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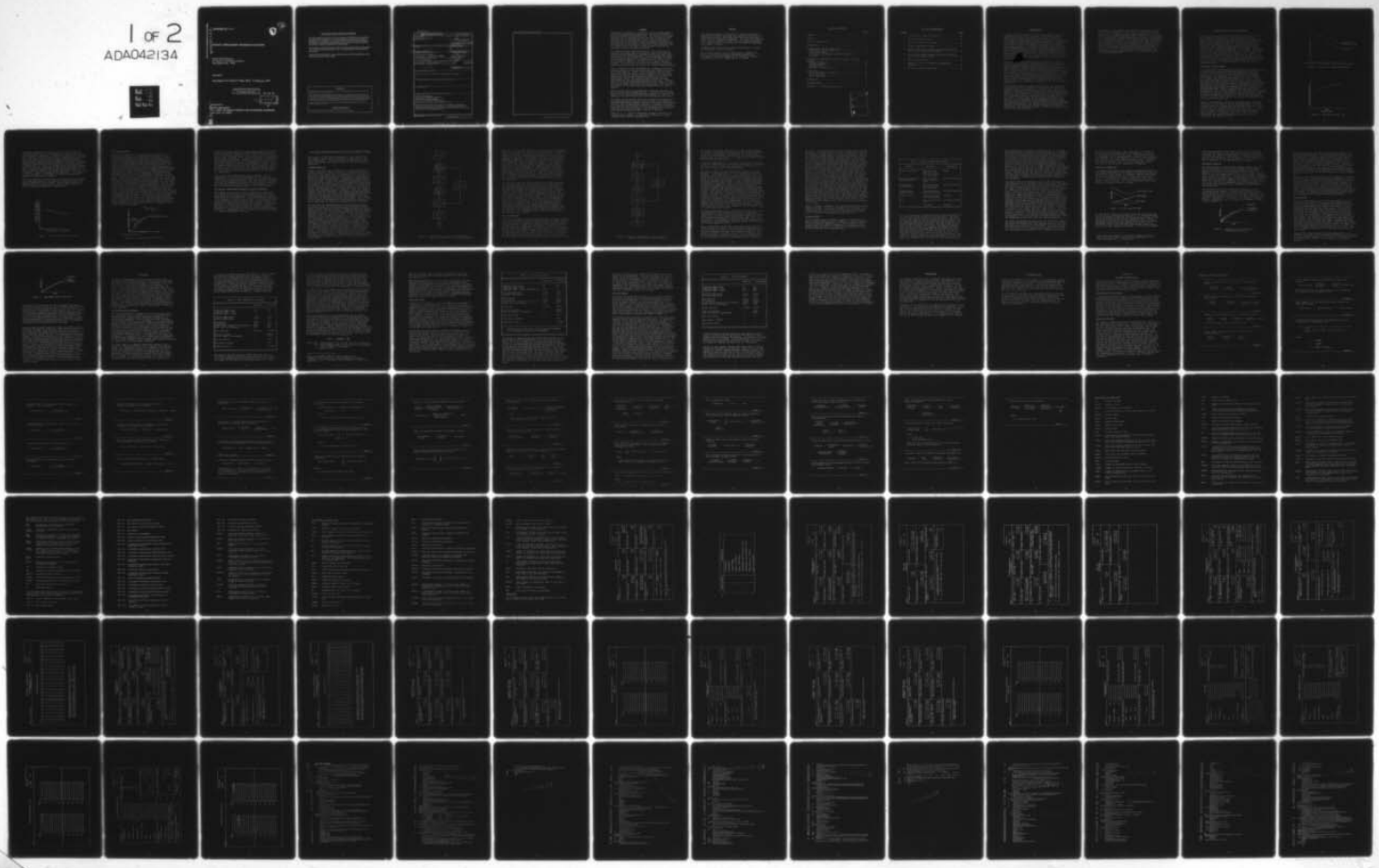

AD A042134

USAAMRDL-TR-77-17

# PRODUCT IMPROVEMENT PROGRAM EVALUATION

Boeing Vertol Company
(A Division of The Boeing Company)
Philadelphia, Penn. 19142

June 1977

Final Report for Period 17 May 1976 - 17 February 1977

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## EUSTIS DIRECTORATE POSITION STATEMENT

This report presents the results of an effort to develop a general technique for evaluating potential aircraft modifications. The technique considers improvements in reliability, maintainability, and capability, and provides measures of life-cycle cost and operational effectiveness. A computer program was produced to implement the analysis technique; this report also serves as documentation for that program.

The technique presented should prove useful in evaluating proposed product improvements and in establishing research priorities in terms of benefits achieved, costs incurred, and risks assumed.

Timothy D. Evans and Robert L. Walker, Military Operations Technology Division, were the technical monitors for this project.


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This report presents the results of a study to develop an analysis technique for evaluating the cost and operational effectiveness of potential aircraft modifications that affect reliability and maintainability.

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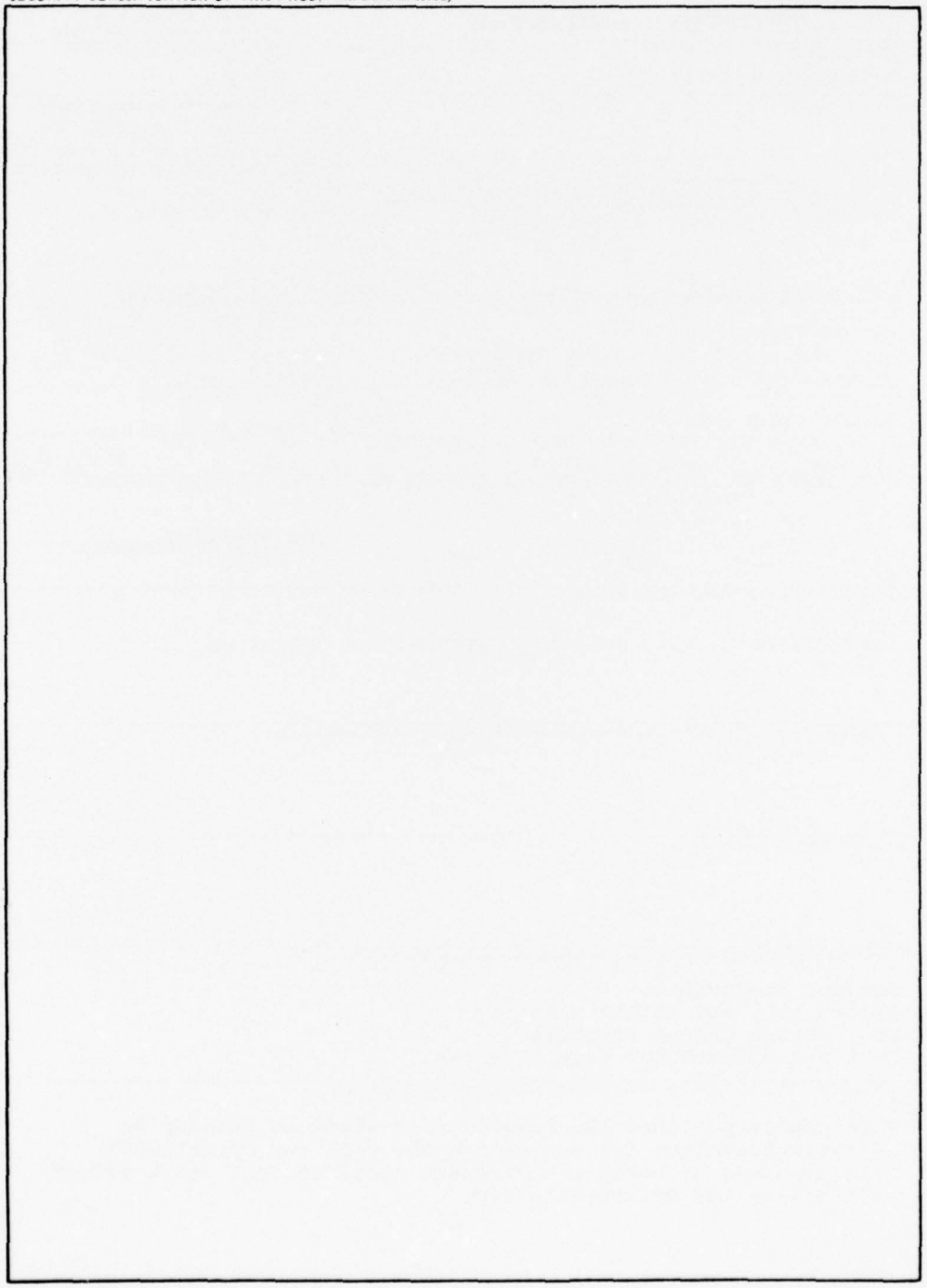

## SUMMARY

Throughout an aircraft's life cycle, various product improvements are recommended to upgrade the vehicle's reliability and maintainability characteristics. The problem for program managers lies in deciding whether the cost of improving the aircraft will be sufficiently offset by the reductions in expenditures for maintenance that are expected to result if the improvements are made. Rigorous analysis techniques that consider all of the variables involved in such decisions were not always used in the past, either because they were not available or were not easily utilized.

The purpose of the program described in this report was to develop a technique for evaluating the cost and operational effectiveness of potential aircraft modifications that affect reliability and maintainability. The methodology developed was to consider the vehicle changes in the context of a task accomplishment approach. In other words, the change was to be evaluated in terms of its ability to perform a specific mission. A further aim was to make the evaluation technique easily useable by those involved in the decision-making process.

Task I consisted of the development of a computer program to evaluate proposed aircraft R&M changes with respect to a baseline configuration. Several cost techniques such as break-even point, rate of return, and net present worth were used. Output included the following cost categories: research and development, investment nonrecurring and recurring, and operational costs. The program allowed analysis between implementation cost and change-to-operational cost. Furthermore, the program permitted assessment of the change in effectiveness in terms of availability, utilization, and fleet size. The results of the first task were documented in an interim report.[1]

Task II called for the construction of several test cases to be run through the computer program. Historical data on modifications of selected components was examined to determine the impact of the modification on aircraft operations and costs.

The result of the project was a new, integrated technique for evaluating potential aircraft modifications, which considers R&M improvements and measures cost and operational effectiveness within a task accomplishment structure. Although this study was undertaken with aircraft in mind (particularly helicopters), there are no limiting factors in the technique which will not allow its application to other vehicles or systems.


[1]Blewitt, S. J., PRODUCT IMPROVEMENT PROGRAM EVALUATION, The Boeing Vertol Company, Philadelphia, Pennsylvania, Boeing Document D210-11146-1, November 1976.

## PREFACE

This report presents the results of a study to develop a generalized analysis technique for evaluating potential aircraft modifications, which may result from the successful completion of advanced R&D programs. The study was conducted under Contract DAAJ02-76-C-0020 for the Eustis Directorate, U. S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia.

USAAMRDL technical direction was provided by Mr. T. Evans, Mr. R. Walker, and Mr. H. Bratt.

The Project Engineer for the Boeing Vertol Company was Mr. S. J. Blewitt of Product Assurance Research and Development. Program management and technical direction were provided by K. G. Rummel and K. T. Waters.

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## INTRODUCTION

In addition to the capacity for achieving greater levels of reliability early in the life cycle of aircraft through aggressive development programs, substantial reliability growth potential is present during the in-service and production phases. Where continued product improvement efforts have been applied, significant reductions in failure or removal rates have resulted. An integral component of any product improvement program is a method for quickly and conclusively determining the most beneficial changes that could be incorporated into in-service aircraft. Program managers are faced with a variety of field problems, proposed changes and possible improvements suggested by a multitude of sources. The proposed changes offer a wide range of benefits and incorporation costs, within the framework of the ever-shrinking defense b[illegible].

There is [illegible]creasing awareness that high system reliability can be obtained through a growth process of test-analyze-fix, which is repeated through the system's life cycle. As the system passes through the design and development phases into full production, changes become increasingly expensive to make. This is due to the cost of retrofit for any modification which cannot be installed at the time of production. A choice is involved between producing kits to be sent out to the field for installation on all the aircraft and waiting for the aircraft to be returned for overhaul for installation of the modified part. An additional alternative is to allow the system to continue operating at present levels with its associated costs.

In the past, proposed aircraft modifications were generally evaluated based on the number of failures or the quantity of manhours spent on the repair of a certain part. One way or another a component rose toward the top of a problem list and began receiving attention. Depending on the seriousness of the problem or the amount of funds available, the item was chosen for improvement, and an engineering change proposal was initiated. In some cases, a cost analysis was done to show that the cost of redesign and incorporation could be offset by savings later on through decreased removals and maintenance manhours expenditures. The process by which one candidate was chosen over another was not always rigorous or consistent. Furthermore, the resultant changes in operational effectiveness were not readily quantified.

The purpose of this report is to document a general technique for evaluating potential modifications to existing aircraft systems. The procedure requires background analysis and the preparation of computer program input, execution of the program with variation of the input parameters, analysis, interpretation and display of the results. The technique permits the evaluation of a proposed change in the context of a task accomplishment structure; that is, it is considered in light of the aircraft's mission. A potential modification is compared to a baseline configuration to quantify the effect of reliability and maintainability changes on availability, utilization, fleet size and cost. The technique is an inexpensive tool suitable for general application to the product improvement decision-making process.

## UNDERSTANDING PRODUCT IMPROVEMENT

Reliability can be improved by increasing the length of time that a piece of hardware will operate without failing. Maintainability can be upgraded by decreasing the length of time it takes to perform a maintenance task or by reducing the number of men required to perform a repair, both of which lower total maintenance manhours. Generally, improving R&M results in fewer failures and maintenance manhours, and a reduction in the number of spare parts that must be kept in the inventory. All of this equates to lower cost. Furthermore, since the aircraft spends less time in the hangar, it is available for use more often and can accumulate more flight time. However these benefits can only be achieved at a price. An improvement in R&M has a cost and this must be offset by lower operating costs in the future or improved operational effectiveness. In addition, R&M benefits sometimes carry a penalty of increased weight or reduced performance which must also be counterbalanced.

### OPERATIONAL EFFECTIVENESS

It is postulated that each type of aircraft has a characteristic availability/utilization relationship associated with it. Availability is defined here as the percentage of calendar hours in a given period that an aircraft is not undergoing maintenance. For example, in a 28-day month of 672 hours, if the aircraft were down for maintenance 67.2 hours, it would have been available for use 90% of the time. The 67.2 hours of maintenance were generated because the aircraft flew a certain number of hours, which required inspections to be performed and failures to be repaired. As the aircraft flies more, it requires more maintenance and consequently has a lower availability percentage. Another aircraft type with better R&M features would also have a characteristic availability/utilization relationship, but on a higher level. This concept is illustrated in Figure 1, with the first aircraft depicted in curve A and the second represented by curve B. For the same availability, aircraft B achieved more flying time because it generated less maintenance per flight hour.

Going a step further, if a series of these curves were added to Figure 1 for various levels of R&M improvement, one could develop a plot of increased utilization capability as a function of R&M level for constant availability. This, of course, is based on the assumption that all other things will be equal, such as number of mechanics, tools and support equipment. This concept is illustrated in Figure 2. As can be seen, utilization per aircraft increases with higher levels of reliability and maintainability.

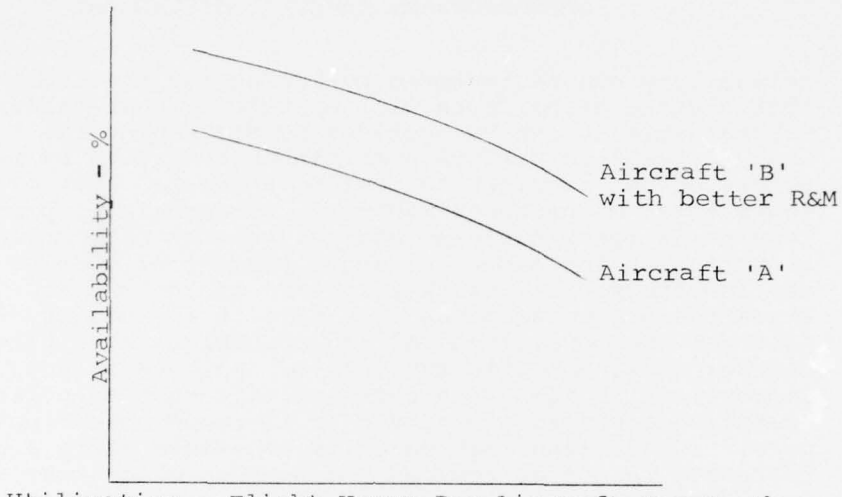


Figure 1. Availability Versus Utilization

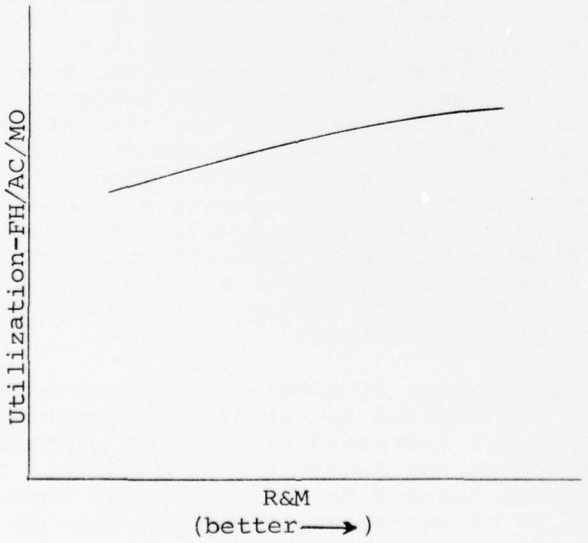


Figure 2. Utilization Versus R&M

If better R&M permits aircraft to achieve more flying time, then this benefit must be quantifiable in terms of the aircraft operator's resources. Assume that a mission is defined that requires a fleet of aircraft of a certain type to fly 7000 hours in a month. This could have been calculated based on the loads to be carried and the capability of the aircraft. Assume further that this type of vehicle can achieve 50 flight hours per aircraft per month (FH/AC/MO) at a certain desired availability level. Then 140 aircraft would be needed to complete the mission (7000 hours divided by 50 hours per aircraft). Now, if another aircraft with better R&M could achieve 70 flight hours per aircraft per month, only 100 of this type would be needed. Figure 3 illustrates this principle. If utilization per aircraft is increased, the fleet size required to perform the same task is reduced.

This section showed how the relative operational effectiveness of an R&M improvement can be measured, in the context of the program described in this report. Better R&M can result in higher aircraft utilization and a smaller fleet size, but, as was stated previously, not without cost.

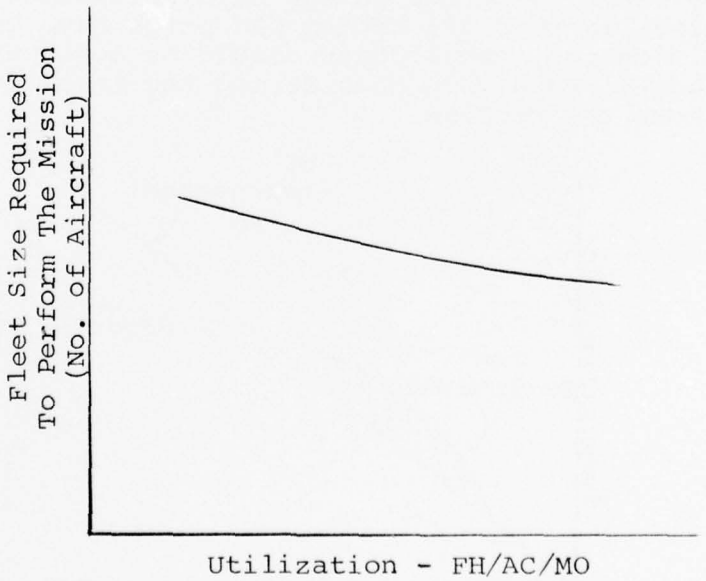


Figure 3. Fleet Size Versus Utilization

COST EFFECTIVENESS

In-service aircraft as a group generate maintenance at a fairly predictable rate. This is obvious in the case of scheduled maintenance and inspections, but perhaps less so in the case of unscheduled maintenance or failures. Nevertheless, as experience is gained and the fleet accumulates hours, it becomes apparent that many components continue to fail at a constant rate over the life of the aircraft. This assumes that the aircraft are past the infant mortality or early failure stage and have not yet reached the wearout phase. Consequently, dollar expenditures are accumulating at a constant rate over time. At some point, a recurring component problem may be identified as a candidate for modification, perhaps because it is a big contributor to downtime, because it is a high cost item, or because its failure rate is getting worse. Whatever the reason, a decision is made to improve the hardware in order to lower the total operating cost. Obviously some amount of investment will have to be made, to design the change, test and qualify it, and incorporate it into the fleet. Sometimes new tooling is required to produce the changed parts. At any rate, total costs are going to be higher during this period than they would have been if no improvement had been made. This is because the old parts are still failing and being repaired with their associated costs while funds are being spent on developing the new parts. Gradually, the improved parts get incorporated into the fleet, and the benefits of the higher reliability start to accrue in the form of reduced operating cost. Ultimately when all of the old parts have been replaced by the modification, total costs should be lower than they were previously, even when considering the investment required. Figure 4 shows the process.

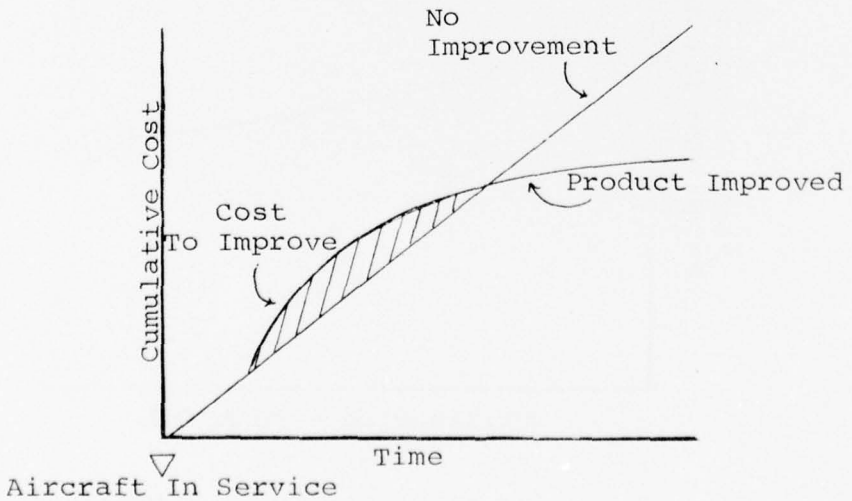


Figure 4. Product Improvement Process

Costs are constant until it is decided to improve the product, at which time they increase. This increase continues until fleet incorporation begins when some payoff starts to show by way of lower operating costs. This is where the curve begins to bend over in Figure 4. As more of the fleet is retrofitted, the savings are increased. The curve eventually intersects the constant cost line of the "no improvement" case. At this point the cumulative costs of both programs are equal. For the improved part case, this is the break-even point, the point at which investment costs have been recovered through lower operating costs. From here on, the operation of the fleet is at a lower cost than could have been achieved by not making the improvement.

This is how cost effectiveness can be measured. The "no improvement" case that was illustrated was for constant operating costs, but the process shown is even more applicable in the case of increasing costs: the total costs of alternatives can be compared and a break-even point can be calculated. Not shown here, but also possible, is the computation of a rate of return on investment based on total cost savings.

## THE PRODUCT IMPROVEMENT PROGRAM EVALUATION TECHNIQUE

The purpose of this section of the report was to introduce the concept of in-service aircraft modification and to show which parameters are important in deciding whether a product improvement will be profitable. Using the procedure described in this report, a potential modification to an aircraft system can be evaluated in two different ways: through changes in operational effectiveness, and by cost analysis. Operational measures of effectiveness include availability, utilization and fleet size, while cost parameters include investment, operational cost, net present worth, rate of return and break-even point. Furthermore, this is achieved within the confines of a task accomplishment structure.

## THE PRODUCT IMPROVEMENT PROGRAM EVALUATION COMPUTER PROGRAM

This section of the report describes the logic and flow of the computer program and the assumptions that underlie the major subroutines. Also included are a description of the data requirements, the output statistics, and the analytical capability.

### PROGRAM OPERATION

Figure 5 is a top-level flowchart of the first half of the computer program. First, a mission is described in terms of the cargo to be carried and the distance to be travelled. It may be the generalized daily routine mission, or it may be a specialized wartime situation. At any rate, it provides the structure within which changes in operational effectiveness can be analyzed. Second, the aircraft's performance characteristics are described in terms of capacity and cruise speed. The computer then calculates the total number of flight hours needed to perform the mission without regard to the number of actual aircraft required. The flight hours are used later to compute the necessary number of aircraft. Next, the computer program digresses temporarily and accepts the R&M characteristics of the total aircraft. The user hypothesizes a steady-state utilization rate, and using classic queueing theory equations, the program derives the availability level associated with the R&M traits and utilization input. This is done for the baseline configuration, and referring to Figure 5, it can be seen that the process is repeated for the alternate.

However, when the queueing section of the program is used this second time, the availability achieved by the baseline design is held constant, and the computer iterates to solve for utilization for the alternate. Assuming that the alternate configuration either fails less frequently or requires fewer manhours to repair, it should be able to fly more often and therefore have a higher utilization. At this point then, the computer program has two utilization levels, the baseline and the alternate, at the same availability. Dividing flight hours per aircraft (utilization) into total flight hours required to perform the mission (calculated earlier) yields the number of aircraft or the fleet sizes necessary for the two configurations to perform the mission. Repeated use of the queueing routine allows utilization to be held constant and the availability to be recalculated for the alternate. Since it is expected that the R&M characteristics of the alternate are better, the availability of the alternate should be higher than the baseline. Additionally, fleet sizes can be held constant with both availability and utilization being recalculated.

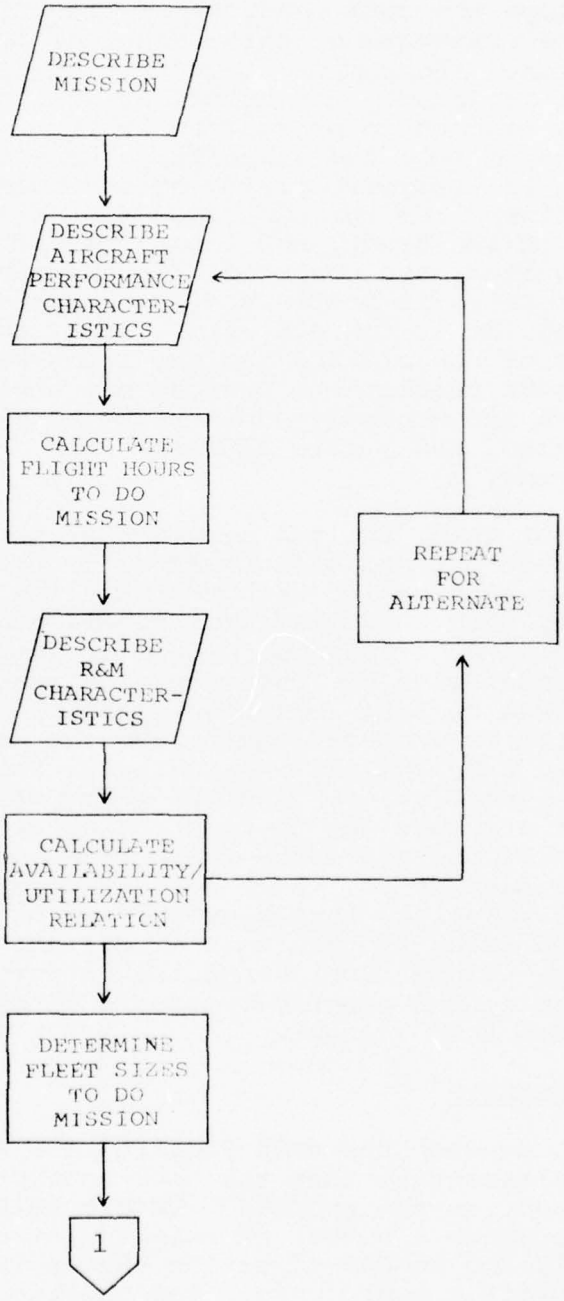


Figure 5. Product Improvement Program Evaluation
Top-level Flow Chart - Operational Analysis

Figure 6 is a top-level flow chart of the rest of the program, which develops the cost measures of effectiveness. Operational costs in the framework of this technique are driven by the number of times the component under consideration fails and is repaired or replaced. The number of failures or maintenance manhours is assumed to be reduced by the incorporation of the proposed change into the aircraft. Therefore, the next step is to input the retrofit policy or schedule. The aircraft are then "flown" for the number of months or years under consideration in the study, and the number of failures of the old and new items are computed. In the baseline situation, there is no retrofit policy, and the component is allowed to continue failing at the old rate. Next, costs associated with repair of the old and the new items are input, including the investment required to procure and install the changed part. Costs are accumulated over the specified life cycle, are discounted, and a rate of return and a break-even point are calculated.

At this point then, the two sections of the computer program have provided cost and effectiveness criteria for comparing one possible alternative with the baseline configuration. The user may then vary his input to discover under what conditions the alternate can be made more attractive. Perhaps he should accelerate the incorporation rate or change the design to make it more reliable or easier to repair. The computer program is executed again, and the next set of results are compared with the previous output. This illustrates one use of the technique, to find the best set of circumstances under which a change may be cost and operationally effective. Another use of the procedure is to rate competing product improvement candidates. Each one is optimized separately against the baseline, then a comparison of the proposals can be conducted using the measures of effectiveness output from the program. Since portions of the output are by year over the life cycle, the program manager's funding constraints can also be taken into account.

## DATA REQUIREMENTS

In order to develop the data required for the technique described here, it is essential that the user understand the basic assumptions inherent to the process. We are talking primarily about a situation where a number of existing aircraft are fielded and operational, and an R&M-affecting change is suggested for one of the aircraft's components. Two questions need to be answered: how will the change impact operational capability and what will the net cost benefits be. Within that scenario, it is possible to hypothesize a second situation where new aircraft deliveries are still being made or, at the extreme, where no deliveries have been made at the time of analysis but the aircraft has been

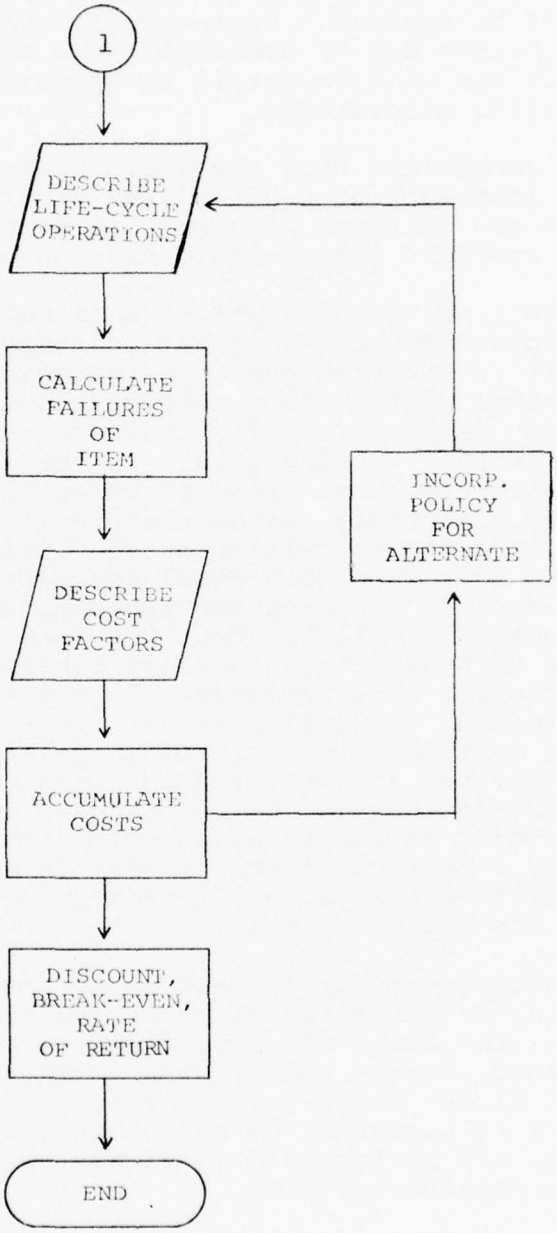


Figure 6. Product Improvement Program Evaluation
Top-level Flow Chart - Cost Analysis

developed. This third application was not the main purpose for which the technique was developed, but in most instances it can still be applied. Furthermore, other performance-impacting changes may be assessed, such as increased speed or payload, but the main thrust is in appraising reliability and maintainability alterations.

It must be remembered that the whole evaluation takes place within the framework of a predefined aircraft role. Therefore, the results are in terms of a particular configuration's ability to complete its assigned mission.

With this in mind, the analytical data requisites will be generally introduced here. First is the task to be accomplished. It is expected that, in the majority of uses, the proposed change will be to a component utilized in the life cycle mission of the aircraft, that is, the application for which the aircraft was designed. If the analysis concerns a transport aircraft, then cargo or troop lift missions should be described. Secondly, since there will usually already be a fleet of aircraft in existence, the mission should be described so that when the actual aircraft performance capability is input to the computer program, the resultant calculated fleet size will be about the same as that which truly exists. In this way, the so-called baseline configuration output statistics will represent the real-world situation that is being studied. Likewise, if the aircraft system has an established availability/utilization relationship, the inputs should be designed and the program executed such that the established relationship is reproduced. In this regard the computer program has a "baseline establishment run" feature, whereby only a portion of the program is executed, until the user is satisfied that a good foundation exists against which to compare any modifications.

The data requirements up to this point are founded on a good understanding of the aircraft under study and its past experience: the basic mission, fleet size, number of seats, useful payload, cruise speed, MTBF, MTTR, NORS, NORM, availability and flight hours per aircraft per month. For the alternate it is necessary to know what the reliability, maintainability, and performance (payload, speed) effects will be; the mission remains the same.

Next, a method for incorporating this improvement into the aircraft must be devised. The information needed here is not as rigid since the user may wish to vary the implementation scheme to determine the most cost-effective schedule. The options available to the user are to have the change put in as the aircraft are being delivered, if new deliveries are still being made, or to have the modifications installed in

the field. If installations are made in the field, they may be made at the organizational level or delayed until the aircraft arrive at depot level for repair or overhaul. Since the computer program accepts a certain quantity per month as input for field installation, the user must know or be able to estimate the rate at which aircraft arrive at the depot level if this is the policy to be followed. Through the use of this implementation philosophy and the components' failure rates, the number of old and new item failures are computed. Following this, the operational costs can be calculated. To do this, the average parts and labor costs associated with the old and new item must be supplied for three levels of repair. Other costs are built into the program but can be changed at the user's discretion. Finally, the user must be aware of the investment required to bring about the change. This includes R&D, investment nonrecurring and investment recurring costs. This is where the costs of the modification kits, if that is the procedure, are tallied. If the user cannot estimate investment costs at this time, the program will do it for him based on operational costs and their relationship to total life cycle costs. This illustrates another use of the model: in addition to being able to examine the cost and effectiveness of a particular program given that all the costs and benefits are known, the technique can also be used to determine what funds will have to be spent to get a certain rate of return given that the user only knows what the R&M improvements are and not the cost. This can be done by parametric variation and repeated runs of the program. Since the program execution time is on the order of 5 to 30 seconds depending on the computer used, this is a relatively inexpensive process.

Table 1 contains a summary of the input data required for the computer program. The input category is listed along with a description and a notation as to whether the information is needed separately for the baseline and alternate configurations, or generally for application to both cases.

PROGRAM OUTPUT

Actual reproductions of computer output are not shown here but are fully illustrated in the appendix. However, specific items of output are summarized in a later section of this report where test cases are discussed. The purpose of the program output section is to describe the output statistics that are available to the program user.

TABLE 1. COMPUTER PROGRAM INPUT SUMMARY

| Category | Description | Requirement |
|---|---|---|
| Mission Description | Passengers and cargo to be carried and distance to be travelled. | General |
| Aircraft Performance Characteristics | Payload, cruise speed, number of seats. | Baseline/Alternate |
| Aircraft R&M Characteristics | Mean time between maintenance, mean time to repair. | Baseline/Alternate |
| Component R&M Characteristics | Maintenance action rates and manhours. | Baseline/Alternate |
| Retrofit Policy | Incorporation technique and schedule. | Alternate |
| Costs | Operations and support | Baseline/Alternate |
| | Investment | Alternate |

The initial portions of output from the computer program concern the operational measures of effectiveness. The total flight hours required to perform the mission are presented for both the baseline and the alternate configurations. If the proposed R&M change will impact the cruise speed or the payload capacity of the alternate, then the alternate will require more or fewer flight hours to perform the mission. Next, holding availability constant, the number of flight hours per aircraft per month that can be achieved by each configuration are shown. Related statistics, such as total down time and total time spent waiting for men, are also computed. Finally, based on the flight hours needed to complete the mission and the utilization capability of the aircraft, the required fleet sizes for the two configurations

are calculated for a constant availability level. The program also displays availability and fleet size for a constant utilization, and availability and utilization for a constant fleet size. In summary then, the measures of effectiveness at this point are the total flight hours required to perform the mission, availability and utilization, and the fleet sizes for both the baseline and alternate aircraft. It should be stated here that such operational parameters are rarely sufficient to justify a product improvement program. However, in a situation where a number of projects have equal merit from a cost viewpoint, yet where only a few can be funded, these parameters can be used to decide which ones should be chosen. Obviously, the fact that the alternate configuration might be able to perform the mission with fewer aircraft does not mean that the Army will return these extra aircraft to the contractor. Nevertheless it does provide a measure of effectiveness.

The program next goes through a month by month process of accumulating hours on the parts, having them fail, and getting them repaired. In the alternate case, incorporations of the new part are made according to the schedule. The result is the number of maintenance actions on the old and new items at the three levels of repair for the baseline and alternate cases. These are then costed out in the next subroutine. Additional output includes the number of spares required to support the described operating level and the number of aircraft lost due to attrition. In the event that a program is underway in which new aircraft are purchased to replace those attrited, this number can be compared to the two fleet sizes generated earlier to see how many fewer aircraft need to be replaced in the alternate case. Although attrited aircraft are seldom replaced during peacetime, the output statistics are there for each user's particular application. Likewise, a reduction in the number of spares required may be of little value if a fleet of components and spares has already been purchased and there is no provision for returning the spares to the contractor. Since policies regarding spares and the replacement of aircraft can vary with each application, these two parameters do not enter into the costing subroutine.

The number of maintenance actions on the old and new items at the three maintenance levels are carried over into the next subroutine for the baseline and alternate cases to calculate the costs associated with these repairs. The output shows the life cycle costs of operating the component in the baseline configuration according to the categories described in

AR37-18.[2] Following this, the yearly cash flow is shown, which includes the annual costs, the cumulative costs, and the discounted costs for both cases. The break-even point is displayed, and to demonstrate the effect of the incorporation schedule, the fleet composition of old and new parts and the resultant operating costs are shown by year. Finally, based on the present value of the life cycle cash flow, a true rate of return on the investment is computed.

ANALYTICAL CAPABILITY

As was stated previously, the computer program described in this report represents a technique for examining the cost and operational effectiveness of a proposed aircraft improvement. In a more universal sense, it is a tool that can be used to solve for an optimum life cycle cost-effective R&M level. Figure 7 illustrates the classic economic principle of the marginal rate of return. It is the relationship between the marginal increment of input to output.

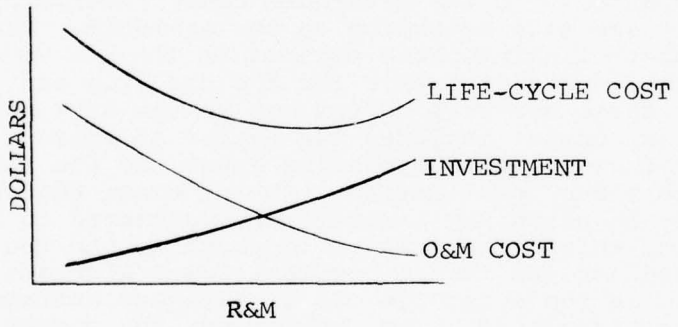


Figure 7. Cost Effective R&M

The top curve, which is the total life cycle cost, is merely the sum of the investment and O&M costs. It is reasoned that higher investment is required to achieve better levels of R&M, and improved R&M results in lower operating cost. However, according to the law of diminishing returns, higher levels of R&M become increasingly more expensive to achieve, until eventually there is no life cycle cost benefit, and in most cases, life cycle costs will increase. In the case of product

[2]Army Regulation Number 37-18, WEAPON/SUPPORT SYSTEMS COST CATEGORIES AND ELEMENTS, Headquarters Department of the Army, Washington, D.C., October 1971.

improvement programs, better R&M levels can be achieved by investing more money in the design or testing of potential candidates or, after the improvement is designed, by accelerating its incorporation into the fleet. In other words, it may cost more to get the new component into the fleet quickly, but the benefits of the improvement begin sooner.

Parametric Analysis

By varying certain of the computer program inputs, the user can decide either the best way to implement a particular product improvement or choose among competing candidates. Obviously, the first set of parameters to be changed are the MTBFs at the three maintenance levels and the MTTRs. Altering these inputs will change the availability/utilization relationships and possibly fleet size for analyzing operational effectiveness, and will change the number of maintenance actions performed and manhours for examining cost impact. The user should have some idea of what investment costs are necessary to change R&M, but the program will estimate investment costs if they are unknown.

The second major area for parametric analysis is in the incorporation philosophy. The modification schedule is of prime importance, since no benefit can be achieved until the modifications have been made to the aircraft. The sooner the new parts are installed, the sooner the overall R&M level will improve. Naturally, it is expected that quicker kit production and installation will cost more. The concept is illustrated in Figure 8.

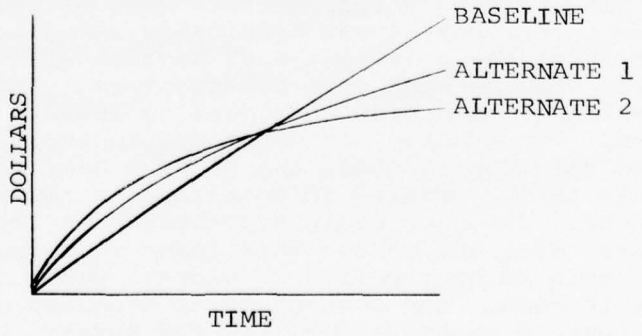


Figure 8. Cumulative Cost of Alternate Incorporation Schedules

One curve shows the cum cost of continuing to operate the baseline configuration. The other two curves show the cost of changing the aircraft. Both of these are lower than the baseline and are viable programs; however, they differ in their change incorporation procedure. Alternate 1 would install the change at overhaul; Alternate 2 would send kits out to the field for immediate implementation. Although Alternate 2 costs more than Alternate 1 in the early stages of the program, in the long run it is less expensive. It could be that funds are not available in the early part of the program, but this is an example of the kind of analysis which can be done by varying the schedule of change incorporation.

These two items, R&M and modification incorporation schedule, are the two main areas for sensitivity analysis, but there are also many minor changes that can be examined in the cost input sections. Perhaps a new manufacturing technique or new materials can be used to lower the value of parts consumed at the depot level. This can be checked for its cost benefit by changing the appropriate input card. Likewise, maybe a less skilled (and less expensive) mechanic can perform the repair. To analyze this, merely change the labor rate. In any case, the model is flexible enough to examine almost any cost-reducing or operations-improving change.

Cost Analysis

One of the most useful areas of the cost output is in the operating cost section. If a particular product improvement is not yielding a satisfactory rate of return or is not saving as much money as was originally thought, a simple examination of the operating cost section will show which categories are the high cost contributors. The user can then backtrack and decide what must be done to remedy the situation. For example, if depot maintenance was found to be a high cost contributor, the program user could change the inputs to the program in an effort to lower depot maintenance costs. The user could hypothesize an improvement in depot level MTBR and change this input to reduce the number of components to be repaired at depot. Other options available are to reduce the cost of parts consumed at depot, reduce the maintenance manhours required for repair, or lower the cost of people working on the component at that level. Any or all of these would result in a decrease in depot maintenance costs.

The cash flow output by year has many applications. For example, the annual costs of competing projects can be plotted, along with budget constraints, as an aid in deciding which can be satisfactorily funded. This concept is illustrated in Figure 9.

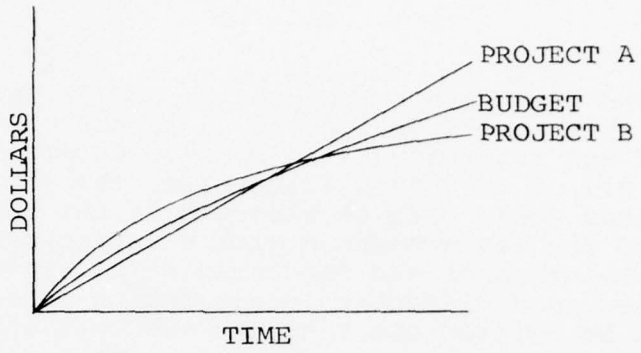


Figure 9. Alternate Project Cash Flows

The output can also be used to show the break-even point, which is the year in which all the investment costs have been recovered in reduced operating costs. This point will be different when discounting has been applied, due to the reduction in value of future cash flows to their present value. Since product improvement programs require investment capital in the early years of program life and since discounting factors in the early project years are higher than in later years, discounting will generally push the break-even point out further than when using actual cash flow. Nevertheless, discounting is the recommended DOD procedure.

Another figure of merit from this section of output is the true rate of return on investment. This figure is most relevant when available funds for investment are constrained. In this situation, the program manager wants to know how he can best invest his money, and this is the appropriate statistic. However, in the situation where available money is relatively unlimited or within a limited range, the difference in life cycle cost between baseline and alternate must be considered. For example, two competing projects may have rates of return of 10% and 20%. The logical choice would seem to be the latter. However, this could be a relatively minor aircraft modification, simple to design and install (keeping investment cost low), and having a relatively small total cost benefit but a high rate of return. The first project could represent the solution to a major aircraft problem. It may have high investment costs, causing the project to have a lower rate of return, but have significantly higher total cost savings than the other candidate. If the manager is not limited in his budget and could afford the investment for either one, then he should consider the one with the lower rate of return.

## TEST CASES

In order to demonstrate the program and illustrate some of the ways that it can be applied, a number of test cases were developed and run through the model. Generally, these cases utilized all of the major features of the program. Two of the cases dealt with an aircraft in the inventory, the CH-47, and one was concerned with a development aircraft, the UH-61A. Maintenance was performed at all levels, fleet sizes were varied, and different incorporation schedules were tested. It should be pointed out that R&M and cost input data used in the test cases was based on best estimates of the engineers and other personnel involved. As such, the results shown in this section should not be construed as the absolute indication of the effectiveness of the product improvements discussed. The purpose of the test cases was to demonstrate the program, and a true product improvement evaluation would require a more rigorous definition of input prior to execution of the program.

### CH-47 Rainshield Stiffener

The Chinook rainshield is mounted on the rotor shaft under the rotor head, and its purpose is to cover and protect the rotor controls, actuators and swashplate assemblies. It provides an aerodynamic flow and keeps rain from entering the aircraft interior. A few years ago, an ECP (Engineering Change Proposal) was submitted to correct a recurring fatigue problem, which manifested itself in the form of cracks in the rainshield stiffener, an integral part of the rainshield. To reduce fatigue failure the proposed new stiffener was the same as the old one except that material would be shotpeened stainless steel instead of the original ALCLAD (aluminum). The standard repair of cracks in the stiffener was to rivet a patch over the cracked area. Although this was simple and inexpensive, it resulted in a lot of down time and consumption of maintenance manhours, since the task required removal of the rotor head. Removal of the Chinook rotor head was estimated to consume about 8.5 maintenance manhours.

The first step in the product improvement analysis was to establish a baseline against which to compare the proposed change. The modification was to be considered only for the CH-47C model aircraft; therefore historical data on this model was examined to determine the appropriate operational parameters. Aircraft mean time between maintenance (MTBM) for all causes was .7505 hour and mean time to repair (MTTR) was 2.15 hours. A representative sample of Vietnam field experience revealed an availability level of about 74% at

50 hours per aircraft per month utilization. Using the MTBM, MTTR and utilization described above as input, varying the crew size eventually yielded an availability level of 73.5%. This was considered to be an acceptable baseline. The organizational level mean time between failures for the rainshield stiffener was expected to improve from 206 hours to 293 hours. This resulted in a change in aircraft MTBM to .7513 hours and a change in MTTR to 2.05 hours. Holding availability constant at the baseline level yielded a new utilization capability of 53 hours per aircraft per month. These figures can be seen in Table 2. A monthly mission

TABLE 2. CH-47 RAINSHIELD STIFFENER

| | Baseline | Alternate |
|---|---|---|
| Component MTBF Hours | 206 | 293 |
| Component MTBR - AVIM | - | - |
| Component MTBR - Depot | - | - |
| Aircraft MTBM Hours | .7505 | .7513 |
| Aircraft MTTR Hours | 2.15 | 2.05 |
| Availability | 73.5% | 73.5% |
| Utilization | 50.0 | 53.0 |
| Flight Hours Required to do Mission | 9849 | 9853 |
| Fleet Size to do Mission | 197 | 186 |
| Total O&M Cost | $662163 | $500558 |
| O&M Cost Savings | - | 161605 |
| Cost to Improve (Investment) | - | 90990 |
| Net Cost Saving | - | 70615 |
| True Rate of Return | - | .81% |
| Break-Even Point | - | 12 Years |

was defined such that when the flight hours required to do the mission (9849) were divided by the baseline utilization (50), the resultant baseline fleet size would be the same as the number of aircraft in the inventory, about 197. Since

the new rainshield stiffeners increased aircraft weight by 7 pounds, payload was reduced by that much, therefore requiring a few more flight hours to perform the mission (9853). When this was divided by the new utilization (53) the fleet size necessary to perform the mission in the alternate configuration was reduced to 186 aircraft. This was the operational measure of effectiveness: the capability of performing the same mission in the same time frame with 11 fewer aircraft.

The second half of the process was to evaluate the cost effectiveness of the change. For both the baseline and alternate cases, a 15-year life cycle was assumed. During this time utilization was 10 hours per aircraft per month, except for 2 periods of 3 years and 2 years respectively, when a surge situation of 50 hours per aircraft per month was hypothesized. Maintenance manhours per repair was 8.9, and material consumed was valued at $5.00 per repair. Finally, it was assumed that at the start of the analysis there were 148 aircraft in the fleet with 100 more to be delivered at the rate of 2 per month. Upon running the program, there were 7781 repairs of the old rainshield stiffener over 15 years at a total O&M (operations and maintenance) cost in excess of $600,000, as shown in Table 2.

In the alternate case, it was assumed that new stiffeners would be available at the beginning of the second year, that new aircraft delivered would have the new stiffener, and that the rest of the aircraft in the field would be retrofitted at a rate of 18 per month. For the 15 year period, there were 5882 repairs of old and new stiffeners at a total O&M cost of about $500,000. Table 2 shows that the O&M cost savings minus the investment costs yielded a net cost savings of $70,605. It took 12 years for investment costs to be recovered, and the true rate of return was .81%. The true rate of return is based on the present value of the cash flow over the life cycle and is calculated using the following equation:[3]

$$\text{TRR}(\%) = \frac{\text{PVB}-\text{PVA}}{\text{I}} \times \frac{100}{\text{N}}$$

where PVB = total present value of cash flow for the baseline
PVA = total present value of cash flow for the alternate
I = total investment (discounted)
N = project life

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[3] Rose, J., ECONOMIC ANALYSIS FOR RELIABILITY AND MAINTAINABILITY TRADES, The Boeing Commercial Airplane Company, Seattle, Washington, Boeing Document D6-22972 TN-1, May 1975.

This is an annual rate, and since the discount rate used was 10%, the true rate of return represents a return over and above the 10%.

This process yielded the second half of the output, the cost measure of effectiveness. It should be remembered that, although the program is run from start to finish as a single entity, the two parts are distinct. The fact that operations could be conducted using 11 fewer aircraft did not cause 11 fewer aircraft to be retrofitted. Furthermore, the operational analysis was done at the higher, wartime utilization of 50 hours, while the costs were computed for a peacetime/wartime scenario. No sensitivity analysis was performed in this test case, but one will be shown in the next one.

CH-47 Fuel Pods

A recent field survey revealed a low MTBF and a low MTBR to scrap for the Chinook fuel pods. The skin of the present configuration's fuel pods is a thin aluminum sandwich which is subject to damage in the maintenance and operational environment. Cracks and punctures develop in the skin, in which moisture accumulates causing corrosion and voids between the metal layers. Although many of the repairs can be made on the aircraft, a large number of pods are removed for repair and have to be scrapped. The proposed remedy for the problem consists of replacing the old pods with new ones of composite construction with a nomex core, which would eliminate corrosion. The new pods would also have a high degree of resistance to the type of damage previoulsy experienced. In addition, it is estimated that the new pods could be acquired at about 85% of the cost of the old ones.

A test case was set up and run through the computer program. The results revealed a net saving of $2.8 million over the 20-year life cycle. However, before the run was made, it was intuitively felt that the benefit would be higher than that. It was decided to run the program again with a different incorporation schedule. The first time through, the entire fleet (361 aircraft) was retrofitted at a rate of 3 aircraft or 18 pods per month. This required the acquisition of 361 sets of fuel pods. In the second case, it was assumed that the new pods would be installed only when the old ones were removed and scrapped, a rate of about 9 pods per month. This required the acquisition of only 184 sets. Table 3 shows the results of the second run.

TABLE 3. CH-47 FUEL PODS

| | Baseline | Alternate |
|---|---|---|
| Component MTBF Hours | 50 | 400 |
| Component MTBR - AVIM | - | - |
| Component MTBR - Depot (scrap rate) | 1975 | * |
| Aircraft MTBM Hours | .7505 | .7605 |
| Aircraft MTTR Hours | 2.15 | 2.13 |
| Availability | 73.5% | 73.5% |
| Utilization | 50.0 | 51.3 |
| Flight Hours Required to do Mission | 18055 | 18055 |
| Fleet Size to do Mission | 361 | 352 |
| Total O&M | $35.7M | $2.2M |
| O&M Cost Savings | - | 33.5M |
| Cost to Improve (Investment) | - | 13.8M |
| Net Cost Saving | - | 19.7 |
| True Rate of Return | - | 7.1% |
| Break-Even Point | - | 8 Years |

*Estimated at 100,000 hours, but for program purposes it was assumed it would not be scrapped.

The change in organizational level MTBF from 50 hours to 400 hours improved the aircraft MTBM from .7505 hours to .7605 hours. At 73.5% availability, the alternate configuration achieved 51.3 flight hours per aircraft per month as compared to the 50 hours per month achieved by the baseline. The fleet sizes required to perform the mission were 361 aircraft for the baseline and 352 aircraft for the alternate. Total O&M cost of the baseline was $35.7 million and included the replacement of over 2,000 spare pods. For the alternate, O&M costs were $2.2 million; however an additional $13.8 million was spent to develop ($.5 million) and acquire the new pods. In the alternate scenario, 1,104 old pods were replaced by new ones. The net cost saving over the life cycle was $19.7 million, the true rate of return was 7.1%, and the break-even point was 8 years.

This case illustrated how sensitivity analyses can be performed using the program. With the fuel pods, due to the nature of the scrap rate it was more profitable to wait for the old pods to be scrapped, than to retrofit the fleet. In other cases or circumstances it could be more effective to install the changed part at a rapid rate. It should be remembered that the purpose of the fuel pod example was to demonstrate the computer program, not to advocate a product improvement program. Data used in the example was based on the best estimates available at the time.

UH-61 FM Homing

This test case shows how the model can be used for analyses concerning aircraft that have been developed but have not yet gone into production. In the UTTAS aircraft, both the pilot and copilot radios had FM homing capability. The radios shared a single antenna by way of two coaxial relays and related wiring. A design-to-cost analysis was performed, and it was decided to take away the FM homing capability of one radio by eliminating the coaxial relay setup and tieing the other radio directly into the antenna. Using data generated from this analysis, a product improvement computer run was made. The results of this run are shown in Table 4.

A new mission was developed to represent the UTTAS operating scenario of 69 hours per aircraft per month. As can be seen from the Table, with an MTBM of 1.9 hours and an MTTR of .85 hour, an availability level of 85.9% was achieved. This included a constant NORS (not operationally ready-supply) rate of 10%, whereas the Chinook runs used 7%. Considering the utilization capability and the flight hours required to perform the mission, a fleet of 1,107 aircraft was needed, thereby representing the true UTTAS procurement planning. Based on the radio system's reliability parameters and repair costs, O&M costs for the 20-year life cycle were $14.2 million. Eliminating the second radio's FM homing capability decreased the frequency of repair at all three maintenance levels. The change from an organizational level MTBF of 94 hours to 134 hours caused an increase in utilization capability of about .4 hour per aircraft per month. This resulted in a reduction in fleet size required to perform the mission to 1,100 aircraft. It is obvious that this measure of effectiveness has greater value in the preproduction phase of the procurement process. O&M costs were reduced by $4.5 million to $9.7 million. Since the change in the system was to be made prior to production and no kits or retrofitting were involved, investment costs were minimal, at $1,862, mostly for drawing changes. Because investment was so low, the net cost saving, the rate of return and the break-even point are not even shown here.

TABLE 4. UH-61 FM HOMING

| | Baseline | Alternate |
|---|---|---|
| Component MTBF Hours | 94 | 134 |
| Component MTBR - AVIM | 99 | 145 |
| Component MTBR - Depot | 2000 | 2900 |
| Aircraft MTBM Hours | 1.900 | 1.912 |
| Aircraft MTTR Hours | .850 | .850 |
| Availability | 85.9% | 85.9% |
| Utilization | 69.00 | 69.42 |
| Flight Hours Required to do Mission | 76391 | 76391 |
| Fleet Size to do Mission | 1107 | 1100 |
| Total O&M Cost | $14.2M | $9.7M |
| O&M Cost Savings | - | 4.5M |
| Cost to Improve (Investment) | - | 1862 |
| Net Cost Saving | - | - |
| True Rate of Return | - | - |
| Break-Even Point | - | - |

It was intuitively obvious that this case would be a cost effective change, but the operational benefits were not as apparent prior to running the program. In addition, it shows another side of the model. In this situation, the entire aircraft delivery process was simulated in order to calculate the number of expected failures over the life cycle.

Earlier in this report, several areas were noted as likely candidates for sensitivity analyses. These were: the R&M inputs, the product improvement incorporation schedule, and parameters from the O&M cost output. An additional area is the aircraft utilization level. Use of the model revealed that what may be a cost and operationally effective product improvement at 50 hours per aircraft per month, may have

little or no payoff at 10 or 20 hours per month. Successive runs of the model can enable the user to determine the aircraft usage level at which a change is profitable. Finally, in the past certain ratios of cost savings to investment have been used by program managers as a criteria for approval of product improvement programs. Ratios of 4 or 6 to 1 have been mentioned. It is felt that this criteria was used in response to a general lack of confidence in cost estimates used as justification for PIP's. However, using the technique described in this report, such high ratios should no longer be required. Since the calculation of the true rate of return takes into account a discount rate of 10%, anytime a PIP analysis results in a positive rate of return, it represents a higher rate of return on investment than that which could be had by not making the change. This is not to say that every PIP in this category should be accepted, since there are cases of high technical risk, but the technique presented in this report does represent a more rigorous approach than that which was used in the past.

## CONCLUSIONS

This report introduced a new, integrated technique for evaluating potential aircraft modifications. The approach is the execution of a computer program that measures the cost and operational effectiveness of reliability and maintainability improvements within a task accomplishment structure. It can be effectively used in three ways. First, it can be employed to evaluate the profitability of a product improvement. Second, it can be used to optimize a candidate product improvement program. This can be achieved by varying the R&M improvement level, varying the incorporation policy and schedule, and analyzing the O&M cost output. Finally, the technique can be used to help choose among competing product improvement programs, by comparing their respective cost and operational measures of effectiveness.

The model is not confined to the applications discussed in the report but is limited only by the particular application of the user and his experience with the program. Although the model had not been widely used at the time of the writing of this report, it is felt that little or no changes to the program will be required; nevertheless, it was designed to be quickly and easily modified should additional capabilities be desired.

## RECOMMENDATIONS

Based on the results of this study, it is recommended that the technique described in this report be used by program managers and product improvement analysts in the evaluation of R&M affecting product improvements. The technique represents an approach more rigorous than some that have been used in the past and will enable PIP decision-making to be more accurate than previously possible.

It is further recommended that additional work be considered in the evaluation of other areas of product improvement, such as performance, safety and increased mission capability. Finally, a feedback process should be initiated involving the users of the model to ensure that the requirements of the users are being met, and to identify any areas of desired additional capability.

# APPENDIX A

## PROGRAM DOCUMENTATION

This section of the report provides computer program documentation for the Product Improvement Program Evaluation (PIPE) model described earlier. It includes a description of the problem and method of solution; a list of equations used; definition of input and output; and listings of the source deck, sample input, and output results from the sample input.

### DESCRIPTION OF THE PROBLEM

A technique was required which could evaluate the cost and operational effectiveness of planned aircraft modifications. The proposed changes to be examined were of the type which affect reliability and maintainability. The analysis was to be performed in the context of a pre-defined mission, with operational measures of effectiveness included in the output. The program was also to consider means of incorporating the change into the aircraft fleet, and allow cost analysis among the various cost categories. The complexities involved in the calculation of availability through the use of queueing equations, plus the iterative process needed to compute yearly costs, made a computer program the logical method for solving the problem.

### METHOD OF SOLUTION

The computer program which was developed compares a baseline configuration with an alternate. It consists of a main program and four major subroutines. Each configuration goes through all four subroutines, and the main program uses results from these to calculate certain measures of effectiveness. The first subroutine, MISHIN, determines how many flight hours would be required for each configuration to complete the described mission. Subroutine QUEUE computes availability/utilization relationships for the baseline and alternate, and the main program combines the results of these first two subroutines to develop the fleet size required by each configuration to perform the mission. The third subroutine, INCORP, accepts the incorporation schedule for the changed component and models the use of the item throughout its life cycle. In the case of the baseline no retrofit schedule is used, and the program flies the components without change. Based on the number of items which fail in this subroutine, the last subroutine, ZCOST, calculates the costs of repairing and replacing the components in both cases. Finally, the main program computes the breakeven point and the true rate of return on investment.

EQUATIONS USED IN THE PROGRAM

---

Number of passenger sorties, based on the described mission.

$$\text{Passenger Sorties} = \text{Total Passengers} \div \text{Aircraft Passenger Capacity}$$

MISHIN 1

---

Excess capacity available for cargo after passengers are on board.

$$\text{Excess Capacity} = \text{Aircraft Payload} - (\text{Aircraft Passenger Capacity} * 240)$$

MISHIN 2

---

Number of cargo sorties based on the described mission.

$$\text{Cargo Sorties} = \left( \text{Total Cargo} - \left( \text{Passenger Sorties} * \text{Excess Capacity} \right) \right) \div \text{Payload}$$

If less than zero, gets set equal to zero.

MISHIN 3

---

Total number of sorties to be flown based on the described mission.

$$\text{Total Sorties} = \text{Passenger Sorties} + \text{Cargo Sorties}$$

MISHIN 4

---

Sortie length (flight hours) based on the described mission.

$$\text{Sortie Length} = \left(\begin{matrix}\text{Mission}\\ \text{Distance}\end{matrix} \div \begin{matrix}\text{Aircraft}\\ \text{Speed}\end{matrix}\right) + \text{Hover Time}$$

When hover time is not used, this value is represented as transition time or take-off time.

MISHIN 5

Total number of flight hours required to perform the described mission.

$$\text{Flight Hours} = \text{Total Sorties} * \text{Sortie Length}$$

MISHIN 6

Probability that there are no maintenance actions in the system at a particular time.

$$Po = \frac{1}{\left(\sum_{k=0}^{n-1} (1/k!)(\lambda/\mu)^k\right) + (1/n!)(\lambda/\mu)^n n\mu/(n\mu - \lambda)}$$

where,

$\lambda$ = 1/MTBM

$\mu$ = 1/MTTR

n = number of crews

QUEUE 1

Expected number of maintenance actions waiting for manpower (on the average).

$$\text{MA's Waiting} = \frac{\lambda\mu(\lambda/\mu)^{n}Po}{(n-1)!(n\mu-\lambda)^{2}}$$

QUEUE 2

Expected number of maintenance actions in the system (on the average).

$$\text{MA's Total} = \frac{\lambda\mu(\lambda/\mu)^{n}Po}{(n-1)!(n\mu-\lambda)^{2}} + \frac{\lambda}{\mu}$$

QUEUE 3

Expected waiting time of a maintenance action.

$$\text{Waiting Time} = \frac{\mu(\lambda/\mu)^{n}Po}{(n-1)!(n\mu-\lambda)^{2}}$$

QUEUE 4

Expected total time a maintenance action spends in the system.

$$\text{Total Time} = \frac{\mu(\lambda/\mu)^{n}Po}{(n-1)!(n\mu-\lambda)^{2}} + \frac{1}{\mu}$$

QUEUE 5

Cumulative number of maintenance actions for a company of aircraft for one month.

MA's Cum = (Utilization * Number of Aircraft) ÷ MTBM

QUEUE 6

Cumulative waiting time of maintenance actions for a company of aircraft for one month.

Cum Waiting Time = MA's Cum * Waiting Time

QUEUE 7

Total Not Operationally Ready-Maintenance (NORM) time for a company of aircraft for one month.

Total NORM Time = MA's Cum * Total Time

QUEUE 8

Total aircraft calendar hours in a 28-day month.

Aircraft Calendar Time = Number of Aircraft * 24 * 28

QUEUE 9

Percentage of monthly calendar time spent awaiting maintenance.

$$\text{NORM \% Waiting} = \left(\begin{matrix}\text{Cum Waiting} \\ \text{Time}\end{matrix} \div \begin{matrix}\text{Aircraft} \\ \text{Calendar Time}\end{matrix}\right) * 100$$

QUEUE 10

Percentage of monthly calendar time spent down for maintenance (includes NORM % Waiting).

$$\text{NORM \% Total} = \left(\begin{matrix}\text{Total NORM} \\ \text{Time}\end{matrix} \div \begin{matrix}\text{Aircraft} \\ \text{Calendar Time}\end{matrix}\right) * 100$$

QUEUE 11

Percentage of monthly calendar time that the aircraft are not down for maintenance, and are available for use.

$$\text{Availability \%} = 100 - (\text{NORM \% Total} + \text{NORS \%})$$

NORS % is an input.

QUEUE 12

Fleet size required to perform the described mission.

$$\text{Fleet Size} = \text{Flight Hours} \div \text{Utilization}$$

Utilization is an input for the baseline and yields an availability %. For the alternate, the program tries different utilizations until the baseline availability is achieved.

MAIN 1

Operating hours per year compiled on the subject components.

Operating Hours (I) = Number of Components *

Utilization * 12

where,

I is the year of the life cycle (up to 20).

INCORP 1

Total number of maintenance actions performed on the subject components by year, by maintenance level over the life cycle.

Life Cycle MA's (I, J) = Operating Hours (I) ÷

MTBX (J)

where,

J is the maintenance level (up to 3).

INCORP 2

Cumulative operating hours compiled on the subject components.

$$\text{Cum Flight Hours} = \sum_{I=1}^{Y} \text{Operating Hours (I)}$$

where,

Y is the last year of the life cycle.

INCORP 3

Number of initial spares required at each location.

$$\text{Initial Spares} = \left(\text{Desired Number Months Supply on Hand} + \text{Number Months in Pipeline}\right) * \text{Utilization} * \text{Number of Components Operating At Each Location} \div \text{MTBR}$$

INCORP 4

Number of components scrapped (replacement spares).

$$\text{Replacement Spares} = \text{Cum Flight Hours} * \text{Scrap Rate}$$

INCORP 5

Total number of maintenance actions performed on the subject components by maintenance level.

$$\text{Sum of MA's (J)} = \sum_{I=1}^{Y} \sum_{J=1}^{3} \text{Life Cycle MA's (I,J)}$$

INCORP 6

Number of depot level maintenance actions performed by contractor.

$$\text{Contractor Overhauls} = \text{Sum of MA's (3)} * \text{\% Depot Maintenance Performed By Contractor}$$

where,

Sum of MA's (3) is the total number of depot level maintenance actions.

ZCOST 1

---

Total contractor shipping weight for items repaired by contractor at depot level.

$$\text{Contractor Shipping Weight} = \text{Contractor Overhauls} * \text{Component Weight} * 2$$

ZCOST 2

---

Multiplier to burden contractor costs to include overhead, general and administrative (G&A) and profit.

$$\text{Burden} = 1 + \text{Overhead Rate} + \text{G\&A Rate} + \text{Profit Rate}$$

ZCOST 3

---

Total cost for contractor transportation of components to and from depot repair facility.

$$\text{Contractor Transportation} = \text{Contractor Shipping Weight} * \text{Shipping Rate} * \text{Burden}$$

ZCOST 4

---

Total cost for depot level maintenance performed by the contractor.

$$\text{Contractor Depot Maintenance} = \text{Contractor Overhauls} * \text{Maintenance Manhours} * \text{Labor Rate} * \text{Parts Cost(3)} * \text{Burden}$$

ZCOST 5

Total contract costs for transportation and depot maintenance.

$$\text{Contract} = \text{Contractor Transportation} + \text{Contractor Overhaul Cost}$$

ZCOST 6

Total In-House (government) cost for parts consumed in the repair of components at the organizational and intermediate levels.

$$\text{Parts} = \sum_{J=1}^{2} \text{Sum of MA's (J)} * \text{Parts Cost (J)}$$

where,

Sum of MA's (1) represents organization level and
Sum of MA's (2) represents intermediate level.

ZCOST 7

Cost of fuel consumed in the operation of the components.

$$\text{POL} = \text{Cum Flight Hours} * \text{SFC} * \text{Fuel Cost}$$

where,

SFC = specific fuel consumption rate

ZCOST 8

Total consumption costs.

Consumption = Parts + POL

ZCOST 9

Total cost of maintenance labor to repair components at organizational and intermediate levels.

$$\text{Maintenance Labor} = \sum_{J=1}^{2} \text{Sum of MA's (J)} * \text{Maintenance Manhours (J)} * \text{Labor Rate (J)}$$

ZCOST 10

Number of depot level maintenance actions performed in-house.

$$\text{In-House Overhauls} = \text{Sum of MA's (3)} - \text{Contractor Overhauls}$$

ZCOST 11

Total in-house shipping weight for items repaired by the government at depot level.

$$\text{In-House Shipping Weight} = \text{In-House Overhauls} * \text{Component Weight} * 2$$

ZCOST 12

Total cost for in-house transportation of components to and from depot repair facility.

In-House Transportation = In-House Shipping Weight * Shipping Rate

ZCOST 13

Total cost for depot level maintenance performed by the government.

In-House Depot Maintenance = In-House Overhauls * Maintenance Manhours (3) * Labor Rate (3) * Parts Cost (3)

ZCOST 14

Total in-house costs for operations and maintenance (O&M).

In-House = Maintenance Labor + Consumption + In-House Transportation + In-House Depot Maintenance + Program Management Costs

ZCOST 15

Total operations and maintenance costs for both in-house and contract costs.

Operating Costs = Contract + In-House

ZCOST 16

Total life cycle cash flow attributable to the subject component.

$$\text{Cumulative Cash Flow Actual} = \text{Operating Costs} + \text{R\&D Costs} + \text{Investment Recurring} + \text{Investment Nonrecurring}$$

ZCOST 17

Discounted value of total life cycle cash flow.

$$\text{Present Value of Cash Flow} = \sum_{I=1}^{Y} \text{Cash Flow (I)} * (1 + i)^{-(I-.5)}$$

where,

I is the year
i is the discount rate

Cash Flow (I) is calculated by year using the ZCOST equations shown in this section.

ZCOST 18

Investment costs for alternate component configuration.

$$\text{Investment} = \text{R\&D Costs} + \text{Investment Recurring} + \text{Investment Nonrecurring}$$

These costs are discounted using equation ZCOST 18.

ZCOST 19

True rate of return on investment.

$$\text{True Rate of Return} = \left(\begin{matrix}\text{Baseline} \\ \text{Discounted} \\ \text{Cash Flow}\end{matrix} - \begin{matrix}\text{Alternate} \\ \text{Discounted} \\ \text{Cash Flow}\end{matrix}\right) \div \text{Investment} * \frac{100}{N}$$

where,

N is the project life.

MAIN 2

DEFINITIONS OF INPUT DATA

| | |
|---|---|
| ILT | mission leg type |
| INLEGS | number of legs |
| ILGDIS | leg distance in kilometers |
| IMD | mission duration in hours (used instead of ILGDIS) |
| IMISND | mission number |
| IMTYP | mission type |
| INPAS | number of passengers |
| INLIT | number of litters |
| INCAR | cargo weight |
| ICLS | aircraft mission class |
| IMLOAD | indivisible load weight if load cannot be broken down into smaller pieces |
| LASTCD | tells the program whether or not this is the last card in the mission description (yes or no; 1 or 0) |
| LSCASE | tells the program whether or not this is the last case to be run (yes or no; 1 or 0) |
| IHTMI | hover time with internal load in minutes |
| IHTMX | hover time with external load in minutes |
| IMCLSS | aircraft mission class |
| NAME | aircraft name |
| ISEAT | number of passenger seats in the aircraft |
| LITTER | number of litters which the aircraft can carry |
| IAMBS | number of ambulatory or attendant seats in the litter configuration |
| KMPHI | cruise speed with internal load in kilometers per hour |
| KMPHX | cruise speed with external load in kilometers per hour |

| | |
|---|---|
| IPAY | payload in pounds |
| IFA | floor area in square feet |
| NX | number of maintenance crews at the organizational level |
| XTBF | total aircraft mean time between maintenance including scheduled and unscheduled maintenance |
| TIMEX | total aircraft mean time to repair |
| TUIL | monthly aircraft utilization |
| AC | number of aircraft per company |
| ZZNORS | not-operationally-ready-supply (NORS) percent |
| IBER | tells the program whether or not this is a baseline establishment run (yes or no; 1 or 0) |
| LR | tells the program whether or not this is the last baseline establishment run (yes or no; 1 or 0) |
| MONTHS | number of months being considered in project study |
| NACSTR | number of components in the fleet at the beginning of the study period |
| NDLVCD | if aircraft are still being delivered with this component on, this tells the program whether they are being delivered at an irregular rate (yes or no; 1 or 0) |
| MODLV | if aircraft are still being delivered with this component on, and the delivery rate is constant, this is the number of components per month |
| MOS | the number of months that deliveries will continue |
| NDLWMD | tells the program whether the aircraft are being delivered with the modified part (yes or no; 1 or 0) |
| MOSTRT | start month for aircraft that are being delivered with the modification |
| NFHCD | tells the program whether the components are operating at an irregular utilization rate (yes or no; 1 or 0) |
| MOFH | flight hours per component per month, if utilization is constant |

| | |
|---|---|
| MODTT4 | total number of aircraft delivered with the modified part |
| OLRATE | subscripted variable which gives the MTBF, MTBR to AVIM and MTBR to depot for the old component configuration |
| EWRATE | subscripted variable which gives the MTBF, MTBR to AVIM and MTBR to depot for the new component configuration |
| NAME | component configuration name |
| INSCD1 | if the new component is to be installed in the field (or at depot), tells the program whether they are being incorporated at an irregular rate |
| LEVEL1 | if the incorporation rate is constant, number of modified parts incorporated per month |
| MEVEL1 | if the incorporation rate is irregular, number of months that incorporations continue |
| MODTT1 | total number of field incorporations |
| MMSTRT | start month for field incorporations |
| LOCAL | regarding the initial inventory level, the number of months' of spares that are kept on hand at each location |
| LINPIP | regarding the initial inventory level, the pipeline length for turnaround of spares |
| NCOMP | the number of aircraft company locations |
| ACATR | component attrition (scrap) rate per 100,000 hours |
| MOAC | subscripted variable (240), which tells the program how many components are being delivered per month, when aircraft are being delivered at an irregular rate |
| MOUTIL | subscripted variable (240), which tells the program the utilization per component per month, when utilization is irregular |
| INC1 | subscripted variable (240), which tells the program how many field incorporations per month take place, when the incorporation rate is irregular |

The following six input definitions apply to both the old item and the new item; the first variable name pertains to the old item and the second pertains to the new item.

| | |
|---|---|
| NDL, NDLN | the percent of depot level maintenance performed by the contractor |
| CRATE, CRATEN | contractor unburdened hourly rate (dollars per hour) |
| HMM, HMMN | subscripted variable (3) which gives average maintenance manhours to repair the component at organizational, intermediate and depot |
| PARTS, PARTSN | subscripted variable (3) which gives average value of parts consumed per repair of the component at the three repair levels |
| POLRA, POLRAN | pounds of fuel consumed per operating hour; this should only be used if the change in the component will change the fuel consumption rate, otherwise leave blank |
| LBSO, LBSN | component shipping weight |
| NOCPM | subscripted variable (20) for yearly cost of program management |
| OHD | contractor overhead percent |
| GNA | contractor general and administrative percent |
| PROFIT | contractor profit percent |
| XPORTC | contractor shipping rate (dollars per 100 lb) |
| XPORTI | in-house shipping rate (dollars per 100 lb) |
| CJP | cost per gallon for fuel (JP-4) |
| FI | discount rate (%) |

The following input definitions describe the subscripted variable OUT. This variable name is used for all of the Army Regulation 37-18 cost categories.

| | |
|---|---|
| OUT (1) | total research and development (R&D) costs |
| OUT (3) | R&D engineering costs |
| OUT (4) | R&D tooling costs |

OUT (5) R&D prototype production

OUT (6) any other R&D costs not itemized

OUT (7) R&D general and administrative costs

OUT (8) R&D profit

OUT (9) quantity of prototypes

OUT (11) in-house R&D program management costs

OUT (14) total investment nonrecurring costs

OUT (16) investment nonrecurring advanced production engineering costs

OUT (17) investment nonrecurring tooling costs

OUT (18) investment nonrecurring manufacturing costs

OUT (19) investment nonrecurring quality control costs

OUT (20) any other investment nonrecurring costs not itemized

OUT (21) investment nonrecurring general and administrative costs

OUT (22) investment nonrecurring profit

OUT (24) investment nonrecurring in-house program management costs

OUT (27) total investment recurring costs

OUT (29) investment recurring engineering costs

OUT (30) investment recurring tooling costs

OUT (31) investment recurring quality control costs

OUT (32) investment recurring manufacturing costs

OUT (33) investment recurring first destination transportation costs

OUT (34) any other investment recurring costs not itemized

OUT (35) investment recurring general and administrative costs

| | |
|---|---|
| OUT (36) | investment recurring profit |
| OUT (38) | in-house transportation costs |
| OUT (39) | in-house program management costs |
| OUT (40) | quantity of components produced |
| NCODE | tells the program whether overhead is included in the cost (yes or no; 1 or 0) |
| NRDEST | tells the program whether to estimate R&D costs (yes or no; 1 or 0) |
| NRD | subscripted variable (5) for yearly cost of R&D |
| NINEST | tells the program whether to estimate investment nonrecurring costs (yes or no; 1 or 0) |
| NIN | subscripted variable (20) for yearly investment nonrecurring costs |
| NUNITC | number of units to be shipped by contractor; use only if first destination transportation costs are unknown |
| LBSC | shipping weight of component for contractor shipping cost calculation |
| NUNITI | number of units to be shipped by government; use only if in-house transportation costs are unknown |
| LBSI | shipping weight of component for in-house shipping cost calculation |
| NIREST | tells the program whether to estimate investment recurring costs (yes or no; 1 or 0) |
| NIR | subscripted variable (20) for yearly investment recurring costs |
| NAME | subscripted variable (57, 8) which gives labels to the cost categories |

DEFINITIONS OF OUTPUT DATA

| | |
|---|---|
| ISOR | number of sorties required to complete a particular mission |
| FLTHL | number of flight hours for each sortie |
| ISORT | total number of sorties required for all missions |
| TFLT | total number of flight hours required for all missions |
| MTL | maximum number of seats utilized when aircraft is payload constrained |
| MLL | maximum number of litters utilized when aircraft is payload contrained |
| MAS | maximum number of ambulatory seats utilized when aircraft is payload constrained |
| IDIV | number of missions that should be deleted on the basis of the indivisable load being greater than the payload capability |
| MNUM | mission number to be deleted |
| LSIZ | load weight to be deleted |
| TILU | flight hours per aircraft per month (utilization) |
| XREORD | mean time to repair (MTTR) |
| XXQ | expected queue length |
| XXWAIT | expected waiting time for men |
| XXNUM | expected number of tasks in the system |
| XXTIME | expected time in the system |
| XZ | probability of no tasks in the system |
| XTWTIM | total waiting time |
| XTDTIM | total not-operationally-ready-maintenance (NORM) time |
| XONORW | NORM percent-waiting |
| XONORT | NORM percent-total |

| | |
|---|---|
| AVAIL | availability percent |
| TUIL | utilization when utilization is so high that it results in a constant queue |
| TFLT1 | baseline flight hours required to perfrom the mission |
| TFLT2 | alternate flight hours required to perform the mission |
| AVAIL1 | baseline availability percent |
| AVAIL2 | alternate availability percent |
| UTIL1 | baseline utilization |
| UTIL2 | alternate utilization, holding availability constant |
| FLTSZ1 | baseline fleet size required to perform the mission |
| FLTSZ2 | alternate fleet size required to perform the mission, holding availability constant |
| ZVAIL2 | alternate availability percent, holding utilization constant |
| ZUTIL2 | alternate utilization |
| FLTSZ4 | alternate fleet size, holding utilization constant |
| AVAIL3 | alternate availability percent, holding fleet size constant |
| UTIL3 | alternate utilization, holding fleet size constant |
| NOLTOT | subscripted variable (3) which gives number of maintenance actions on the old item at the three repair levels |
| NEWTOT | subscripted variable (3) which gives number of maintenance actions on the new item at the three repair levels |
| LOCMFH | total operating hours accumulated on the old items over the life cycle |
| NWCMFH | total operating hours accumulated on the new items over the life cycle |

| | |
|---|---|
| NSPARS | initial spares required per location |
| NACATR | parts scrapped over the life cycle |
| OUT | subscripted variable (60) which gives total costs by category for the baseline |
| OUTA | subscripted variable (60) which gives total costs by category for the alternate |
| COST | double subscripted variable (20, 3) which gives costs by year by category (annual cost, cumulative cost, present value) for the baseline |
| COSTA | double subscripted variable (20, 3) which gives costs by year by category (annual cost, cumulative cost, present value) for the alternate |
| IBRKEV | symbol to designate in which year the break-even point is reached, when costs are not discounted |
| IBRDIS | symbol to designate in which year the break-even point is reached, when costs are discounted |
| OM | subscripted variable (20) which gives annual operations and maintenance (O&M) costs for the alternate |
| TEMP | cumulative O&M costs for the alternate |
| NOLD | subscripted variable (20) which gives number of old items in the fleet by year |
| NNEW | subscripted variable (20) which gives number of new items in the fleet by year |
| NUMTOT | total number of components, both old and new in the fleet |
| VEST | total investment, discounted |
| TRR | true rate of return on investment |

INPUT DATA

The following section shows the input data as it was coded on the forms for the sample test case.

Run no.

Page of

MISSION DATA

Card A

| 1. Leg type *1 | 2. Number of legs | 3. Leg distance (km) |
|---|---|---|
| 1 (1) | 1 (2) | 2,5,5 (3–5) |
| **3. Mission duration** | **5. Mission number** | **6. Mission type *5** |
| 0.0 (6–8) | 1 (9) | 6 (10) |
| **7. Number of passengers** | **8. Number of litters** | **9. Cargo weight** |
| 2,1,2,8,7,2 (11–16) | 0 (17–21) | 6,5,0,2,2,7,2,0 (22–29) |
| **10. Aircraft mission Class *2** | **11. Indivisible load weight** | **12. Last card in mission description? * 3** |
| 1 (30) | 1 (31–35) | 1 (36) |

*1 Leg types - 1 = round trip, carries load out returns empty.
2 = one way

*2 Mission class - 3 = medevac, 1 = all others

**13. Last case? * 4**

1 (37)

*3 When only one card describes the mission, should have a 1 (yes); when using more than one card, last card should have a 1.

*4 1 = yes.

*5

| MISSION TYPE | DESCRIPTION |
|---|---|
| 1 | Passengers |
| 2 | Passengers |
| 3 | Litter Tasks |
| 4 | Cargo (internal) |
| 5 | Cargo (external) |
| 6 | Passengers and internal cargo |
| 7 | Passengers and external cargo |
| 8 | Observation or attack |
| 9 | Move to position |

Run no.

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Card B

AIRCRAFT CAPABILITY
(BASELINE)

| 1. Hover time with internal load (min.) | 2. Hover time with external load (min.) | 3. Mission class *1 |
|---|---|---|
| 2 (1–3) | 2 (4–6) | 1 (7–9) |
| **4. Aircraft name** | **5. Number of seats** | **6. Number of litters** |
| 4,7,C, ,B,A,S,E,L,I,N,E (10–18) | 4,4 (22–24) | 2,4 (25–27) |
| **7. No. of ambulatory seats *2** | **8. Cruise speed with internal load (kmph)** | **9. Cruise speed with external load (kmph)** |
| 2 (28–30) | 2,5,9 (31–33) | 2,3,8 (34–36) |

| 10. Payload (pounds) | 11. Floor area (square feet) *3 |
|---|---|
| 2,4,0,0,0 (37–41) | 2,4,0 (42–46) |

*1 Mission class - 3 = medevac, 1 = all others; this must agree with mission class in block 9 of mission data card in order for this aircraft to fly that mission.

*2 Seats in addition to litters on medevac flights.

*3 Used for killed in action (KIA) evacuation. 1 KIA = 10 sq. ft.

RAM DATA

(BASELINE)

Run no.

Page of

Card C

| | |
|---|---|
| 1. Number of crews: 6 (1) | 2. Aircraft MTBF: 0.7505 (3–11) |
| 3. Aircraft average MTTR: 2.15 (12–17) | 4. Monthly aircraft utilization: 50.0 (18–22) |

| | | |
|---|---|---|
| 5. Number of aircraft per company: 16. (23–27) | 6. NORS level: 7.0 (28–31) | 7. Baseline establishment run? *1: 0 (32) |

*1 1 = yes; if yes, run will terminate after giving availability/utilization output.

*2 1 = yes; if no, additional 'c' cards may follow.

8. Last baseline establishment run? *2 (33)

Run no.

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Card D

AIRCRAFT CAPABILITY
(ALTERNATE)

| 1. Hover time with internal load (min.) | 2. Hover time with external load (min.) | 3. Mission class *1 |
|---|---|---|
| 2 (1–3) | 2 (4–6) | 1 (7–9) |
| **4. Aircraft name** | **5. Number of seats** | **6. Number of litters** |
| 47 ALTERNATE (10–18) | 44 (22–24) | 24 (25–27) |
| **7. No. of ambulatory seats *2** | **8. Cruise speed with internal load (kmph)** | **9. Cruise speed with external load (kmph)** |
| 2 (28–30) | 259 (31–33) | 238 (34–36) |
| **10. Payload (pounds)** | **11. Floor area (square feet) *3** | |
| 23993 (37–41) | 240 (42–46) | |

*1 Mission class - 3 = medevac, 1 = all others; this must agree with mission class in block 9 of mission data card in order for this aircraft to fly that mission.

*2 Seats in addition to litters on medevac flights.

*3 Used for killed in action (KIA) evacuation. 1 KIA = 10 sq. ft.

Run no.

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RAM DATA
(ALTERNATE)

Card E

| 1. Number of crews (1) | 2. Aircraft MTBF (3–11) |
|---|---|
| 6 | 0.7513 |
| **3. Aircraft average MTTR (12–17)** | **4. Monthly aircraft utilization (18–22)** |
| 2.05 | |
| **5. Number of aircraft per company (23–27)** | **6. NORS level (28–31)** |
| 16. | 7.0 |

Run no.

Page of

Card F

INCORPORATION DATA
(BASELINE)

| | | |
|---|---|---|
| 1. Number of months in study: 180 (1–3) | 2. Number of components in fleet: 296 (4–7) | 3. If AC still being delivered, irregular delivery rate? *1: 0 (8) |
| 4. If constant delivery rate, no. components per mo.: 4 (9) | 5. Number of months: 25 (11–13) | 6. AC delivered with modification? *2: 0 (14) |
| 7. Start month for deliveries *3: 1 (15–17) | 8. Irregular utilization? *1: 0 (18) | 9. If constant utilization, flight hours/component/month: 50 (19–21) |
| 10. Total no. mods to be installed on new aircraft as delivered.: 0 (22–25) | 11. | Old item / New item |
| | MTBF: 206.0 (26–32) | 292.7 (33–39) |
| | MTBR to AVIM: (40–46) | (47–53) |
| | MTBR to depot: (54–60) | (61–67) |

*1 1 = yes; if yes, irregular rate and/or utilization can be entered on special succeeding cards.

*2 1 = yes

*3 with reference to block 1, no. months in study

12. Configuration name: OLD STIFFNER (68–76)

Run no.

Page of

## FIELD INCORPORATION (BASELINE)

Card G

| 1. Irregular field mod incorporation rate? *1 [0] (1) | 2. If constant, no. incorporated per mo. [.0] (2–4) | 3. If irregular, number of months [.0] (5–7) |
|---|---|---|
| 4. Total field incorporations [.0] (8–11) | 5. Start month *2 [.0] (12–14) | |
| 6. Spares stocking level:<br>1 month's quantity on hand, or [ ] (15) months<br>4 months pipeline quantity, or [ ] (17) months | | 7. Comp. attrition rate<br>2 per 100,000 hrs, or<br>[ . ] (19–24) /100,000 |
| *1 1 = yes; if yes, irregular rate can be entered on special succeeding cards.<br>*2 With reference to block 1 of incorporation data card (previous card). | | 8. No. of company locations. [ ] (25) |

Card H (optional)

DELIVERIES, FLIGHT HOURS, OR

INCORPORATIONS PER MONTH
(BASELINE)

Run no.

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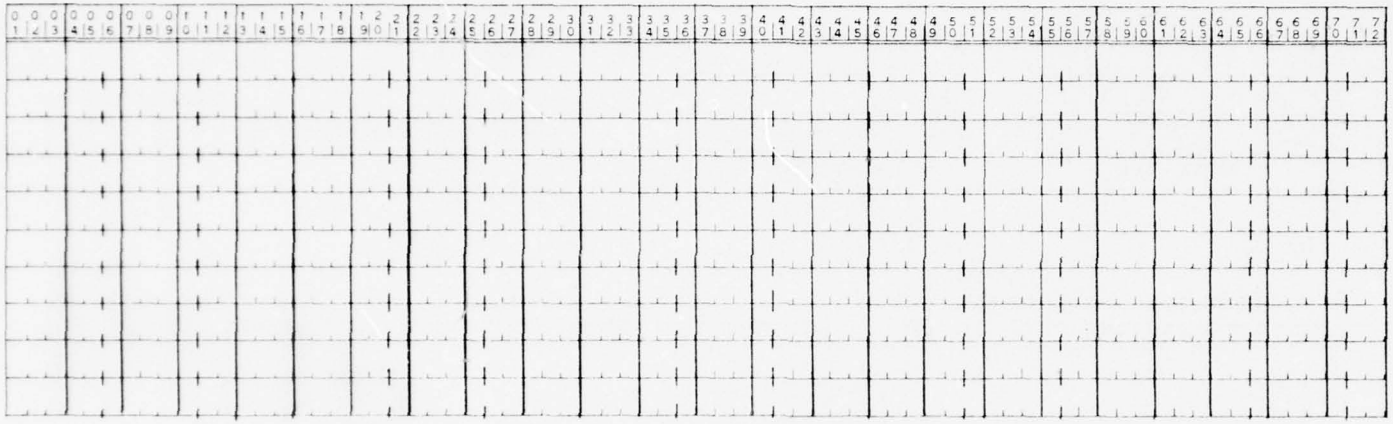
(NOT REQUIRED THIS RUN)



This card may be used when deliveries, flight hours, and/or incorporations per month occur at an irregular rate.

Each 3-column field represents 1 month. There are 24 fields per line, and 10 lines for a total of 240 months or 20 years.

Run no.

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Card I

INCORPORATION DATA
(ALTERNATE)

| | | |
|---|---|---|
| 1. Number of months in study: 180 (1–3) | 2. Number of components in fleet: 296 (4–7) | 3. If AC still being delivered, irregular delivery rate? *1: 0 (8) |
| 4. If constant delivery rate, no. components per mo.: 4 (9) | 5. Number of months: 25 (11–13) | 6. AC delivered with modification? *2: 1 (14) |
| 7. Start month for deliveries *3: 13 (15–17) | 8. Irregular utilization? *1: 0 (18) | 9. If constant utilization, flight hours/component/month: 50 (19–21) |
| 10. Total no. mods to be installed on new aircraft as delivered.: 52 (22–23) | 11. | Old item / New item |
| | MTBF: 206.0 (26–32) | 292.7 (33–39) |
| | MTBR to AVIM: (40–46) | (47–53) |
| | MTBR to depot: (54–60) | (61–67) |

*1 1 = yes; if yes, irregular rate and/or utilization can be entered on special succeeding cards.

*2 1 = yes

*3 with reference to block 1, no. months in study

12. Configuration name: NEW STIFFNER (68–72, 73–76)

Run no.

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FIELD INCORPORATION
(ALTERNATE)

Card J

| 1. Irregular field mod incorporation rate? *1 | 2. If constant, no. incorporated per mo. | 3. If irregular, number of months |
|---|---|---|
| 0 (1) | 3.7 (2–4) | .0 (5–7) |

| 4. Total field incorporations | 5. Start month *2 |
|---|---|
| 344 (8–11) | 13 (12–14) |

| 6. Spares stocking level: | 7. Comp. attrition rate |
|---|---|
| 1 month's quantity on hand, or ____ (15) months | 2 per 100,000 hrs, or |
| 4 months pipeline quantity, or ____ (17) months | ____ (19–24) /100,000 |

*1 1 = yes; if yes, irregular rate can be entered on special succeeding cards.

*2 With reference to block 1 of incorporation data card (previous card).

8. No. of company locations. ____ (25)

Card K (optional)

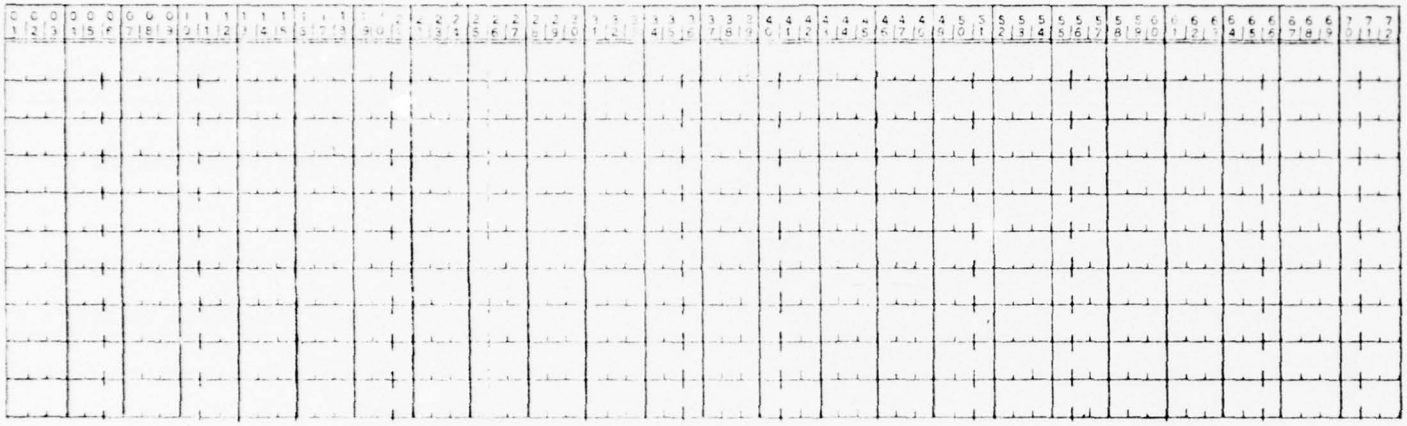
DELIVERIES, FLIGHT HOURS, OR

INCORPORATIONS PER MONTH
(ALTERNATE)

Run no.

Page of

(NOT REQUIRED THIS RUN)



This card may be used when deliveries, flight hours, and/or incorporations per month occur at an irregular rate.

Each 3-column field represents 1 month. There are 24 fields per line, and 10 lines for a total of 240 months or 20 years.

OPERATING COST DATA
(BASELINE - OLD ITEM)

Run no.

page of

Card L

| | | |
|---|---|---|
| 1. % of depot level maintenance performed by contractor<br>0 (1–3) | 2. Contractor unburdened hourly rate<br>0.00 (4–8) | 3. Avg. MMH to repair at depot level<br>0.0 (9–14) |
| 4. Avg. value of parts consumed at depot repair<br>0.00 (15–22) | 5. Avg. value of parts consumed at AVUM repair<br>5.00 (23–28) | 6. Avg. MMH to repair at AVUM level<br>8.9 (29–33) |
| 7. Lbs. of fuel consumed per flt. hr. *1<br>0.0 (34–39) | 8. Avg. value of parts consumed at AVIM repair<br>0.00 (39–44) | 9. Avg. MMH to repair at AVIM level<br>0.0 (45–49) |
| 10. Component shipping weight<br>0 (50–53) | | |

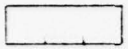
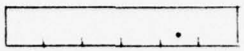
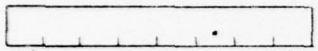
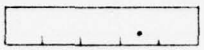
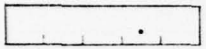
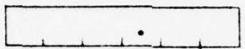
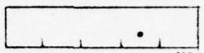
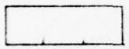
*1 Should only be completed if the new item will cause this to change.

OPERATING COST DATA
(BASELINE - NEW ITEM)

Run no.

page of

Card M

| | | |
|---|---|---|
| 1. % of depot level maintenance performed by contractor   | 2. Contractor unburdened hourly rate | 3. Avg. MMH to repair at depot level   |
| 4. Avg. value of parts consumed at depot repair   | 5. Avg. value of parts consumed at AVUM repair | 6. Avg. MMH to repair at AVUM level   |
| 7. Lbs. of fuel consumed per flt. hr. *1   | 8. Avg. value of parts consumed at AVIM repair   | 9. Avg. MMH to repair at AVIM level   |
| 10. Component shipping weight   | | |

*1 Should only be completed if the new item will cause this to change.

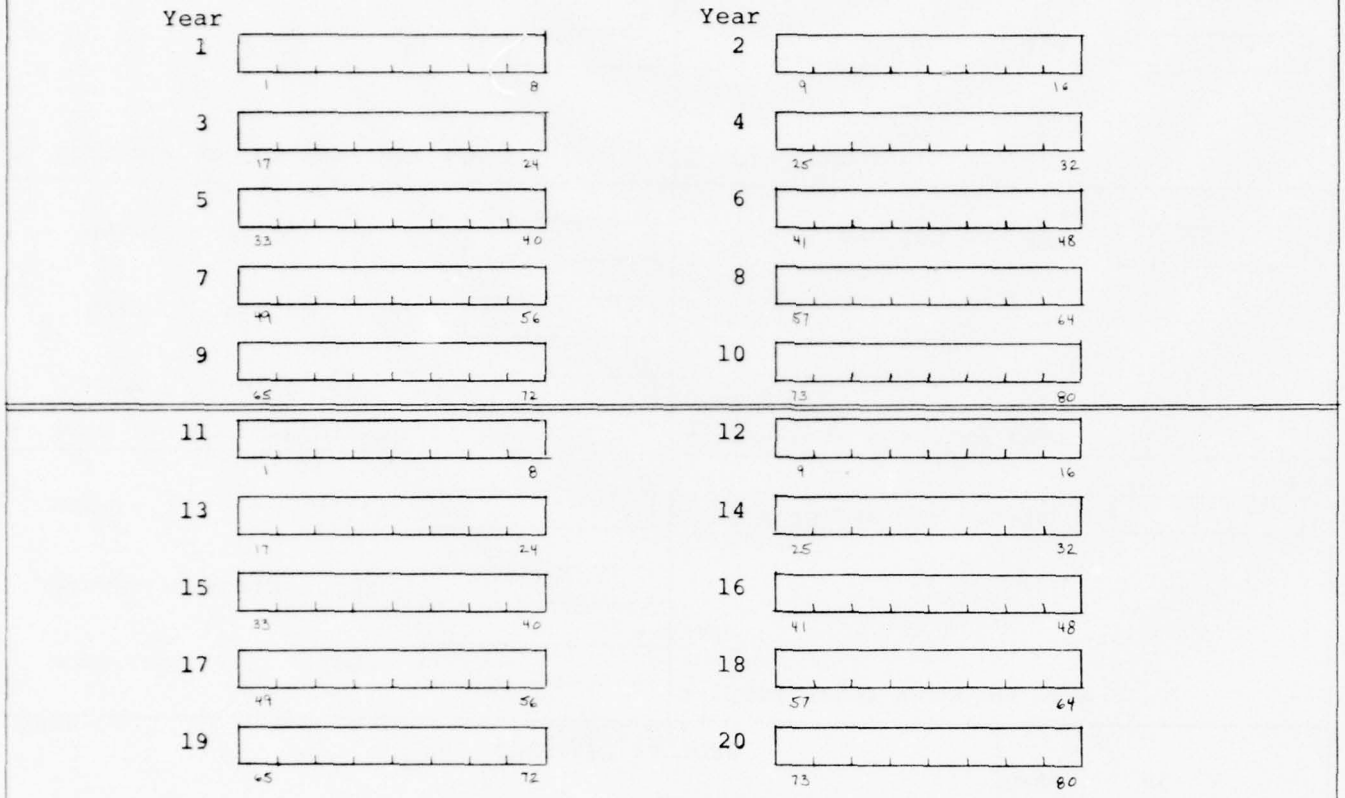
OPERATING COST - PROGRAM MGMT.

(BASELINE)

Run no.

Page of

Card N



Run no.

Page of

Card Q

## CONSTANT FACTORS (BASELINE)

1.
overhead 180% (1 – 6)

general & admin. 17% (7 – 12)

profit 10% (13 – 18)

2. Contractor shipping rate

$17.00 per 100 pounds (19 – 23)

3. Army labor rates per hr.

AVUM $10.00 (24 – 28)

AVIM 11.00 (29 – 33)

depot 13.50 (34 – 38)

4. In-house shipping rate

$13.00 per 100 pounds (39 – 43)

5. Cost per gallon for fuel (JP-4)

$ 0.45 (44 – 47)

6. Discount rate

10% (48 – 51)

This card shows values used in the program, which may be changed by the user.

OPERATING COST DATA
(ALTERNATE - OLD ITEM)

Run no.

page of

Card P

| | | |
|---|---|---|
| 1. % of depot level maintenance performed by contractor (1–3) 0 | 2. Contractor unburdened hourly rate (4–8) 0.00 | 3. Avg. MMH to repair at depot level (9–14) 0.0 |
| 4. Avg. value of parts consumed at depot repair (15–22) 0.00 | 5. Avg. value of parts consumed at AVUM repair (23–28) 5.00 | 6. Avg. MMH to repair at AVUM level (29–33) 8.9 |
| 7. Lbs. of fuel consumed per flt. hr. *1 (34–38) 0.0 | 8. Avg. value of parts consumed at AVIM repair (39–44) 0.00 | 9. Avg. MMH to repair at AVIM level (45–49) 0.0 |
| 10. Component shipping weight (50–52) 0 | | |

*1 Should only be completed if the new item will cause this to change.

OPERATING COST DATA
(ALTERNATE - NEW ITEM)

Run no.

page of

Card Q

| | | |
|---|---|---|
| 1. % of depot level maintenance performed by contractor (1–3) 0 | 2. Contractor unburdened hourly rate (4–8) 0.00 | 3. Avg. MMH to repair at depot level (9–14) 0.0 |
| 4. Avg. value of parts consumed at depot repair (15–22) 0.00 | 5. Avg. value of parts consumed at AVUM repair (23–28) 5.00 | 6. Avg. MMH to repair at AVUM level (29–33) 8.9 |
| 7. Lbs. of fuel consumed per flt. hr. *1 (34–38) 0.0 | 8. Avg. value of parts consumed at AVIM repair (39–44) 0.00 | 9. Avg. MMH to repair at AVIM level (46–49) 0.0 |
| 10. Component shipping weight (50–52) 0 | | |

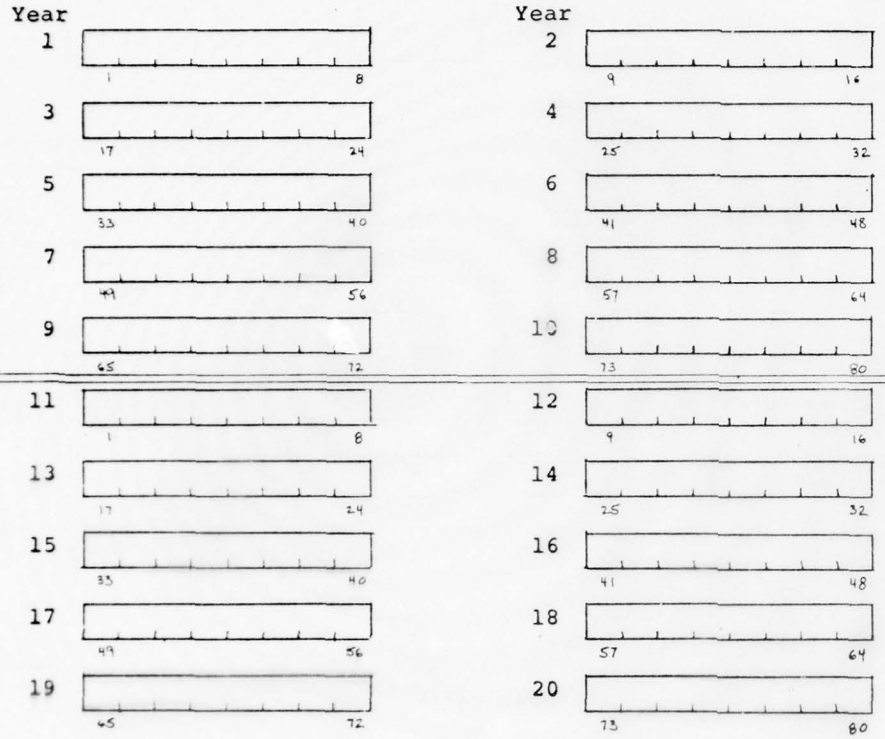
*1 Should only be completed if the new item will cause this to change.

OPERATING COST - PROGRAM MGMT.
(ALTERNATE)

Run no.

Page of

Card R



Run no.

Page of

Card S

CONSTANT FACTORS
(ALTERNATE)

1.

| | | |
|---|---|---|
| overhead | 180% | 1 – 6 |
| general & admin. | 17% | 7 – 12 |
| profit | 10% | 13 – 18 |

2. Contractor shipping rate

$17.00 per 100 pounds (19 – 23)

3. Army labor rates per hr.

| | | |
|---|---|---|
| AVUM | $10.00 | 24 – 28 |
| AVIM | 11.00 | 29 – 33 |
| depot | 13.50 | 34 – 38 |

4. In-house shipping rate

$13.00 per 100 pounds (39 – 43)

5. Cost per gallon for fuel (JP-4)

$ 0.45 (44 – 47)

6. Discount rate

10% (48 – 51)

This card shows values used in the program, which may be changed by the user.

Run no.

Page of

R&D COSTS

Card T

1. Contract

Overhead already included (1 = yes)

| | | | |
|---|---|---|---|
| Engineering | 1 | 7 | 8 |
| Tooling | 9 | 15 | 16 |
| Prototype prod. | 17 | 23 | 24 |
| Other | 25 | 30 | 31 |
| G&A | 32 | 37 | |
| Profit | 38 | 43 | |
| Qty. of prototypes | 44 | 46 | |
| In-house Program mgmt. | 47 | 53 | |

2. If you do not wish to break out cost elements,

Total R&D costs (54–61)

3. R&D costs are unknown - Estimate (1 = yes) (62) 0

4. R&D costs per year:

| Year | | Year | |
|---|---|---|---|
| 1 | 1–8 | 4 | 9–16 |
| 2 | 17–24 | 5 | 25–32 |
| 3 | 33–40 | | |

INVESTMENT NONRECURRING COSTS

Run no.

Page of

Card U

1. Contract

Overhead already included? (1 = yes)

| | | | |
|---|---|---|---|
| Adv. prod. eng. | 1 | 7 | 8 |
| Tooling | 9 | 15 | 16 |
| Manufacturing | 17 | 23 | 24 |
| Quality Control | 25 | 31 | 32 |
| Other | 33 | 38 | 39 |
| G&A | 40 | 45 | |
| Profit | 46 | 51 | |
| In-house Program mgmt. | 52 | 58 | |

2. If you do not wish to break out cost elements,

Total Inv. Nonrecurring Costs (59–66): 1,6,0,2,7

3. Inv. nonrecurring costs are unknown - Estimate (1 = yes) (67)

INVESTMENT NONRECURRING COSTS

Run no.

Page of

Card V

| | | | |
|---|---|---|---|
| Year 1 | 1,6,0,2,7 (1–8) | Year 2 | (9–16) |
| 3 | (17–24) | 4 | (25–32) |
| 5 | (33–40) | 6 | (41–48) |
| 7 | (49–56) | 8 | (57–64) |
| 9 | (65–72) | 10 | (73–80) |
| 11 | (1–8) | 12 | (9–16) |
| 13 | (17–24) | 14 | (25–32) |
| 15 | (33–40) | 16 | (41–48) |
| 17 | (49–56) | 18 | (57–64) |
| 19 | (65–72) | 20 | (73–80) |

INVESTMENT RECURRING COSTS

Run no.

Page of

Card W

1. Contract

Overhead already included? (1 = yes)

| | | |
|---|---|---|
| Engineering | 1–7 | 8 |
| Tooling | 9–15 | 16 |
| Quality Control | 17–23 | 24 |
| Manufacturing | 25–32 | 33 |
| First dest. transp. | 34–40 | |
| Other | 41–47 | |
| G&A | 53–59 | |
| Profit | 63–69 | |

OR

2. No. of units to be shipped: 48–52

lbs/unit 60–62

3. In-house

| | |
|---|---|
| Transportation | 1–7 |
| Program mgmt. | 8–14 |

OR

4. No. of units to be shipped: 15–19

lbs/unit 20–22

5. If you do not wish to break out elements,

Total Inv.Rec. costs 7,496,3 (23–31)

6. Inv. recurring costs unknown - Estimate (1 = yes) 32

7. Qty. of kits or components produced 450 (33–36)

INVESTMENT RECURRING COSTS

Run no.

Page of

Card X

| Year | | Year | |
|---|---|---|---|
| 1 | (1–8) | 2 | 2382 (9–16) |
| 3 | 72581 (17–24) | 4 | (25–32) |
| 5 | (33–40) | 6 | (41–48) |
| 7 | (49–56) | 8 | (57–64) |
| 9 | (65–72) | 10 | (73–80) |
| 11 | (1–8) | 12 | (9–16) |
| 13 | (17–24) | 14 | (25–32) |
| 15 | (33–40) | 16 | (41–48) |
| 17 | (49–56) | 18 | (57–64) |
| 19 | (65–72) | 20 | (73–80) |

BEST AVAILABLE COPY

PROGRAM LISTING

```
*JOB              STEVE,KP=29,LINES=60,PAGES=99,TIME=180,RUN=CHECK LIST=NO
 1        DIMENSION OUT(60),OUTA(60),NUMOL(20,3),NUMEW(20,3),NOLTOT(3),
         1 NEWTOT(3),          NFHYR(20,2),COST(20,3),COSTA(20,3),IBRKEV(20),
         2 IBRDIS(20),NOLD(20),NNEW(20),DM(20),NUMO1(20,3),NAME(57,8),
         3 NUME1(20,3),NOLTO1(3),NEWTO1(3),NFHY1(20,2)
 2        COMMON ILT(100), INLEGS(100), ILGDIS(100), IMISND(100),
         1                             IMTYP(100), IMD(100), INPAS(100),
         2 INLIT(100), INCAR(100),ICLS(100), IMLOAD(100)
 3        DATA                  IRECUM/'*'/,IBEDIS/'#'/,IBLAN1/' '/
C-----READ LABELS
 4        DO 5 I=1,57
 5      5 READ(5,7) (NAME(I,J),J=1,8)
 6      7 FORMAT(8A4)
C-----READ IN MISSION CARDS
 7     10 DO 14 I=1,100
 8        READ(5,15) ILT(I),INLEGS(I),ILGDIS(I),IMD(I),IMISND(I),
         1           IMTYP(I),        INPAS(I),INLIT(I),INCAR(I),
         2  ICLS(I),IMLOAD(I),LASTCD,LSCASE
 9        NA=I
10        IF(LASTCD.EQ.1) GO TO 16
11     14 CONTINUE
12     15 FORMAT(2I1,I3,F3.1, 2I1,    I6,I5,I8,I1,I5,2I1)
13     16 CALL MISHIN(NA,TFLT1)
14        NFLAG=0
15        CALL QUEUE(UTIL1,TDTIME,AVAIL1,DESNOR,NFLAG,X,Z,DUMMY1,DUMMY2,XYZ)
C       MAIN 1
16        FLTSZ1=TFLT1/UTIL1
17        CALL MISHIN(NA,TFLT2)
18        UTIL3=TFLT2/FLTSZ1
19        NFLAG=1
20        CALL QUEUE(UTIL2,TDTIME,AVAIL2,DESNOR,NFLAG,ZUTIL2,ZVAIL2,UTIL3,
         1 AVAIL3,XYZ)
21        FLTSZ2=TFLT2/UTIL2
22        FLTSZ4=TFLT2/ZUTIL2
23        WRITE(6,9000) TFLT1,TFLT2,AVAIL1,AVAIL2, UTIL1,UTIL2,
         1 FLTSZ1,FLTSZ2,AVAIL1,ZVAIL2,UTIL1,ZUTIL2,FLTSZ1,FLTSZ4,AVAIL1,
         2 AVAIL3,UTIL1,UTIL3,FLTSZ1,FLTSZ1
C-----FIRST INCORP CALL PROVIDES DATA FOR
C-----FIRST ZCOST CALL. DITTO SECOND CALLS.
24        LFLAG=1
25        CALL INCORP(MODTT1,MODTT2,MODTT3,MODTT4,NUMO1,NUME1,NOLTO1,
         1 NEWTO1,LOCMF1,NWCMF1,MAC,NFHY1,NYR,NOLD,NNEW,LFLAG)
26        LFLAG=2
27        CALL INCORP(MODTT1,MODTT2,MODTT3,MODTT4,NUMOL,NUMEW,NOLTOT,
         1 NEWTOT,LOCMFH,NWCMFH,JAC,NFHYR,NYR,NOLD,NNEW,LFLAG)
28        JFLAG=0
29        CALL ZCOST(NUMO1,NUME1,NOLTO1,NEWTO1,JFLAG,LOCMF1,NWCMF1,OUT,COST,
         1 NFHY1,DM,VEST,NYRCHK,TMP)
30        JFLAG=1
31        CALL ZCOST(NUMOL,NUMEW,NOLTOT,NEWTOT,JFLAG,LOCMFH,NWCMFH,OUTA,
         1 COSTA,NFHYR,DM,VEST,NYRCHK,TMP)
32        OUT(57)=MAC
33        OUTA(57)=JAC
34        WRITE(6,8449)
35        DO 500 I=1,57
36        IF(I.EQ.1.OR.I.EQ.14.OR.I.EQ.27.OR.I.EQ.43) GO TO 450
37        IF(I.EQ.2.OR.I.EQ.10.OR.I.EQ.15.OR.I.EQ.23.OR.I.EQ.28) GO TO 475
38        IF(I.EQ.37.OR.I.EQ.40.OR.I.EQ.44.OR.I.EQ.49.OR.I.EQ.57) GO TO 475
39        WRITE(6,8500) (NAME(I,K),K=1,8),OUT(I),OUTA(I)
40        GO TO 500
```

```
      450 WRITE(6,8450) (NAME(I,K),K=1,8),OUT(I),OUTA(I)
          GO TO 500
      475 WRITE(6,8475) (NAME(I,K),K=1,8),OUT(I),OUTA(I)
      500 CONTINUE
          WRITE(6,8600)
          ICHCUM=0
          ICHDIS=0
          TEMP=OM(1)
          DO 601 I=1,NYR
          IBRKEV(I)=IBLAN1
          IBRDIS(I)=IBLAN1
          IF(ICHCUM.NE.0) GO TO 580
          IF(COSTA(I,2).GT.COST(I,2)) GO TO 580
          IF(I.GE.NYRCHK) IBRKEV(I)=IBECUM
          ICHCUM=1
      580 IF(ICHDIS.NE.0) GO TO 600
          IF(COSTA(I,3).GT.COST(I,3)) GO TO 600
          IF(I.GE.NYRCHK) IBRDIS(I)=IBEDIS
          ICHDIS=1
      600 IF(I.GT.1) TEMP=TEMP+OM(I)
          NUMTOT=NOLD(I)+NNEW(I)
      601 WRITE(6,8700) I,(COST(I,J),J=1,3),(COSTA(I,J),J=1,2),IBRKEV(I),
         1 COSTA(I,3),IBRDIS(I),OM(I),TEMP,NOLD(I),NNEW(I),NUMTOT
C         MAIN 2
          WRITE(6,8800)
          RETURN=COST(NYR,3)-COSTA(NYR,3)
          TRR=(RETURN/VEST)*(100/NYR)
          WRITE(6,8900) COST(NYR,2),COSTA(NYR,2),COST(NYR,3),COSTA(NYR,3),
         1VEST,TRR
          WRITE(6,9010)
     8000 FORMAT(8A4)
     8449 FORMAT(1H1,T3,'OUTPUTS :',T41,'BASELINE',T64,'ALTERNATE',/)
     8450 FORMAT(T3,8A4,1XF10.0,13XF10.0)
     8475 FORMAT(T3,8A4,7XF10.0,13XF10.0)
     8500 FORMAT(T3,8A4,13XF10.0,13XF10.0)
     8600 FORMAT(1H1,/////T18,'B A S E L I N E',T72,'A L T E R N A T E',
         1 /T12,'ANNUAL        CUM,     PRESENT',
         2  T47,'ANNUAL        CUM,     PRESENT',
         A T85,'ANNUAL       CUM       OLD    NEW    TOTAL',/T3,'YEAR',
         3   T13,'COST         COST      VALUE',
         4   T48,'COST         COST      VALUE'
         B T83,'O&M COSTS  O&M COSTS  ITEMS  ITEMS  ITEMS',/)
     8700 FORMAT(T5,I2,3(1X,F10.0),2X,2(1X,F10.0), 1X,1A1,1X,F10.0,1X,1A1,
         1 2X,    2(1X,F10.0),3(3X,I4))
     8800 FORMAT(         //T3,' * = BREAK EVEN POINT, (COSTS NOT DISCOUNTED)
         1.',/T3,' # = BREAK EVEN POINT, (PRESENT VALUE).',///)
     8900 FORMAT(/////T40,'BASELINE   ALTERNATE',
         1 //T3,'CUMULATIVE CASH FLOW, ACTUAL',T36,2(2XF10.0),
         2 //T3,'PRESENT VALUE OF CASH FLOW  ',T36,2(2XF10.0),
         3 //T3,'INVESTMENT (PRESENT VALUE)',   T50,F10.0,
         4 //T3,'TRUE RATE OF RETURN ON INVESTMENT',T51,F8.2' %'//)
     9000 FORMAT(1H1,///T19,'FLEET SIZING SUMMARY',//
         Z                T37,'BASELINE    ALTERNATE',//T3,'FLT. HRS. REQUIRED
         1',/T3,'TO PERFORM MISSION',T35,2(F10.2,3X),//T3,'HOLDING AVAILABIL
         2ITY CONSTANT :',
         3/T3,'AVAILABILITY %',T39,2(F6.2,7X),/T3,'UTIL. (FH/AC/MO)',T39,
         4 2(F6.2,7X),/T3,'FLEET SIZE (AC)',T38,2(F7.2,6X),
         5 //T3,'HOLDING UTILIZATION CONSTANT :',
         6/T3,'AVAILABILITY %',T39,2(F6.2,7X),/T3,'UTIL. (FH/AC/MO)',T39,
         7 2(F6.2,7X),/T3,'FLEET SIZE (AC)',T38,2(F7.2,6X),
```

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```
     8 //T3,'HOLDING FLEET SIZE CONSTANT :',
     9/T3,'AVAILABILITY %',T39,2(F6.2,7X),/T3,'UTIL. (FH/AC/MO)',T39,
     A 2(F6.2,7X),/T3,'FLEET SIZE (AC)',T36,2(F7.2,6X),/)
78   9010 FORMAT(1H1)
79        IF(LSCASE.NE.1) GO TO 10
80        STOP
81        END
```

BEST AVAILABLE COPY

```
 82          SUBROUTINE MISHIN(NA,TFLT)
 83          DIMENSION IMCLSS(2),NAME(3,03),ISEAT(02),LITTER(02),KMPHI(02),KMPH
            1X(02),IPAY(02),MNUM(20),LSIZ(20),IAMBS(02),IFA(02)
 84          COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
            1                           IMTYP(100),IMD(100),INPAS(100),
            2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
 85          READ(5,10)                  IMTMI,IMTMX,IMCLSS(1),(NAME(1,I),I=1,3),
            1 ISEAT(1),LITTER(1),IAMBS(1),KMPHI(1),KMPHX(1),IPAY(1),IFA(1)
 86       10 FORMAT(3I3,3A4,5I3,2I5)
 87          INL=0
 88          K=1
 89          IC=0
          C  DETERMINE AIRCRAFT CONSTRAINTS  ( IF ANY )
          C  MAX TROOPS LIFTED PER SORTIE  ( MTL)
 90          MTL=IPAY(K)/240
 91          IF(MTL.LT.ISEAT(K))IC=1
 92          IF(ISEAT(K).LT.MTL)MTL=ISEAT(K)
          C  MAX LITTERS LIFTED PER SORTIES  (MLL )
 93          MLL=IPAY(K)/240
 94          IF(MLL.LT.LITTER(K))IC=1
 95          IF(LITTER(K).LT.MLL)MLL=LITTER(K)
          C  AMBULATORY SEATS  (MAS )
 96          MAS=(IPAY(K)-(MLL*240))/240
 97          IF(MAS.GT.IAMBS(K))MAS=IAMBS(K)
 98          KI=1
 99          I=0
100          FLT2CS=0.
101          IDIV=0
102          ISORT=0
103          IDUM=0
          C  WRITE AIRCRAFT CHARACTERISTICS
104          WRITE(6,100)(NAME(K,J),J=1,3),IMCLSS(KI),     IPAY(K),KMPHI(K),
            1KMPHX(K),IFA(K),ISEAT(K),LITTER(K),IAMBS(K)
105          IF(IC.GT.0)WRITE(6,99)MTL,MLL,MAS
106          WRITE(6,1101)
107          LINES=4
108          DO 80 M=1,NA
109          IF(ICLS(M).NE.IMCLSS(KI))GO TO 80
110          IF(INL.GT.0)GO TO 1
111          FLT=0.
112          SORTR=0.
113          FLTHM=0.
114          INL=INLEGS(M)
115       1  IF((INPAS(M)+INLIT(M)+INCAR(M)+IMLOAD(M)+IMD(M)).EQ.0)IMTYP(M)=9
116          IF(ILT(M).EQ.0)ILT(M)=4
117          IF(ILT(M).EQ.9)GO TO 81
118          IF(IMLOAD(M).LT.IPAY(K))GO TO 19
119          IDIV=IDIV+1
120          MNUM(IDIV)=IMISND(M)
121          LSIZ(IDIV)=IMLOAD(M)
122       19 IGRP=IMCLSS(KI)
123          GO TO (25,80,20,25,80),IGRP
          C MEDICAL EVACUATION PHASE
          C EMPTY LEG
124       20 IF((INLIT(M)+INPAS(M)+INCAR(M)).NE.0)GO TO 21
125          ISOR=1
126          GO TO 50
          C LITTERS ONLY
127       21 IF((INPAS(M)+INCAR(M)).NE.0)GO TO 22
128          ISOR=FLOAT(INLIT(M))/FLOAT(MLL)+.99
```

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```
129         GO TO 50
      C LITTERS & PASSENGERS
130   22    IF(INCAR(M).NE.0)GO TO 23
131         ISOR1=INLIT(M)/MLL
132         IF(INLIT(M).LT.MLL)ISOR1=1
133         ILITL=INLIT(M)-(ISOR1*MLL)
134         IF(ILITL.LE.0)ILITL=0
135         INPASC=MAS*ISOR1
136         INPASL=INPAS(M)-INPASC
137         IF(INPASL.LE.0)GO TO 28
138         ISOR2=FLOAT(ILITL+INPASL)/FLOAT(MLL+MAS)+.99
139         GO TO 26
140   28    ISOR2=1
141   26    ISOR=ISOR1+ISOR2
142         GO TO 50
      C EXTERNAL LOAD
143   23    IF(IMLOAD(M).GT.IPAY(K))GO TO 24
144         ISOR=FLOAT(INCAR(M))/FLOAT(IPAY(K))+.99
145         GO TO 70
146   24    ISOR=0
147         FLTHL1=0.
148         FLTHL2=0.
149         GO TO 62
      C
      C EMPTY LEG
150   25    IF((IMLOAD(M)+INCAR(M)+INPAS(M)).NE.0)GO TO 27
151         ISOR=1
152         GO TO 50
      C  KIA    ( 10 SQ. FT. PER MAN)
153   27    IF(IMTYP(M).NE.4)GO TO 30
154         IF((INCAR(M)/IMLOAD(M)-INCAR(M)/240).NE.0)GO TO 30
155         KIA=INCAR(M)/IMLOAD(M)
156         KFLA=KIA*10
157         ISOR=FLOAT(KFLA)/FLOAT(IFA(K))+.99
158         IF(IPAY(K).LT.(240*(IFA(K)/10)))ISOR=FLOAT(KIA*240)/FLOAT(IPAY(K))
           1+.99
159         GO TO 50
      C PASSENGERS ONLY
      C     MISHIN 1
160   30    IF(INCAR(M).NE.0)GO TO 31
161         ISOR=FLOAT(INPAS(M))/FLOAT(MTL)+.99
162         GO TO 50
      C CARGO ONLY OR PASSENGERS LESS THAN SEATS AND CARGO
163   31    IF(INPAS(M).GT.MTL)GO TO 32
164         ISOR=FLOAT( INPAS(M)*240+INCAR(M))/FLOAT(IPAY(K))+.99
165         GO TO 50
      C PASSENGER GREATER THAN SEATS & CARGO
      C     MISHIN 2,3,4
166   32    ISOR2=0
167         ISOR1=INPAS(M)/MTL
168         INPASL=INPAS(M)-(ISOR1*MTL)
169         INCARN=INCAR(M)-(ISOR1*(IPAY(K)-MTL*240))
170         IF(INCARN.LE.0)GO TO 33
171         ISOR2=FLOAT(INPASL*240+INCARN)/FLOAT(IPAY(K))+.99
172         GO TO 34
173   33    IF(INPASL.GT.0)ISOR2=1
174   34    ISOR=ISOR1+ISOR2
      C FLIGHT TIME LEG INTERVAL
175   50    IF(IMTYP(M).EQ.5)GO TO 70
176         IF(IMTYP(M).EQ.7)GO TO 70
```

```
      C     MISHIN 5
177           FLTHL1=((FLOAT(ILGDIS(M))/FLOAT(KMPHI(K)))*60.+FLOAT(IHTMI))/60.
178           FLTHL2=FLOAT(IMD(M))/60.
179           KLT=ILT(M)
180           GO TO (61,62,62,62),KLT
181     61    SORT=FLOAT(ISOR)
182           FLTHL=(2.*FLTHL1)+FLTHL2
183           GO TO 103
184     62    SORT=FLOAT(ISOR)
185           FLTHL=FLTHL1+FLTHL2
186           IF(INL.LT.INLEGS(M))GO TO 103
187           IF((LINES+INLEGS(M)+1).LT.57)GO TO 103
188           WRITE(6,1101)
189           LINES=4
      C PRINT LEG DATA
190       103 WRITE(6,1104) IMISND(M),IMTYP(M),IMCLSS(KI),ILT(M),INLEGS(M),
             1 ILGDIS(M), INPAS(M),INLIT(M),INCAR(M),IMLOAD(M),ISOR,FLTHL
191           LINES=LINES+1
      C FLIGHT TIME MISSION
192           IF(SORT.GT. SORTR)SORTR=SORT
193           FLTHM=FLTHM+FLTHL
194           INL=INL+1
195           IF(INL.GT.0)GO TO 80
196           GO TO 105
      C FLIGHT TIME - LEG EXTERNAL
197     70    FLTHL1=(((FLOAT(ILGDIS(M))/FLOAT(KMPHI(K)))*60.)+FLOAT(IHTMI))/60.
198           FLTHL2=(((FLOAT(ILGDIS(M))/FLOAT(KMPHX(K)))*60.)+FLOAT(IHTMX))/60.
199           FLTHL3=IMD(M)/60.
200           KLT=ILT(M)
201           GO TO (71,72,72,72),KLT
202     71    SORT=FLOAT(ISOR)
203           FLTHL=FLTHL1+FLTHL2+FLTHL3
204           GO TO 103
205     72    SORT=FLOAT(ISOR)
206           FLTHL=FLTHL2+FLTHL3
207           GO TO 103
      C TOTAL FLIGHT TIME BY CLASS
      C     MISHIN 6
208     105   FLT=FLTHM*SORTR
209           LINES=LINES+2
210           ISORT=ISORT+SORTR
211           IF(IMISND(M).EQ.IDUM)GO TO 79
212           I=I+1
213           IDUM=IMISND(M)
214     79    FLT2CS=FLT2CS+FLT
215     80    CONTINUE
      C TOTAL FLIGHT TIME
216     81    TFLT=FLT2CS
217           WRITE(6,1107) ISORT,TFLT
218           IF(IDIV.EQ.0)GO TO 90
219           WRITE(6,108)IDIV
220           DO 109 J1=1,IDIV
221     109   WRITE(6,110)MNUM(J1),LSIZ(J1)
222     90    CONTINUE
223     99    FORMAT(////,T8,'*** PAYLOAD  CONSTRAINED ***'//T10,'MAX SEATS UTIL
           1IZED =',I5/T10,'MAX LITTERS =========',I5/T10,'AMBULATORY SEATS =
           2===',I5)
224     100   FORMAT(1H1,////////,T8,'AIRCRAFT = ',2X,3A4/T8,'CLASS = ',I2,
           1                  ///T8,'PAYLOAD  ==============',I6,' LBS'/T8,'CRU
           2ISE SPEED (KMPH)'/T12,'INTERNAL  ==========',I5/T12,'EXTERNAL  ===
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```
     3-------',I5//T8,'CABIN COMPARTMENT'/T10,'FLOOR AREA ----------',
     4I5,' SQ.FT.'/T10,'NUMBER OF SEATS ------',I5/T10,'NUMBER OF LITTER
     5S ----',I5/T12,'AMBULATORY SEATS ---',I5)
225  108  FORMAT(T40,I2,' MISSIONS SHOULD BE DELETED ON BASIS OF'/T36,'INDIV
     1ISABLE LOADS GREATER THAN PAYLOAD CAPABILITY')
226  110  FORMAT(T43,'MISSION ',I3,10X,'LOAD WT ',I5,' LBS')
227   1101 FORMAT(///////T5,'MISSION',T20,'LEG          NUMBER OF    CARGO  I
     ANDV',
     1  /T3,'NO TYPE CLS  TYPE NO DIST    PAX   LITS   POUNDS  LOAD SORT
     2IES   FLT. HRS.',/)
228   1104 FORMAT(T2,I3,1XI3,2(2XI3),2XI2,1XI4,2(1XI6),1XI8,1XI5,1XI7,1X,
     1F11.3)
229   1107 FORMAT(T58,I7,1X,F11.3)
230       RETURN
231       END
```

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```
232         SUBROUTINE QUEUE(PTILU,TDTIME,PAVAIL,DESNOR,NFLAG,ZTILU,ZAVAIL,
           1 ZUTIL3,ZVAIL3,NXYZ)
      C-----
      C-----EXCESS OF COMMENT/FORTRAN CARDS DUE TO INPUT INSTEAD OF CALCULATED NORS
      C-----
233         DIMENSION ELOW(7),HIGH(7),NHEAD(2,2),NUMS(2,3),
           1 NCREW(2,2), INTVL(2,3), LENGTH(2,2),NUNITS(2,2),
           2         XREORD(2),XXQ(2),XXWAIT(2),XXNUM(2),XXTIME(2),XZ(2),
           3XTWTIM(2),XTDTIM(2),XONORW(2),XONORT(2),NX(2),TIMEX(2),
           4XTBF(2),FA(100)
234         COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
           1                            IMTYP(100), IMD(100), INPAS(100),
           2INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
235         DATA ELOW/1.2,1.1,1.05,1.01,1.001,1.0001,1.00001/,
           1 HIGH/.8,.9,.95,.99,.999,.9999,.99999/, NHEAD/'N O ','N O ',
           2'R M ','R S '/, NUMS/'TO &','ND. ',' F S','SPAR','IZE ','ES  '/,
           3 NCREW/'CREW','    ','S   ','    '/, INTVL/'MTTR','REOR','    ',
           4'DER ','    ','TIME'/, LENGTH/'HOUR','DAYS','S   ','    '/,
           5 NUNITS/'MEN ','SPAR','    ','E   '/
236         REAL NUM,UM,FACTM
237         NZFLAG=0
238         NEWFLG=0
      C  50 READ(5,55)NX(1),XTBF(1),TIMEX(1),TUIL,AC,NX(2),XTBF(2),TIMEX(2)
239      50 READ(5,55)NX(1),XTBF(1),TIMEX(1),TUIL,AC,ZZNORS,IBER,LR
240         IF(NFLAG.EQ.0) NXYZ=TUIL
241         IF(NFLAG.EQ.1) TUIL=NXYZ
      C  55 FORMAT(I2,F9.4,F6.2,F5.1,F5.0,I4,F9.4,F6.2)
242      55 FORMAT(I2,F9.4,F6.2,F5.1,F5.0,F4.1,2I1)
243         TIMEX(1)=1./TIMEX(1)
      C     TIMEX(2)=1./TIMEX(2)
244         NDTFLG=3
      C     IF(NX(1).GE.NX(2)) NKNT=NX(1)
      C     IF(NX(2).GE.NX(1)) NKNT=NX(2)
245         NKNT=NX(1)
246         CALL FACTOR(NKNT,FA)
247         GO TO 70
248      60 TUIL=ZUTIL3
249         NEWFLG=1
250      70 DO 4200 KL=1,2
251         IF(KL.EQ.2) GO TO 4200
252         UTIL=TUIL
253         TIME=TIMEX(KL)
254         IF(KL.EQ.2) TIME=TIMEX(KL)/24.
255         N=NX(KL)
256         TILU=UTIL
257         IF(N.EQ.1) GO TO 1000
258         REORDR=(1./TIME)/24.
259         TBR=1./(672/(AC*UTIL/XTBF(KL)))
260         UTIL=UTIL*AC
261         LINES=0
262         ULAM=TBR/TIME
263         M=N+1
264         SUM=1.+ULAM
265         IF(N.EQ.2) GO TO 110
266         DO 100 I=2,M
267         UM=FA(I)
268         AULAM=ALOG(ULAM)
269         AULAM=AULAM*I
270         DUM=AULAM-UM
271         IF(DUM.GT.174.673) GO TO 115
```

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```
272           SUMCHK=ALOG(SUM)
273           SIZCHK=SUMCHK+DUM
274           IF(SIZCHK.GT.174.673) GO TO 115
275           DUM=EXP(DUM)
276       100 SUM=SUM+DUM
277       110 XULAM=ALOG(ULAM)
278           XULAM=XULAM*N
279           UM=FA(N)
280           XNX=N
281           XYZ=N*TIME-TBR
      C-----POTENTIAL INFINITE QUEUE
282           IF(XYZ.GT.0) GO TO 113
283           IF(NFLAG.EQ.0) GO TO 5026
284           WRITE(6,5100) TUIL
285           N1=1000000
286           GO TO 4800
287       113 TEMP=-UM+      XULAM +ALOG(XNX)+ALOG(TIME)-ALOG((XYZ))
288           TEMP=EXP(TEMP)
289           Z=1./(SUM+TEMP)
290           GO TO 120
291       115 Z=0.1E-75
      C
      C-----CALCULATE REPEATED VALUES
      C     QUEUE 1
292       120 ULAMN=(ALOG(ULAM))*N
293           ULAM2=(N*TIME-TBR)**2
294           FACTM=FA(M)
      C-----EXPECTED Q LENGTH
      C     QUEUE 2
295           XQ=ALOG(TBR)+ALOG(TIME)+      ULAMN +ALOG(Z)-FACTM-ALOG(ULAM2)
296           XQ=EXP(XQ)
297           IF(XQ.LT.0) GO TO 5026
      C-----EXPECTED NUMBER OF UNITS IN THE SYSTEM
      C     QUEUE 3
298           XNUM=XQ+ULAM
      C-----EXPECTED WAITING TIME OF AN ARRIVAL
      C     QUEUE 4
299           XWAIT=ALOG(TIME)+ULAMN+ALOG(Z)-FACTM-ALOG(ULAM2)
300           XWAIT=EXP(XWAIT)
      C-----EXPECTED TIME AN ARRIVAL SPENDS IN THE SYSTEM
      C     QUEUE 5
301           XTIME=XWAIT+(1./TIME)
302           GO TO 1010
      C-----IF N=1
303        1000 XQ=(TBR**2)/(TIME*(TIME-TBR))
304           XNUM=TBR/(TIME-TBR)
305           XWAIT=TBR/(TIME*(TIME-TBR))
306           XTIME=TIME/(TIME-TBR)
307           Z=1.-(TBR/TIME)
308        1010 REORDR=REORDR*24
      C     QUEUE 6
309           XFAILS=UTIL/XTBF(KL)
      C     QUEUE 7
310           TWTIME=XWAIT*XFAILS
      C     QUEUE 8
311           TDTIME=XTIME*XFAILS
312           IF(KL.EQ.2) TDTIME=XWAIT*XFAILS
      C     QUEUE 9,10,11
313           OONORW=TWTIME/(AC*24*28)*100
314           OONORT=TDTIME/(AC*24*28)*100
```

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```
315           TOTAL=Z
316           P=TBR/(N*TIME)
317           K=N
318           G=K**P
319           I=1
320           PN=G*Z
321           TOTAL=TOTAL+PN
322           IF(N.EQ.1) GO TO 4100
323    4100 CONTINUE
324           XREORD(KL)=REORDR
325           XXQ(KL)=XQ
326           XXWAIT(KL)=XWAIT
327           XXNUM(KL)=XNUM
328           XXTIME(KL)=XTIME
329           IF(KL.EQ.2) XXTIME(KL)=XWAIT
330           XZ(KL)=Z
331           XTWTIM(KL)=TWTIME
332           XTDTIM(KL)=TDTIME
333           XONORM(KL)=OONORM
334           XONORT(KL)=OONORT
      C
335    4200 CONTINUE
      C       TOTDT=XTDTIM(1)+XTDTIM(2)
336           TOTDT=XTDTIM(1)
      C       QUEUE 12
337           AVAIL=100.-(TOTDT/(672.*AC))*100.
338           ZVAIL3=AVAIL-ZZNORS
339           IF(NEWFLG.EQ.1) GO TO 6000
340           IF(NFLAG.EQ.0) DESNOR=TOTDT
341           IF(NFLAG.EQ.0) GO TO 5020
342           IF(NZFLAG.EQ.1) GO TO 4300
343           ZTILU=TUIL
344           ZAVAIL=AVAIL-ZZNORS
345           NZFLAG=1
346    4300 DESDT=DESNOR
347           N1=TOTDT*10.
348           N2=DESDT*10.
349           IF(N1.EQ.N2) GO TO 5020
350           GO TO (4500,4900,4400),NDTFLG
      C
      C-----DOWNTIME LOWER THAN DESIRED ON FIRST PASS
351    4400 IF(N1.GT.N2) GO TO 4800
352           UTLSAV=TUIL
353           NDTFLG=1
354           KNTDLT=1
355    4500 IF(N1.LT.N2) GO TO 4550
356    4525 KNTDLT=KNTDLT+1
357           UTLNEW=OLDUTL*ELOW(KNTDLT)
358           GO TO 4575
359    4550 UTLNEW=UTLSAV*ELOW(KNTDLT)
360           OLDUTL=TUIL
361    4575 TUIL=UTLNEW
362           UTLSAV=TUIL
363           GO TO 70
      C
      C-----DOWNTIME HIGHER THAN DESIRED ON FIRST PASS
364    4800 UTLSAV=TUIL
365           NDTFLG=2
366           KNTDLT=1
367    4900 IF(N1.GT.N2) GO TO 4950
```

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```
368          KNTDLT=KNTDLT+1
369          UTLNEW=OLDUTL*HIGH(KNTDLT)
370          GO TO 4975
371     4950 UTLNEW=UTLSAV*HIGH(KNTDLT)
372          OLDUTL=TUIL
373     4975 TUIL=UTLNEW
374          UTLSAV=TUIL
375          GO TO 70
       C
       C-----PRINT NORM AND NORS OUTPUT
       C5020 XREORD(2)=XREORD(2)/24
376     5020 CONTINUE
       C     WRITE(6,5070)
377          DO 5025 I=1,2
378          IF(I.EQ.2) GO TO 5025
379          WRITE(6,5030)                                  AC, TILU
380          WRITE(6,5010) XTBF(I), (NUMS(I,J),J=1,3), NX(I), (NCREW(I,J),J=1,2
            1), (INTVL(I,J),J=1,3), XREORD(I), (LENGTH(I,J),J=1,2), XXQ(I),
            2(NUNITS(I,J),J=1,2), XXWAIT(I), XXNUM(I), XXTIME(I), XZ(I)
381          WRITE(6,5015) XTWTIM(I), XTDTIM(I), XONORW(I), XONORT(I)
382     5025 CONTINUE
       C     QUEUE 12
383          AVAIL=AVAIL-ZZNORS
384          WRITE(6,5017) ZZNORS,AVAIL
385          PTILU=TILU
386          PAVAIL=AVAIL
387          IF(NFLAG.EQ.1.AND.NEWFLG.EQ.0) GO TO 60
388          IF(IBER.EQ.1.AND.LR.EQ.1) GO TO 7000
389          IF(IBER.EQ.1.AND.LR.NE.1) GO TO 50
390          GO TO 6000
391     5026 WRITE(6,5075)
       C
       C-----FORMAT STATEMENTS
392     5000 FORMAT(1H1)
393     5010 FORMAT( T5,'MEAN TIME BETWEEN MAINTENANCE',
            1 T36,F12.4,3X,'HOURS',/T5,3A4,T38,I5,7X,2A4,/
            2 T5,3A4,T39,F8.3,3X,2A4,/
            4 T5,'EXPECTED QUEUE LENGTH',T39,F9.4,2X,'TASKS',/
            5 T5,'EXPECTED WAITING TIME FOR ',2A4,T39,F9.4,2X,'HOURS',/
            6 T5,'EXPECTED NO. TASKS. IN SYSTEM',T39,F9.4,/
            7 T5,'EXPECTED TIME IN SYSTEM',T39,F9.4,2X,'HOURS',/
            8 T5,'PROBABILITY OF NO TASKS. IN SYSTEM',T41,F7.4)
394     5015 FORMAT(   T5,'TOTAL WAITING TIME',T38,F10.4,T50,'HOURS (FAILS. X
            1EXP. WAIT TIME)',/T5,'TOTAL DOWN TIME',T38,F10.4,T50,'HOURS ( FAIL
            2S. X EXP. TIME IN SYS.)',/T5,'NORM- WAITING',T38,F10.4,T50,'% ( TO
            3T. WAIT TIME/TOT AC CAL. HRS.)',/T5,'NORM- TOTAL',T38,F10.4,T50,
            4'% ( TOT. DOWN TIME/TOT AC CAL. HRS.)')
395     5017 FORMAT(/T5,'NORS - (INPUT)',T38,F10.4,T50,'%',
            1       //T5,'AVAILABILITY',T38,F10.4,T50,'%')
396     5030 FORMAT(            ////T5,'NUMBER OF AIRCRAFT',T40,F4.0,/
            1 T5,'UTILIZATION',T40,F6.2,4X,'HRS/AC/MO')
397     5040 FORMAT(T19,I3,T41,F7.4)
398     5050 FORMAT(T41,F7.4)
399     5060 FORMAT(///T5,'DESIRED NOR',2X,F7.4,1X,'%',///)
400     5070 FORMAT(1H1)
401     5075 FORMAT(1H1,///T3,'*** INPUT PARAMETERS RESULT IN CONSTANT QUEUE.',
            1 ' EXECUTION STOPPED. ',///)
402     5100 FORMAT(/  T90,'ATTEMPTED UTIL. OF ',F5.1,' HRS.',
            1/T90,'IS TOO HIGH',/)
403          STOP
404     6000 RETURN
405     7000 STOP
406          END
```

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PRODUCT IMPROVEMENT PROGRAM EVALUATION.(U)
JUN 77 S J BLEWITT DAAJ02-76-C-0020
UNCLASSIFIED D210-11146-2 USAAMRDL-TR-77-17 NL

2 OF 2
ADA042134

END

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```
      SUBROUTINE FACTOR(N,FA)
      DIMENSION FA(100)
      COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
     1                             IMTYP(100), IMD(100), INPAS(100),
     2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
      FA(1)=0.
      DO 10 I=2,N
      X=I
   10 FA(I)=FA(I-1)+ALOG(X)
      RETURN
      END
```

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```
      SUBROUTINE INCORP(MODTT1,MODTT2,MODTT3,MODTT4,NUMOL,NUMEW,NOLTOT,
     1 NEWTOT,LOCMFH,NACMFH,NAC,NFHYR,IYR,NOL,NNE,LFLAG)
      DIMENSION MOAC(240), MOUTIL(240), INC1(240), INC2(240),NAME(3),
     1 INC3(240),OLRATE(3),EWRATE(3),NUMOL(20,3),NUMEW(20,3),NOLTOT(3),
     1 NEWTOT(3),NFHYR(20,2),FACTOR(20),NOL(20),NNE(20),NY(2)
      COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
     1                            IMTYP(100), IMD(100), INPAS(100),
     2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
      DATA NY/' YES',' NO'/,MOAC/240*0/
      DO 300 I=1,20
      DO 300 J=1,3
      IF(J.NE.3) NFHYR(I,J)=0
      NUMOL(I,J)=0
  300 NUMEW(I,J)=0
      READ(5,400) MONTHS,NACSTR,NDLVCD,MODLV,MOS,NDLWMD,MOSTRT,
     A NFHCD,MOFH,
     1 MODTT4, (OLRATE(I),EWRATE(I),I=1,3),NAME
      READ(5,410) INSCD1,LEVEL1,MEVEL1,MODTT1,MMSTRT,LOCAL,LINPIP,
     1 ACATR,NCOMP
      IF(LOCAL.EQ.0) LOCAL=1
      IF(LINPIP.EQ.0) LINPIP=4
      IF(ACATR.EQ.0.) ACATR=2.
      IF(NDLVCD.EQ.0) NDLVCD=2
      IF(NDLWMD.EQ.0) NDLWMD=2
      IF(NFHCD.EQ.0) NFHCD=2
      IF(INSCD1.EQ.0) INSCD1=2
      IYR=MONTHS/12
      OLMTBF=OLRATE(1)
      EWMTBF=EWRATE(1)
  400 FORMAT(I3,I4,I1,I2,I3,I1,I3,I1,I3,I4,6(F7.1),3A4)
  410 FORMAT(I1,2I3,I4,I3,2I2,F6.2,I2)
      WRITE(6,2000)NAME,MONTHS,NACSTR,NY(NDLVCD),MODLV,MOS,NY(NDLWMD),
     1 MOSTRT, NY(NFHCD), MOFH
      WRITE(6,2001)                MODTT4, NY(INSCD1), LEVEL1, MEVEL1,
     2 MODTT1, MMSTRT,LOCAL,LINPIP,ACATR,
     3                 (OLRATE(I),EWRATE(I),I=1,3)
C
C-----IF DELIVERIES ARE AT A CONSTANT RATE
      IF(NDLVCD.EQ.1) GO TO 525
      IF(MOS.EQ.0) GO TO 575
      DO 500 I=1,MOS
  500 MOAC(I)=MODLV
      GO TO 575
C-----IF DELIVERIES ARE AT AN IRREGULAR RATE
  525 K=MOS/24
      KREM=MOS-(K*24)
      L=-23
      M=0
      IF(K.LE.0) GO TO 550
      DO 535 I=1,K
      L=L+24
      M=M+24
  535 READ 537, (MOAC(J),J=L,M)
  537 FORMAT(26I3)
  550 L=L+24
      M=M+KREM
      READ 537, (MOAC(J),J=L,M)
C-----IF FLT. HRS. ARE AT A CONSTANT RATE
  575 IF(NFHCD.EQ.1) GO TO 625
      DO 600 I=1,MONTHS
```

```
      600 MOUTIL(I)=MOFH
          GO TO 675
C-----IF FLT. HRS. ARE AT AN IRREGULAR RATE
      625 K=MONTHS/24
          KREM=MONTHS-(K*24)
          L=-23
          M=0
          IF(K.LE.0) GO TO 650
          DO 635 I=1,K
          L=L+24
          M=M+24
      635 READ 537, (MOUTIL(J),J=L,M)
      650 L=L+24
          M=M+KREM
          READ 537, (MOUTIL(J),J=L,M)
C-----INSTALLATIONS
C
C-----CONSTANT RATE - LEVEL 1
      675 IF(INSCD1.EQ.1) GO TO 725
          DO 700 I=1,MONTHS
      700 INC1(I)=LEVEL1
          GO TO 775
C-----IRREGULAR RATE
      725 K=MEVEL1/24
          KREM=MEVEL1-(K*24)
          L=-23
          M=0
          IF(K.LE.0) GO TO 750
          DO 735 I=1,K
          L=L+24
          M=M+24
      735 READ 537, (INC1(J),J=L,M)
      750 L=L+24
          M=M+KREM
          READ 537, (INC1(J),J=L,M)
      775 LODFLS=0
          NEWFLS=0
          LOCMFH=0
          NWCMFH=0
          LODREM=0
          NWREM=0
          NAC=NACSTR
          ITMSOL=NACSTR
          ITMSNW=0
C-----MAJOR LOOP - (MONTHS)
          DO 1001 J=1,MONTHS
C-----AIRCRAFT STILL BEING DELIVERED
          IF(J.GT.MOS) GO TO 895
          NAC=NAC+MOAC(J)
          IF(J.LT.MOSTRT) GO TO 890
          IF(MODTT4.LE.0) GO TO 890
          IF(NDLWMD.EQ.1) ITMSNW=ITMSNW+MOAC(J)
      885 MODTT4=MODTT4-MOAC(J)
      890 IF(NDLWMD.NE.1) ITMSOL=ITMSOL+MOAC(J)
          IF(NDLWMD.EQ.1.AND.MOSTRT.GT.J) ITMSOL=ITMSOL+MOAC(J)
C-----FLT. HRS.
C     INCORP 1,3
      895 LODFH=ITMSOL*MOUTIL(J)+LODREM
          NWFH=ITMSNW*MOUTIL(J)+NWREM
          LOCMFH=LOCMFH+(ITMSOL*MOUTIL(J))
```

```
512         NWCMFH=NWCMFH+(ITMSNW*MOUTIL(J))
      C-----FAILURES
      C     INCORP 2
513         MLDFLS=LODFH/OLMTBF
514         LODREM=LODFH-(MLDFLS*OLMTBF)
515         LODFLS=LODFLS+MLDFLS
516         IF(EWMTBF.GT.0) GO TO 8950
517         MNWFLS=0
518         GO TO 8951
519    8950 MNWFLS=NWFH/EWMTBF
520    8951 NWREM=NWFH-(MNWFLS*EWMTBF)
521         NEWFLS=NEWFLS+MNWFLS
      C-----YEARLY FAILURES (CUM)
522         YR=J/12.
523         MYR=YR
524         REMYR=MYR
525         IF(REM.NE.0) GO TO 898
526         DO 897 L=1,3
527         IF(OLRATE(L).LE.0) GO TO 896
528         NUMOL(MYR,L)=LOCMFH/OLRATE(L)
529     896 IF(EWRATE(L).LE.0) GO TO 897
530         NUMEW(MYR,L)=NWCMFH/EWRATE(L)
531     897 CONTINUE
      C-----YEARLY FLT.HRS.
532         IF(MYR.EQ.1) NFHYR(MYR,1)=LOCMFH
533         IF(MYR.EQ.1) NFHYR(MYR,2)=NWCMFH
534         IF(MYR.NE.1) NFHYR(MYR,1)=LOCMFH-LOPREV
535         IF(MYR.NE.1) NFHYR(MYR,2)=NWCMFH-NWPREV
536         LOPREV=LOCMFH
537         NWPREV=NWCMFH
      C-----INCORPORATIONS OR INSTALLATIONS
      C
      C-----LEVEL 1
538     898 IF(MODTT1.LE.0) GO TO 910
539         IF(J.LT.MMSTRT) GO TO 910
540         IF(ITMSOL.LT.INC1(J)) GO TO 905
541         ITMSNW=ITMSNW+INC1(J)
542         ITMSOL=ITMSOL-INC1(J)
543         MODTT1=MODTT1-INC1(J)
544         GO TO 910
545     905 ITMSNW=ITMSNW+ITMSOL
546         MODTT1=MODTT1-ITMSOL
547         ITMSOL=0
548     910 CONTINUE
549         IF(REM.EQ.0) NOL(MYR)=ITMSOL
550    1001 IF(REM.EQ.0) NNE(MYR)=ITMSNW
551         NAC=ITMSOL+ITMSNW
      C-----FAILURES BY YEAR (NOT CUM)
      C     INCORP 6
552         DO 1005 I=1,3
553         NOLTOT(I)=NUMOL(1,I)
554    1005 NEWTOT(I)=NUMEW(1,I)
555         N=21
556    1010 N=N-1
557         IF(N.EQ.1) GO TO 1050
558         DO 1025 I=1,3
559         M=N-1
560         NUMOL(N,I)=NUMOL(N,I)-NUMOL(M,I)
561         NUMEW(N,I)=NUMEW(N,I)-NUMEW(M,I)
562         IF(NUMOL(N,I).LE.0) NUMOL(N,I)=0
```

```
563         IF(NUMEW(N,I).LE.0) NUMEW(N,I)=0
564         NOLTOT(I)=NOLTOT(I)+NUMOL(N,I)
565         NEWTOT(I)=NEWTOT(I)+NUMEW(N,I)
566    1025 CONTINUE
567         GO TO 1010
568    1050 NTOTFH=LOCMFH+NWCMFH
     C-----CALCULATE SPARES AND ATTRITED AC
     C       INCORP 3
569         IF(LFLAG.EQ.1) NACATR=LOCMFH/100000.*ACATR
570         IF(LFLAG.EQ.2) NACATR=NWCMFH/100000.*ACATR
     C       INCORP 4
571         SPRHRS=(LOCAL+LINPIP)*(NTOTFH/MONTHS)
572         NSPARS=0
573         SPARS=0.
574         IF(OLRATE(2).GT.0)  SPARS=SPRHRS/OLRATE(2)
575         IF(NEWTOT(2).NE.0.AND.EWRATE(2).GT.0)  SPARS=SPRHRS/EWRATE(2)
576         NSPARS=SPARS
577         IF(NSPARS.LT.NCOMP) GO TO 1100
578         IF(NSPARS.EQ.NCOMP) GO TO 1200
579         SPARES=SPARS/NCOMP+.5
580         NSPARS=SPARES
581         GO TO 1200
582    1100 NSPARS=NCOMP
583    1200 WRITE(6,2100)  (NOLTOT(I),NEWTOT(I),I=1,3)
584         WRITE(6,2050) LOCMFH,NWCMFH
585         WRITE(6,2060) NSPARS,NACATR
     C-----FORMAT STATEMENTS
586    2000 FORMAT(1H1,///T2, 'MODIFICATION INCORPORATION DATA - ',3A4,
          A ///T3,'I N P U T S :',
          1 //T3,'NO. OF MONTHS IN STUDY',T35,I4,
          2  /T3,'NO. OF COMPONENTS IN FLEET      ',T35,I4,
          3  /T3,'IRREG. DELIVERY RATE ?          ',T35,1A4,
          4  /T3,'IF CONSTANT, DELIVS. PER MO.    ',T35,I4,
          5  /T3,'NO. OF MONTHS                    ',T35,I4,
          6  /T3,'AC DELIVERED WITH MOD ?          ',T35,1A4,
          7  /T3,'START MONTH                      ',T35,I4,
          8  /T3,'IRREG. UTILIZATION ?             ',T35,1A4,
          9  /T3,'FLT. HRS./COMP./MO.              ',T35,I4)
587    2001 FORMAT(
          A   T3,'TOTAL AC DELIV. WITH MOD        ',T35,I4,
          B  /T3,'IRREG. FIELD MOD INCORP. RATE ?',T35,1A4,
          C  /T3,'IF CONSTANT, INCORPS. PER MO.   ',T35,I4,
          D  /T3,'IF IRREG., NO. OF MONTHS        ',T35,I4,
          E  /T3,'TOTAL INCORPORATED              ',T35,I4,
          F  /T3,'START MONTH                     ',T35,I4,
          F /T3,'QTY. SPARES ON HAND',T35,I4,' MONTHS',
          F /T3,'QTY. PIPELINE SPARES',T35,I4,' MONTHS',
          F /T3,'COMP. ATTR.  RATE/100000 HRS.',T36,F6.2,//
          G T22,'OLD ITEM   NEW ITEM',/T3,'MTBF',T23,2(F7.2,4X ),/T3,'MTBR TO
          H AVIM',T22,2(F8.2,3X),/T3,'MTBR TO DEPOT',T22,2(F8.2,3X))
588    2050 FORMAT( /T3,'FLT. HRS.@',T22,2(I8,3X))
589    2060 FORMAT(//T3,'INIT. SPARES REQ. PER LOC.',T29,I4,/T3,
          1 'COMPS. ATTRITED',T29,I4)
590    2100 FORMAT(/////T3,'O U T P U T S :',//T22,'OLD ITEM   NEW ITEM',
          1 /T3,'MAINT. ACTIONS AT',/T3,'AVUM',T23,2(I7,4X),/T3,'AVIM',
          2 T23,2(I7,4X),/T3,'DEPOT',T23,2(I7,4X))
591         RETURN
592         END
```

```
593         SUBROUTINE ZCOST(NUMOL,NUMEW,NOLTOT,NEWTOT,JFLAG,LOCMFH,NWCMFH,
           1 OUT,COST,NFHYR,ZOM,VVEST,NCHKYR,TMMPP)
594         COMMON ILT(100),INLEGS(100),ILGDIS(100),IMISND(100),
           1                              IMTYP(100), IMD(100), INPAS(100),
           2 INLIT(100),INCAR(100),ICLS(100),IMLOAD(100)
595         DIMENSION HMM(3),PARTS (3),NOCPM (20),OUT(60),NCODE(5),FACTOR(20),
           1 NRD(5),NIN(20),NIR(20),NFHYR(20,2),        NOLTOT(3),NEWTOT(3),
           2 HMMN(3),PARTSN(3),NUMOL(20,3),NUMEW(20,3),COST(20,3),ZOM(20),
           3 RATLAB(3),NY(2)
596         DATA NY/' YES','  NO'/
597         DO 20 I=1,60
598      20 OUT(I)=0.
599         DO 25 I=1,20
600         DO 25 J=1,3
601      25 COST(I,J)=0.
602         VVEST=0.
      C-----READ OPERATIONAL COST DATA
      C
      C-----SUFFIX C=CONTRACT, I=IN-HOUSE, O=OLD ITEM, N=NEW ITEM
603         READ(5,100) NDL,CRATE,HMM(3),PARTS (3),PARTS (1),HMM(1),POLRA,
           1 PARTS (2),HMM(2),LBSO
604         PDL=NDL
605         POL=PDL/100.
606         POLRA =POLRA /6.7
607         READ(5,100) NDLN,CRATEN,HMMN(3),PARTSN(3),PARTSN(1),HMMN(1),
           1 POLRAN, PARTSN(2),HMMN(2),LBSN
608         READ(5,105) NOCPM
609         PDLN=NDLN
610         PDLN=PDLN/100.
611         POLRAN=POLRAN/6.7
      C-----READ CONSTANT FACTORS
612         READ(5,110) OHD,GNA,PROFIT,XPORTC,(RATLAB(I),I=1,3),XPORTI,CJP,FI
613         IF(OHD.EQ.0) OHD=180.
614         IF(GNA.EQ.0) GNA=17.
615         IF(PROFIT.EQ.0) PROFIT=10.
616         IF(XPORTC.EQ.0) XPORTC=17.
617         IF(RATLAB(1).EQ.0) RATLAB(1)=10.
618         IF(RATLAB(2).EQ.0) RATLAB(2)=11.
619         IF(RATLAB(3).EQ.0) RATLAB(3)=13.50
620         IF(XPORTI.EQ.0) XPORTI=13.
621         IF(CJP.EQ.0) CJP=.45
622         IF(FI.EQ.0) FI=10.
      C-----PRINT INPUT
623         IF(JFLAG.EQ.0) WRITE(6,2000)
624         IF(JFLAG.EQ.1) WRITE(6,2010)
625         WRITE(6,2100) OHD,GNA,PROFIT,XPORTC,XPORTI,RATLAB,CJP,FI
626         WRITE(6,2200) NDL,NDLN,CRATE,CRATEN,HMM(3),HMMN(3),HMM(1),HMMN(1),
           1 HMM(2),HMMN(2),PARTS(3),PARTSN(3),PARTS(1),PARTSN(1),PARTS(2),
           2 PARTSN(2),LBSO,LBSN,POLRA,POLRAN
627         OHD=OHD/100.+1.
628         GNA=GNA/100.
629         PROFIT=PROFIT/100.
630         FI=FI/100.
631         WRITE(6,2300) (I,NOCPM(I),I=1,20)
632         IF(JFLAG.EQ.0) GO TO 200
      C-----READ R&D COSTS
633         READ(5,115) OUT(3),NCODE(1),OUT(4),NCODE(2),OUT(5),NCODE(3),
           1 OUT(6),NCODE(4),(OUT(I),I=7,9),OUT(11), OUT(1),NRDEST
634         SUM=0.
635         DO 30 I=1,4
```

```
636         J=I+2
637         IF(NCODE(I).NE.1) OUT(J)=OUT(J)*OHD
638         IF(NCODE(I).EQ.0) NCODE(I)=2
639      30 SUM=SUM+OUT(J)
640         IF(NRDEST.EQ.0) NRDEST=2
      C-----PRINT INPUT
641         WRITE(6,2010)
642         WRITE(6,2400) (OUT(I),NY(NCODE(I-2)),I=3,6),(OUT(I),I=7,9),
           1 OUT(11),OUT(1),NY(NRDEST)
643         IF(OUT(7).EQ.0) OUT(7)=SUM*GNA
644         SUM=SUM+OUT(7)
645         IF(OUT(8).EQ.0) OUT(8)=SUM*PROFIT
646         SUM=SUM+OUT(8)
647         OUT(2)=SUM
648         OUT(10)=OUT(11)
649         SUM=SUM+OUT(11)
650         IF(OUT(1).EQ.0) OUT(1)=SUM
651         READ(5,105) NRD
      C-----READ INVESTMENT NONRECURRING COSTS
652         READ(5,120) OUT(16),NCODE(1),OUT(17),NCODE(2),OUT(18),NCODE(3),
           1 OUT(19),NCODE(4),OUT(20),NCODE(5),OUT(21),OUT(22),OUT(24),
           2 OUT(14),NINEST
653         SUM=0.
654         DO 35 I=1,5
655         J=I+15
656         IF(NCODE(I).NE.1) OUT(J)=OUT(J)*OHD
657         IF(NCODE(I).EQ.0) NCODE(I)=2
658      35 SUM=SUM+OUT(J)
659         IF(NINEST.EQ.0) NINEST=2
      C-----PRINT INPUT
660         WRITE(6,2500) (OUT(I),NY(NCODE(I-15)),I=16,20),OUT(21),OUT(22),
           1 OUT(24),OUT(14),NY(NINEST)
661         IF(OUT(21).EQ.0) OUT(21)=SUM*GNA
662         SUM=SUM+OUT(21)
663         IF(OUT(22).EQ.0) OUT(22)=SUM*PROFIT
664         SUM=SUM+OUT(22)
665         OUT(15)=SUM
666         OUT(23)=OUT(24)
667         SUM=SUM+OUT(24)
668         IF(OUT(14).EQ.0) OUT(14)=SUM
669         READ(5,105) NIN
      C-----READ INVESTMENT RECURRING COST DATA
670         READ(5,125) OUT(29),NCODE(1),OUT(30),NCODE(2),OUT(31),NCODE(3),
           1 OUT(32), NCODE(4), OUT(33),OUT(34), NUNITC, OUT(35), LBSC,
           2 OUT(36)
671         READ(5,130) OUT(38),OUT(39),NUNITI,LBSI,OUT(27),NIREST,OUT(40)
672         SUM=0.
673         DO 40 I=1,4
674         J=I+28
675         IF(NCODE(I). NE.1) OUT(J)=OUT(J)*OHD
676         IF(NCODE(I).EQ.0) NCODE(I)=2
677      40 SUM=SUM+OUT(J)
678         IF(NIREST.EQ.0) NIREST=2
      C-----PRINT INPUT
679         WRITE(6,2600) (OUT(I),NY(NCODE(I-28)),I=29,32), (OUT(I),I=33,36),
           1 OUT(38),OUT(39),OUT(40),OUT(27),NY(NIREST)
      C-----CONTRACT TRANSPORTATION COSTS
680         IF(OUT(33).NE.0) GO TO 45
681         IF(NUNITC.EQ.0) GO TO 45
682         TOTWT=NUNITC*LBSC
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683           SHPWT=TOTWT/100.
684           OUT(33)=SHPWT**PORTC
685        45 SUM=SUM+OUT(33)+OUT(34)
686           IF(OUT(35).EQ.0) OUT(35)=SUM*GNA
687           SUM=SUM+OUT(35)
688           IF(OUT(36).EQ.0) OUT(36)=SUM*PROFIT
689           SUM=SUM+OUT(36)
690           OUT(28)=SUM
      C-----IN-HOUSE TRANSPORTATION COSTS
691           IF(OUT(38).NE.0) GO TO 50
692           IF(NUNITI.EQ.0) GO TO 50
693           TOTWT=NUNITI*LBSI
694           SHPWT=TOTWT/100.
695           OUT(38)=SHPWT*XPORTI
696        50 OUT(37)=OUT(38)+OUT(39)
697           SUM=SUM+OUT(37)
698           IF(OUT(27).EQ.0) OUT(27)=SUM
699           READ(5,105) NIR
      C-----PRINT INPUT
700           WRITE(6,2020)
701           WRITE(6,2700) (I,NRD(I),NIN(I),NIR(I),I=1,5), (I,NIN(I),NIR(I),
             1 I=6,20)
      C-----FORMAT STATEMENTS - READ
702       100 FORMAT(I3,F5.2,F6.1,F8.2,F6.2,F5.1,F5.1,F6.2,F5.1,I3)
703       105 FORMAT(10I8)
704       110 FORMAT(3F6.2,5F5.2,F4.2,F4.1)
705       115 FORMAT(3(F7.0,I1),F6.0,I1,2F6.0,F3.0,F7.0,F8.0,I1)
706       120 FORMAT(4(F7.0,I1),F6.0,I1,2F6.0,F7.0,F8.0,I1)
707       125 FORMAT(3(F7.0,I1),F8.0,I1,2F7.0,I5,F7.0,I3,F7.0)
708       130 FORMAT(2F7.0,I5,I3,F9.0,I1,F4.0)
      C-----CALCULATE OPERATING COSTS
      C
      C-----CONTRACT TRANSPORTATION COSTS
      C     ZCOST 1
709       200 NDOHC =NOLTOT(3)*PDL
710           NDOHCN=NEWTOT(3)*PDLN
      C     ZCOST 2
711           SHPWT=NDOHC *2*LBSO/100.
712           SHPWTN=NDOHCN*2*LBSN/100.
      C     ZCOST 4
713           OUT(46)=SHPWT*XPORTC+SHPWTN*XPORTC
      C     ZCOST 3
714           BURDEN=OHD+GNA+PROFIT
715           OUT(46)=OUT(46)*BURDEN
      C-----CONTRACT DEPOT LABOR & PARTS
      C     ZCOST 5,6
716           OUT(47)=(NDOHC*HMM(3)*CRATE+NDOHCN*HMMN(3)*CRATEN)
717           OUT(47)=(OUT(47)+(NDOHC*PARTS(3)+NDOHCN*PARTSN(3)))*BURDEN
718           DO 210 I=45,48
719       210 OUT(44)=OUT(44)+OUT(I)
      C-----IN-HOUSE LABOR & PARTS
      C     ZCOST 7,10,11
720           NDOHI =NOLTOT(3)-NDOHC
721           NDOHIN=NEWTOT(3)-NDOHCN
      C     ZCOST 14
722           OUT(55)=NDOHI*HMM(3)*RATLAB(3)+(NDOHI*PARTS(3))
723           OUT(55)=OUT(55)+NDOHIN*RATLAB(3)*HMMN(3)+(NDOHIN*PARTSN(3))
724           DO 225 I=1,2
725           OUT(50)=OUT(50)+NOLTOT(I)*RATLAB(I)*HMM(I)
726           OUT(50)=OUT(50)+NEWTOT(I)*RATLAB(I)*HMMN(I)
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727         OUT(52)=OUT(52)+NOLTOT(I)*PARTS(I)
728       225 OUT(52)=OUT(52)+NEWTOT(I)*PARTSN(I)
          C       ZCOST 8
          C-----POL
729         OUT(53)=(LOCMFH*POLRA*CJP)+(NWCMFH*POLRAN*CJP)
          C       ZCOST 9
730         OUT(51)=OUT(52)+OUT(53)
          C-----IN-HOUSE TRANSPORTATION COSTS
          C       ZCOST 12,13
731         SHPWT=NDOHI*2*LBSO/100.
732         SHPWTN=NDOHIN*2*LBSN/100.
733         OUT(54)=(SHPWT+SHPWTN)*XPORTI
734         DO 235 I=1,20
          C       ZCOST 15
735       235 OUT(56)=OUT(56)+NOCPM(I)
736         DO 250 I=50,56
737         IF(I.EQ.52.OR.I.EQ.53) GO TO 250
738         OUT(49)=OUT(49)+OUT(I)
739       250 CONTINUE
          C       ZCOST 16
740         OUT(43)=OUT(44)+OUT(49)
            -ESTIMATE NON-OPERATING COST CATEGORY AMOUNTS
741         IF(JFLAG.EQ.0) TMPP=OUT(43)=OUT(55)
742         IF(JFLAG.EQ.0) GO TO 280
743         TEMP=TMPP
744         IF(JFLAG.EQ.1.AND.NRDEST.EQ.1) OUT(1)=TEMP*.05
745         IF(JFLAG.EQ.1.AND.NINEST.EQ.1) OUT(14)=TEMP*.014167
746         IF(JFLAG.EQ.1.AND.NIREST.EQ.1) OUT(27)=TEMP*.269167
          C-----ESTIMATED NON-OP COSTS PER YEAR
747         IF(NRDEST.EQ.1) NRD(1)=OUT(1)
748         IF(NINEST.EQ.1) NIN(2)=OUT(14)
749         IF(NIREST.NE.1) GO TO 280
750         DO 275 N=3,5
751       275 NIR(N)=OUT(27)/3.
752       280 DO 1000 I=1,20
          C-----YEARLY OPERATING COSTS
          C
          C-----CONTRACT TRANSPORTATION COSTS TO DEPOT
753          DOHCO=NUMOL(I,3)*POL
754          DOHCN=NUMEW(I,3)*POLN
755         SHPWTO= DOHCO*2*LBSO/100.
756         SHPWTN= DOHCN*2*LBSN/100.
757         COST(I,1)=COST(I,1)+((SHPWTO+SHPWTN)*XPORTC)
          C-----DEPOT LABOR AND PARTS
758         COST(I,1)=COST(I,1)+( DOHCO*HMM(3)*CRATE+ DOHCN*HMMN(3)*CRATEN)
759         COST(I,1)=COST(I,1)+( DOHCO*PARTS(3)+ DOHCN*PARTSN(3))
          C-----APPLY OVERHEAD
760         COST(I,1)=COST(I,1)*BURDEN
          C-----IN-HOUSE LABOR & PARTS
          C
          C-----DEPOT
761          DOHIO=NUMOL(I,3)- DOHCO
762          DOHIN=NUMEW(I,3)- DOHCN
763         TEMP= DOHIO*RATLAB(3)*HMM(3)+ DOHIO*PARTS(3)
764         TEMP=TEMP+( DOHIN*RATLAB(3)*HMMN(3)+ DOHIN*PARTSN(3))
765         COST(I,1)=COST(I,1)+TEMP
          C-----AVUM & AVIM
766         TEMP=0.
767         DO 300 J=1,2
768         TEMP=TEMP+(NUMOL(I,J)*RATLAB(J)*HMM(J)+NUMOL(I,J)*PARTS(J))
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769      300 TEMP=TEMP+(NUMEW (I,J)*RATLAB(J)*HMMN(J)+NUMEW(I,J)*PARTSN(J))
770          COST(I,1)=COST(I,1)+TEMP
     C-----POL
771          TEMP=(NFHYR(I,1)*POLRA*CJP)+(NFHYR(I,2)*POLRAN*CJP)
772          COST(I,1)=COST(I,1)+TEMP
     C-----IN-HOUSE TRANSPORTATION COSTS TO DEPOT
773          SHPWTO= DOHIO*2*LBSO/100.
774          SHPWTN= DOHIN*2*LBSN/100.
775          COST(I,1)=COST(I,1)+((SHPWTO+SHPWTN)*XPORTI)
776          COST(I,1)=COST(I,1)+NOCPM(I)
777          ZOM(I)=COST(I,1)
778          IF(JFLAG.EQ.0) GO TO 900
     C-----ADD IN OTHER COST CATEGORIES BY YEAR
779          IF(I.GT.5) GO TO 800
780          IF(NRD(I).NE.0) NCHKYR=I
781        800 IF(NIN(I).NE.0.OR.NIR(I).NE.0) NCHKYR=I
     C       ZCOST 17
782          COST(I,1)=COST(I,1)          +NIN(I)+NIR(I)
783          IF(I.LT.6) COST(I,1)=COST(I,1)+NRD(I)
     C-----CALCULATE CUM & DISCOUNTED COSTS
784        900 COST(1,2)=COST(1,1)
785          XI=I
786          COST(1,3)=COST(1,1)*((1.+FI)**(-(1.-.5)))
787          M=I-1
     C       ZCOST 17
788          IF(I.GT.1) COST(I,2)=COST(M,2)+COST(I,1)
     C       ZCOST 18
789          IF(I.GT.1) COST(I,3)=COST(M,3)+(COST(I,1)*((1.+FI)**(-(XI-.5))))
     C-----DISCOUNT INVESTMENT
790          IF(JFLAG.EQ.0) GO TO 1000
     C       ZCOST 19
791          IF(I.LT.6) VTEMP=NRD(I)+NIN(I)+NIR(I)
792          IF(I.GT.5) VTEMP=NIN(I)+NIR(I)
793          IF(I.GT.1) GO TO 990
794          VVEST=VTEMP*((1.+FI)**(-(.5)))
795          GO TO 995
796        990 VVEST=VVEST+(VTEMP*((1.+FI)**(-(XI-.5))))
797        995 CONTINUE
798       1000 CONTINUE
     C-----FORMAT STATEMENTS - PRINT INPUT
799       2000 FORMAT(1H1,///T22,'COST INPUT DATA - BASELINE')
800       2010 FORMAT(1H1,///T22,'COST INPUT DATA - ALTERNATE')
801       2020 FORMAT(1H1,///T16,'COST INPUT DATA - ALTERNATE',///T3,
              1 'INVESTMENT COSTS BY YEAR : ',//T24,'NON',/T3,'YEAR',T15,
              2 'R&D   RECURRING   RECURRING',/)
802       2100 FORMAT(///T3,'CONSTANT FACTORS :',/T5,'OVERHEAD',T47,F6.2,1X,'%',
              1 /T5,'G&A',T47,F6.2,1X,'%',/T5,'PROFIT',T47,F6.2,1X,'%',/T5,
              2 'SHIPPING RATE - CONTRACT',T46,'$',T48,F5.2,1X,'PER 100 LBS.',
              3 /T21,'IN-HOUSE',T48,F5.2,1X,'PER 100 LBS.',/T5,'ARMY LABOR RATE -
              4 AVUM',T48,F5.2,1X,'PER HR.',/T23,'AVIM',T48,F5.2,1X,'PER HR.',
              5 /T23,'DEPOT',T48,F5.2,1X,'PER HR.',/T5,'FUEL COST',T48,F5.2,1X,
              6 'PER GALLON',/T5,'DISCOUNT RATE',T47,F6.2,1X,'%')
803       2200 FORMAT(///T3,'OPERATING COST DATA :',T45,'OLD ITEM',T65,'NEW ITEM'
              1 ,/T5,'% DEPOT MAINT. PERFORMED BY CONTR.',T47,I3,  1X,'%',T67,
              2 I3,  1X,'%',/T5,'UNBURDENED RATE',T44,'$',T48,F5.2,1X,'PER HR.'
              3,T64,'$',T68,F5.2,1X,'PER HR.',/T5,'AVG. MMH TO REPAIR AT DEPOT',
              4 T46,2(F7.2,13X),/T27,'AVUM',T47,2(F6.2,14X),/T27,'AVIM',T47,
              5 2(F6.2,14X),/T5,'AVG. VALUE OF PARTS CONSUMED AT DEPOT $ ',F8.2,
              6 T63,'$ ',F8.2,/T37,'AVUM',T47,2(F6.2,14X),/T37,'AVIM',T47,
              7 2(F6.2,14X),/T5,'PART SHIPPING WEIGHT',T47,I3,4X,'LBS.',T67,I3,
```

```
     8 4X,'LBS.',/T5,'SFC PER FLT. HR.',T47,F6.2,1X,'LBS.',T67,F6.2,1X,
     9 'LBS.',///T3,'PROGRAM MGMT. COST PER YEAR :',/)
804  2300 FORMAT(20(/T36,I2,5X,I8))
805  2400 FORMAT(//T3,'R+D COSTS',T49,'OVERHEAD ALREADY',/T5,'CONTRACT',
     1 T51,'INCLUDED ?',/T7,'ENGINEERING',T38,F9.0,7X,1A4,/T7,'TOOLING',
     2 T38,F9.0,7X,1A4,/T7,'PROTOTYPE PRODUCTION',T38,F9.0,7X,1A4,/T7,
     3 'OTHER',T38,F9.0,7X,1A4,/T7,'G&A',T38,F9.0,/T7,'PROFIT',T38,F9.0,
     4 /T7,'QTY. OF PROTOTYPES',T38,F9.0,/T5,'IN-HOUSE',/T7,'PROGRAM MGM
     5T.',T38,F9.0,/T3,'IF ELEMENTS NOT BROKEN OUT, TOTAL  ',F9.0,/T3,
     6 'ESTIMATE R&D COSTS ?',T42,1A4)
806  2500 FORMAT(//T3,'INVESTMENT NONRECURRING COSTS',/T5,'CONTRACT',/T7,
     1 'ADV PROD ENGINEERING',T38,F9.0,7X,1A4,/T7,'TOOLING',T38,F9.0,7X,
     2 1A4,/T7,'MANUFACTURING',T38,F9.0,7X,1A4,/T7,'QUALITY CONTROL',
     3 T38,F9.0,7X,1A4,/T7,'OTHER',T38,F9.0,7X,1A4,/T7,'G&A',T38,F9.0,
     4 /T7,'PROFIT',T38,F9.0,/T5,'IN-HOUSE',/T7,'PROGRAM MGMT.',T38,
     5 F9.0,/T3,'IF ELEMENTS NOT BROKEN OUT, TOTAL  ',F9.0,/T5,
     6 'ESTIMATE NONRECURRING COSTS ?',T42,1A4)
807  2600 FORMAT(//T3,'INVESTMENT RECURRING COSTS',/T5,'CONTRACT',/T7,
     1 'ENGINEERING',T38,F9.0,7X,1A4,/T7,'TOOLING',T38,F9.0,7X,1A4,/T7,
     2 'QUALITY CONTROL',T38,F9.0,7X,1A4,/T7,'MANUFACTURING',T38,F9.0,
     3 7X,1A4,/T7,'FIRST DEST. TRANSPORTATION',T38,F9.0,/T7,'OTHER',
     4 T38,F9.0,/T7,'G&A',T38,F9.0,/T7,'PROFIT',T38,F9.0,/T5,'IN-HOUSE',
     5          /T7,'TRANSPORTATION',T38,F9.0,/T7,'PROGRAM MGMT.',T38,
     6 F9.0,/T5,'TOTAL QTY.',T40,F7.0,/T3,'IF ELEMENTS NOT BROKEN OUT, T
     7OTAL',T38,F9.0,/T3,'ESTIMATE RECURRING COSTS ?',T42,1A4)
808  2700 FORMAT(5(/,4X,I2,3(3X,I8  )),15(/,4X,I2,14X,I8,  3X,I8  ))
809       RETURN
810       END
```

PROGRAM OUTPUT

```
AIRCRAFT =   47C BASELINE
CLASS =  1


PAYLOAD  ---------------  24000 LBS
CRUISE SPEED (KMPH)
    INTERNAL  ----------  259
    EXTERNAL  ----------  238

CABIN COMPARTMENT
  FLOOR AREA -----------  240 SQ.FT.
  NUMBER OF SEATS ------   44
  NUMBER OF LITTERS ----   24
    AMBULATORY SEATS ---    2
```

| MISSION NO | TYPE | CLS | LEG TYPE | NO | DIST | NUMBER OF PAX | LITS | CARGO POUNDS | INDV LOAD | SORTIES | FLT. HRS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 1 | 1 | 1 | 255 | 212872 | 0 | 65022720 | 1 | 4838 | 2,036 |
| | | | | | | | | | | 4838 | 9849,094 |

| | | |
|---|---|---|
| NUMBER OF AIRCRAFT | 16. | |
| UTILIZATION | 50.00 | HRS/AC/MO |
| MEAN TIME BETWEEN MAINTENANCE | 0.7505 | HOURS |
| TO & E SIZE | 6 | CREWS |
| MTTR | 2.150 | HOURS |
| EXPECTED QUEUE LENGTH | 0.2125 | TASKS |
| EXPECTED WAITING TIME FOR MEN | 0.1340 | HOURS |
| EXPECTED NO. TASKS. IN SYSTEM | 3.6229 | |
| EXPECTED TIME IN SYSTEM | 2.2840 | HOURS |
| PROBABILITY OF NO TASKS. IN SYSTEM | 0.0319 | |
| TOTAL WAITING TIME | 142.7950 | HOURS (FAILS. X EXP. WAIT TIME) |
| TOTAL DOWN TIME | 2434.5980 | HOURS ( FAILS. X EXP. TIME IN SYS.) |
| NORM. WAITING | 1.3281 | % ( TOT. WAIT TIME/TOT AC CAL. HRS.) |
| NORM. TOTAL | 22.6432 | % ( TOT. DOWN TIME/TOT AC CAL. HRS.) |
| NORS = (INPUT) | 7.0000 | % |
| AVAILABILITY | 70.3568 | % |

AIRCRAFT = 47 ALTERNATE
CLASS = 1

PAYLOAD ---------- 23993 LBS
CRUISE SPEED (KMPH)
INTERNAL ---------- 259
EXTERNAL ---------- 238

CABIN COMPARTMENT
FLOOR AREA ---------- 240 SQ.FT.
NUMBER OF SEATS ------ 44
NUMBER OF LITTERS ---- 24
AMBULATORY SEATS --- 2

| MISSION NO | TYPE | CLS | LEG TYPE | NO | DIST | NUMBER OF PAX | LITS | CARGO POUNDS | INDV LOAD | SORTIES | FLT. HRS. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 1 | 1 | 1 | 255 | 212872 | 0 | 65022720 | 1 | 4840 | 2.036 |
| | | | | | | | | | | 4840 | 9853.164 |

| | | |
|---|---|---|
| NUMBER OF AIRCRAFT | 16. | |
| UTILIZATION | 52.49 | HRS/AC/MO |
| MEAN TIME BETWEEN MAINTENANCE | 0.7513 | HOURS |
| TO & E SIZE | 6 | CREWS |
| MTTR | 2.050 | HOURS |
| EXPECTED QUEUE LENGTH | 0.2125 | TASKS |
| EXPECTED WAITING TIME FOR MEN | 0.1277 | HOURS |
| EXPECTED NO. TASKS. IN SYSTEM | 3.6228 | |
| EXPECTED TIME IN SYSTEM | 2.1777 | HOURS |
| PROBABILITY OF NO TASKS. IN SYSTEM | 0.0319 | |
| TOTAL WAITING TIME | 142.7707 | HOURS (FAILS. X EXP. WAIT TIME) |
| TOTAL DOWN TIME | 2434.5100 | HOURS ( FAILS. X EXP. TIME IN SYS.) |
| NORM. WAITING | 1.3279 | % ( TOT. WAIT TIME/TOT AC CAL. HRS.) |
| NORM. TOTAL | 22.6424 | % ( TOT. DOWN TIME/TOT AC CAL. HRS.) |
| NORS = (INPUT) | 7.0000 | % |
| AVAILABILITY | 70.3576 | % |

FLEET SIZING SUMMARY

| | BASELINE | ALTERNATE |
|---|---|---|
| FLT. HRS. REQUIRED TO PERFORM MISSION | 9849.09 | 9853.16 |
| HOLDING AVAILABILITY CONSTANT : | | |
| AVAILABILITY % | 70.36 | 70.36 |
| UTIL. (FH/AC/MO) | 50.00 | 52.49 |
| FLEET SIZE (AC) | 196.98 | 187.70 |
| HOLDING UTILIZATION CONSTANT : | | |
| AVAILABILITY % | 70.36 | 71.71 |
| UTIL. (FH/AC/MO) | 50.00 | 50.00 |
| FLEET SIZE (AC) | 196.98 | 197.06 |
| HOLDING FLEET SIZE CONSTANT : | | |
| AVAILABILITY % | 70.36 | 71.69 |
| UTIL. (FH/AC/MO) | 50.00 | 50.02 |
| FLEET SIZE (AC) | 196.98 | 196.98 |

MODIFICATION INCORPORATION DATA - OLD STIFFNER

I N P U T S :

| | |
|---|---|
| NO. OF MONTHS IN STUDY | 180 |
| NO. OF COMPONENTS IN FLEET | 296 |
| IRREG. DELIVERY RATE ? | NO |
| IF CONSTANT, DELIVS. PER MO. | 4 |
| NO. OF MONTHS | 25 |
| AC DELIVERED WITH MOD ? | NO |
| START MONTH | 1 |
| IRREG. UTILIZATION ? | NO |
| FLT. HRS./COMP./MO. | 50 |
| TOTAL AC DELIV. WITH MOD | 0 |
| IRREG. FIELD MOD INCORP. RATE ? | NO |
| IF CONSTANT, INCORPS. PER MO. | 0 |
| IF IRREG., NO. OF MONTHS | 0 |
| TOTAL INCORPORATED | 0 |
| START MONTH | 0 |
| QTY. SPARES ON HAND | 1 MONTHS |
| QTY. PIPELINE SPARES | 4 MONTHS |
| COMP. ATTR. RATE/100000 HRS. | 2.00 |

| | OLD ITEM | NEW ITEM |
|---|---|---|
| MTBF | 206.02 | 292.65 |
| MTBR TO AVIM | 0.00 | 0.00 |
| MTBR TO DEPOT | 0.00 | 0.00 |

O U T P U T S :

| | OLD ITEM | NEW ITEM |
|---|---|---|
| MAINT. ACTIONS AT | | |
| AVUM | 17006 | 0 |
| AVIM | 0 | 0 |
| DEPOT | 0 | 0 |
| FLT. HRS. | 3504000 | 0 |

| | |
|---|---|
| INIT. SPARES REQ. PER LOC. | 0 |
| COMPS. ATTRITED | 70 |

MODIFICATION INCORPORATION DATA - NEW STIFFNER

I N P U T S :

| | |
|---|---|
| NO. OF MONTHS IN STUDY | 180 |
| NO. OF COMPONENTS IN FLEET | 296 |
| IRREG. DELIVERY RATE ? | NO |
| IF CONSTANT, DELIVS. PER MO. | 4 |
| NO. OF MONTHS | 25 |
| AC DELIVERED WITH MOD ? | YES |
| START MONTH | 13 |
| IRREG. UTILIZATION ? | NO |
| FLT. HRS./COMP./MO. | 50 |
| TOTAL AC DELIV. WITH MOD | 52 |
| IRREG. FIELD MOD INCORP. RATE ? | NO |
| IF CONSTANT, INCORPS. PER MO. | 37 |
| IF IRREG., NO. OF MONTHS | 0 |
| TOTAL INCORPORATED | 344 |
| START MONTH | 13 |
| QTY. SPARES ON HAND | 1 MONTHS |
| QTY. PIPELINE SPARES | 4 MONTHS |
| COMP. ATTR. RATE/100000 HRS. | 2.00 |

| | OLD ITEM | NEW ITEM |
|---|---|---|
| MTBF | 206.02 | 292.65 |
| MTBR TO AVIM | 0.00 | 0.00 |
| MTBR TO DEPOT | 0.00 | 0.00 |

O U T P U T S :

| | OLD ITEM | NEW ITEM |
|---|---|---|
| MAINT. ACTIONS AT | | |
| AVUM | 1368 | 11009 |
| AVIM | 0 | 0 |
| DEPOT | 0 | 0 |
| FLT. HRS. | 281950 | 3222050 |

| | |
|---|---|
| INIT. SPARES REQ. PER LOC. | 0 |
| COMPS. ATTRITED | 64 |

COST INPUT DATA - BASELINE

CONSTANT FACTORS :

| | | |
|---|---|---|
| OVERHEAD | 180.00 % | |
| G&A | 17.00 % | |
| PROFIT | 10.00 % | |
| SHIPPING RATE - CONTRACT | $ 17.00 | PER 100 LBS. |
| IN-HOUSE | 13.00 | PER 100 LBS. |
| ARMY LABOR RATE - AVUM | 10.00 | PER HR. |
| AVIM | 11.00 | PER HR. |
| DEPOT | 13.50 | PER HR. |
| FUEL COST | 0.45 | PER GALLON |
| DISCOUNT RATE | 10.00 % | |

| OPERATING COST DATA : | | OLD ITEM | | NEW ITEM | |
|---|---|---|---|---|---|
| % DEPOT MAINT. PERFORMED BY CONTR. | | 0 % | | 0 % | |
| UNBURDENED RATE | | $ 0.00 | PER HR. | $ 0.00 | PER HR. |
| AVG. MMH TO REPAIR AT DEPOT | | 0.00 | | 0.00 | |
| | AVUM | 8.90 | | 0.00 | |
| | AVIM | 0.00 | | 0.00 | |
| AVG. VALUE OF PARTS CONSUMED AT DEPOT | | $ 0.00 | | $ 0.00 | |
| | AVUM | 5.00 | | 0.00 | |
| | AVIM | 0.00 | | 0.00 | |
| PART SHIPPING WEIGHT | | 0 | LBS. | 0 | LBS. |
| SFC PER FLT. HR. | | 0.00 | LBS. | 0.00 | LBS. |

PROGRAM MGMT. COST PER YEAR :

| | |
|---|---|
| 1 | 0 |
| 2 | 0 |
| 3 | 0 |
| 4 | 0 |
| 5 | 0 |
| 6 | 0 |
| 7 | 0 |
| 8 | 0 |
| 9 | 0 |
| 10 | 0 |
| 11 | 0 |
| 12 | 0 |
| 13 | 0 |
| 14 | 0 |
| 15 | 0 |
| 16 | 0 |
| 17 | 0 |
| 18 | 0 |
| 19 | 0 |
| 20 | 0 |

COST INPUT DATA - ALTERNATE

CONSTANT FACTORS :

| | | | |
|---|---|---|---|
| OVERHEAD | | 180.00 | % |
| G&A | | 17.00 | % |
| PROFIT | | 10.00 | % |
| SHIPPING RATE - CONTRACT | | $ 17.00 | PER 100 LBS. |
| | IN-HOUSE | 13.00 | PER 100 LBS. |
| ARMY LABOR RATE - AVUM | | 10.00 | PER HR. |
| | AVIM | 11.00 | PER HR. |
| | DEPOT | 13.50 | PER HR. |
| FUEL COST | | 0.45 | PER GALLON |
| DISCOUNT RATE | | 10.00 | % |

| OPERATING COST DATA : | | OLD ITEM | | NEW ITEM | |
|---|---|---|---|---|---|
| % DEPOT MAINT. PERFORMED BY CONTR. | | 0 | % | 0 | % |
| UNBURNDENED RATE | | $ 0.00 | PER HR. | $ 0.00 | PER HR. |
| AVG. MMH TO REPAIR AT DEPOT | | 0.00 | | 0.00 | |
| | AVUM | 8.90 | | 8.90 | |
| | AVIM | 0.00 | | 0.00 | |
| AVG. VALUE OF PARTS CONSUMED AT DEPOT | | $ 0.00 | | $ 0.00 | |
| | AVUM | 5.00 | | 5.00 | |
| | AVIM | 0.00 | | 0.00 | |
| PART SHIPPING WEIGHT | | 0 | LBS. | 0 | LBS. |
| SFC PER FLT. HR. | | 0.00 | LBS. | 0.00 | LBS. |

PROGRAM MGMT. COST PER YEAR :

| | |
|---|---|
| 1 | 0 |
| 2 | 0 |
| 3 | 0 |
| 4 | 0 |
| 5 | 0 |
| 6 | 0 |
| 7 | 0 |
| 8 | 0 |
| 9 | 0 |
| 10 | 0 |
| 11 | 0 |
| 12 | 0 |
| 13 | 0 |
| 14 | 0 |
| 15 | 0 |
| 16 | 0 |
| 17 | 0 |
| 18 | 0 |
| 19 | 0 |
| 20 | 0 |

COST INPUT DATA - ALTERNATE

| | | OVERHEAD ALREADY INCLUDED ? |
|---|---|---|
| R+D COSTS | | |
| CONTRACT | | |
| ENGINEERING | 0. | NO |
| TOOLING | 0. | NO |
| PROTOTYPE PRODUCTION | 0. | NO |
| OTHER | 0. | NO |
| G&A | 0. | |
| PROFIT | 0. | |
| QTY. OF PROTOTYPES | 0. | |
| IN-HOUSE | | |
| PROGRAM MGMT. | 0. | |
| IF ELEMENTS NOT BROKEN OUT, TOTAL | 0. | |
| ESTIMATE R&D COSTS ? | NO | |
| INVESTMENT NONRECURRING COSTS | | |
| CONTRACT | | |
| ADV PROD ENGINEERING | 0. | NO |
| TOOLING | 0. | NO |
| MANUFACTURING | 0. | NO |
| QUALITY CONTROL | 0. | NO |
| OTHER | 0. | NO |
| G&A | 0. | |
| PROFIT | 0. | |
| IN-HOUSE | | |
| PROGRAM MGMT. | 0. | |
| IF ELEMENTS NOT BROKEN OUT, TOTAL | 16027. | |
| ESTIMATE NONRECURRING COSTS ? | NO | |
| INVESTMENT RECURRING COSTS | | |
| CONTRACT | | |
| ENGINEERING | 0. | NO |
| TOOLING | 0. | NO |
| QUALITY CONTROL | 0. | NO |
| MANUFACTURING | 0. | NO |
| FIRST DEST. TRANSPORTATION | 0. | |
| OTHER | 0. | |
| G&A | 0. | |
| PROFIT | 0. | |
| IN-HOUSE | | |
| TRANSPORTATION | 0. | |
| PROGRAM MGMT. | 0. | |
| TOTAL QTY. | 450. | |
| IF ELEMENTS NOT BROKEN OUT, TOTAL | 74963. | |
| ESTIMATE RECURRING COSTS ? | NO | |

COST INPUT DATA - ALTERNATE

INVESTMENT COSTS BY YEAR :

| YEAR | R&D | NON RECURRING | RECURRING |
|---|---|---|---|
| 1 | 0 | 16027 | 0 |
| 2 | 0 | 0 | 2382 |
| 3 | 0 | 0 | 72581 |
| 4 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 |
| 6 | | 0 | 0 |
| 7 | | 0 | 0 |
| 8 | | 0 | 0 |
| 9 | | 0 | 0 |
| 10 | | 0 | 0 |
| 11 | | 0 | 0 |
| 12 | | 0 | 0 |
| 13 | | 0 | 0 |
| 14 | | 0 | 0 |
| 15 | | 0 | 0 |
| 16 | | 0 | 0 |
| 17 | | 0 | 0 |
| 18 | | 0 | 0 |
| 19 | | 0 | 0 |
| 20 | | 0 | 0 |

| OUTPUTS : | | BASELINE | | ALTERNATE | |
|---|---|---|---|---|---|
| 1.0 | RESEARCH & DEVELOPMENT | 0. | | 0. | |
| 1.01 | CONTRACT | | 0. | | 0. |
| 1.011 | ENGINEERING | | 0. | | 0. |
| 1.012 | TOOLING | | 0. | | 0. |
| 1.013 | PROTOTYPE PRODUCTION | | 0. | | 0. |
| 1.014 | OTHER | | 0. | | 0. |
| 1.015 | G. & A | | 0. | | 0. |
| 1.016 | PROFIT | | 0. | | 0. |
| 1.017 | QUANTITY OF PROTOTYPES | | 0. | | 0. |
| 1.02 | IN-HOUSE | | 0. | | 0. |
| 1.024 | PROGRAM MANAGEMENT | | 0. | | 0. |
| | | | 0. | | 0. |
| | | | 0. | | 0. |
| 2.0 | INVESTMENT NONRECURRING | 0. | | 16027. | |
| 2.01 | CONTRACT | | 0. | | 0. |
| 2.011 | ADV PROD ENGINEERING | | 0. | | 0. |
| 2.012 | TOOLING | | 0. | | 0. |
| 2.013 | MANUFACTURING | | 0. | | 0. |
| 2.014 | QUALITY CONTROL | | 0. | | 0. |
| 2.015 | OTHER | | 0. | | 0. |
| 2.016 | G & A | | 0. | | 0. |
| 2.017 | PROFIT | | 0. | | 0. |
| 2.02 | IN-HOUSE | | 0. | | 0. |
| 2.023 | PROGRAM MANAGEMENT | | 0. | | 0. |
| | | | 0. | | 0. |
| | | | 0. | | 0. |
| 3.0 | INVESTMENT RECURRING | 0. | | 74963. | |
| 3.01 | CONTRACT | | 0. | | 0. |
| 3.011 | ENGINEERING | | 0. | | 0. |
| 3.012 | TOOLING | | 0. | | 0. |
| 3.013 | QUALITY CONTROL | | 0. | | 0. |
| 3.014 | MANUFACTURING | | 0. | | 0. |
| 3.016 | FIRST DEST TRANSPORT | | 0. | | 0. |
| 3.017 | OTHER | | 0. | | 0. |
| 3.018 | G & A | | 0. | | 0. |
| 3.019 | PROFIT | | 0. | | 0. |
| 3.02 | IN-HOUSE | | 0. | | 0. |
| 3.025 | TRANSPORTATION | | 0. | | 0. |
| 3.026 | PROGRAM MANAGEMENT | | 0. | | 0. |
| 3.03 | TOTAL QUANTITY | | 0. | | 450. |
| | | | 0. | | 0. |
| | | | 0. | | 0. |
| 4.0 | OPERATING COSTS | 1598751. | | 1163437. | |
| 4.01 | CONTRACT | | 0. | | 0. |
| 4.012 | | | 0. | | 0. |
| 4.015 | TRANSPORTATION | | 0. | | 0. |
| 4.016 | DEPOT MAINTENANCE | | 0. | | 0. |
| 4.017 | OTHER | | 0. | | 0. |
| 4.02 | IN-HOUSE | 1598751. | | 1163437. | |
| 4.021 | MAINTENANCE LABOR | | 1513711. | | 1101552. |
| 4.022 | CONSUMPTION | | 85040. | | 61885. |
| 4.0221 | PARTS | | 85040. | | 61885. |
| 4.0222 | POL | | 0. | | 0. |
| 4.025 | TRANSPORTATION | | 0. | | 0. |
| 4.026 | DEPOT MAINTENANCE | | 0. | | 0. |
| 4.027 | PROGRAM MANAGEMENT | | 0. | | 0. |
| 4.03 | TOTAL QTY OPERATED | 396. | | 396. | |

BEST AVAILABLE COPY

| | BASELINE | | | ALTERNATE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | ANNUAL COST | CUM. COST | PRESENT VALUE | ANNUAL COST | CUM. COST | PRESENT VALUE | ANNUAL O&M COSTS | CUM O&M COSTS | OLD ITEMS | NEW ITEMS | TOTAL ITEMS |
| 1 | 88078. | 88078. | 83979. | 104105. | 104105. | 99260. | 88078. | 88078. | 344 | 0 | 344 |
| 2 | 101332. | 189410. | 171812. | 85666. | 189771. | 173514. | 83284. | 171362. | 0 | 392 | 392 |
| 3 | 108382. | 297792. | 257215. | 148909. | 338680. | 290852. | 76328. | 247690. | 0 | 396 | 396 |
| 4 | 108382. | 406174. | 334855. | 76328. | 415008. | 345530. | 76328. | 324018. | 0 | 396 | 396 |
| 5 | 108476. | 514650. | 405498. | 76234. | 491242. * | 395176. # | 76234. | 400252. | 0 | 396 | 396 |
| 6 | 108382. | 623032. | 469663. | 76328. | 567571. | 440864. | 76328. | 476580. | 0 | 396 | 396 |
| 7 | 108382. | 731414. | 527995. | 76328. | 643899. | 481444. | 76328. | 552908. | 0 | 396 | 396 |
| 8 | 108476. | 839890. | 581069. | 76328. | 720226. | 518790. | 76328. | 629236. | 0 | 396 | 396 |
| 9 | 108382. | 948271. | 629278. | 76328. | 796553. | 552740. | 76328. | 705563. | 0 | 396 | 396 |
| 10 | 108382. | 1056653. | 673103. | 76328. | 872881. | 583604. | 76328. | 781891. | 0 | 396 | 396 |
| 11 | 108382. | 1165034. | 712945. | 76328. | 949209. | 611663. | 76328. | 858219. | 0 | 396 | 396 |
| 12 | 108476. | 1273509. | 749196. | 76328. | 1025537. | 637170. | 76328. | 934547. | 0 | 396 | 396 |
| 13 | 108382. | 1381890. | 782123. | 76328. | 1101865. | 660359. | 76328. | 1010875. | 0 | 396 | 396 |
| 14 | 108382. | 1490271. | 812056. | 76328. | 1178192. | 681440. | 76328. | 1087203. | 0 | 396 | 396 |
| 15 | 108476. | 1598746. | 839292. | 76234. | 1254425. | 700580. | 76234. | 1163436. | 0 | 396 | 396 |

* = BREAK EVEN POINT, (COSTS NOT DISCOUNTED).
# = BREAK EVEN POINT, (PRESENT VALUE).

| | BASELINE | ALTERNATE |
|---|---|---|
| CUMULATIVE CASH FLOW, ACTUAL | 1598746. | 1254425. |
| PRESENT VALUE OF CASH FLOW | 839292. | 700580. |
| INVESTMENT (PRESENT VALUE) | | 74539. |
| TRUE RATE OF RETURN ON INVESTMENT | | 11.17 % |