RESEARCH BRIEF
Defense Manpower Research Center
Rand

MODELING HOW MAINTENANCE MANPOWER CONTRIBUTES TO READINESS AND SUSTAINABILITY

Although maintenance manpower contributes to readiness and sustainability, important aspects of the relationship have not been quantified. Most models that relate other support resources, such as spare parts, to weapon system availability do not capture the rich and complex contribution of maintenance personnel. Some current models have the capability to treat manpower contributions, but that capability has not been exercised in manpower planning, in part perhaps because the required data concerning manpower productivities are not routinely gathered.

A recent Rand study demonstrates the importance of evaluating the wartime implications of alternative experience and skill mixes of maintenance personnel. The study developed a simple, prototype simulation model that illustrates how the types and numbers of repairmen affect measures of readiness and sustainability (such as the expected number of available weapon systems and the average time to repair broken parts) in dynamic wartime scenarios. Although the simulations reported here do not simulate a real unit or use actual data, they do illustrate the importance of modeling a richer mix of manpower while explicitly considering inherent uncertainties about the demand for maintenance skills during war.

ASSUMPTIONS UNDERLYING THE SIMULATIONS

The study reported here simulated weapon system availability under varying wartime maintenance scenarios and for varying mixes of maintenance manpower. The weapons systems under maintenance are assumed to be aircraft that, for the purpose of the illustration, have only two mission-essential parts. The maintenance scenarios differ in terms of failure rates, repair rates, and numbers of spare parts. These differences acknowledge the uncertainty concerning failure and repair rates during wartime. The mixes of maintenance manpower differ by number of personnel in each occupation, their skill levels, and their cross-training.

THE CONTRIBUTION OF CROSS-TRAINING

The results of the simulations indicate that **the value of cross-training varies greatly depending on the scenario.** Figure 1 compares how two mixes of maintenance personnel contribute to the performance of the unit under two scenarios. The curves in Fig. 1 graph the number of unavailable aircraft at the end of each day. Unavailable aircraft are non-attrited aircraft missing at least one mission-essential part. Each curve first rises and then falls because the broken parts initially arrive faster than they can be repaired; as the war proceeds and aircraft are lost in combat, however, the repair rate eventually exceeds the arrival rate.

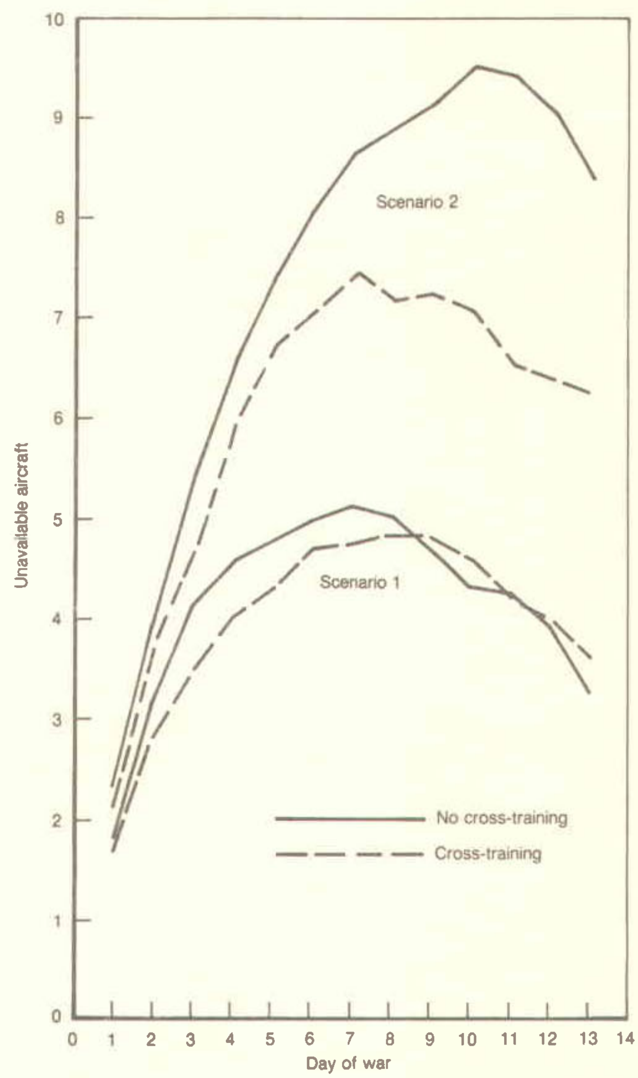

Fig. 1—The Contribution of Cross-Trained Personnel Varies by Scenario

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The first mix of maintenance personnel (solid curves) assumes two occupations (one associated with each mission-essential part) with one skill level in each occupation and no cross-training. The second mix (dashed curves) assumes cross-training in the second occupation at a lower skill level. In one scenario, cross-training contributes substantially to weapon system availability; in the other it does not.

The first scenario (lower two curves) assumes that the two mission-essential parts have identical failure and repair rates and that there are no spares. In this scenario, demands for repair are proportional to repair capability, and cross-trained personnel confer benefits too slight to justify the costs of cross-training.

The second scenario (upper two curves) illustrates that the value of cross-trained skills increases when the supply of primary skills does not match up with the wartime demand. This scenario differs from the first in that one part fails more often and takes longer to repair than does the other—contrary to prewar expectations. In this scenario, the flexibility afforded by cross-trained personnel reduces the number of unavailable aircraft both early and late and allows the number of unavailable aircraft to begin declining earlier in the war.

COMBAT-RELATED OUTPUT MEASURES VS. TIME TO REPAIR

The results of the simulations also demonstrate that **combat-related output measures of maintenance effectiveness, such as available aircraft or aircraft days lost, offer advantages over such intermediate measures as time to repair.** Table 1 illustrates how time to repair (time awaiting repair plus time being repaired) may potentially mislead as a measure of maintenance effectiveness in war. The table presents the average time to repair for the two part types under three scenarios. The first and second scenarios are those used in Figure 1; the third scenario is like the second except that it assumes a small number of spares to offset the high failure rate and slow repair rates of part I.

Table 1

AVERAGE TIME TO REPAIR
(Days)

Part	Scenario 1	Scenario 2	Scenario 3
I	1.60	3.83	4.32
II	1.42	1.37	1.44

Note the average time to repair for part I under Scenarios 2 and 3. Scenario 3 differs from 2 only in that it includes more spares for part I. Nevertheless, the average time to repair for part I increases by one half day, from 3.83 to 4.32. This happens simply because the additional spares enable more flights, which yield more failures, which in turn increase the waiting time in the repair queue.

IMPLICATIONS OF THE DEMONSTRATION

Uncertainty concerning the wartime maintenance scenario argues for more flexible manpower structures. Since wartime demand is impossible to forecast with confidence, the uncertainties of the wartime environment must be taken into account if flexible assets such as personnel—and cross-trained personnel in particular—are not to be undervalued.

The simulations summarized here demonstrate the feasibility and utility of modeling wartime equipment availability with alternative mixes of maintenance manpower and under varied wartime scenarios. With a more comprehensive model and actual data on maintenance performance (more detailed than is now routinely gathered), it would be possible to specify alternative combinations of skill mixes in units that would result in the same performance. Personnel planners would then be able to determine the least costly mix that satisfies performance requirements. In addition, simulating different mixes of specialized and cross-trained personnel would help indicate the value of different training and occupational strategies.

Rand's Defense Manpower Research Center, established in 1976, conducts interdisciplinary research into the manpower problems facing the armed services. The Center's primary sponsors are the Office of the Assistant Secretary of Defense for Force Management and Personnel, and the Office of the Assistant Secretary of Defense for Reserve Affairs. The research described in this brief was sponsored by the Office of the Assistant Secretary of Defense for Force Management and Personnel. For more information about the research described here, see R-3200-FMP, *Modeling the Contribution of Maintenance Manpower to Readiness and Sustainability*, Glenn A. Gotz and Richard E. Stanton, January 1986, or contact the authors, The Rand Corporation, 1700 Main Street, P.O. Box 2138, Santa Monica, CA 90406-2138, (213) 393-0411.