RAND ARROYO CENTER

RESEARCH BRIEF

The Effect of Age on the M1 Tank

Implications for Readiness, Workload, and Recapitalization

Many of the Army's major weapon systems were procured as part of a major investment cycle that ended in the early 1990s. They are expected to remain in use until about 2030, when the Army has fully fielded its next generation of forces. Thus, large portions of some fleets are already more than ten years old, with little prospect for near-term replacement. The Army has grown increasingly concerned about sustaining an acceptable level of operational readiness in its aging fleets. In response, it has embarked on recapitalization programs to rebuild (make like new) and upgrade (replace an old component with a new version, to enhance capability) equipment. In this endeavor, a critical question is how to scale and design recapitalization programs so that they can achieve the desired level of operational readiness. RAND Arroyo Center sought to help answer this question by conducting a statistical analysis of the relationship between age and equipment readiness on a key item of equipment, the M1 Abrams tank. The results of this analysis appear in *The Effects of Equipment Age on Mission-Critical Failure Rates: A Study of M1 Tanks*.[1]

The study investigated the relationship between age and mission-critical failures and how other factors such as use and location affected the failure rate in M1 tanks. It also determined which subsystems and individual parts factor into the relationship between age and failures.

Results

The analysis yields valuable results on how age affects system, subsystem, and individual component failures.

[1] A mission-critical failure is one that renders an item of equipment incapable of carrying out its mission. These are also called "deadlining" events.

Key findings:

- **A 14-year-old tank has twice as many critical failures as a new one**
- **Some Army tanks may have already reached the age where they must operate at a reduced level of readiness or enter a recapitalization program**
- **Recapitalization programs should reflect how age effects differ by subsystem and by components within subsystems**

Age Matters: Abrams Tank Failures Increase at a Compound Rate of 5 Percent per Year

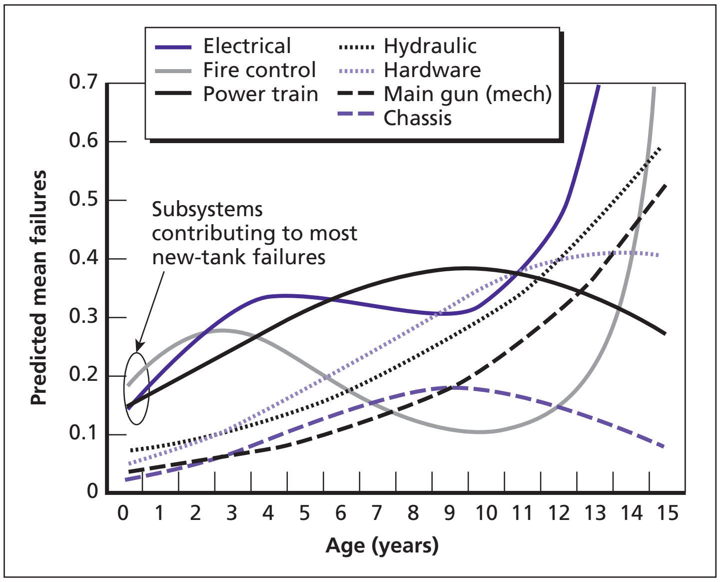
Controlling for location and level of usage, RAND Arroyo Center researchers estimate that a 14-year-old tank has, on average, about twice as many mission-critical failures for a given amount of use as a new tank. This equates to an estimated compound annual growth rate of between 3 and 7 percent. The estimate is based upon individual tank failures across the active Army over approximately one year. These tanks ranged from brand new to 14 years old, so this result cannot be extrapolated beyond 14 years. The study included both M1A1s and M1A2s. Although the study could not control for the two variants because they are confounded with age, detailed analysis indicates that components common to the two variants drive the age effect.

The Relationship Between Age and Failure Differs by Subsystem

The magnitude and pattern of the effects differ by subsystem. For some subsystems, the age effect stops leading to increasing failures from a tank perspective or even diminishes over time, which indi-

Corporate Headquarters
1700 Main Street
P.O. Box 2138
Santa Monica, California
90407-2138
TEL 310.393.0411
FAX 310.393.4818

Aging Effects Differ Markedly by Component Group



cates that the tanks themselves are older than the typical wear-out point for the subsystem. In other words, after a number of years, enough subsystems have been replaced across the fleet to reduce the average age of that subsystem. Other parts do not exhibit a failure rate associated with age. Another group of parts was found to be unreliable from the start.

As the figure indicates, failure profiles differ by part and can change markedly over time. These differences suggest that the Army can target its recapitalization programs cost-effectively. A rebuild strategy is more appropriate for component groups with stronger aging effects but relatively low failure rates when new, which generally include basic hardware, the hydraulic system, the chassis, and the main gun system. By contrast, design upgrades are more appropriate to improve the reliability of components that show high failure rates regardless of age, which include electronic fire control and some power train components. Basic electrical components exhibit both a high level of initial failures and a substantial aging effect, indicating the need to apply a mix of rebuild and upgrade based upon component-level analysis.

Implications for Recapitalization and Readiness

Analysis of the data provides important insights into and implications for the maintenance and recapitalization of the M1 fleet. One insight confirms the long-held belief of Army leaders: older tanks fail at a greater rate than do newer ones. Thus, it is reasonable to conclude that age, absent any modernization program, will jeopardize operational readiness and drive up the demand on resources. Another important insight is that age is harder on some subsystems than on others. Furthermore, within subsystems, age has different effects on different components.

A number of implications flow from these insights. First, an understanding of the patterns of age effects can help Army planners prioritize their efforts. For example, they can indicate which subsystems and components benefit from replacement with new but like parts, the "rebuild" aspect of a recapitalization program. Furthermore, the data show which subsystems and components are likely to cause failures in new tanks. Fire control, electrical, and power train subsystems are likely sources of problems in new tanks and are therefore promising candidates for upgrade programs such as engineering redesign to improve inherent reliability.

Much of the age effect results from what are, in an Abrams tank, relatively low-cost components. Thus, the age effect is less likely to manifest itself as an increase in the budget accounts for operation and maintenance than it is to affect readiness and workload. The components that fail more with age are typically simple parts that fail as a result of wear and tear, e.g., roadwheel arms. This type of failure affects labor hours, but Army labor costs are essentially fixed for uniformed personnel because overtime is not paid. However, increased component failures can lower the quality of life for maintenance personnel by increasing the effort they must expend to maintain desired readiness levels.

The study also suggests that the effects of age have significant implications for future operational readiness. Once a tank reaches a certain age, the maintenance system may not be able to keep it at a satisfactory level of operational readiness. At that point, the tank must be either replaced or rebuilt. Some evidence suggests that a portion of the M1 fleet may be reaching that point. The units with the oldest M1 tanks are the only ones that consistently struggle to meet the Army's operational readiness standards. Tank battalions at the Army's National Training Center with relatively old M1A1 tanks (both those that deployed their tanks from home station and those that used National Training Center tanks) averaged only 74 percent operational readiness during rotational training conducted there from 1999 through 2001; 4 of 22 battalions achieved less than 70 percent, a figure often viewed as the breakpoint for combat readiness. This figure contrasts with 84 percent for units with relatively new M1A2s.

Thus, for the Abrams fleet, age most likely increases the workload gradually, possibly lowering quality of life and operational readiness, and it builds up a deferred financial cost that emerges in the form of recapitalization programs. The analysis in this study provides Army planners a framework for scheduling and structuring such programs so that they yield the best result for the investment. ■

This research brief describes work done for RAND Arroyo Center documented in *The Effects of Equipment Age on Mission-Critical Failure Rates: A Study of M1 Tanks*, by Eric Peltz, Lisa Colabella, Brian Williams, and Patricia M. Boren, MR-1789-A (available at http://www.rand.org/publications/MR/MR1789/), 2004, 126 pp., $20.00, ISBN: 0-8330-3493-6. MR-1789-A is also available from RAND Distribution Services (phone: 310.451.7002; toll free: 877.584.8642; or email: order@rand.org). The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

RAND Offices Santa Monica • Washington • Pittsburgh • New York • Doha • Berlin • Cambridge • Leiden