U. S. AIR FORCE

PROJECT RAND

RESEARCH MEMORANDUM

BASELOGS—A BASE LOGISTICS MANAGEMENT GAME

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SUMMARY

This paper describes a game, Baselogs, which demonstrates the interactions between logistics and operations on a fighter-interceptor air base of the ADC type. The player assumes the composite role of director of finance at USAF and command level, as well as director of base-level operations, supply and maintenance at a simulated ADC-type base. The game may be used as a demonstration tool; it may also be valuable in further research on maintenance-operations interactions.

We have isolated a small number of bottleneck areas, known to impede the smooth operation of a base. These are: 1) aircraft, 2) maintenance personnel, 3) maintenance facilities and equipment, and 4) spare parts. The Baselogs game is played with a fixed budget, which the player may apportion to the resources in these areas as he sees fit. He thus becomes acutely aware of trade-off problems--for example, that more aircraft in the inventory may be available only at the cost of reducing maintenance facilities.

The game starts with a discussion of the rules. The player, acting as a base manager, and the play director discuss the objective of the simulated base, that of flying training sorties and maintaining a ready alert capability; and they go over the resources available for pursuing this objective. The player is given a sum of money and a price list for each item which may be provisioned. He allots his limited funds to a mixture of resources which he believes will accomplish the mission. For example, he may buy six aircraft, two of each type of maintenance specialty, the best available supply policy, and three hangars. The base manager then commits the alert aircraft to standby, and schedules the remaining serviceable aircraft for training sorties.

Some of the aircraft which take off return with specific malfunctions, which the director of play reveals. He also indicates requirements for maintenance specialists and, possibly, hangar space and spare parts; and he says whether the parts are available or will be delayed, depending on the level of spare support bought.

Props, including representations of an airfield, aircraft, hangars, engines, maintenance teams, and spare engines, aid the player in visualizing the course of events. A Status Board is kept current and enables the player to experience the passage of time. Seven days of activity are simulated, during which the alert aircraft are scrambled, and malfunctions cause maintenance and/or supply queues to form. A daily score is kept of successfully flown sorties, and of penalties resulting from failures to maintain the required alert status aircraft.

At the time of writing, Baselogs has been played only by members of the RAND Logistics Department; but the rules of play and the procedures of manipulating the props have been established and tried. A variety of other individuals and groups will play the game, and their experience will be reported on at a later date.

CONTENTS

I. INTRODUCTION

Games offer interesting opportunities to simulate the operations of a real-world system and to highlight important interactions that occur within it. The player experiences the events through his active participation. He faces problems similar to those in the real world, makes decisions and observes their effect. Such games can be highly educational and valuable as research tools.[1] Recently, the American Management Association put a participation game into a prominent position on the curriculum of its newly established academy.[2] Role-playing sessions are gaining wide acceptance in organizations where complex problems are to be worked out, and the participants are to be parties to the decision process.

The Logistics Department of RAND previously designed Monopologs,[3] an inventory management game in which the interactions of procurement, repair and spare parts distribution are demonstrated. With the thought in mind that Air Force base interactions between squadron operations, maintenance and supply could be demonstrated similarly, the authors set out to develop the Base Management Game--Baselogs.

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[1] For a more complete discussion of the games and their uses see: H. Kahn and I. Mann, War Gaming, The RAND Corporation, P-1167, 30 July 1957.

[2] Bellman, R. et al, "On the Construction of a Multi-Stage, Multi-Person Business Game," The Journal of the Operations Research Society of America, August 1957.

[3] Rehkop, J., Experience With the Management Decision Simulation Game--Monopologs, The RAND Corporation, Research Memorandum RM-1917, 17 July 1957.

II. DEVELOPING BASELOGS

The Purpose of Baselogs

Baselogs is derived from some of the research models of base logistics-operations interactions that are currently being worked on in the RAND Logistics Department. While the structure and the numerical inputs of Baselogs are not the same as in research models which attempt to reproduce Air Force reality, the game is designed to reproduce in a general way some of the important interactions and trade-offs between logistics and operations at base level, which we try to simulate more specifically and exactly in our research models.

Interactions to be Demonstrated

Underlying the game of Baselogs and the research models upon which it is based is the idea that in any operational situation, there will be logistics bottlenecks which will hold down flying and alert programs. For example, Air Force Project Lock-On II, the operational suitability test on the F-86B, showed that the major bottleneck at the given flying program was a comparative shortage of radar repairmen. If attempts had been made to carry out a heavier flying program, lack of engine mechanics would have become the bottleneck.[1] Examples of this kind can easily be multiplied.

The greatest operational capability of a flying organization with limited logistics resources is attained when as many bottlenecks as possible are broken, given the money available for logistics and operations. Baselogs shows how funds can be spent on various alternative areas of logistics support. It also shows how funds taken from one area and put into another

[1] For a thorough discussion of both the Lock-On II experience and the general concepts discussed here, see: Sewell, W.P., Maintenance-Operations Interactions at Base Level (U), The RAND Corporation, RM-1960 (S), 1 August 1957.

will increase the bottleneck probability in the former and decrease it in the latter. These trade-offs are possible among more than two areas. The larger the number of alternatives, the more complicated, of course, is the discovery of the optimal allocation.

Baselogs covers the following major areas for fund expenditures and bottlenecks:

1. Aircraft. The maximum flying program for a squadron is the product of the number of aircraft in the squadron and the maximum per plane. One more airplane in a squadron will produce a greater total number of flying hours, provided of course that it, like the others, will be able to fly. It follows that, within certain limits, additional expenditures on aircraft would increase flying program and/or alert capabilities. This is not to say that the same additional expenditures on other things might not increase operational capabilities even more.

2. Maintenance personnel. The number of maintenance personnel within a flying organization is always large enough to handle at least the average load of maintenance work generated by the flying program. If this were not so, operations would grind to a halt. Even with enough personnel to handle more than the average load, however, the fact that the number of malfunctions per flight varies randomly and is frequently much higher than average will mean that, at times, all the people of one particular skill will be busy and additional aircraft having malfunctions requiring that skill will be on the ground. The aircraft will be out of commission but not being worked on until a mechanic becomes available. It follows that the higher the expenditures on maintenance personnel, the more likely it is that mechanics of the required skill will be available, and the less likely that there will be aircraft out of commission awaiting maintenance.

3. Maintenance Facilities and Equipment. Just as in the case of maintenance personnel, the facilities and equipment available to a flying organization will usually suffice for the average requirements, but there will be times when requirements are well above average, and aircraft are out of commission awaiting facilities or equipment. Higher expenditures on facilities and equipment will reduce the frequency and the length of these occasions.

4. Parts. A reasonable inventory policy based on sufficient experience will stock at the base at least enough high-demand, low-cost parts to cover average demands, and will have available at the base, or some other site, enough low-demand, high-value parts to cover most of the demands for these. However, even with the best-conceived inventory policy, there will be occasions when demands are far enough above the expectation to cause stockouts and AOCP's, and there will be transportation and other delays which will cause AOCP's while parts not stocked on base are being shipped in. Higher expenditures on supply will increase the level of stockage and the breadth of supply support at the base and reduce the probability of AOCP's. It may also decrease transit and delay times and reduce the duration of AOCP's.

With limited funds, bottlenecks are likely to appear in all four of these categories. The problem of the Air Force is to allocate its limited funds among aircraft, ten to twenty types of maintenance personnel, up to fifty or more types of maintenance facilities and equipment, inventory and resupply resources, etc., so as to minimize the effects of these bottlenecks on operations. The number of factors entering into a solution is so large and the solutions are so complex, that we can only hope to get approximate answers by analytical means.

Limiting the Scope of the Game

It would obviously be impossible to get any large fraction of the total number of factors into a game to be played by a few people in one or two hours. In Baselogs, we have attempted to use a few items to represent each of the four classes of factors. A fixed budget is given to the player. He is allowed to buy a variable number of aircraft, three representative types of maintenance mechanics, and hangar space (which represents maintenance facilities and equipment). Supply is represented both by the availability of a number of spare engines, which can substitute for a certain portion of the time spent by engine mechanics in repairing existing engines, and by certain alternative inventory policies which imply in a predictable way a certain frequency and duration of AOCP's. The player purchases a mix of these resources in a way which he hopes will minimize his delays and maximize his flying program while maintaining a required alert status.

It should be noted that, although the game is called Baselogs, the decisions to be made by the player are not limited to those ordinarily made by base or squadron commanders; they include important decisions which must be made at command and Pentagon levels. Both our research and the game are designed to develop a new methodology for looking at the interactions between operations and logistics at these levels. The game itself, being based on hypothetical situations, does not have a problem-solving function, but it does inform those outside of the RAND Logistics Department as to what problems we are trying to solve and how we try to go about solving them. The malfunction, maintenance demand, parts demand, cost and operations data are based on statistics for the F-86D, but these have been ruthlessly adjusted to bring them in line with the many simplifications needed to illustrate a real-world situation in a short game, and to make the play of the game interesting and enjoyable as well as informative.

III. PLAYING THE GAME

Baselogs is played by a single person (or a group acting as a single person) who assumes the role of base manager, a composite of all managerial talent required to operate a simulated base. The aim of the base manager is to score the highest total of sorties possible of his fighter-interceptor aircraft, using resources purchased by him before the start of play with a fixed amount of money. He must also satisfy a requirement of two aircraft-on-alert. If he fails to meet this alert schedule, he will be heavily penalized by a reduction in the score of sorties flown. For each sortie taking off, a single point is scored; for each aircraft hour he fails to maintain the required alert status, he loses three points.

Resources Purchasable by Player

The following kinds of resources are available to the base manager for provisioning his base:

1) Aircraft, necessary in some number (to be decided by the base manager) to meet alert and sortie requirements. Since flights to meet a training program can be expected to generate equipment malfunctions which disable these aircraft, he also needs:

2) Hangar space (HS). For some of the malfunctions, there will be a requirement that maintenance be accomplished inside hangars.

3) Maintenance specialist teams. For the purpose of simplifying play without too great a loss of realism, these will be limited to: a) Air Frame (AM), b) Radar (RM), c) Engine (EM).

4) Supply Policy (SP). Supply will be considered only insofar as it affects the maintenance of aircraft. Insufficient supply will, therefore, be stated as a delay of the start of maintenance for lack of sufficient numbers

and kinds of necessary parts.

5) Serviceable Spare Engines (SSE). The important role that engines play in the fighter-interceptor picture is recognized in Baselogs by considering them as a special kind of spare part to be separately provisioned.

Each play simulates a week of activity at the base: commitment of funds for the purchase of resources will be at the discretion of the base manager at the beginning of the play.

The Rules

The game starts with a discussion of the set of rules. The manager is told he should plan to fly about 65 missions by the end of a 5-day week, the length of the simulated activity. He must have two aircraft in alert status at all times during the week. The day is nine hours long, beginning at 0800 and ending at 1700. Flights may be scheduled to take off at 0800, 1000, 1200 or 1400 hours of each day; each flight is of one-hour duration. A one-hour pre-flight must precede each take-off, except for aircraft returning to operational status from maintenance. Ground aborts will occur on some attempted flights. After each flight, a malfunction that may have happened to an aircraft will be indicated to the base manager by the display of a card showing the <u>expected</u> requirement in maintenance hours for: 1) EM, including replacement time if a Serviceable Spare Engine is on the base; 2) AM, or RM (not both simultaneously); 3) HS; 4) SP, if any. He may then commit these disabled aircraft to maintenance, if parts are available. The availability of spares under the Supply Policy purchased by the manager is made known to him by the display of cards, which indicate that the needed parts:

1) are immediately available to the maintenance crew, or

2) will be available after a one-day delay in shop repair, or

3) will be requisitioned from a depot, and consequently, will not be available for the start of maintenance work until next week (after the game is over). In this case, the aircraft is lost to the base manager for the remainder of the game.

Three alternative supply policies, called A, B, and C, involving different expenditures of funds, are available to the player. The smaller the expenditures on supply, the smaller the probability that parts will be immediately available to the player and the greater will be the transit time from the Depot for those parts not immediately available.

For AM, RM, and EM, once a decision is made to begin repair, the <u>actual</u> time at which work is completed is disclosed on the hour that the aircraft is ready for operation.

Only one specialist team may be assigned to each aircraft for each type of failure, and no reassignment of specialist teams is allowed once a job has been started.

A Status Board, shown in Figure 1, advises the manager of the flying program and alert status progress and indicates the numbers of aircraft in maintenance, awaiting maintenance, awaiting parts, awaiting hangar space, and those held in reserve.

Scrambles of the alert aircraft will be called for during play. Two operational aircraft, i.e., pre-flight completed, returned from maintenance, or out of reserve, must be moved to the alert strip at the end of the hour-long scramble. An aircraft may be on alert for a maximum of 24 hours, after which it must be scheduled to a one-hour pre-flight servicing; a serviceable aircraft must replace the alert aircraft thus rotated, or a penalty will be charged for failure to comply with this requirement.

FIGURE 1

BASELOGS STATUS BOARD

AIRCRAFT STATUS	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700
IN FLIGHT									
POST FLIGHT									
AWHS									
AWM									
AWP									
IN MTCE									
DUE OUT MTCE									
RESERVE									
ON ALERT									

The Budget

A one-million-dollar appropriation is provided the player which may be spent for the required resources. The price list, approximating annual cost equivalents of these items, is:

Aircraft, apiece	$ 75,000
Engines, apiece	25,000
Hangars, two-aircraft capacity	25,000
Maintenance Teams, including tools and support equipment (any specialty), per team	30,000
Supply Policy A	150,000
Supply Policy B	200,000
Supply Policy C	225,000

Planning Factors

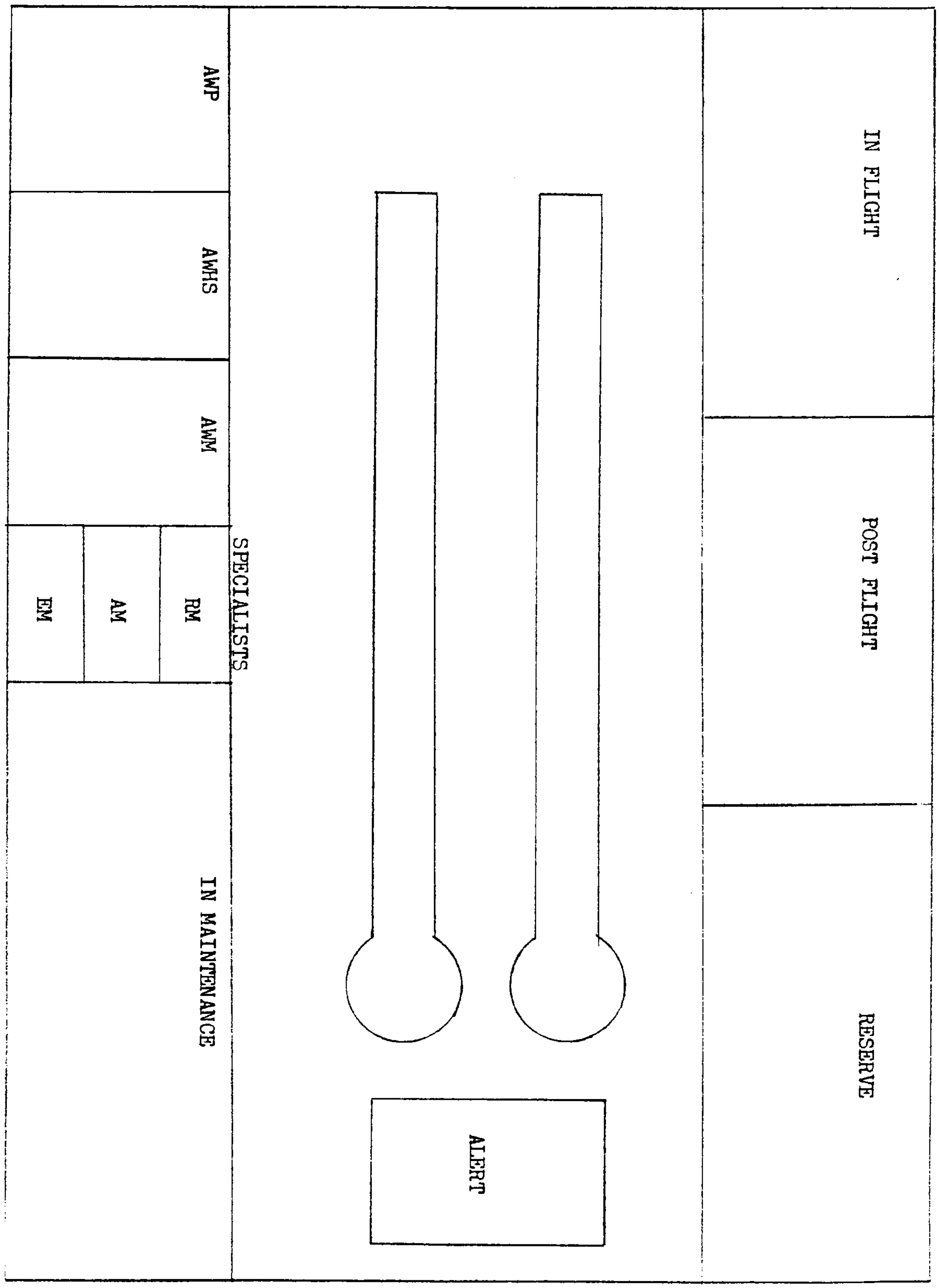
Among the fixed facilities which the base manager is supposed to inherit from the previous manager is a complete and well-documented data processing unit. Any previous operational experience about which the new base manager may have some query is available to him without cost, to assist him in planning the buy and choosing the strategy he may wish to use. During the conference which precedes the play, these planning factors will be listed for the player in response to his queries and to the extent that documentation exists in the data processing center.

The Playing Field

After the base manager commits his funds, play starts. A playing field, shown in Figure 2, is used for display of all of the aircraft in any of the

FIGURE 2

BASELOGS PLAYING AREA



conditions possible during the game. Props are used to represent the aircraft, the maintenance specialists, the engines, and the hangars which were purchased by the manager. At the beginning of each hour of each day, the Status Board is reviewed, and such things as aircraft due out of maintenance, availability of maintenance crews, parts arrival, etc., are checked.

Scoring

Scoring for Baselogs is calculated to give the highest scores to the player who achieves the greatest number of sorties with the least violation of alert requirements. The player receives one point for each training (non-scramble) sortie flown. He loses three points for each hour in which only one, rather than the required two, aircraft are on alert, and six points for each hour in which no aircraft is on alert. Since aircraft cannot be returned to alert status immediately after a surprise scramble, and since alert aircraft must be rotated daily, the player may choose to maintain extra aircraft available for alert in order to avoid these penalties.

IV. THE GAME AS A SIMULATION DEVICE

Some of the recent work done in the Logistics Department has been in the area of detailed modeling of large organizations.[1] The operations of these large models involve individuals, representing certain functions of an organization, or they may be completely programmed for high-speed computers. In some studies, a combination of these techniques is used: those decisions which require considerable flexibility are made by persons representing a manager in the system, and the more routine operations are simulated on the computer.

Simplified games of the kind described in this paper are often beneficial in the development of these large-scale simulations. They serve as pilot studies which guide the general direction of the study, provide important information on the parameters to which the system performance is most sensitive, and show what aspects may be simplified or omitted without distorting the over-all results. For models using individuals, small games aid in defining the boundaries of the simulation and the types of interaction that are needed between non-simulated (embedded) agencies. In cases where a combination of individual and computer simulation is used, games help determine which parts of the model are sufficiently routine to be programmed for the computer. Finally, for models to be simulated entirely on a computer, Baselogs-size games can provide savings in the time required to arrive at the final configuration. Programming of large computers is a lengthy process and programs are relatively inflexible. Preliminary games can be used to arrive at a final form of the model before it is submitted for programming.

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[1]See RAND Corporation publications: First Tooling-Up Exercise for Logistics Systems Laboratory (Oct.-Nov. 1956), RM-1924, 1 July 1957; Second Tooling-Up Exercise for Logistics Systems Laboratory (Jan.-Feb. 1957), RM-1961, 19 August 1957; S. Enke, Logistics Laboratory Problem I After Two (Simulated) Years, RM-1993, 10 October 1957.

V. CONCLUSION

Games may be used for a variety of purposes in the study of complex organizations. This paper describes how the new Baselogs game can be used to elucidate the interdependence between logistics and operations at an Air Force base. The playing of such a game often stimulates considerably more interest than does a verbal description of the phenomena and, as a result, a player may attain a higher degree of understanding of the system than a mere listener or reader.

The Baselogs game will be played by individuals and groups of people. The experience gathered will be reported on at some future time.