ASSESSING AIR FORCE LOGISTICS SUPPORT: A SIMULATION APPROACH

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ABSTRACT

The study reported in this paper focuses upon the computer simulation of the operational needs of U.S. Air Force units. The model is used to determine support requirements for wartime operations and to assess a unit's ability to sustain those operations. The model used to illustrate the concept is of a War Reserves Supply Kit stockage requirements.

1. INTRODUCTION

The watchword in today's U.S. Air Force is readiness! The concern with the Air Force's readiness to meet the Soviet threat in Europe has spurred a number of studies to assess capability and aid managers with the decisions to enhance capability. The research reported in this paper was directed toward developing a method to assess a key element in the capability of the Air Force to meet its wartime threat.

In preparation to meet this threat, each Air Force flying unit is provided an inventory of spare parts to support the war effort during the initial critical stages of conflict. These inventories are called War Readiness Spare Kits (WRSK). The decisions about the number and types of items to stock are complex. Unit commanders are responsible for these complex decisions.

Estimating the capability of a WRSK to meet the threat has become a problem because the WRSK usually is not fully stocked. Stockage problems occur because WRSK assets are used to supplement depleted base supply stocks if the assets will make an aircraft flyable. The effect of these asset withdrawals on the WRSK's capability to support a war is difficult to assess under the present evaluation system.

The present method of assessing capability depends upon an "aggregate percentage" approach. Under this method, the percentage of components actually available to those required is determined. This percentage is then equated to one of four categorical ratings which are intended to reflect a hierarchy of support capability. For example, a category I rating is given for a 90-100% fill rate. A local commander has the authority to change this rating based on a subjective appraisal to the impact of the accumulated shortages on the unit's capability.

The rating system has received considerable criticism. A common question asked is, what is the correlation between an aggregate percentage and combat capability? Critics maintain that the quantity and nature of specific line-item shortages should be the primary evaluation consideration, not the aggregate percentage of available assets. Another criticism is that even if the aggregate percentage is used, what does a categorical rating really mean? Can the WRSK in question support the planned wartime flying hour program for two weeks, a month, or two months? To study the problem and provide an evaluative vehicle, a simulation approach was taken. The research process and results are presented in this paper.

2. METHODOLOGY

The first step in the research process was to explicitly define the objective of a WRSK evaluative device. Simply stated, the device should measure the ability, over time, of a WRSK to support a wartime flying hour program. To meet the objective, the factors that effect the ability of a unit to meet the war program must be defined. The factors which affect WRSK capability, however, are not easily exposed. This stems primarily from a difference between the assumptions necessary to develop the WRSK and the assumptions about a wartime operation. For example, the current WRSK computation process does not consider battle damage or aircraft attrition while both are strong possibilities. Likewise, the computation process assumes that all parts in the WRSK are equally important and completely interchangeable between aircraft. Experience indicates otherwise. As a result, the simulation device developed evaluates the WRSK against the assumptions used to develop the kit. The structure of the device, however, has been designed to accommodate the additional information about wartime factors as well as the peacetime

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development information.

3. MODEL STRUCTURE

To simulate the actual process of using WRSK assets, the model structure illustrated in Figure 1 was developed and programmed in FORTRAN. FORTRAN was chosen because of the necessity for programming flexibility. The information required to drive the model is listed in Table 1. After this information is initially reviewed, the simulation model goes into a daily routine. At the beginning of each day, repaired items (those items repaired at the unit) are returned to the WRSK. Next, the aircraft status is reviewed. If all aircraft are Fully Mission Capable (FMC), the program moves directly to a flying operation subroutine. Otherwise, the program evaluates the shortages on each Not Mission Capable Supply (NMCS) aircraft against the items stocked in the WRSK. If the shortages on an aircraft can be completely satisfied, the aircraft becomes flyable, and the program returns to reevaluate the status of the remaining NMCS aircraft. After all of the NMCS aircraft have been evaluated against the WRSK, the program then moves into the cannibalization (removing a part from one aircraft and using it on another aircraft) routine. Each of the NMCS aircraft are compared with the other NMCS aircraft to determine if its shortages can be provided through cannibalization. Eventually, the program reaches a point where all unit assigned aircraft are either flyable or none of the remaining NMCS aircraft can be repaired. At this point, the program moves into the flying subroutine.

TABLE 1
Inputs to Simulation Model

WRSK Data File[a]
Number of aircraft being supported
Maximum sorties allowed per day per aircraft[b]
Sorties or flying hours required per day
Number of days being evaluated
Grounded aircraft and their shortages (optional)[c]

[a] Consists of stock number, consumption factors, repair time (if applicable), and other assorted information on each of the several hundred items in a WRSK.

[b] A commonly accepted figure for fighter aircraft is three sorties per day. This input essentially serves as a timing mechanism for daily maintenance and servicing actions.

[c] This input allows the unit to assess capability at a specific point in time. Grounded aircraft could be used as a source of parts.

Several actions take place in the flying routine. If aircraft are available and the required number of sorties has not been flown, each aircraft is individually launched on a mission. When the aircraft lands, each item on the aircraft that is stocked in the WRSK is checked for possible failure. When failures can be satisfied by the WRSK, the WRSK quantities are appropriately reduced. If all requirements are met by the WRSK, the

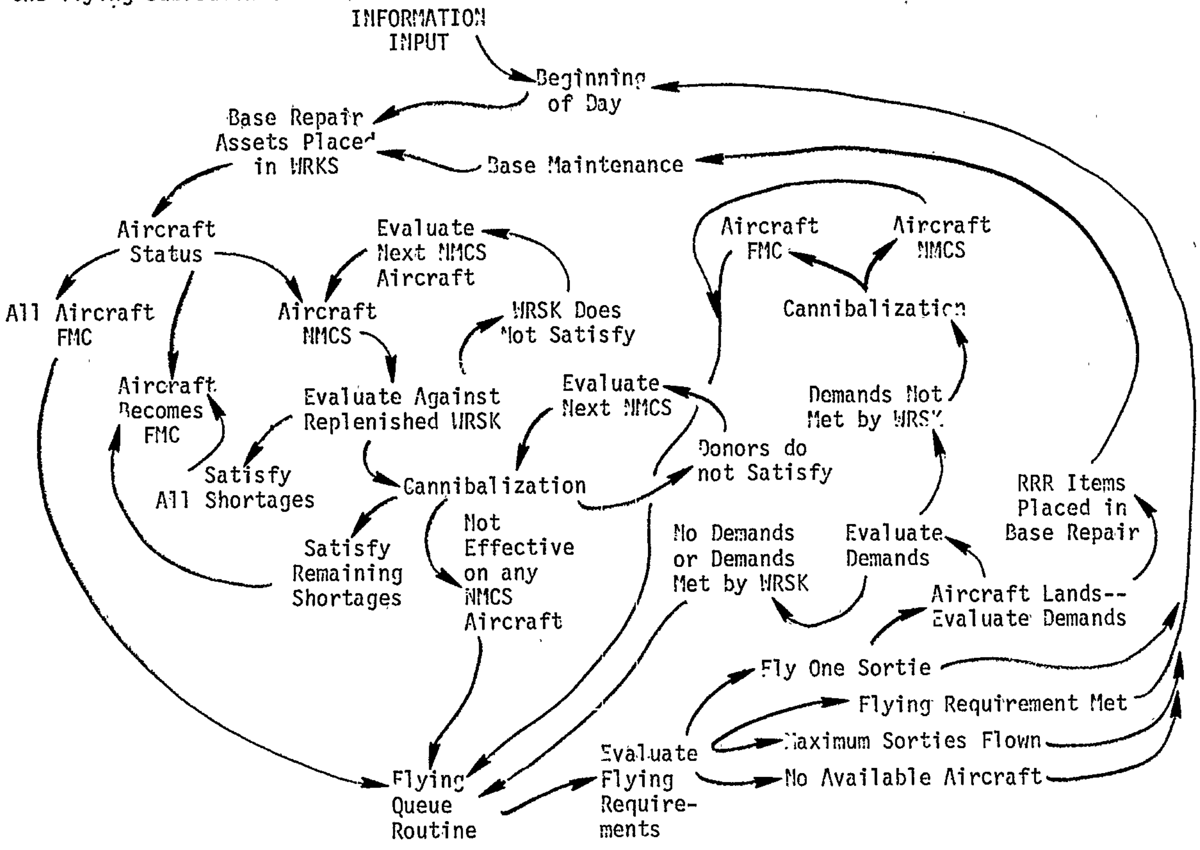

Fig. 1. Decision Logic for Proposed WRSK Assessment Computer Program

aircraft returns to the flying routine to fly the next round of sorties. If all requirements are not satisfied, the aircraft goes into a cannibalization routine. If a part can be provided by cannibalization, the aircraft becomes FMC and returns to the flying routine for the next round of sorties. If not, the aircraft becomes Not Mission Capable Supply (NMCS) and the program returns to the flying routine with one less FMC aircraft for the next round of sorties. After all the initially FMC aircraft have flown a sortie, the program determines if the maximum number of sorties per aircraft has been flown. If so, the program moves to the beginning of a new day and repeats the daily process.

4. MODEL OUTPUT

The output duplicates the type of information that would be necessary to management if a unit was using its WRSK to support a wartime mission. The information includes the cannibalization rate, the repair rate for critical parts, parts use rate, and the sortie flying rates. The model collects several other pieces of data which are not routinely output but which can be provided on demand. Of primary interest to a commander is information that reflects a unit's ability to meet its wartime commitment. Such information is depicted simply in a graph such as the one shown in Figure 2.

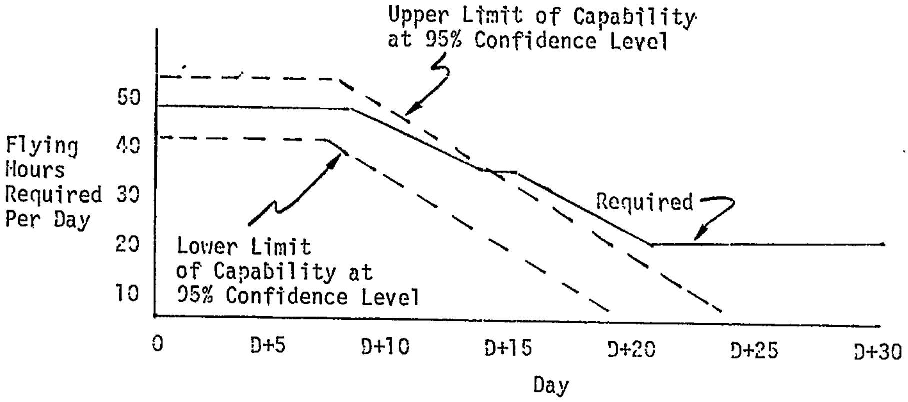

Figure 2. Graph of Support Capability of WRSK

The graph provides an estimate of the support capability of a WRSK. Production of such a graph meets the key objective of this study.

In another section of the output, information about the importance of specific items limiting the support capability of the WRSK is portrayed. This section of the output allows a logistician to recognize the more critical shortages. Stocking decisions for these assets can be made to eliminate shortages. The information about repair rates provides the unit commander with essential information about the wartime maintenance work load. The reliability of this output is discussed in the next section.

5. MODEL RELIABILITY

Work with the model was concerned primarily with validating and verifying its structure and operation. As Forrester stated,

> The significance of a model depends on how well it serves its purpose. The purpose of . . . models is to aid in designing better management systems. The final test of satisfying this purpose must awit the evaluation of the better management . . . . The defense of a model rests primarily on the individual defense of each detail of structure and policy, all confirmed when the total behavior of the model system shows the performance characteristics associated with the real system [2:115].

5.1 Validation

In the validation effort, the WRSK samples of a nine aircraft RF-4C Phantom cell and an eighteen aircraft F-4D Phantom squadron were compared with the "established support" (number of FMC aircraft at end of 30-day period) expected from the WRSK authorization system.

This "established support" is depicted in the model by a confidence interval representing the number of FMC aircraft available on day thirty of a war. The use of a confidence interval to predict FMC aircraft agrees with the random possibility for the failure of parts. Confidence intervals obtained from the proposed model included the expected values obtained from the WRSK computation system. Using this method, the model output matched system historical output at the 95% confidence level.

5.2 Verification

The model was verified by tests run under a variety of circumstances. The emphasis in this area of the model's evaluation was to determine if the model behaved as expected. There were numerous experiments which could have been accomplished in this area, but experimentation was limited to testing the model against the purpose for constructing it--assessment of a WRSK.

The first area of experimentation, therefore, involved a comparison of the capability of a full WRSK against the capability of an incomplete WRSK. The intuitive response expected was for an incomplete WRSK to provide less support than a complete WRSK.

The basic test was conducted in a realistic manner by operating the model with several of the actual shortages experienced by two RF-4C units and one F-4D unit. Two different series of runs were required to determine if the shortages caused a decrease in capability. The first series of runs determined the capability of a WRSK with 100 percent of all items on hand. The second series of runs determined the capability of a WRSK with shortages.

The results on all samples showed that as shortages increased for specific line items in the WRSK, capability decreased. The complete results are too lengthy to present here. The tests did produce what was expected. Consequently, the model is judged to have veracity. The validation and verification of the model mean that the output is useful as an analytical tool in assessing capability.

6. SUMMARY

The purpose of this article was to explain a simulation-study approach of U.S. Air Force capability assessment. The study area represents a contemporary management issue affecting all unit commanders of flying units equipped with WRSKs. The model does have promise for removing portions of the subjectivity from the present WRSK evaluation system. The effort, and the method used to remove the subjectivity element, may be applicable to other management problems. Use of the model in flying units is now being assessed by Air Force logisticians.