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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.

**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-
Aging Effects Differ Markedly by Component Group

Subsystems contributing to most new-tank failures

<table>
<thead>
<tr>
<th>Subsystems</th>
<th>Predicted mean failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
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<tr>
<td>Power train</td>
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<tr>
<td>Chassis</td>
<td>0.5</td>
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<tr>
<td>Main gun (mech)</td>
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</tr>
<tr>
<td>Hardware</td>
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<td>Fire control</td>
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</tbody>
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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.

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.