An Optimal Investment Scheduling Framework for Intelligent Transportation Systems Architecture

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Transportation planning in general, and planning for intelligent transportation systems (ITSs) in particular, are notable for multiple goals and for multiple constituencies. A review of the current literature offers several ITS investment evaluation methods that provide frameworks for the quantification of risks and benefits. Nevertheless, the traditional selection methods overemphasize quantitative and economic analysis and often neglect to consider qualitative and noneconomic data in the formal selection process. Furthermore, crisp data are fundamentally indispensable in traditional ITS investment selection methods. However, the data in real-world problems are often imprecise or ambiguous. In this article, we propose a novel fuzzy group multi-criteria framework for ITS investment evaluation and selection that takes into consideration (1) the qualitative and quantitative criteria and their respective value judgments; (2) the verbal expressions and linguistic variables for qualitative judgments which lead to ambiguity in the decision process; and (3) imprecise or vague judgments. First, we use fuzzy TOPSIS to calculate the fuzzy risk values with each ITS architecture subsystem. Next, we use fuzzy ROA to calculate the fuzzy real option values of the ITS subsystems. Last, we determine the optimal investment schedule for the ITS subsystems by considering the risk and option values as the coefficients of the objective functions in a group multi-objective decision-making model.

Keywords Intelligent Transportation System Architecture; Multi-Criteria Decision Analysis; Fuzzy Real Option Analysis; Group Multi-Objective Decision Making

INTRODUCTION

Over the past decade, the importance of and reliance on systems architectures has grown substantially because of the increasing complexity in information- and computer-based systems. The systems architecture is a framework that guides and moderates the evolution of many interrelated elements in a complex system and provides order and rules so that hardware, software, data, and communications can work in harmony. An intelligent transportation system (ITS) applies advanced technologies such as electronics, communication, information, image processing, and various sensors to catch real-time information that helps not only to improve transportation safety, mobility, and productivity, but also to reduce transportation impacts on the environment (Shaheen and Finson, 2004).

The rapid advances in technology have created many new opportunities for transportation agencies to deliver safer and more efficient transportation services. However, many of these new opportunities are based on effective coordination among different public and private agencies. To encourage this coordination, the U.S. Department of Transportation (2009) developed the National ITS Architecture to help identify and exploit these opportunities for cost-effective cooperation. The national ITS architecture has a total of 21 subsystems with interconnections depicted in Figure 1.

The ITS architecture describes interaction among physical components of the transportation systems including control centers, travelers, vehicles, and roadside devices. The control center subsystems provide management, administrative, and support functions for the transportation system. The traveler subsystems include services that are owned and operated by