DSTA'S APPLICATION OF ANALYTIC HIERARCHY PROCESS FOR TENDER EVALUATION

KAM Han Jie

ABSTRACT

The adoption of the Analytic Hierarchy Process (AHP) by DSTA, the Ministry of Defence (MINDEF) and the Singapore Armed Forces (SAF), has contributed in the establishment of Singapore's reputation as being a smart buyer of military systems and technology. Developed by academics, the AHP methodology is employed by DSTA, MINDEF and the SAF – together with an evaluation framework and acquisition strategy – to measure the programme benefits of proposals objectively and quantitatively. The benefits are subsequently weighed against the programme cost of each proposal to identify the most cost-effective one for contract award. This article describes the processes and key application challenges that have to be overcome by DSTA, MINDEF and the SAF to ensure the effective use of AHP.

Keywords: analytic hierarchy process, cost-effective solution

INTRODUCTION

In 1988, MINDEF approved the use of quantitative selection methodology as a method of supplier selection for weapon acquisition. The Analytic Hierarchy Process (AHP) was chosen and applied in several projects before it was formally mandated in 1993 for use in all complex and high value weapon acquisition.

Following the successful implementation of the AHP for weapons and platforms, its use was extended to design-and-build construction projects, software developmental projects and more recently, outsourcing tenders for the Ministry of Defence (MINDEF) and the Singapore Armed Forces (SAF). The success of DSTA in acquiring cost-effective solutions has also garnered the interest of the Public Service as a whole and in 2005, the Singapore Tourism Board engaged DSTA as a consultant on the selection of proposals for its integrated resorts. This led to other ministries and government agencies seeking to apply AHP for their projects. In 2009, the Ministry of Finance (MOF) found it opportune to make AHP a mandatory evaluation tool for all complex and high value government acquisition projects. This policy was incorporated into the MOF's revised Instruction Manual on Procurement issued in June 2009.

EVALUATION FRAMEWORK

To apply AHP effectively for tender evaluation, an evaluation framework must first be established to supplement the methodology with procurement processes and acquisition strategies. This would ensure a fair and transparent evaluation in which tenderers are motivated to propose value for money solutions. Additionally, this framework has in place procurement safeguards whereby fundamental and mandatory system or contractor requirements are specified upfront in the tender to rule out proposals that do not qualify for evaluation. This ensures that only credible proposals will proceed on for evaluation. Another key feature of the framework is its two envelope system, where tenderers are required to submit their programme proposals and price proposal separately. AHP is first used to measure the effectiveness and benefits of each programme proposal. The price proposals are not released to the evaluation team so as to ensure the objective assessment of the programme proposal. The programme benefits (operation utility, technical merits etc.) of each proposal will subsequently be weighed against its cost in a process known as benefit-cost evaluation, in order for the evaluation team to select the most cost-effective and suitable proposal for contract award.

AHP PROGRAMME BENEFIT AND BENEFIT-COST EVALUATION

Development of AHP Evaluation Model

AHP is a decision-making support tool developed in the 1970s by Thomas Saaty, a mathematics lecturer from the University of Pittsburgh, USA. The process requires the establishment of a hierarchy of criteria and sub-criteria which is important to reach a decision objectively and systematically. This is especially true when there are multiple stakeholders with different criteria and needs. These criteria and sub-criteria are weighted to determine their relative importance in reaching the decision, eventually forming the AHP model. As part of the evaluation framework, the AHP model – or what is commonly called the AHP tree – will need to be finalised and approved prior to the close of the tender to ensure that the model is objective and does not favour any particular submitted proposal.

Contrary to some decision-making methodologies where the weightages of criteria are estimated, AHP has a scientific and systematic approach to help decision makers sieve out the relative importance of criteria and sub-criteria as well as allocate the weightages accordingly (see Figure 1). This scientific approach to determine weightages is done via pair comparison, otherwise known as pairwise comparison (see Figure 2). Saaty (1980) provided a scale for the pairwise comparison, together with eigenvectors and eigenvalues mathematical principles, to derive the weightages of criteria from the pairwise comparison matrix at a particular level of the AHP model (see Figure 3). The allocated weightages from pairwise comparison reflects the importance of criteria that would influence the evaluation outcome.
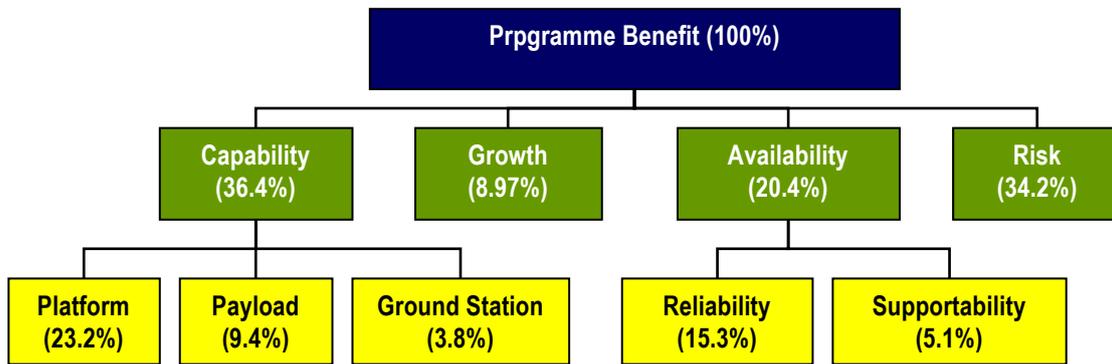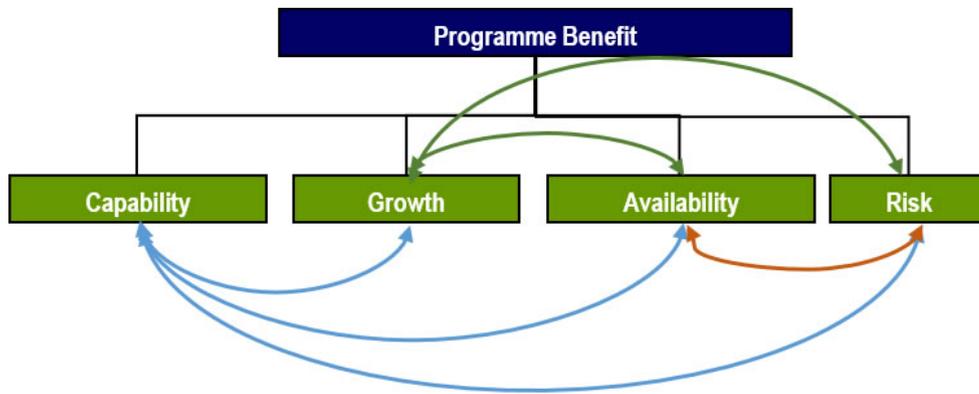

Figure 1. Example of an AHP hierarchy of criteria and sub-criteria with weightages

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Essential or Strong Importance
7	Very Strong Importance
9	Extreme Importance
2, 4, 6, 8	Intermediate Values

Figure 2. Scale for pairwise comparison in AHP

Programme Benefits	Capability	Growth	Availability	Risk
Capability	1	4	2	1
Growth	1/4	1	1/3	1/3
Availability	1/2	3	1	1/2
Risk	1	3	2	1

Figure 3. Pairwise comparison and comparison matrix of criteria at the top level to allocate weightages

The establishment of criteria and weightages is an important step in any decision-making process. Saaty (1980) emphasised that decision making would not be holistic without the involvement of relevant stakeholders. Hence, the formulation of the criteria and weightages cannot be done solely by DSTA without the involvement of stakeholders from the SAF such as operational users, the service logistics department and the future capability planning department. Their involvement means that the AHP criteria is more comprehensive as it takes into consideration operational, maintenance, logistics and future capability growth on top of programme delivery and system technical requirements. This holistic approach is a key factor in DSTA's application of AHP in which all aspects of an acquired system are considered and evaluated.

Proposal Evaluation

In the evaluation of programme proposals, pairwise comparison is again applied to all of the proposals under each of the last level criterion in the AHP tree (see Figure 4). A scale is used for the pairwise comparison with the level of importance changed to level of preference. The end result will be a ratio of scores for each proposal with respect to the weight of the criterion. The summation of all the derived benefit scores for each criterion would give the overall benefit score of each proposal.

Price proposals will only be released after the completion and approval of the programme proposal evaluation report, where the programme benefit scores for each proposal is fixed. The evaluation team would then proceed to conduct a benefit-cost evaluation to determine the most cost-effective proposal with the greatest benefit per dollar for contract award. For cost proposal assessment, the evaluation team does not consider only the front-end acquisition cost of the system. It also takes into account the system's Life Cycle Cost (LCC) or Total Cost of Ownership (TCO), which include the cost of operating, maintaining and supporting the system throughout its planned life cycle with the SAF. The rationale for using LCC or TCO is to ensure that the acquired system is not only cost-effective in the initial acquisition phase, but also for the rest of its operating service life. This key application of AHP helps DSTA, MINDEF and the SAF ensure that the acquired system is cost-effective yet sustainable.

EFFECTIVE APPLICATION OF AHP

While the AHP methodology seems simple and direct on paper, practitioners will highlight that it is not as straightforward to apply. Some challenges for practitioners to apply AHP effectively for tender evaluation are discussed below.
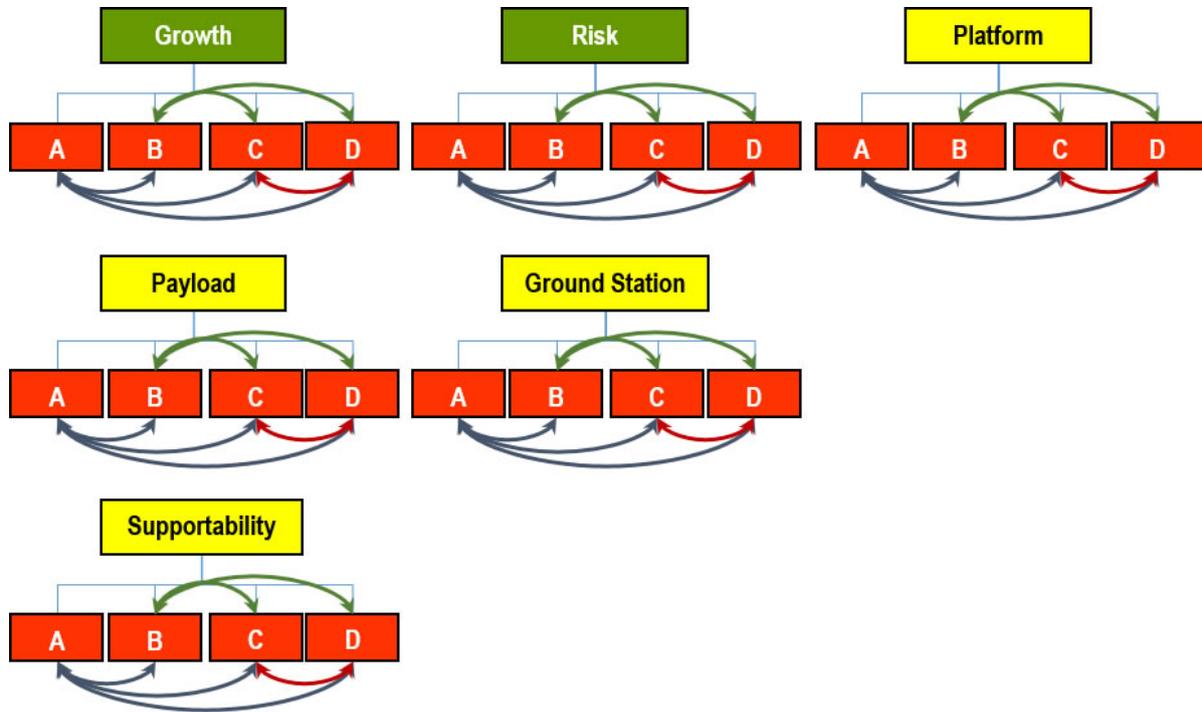
Figure 4. Proposal evaluation using pairwise comparison for Proposals A, B, C and D under each last level criterion

AHP Evaluation Model Criteria Formulation

The AHP tree needs to be comprehensive in order to select a system that is not only capable, but also sustainable, logistically supportable as well as having the ability to incorporate future upgrades with minimum programme risk. Hence, the evaluation team would require in-depth system knowledge, market knowledge as well as understanding of the system's intended operation and logistic support concept from various stakeholders. When framing the criteria under the AHP tree, care must be taken to ensure that criteria are mutually exclusive to avoid double counting of benefits. For example, the criterion on excess system electrical capacity overlaps with growth potential of system and double scoring may occur if they are structured as two independent criteria. Ensuring mutually exclusive criteria will be difficult if the team starts formulating all of the lowest level criteria based on tender requirements without taking a more macro and holistic perspective.

AHP Evaluation Model Weight Allocation

Another challenge is the need to balance the requirements and priorities of different stakeholders in the evaluation team when developing the criteria weightages. The team lead,

typically the project or programme manager, would need to manage the expectations of each stakeholder, remain neutral to their different needs and possess the ability to align the team to a common goal. Hence, the process to determine the weightages can be time-consuming, requiring several rounds of discussions and resulting in numerous iterations of criteria and weightages being generated among the stakeholders. Therefore, discussions on criteria and weightages should start as early as possible to ensure sufficient time to finalise the AHP model. The PMT should treat this process not as negotiation sessions but team learning opportunities.

Effective Differentiable Evaluation Criteria

When formulating the criteria, driving the last level criteria down to every possible lowest level resolution will result in an ineffective and unproductive AHP tree. Such an AHP tree will have many last level criteria with negligible weight resulting in no real impact to the overall evaluation. The evaluation team will spend unproductive effort to evaluate these criteria. Hence, guidelines were developed with experienced practitioners for evaluation teams to formulate AHP tree to the appropriate level and weights. In addition, evaluation teams were trained to pay more focus on important differentiable technology and criteria. This will aid the team to better differentiate superior proposed

systems in AHP. Embodying years of extensive experience in evaluating numerous systems, these guides and strategies enable evaluation teams to be productive and focused when evaluating proposed systems.

Benefit Pairwise Comparison of Proposals

In AHP, pairwise comparison cannot be carried out based on the quantitative attributes of the proposed systems alone. Evaluation teams need to assess the benefit or utility derived from each attribute of the proposed system for the intended operational use and not based on pure comparison of system specifications among the proposals. In addition, the law of diminishing marginal utility postulates that increased system specifications does not guarantee a linear increase in utility or benefit. There will be a point where the increased specifications of the system would yield only marginal utility or benefits for operations as shown in Figure 5.

Evaluation teams will therefore need to exercise sound judgment in order to sieve out proposals that fail to meet operational requirements. To determine the true utility or benefit of the system attributes, technical and operational knowledge is essential and invaluable. This is also one of the reasons why DSTA does not set out to acquire the best, most advanced and costliest system in the world for every tender evaluation. Instead, the objective of the evaluation is to identify the most cost-effective solution that meets the operational needs of MINDEF and the SAF.

To overcome the challenges faced in applying AHP effectively, DSTA holds training, workshops, guidelines and facilitates guidance from experienced practitioners regularly. This ensures continuity of knowledge and taps past experiences of previous evaluation teams in order to conduct an efficient, effective and objective evaluation.

EMERGING CHALLENGES

AHP has served DSTA, MINDEF and the SAF well in identifying the most cost-effective proposals in system acquisition. However, system requirements have become more massive and complex over the years. This rising complexity of requirements often means that proposals are unable to fulfil all requirements fully, resulting in trade-offs. Furthermore, the system or solution selected via the evaluation may not be the most optimal. While a mix of sub-systems from different suppliers may serve as a better solution, effort is required to manage the risks and issues associated with systems integration. As such, the current AHP methodology of selecting the single most cost-effective proposal needs to be developed further.

CONCLUSION

The ability to apply AHP effectively for tender evaluation has enabled DSTA, MINDEF and the SAF to acquire optimised and cost-effective systems and capabilities. Besides the standard academic methodology, deep understanding of the relevant technology domain, key application considerations and the ability to relate to the operational needs of users are also imperative in identifying the most suitable solution. Many of the experiences in AHP application are institutionalised in DSTA's courses, workshops and guides conducted by experienced practitioners to ensure that robust evaluation practices are employed by future evaluation teams.
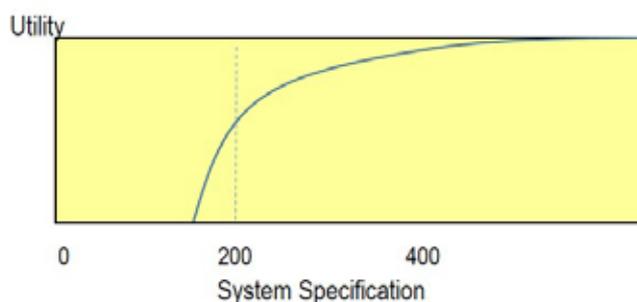

Figure 5. Graph illustrating the law of diminishing marginal utility arising from increased system specification

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BIOGRAPHY

KAM Han Jie is Principal Engineer (DSTA Masterplanning and Systems Architecting) responsible for the development and enhancement of evaluation methodologies such as the Analytic Hierarchy Process (AHP). He also provides consultancy support to the Singapore Armed Forces as well as other external government agencies in the use of AHP for the complex evaluation of acquisition programmes. Han Jie graduated with a Masters of Science degree specialising in Smart Product Design from Nanyang Technological University in 2010.