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DOCUMENTED BRIEFING

Measuring the Value of Renewal

Age, Operational Tempo, Deployment, and Reset Effects on the Readiness and Maintenance Costs of Army Vehicles

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Summary

Background and Purpose of Study

Faced with a complex and rapidly changing security environment, the Army has been pursuing multiple initiatives to increase preparedness for a wide range of contingencies. One such initiative is the renewal of ground systems. Renewal refers to equipment reset (return to combat-ready or "10/20" condition),[1] overhaul, or recapitalization (overhaul and upgrade to return vehicle to "zero hours/zero miles condition" (Boucher, 2007)). Anecdotal reports (e.g., Lorge, 2008) suggest that the renewal program has been valuable; however, there is a need for quantitative analyses measuring its impact and, more generally, whether the effects of age, usage, and deployed operating environments on a vehicle justify renewal.

Two prior RAND studies (Peltz et al., 2004; Pint et al., 2008) conducted multivariate analyses of the effects of age (years since manufacture date), annual usage (miles traveled during a year or portion of a year), and location (site of usage) on readiness and maintenance costs. However, both studies were based on one to three years of peacetime data per vehicle, as the policy of archiving usage and mission-critical failure records was fairly new when data were gathered for those studies.[2] Also, maintenance costs were based on mission-critical failures that had part orders; they did not include the costs of repairs

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[1] The term "reset" can also be used more broadly, to refer to renewal in general. For example, the *2010 Army Posture Statement* describes reset as the "repair, recapitalization, or replacement of equipment to a desired level of combat capability commensurate with a unit's future mission" (HQDA, *2010 Army Posture Statement*). However, consistent with the repair facilities that provided data for this study and with other Army sources, this study treated reset as work performed to technical manual (TM) 10/20 standards (Bacchus, 2010; Dwyer, 2009).

[2] Data gathering for the Pint et al. (2008) study began in 2004, and analyses were completed in 2005.

without part replacements or repairs that were non-mission-critical. Additionally, the studies did not assess renewal effects, as the Army's renewal program had not yet begun. (Overhauls had occurred but were not routinely tracked.) Other studies of age and/or usage effects on Army equipment (Simberg, 2001; Congressional Budget Office, 2007) used similar data and methods and were based on maintenance actions before the current comprehensive renewal initiative.

Thus, there was a need to build on prior studies by using data from deployed operating environments, incorporating more observations (vehicles and years of data), expanding the set of maintenance costs in analyses, and assessing renewal effects. The present study aimed at meeting that need, assessing the impact of vehicle age, usage, Southwest Asia (SWA) deployment, and specifically the reset level of renewal on mission-critical failures and unscheduled field maintenance costs.

Method

We prepared two datasets, each integrating serial number–level data from multiple sources. The first dataset (hereafter called the "SDC dataset") included vehicle usage, location, and field maintenance records from the Army Materiel Systems Analysis Activity (AMSAA) Sample Data Collection (SDC) program; vehicle manufacture dates from both SDC and the Logistics Integrated Database (LIDB); and reset dates and costs from Tank-automotive and Armaments Life Cycle Management Command (TACOM) and the Defense Logistics Agency (DLA). The second dataset (hereafter called the "EDA dataset") included mission-critical failure records from the Equipment Downtime Analyzer (EDA); vehicle manufacture dates, usage (odometer readings), and locations from LIDB serial number usage reports;[3] and reset

[3] Unit Identification Codes (UICs) identified the location at which a vehicle was operated each month. We needed to use LIDB UICs (locations) rather than locations in EDA maintenance records because our predictor variable was the location of *operation*

dates and costs from TACOM and DLA. We analyzed both the SDC and EDA datasets to assess effects on system mission-critical failures, and we analyzed the SDC dataset alone to assess effects on maintenance costs and subsystem failures.

Our analyses focused on three fleets: (1) M2 and M3 series Bradley Fighting Vehicles; (2) M1 Abrams tanks; and (3) Family of Medium Tactical Vehicles (FMTV) M1078 series trucks. The Bradley sample included the M2A2, M2A2 Operation Desert Storm (ODS), M3A2, and M3A2 ODS variants. The Abrams sample included M1A1, M1A1 AIM, M1A2, and M1A2 SEP tanks. The FMTV sample included M1078, M1078 with winch (W/W), M1078A1, and M1078A1W/W trucks. The bases for selecting these fleets were that they had large SDC sample sizes relative to other fleets; had multiple years of EDA data; were used in SWA and in CONUS; and had reset data available.[4]

Our analyses called for multiple variables at the vehicle serial-number level. Key predictor variables were vehicle usage (miles driven), age, the location

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(usage) of a vehicle. Many times a vehicle was used in a particular year but had no mission-critical failures during that year. There was no EDA record—and thus, no EDA location information—for the vehicle in such cases. Also, consistent with prior studies (Peltz et al., 2004; Pint et al., 2008), the intent was to see the effect of operating a vehicle under different conditions. The UIC translation file (UIC_history), which we obtained from the Integrated Logistics Analysis Program (ILAP), had some inaccurate translations, and an alternative source of translations was not available.

[4] Standard Army Management Information Systems (STAMIS) generally do not contain vehicle reset and recapitalization dates and costs by serial number. The Logistics Support Activity (LOGSA) stores any renewal data it receives (via form 2408-9) in a Recap-Rebuild-Overhaul table, but most of the data in the table are overhauls that occurred prior to 1998. PM Bradley and the Abrams Mobility Group at TACOM Integrated Logistics Support Center (ILSC) maintain detailed reset (10/20 repair) and recapitalization records by serial number for Bradley Fighting Vehicles and M1 Abrams tanks, however. The Bradley renewal data spanned FY 2005 to FY 2009, and the Abrams renewal data spanned FY 2003 to FY 2010. Also, a contact at HQDA G-48 provided 10 years of DLA data on vehicles that went through Red River Army Depot (RRAD). These included “dates received” for FMTVs arriving from Kuwait, the port at Beaumont, Texas, and the port at Charleston, South Carolina. Given that FMTVs are reset at RRAD, we treat the year of the date received as the year of reset.

at which a vehicle was driven, reset, and national stock number (the variant of a particular vehicle). The primary outcome variables in the study were vehicle mission-critical failures and field maintenance costs.

To assess the impact of predictor variables on mission-critical failures of systems and subsystems, we used Poisson and negative binomial regressions. To assess the impact of predictor variables on vehicle maintenance costs, we used a technique called two-part or "hurdle" regression. The final regression models served as the basis for plots showing the predicted effects of vehicle age, usage, location, and reset on failures and costs. Based on the cost of reset versus the maintenance savings due to reset, we calculated, via net present value, when reset becomes cost-effective—or, the cost-effective number of years between resets of a vehicle.

Findings

Analyses for the three systems in this study revealed a set of noteworthy patterns. First, age increased mission-critical failures very mildly, and only up to a point. Plots corresponding to SDC as well as EDA data consistently showed a downturn in the tail region of failure-versus-age curves. This downturn may reflect the limitations of measuring age based on manufacture date. That is, the age measure did not capture the age of vehicle components—(the component replacement history). Some older vehicles may have had newer components, and therefore fewer failures, than some younger vehicles.

Second, for the heavy combat vehicles (Bradley and Abrams), usage had stronger effects than age, and power train and electrical systems were among the key drivers of those usage effects. The magnitude and form of usage effects differed in the SDC and EDA analyses, however.

Several factors may account for discrepancies in the SDC and EDA usage findings, including the tendency for SDC curves to show larger usage effects but, in some cases, to have unexpected dips. The usage data in SDC are much higher quality than the LIDB usage data used in the EDA analysis. Thus, even though the LIDB/EDA dataset has the advantage of a large sample size, the

LIDB/EDA usage effect may be underestimated. However, since the SDC dataset is cross-sectional while the EDA dataset is longitudinal, the shape of the SDC curve is potentially more susceptible to confounding factors; additionally, the smaller SDC sample size may make the shape of the curve more susceptible to influence from outliers.

In addition to usage effects, there were sizable location effects in this study. Heavy combat vehicle location clearly affected failures and costs; however, after controlling for usage, some CONUS locations were associated with higher expected failure counts and costs than Iraq.

Another key finding was the effect of reset. Both Bradley and Abrams reset reduced predicted annual mission-critical failures and maintenance costs by as much as 50 percent. The net present value of maintenance savings versus reset cost indicated that, for vehicles driven 1,000 miles per year, both Bradley and Abrams reset became cost-effective four years after reset. However, more frequent reset could be appropriate if justified by readiness gains; if the vehicle reset cost decreases; or if vehicles have higher usage.[5] In general, reset decisions should be based not only on time since reset, but also on usage and location.

Implications

The small age effects found in this study suggest that while a vehicle's original manufacture date merits some consideration when developing reset plans for ground systems, it should not be the sole criterion—or even a key criterion—for inducting vehicles into the program. By the same token, being located in SWA is not a sufficient criterion for reset induction; vehicles driven few miles in SWA may not need reset immediately after redeployment. Rather, a combination of vehicle attributes may help identify suitable candidates for reset. The relatively strong impact of usage and location (not necessarily

[5] At higher usage levels, predicted maintenance savings from reset are greater.

deployment) in this study support including those attributes among key reset selection criteria.

This study also provides statistical evidence that national reset (returning vehicles to 10/20 condition) yields substantial readiness benefits and maintenance cost savings for heavy combat vehicles. By demonstrating that current reset programs are bearing fruit, the study suggests that funding of such programs is a sound investment.

Additionally, the finding that reset becomes cost-effective after four years (for Bradley and Abrams) may inform Army decisions about when and how often vehicles should be renewed. However, most of the vehicles in our analyses had been reset once. Over time, once the reset program has a longer history, it would be worthwhile to assess the effects of multiple resets on the same vehicle.

Other follow-up steps may also be valuable extensions of the analyses completed to date. First, it is important to further investigate the reasons that some of the SDC findings were not identical to the EDA findings; this may help identify additional steps needed to resolve inconsistencies (where possible) and assess the validity of findings that emerged with one dataset but not another. Second, a regression of downtime on predictor variables may provide a fuller picture of how age, usage, deployment, and reset affect vehicle readiness. Third, further examination of subsystem effects may shed more light on the factors behind the relatively strong usage effects in this study. Finally, the effects of other types of renewal, especially recapitalization, need to be assessed.