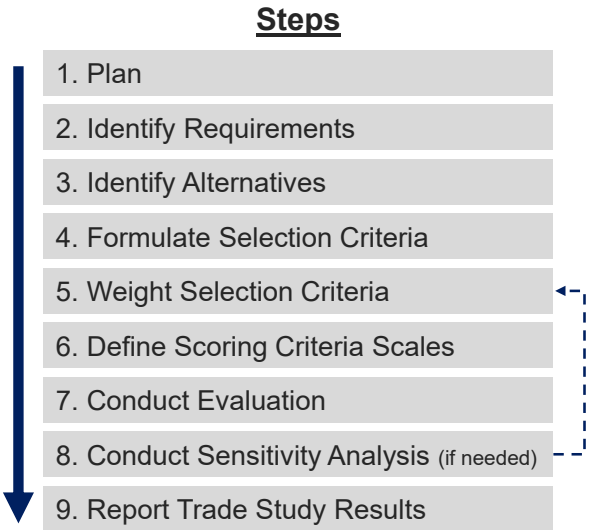

Figure 1. Trade Study Process

Prior to initiation of the Trade Study, the sponsoring organization must commission the study and provide initial guidance. Guidance will provide clarity on what is to be studied and should be as specific as possible without unnecessarily constraining the study. This can be expressed in terms of the decision that is at stake. Guidance will also include the study duration and study resources (including funding). Note that the sponsoring organization should be available during the conduct of the Trade Study to provide information on current requirements, design constraints, and sponsor priorities.

Step 1 – Plan

The Trade Study team, in cooperation with the sponsoring organization, determines the scope of the study. Identify the available resources, including available time, personnel, computing and testing environments, infrastructure support, desired outputs, and any

other parameters needed prior to conducting the study. The plan must be documented and agreed upon with the sponsoring organization prior to initiation of the study itself.

Step 2 – Identify Requirements

Identify the requirements to be used as a basis for the study, including formally baselined requirements, any design constraints that will bound the selection of alternatives to be studied, and the criteria that will be used to conduct the evaluation. It is important to understand the sponsor organization's intent for the study and uncover any additional requirements and constraints that may not be in the sponsor's baseline but are nonetheless important to the study. Examples could include the requirement to interoperate with products in the current system or the constraint that only certain manufacturers are authorized for use in the sponsor environment. Requirements must be met by all alternatives, whereas criteria are the measures used to evaluate the alternatives.

Step 3 – Identify Alternatives

Identify the possible solution alternatives to be studied. Alternatives may include competing products and services, operational processes and techniques, or types of human resources (e.g., teams composed of different skill mixes) to be studied. The alternatives may be composed of various combinations of technology, process, and people components. The number of alternatives should be based upon the time and resources available to conduct the study. Alternatives should be similar enough to enable a relevant comparison using criteria and associated measures across all alternatives. If this is not possible, the scope of the study may need to be revisited and narrowed. In other words, the alternatives should consist of like entities, such as competing products, service types, or delivery models. Where appropriate, maintaining the existing solution may be included as an alternative, even if only for comparison.

Step 4 – Formulate Selection Criteria

Develop the set of criteria to be evaluated. Criteria should be applicable to all alternatives and germane to the requirements. Measurement of each criterion must be feasible using available resources and methods such as testing, observation, previously collected data, or analysis. Criteria should be distinct, or independent, from one another.

Cost may be included as a criterion but must be handled carefully. In many instances, cost will be reflected in other criteria. For example, if study authors include criteria for CPU speed and cost, alternatives with higher CPU speeds will likely have higher costs. This reflects a dependency between criterion that may distort statistical validity. If cost is chosen as a criterion, it should be applied after the steps in this process. Alternatively, study authors can include cost but should perform a sensitivity check on the cost criterion.

Step 5 – Weight Selection Criteria

Assign relative weights to each criterion. Ideally, weights should be developed using a statistically significant method. This can include subject matter opinion, ideally

conducted using a group of experts by applying statistical methods such as Delphi[1]. The weights must total to 100%.

Step 6 – Define Criteria Scoring Scales

Define scoring scales for each of the selection criteria. This can include assignment of point values to ranges of measures, binary indicators, or linear or non-linear functions associated with each selection criteria. For selection criteria that are measured numerically, scales are typically easy to create. For criteria that are not measured numerically, additional analysis is needed to develop a scale. For example, the measures collected for a given criterion may be: Low, Medium, High. The study authors must create a numerical scale that reflects the relative value of the measures, such as: Low = 0 points, Medium = 3 points, High = 10 points. Ideally the point system for all criteria should have the same numerical ranges (e.g., all criteria will have a minimum of 0 points and a maximum of 20 points). Having scores expressed numerically enables the creation of a combined score.

Step 7 – Conduct Evaluation

Using methods previously identified, collect measures for all alternatives and all criteria. The raw evaluation data can now be converted into scores for each alternative by applying the scales defined in Step 6 and a total score can be calculated by applying the weights defined in Step 5.

Step 8 – Conduct Sensitivity Analysis (if needed)

Assess the need for a sensitivity analysis by examining the scores for each alternative and each criterion to determine if there is unusual variance, lack of variance (e.g., clustering), or if the results are divergent from expected. In doing so, Trade Study authors must remain objective and avoid injecting bias into the assessment of results. In cases where confidence in the results is low, the Trade Study authors must revisit the analysis conducted to date by varying criteria weights (e.g., setting the weight to zero for each criterion in turn) and scoring scales and determining if results improve. If attempts to revise the analysis are unsuccessful, Study Authors should revisit the Trade Study requirements, alternatives, and criteria.

As described in Step 4, if cost is used as a criterion, a specific sensitivity analysis should be conducted with the cost criteria weight set to zero to ensure that cost dependencies with other selection criteria are not distorting results.

Step 9 – Report Trade Study Results

Report results by providing Trade Study results and recommendations. Also provide evidence showing the data gathered and created throughout the study, including all supporting logic (formulas, statistical calculations, methods). This information will demonstrate the objectivity needed to defend Trade Study recommendations.

[1] https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1171&context=pare. This article describes the multi-step process to establish consensus amongst expert opinions.

Recommendations should be justified with written rationale and may include a single alternative or other permutations (e.g., a bakeoff between the top two alternatives).

Appendix. Trade Study Example

The Trade Study Process is best illustrated using an example. The following notional example describes the process steps and includes example numerical data and calculations that are used to create the Trade Study Results.

Example spreadsheet. Readers can obtain a copy of our Trade Study spreadsheet containing formulas and a sensitivity example by emailing us at InformedDecisions@mitre.org.

Example Trade Study Guidance: The Department of Redundancy Department (DRD) is seeking to procure replacement data processors. DRD wishes to use widely available commercial technology and is commissioning this study to identify the best product. Study results are needed in 90 days and the study should be executed using existing resources (funding under contract).

Step 1 – Plan

Planning identifies the following:

- *Study Scope: commercial data processors*
- *Available resources: engineering staff under current contract*
- *Due Date: 90 days after start*
- *Computing environments: current contractor lab*
- *Desired outputs: recommended commercial data processor and supporting evidence*

Step 2 – Identify Requirements

Identify requirements and design constraints that apply to the sponsor data processing mission. For the purposes of this example, the following are identified:

- *Requirement ID – Data Process 1: DRD data processors shall operate at a minimum of 1.8 GHz.*
- *Requirement ID – Data Process 2: DRD data processors shall index data during ingest at a minimum speed of 5 MB/s.*
- *Design Constraint – Data Feeds: DRD receives data feeds from its partners in a wide variety of standard formats. DRD seeks to leverage commercial data processors with a maximum number pre-built connectors for standard formats.*
- *Design Constraint – Engineering Resources: DRD engineering resources are limited, and therefore the amount of engineering labor required to implement replacement data processors must be minimized.*

Step 3 – Identify Alternatives

In this example, the requirements and design constraints are clear, and identification of alternatives can be accomplished using market research and subject matter interviews.

This example assumes that the Trade Study authors identify a set of leading commercial products as follows:

Step 4 – Formulate Selection Criteria

Next, Selection Criteria are created using the sponsor's requirements. Care must be taken to ensure that criteria can be measured. In our example, the authors use the following table:

Sponsor Requirements	***Selection Criteria***	***Measurement Method***
Requirement ID – Data Process 1	***CPU Speed***	*Manufacturer Specification, Verified by Inspection*
Requirement ID – Data Process 2	***Index Speed***	*Laboratory Test*
Design Constraint – Data Feeds	***Connectors***	*Manual Count and Smoke Test*
Design Constraint – Engineering Resources	***Integration LOE***	*Subject Matter Expert (SME) Input*

Step 5 – Weight Selection Criteria

Weighting is done using experts on the Trade Study team and results in the following:

Selection Criteria	***CPU Speed***	***Index Speed***	***Connectors***	***Integration LOE***
Criteria Weight	*0.3*	*0.25*	*0.25*	*0.2*

Note that this step can be accomplished using the Delphi method, or any number of other statistical methods. The objective is to ensure that value is measured as accurately and objectively as possible. In this example, Criteria Weights are similar, reflecting that each of the four Selection Criteria are important.

Step 6 – Define Criteria Scoring Scales

Next, develop the criteria scoring scales.

Selection Criteria	***CPU Speed***	***Index Speed***	***Connectors***	***Integration LOE***
Criteria Score Scale	<2 GHz = 0 points	<5 MB/S = 0 points	<10 = 0 points	>500 = 0 points
	2.0-2.2 GHz = 5 points	5-8 MB/S = 5 points	11-15 = 10 points	300-500 = 10 points
	2.2-2.6 GHz = 10 points	8-12 MB/S = 10 points	16-20 = 15 points	150-299 = 15 points
	>2.6 GHz = 20 points	>12 MB/S = 20 points	>20 = 20 points	<150 = 20 points

Step 7 – Conduct Evaluation

Now the evaluation of the four alternatives is conducted using the methods identified as part of Step 4. For our example, the following raw data is collected:

Selection Criteria	Product A	Product B	Product C	Product D
CPU Speed	2.4 GHz	1.9 GHz	2.1 GHz	2.7 GHz
Index Speed	7 MB/S	9 MB/S	11 MB/S	13 MB/S
Connectors	26	17	8	19
Integration LOE	550 Hours	375 Hours	200 Hours	250 Hours

The raw data must now be converted into point values by applying the Scoring Scales identified in Step 6. This provides scaled evaluation data and is done using a simple lookup and does not require any calculations.

Selection Criteria	Product A	Product B	Product C	Product D
CPU Speed	10	0	5	20
Index Speed	5	10	10	20
Connectors	20	15	0	15
Integration LOE	0	10	15	15

Next, Weighted Scores are created by applying Criteria Weights identified in Step 5. This is done by multiplying the Criteria Weight by each of the respective scaled evaluation data elements. For example, the CPU Speed Criteria Weight = 0.3. The Weighted Score for CPU Speed for Product A = 0.3 x 10 = 3. This calculation is completed to create Weighted Scores for all Alternatives across all Selection Criteria.

Selection Criteria	Product A	Product B	Product C	Product D
CPU Speed	3	0	1.5	6
Index Speed	1.25	2.5	2.5	5
Connectors	5	3.75	0	3.75
Integration LOE	0	2	3	3

Finally, the Weighted Scores can be summed to create a Total Score for each Alternative.

	Product A	Product B	Product C	Product D
Total Score	9.26	8.25	7	17.75

Step 8 – Conduct Sensitivity Analysis (if needed)

In this case, the result clearly favors Product D. A Sensitivity Analysis can be conducted to confirm the statistical validity of the result. This can be done by varying, or zeroing out, Criteria Weights one at a time and identifying differences in Total Scores.

This is shown in our example spreadsheet (email InformedDecisions@mitre.org to obtain a copy). See the “Sensitivity Example” tab. In this example, Product D outperforms all alternatives for all variations. This verifies the initial result.

Step 9 – Report Trade Study Results

In this example, the information shown herein will be provided to the Trade Study sponsor along with a clear statement recommending that Product D be selected.