# PLANET - A USER'S VIEWPOINT

John E. Barker
Honeywell Aerospace Division
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

## Abstract

This paper describes PLANET (Planned Logistics ANalysis and Evaluation Technique), the generalized maintenance and logistics model developed at RAND. Particular mention is made of problems encountered and solved in the application of PLANET to large-scale maintenance and logistics systems. The use of PLANET's generality to model unusual (i.e., beyond the normal scope of the model) maintenance policies is discussed, with examples. The paper further considers some of the operational techniques found useful in performing maintenance and logistics simulations.

## Introduction

PLANET (the acronym for Planned Logistics ANalysis and Evaluation Technique) is the large-scale logistics model, written in SIMSCRIPT, which was introduced to the simulation/operational-analysis community in 1967 by RAND. The model was a response to an obvious need for a way to analyze complex logistics/weapon systems and their associated operational actions and interactions. Because no one could reasonably predict the nature of problems the model would encounter, PLANET was written in modular fashion with generality as a primary goal. That this objective was realized is evidenced by Honeywell's four-year usage without significant alteration to basic model logic or modularity.

The model consists of four parts as follows:

1. Availability and Base Cadre Simulator (ABC) - A model of base (organizational level) operations using resource pooling to respond to scheduled and unscheduled support demands.

2. Bench Repair Simulator (BRS) - A model of repair stations comprising the process flow points of a repair shop.

3. Depot Transportation Simulator (DTS) - A model of the movement of repairables from bases to the depot or factory and return.

4. Depot Repair and Overhaul Simulator (DROS) - A model of the functions performed in a depot repair/overhaul facility.

Each of the simulators may be operated independently or all may be joined to simulate in detail the relevant aspects of an entire logistics system. Of the four, the ABC model is the largest, and by its very nature implicitly contains the functional equivalent of the remaining three models.

Since the ABC model does contain sufficient modeling capacity to stand alone, it is this model that is treated in the remainder of this paper. Further note that the "organizational level" framework of the ABC simulator provides a basic investigatory vehicle for the analysis of first-line maintenance and logistics requirements. The analyses appearing in the following discussion reflect this organizational-level approach to the simulation of typical Air Force and Army working units.

## Planet Application Experience

### CAPA Study

The first of the two studies discussed in this paper was requested by the Air Force in order to determine the cost effectiveness of an airborne fault-monitor/detection system called CAPA (Central Airborne Performance Analyzer). The question addressed by the study was whether or not CAPA would be cost effective if the systems being monitored increased markedly in inherent reliability. As it was desirable that as much "real-world" data as possible be obtained for the model, data-gathering trips were made to a typical user organization to acquire flight-line information.

One of the problems in this use of the PLANET model developed in considering the less than 100 percent fault-detection capability of CAPA. There was no direct way to incorporate this feature in the model without modifying the model logic. However, an indirect scheme provided the answer through use of the false removal rate:

> Every "reported" subsystem MTBF has concealed within it a percentage of "false removals". Such maintenance actions (later shown to be erroneous) often comprise 50 percent or more of the total unscheduled maintenance actions at a given base. Assuming the 50-percent false-removal factor with an 80-percent CAPA fault-detection rate (proven in feasibility demonstrations) then the following computation applies:

$$MTBF_{Monitored} = \frac{MTBF_{Reported}}{1 - [(0.80)(0.50)]}$$

$$= 1.667\ MTBF_{Reported}$$

Thus the MTBF's of those subsystems being monitored were increased by 66.7 percent to simulate the 80-percent detection rate of the analyzer system.

Four comparison runs were made consuming 200 minutes on a CDC 3600. The results were very unexpected and can best be shown in a graph of operational availabilities for the four cases (Figure 1).

The abcissa is percent operational-availability (missions launched/missions scheduled) graphed against number of aircraft (maximum 60). The solid curves illustrate the availability improvement using the reported MTBF's of the subsystems being monitored. The dashed curves represent the availabilities achieved after multiplying all of the monitored subsystem MTBF's by four. Significant operational advantage still occurred even though the subsystems being monitored were modeled four times as reliable as the originals. This result indicated that the key to RF-4 operational improvement was not in improving the reliability of the subsystems but in reducing the quantity and duration of scheduled support maintenance actions.

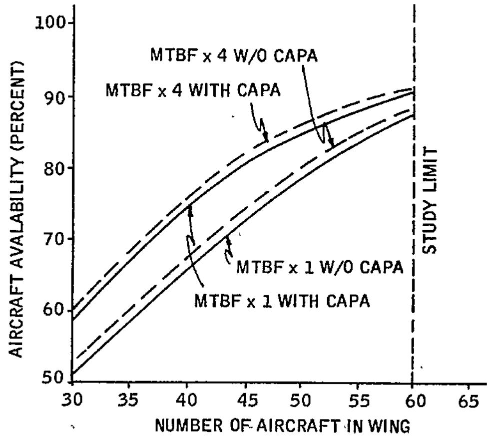


Figure 1. Availability Curves for Monitored and Unmonitored Aircraft

For verification purposes the model data was compared with actual operational experience yielding a correlation coefficient of 0.78. This was considered reliable enough to allow inclusion of the simulation results in an Air Force report on potential diagnostic system cost savings.

## Helicopter Study

This second in-house study used PLANET to determine the availabilities that could be expected from seven configurations of a postulated 1975-1980 Army helicopter. The problem in this case was not the modeling of the aircraft as much as it was determining and then correctly modeling the support concept the Army was likely to apply to this aircraft. After many data-gathering excursions and conferences with potential users and policy makers, a maintenance concept was chosen. An attempt was made to get direct field-data backup for those subsystems already in federal inventory, but the data arrived too late to be reduced to model terms. This necessitated elimination of two helicopter subsystems from the simulation which proved to be fortunate as the study was ultimately desensitized to those subsystems anyway.

Applying PLANET to the problem proved to be an excellent exercise in model parameterization as problem requirements and model capabilities provided some conflicts. PLANET was organized to automatically schedule periodic maintenance actions at fixed calendar-time intervals. However, in the helicopter warring situation the periodic maintenance actions were to be performed on a catch-as-catch-can basis. Rather than change the model logic, the model's capabilities were used in an unusual manner. The distributions for the lengths of time consumed by maintenance actions were skewed to yield the abnormal pattern shown in Figure 2.

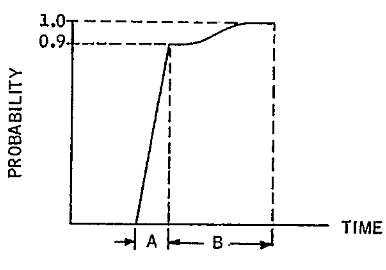


Figure 2. Cumulative Periodic Maintenance Time Distribution

The result was that most of the scheduled maintenance actions consumed a shortened time, falling somewhere in A. The remaining 10 percent of the maintenance actions were normally distributed in B.

One of the problem/model conflicts that could not be resolved and which did force a small change in model logic was the following:

> It was decided that seven helicopter configurations would be simulated together to economize in running time. This necessitated separate pooling of the helicopters with separate flight schedules for each pool. The model scheduling logic did not allow this mode of operation, so the model was reprogrammed to accept any number of pools consisting of consecutively numbered aircraft. Thus with one computer run the availabilities for all seven configurations could be determined.

The result of helicopter pooling was made graphically visible by the final overall operational availability curve shown in Figure 3 where the standard availability curve (as shown in Figure 1) is replicated in each pool.

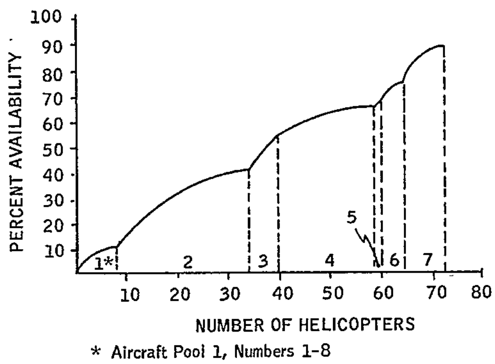


Figure 3. Overall Availability Curve for Helicopter Simulation

Several other aspects of the problem uncovered by the simulation were:

1. The critical factor in three of the seven pools was not subsystem reliability but turnaround time.
2. Subsystem failures accounted for only 21.4 percent of the missed flights.
3. One helicopter pool alone generated almost half of all missed flights due to heavy flight scheduling.

The 28-day simulation of 72 aircraft (variably sized pools) ran 90 minutes, consuming 85,000 words on a CDC 3600. The summarizing reports ran an additional 45 minutes.

## Conclusions

PLANET is a powerful logistics simulation/analysis tool which can be applied to a wide variety of problems with little or no change in basic model logic. The user is called upon to be ingenious in the use of PLANET capabilities, but the insight engendered by this demand leads to more understanding of both the model and the system being modeled.