# Chapter 9
# A Fuzzy MCDM Framework for Weapon Systems Selection

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## ABSTRACT

*The weapon system selection problem is a crucial issue for military logistics managers and decision makers. In most real-world cases, such critical selection problems include many alternatives, and those alternatives have to be assessed with respect to multiple criteria. In this chapter, the use of multi-criteria decision making (MCDM) approaches to tackle the weapon selection problem is discussed. Next, a fuzzy MCDM framework that is based on the hierarchical fuzzy technique for order preference by similarity to ideal solution (HFTOPSIS) method is proposed to solve the problem. The proposed approach is capable of incorporating both crisp and fuzzy data. The authors demonstrate the performance of the proposed methodology on a missile system selection problem which incorporates fuzzy environment elements.*

## INTRODUCTION

One of the critical tools that is important in determining the outcome of a war is the selection of the weapon systems that will be used during the war. Selection of a weapon system requires an assessment of those systems with respect to multiple and possibly conflicting criteria (Lee, Kang, Rosenberger, & Kim, 2010). This makes the selection and evaluation process a difficult task for decision-makers. The two most common criteria used in weapon system assessment are the weapon performance and cost. The performance and cost depend on the improvement of science/technology and economic resources. Technology is improved by ideas and resources; politics support ideas for their acceptance and so on. These factors directly rely on the expectations of the decision-makers, and on some other factors (Cheng, Yang, & Hwang, 1999).

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Since technology develops rapidly in recent years, the number of weapon systems, i.e. number of alternatives, increases and each of the newly developed system has superiorities in one or more factor and one system cannot be named as the best one in terms of all factors. Therefore, the problem includes several alternatives and these alternatives must be assessed in terms of several conflicting criteria/factors in a weapon selection problem (Dağdeviren, Yavuz, & Kılınç, 2009). Some of these criteria are defined by ambiguous phrases and some quantitative requirements are expressed by quality measures (Cheng, Yang, & Hwang, 1999). Hence in this study, the fuzzy theory is utilized to deal with some vague or not well-defined language variables and qualitative requirements. Real-world problems mostly involve conflicting, multiple, implicit or explicit criteria (Karatas, 2007b; Karatas & Akman, 2014; Karacan, Karatas, Tozan, & Sulukan, 2015, Karatas & Yakıcı, 2018). In those cases, decision-makers generally tend to consider all criteria simultaneously to increase the efficiency of their operations (Karatas, 2017a). Problems which incorporate multiple criteria are handled with Multi-Criteria Decision Making (MCDM) methods. There exist several military applications which involve multiple criteria or objectives, such as search and rescue boat and helicopter location and allocation planning (Razi & Karatas, 2016; Razi, Karatas, & Gunal, 2016; Karatas, Razi, & Gunal, 2017).

In classic MCDM methods, the ratings and weights of the criteria are assumed to be known precisely. However, some critical criteria are usually evaluated subjectively for each of the evaluated criteria. The fuzzy MCDM methodology is more appropriate to help decision-makers make their evaluation of available alternatives and find the best one (Wang & Lee, 2009). Furthermore, the selection of the best weapon system involves the consideration of numerous criteria, hence a multiple level hierarchy structure is required in order to make an effective analysis. A methodology, which is developed for complex, uncertain and vague characteristics of the weapon systems selection problem, is needed. By that manner, the Hierarchical Fuzzy Technique for Order Preference by Similarity to Ideal Solution (HFTOPSIS) model proposed by Kahraman et al. (2007) has been used for evaluating alternative missile systems for the air force in this study as a military application.

This chapter includes four more sections. The following section summarizes the existing studies on the selection of weapon systems. The other two sections present the HFTOPSIS method and include the application of the method to the missile systems selection problem. The last section finalizes the paper with the conclusion and future research directions.

## LITERATURE REVIEW ON SELECTION OF WEAPON SYSTEMS

The existing studies on the selection of weapon systems are grouped into three. The first group includes MCDM methods, while the second group includes fuzzy applications of these methods. The third group consists of hybrid methods, usually combining an MCDM method and a linear programming model.

In the first group of studies, Mon et al. (1994) state that performance evaluation and optimal design of weapon systems are MCDM problems. Ashari and Parsaei (2014) solve the infantry rifle selection problem by using MCDM methods. They determine the available alternatives and criteria through Simos method and use ELECTRE (Elimination Et Choix Traduisant la Realité) III to rank various alternatives. Wang et al. (2014) propose a mathematical model based on the Response Surface Method (RSM) and the Grey Relational Analysis (GRA), to solve the weapon selection problem. RSM is used to obtain