

APPLYING MULTI-ATTRIBUTE DECISION ANALYSIS (MADA) TO VALUE ENGINEERING

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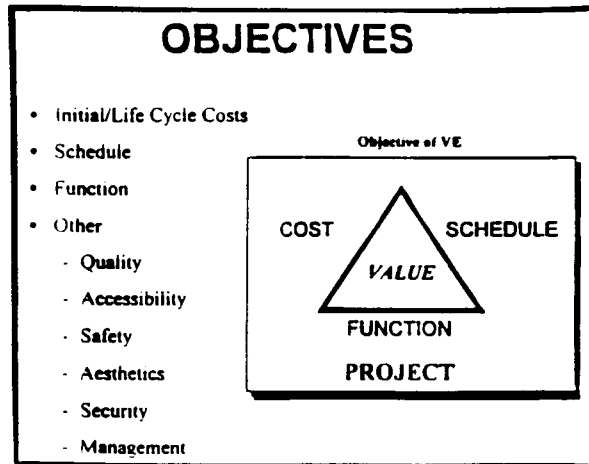
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ABSTRACT

Multi-attribute decision analysis (MADA) is a powerful and flexible decision-making tool that gives value engineers a structured way to integrate qualitative factors along with cost factors. Formerly, value engineers used the method of paired comparisons to evaluate diverse objectives. Now, using MADA's PC-based analytical hierarchy process, VE teams can more quickly and effectively include important considerations such as security and aesthetics when choosing project alternatives.

INTRODUCTION

Value engineers must consider a growing number of non-economic, qualitative factors when presenting alternatives to clients. Issues such as the quality of the work environment, aesthetics, and security are becoming increasingly important to decision-makers. To effectively serve clients, value engineers must have a fast, practical way to compare less quantifiable criteria such as safety with quantitative measures, such as the present value of life-cycle costs.



Carlos Fallon, the creator of the combined method of paired comparisons on which MADA is based, includes this as a prelude to his work:

*"All the 'keys to value' and all the 'reasons for needless cost' hinge on good or bad decision patterns. The value specialist does not make decisions for others, but he must provide the kind of methods for scientific decision that can actually be used by the diverse specialists who control product value."*¹

MADA can provide such methods.

Ever since Fallon developed the method of paired comparisons, VE has used it to examine the relationships between qualitative and cost elements. The technique is effective but time-consuming and therefore has not been viewed as an easily accessible tool. Now, the method of paired comparisons has been computerized as multi-attribute decision analysis, a PC-based analytical hierarchy process. Computers using MADA do calculations and present clear graphics to support selected alternatives. A recent draft ASTM standard validates MADA as both standard practice and leading edge technology.²

However, few VE professionals use MADA. It may, like the original method of paired comparisons, be viewed as too time-consuming. Yet MADA can actually save time. During an emergency 4-and-a-half hour workshop that was part of the recovery effort following the World Trade Center bombing, MADA was a critical decision-making tool. It allowed VE team members to quickly and effectively combine qualitative criteria with cost factors. In disaster recovery and in traditional VE studies, MADA can provide a powerful technique for sorting through complex and varied issues.

WHEN TO USE MADA

MADA, like the method of paired comparisons, is used when qualitative elements must be considered during the process of ranking a number of alternatives or choosing the best of several alternatives. When VE professionals take an integrated, system-wide approach to design and construction projects - examining how changes in one building element impact other building elements - qualitative issues invariably appear. If these qualitative issues are important to decision-makers, value engineers should consider using MADA as the most effective way to integrate non-quantifiable factors with all the economic factors that go into decision-making.

Among the most common qualitative issues looked at in design and construction projects are location (neighborhood safety, attractiveness, nearness to transportation), the quality of the work environment (sound, light, and air quality;

privacy; comfort; degree of control over temperature, etc.), and public image (how open or inviting a facility appears, aesthetics). Security is becoming an increasingly important qualitative consideration. GSA's Draft Security Criteria for new government facilities and major renovations considers many qualitative elements related to building security, from parking lot lighting to crime-detering landscaping to the location of office space.

To give one example of MADA's usefulness in sorting through such issues, the computerized technique can allow decision-makers to compare the security, aesthetic, and cost impacts of using various types of window glass or treatment. A protective window film might improve security against certain exterior blasts but impede air flow following an internal fire; the film might cut energy costs but compromise a building's appearance and affect its rentability. MADA offers a systematic way to compare and evaluate effects and alternatives.

THE CLASSIC METHOD OF PAIRED COMPARISON

Paired comparisons are used to determine the weights of importance for each criterion used in decision-making.³ The method is based on the assumption that everyone can choose between two things, giving a "yes-no," "either-or" answer. The GSA Value Engineering Handbook describes the method of paired comparisons as having two basic parts: weighting the criteria and evaluating the alternatives.⁴ The technique for weighting the criteria is as follows:

1. First, list criteria, features, or attributes considered important in the final selection of alternatives.
2. Determine how important each of these is to the evaluator. When recorded in the criteria weighting format, each criterion is assigned a letter; these letters are used to compare A against B, A against C, and so on, as the criteria scoring matrix is filled out. When selecting between two criteria, the degree of importance of the selection can also be indicated. The preference for (or importance of) one criterion decision over another can be listed as major, medium, minor or

none. From 1 to 3 points are assigned, depending on the degree of preference.

A. To give an example, Figure 1 shows criteria evaluation as part of the method of paired comparisons used to decide among HVAC systems. When initial cost (A) was compared to aesthetics (D), it was decided that (A) was more important than (D). How much more important? It was of medium preference so it received a score of A-2.

B. When a decision cannot be made between two criteria (deadlock), the criteria are considered equal: both letters are used in the scoring matrix and given one point each. This happened at intercept A-C in the above HVAC example when the evaluator, comparing initial cost against energy usage, felt the criteria were equally important.

- When all comparative evaluations are made, total the raw score of each criterion by summing the assigned letters in the matrix.
- Adjust the raw scores to an assigned weight, if desired. In the HVAC example, the raw scores were converted to a scale of 1-10, 10 being the highest raw score.

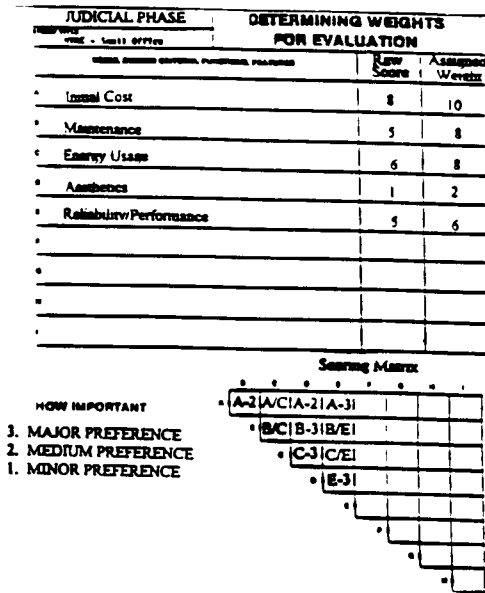


Fig. 1 Matrix evaluating criteria using the conventional method of paired comparisons.

Once the criteria and their weights have been established, the next task is to use these in evaluating the alternatives. The criteria elements are first entered on the top of the evaluation matrix with their weights of importance beneath. The following procedure is then followed:

- Rank each criterion against each of the alternatives. The scoring system used in the analysis matrix assigns 6 to 10 points on a scale of poor to excellent:

Poor	6
Fair	7
Good	8
Very good	9
Excellent	10

The ranking is selected by taking into consideration how each alternative compares with the criterion.

- Multiply the rank of each with the weight of each criterion and enter the subtotal in the space provided.
- Total the score for each alternative and rank these for selection. The alternative with the highest total points is the optimum selection of the choices available.

Figure 2 is an example of the weighted alternatives for the HVAC example given above.

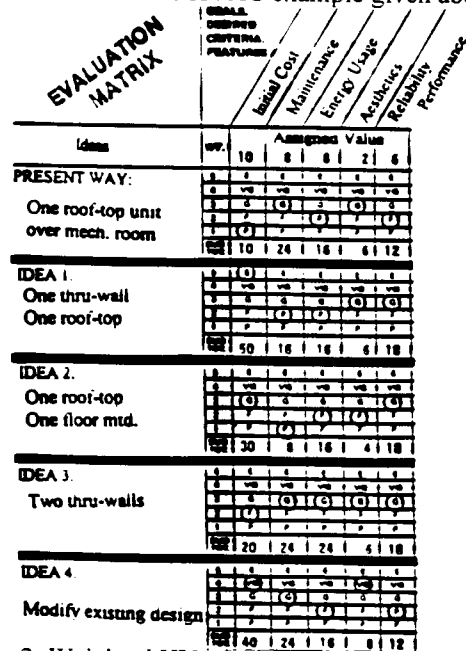


Fig. 2 Weighted HVAC alternatives.

HOW TO USE MADA

MADA is a computerized version of the method of paired comparisons, using techniques similar to those described above and adding graphic representations. The following is an example of MADA as it would be used to decide among three alternatives for placement of an atrium in a new building.

In this atrium example, the output of the creativity phase and initial evaluation results in three alternatives:

1. An atrium with a significant amount of exterior glass.
2. An atrium with no exterior glass.
3. No atrium.

The criteria to be used in evaluating the alternatives are:

1. Cost — total life-cycle cost.
2. Aesthetics — as perceived by visitors and people looking at the exterior of the building.
3. Quality — quality of the environment provided for tenants.
4. Security — impact on tenant security.

The attributes and sub-attributes are arranged in a matrix that gives information about each attribute for each alternative. A MADA model for these alternatives and criteria is shown in Figure 3.

GOAL (1.000)			
Cost (0.108)	Aesthetic (0.046)	Quality (0.329)	Security (0.518)
Exterior	Exterior	Exterior	Exterior
Interior	Interior	Interior	Interior
None	None	None	None

Fig. 3 Structure of atrium model.

Pairwise comparisons are made to determine how much better one alternative performs than another for each criterion. Based on the comparisons, an overall desirability score is given for each alternative. These are graphically shown on the right side of Figure 4.

Dynamic Sensitivity w.r.t. GOAL for nodes below GOAL

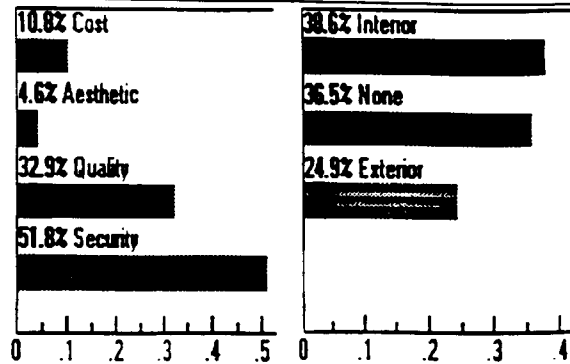
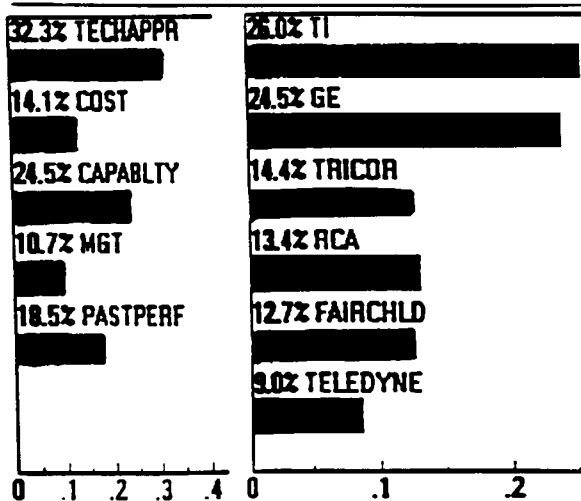


Fig. 4 Weighted value of each criterion and each alternative.

MADA can be used in a variety of other situations requiring consideration of qualitative criteria. Figure 5 illustrates how MADA can be used in source selection.

Dynamic Sensitivity w.r.t. GOAL for nodes below GOAL



Abbreviation	Definition
TECHAPPR	Technical approach
COST	
CAPABLY	Contractor capability
MGT	Management approach
PASTPERF	Past performance

Fig 5 Example of MADA applied to source selection.⁵

CONCLUSION

The computerization of MADA is a VE breakthrough equivalent to the original development of the method of paired comparisons. Like the earlier method, MADA allows VE professionals and decision makers to evaluate non-quantifiable factors in a systematic way. What MADA adds to the earlier process is speed, clear and effective graphics, and ease of use. VE analysts who wish to offer services that comply with ASTM standard practices and are supported by leading edge technology, need to understand and use MADA.

NOTE: Neither Douglas Mitten, the presenter, nor Project Management Services, Inc., his employer, has any financial interest in MADA software.

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