A Network Approach to Identifying Military Fleet Replacement Strategies

Patrick J. Driscoll, Department of Systems Engineering, U.S. Military Academy, West Point, NY, USA
Harry Newton, Innovative Decisions, Inc., Vienna, VA, USA
Russell Mosier, Innovative Decisions, Inc., Vienna, VA, USA

ABSTRACT

The Motor Transport Program Office for the U.S. Marine Corps (PM MT) manages the Light Tactical Wheeled Vehicle (TWV) fleet and must make decisions each year about vehicle procurements, overhauls, and retirements. These decisions are based on projected costs to maintain current vehicles, estimates of the remaining useful life of the vehicles, availability of new vehicles and individual vehicle capabilities and budgets. In this portfolio analysis, the authors developed a flexible, optimization-based methodology for supporting these fleet level decisions based on cost estimates, initial inventories, operational tempo (OPTEMPO), and approved requirements documents (capabilities). Accommodating user requirements, the model uses Frontline Solver in an Excel environment, leveraging network flow constraints to decrease runtime to solution so that multiple runs of scenario excursions can expose advantages and disadvantages of different fleet management policies. A user interface was developed to allow for batch runs using design of experiment or parametric analysis of the data. The interface also helped manage the model complexity of roughly 6,000 decision variables that were developed dynamically depending on the input assumptions.

Keywords: Fleet Replacement, Linear Programming, Network Flow, Scheduling, Spreadsheet Models, Tactical Vehicle Fleet Management

INTRODUCTION

The Motor Transport Program Office for the U.S. Marine Corps Light Tactical Wheeled Vehicle (TWV) fleet makes decisions each year concerning the timing of new procurements, inspections and repair only as necessary (IROAN), existing fleet overhauls contributing to service life extension programs (SLEP), and end-of-service retirements on all of the vehicles in their fleet. Because of the dynamic nature of vehicle life-cycle management and ever-changing budgetary and policy constraints, any decision support model needs to have the flexibility to run a broad range of quick-turn course-of-action (COA) excursions and “what if” drills on a host of parameters that drive both of the underlying cost and value return models.

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Included among the varying assumptions and conditions is a definition of what is ‘best’ for a set of scenarios. For example, during one excursion ‘best’ may mean meeting fleet sustainment requirements at the lowest possible life cycle cost to the Marine Corps, while in another it may mean maximizing troop protection while meeting other requirements and possibly flexing on budget limits. As shown in the workflow of Figure 1, supporting cost and value models were developed in a coordinated, parallel effort as part of the overall project. The multiple objective decision analysis (MODA) based value model (Keeney & Raiffa, 1993; Keeney, 2008; Parnell et al., 2010) assesses the military effectiveness of each COA, complementing the life cycle cost models (Dhillon, 2010) that estimate associated COA cost burdens. These cost burdens represent projections for a fifteen year planning horizon associated with maintaining vehicles over their remaining useful life, availability of the suite of new vehicles, and various budgetary considerations within and external to the organization (USMCLC, 2008).

The cost model populates the network optimization model with procurement (PCM) and operations and support (O&S) coefficients for maintaining each vehicle type. These costs included annual and event-based costs comprised of Inspect and Repair Only as Necessary (IROAN), Service Life Extension Program (SLEP), and Procurement activities. These estimates represent one-time costs to procure or overhaul a vehicle in any year.

O&S costs are annualized and include the per vehicle cost for fuel, consumables, and repairs. Annual costs are driven by vehicle age instead of being organized relative to a fiscal year. Since HMMWV A2s have been fielded since 1995, and the ECVs since 2004, data related to procurement and maintenance of these vehicles has been well established. Procurement, SLEP, IROAN, and annual O&S costs have been forecasted for developmental systems ECV II and JLTV based on the costs and performance metrics of analogous existing systems. The overall cost estimation methodology is shown in Figure 2.

In a similar practice as the U.S. Army Tank-Automotive Command (TACOM) previously imposed (Seng, 2007), the Program Office required any resulting analytical models to remain within the capabilities of standard desktop software (i.e., Excel with Premium Solver) primarily for rapid ‘what if?’ explorations, transparency, ease of future in-house modifications, and budgetary reasons. While understandable, this requirement generally ruled out adopting more computationally taxing or sophisticated approaches employed in maintenance and replacement scheduling such as genetic algorithms (Maji, 2007), dynamic programming (Hsu et al., 2011), integer programming (Stasko & Gao, 2010), ant colony optimization (Abrahão & Gualda, 2006), integrated analytic hierarchy
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