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BRIEFING

The Impact of Equipment Availability and Reliability on Mission Outcomes

An Initial Look

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SUMMARY

Two important measures of Army readiness are the availability of equipment for use at the beginning of a combat mission ("start-of-mission capability") and the reliability of that equipment over the course of the mission ("during-mission reliability"). While the usefulness of these measures is widely recognized, few attempts have been made to quantify their impact on combat capability.

A better understanding of the relationship of equipment availability and reliability to combat capability can help the Army address both current and future force needs. Army planners need to understand how current equipment availability and reliability rates are affecting combat capabilities, and how those capabilities might be impacted due to equipment age and/or rebuilding. Those involved in the design and development of future forces need to understand how to achieve the greatest leverage in these systems, e.g., whether through significant improvements in equipment reliability or investments in other system-enhancing characteristics, such as robotics.

In this documented briefing we describe an initial effort to quantify the effects of start-of-mission availability and during-mission reliability of Army ground equipment on combat capability. This "first look" analysis used JANUS, a force-on-force simulation model, to examine four issues relevant to current and future forces.

For the current force:

- How do changes in equipment availability and/or reliability affect combat results?
- How does equipment degradation due to age affect combat capability?
- To what degree could the combat capability of current systems be enhanced through rebuilding to mitigate the effects of aging?

For the Objective Force:

- How might a very significant improvement in equipment supportability affect combat capability relative to other system-enhancing characteristics, such as robotics?

Our main scenario for analysis involved a small-scale contingency (SSC) with a U.S. brigade-sized force on the offense against a comparably-sized, but less effective, adversary. The principal scenario takes place on heavily wooded terrain (based on digital terrain data from Kosovo). For purposes of comparison, we also considered a second scenario in more open terrain.

For the current force, the U.S. unit is a heavy brigade with more than 400 pieces of heavy equipment, including three predominant systems—referred to here as the "Big 3"—54 M1A1s, 159 M2A2s, and 45 M2A3s. In JANUS, these U.S. systems achieved nearly 90 percent of the kills and suffered about 70 percent of the casualties. For the Objective Force, the U.S. unit is a brigade combat team (BCT) or Unit of Action (UA).

We used data collected at the National Training Center (NTC) in order to explicitly model equipment availability and/or reliability at the start of the operation; after a road march of 0, 50, or 100 kilometers; and at the time of shots during the engagement.

Initial Equipment Availability Has a Moderate Effect on Combat Outcomes

To understand the sensitivity of combat results to different levels of equipment availability, we arbitrarily decreased the availability of "Big 3" systems from 100 to 40 percent in steps of ten percentage points. Our analysis found that varying the level of initial equipment availability had a moderate effect on combat outcomes. We measured this effect using the loss exchange ratio, which refers to the total number of enemy losses divided by the total number of U.S. losses.

We found that as the availability of equipment decreases, the loss exchange ratio decreases moderately. A second scenario in more open terrain yielded similar results. But while we found that equipment availability has a moderate effect on combat outcomes, we did not see a catastrophic fall-off in capability. In other words, the simulation showed no clear threshold beyond which a force would not be mission-capable. The lack of such a fall-off in the simulation could be at least partially the result of the model construct, however, since it does not account for human behavior or organizational network effects.

Some Initial Availability and Engagement Failures Have a Significant Adverse Impact

While equipment availability had a relatively modest effect on the loss exchange ratio, availability and reliability failures were found to have significant adverse impacts on other measures of effectiveness, particularly the number of vehicles available for a second engagement. Figure S.1 shows the loss exchange ratio, the number of enemy units killed, and the number of U.S. Big 3 vehicles available at the end of the combat engagement over a base case and three alternative scenarios. The base case uses 100 percent initial equipment availability and reliability, while all of the alternatives use current equipment availability and reliability data derived from NTC experience, and each progressively

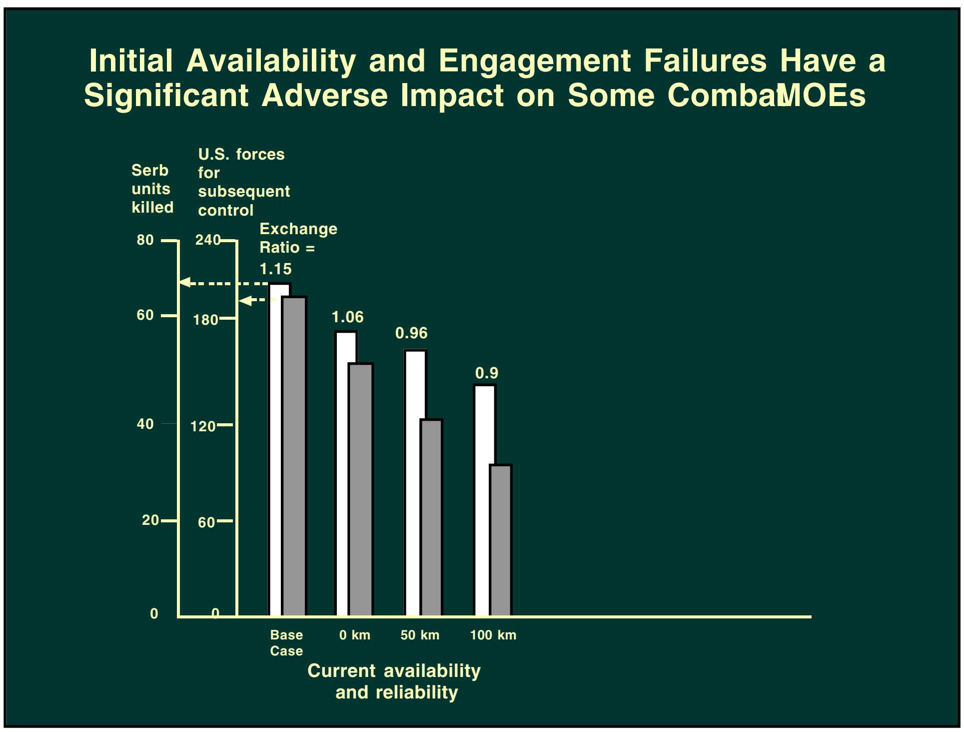

Figure S.1—Impact of Availability and Reliability Failures on Combat Measures of Effectiveness (MOEs)

illustrates the effects of distance traveled (0, 50, or 100 km) before the engagement commences. The loss exchange ratio is indicated by the number on top of each bar, while the upper dashed line indicates the number of enemy platforms killed and the lower dashed line indicates the size of the U.S. force immediately at the end of the engagement, as measured by the number of active Big 3 vehicles.

As indicated by the figure, shifting from the base case to cases using an estimate of current equipment supportability shows a significant degradation in the combat performance of the U.S. heavy brigade. This degradation becomes more pronounced the farther the distance traveled. For example, for the 100-km road march, the size of the U.S. force at the end of combat drops to about 100 from about 200 Big 3 vehicles in the base case. Such a significant drop-off in availability could create a high level of risk, potentially leaving the force with low readiness for an immediate second engagement.

Capability Degrades Further With Equipment Age

Combat capability was found to degrade further as reliability decreases with equipment age. In the simulation, we assumed that from 2000 to 2015, availability would remain at current rates while reliability would decrease by about 4 percent a year, which is approximately the rate at which M1 reliability has been shown to decrease during the first 14 years of its operation.

The resulting analysis showed that combat capability of the force degrades as the force ages. In the worst case, the loss exchange ratio fell from 1.15 in the base case to 0.87, while the number of enemy elements killed dropped from 70 to 45, and the size of the Big 3 occupying force fell to 75 vehicles, only about a third as large as the 205 remaining in the base case.

Rebuilding Equipment Can Substantially Increase Equipment Availability and Reliability

Further analysis showed that rebuilding equipment can substantially increase availability. Our analysis showed that rebuilding equipment can more than maintain current combat capability. We modeled the results of 2015 reliability after a rebuild of Big 3 equipment to M1A2 availability and reliability levels. The analysis found that the capability of the rebuilt equipment in 2015 more than matches the capability of current equipment in 2000, if the enemy does not also make comparable improvements.

Technologies May Have Greater Benefit to Future Systems Than Improvements in Reliability, If Costs Are Not an Issue

To evaluate BCT issues for the Objective Force, we used a series of alternative BCT configurations developed as part of an earlier RAND Arroyo Center study for the Army Science Board (ASB). Our analysis used the same Kosovo scenario but replaced the M1, M2, and HMMWV with the Future Combat System (FCS) and included an upgraded enemy threat. We examined the performance of five BCT configurations as defined in the ASB study. These ranged from a "vanilla" configuration, with standard versions of the 20-ton Light Armored Vehicle (LAV) with Level III protection, to alternative configurations, each of which adds increasingly sophisticated technologies, such as robotic vehicles for reconnaissance; notional miniature line-of-sight anti-tank (LOSAT) missiles and a machine gun; "Quickdraw" to detect muzzle flash and immediately return fire; and an active protection system (APS) for combat vehicles.

The analysis indicated that the combat capability enhancements produce much greater leverage than do improvements to supportability alone. Figure S.2 illustrates the results.

The capabilities possible through improved availability and reliability are indicated by the lower and higher dots to the left of the diagram. The lower dot indicates the loss exchange ratio for a vanilla BCT with FCSs that have the same availability and reliability as today's M1A1, while the higher dot indicates the loss exchange ratio for a vanilla BCT with FCSs that are significantly more reliable than today's M1A1s.

While higher availability and reliability led to an improved loss exchange rate in the simulation, much greater gains were found to be possible through the addition of technology, as indicated by the step-like lines extending across the figure. The dashed line represents the kills of manned and robotic vehicles, while the solid line represents the kills of manned vehicles only.

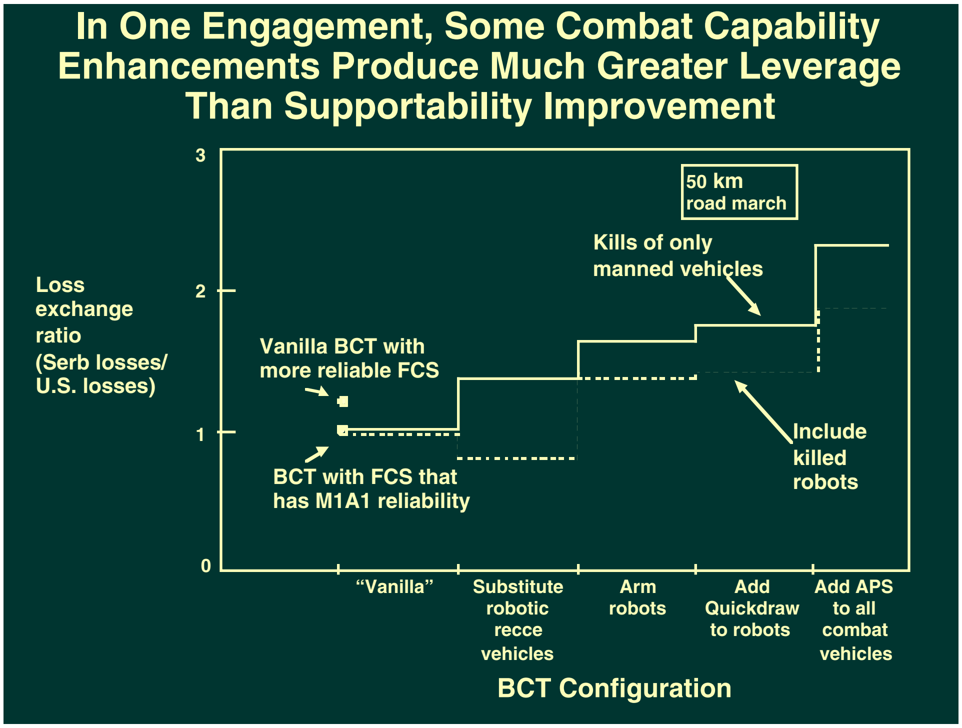

Figure S.2—Effect of Reliability and Technological Advances on Combat Capability

By including all improvements to the vanilla BCT, the loss exchange ratio increases to about 2.0 (2.4 for manned vehicles only) compared to a loss exchange ratio of about 1.0 for the vanilla BCT with M1A1-like supportability. When only manned vehicles are considered, except for the addition of Quickdraw, the technologies improve the loss exchange rate by a greater amount than the improvement to reliability alone. When both manned and unmanned vehicles are considered, there is a decrease in loss exchange ratio when only robots are added to the force, indicating that they are being killed at a faster rate than were the manned vehicles they replaced.

Although these results suggest that performance-enhancing improvements are more valuable than this level of supportability improvements for one engagement, it must be remembered that no account was taken of the costs of achieving either improved supportability or the technological advances in performance. Nor did the analysis evaluate the likelihood of achieving improved supportability or the technological advances that were modeled.

CONCLUSIONS

We found that JANUS was a useful tool for analyzing some of the implications of equipment availability and reliability on ground combat outcomes. However, future analyses should explore additional approaches, including the potential for a catastrophic fall-off in combat effectiveness due to equipment unavailability, the effects of availability and reliability over a series of engagements, and the cost-effectiveness of reliability and other system-enhancing improvements.