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Improving Recapitalization Planning

Toward a Fleet Management Model for the High-Mobility Multipurpose Wheeled Vehicle

Ellen M. Pint • Lisa Pelled Colabella • Justin L. Adams • Sally Sleeper

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Summary

The Army is currently in the midst of a recapitalization (RECAP) program that calls for the rebuilding and selective upgrading of 17 systems. Because this program’s plans for the scale, scope, and type of RECAP for each of these systems have been evolving over time, the program may benefit from additional information about the relationships between Army vehicle ages and operating costs and the practical implications of those relationships. In this study, we analyzed the effects of vehicle age and other factors (such as usage, initial odometer reading, and location) on repair costs and availability and embedded our results in a spreadsheet-based vehicle replacement model used to estimate optimal replacement or RECAP age for a specific model fleet.

Several prior studies that looked at vehicle age-cost relationships used such fleet-level Army data as average fleet age and total operations and maintenance (O&M) spending for a fleet. Our study used vehicle-level data, which may provide a more complete picture of aging effects.

Research Questions

We focused on the high-mobility multipurpose wheeled vehicle (HMMWV) because of the wide age range of HMMWVs in the Army fleet, the fact that the Army has placed a high priority on HMMWV RECAP, and the HMMWV’s critical role in ongoing operations. Specific research questions were as follows:

1. How are the HMMWV’s repair costs related to its age?
2. How is the HMMWV’s availability (or, conversely stated, downtime) related to its age?
3. How can information on such relationships be used to determine the ideal timing of replacement or RECAP of different HMMWV variants?

Methodology

We used a two-part methodology to address the research questions. The first part of the methodology entailed integrating data from multiple sources and using a technique called “hurdle
regression analysis” to quantify the effects of age on vehicle repair costs and downtime. Individual vehicle-level data recently became more accessible because of the development of the Logistics Integrated Database (LIDB) and the Equipment Downtime Analyzer (EDA) (and its database), which are now components of the Logistics Information Warehouse. Our analyses incorporated fiscal year 2000–2002 peacetime data from those and other sources. Our sample of 21,700 vehicles included 15 HMMWV variants at 12 locations. Although the focus of our analysis was on aging effects, we also captured the influence of other key predictors—specifically, usage, odometer reading, location, and HMMWV variant.

The second part of the methodology involved using the regression models and associated data to derive inputs for the VaRooM spreadsheet-based vehicle replacement model. Dietz and Katz (2001) designed VaRooM to calculate optimal vehicle replacement age—i.e., the age at which replacement yields the lowest average cost per mile over the vehicle’s lifetime—based on a set of inputs. We selected the VaRooM model for this study because it is adaptable and user friendly, employs the widely available Microsoft Excel® platform, has inputs and outputs applicable to Army vehicle replacement decisions, and is particularly well suited to the HMMWV data available from Army sources.

The VaRooM inputs derived from our regression models and associated data included number of vehicles by age, estimated odometer reading by age, annual mileage by age, estimated annual down days by age, and estimated annual parts and labor cost by age. VaRooM also required economic parameters as inputs—specifically, vehicle replacement cost, cost of downtime, annual discount rate, salvage value factor, and depreciation rates. We ran the model using a range of assumptions to test its sensitivity to the various inputs.

We modified the VaRooM model to make it capable of assessing vehicle RECAP options as well as optimal replacement age. In doing so, we treated RECAP as an action taking vehicles back to a specific equivalent age, which we called the “post-RECAP age.” Thus, to analyze a specific RECAP plan, our modified VaRooM model called for three additional inputs: year of RECAP, RECAP cost (planned investment), and RECAP effectiveness, or post-RECAP age. If the resulting minimum cost per mile with RECAP was less than the minimum cost per mile with replacement only (no RECAP), we inferred that RECAP was cost-effective given our inputs to the model.

Results

Our regression analyses showed that age and usage are significant predictors of HMMWV repair costs and downtime when odometer reading, location, and variant (HMMWV type) are controlled for. More specifically, repair costs and downtime increase with age, the increase tapering off for older vehicles. Additionally, the effects of usage on repair costs and downtime were found to be positive but weaker than the effects of age. Although the regression equations only explained a small percentage of the variance in maintenance costs for individual vehicles, sensitivity analyses indicated that the equations yielded good predictions of average vehicle costs by age group (for a given location and usage level), as well as aggregate repair costs at the battalion and brigade levels.
Using the modified VaRooM model, we generated recommended replacement and RECAP ages for HMMWV variants based on our regression models and data. We found that without RECAP, the estimated optimal replacement age for the HMMWV ranged from 9 to 16 years, depending on the HMMWV variant. For the most prevalent variant, the M998, the estimated optimal replacement point without RECAP occurred at age 12, yielding an average cost per mile of $5.53 over the lifetime of the vehicle. However, because predicted costs per mile were found to grow slowly beyond optimal replacement age, there appears to be no large cost penalty for retaining vehicles a few years past optimal age. In addition, we found that the recommended replacement ages can vary by several years depending on the set of assumptions used. In particular, varying the cost of downtime produced great variation in the recommended replacement age. Therefore, it is important to ensure that key assumptions about such factors as cost of replacement vehicles and cost of downtime are as accurate and well founded as possible. These are important policy issues.

We also used the model to evaluate hypothetical RECAP plans relative to replacement without RECAP; this process entailed comparing model outcomes to find the year of RECAP that minimized cost per mile for a given RECAP cost and post-RECAP age. For example, if a RECAP program for the M998 costs $20,000 and returns the vehicle to an age of 0 (“like-new” condition), the estimated optimal time for RECAP is age 9, cost per mile is $5.23, and the estimated optimal vehicle replacement age is 16. We found that the potential cost savings and optimal timing of RECAP depend heavily on RECAP cost and effectiveness (post-RECAP age). For example, if the cost of RECAP is $25,000, the vehicle has to be returned to an age of 0 to justify RECAP on the basis of cost per mile—i.e., to yield an average lifetime cost per mile below $5.53. If the cost of RECAP is $20,000, however, the vehicle has to be returned to age 1 or lower to justify RECAP on a cost-per-mile basis.

**Implications**

Overall, this research has made several advances that are likely to benefit Army fleet modernization efforts. Previously, lack of vehicle-level data constrained studies assessing the age-cost relationships of Army vehicles. By incorporating data from sources such as the EDA and the LIDB, we were able to conduct vehicle-level analyses and offer a more in-depth look at the effects of aging on HMMWV repair costs and availability. Additionally, embedding the results of these analyses in the modified VaRooM model yielded concrete information to guide decisions about the optimal timing of, and cost trade-offs associated with, HMMWV RECAP and replacement. Adoption of a similar methodology for other Army vehicles may further assist with RECAP planning and may help the Army assess the cost-effectiveness of proposed RECAP programs. The model could also offer guidance on resource allocation. In particular,

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1 Although we evaluated hypothetical RECAP programs, the cost-effectiveness of an actual RECAP program can potentially be estimated based on the specific parts being replaced and a comparison of old and new parts’ failure rates and costs.
the finding that modest savings may result from earlier replacement of HMMWVs suggests that transferring a portion of O&M funds to procurement may be worthwhile.

The analysis also demonstrated that policy decisions are required for some of the assumptions used in RECAP and replacement modeling—for example, the type and cost of replacement vehicles and the cost of downtime. Additionally, the analysis suggests that determining which specific vehicles are the best candidates for RECAP will be difficult if only their maintenance histories are used. Potentially, physical inspections could better identify the best candidates, but extended studies to correlate inspection results and subsequent failure events would be required. Nonetheless, our analysis suggests that vehicle induction into the RECAP program based on age can be expected to reduce costs, and that whether inspection costs would be worth the additional savings realizable from more-focused RECAP efforts will depend on the predictive value of physical inspections, which is currently unknown.

Finally, as the availability and quality of Army data continue to increase, so, too, will the precision of model outputs. For example, additional data on the failure rates of older vehicles and of vehicles with high annual usage will provide greater information about these vehicles’ age and usage effects. Our estimates of cost-versus-age and downtime-versus-age relationships were based on peacetime data, but they could potentially be used as a baseline against which to measure the effects of stress on equipment deployed to Operation Iraqi Freedom. Also, access to a broader set of vehicle repair costs—beyond those associated with mission-critical failures, which were the basis of this study—will increase the validity of cost inputs for the VaRooM model. Collecting these data in the future Global Combat Support System-Army may help ensure that the Army has more of the information it needs to manage the life-cycle costs of its vehicle fleets. Such improvements will help maximize the model’s potential contribution to Army fleet management.