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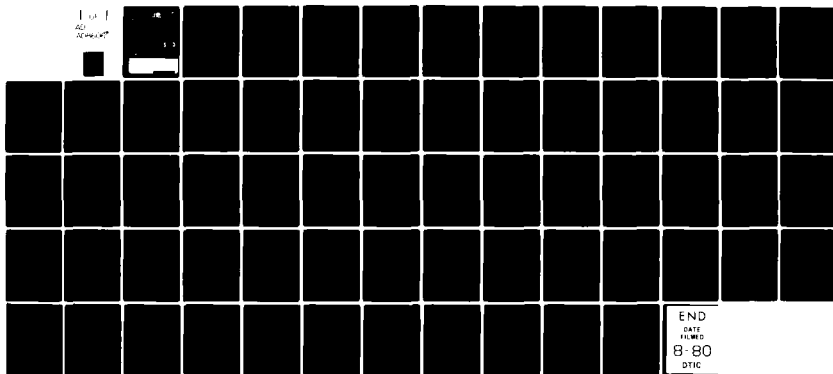
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Analyses indicated that a very good correlation exists between the Aviation Component Repair Program funding level and aircraft readiness as measured by the Mission Capable (MC) rate when a "lag-time" of twelve months is taken into consideration. It also indicated a very good correlation when the component repair funding is combined with the Aviation Component Procurement Program and compared to the Not Mission Capable - Supply (NMCS) and the Supply/System Material Availability (SMA) rate.

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PREFACE

The Aviation Component Repair Program Analysis was conducted by CACI, Inc. - Federal under Contract N00014-80-C-0097, dated December 17, 1979, with the Director, Systems Analysis Division, Navy Program Planning Office.

An essential element in the very complex field of aviation logistics management is the acquisition of adequate resources to repair aviation components in support of operating aircraft. Since Fiscal Year 1975, funding for the Aviation Component Repair Program has increased steadily. However, a clearly demonstrated improvement in mission capable aircraft has not occurred. Consequently, as the resource requirements for the Aviation Component Repair Program continued to increase, the Navy was faced with an urgent requirement to develop a measurement of effectiveness which would be useful in demonstrating how incremental improvements in mission capable aircraft could be achieved by the application of additional resources.

This requirement was needed for use in the Fiscal Year 1982 Program Objectives Memorandum review. In recognition of its urgency, the Director, Systems Analysis Division, Navy Program Planning Office initiated efforts to acquire contract support in the development of a measure of effectiveness for the Aviation Component Repair Program.

The analysis contained in this report is the result of the efforts undertaken by CACI and is presented in Volumes I and II. Volume II is a classified Appendix and includes detailed data used in developing the analysis and detailed statistical calculations.

The advice, cooperation and constructive criticism provided by members of the Staffs of the Office of the Chief of Naval Operations and the Comptroller of the Navy, the Naval Air Systems Command, Naval Supply Systems Command and the field activities of the Systems Commands are greatly appreciated by CACI.

These contributions were of immense value in accomplishing this analysis. However, their involvement and cooperation with CACI's effort in no way signifies that they endorse this report. The findings, conclusions and recommendations contained in this report are the sole responsibility of CACI, Inc. - Federal.

EXECUTIVE SUMMARY

During the early seventies, the Navy was funding the Aviation Component Repair Program at approximately \$200 million annually. During this period, the Mission Capable (MC) rate, was declining each year and reached a low point of 56.4 percent in Fiscal Year 1976. Over this same period, the Non-Mission Capable -Supply (NMCS) rate, was increasing each year and reached a high point of 23.3 percent in Fiscal Year 1976.

There was a general consensus of opinion within the Navy that improvement in aircraft readiness, as measured by the MC rate, was directly dependent upon the availability of aviation repairable components. Thus, the Navy commenced increasing the amount of resources applied to the Aviation Component Repair Program in Fiscal Year 1975 to arrest the declining MC rate experienced in the early seventies.

Even with the increased funding levels in the late seventies, however, the Navy did not achieve a corresponding increase in aircraft readiness, as measured by traditional management indicators. Specifically, between Fiscal Years 1975 and 1979, funding levels for component repair increased by 54 percent in constant dollars whereas the MC rate increased by only 15 percent. Similarly, the NMCS rate decreased by only 12 percent. Based upon these observed trends, the validity of the relationship between component repair funding and the traditional management indicators became questionable.

In view of the above, an analysis of the Aviation Component Repair Program was conducted to identify a measure of effectiveness which would be useful in assessing the Program's funding requirements.

ANALYSIS FINDINGS AND CONCLUSIONS

The analysis of the Aviation Component Repair Program covered the period of 1970 to 1979 and all resource data was converted to Fiscal Year 1980 dollars. The analysis revealed the following:

- o The MC rate was very dependent upon the amount of component repair funding applied twelve months in advance of the observed rate. The relationship found most appropriate for linking funding to readiness is $MC = .43 + .00047X$ (Component Repair, Fiscal Year 1980 constant dollars in millions). The data used implicitly assumed that the total maintenance and supply system is operating with resources being balanced. To fund component repair at the expense of another segment of the system would violate the ground rules used in the analysis. The results of this analysis show that as component repair funding increased, the MC rate also increased.

- o No relationship between component repair funding and the NMCS or SMA (Systems Material Availability) was determined.
- o A very significant relationship existed between the component repair and repairable procurement funding and the MC rate. The "lag-time" for repair funding was ten to twelve months and for the procurement funding was eighteen to twenty-four months.
- o Using both component repair and procurement funding, a very good relationship was found with NMCS and SMA rates.

The following observations were noted during the course of the analysis:

- o The cost of repair at commercial facilities was twice that experienced at Naval Air Rework Facilities.
- o The number of components requiring repair per aircraft flight hour has increased approximately forty percent since Fiscal Year 1975.
- o The number of components returned from the Intermediate level to the Depot for repair has increased thirty percent since Fiscal Year 1975 while the number of components repaired at the Intermediate level has also increased slightly.
- o The cost to repair in constant dollars has increased approximately fifty percent since Fiscal Year 1975.

The above observations indicate that the increasing cost of the component repair program may have been driven by more complex weapon systems as well as a possible change in maintenance strategy, e.g., modular replacement.

RECOMMENDATIONS

Based upon the findings and conclusions outlined above, the following recommendations are offered for consideration:

- o The MC rate, and the relationship previously mentioned, should be utilized as a measure of effectiveness in evaluating the funding requirements for the Aviation Component Repair Program.
- o Further analysis should be performed to evaluate readiness indicators and funding by weapon system, the causative factors for the dramatic increase in the cost of repair at commercial facilities, and the impact of more complex weapon systems on funding requirements.

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CHAPTER I

INTRODUCTION

A. Problem

Historically, the traditional perception within the Navy has been that improvement in mission capable aircraft, or aircraft readiness, was directly dependent upon the availability of aviation repairable components. There was also a widespread opinion within the Navy that the most effective and timely method of increasing component availability was through component repair rather than procurement of additional components. As such, the Navy believed that increasing the funding of component repair would yield significant improvements in aircraft readiness. Consequently, the Navy commenced increasing the level of funding for the Aviation Component Repair Program in Fiscal Year 1975. The program increased from a level of approximately \$200 million in the early seventies to a level of nearly \$500 million in Fiscal Year 1979.

Even with the increased funding levels in the late seventies, however, the Navy did not experience a corresponding improvement in aircraft readiness as measured by traditional management indicators, e.g., Mission Capable (MC), Not-Mission Capable-Supply (NMCS) and Supply/System Material Availability (SMA). Between Fiscal Year 1975 and Fiscal Year 1979, an increase of 54 percent in real growth was provided in component repair funding, yet the MC rate improved by only 15 percent and the NMCS rate improved by only 12 percent.

It was concluded that the relationship between component repair funding levels and traditional management indicators of aircraft readiness was less than satisfactory. Because of the constrained timeframes of the POM review process, the Navy urgently needed an in-depth and objective analysis of this program which would identify a measure of effectiveness that would be useful in assessing and supporting future funding requirements.

In view of the above situation, the Director, Systems Analysis Division, Navy Program Planning Offices contracted with CACI, Inc. - Federal to perform an analysis of the Aviation Component Repair Program.

B. Objective

The objective of this contractual effort was to determine a measure of effectiveness for use in evaluating the funding requirements for the Aviation Component Repair Program.

C. Scope

The Aviation Component Repair Program as envisioned in this study is the depot level repair of repairable components which is budgeted and funded by the Naval Air Systems Command in the Operations and Maintenance, Navy (O&MN) appropriation. It does not include any repair below depot level, i.e., at the squadron or IMA level, nor does it include any repair funded by appropriations other than the O&MN appropriation.

This study was performed at the "macro" level, i.e., consideration was not given to either funding or readiness indicators for individual type, model or series of aircraft, individual Fleets or Type Commanders, or various segments of the component repair program such as Closed Loop Aeronautical Management Program (CLAMP).

D. Approach

The initial effort in this study was collecting and assembling statistical data available on component repair, aviation-related programs and operational readiness indicators.

The next step was to organize data and data sub-sets into categories appropriate for comparison. Beginning with simple and progressing through more complex statistical formulae, over 30 different comparisons were made with several iterations of each comparison.

From these comparisons, findings, conclusions and recommendations were formed and are presented in this study.

E. Format

Chapter I of this volume provides an introduction and describes the problem, objective, scope, approach and format.

The remainder of this volume contains the following:

- o Chapter II presents a description of the data utilized in this study,
- o Chapter III describes the methods of comparison,
- o Chapter IV describes the various comparative analyses,
- o Chapter V presents the findings,
- o Chapter VI presents the conclusions, and
- o Chapter VII presents the recommendations.

Volume II is classified CONFIDENTIAL and contains the data utilized in this study (Appendix A) and the detailed calculations used in the comparisons (Appendix B).

CHAPTER II

DATA DESCRIPTION

The following four types of data were assembled for use in this study.

Escalation Indices: All comparisons in this study using cost data have been converted to Fiscal Year 1980 constant dollars by use of escalation indices for Operations and Maintenance, Navy (O&MN) and Aircraft Procurement, Navy (APN). APN indices have been used for procurement of spares and O&MN indices for all other costs.

Cost Data: All cost data used has been based on "then year" dollar cost prior to converting to Fiscal Year 1980 constant dollars. Cost tables shown in Appendix A are in "then year" figures.

Workload Data: Workload data used in this study have been reported at summary levels. No adjustments have been made to reflect the weight of this data as it varies during the reporting period. For example, Aircraft Flying Hours are the total for all aircraft without regard to the individual type, model or series.

Measure of Effectiveness: Readiness indicators used are those officially recognized and used by the Navy at the time the study was undertaken. Adjustments have not been made to reflect changes in terminology or reporting procedures. For example, NMCS as used in the study to reflect Not Mission Capable due to a supply deficiency, is used synonymously with readiness indicators formerly reported as NORS, Not Operationally Ready-Supply.

Tables of data used in this study are included in the appendixes with appropriate explanations provided below:

Escalation Indices

Escalation indices are those prescribed by the Office of the Secretary of Defense (OSD) for use in budgeting and programming. These indices are broad and represent averages for all costs within the various appropriations. The Navy's Aviation Repair Program is executed through the use of Navy Industrial Fund Activities, Commercial Contracts, Navy Overseas Repair Activities and through inter-service agreements with other defense agencies. Each of these repair services experiences differing rates of inflations. Notwithstanding this, all analysis in this study has been made by converting "then year" dollars to Fiscal Year 1980 constant dollars by using the OSD indices.

Component Rework Requirements

Component Rework Requirements reflected in Naval Air Systems Command (NAVAIRSYSCOM) budget documents are identified by material or type of requirement. Requirements calculations vary as follows:

2R/8R Cognizance Material: Requirements are determined by the Aviation Supply Office (ASO) stratification process and coordinated with the NAVAIRSYSCOM for manhour norms, pricing, etc.

4A Cognizance Material: Requirements are determined by the Ship Parts Control Center (SPCC) stratification process and coordinated with the NAVAIRSYSCOM for manhour norms, pricing, etc.

Repair of Repairables: These are component repair requirements that exist prior to the Navy Support Date and are determined by NAVAIRSYSCOM.

Concurrent Repair: Components repaired concurrently with other major rework, e.g., airframes and engines, are currently identified as a separate line in the component repair budget beginning in Fiscal Year 1980. This type of repair is not identified for years prior to Fiscal Year 1980 and, therefore, has not been considered in this study.

Requirements used in this study have been calculated by using the actual funding for the fiscal year and adding to that the latest unfunded deficiency projected by the NAVAIRSYSCOM at varying points in the budget cycle. Since the stratification process is not performed with every budget iteration, a final residual unfunded requirement is not available for an "actual" year. Therefore, the latest calculated deficiency is used by the NAVAIRSYSCOM and is also used in this study.

Component Repair Funding

This study has used the actual certified obligations reported to Congress as funding for each fiscal year for each category of material repaired in the component repair program. Subsequent to the reporting of certified obligations, minor adjustments are made each year until the program is finally expended. No provision has been made in this study to reflect these minor changes.

Component Repair Manhours

Manhours utilized in this study are those direct manhours for the Naval Air Rework Facilities as reported by the NAVAIRSYSCOM in their budget documents. Indirect manhours are

an overhead cost at the rework facilities and are included in the component repair cost, but indirect manhours are not used in measuring output performance. Also, these manhours are associated with Navy in-house efforts only. Manhour data is not available for commercial or inter-service repair.

NRFI Components Generated and Repaired

These data represent the number of unserviceable components generated at the Intermediate Maintenance Facilities (IMAs), the number being repaired at the IMA's and the number being repaired at the depot level. Depot level repair includes those being repaired commercially and by inter-service facilities as well as those repaired by Naval Air Rework Facilities.

However, the validity of the units repaired at the depot level is questionable. The cost of repairing a unit can vary significantly and because of this, the NAVAIRSYSCOM has not used a unit count as a significant measure. In most cases, the units shown for Fiscal Year 1970-1974 were derived numbers, i.e., the total cost divided by a calculated manhour norm.

Component Repair (Commercial/In-house) Funding

The categorization of commercial/in-house component repair is that reflected in budget documents submitted to the Congress. The in-house effort includes the cost of components repaired at the Naval Air Rework Facilities, the Naval Avionics Facility at Indianapolis (NAFI), and interservice repair performed at Army and Air Force activities. Commercial repair includes the cost of contract repairs at overseas activities as well as commercial contractors in the United States.

Component Procurement Funding

Although the component repair program encompasses more than 2R/8R cognizance material, the other costs make up less than 5 percent of the total program cost. For purposes of using procurement funding in this study, initial and replenishment procurement have been limited to 2R/8R cognizance material managed by the Aviation Supply Office.

Total Aircraft Rework Funding

Actual funding for the total aircraft rework program is the actual certified obligation as reflected in the congressional budget submissions for each fiscal year. Subsequent to the reporting of certified obligations, minor adjustments are made each year until the program is finally expended. No provision has been made in this study to reflect these minor changes.

Because of continuous change in the budget structure, this data is valid only for use in a "macro" sense for individual

segments of the rework budget. For example, Airframe Rework funding for Fiscal Years 1970 through 1975 includes the cost of installation of modification kits which were budgeted separately in subsequent fiscal years.

The total aircraft rework program is generally on a comparable basis with two exceptions; (1) the Fiscal Year 1970 program includes funding for the Reserve program as well as the Active program, and (2) the Weapon Systems Support Departments at the Naval Air Rework Facilities were included as a part of the rework programs and funded in the Aircraft Support Services line for Fiscal Years 1970 through 1978. In Fiscal Year 1979, this was transferred to other Naval Aviation programs.

It should be noted that although the component repair program is identified and funded in the Active program, it also supports the Reserve programs as well.

Aircraft Inventory

Aircraft inventory used in this study is the end-year and average operating count of active inventory comprising Active, Reserve, Research and Pipeline Aircraft, since the component repair program supports all of these aircraft. Inactive aircraft stowed at the storage facility at Davis-Monthan Air Force Base is not included.

Aircraft Flying Hours

Flying hours represent those flown and supported by the O&MN and the O&MNR appropriations. Flying hours for aircraft supported by the Research, Development, Test and Evaluation, Navy (RDT&E,N) appropriation have not been included since they weren't readily available.

The flying hours shown in the Appendixes represent data included in three consecutive budget submissions to Congress. For example, Fiscal Year 1979 flying hours were obtained from the following:

Initial - Budget Year	Fiscal Year 1979 Congressional Budget of January 1978 (Fiscal Year - 1977, 1978, 1979)
Execution - Current Year	Fiscal Year 1980 Congressional Budget of January 1979 (Fiscal Year - 1978, 1979, 1980)
Actual - Past Year	Fiscal Year 1981 Congressional Budget of January 1980 (Fiscal Year - 1979, 1980, 1981)

Direct Maintenance Manhours

Direct Maintenance Manhours per Flight Hour are those man-hours of maintenance reported in the 3M system for Organizational and Intermediate Maintenance Activities. It does not include depot level maintenance performed at the Naval Air Rework Facilities (NARF's), Naval Avionics Facility, Indianapolis (NAFI), commercial contractors plants or at interservice activities.

Cannibalization Rates

Cannibalization is the removal of a Ready-for-Issue (RFI) component from one aircraft for use on another when the component is not available otherwise. Cannibalization data was not available prior to Fiscal Year 1974.

Readiness Indicators

OPNAVINST 5442.4F (OP-514) of 29 January 1979 defines Mission Capable (MC), Not Mission Capable (NMC), Not Mission Capable-Maintenance (NMCM) and Not Mission Capable-Supply (NMCS) as follows:

Mission Capable (MC)

The material condition status of an aircraft, training device or item of ground support equipment, indicating it can perform at least one and potentially all of its designated missions, category A through L, as defined by the applicable mission description (enclosures (1), (2), and/or (3)). MC is further defined as the sum of Full Mission Capable (FMC) and Partial Mission Capable (PMC).

Not Mission Capable (NMC)

The material condition status of an aircraft, a training device or an item of ground support equipment indicating that it is not capable of performing any of the missions, category A through L, as defined by the applicable mission description (enclosures (4), (5), and/or (6)) by the use of the corresponding Mission Essential Subsystem Matrix (enclosures (1), (2), and/or (3)). NMC is further defined as the sum of Not Mission Capable-Maintenance (NMCM) and Not Mission Capable-Supply (NMCS).

Not Mission Capable - Maintenance (NMCM)

The material condition status of an aircraft, a training device or, an item of ground support equipment indicating it is not capable of performing any of its missions, category A through L, as determined by use of the applicable Mission Essential Subsystem Matrix (enclosures (1), (2) and/or (3)) because of organizational or

intermediate level maintenance requirements. Recording of NMCM time shall start when it is first known that the condition exists, except in the case of an aircraft when caused by an in-flight malfunction, then the time will start at termination of the flight. Time shall stop when maintenance has been completed or is interrupted by work stoppage due to supply shortage. (The period of work stoppage due to supply shall be measured as NMCS).

Not Mission Capable - Supply (NMCS)

The material condition status of an aircraft, training device or item of ground support equipment indicating that it is not mission capable because maintenance required to clear the discrepancy cannot continue due to a supply shortage. Recording of NMCS time shall start when a supply demand has been made for an item(s) required for maintenance. NMCS time shall stop when the item(s) are delivered to the maintenance activity.

This instruction further defines each of the Missions and each Mission Essential Subsystem Matrix which is used to determine the capability or non-capability of an aircraft. The above readiness indicators used in this study are annual average rates for each category.

Airframe Reworks

Airframe Rework requirements are based upon the A-VII Issue Requirements formulated by OPNAV. Aircraft are scheduled for maintenance, modifications, conversion, crash damages, or special rework. During the ten-year period (Fiscal Year 1970 - Fiscal Year 1979) a significant change in maintenance policy occurred which tends to distort any comparisons made. This change has been an evolvement from the Progressive Aircraft Rework (PAR) maintenance, through the Aircraft Conditional Evaluation (ACE) to the current Standard Depot Level Maintenance (SDLM). The philosophy for maintenance varied with each. In Fiscal Year 1970, approximately 85 percent of the airframe rework was PAR or Overhaul, 15 percent was conversions or modifications. In Fiscal Year 1974, 45 percent was PAR or Overhaul, 45 percent was ACE and 10 percent was conversions or modifications. In Fiscal Year 1975, 35 percent was PAR or Overhaul, 25 percent ACE, 32 percent SDLM and 8 percent conversions or modifications. Currently all reworks are SDLM and conversions/ modifications.

Reworks funded are those actually inducted during the fiscal year for repair. Requirements less those funded are categorized as "Aircraft on Extension". These aircraft are operating beyond their prescribed maintenance cycle and are not funded either due to funding constraints or for operational reasons.

A standard measure of effectiveness for this program is the percentage of aircraft on extension which is derived by dividing the number on extension by the average active operating aircraft.

Pilot Training Output

Pilot Training Output includes the Pilot Training Rate (PTR) for Navy Pilots training in jet, propeller and helicopter aircraft. It also includes Navy Flight Officer (NFO) training in such things as radar, instruments, etc. as well as a small amount of foreign and Coast Guard officers. All training is performed at Naval and Marine Corps Activities.

Supply/System Material Availability

Supply or System Material Availability (SMA) is a measure of effectiveness of the wholesale supply system and is expressed as a percentage of requisitions filled divided by the total number of requisitions received. This is also commonly referred to as the "Fill Rate". The SMA rates used in this study are annual average rates for 2R cognizance material managed by the Aviation Supply Office in Philadelphia.

CHAPTER III
METHODS OF COMPARISON

A. General

In order to determine a measure of effectiveness which could be best applied to assess the impact of the component repair program, several types of comparisons were performed:

- o Component repair program was compared to various measures of effectiveness.
- o Component repair-related programs were compared to various measures of effectiveness.
- o Component repair and related programs were jointly compared to various measures of effectiveness.
- o Comparisons were made between various measures of effectiveness to determine relationships, if any.

The statistical analyses techniques used in this study are basic techniques commonly applied throughout government and industry. Each of these techniques are described in the following paragraphs.

B. Simple Linear Regression

A simple linear regression analysis is a technique used to predict the value of one quantitative (dependent) variable by using its relationship with an independent variable. The equation for this technique and for the coefficient of determination (R^2) and correlation coefficient (r) are as follows:

EQUATION: $Y = a + bx$

WHERE: Y = Dependent Variable (MC, NMCS, or SMA)

x = Independent Variable (Funding, Direct Maintenance Manhours per Flying Hour, Cannibalization)

a = Y Intercept

b = Regression Coefficient

COEFFICIENT OF DETERMINATION

$$R^2 = \frac{\Sigma(Y - \bar{Y})^2 - \Sigma(Y - \hat{Y})^2}{\Sigma(Y - \bar{Y})^2}$$

WHERE:

R^2 = Coefficient of Determination

Y = Observed Values of Dependent Variable

$\bar{Y}$ = Mean of Y Values

$\hat{Y}$ = Expected Value of Y

CORRELATION COEFFICIENT

$$r = \frac{b\sigma_x}{\sigma_y}$$

WHERE:

r = Correlation Coefficient

σ_x = Standard Deviation of x Values

σ_y = Standard Deviation of y Values

R^2 = Coefficient of Determination

- oo Explains the strength of the relationship between the independent and dependent variable.
- oo Describes the proportion of variability in the dependent variable that is explained by the independent variable.
- oo $R^2 > .50$ is generally accepted as a good relationship.

r = Correlation Coefficient

- oo Explains the correlation between two variables.
- oo Describes positive or negative correlations.
- oo $r > .50$ is generally accepted as a strong correlation.

C. Multiple Linear Regression

Multiple linear regression analysis is an extension of the simple linear regression model where more than one independent variable is used. The equation for this technique is as follows:

EQUATION: $Y = a_0 + a_1 x_1 + a_2 x_2 + \dots + a_n x_n$

WHERE: Y = Dependent variable (MC, NMCS or SMA)

$x_1 \dots x_n$ = Independent variables (Procurement Funding
Repair Funding, Direct Maintenance
Manhours, Flying Hours, etc.)

a_0 = Y intercept

$a_1 \dots a_n$ = Regression coefficients

D. Confidence Levels

The confidence limits computed in the single linear regression analyses used in this study were based on the following:

$$\hat{Y}_k \pm t(v, 0.975) \left[\frac{1}{q} + \frac{1}{n} + \frac{(X_k - \bar{X})^2}{\sum (X_i - \bar{X})^2} \right]^{1/2} s.$$

WHERE: Y_k = Expected value of Y for a given X_k
 $t(v, 0.975)$ = Percentage points of the t - distribution where
 v equals the degrees of freedom (for our computation $v = 7$ degrees of freedom and $t(7, 0.975)$ equals 2.365)
 q = Number of observations at X_k
 n = Number of X and Y observations (9 for our computations)
 X_k = Given value of X
 $\bar{X}$ = Mean of observed X values
 X_i = Observed X values
 s = Square root of the mean square about regression based on $n-2$ degrees of freedom

E. Conversion of Dissimilar Variables

Aviation repairables requirements are determined by the Aviation Supply Office through the use of a "stratification" procedure. Procurement requirements of initial and replenishment repairables are calculated by this stratification process as are the repair requirements. The basic calculation of requirement is based on procurement cost with a secondary calculation for computing the repair costs for component repair. One of the common measurements used by the Navy in various budget exhibits is a calculated "cost of repair" which is a percentage ratio of the cost of repair compared to the cost of procurement. Data for the ten-year period utilized in this study revealed an average "cost of repair" of 22.59 percent; i.e., 22.59 percent of the procurement cost was comparable to the repair cost. In order to do a simple linear regression analysis on a "macro" basis, repairable procurement costs were converted to comparable repair costs and added to the repair costs for analysis.

F. Funding Lag

When comparing funding to readiness indicators, the events occur at different points in time. Funding occurs when resources are actually obligated and readiness indicators are affected when the "results" of the funding occur.

In order to perform meaningful comparisons of readiness indicators with funding levels it was necessary to develop a technique to lag the funding to coincide with the "results" generated by the funding. In addition to delay from normal repair time, work is performed throughout the year so that material repaired with a given fiscal year's funding level becomes available in a ready-for-issue condition on a gradual basis over a period of many months. Once material is returned to the supply system in a ready-for-issue condition, it will not necessarily be issued immediately. For study purposes, it was assumed that work is accomplished in equal monthly increments. Thus, for a six month lag, one-half of the prior fiscal years funds plus one-half of the current fiscal years funds were used to compare to current fiscal year readiness

indicators i.e., the last half of Fiscal Year 1971 funds plus the first half of Fiscal Year 1972 funds were compared to Fiscal Year 1972 indicators. The following table displays this technique for a 6 months lag time and for a 12 months lag time.

COMPONENT REPAIR
EXAMPLE OF FUNDS LAG TECHNIQUE

(In Millions of Dollars)*

	<u>FISCAL YEAR OF APPROPRIATION AND AMOUNT</u>										<u>YEAR OF IMPACT</u>
	<u>FY 1970</u>	<u>FY 1971</u>	<u>FY 1972</u>	<u>FY 1973</u>	<u>FY 1974</u>	<u>FY 1975</u>	<u>FY 1976</u>	<u>FY 1977</u>	<u>FY 1978</u>	<u>FY 1979</u>	
	417.0	374.1	372.7	333.2	330.5	314.0	367.7	86.1	433.2	517.8	482.1
	<u>6 Months Lag</u>										
FY 1971	208.5	187.1	-	-	-	-	-	-	-	-	395.6
FY 1972	-	187.0	186.4	-	-	-	-	-	-	-	373.4
FY 1973	-	-	186.3	166.6	-	-	-	-	-	-	352.9
FY 1974	-	-	-	166.6	165.3	-	-	-	-	-	331.9
FY 1975	-	-	-	-	165.2	157.0	-	-	-	-	322.2
FY 1976	-	-	-	-	-	157.0	183.9	-	-	-	340.9
FY 1977	-	-	-	-	-	-	91.9	-	-	-	91.9
FY 1978	-	-	-	-	-	-	91.9	86.1	216.6	-	394.6
FY 1979	-	-	-	-	-	-	-	-	216.6	258.9	475.5
	-	-	-	-	-	-	-	-	-	258.9	241.1
	-	-	-	-	-	-	-	-	-	-	500.0
	<u>12 Months Lag</u>										
FY 1971	417.0	-	-	-	-	-	-	-	-	-	417.0
FY 1972	-	374.1	-	-	-	-	-	-	-	-	374.1
FY 1973	-	-	372.7	-	-	-	-	-	-	-	372.7
FY 1974	-	-	-	333.2	-	-	-	-	-	-	333.2
FY 1975	-	-	-	-	330.5	-	-	-	-	-	330.5
FY 1976	-	-	-	-	-	314.0	-	-	-	-	314.0
FY 1977	-	-	-	-	-	-	91.9	-	-	-	91.9
FY 1978	-	-	-	-	-	-	275.8	86.1	-	-	361.9
FY 1979	-	-	-	-	-	-	-	-	433.2	-	433.2
	-	-	-	-	-	-	-	-	-	517.8	517.8

* Dollars shown have been converted to FY 1980 constant dollars.

CHAPTER IV

COMPARATIVE ANALYSES

A. General

Over thirty different comparisons, with several iterations for each comparison totalling over 350 calculations, have been made in this study. The various iterations within each comparison were performed in order to determine the most appropriate "lag-time" for a particular comparative analysis. All detailed calculations for each iteration are contained in Appendix B. A display of comparative analyses with the most appropriate "lag-time" are contained in this Chapter.

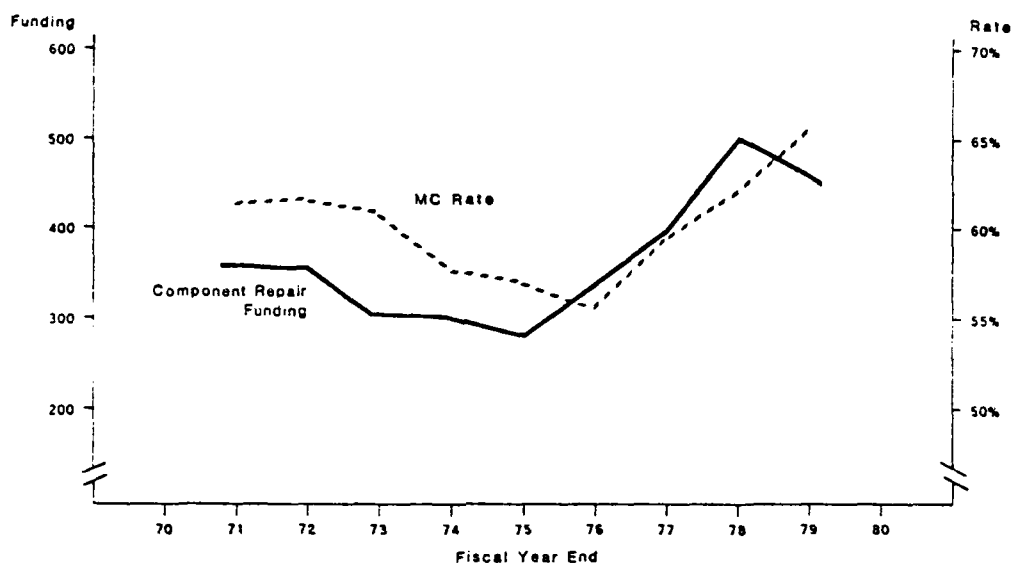
Presentation of the comparative analyses is accomplished through the use of graphs and narrative description. It should be noted the graphs have been structured using the actual data of the variables being analyzed rather than any statistical calculation of data. It was believed this method of data presentation would enhance the useability of the study's findings. Also, it should be mentioned that in some instances the reciprocals of the NMCS and NMCM rates were used to graphically display similar trends rather than divergent trends. However, all statistical calculations and the computed correlation factors were based upon the actual NMCS and NMCM rates.

B. Comparative Analyses

The comparative analyses performed in this effort are displayed on pages 15 through 46:

Component Repair Dollars Vs. MC Rate

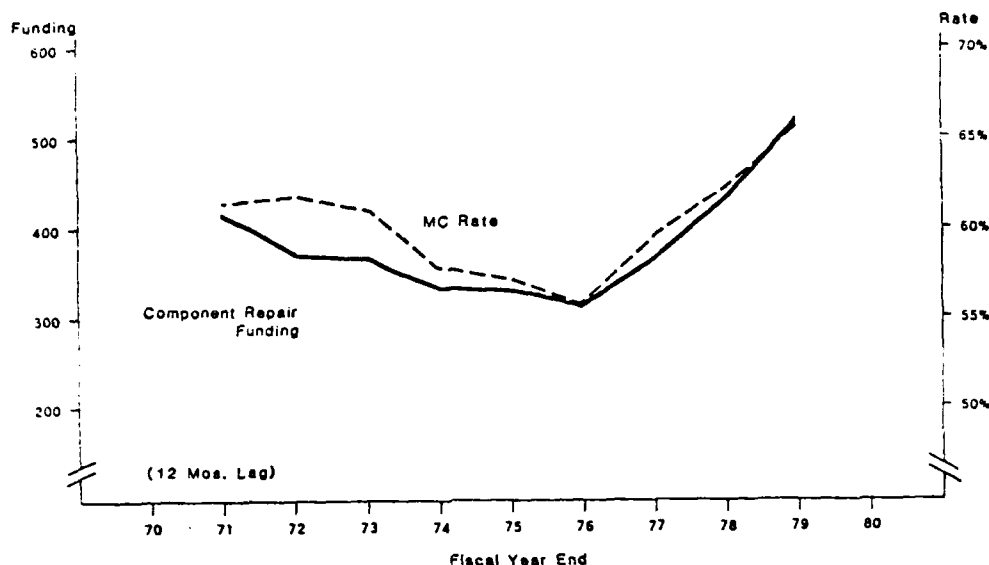
(Funding in Millions - Rates in Percentage)



This chart depicts component repair funding for Fiscal Years 1970 through 1979 in Fiscal Year 1980 constant dollars compared to the MC rate achieved during the same period. No funding lag has been used for this display. A linear regression analysis of the above data indicates little or no correlation between the two variables. It is intuitively obvious that component repair funding would not have an immediate impact on operational readiness.

Although component repair does not have an immediate impact on the MC rate, it can be seen from the above graph that some type of relationship exists. Therefore, comparisons of several iterations of the data were made by lagging the funding from two to sixteen months. A funding lag of twelve months has a strong statistical correlation (R^2 of .90). The following chart reflects the same comparison with the funding lagged twelve months.

Component Repair Vs. MC Rate
(Funding in Millions - Rates in Percentage)



Although this data has a very good correlation (R^2 of .90), there appears to be a much better correlation in the latter half of the period than in the early years. Several factors seem to indicate that data may not be truly comparable over the full ten year period; such as:

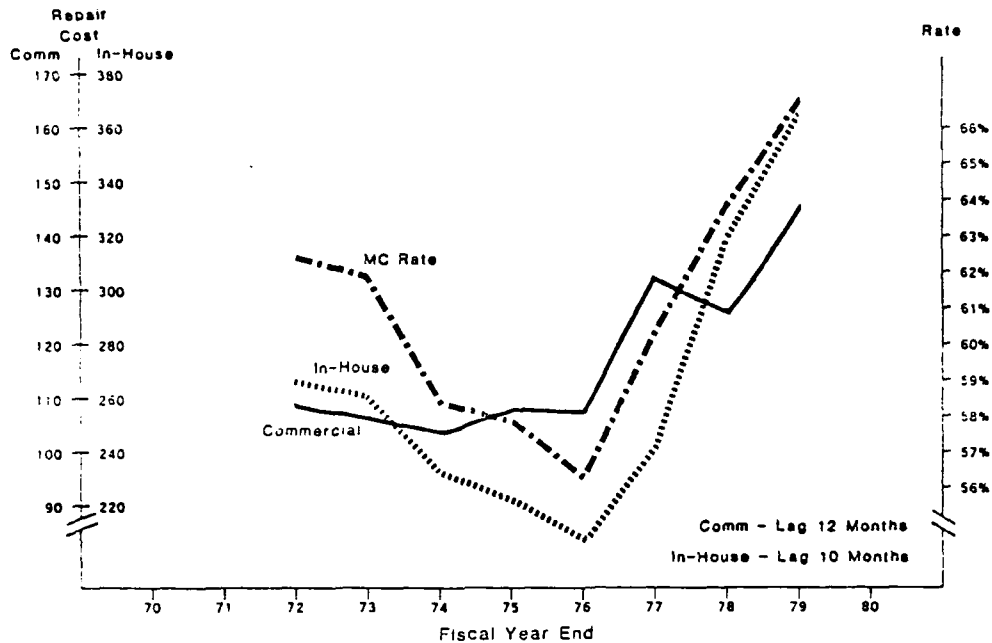
- o Almost all indicators such as requirements, funding, MC rates, SMA rates, etc. decline from Fiscal Year 1970 through Fiscal Year 1976 and increase in latter years.
- o A significant change in maintenance philosophy occurred during the mid-seventies.
- o Methods of calculating Mission Capable categories changed during the mid-seventies.

A separate comparative analysis using only the past five years data revealed a higher coefficient of determination (R^2 of .98) with funding lagged between nine and eleven months compared to the ten year period analysis.

An additional comparison was made by identifying the commercial/in-house aspects of the component repair programs to determine if distribution had any appreciable impact on the correlation. This analysis is displayed on the next graph.

Commercial/In-House Component Repair Vs. MC Rate

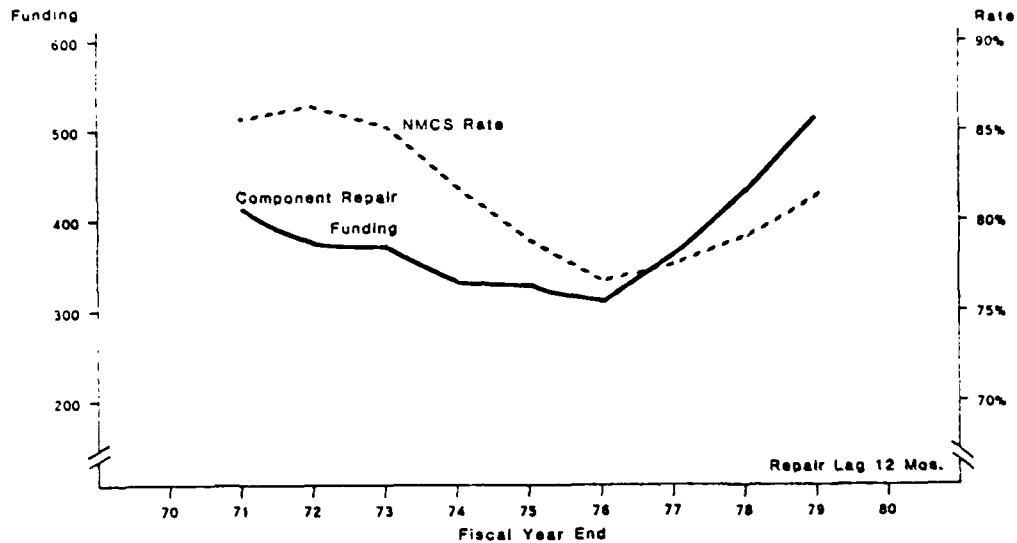
(Dollars in Millions - Rates in Percentages)



A multiple regression analysis of commercial and in-house repair compared to the MC rate is not significantly different than when comparing the total repair effort. The best correlation appears to be when in-house repair funding is lagged nine months and commercial repair by ten months. The coefficient of determination in this analysis was .93 which is extremely close to the .90 determined for the total repair effort. Further, when linear regression analysis is performed on each variable, a correlation of $R^2=.92$ is achieved for in-house repair with funding lagged ten months and a correlation of $R^2=.56$ is achieved for commercial repair when funding is lagged twelve months.

Component Repair Dollars Vs. NMCS Rate

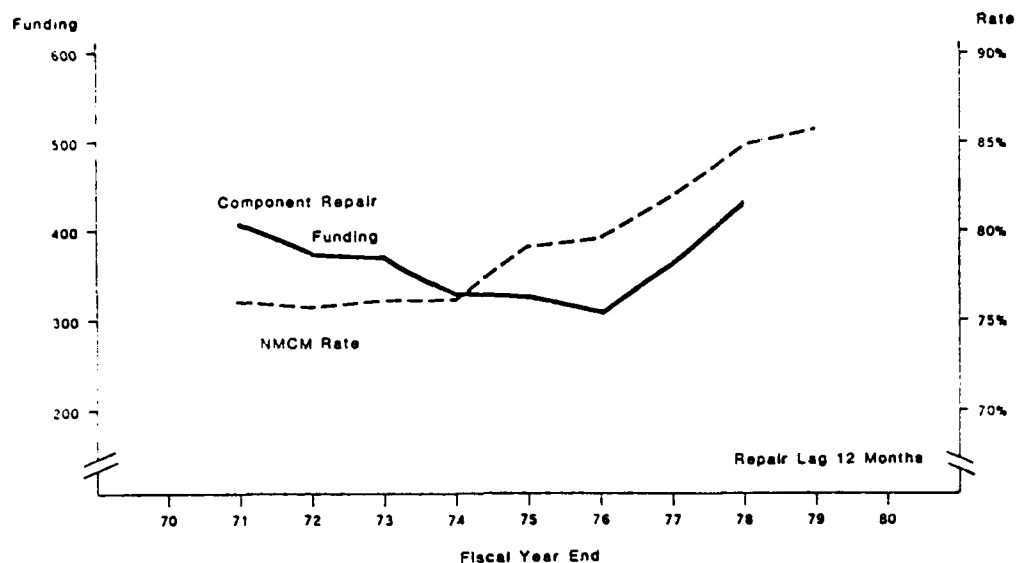
(Funding in Millions - Rate in Percentage)



This chart reflects a comparison of component repair funding and the NMCS rate with the funding lagged by twelve months. The coefficient of correlation was extremely low ($R^2=.06$) in this analysis. Funding lags of anything less than twelve months give even less correlation.

This comparison is with component repair funding alone. When combined with component procurement funding and compared to the NMCS rate, a better correlation is found, indicating a better correlation between component procurement to NMCS than repair. This is discussed further under the component procurement and repair funding and NMCS rate comparison.

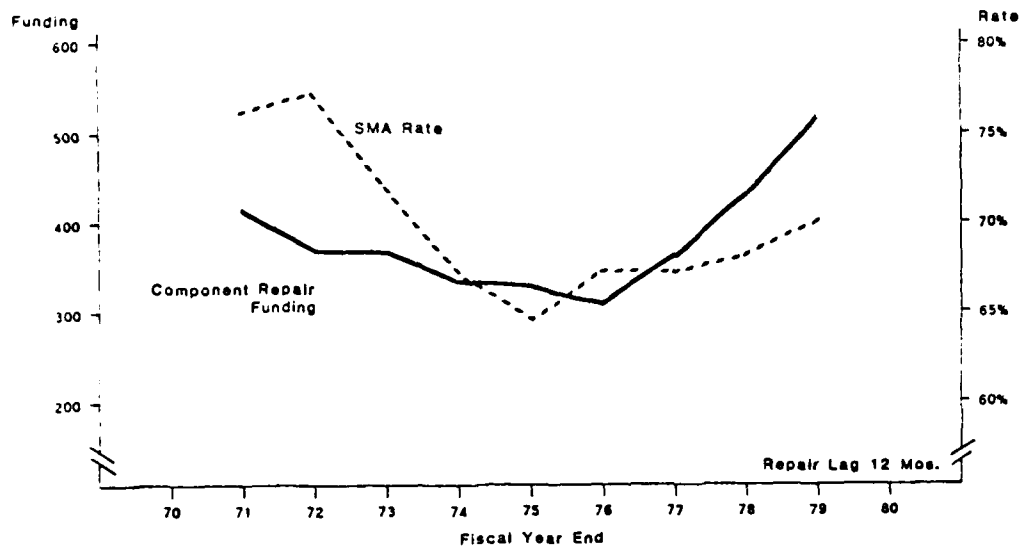
Component Repair Dollars Vs. NMCM Rate
(Funding in Millions - Rate in Percentage)



This chart reflects a comparison of component repair funding and the NMCM rate with the funding lagged by twelve months. A very low coefficient of correlation ($R^2=.33$) was determined and is considered insignificant.

Component Repair Dollars Vs. SMA Rate

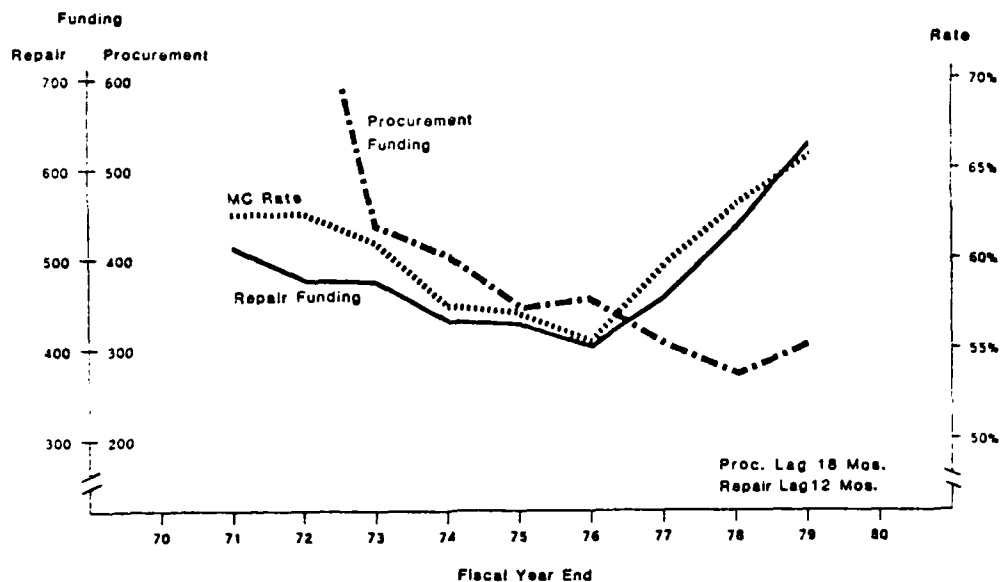
(Funding in Millions - Rate in Percentage)



This chart reflects a comparison of component repair funding and the SMA rate with the funding lagged by twelve months. As with component repair and the NMCS rate, there is little or no practical correlation between repair and SMA, ($R^2=.11$). Funding lags of less than twelve months give even less correlation.

Component Procurement & Repair Dollars Vs. MC Rate

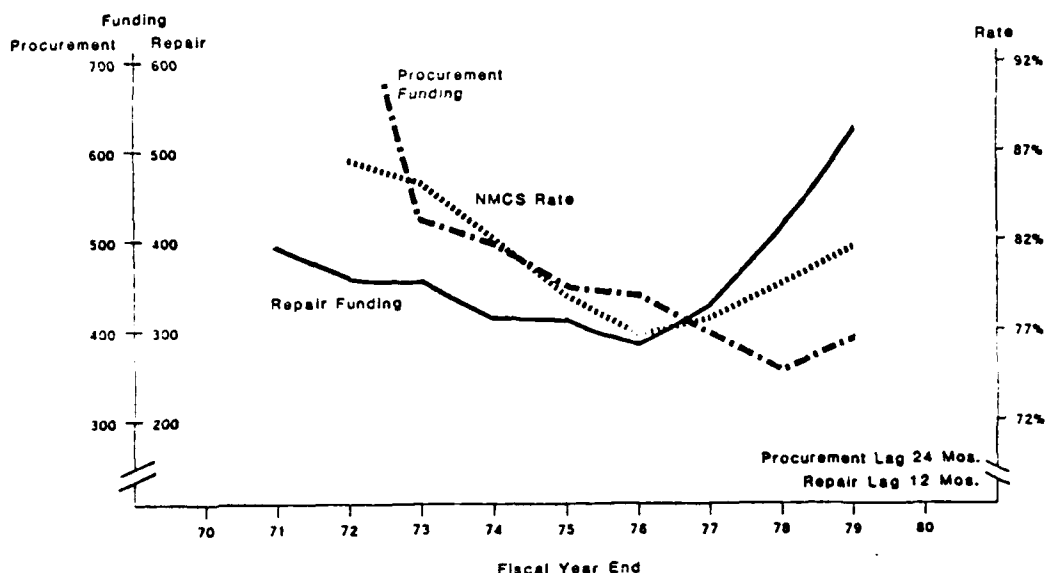
(Funding in Millions - Rate in Percentage)



Since component procurement is closely related to the component repair program, several comparisons were made incorporating funding for both. The above chart depicts 2R/8R component procurement and component repair programs compared to the MC rate.

Using multiple regression analysis, a very high coefficient of determination ($R^2=.95$) was determined with lag times varying from eighteen to twenty-four months for procurement and from ten to twelve months for repair. A similar comparison using only data for the latest five years yields a correlation of $R^2=.99$.

Component Procurement & Repair Dollars Vs. NMCS Rate



This chart depicts a comparison of 2R/8R component procurement and component repair funding to the NMCS rates. A reasonably good correlation exists with a coefficient of determination ranging from .74 to .82 when procurement funding is lagged from fifteen to twenty-four months and repair is lagged up to twelve months. The best correlation is when procurement funding is lagged fifteen months and repair funding is lagged between nine and twelve months ($R^2=.82$).

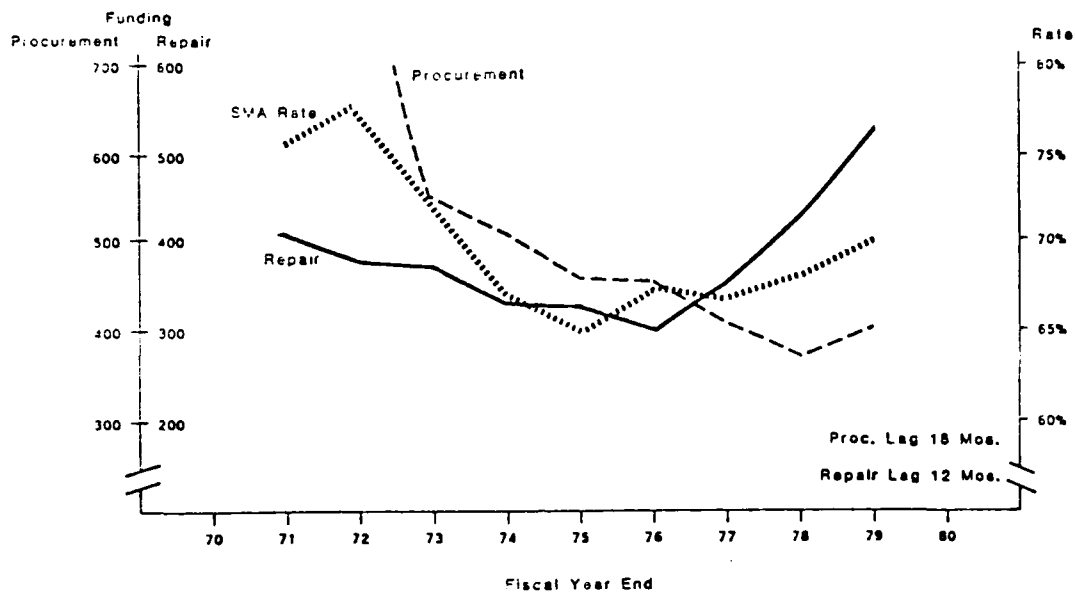
Since component repair funding alone compared to the NMCS rate had an insignificant correlation ($R^2=.06$) the results of this multiple regression analysis suggest that procurement funding may have more of an impact on the NMCS rate than repair funding.

This suggestion would appear to be in conflict with the common perception within the Navy that component repair is the driving factor in reducing the NMCS rate. The parameters of this study have not permitted an in-depth analysis, however, this correlation does suggest the following:

- o Aircraft persistently reporting a high level of NMCS are being satisfied by component procurement more than repair.
- o A strong possibility that the reporting system which distinguishes whether an NMC aircraft is due to supply or maintenance may be distorted.

Component Procurement & Repair Dollars Vs. SMA Rate

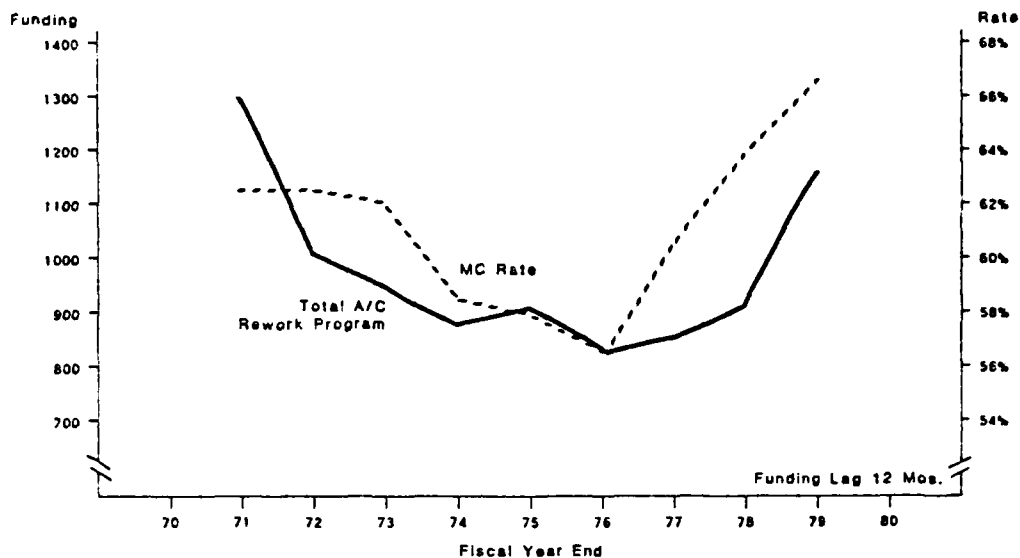
(Funding in Millions - Rates in Percentage)



This chart depicts a comparison of 2R/8R component procurement and component repair funding to the SMA rate. The result of this comparison is similar to the comparison with the NMCS rate. The best correlation ($R^2=.94$) was achieved when procurement funding was lagged sixteen and seventeen months and repair funding was not lagged. This suggests that procurement funding is more of a determinant on the SMA rate than component repair. This is also substantiated by the best correlation ($R^2=.11$) achieved when component repair funding alone is compared to the SMA rate and lagged by twelve months.

Total Aircraft Rework Program Vs. MC Rate

(Funding in Millions - Rate in Percentage)

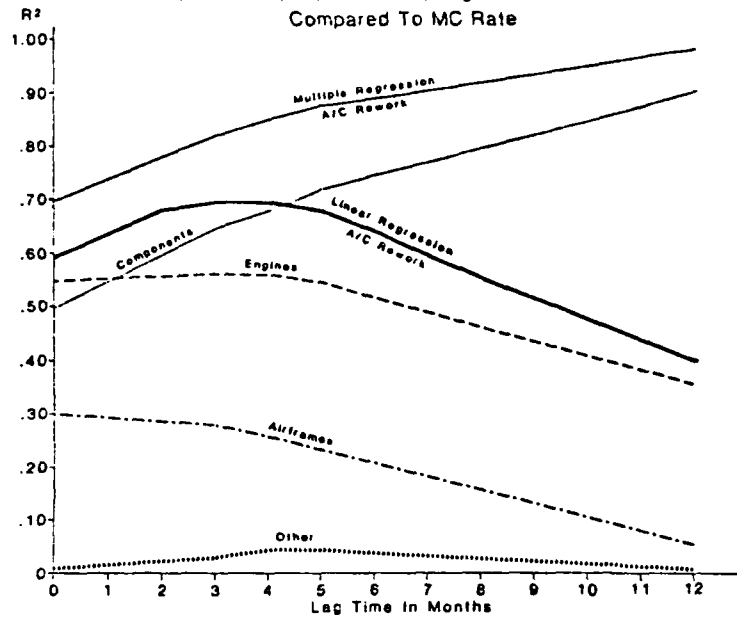


This chart depicts the total aircraft rework program compared to the MC rate. Several iterations of comparison of this data were made with no funding lag and with funding lags of two to twelve months. With a funding lag of twelve months, the correlation ($R^2=.40$) is considered of little significance.

However, an apparent anomaly exists in that a reasonably good correlation ($R^2=.69$) exists when funding is lagged only three to four months. Since a twelve month lag appears appropriate for the component repair program, further analysis was deemed appropriate in this case.

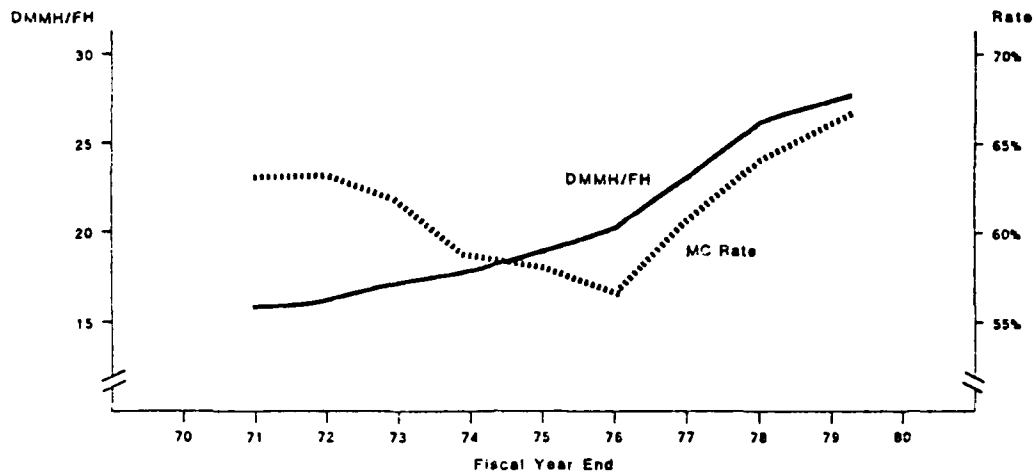
The aircraft rework program is essentially made up of four programs; Airframes, Engines, Components, and Support. Separate comparisons were made on each of these sub-programs with a linear regression and with all of the programs using a multiple regression analysis technique. The correlations of these comparisons are depicted in the next graph.

Comparison of Coefficient of Determination (R^2)
for Component Repair, Airframes, Engines and Other Rework
Compared To MC Rate



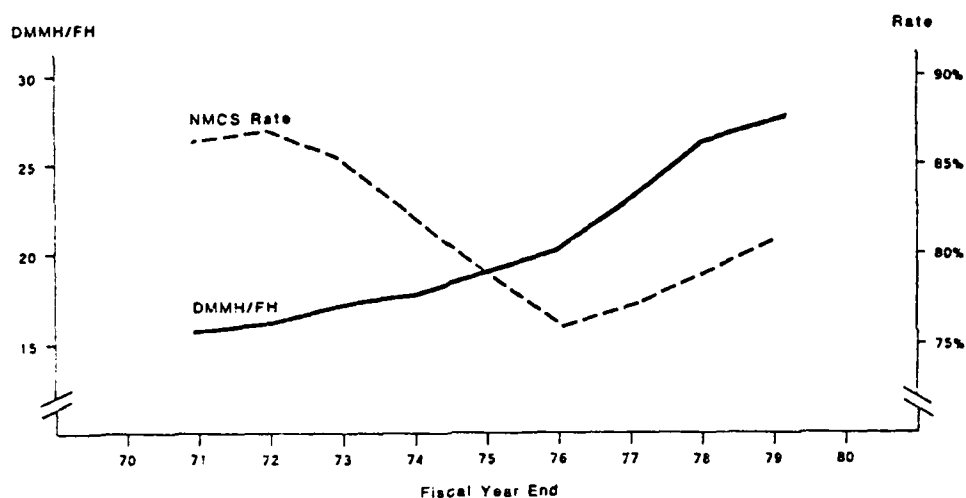
It can be readily seen that although component repair has a very high correlation, the other programs have little or no correlation and tend to degrade the correlations of the total rework program as funding is lagged beyond four months.

Direct Maintenance Manhours Per Flight Hour (DMMH/FH) Vs. MC Rate



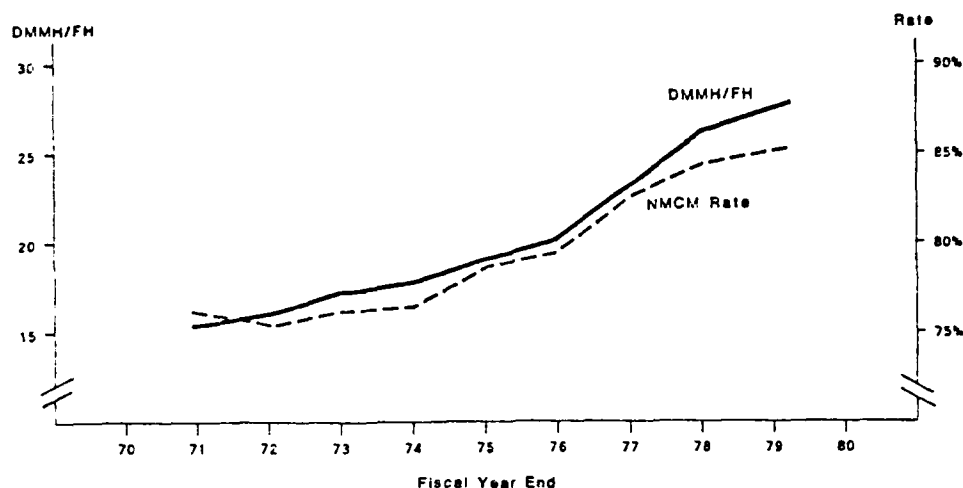
This chart depicts a comparison of Direct Maintenance Manhours per Flight Hour compared to the MC rate. There is little or no correlation ($R^2=.19$).

Direct Maintenance Manhours Per Flight Hour (DMMH/FH) Vs. NMCS Rate



This chart depicts the Direct Maintenance Manhours per Flight Hour compared to the NMCS rate. A linear regression analysis indicated no correlation ($R^2=.02$).

Direct Maintenance Manhours Per Flight Hour (DMMH/FH) Vs. NMCM Rate

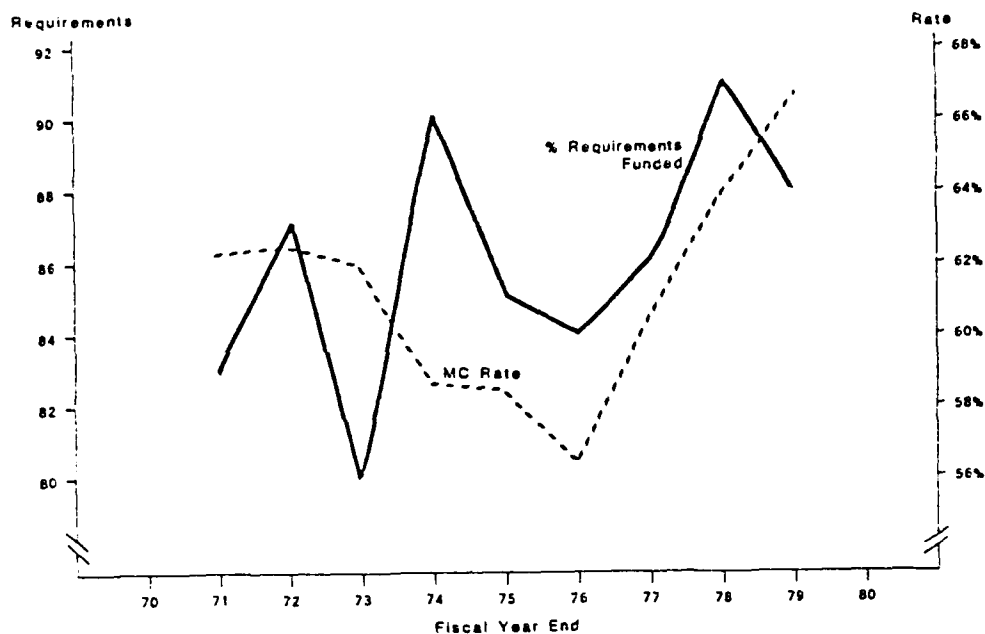


This chart depicts a comparison of Direct Maintenance Manhours per Flight Hour compared to the NMCM rate for Fiscal Years 1971 through 1979. A linear regression analysis indicates a very good correlation ($R^2=.95$).

It should be noted that although the above chart indicates a progressively increasing number of Direct Maintenance Manhours, the comparison is per flight hour. The total Direct Maintenance Manhours in support of all Naval Aviation remained relatively constant for Fiscal Years 1971 through 1976 and has increased subsequently. This can be seen in the following table:

	<u>DMMH/FH</u>	<u>Flight Hours</u>	<u>Total DMMH</u>
		(Thousands)	(Millions)
FY 1971	14.8	2,811	41.6
FY 1972	15.9	2,638	41.9
FY 1973	17.1	2,493	42.6
FY 1974	18.1	2,146	38.8
FY 1975	18.9	2,114	40.0
FY 1976	20.3	1,974	40.1
FY 1977	22.9	1,932	44.2
FY 1978	25.9	1,838	47.6
FY 1979	27.6	1,902	52.5

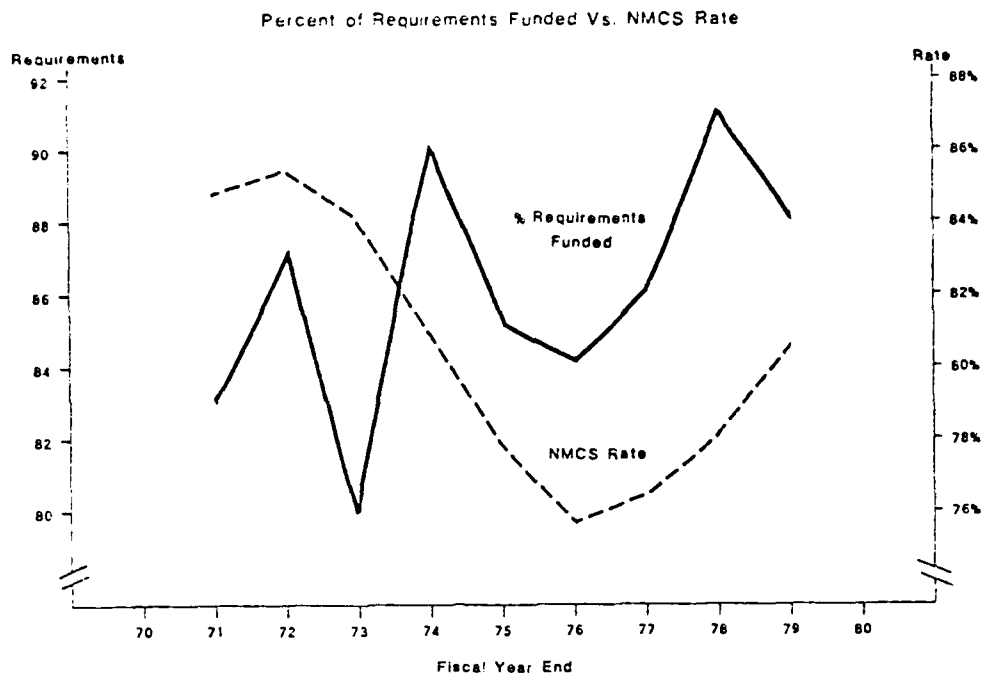
Percentage of Requirements Funded Vs. MC Rate



This chart depicts the percentage of componet rework requirements funded for the ten year period compared to the MC rate. Normally actual requirements are not computed at end year to match the actual dollars spent. Therefore the requirements utilized for the analysis are those last computed for the year prior to actual closing. (Informal discussions with NAVAIRSYSCOM indicate they consider this to be the best information available.)

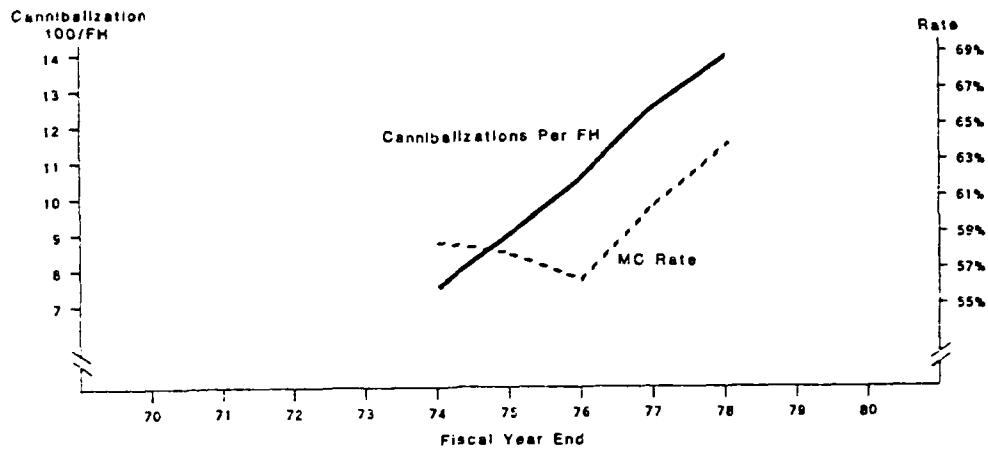
As can be seen in the above chart, there is little or no correlation between the percentage of requirements funded and the actual MC rate experienced ($R^2=.10$). NAVAIRSYSCOM, however, uses a system very similar to this to project MC rates in the short term but uses it in a very "macro" sense. For example, if requirements were funded in a prior year at about 80 percent, but an increased percentage of funding to requirements is planned, the MC rate would be projected to increase also.

The difficulty with this type of analysis is that requirements are dynamic and change almost with each iteration of the budget throughout the cycle. The final funding actually applied and the MC rate actually achieved have practically no relationship to the initial plan at the beginning of the budget cycle.



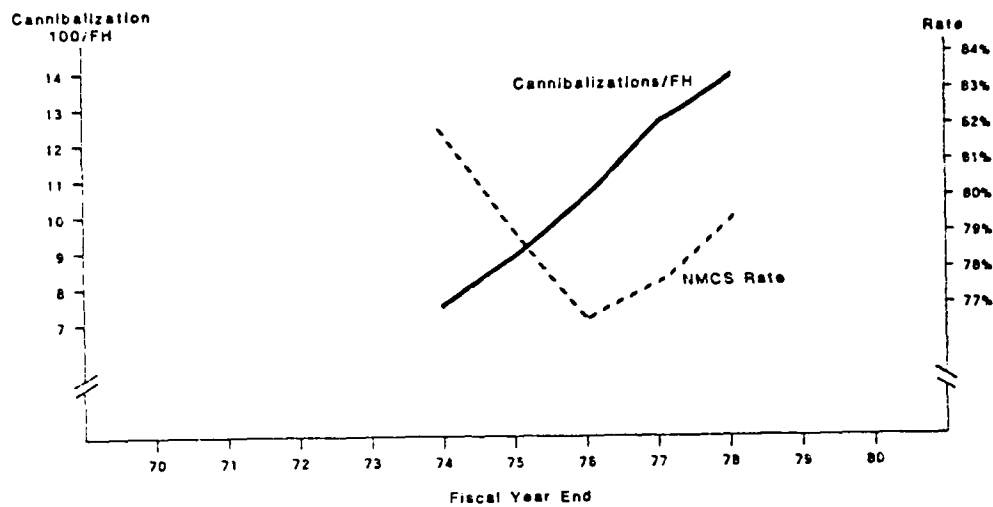
This chart depicts the percentage of requirements funded and the NMCS rate. As is the case with the MC rate, there is little or no correlation ($R^2=.0002$).

Cannibalizations Per Flight Hour Vs. MC Rate

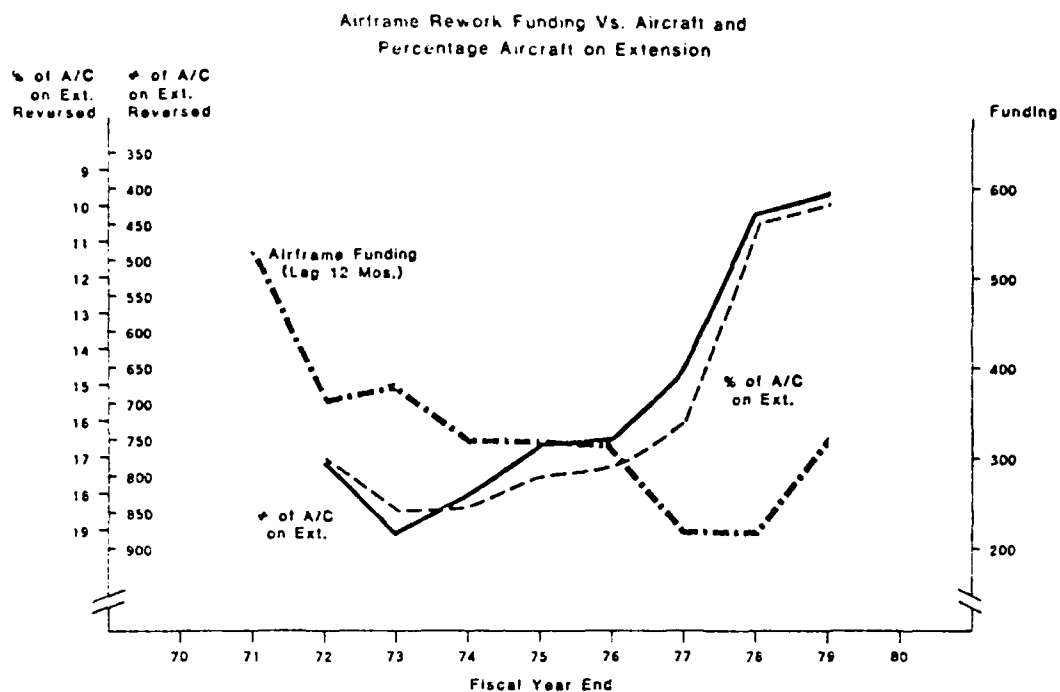


This chart depicts the number of cannibalizations per flight hour compared to the MC rate. Data for this comparison was available only for the Fiscal Years 1974 through 1978. A linear regression analysis indicates a correlation of $R^2=.53$. While cannibalizations do affect the MC rate, this correlation is not considered significant in view of the extremely high correlations of the other variables analyzed.

Cannibalizations Per Flight Hour Vs. NMCS Rate



This chart depicts the number of cannibalizations per flight hour compared to the NMCS rate. A linear regression analysis indicates a correlation of $R^2=.26$, which is less than that obtained in comparing cannibalizations to the MC rate and is considered insignificant.



This chart depicts funding for rework of airframes compared to the numbers and percentages of aircraft beyond their maintenance cycle (on extension). Funding has been lagged by twelve months. A linear regression analysis indicates little or no correlation ($R^2=.02$ for numbers of aircraft on extension and $R^2=.00009$ for percentage of aircraft on extension.)

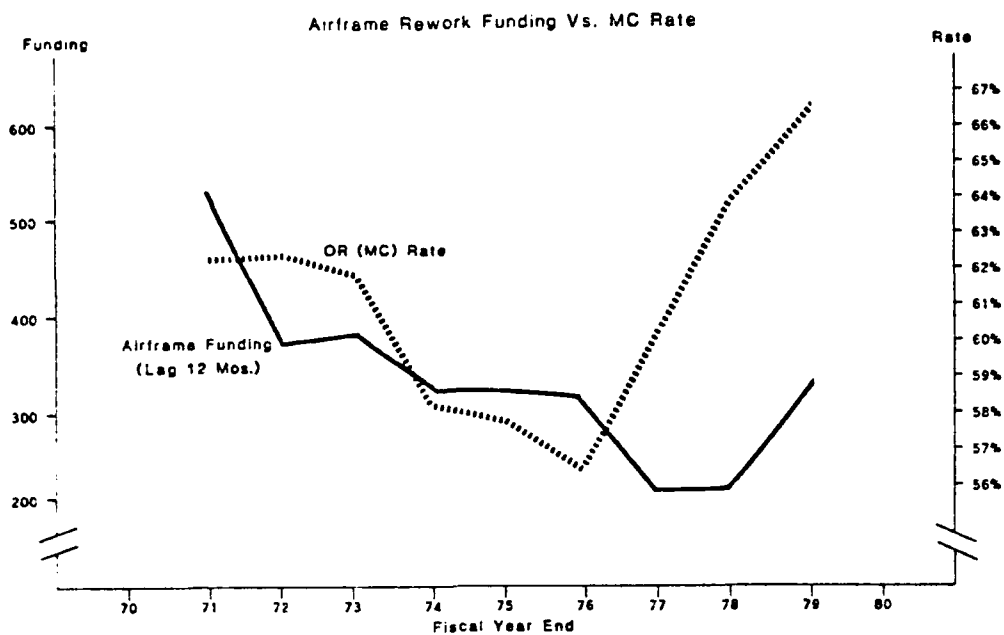
In the formulation of an initial budget request, the calculation of the numbers and percentages of aircraft on extension is a simple arithmetical computation; total numbers of reworks required, less those planned for rework priced within the dollars available, equals the numbers calculated to be on extension; this number divided by the average operating inventory of aircraft equals the percentage of aircraft on extension. Because this calculation is a straight-forward pricing of each aircraft, it is a common perception in the Navy that there should be a very good correlation between funding and the resulting aircraft on extension.

This lack of a good correlation is due to several factors. Throughout the various iterations of the budget process the aircraft inventory changes, the specific aircraft requiring rework changes and the available dollars changes. A typical example of this is shown in the table for Fiscal Year 1978 on the following page.

FY 1978 AIRFRAME REWORKS

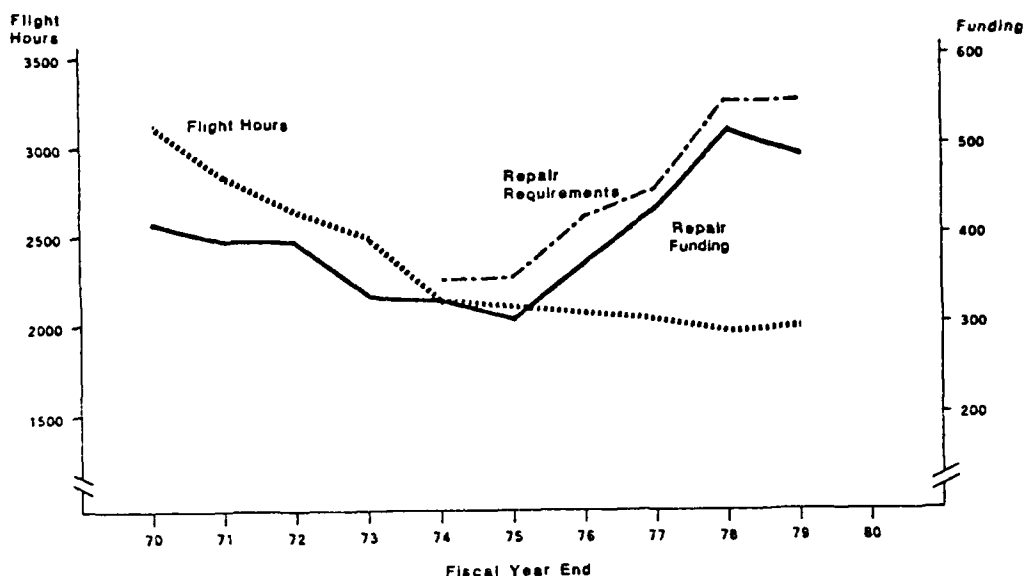
<u>Budget</u>	<u>Reworks</u>	<u>Funding</u>	<u>Avg.Opr. Aircraft</u>	<u>A/C on Extension</u>	<u>% on Extension</u>	<u>Unfunded Requirement</u>
1978 NC	1156	\$231.1	4098	830	20.3	\$169.0
1978 OSD	1097	223.2	4107	980	23.9	95.9
1978 Cngr.	1093	227.4	4084	949	23.2	99.8
1978 Cngr.(R)	1376	226.8	4084	666	16.3	60.4
1979 NC	1406	226.8	4058	561	12.5	51.3
1979 OSD	1345	262.8	4221	749	17.7	49.5
1979 Cngr.	1345	263.5	4221	686	16.3	42.0
1980 NC	1497	272.1	4222	397	9.4	-
1980 OSD	1497	272.1	4222	397	9.4	-
1980 Cngr.	1504	278.7	4221	437	10.4	-

While aircraft on extension is probably a reasonable measure of effectiveness for use in evaluating airframe funding requirements, caution must be exercised relative to the timing of any given analysis. As can be seen from the above, the number of aircraft on extension decreased by 393 aircraft from the beginning of the budget cycle until actual completion. Funding was increased \$47.6 million; however, the unfunded requirement of \$169.0 million was eliminated. These apparent inconsistencies may be the result of budgeting a particular "program" and executing another "program".



This chart depicts the airframe rework funding compared to the MC rate. Funding has been lagged twelve months. A linear regression analysis indicates little or no correlation ($R^2=.14$).

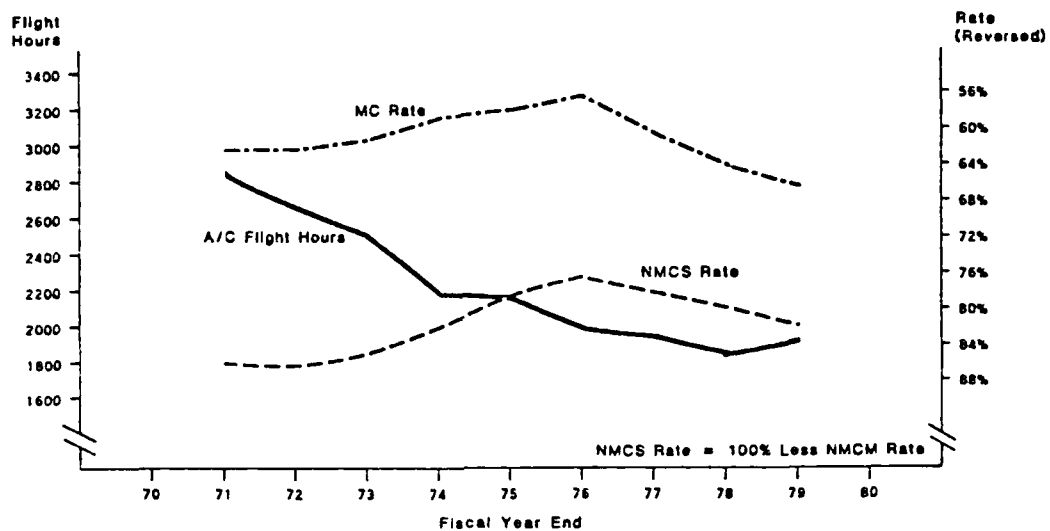
Aircraft Flight Hours Vs. Component Repair Requirements & Funding



This chart depicts the total aircraft flight hours compared to Component Repair Requirements and Component Repair Funding. Since the total component repair requirements are not available prior to Fiscal Year 1974, a linear regression analysis was performed using data for Fiscal Year 1974 through Fiscal Year 1979. The correlation between flight hours and requirements is very good ($R^2=.96$) and is also good between flight hours and funding ($R^2=.89$). This is, however, a negative correlation; the requirements and funding increase as the flying hours decrease.

Since component repair requirements are calculated by using demand data which is a function of the flying hour program, this strong negative correlation appears to be an anomaly. Further analysis indicates that within the component repair program, the numbers of units requiring repair per flying hour is increasing by approximately 38 percent and the cost of repair is increasing approximately 51 percent. These trends suggest the Navy is experiencing increased complexity in the component repair program. The increased complexity, in turn, suggests that the meaningfulness of the high negative correlation to the flying hour program is questionable.

Aircraft Flight Hours Vs. MC & NMCS Rates

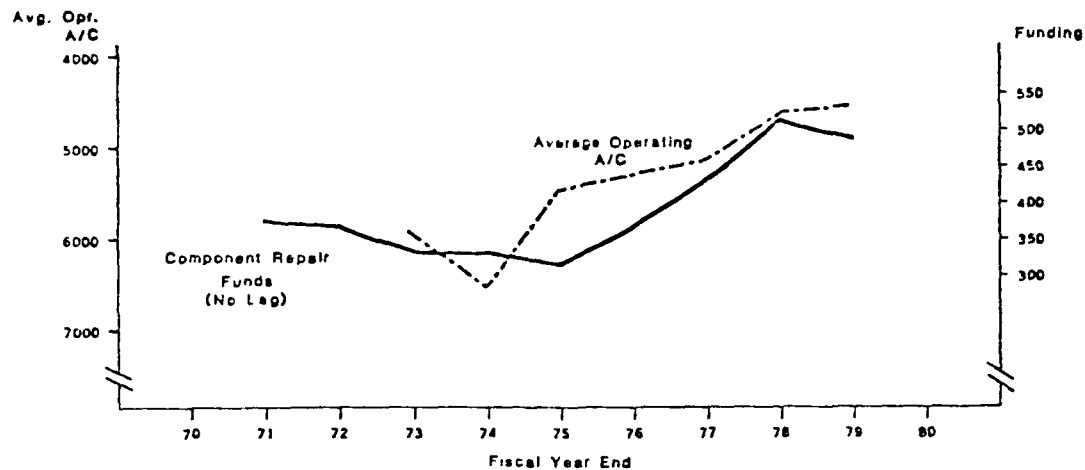


This chart depicts aircraft flight hours compared to the MC and NMCS rates. A linear regression analysis indicates little or no correlation between flight hours and the MC rate ($R^2=.14$) but a reasonably good correlation to the NMCS rate ($R^2=.83$).

The correlation to the NMCS rate indicates a lower incident of failures due to supply as the flying hours program decreases.

Average Operating Aircraft Vs. Component Repair Funding

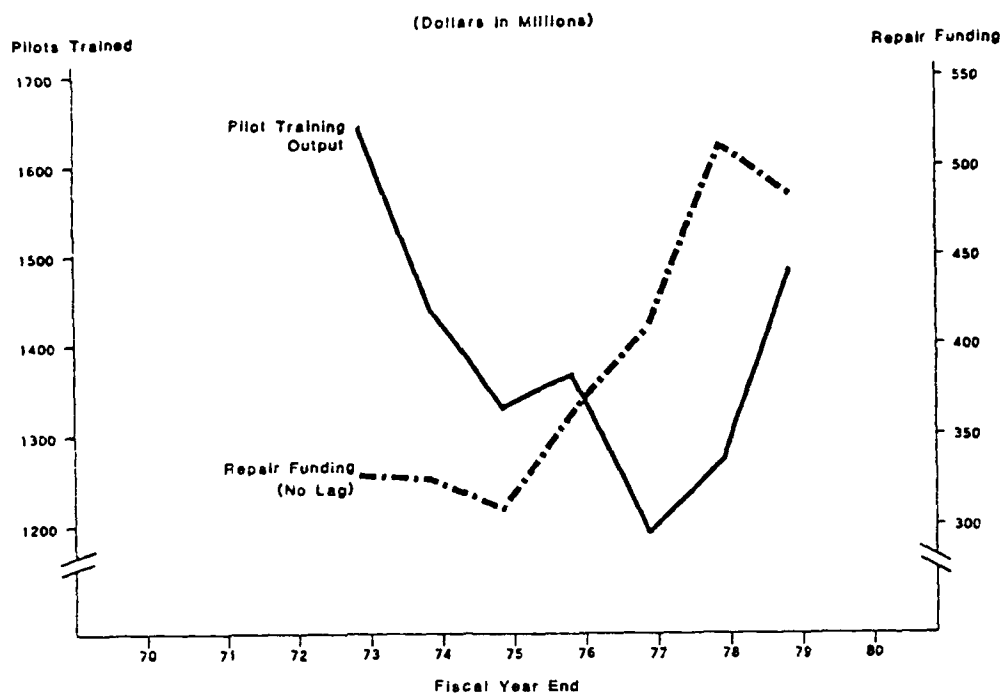
(Funding in Millions - Avg. Opr. A/C in Units)



This chart depicts the average operating aircraft compared to component repair funding. A linear regression analysis indicates a poor correlation ($R^2=.48$) with funding lagged 12 months.

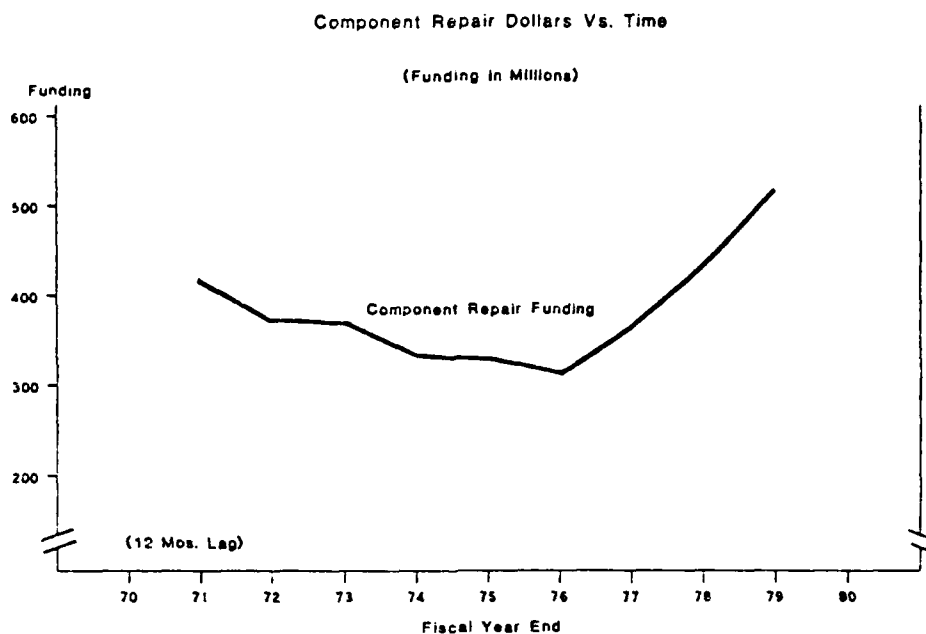
This comparison is based on data for Fiscal Year 1973 - 1979 since average operating aircraft data was not available prior to Fiscal Year 1973.

Pilot Training Output Vs. Component Repair Funding

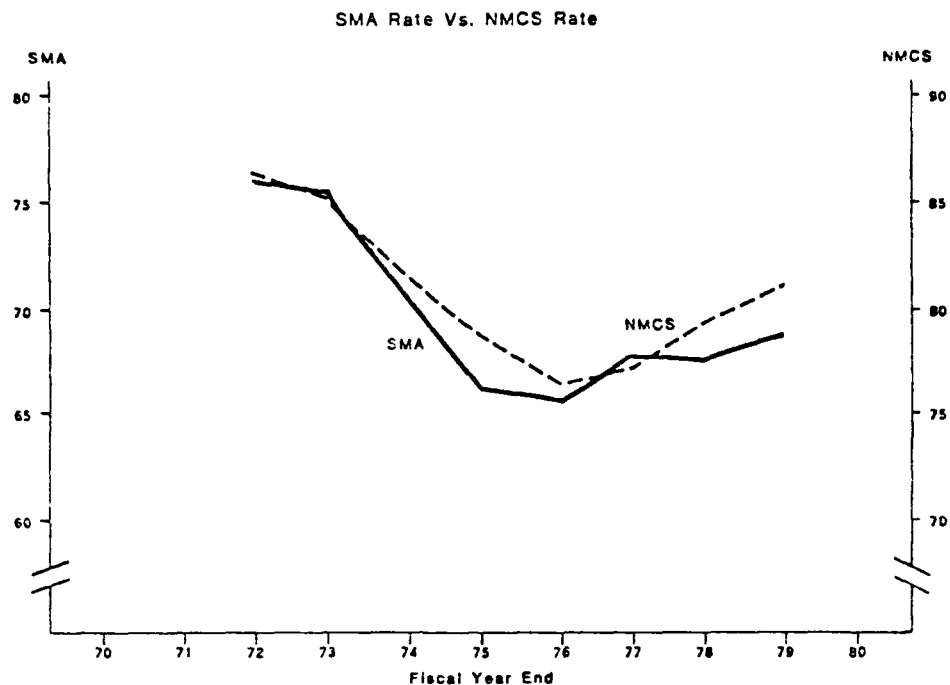


This chart depicts the Pilot Training Output compared to the Component Repair Funding. A linear regression analysis indicates little or no correlation ($R^2=.03$).

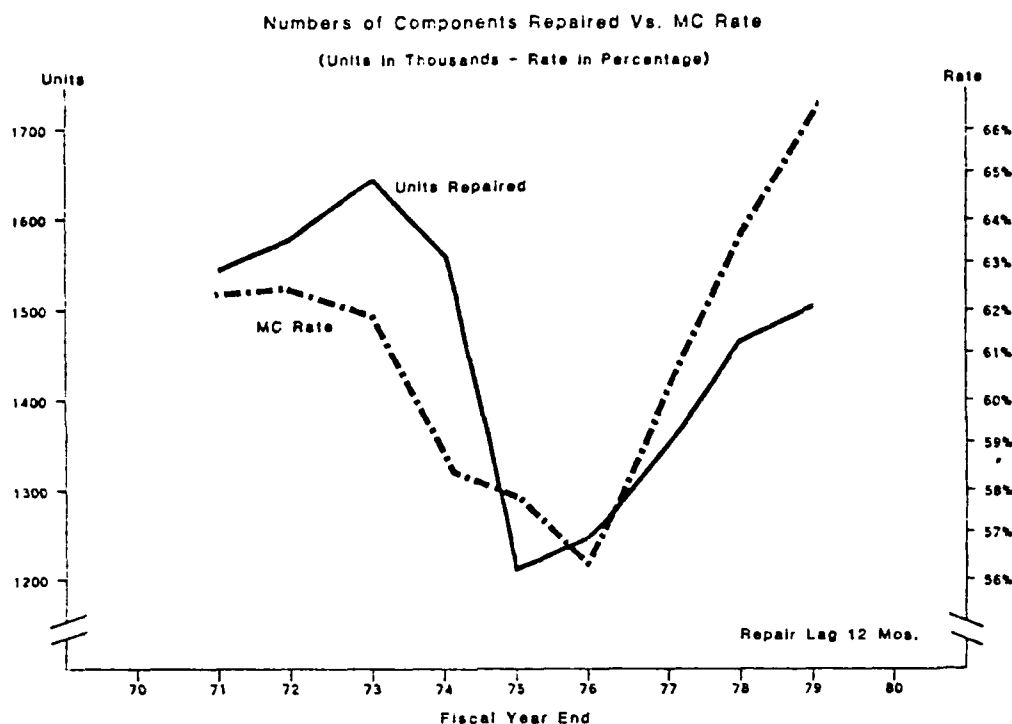
This comparison was based on data for Fiscal Years 1973 through 1979 since Pilot Training Output data was not readily available prior to Fiscal Year 1973.



This chart depicts component repair funding compared to time. With funding lagged twelve months, a regression analysis indicates a poor correlation ($R^2=.37$).

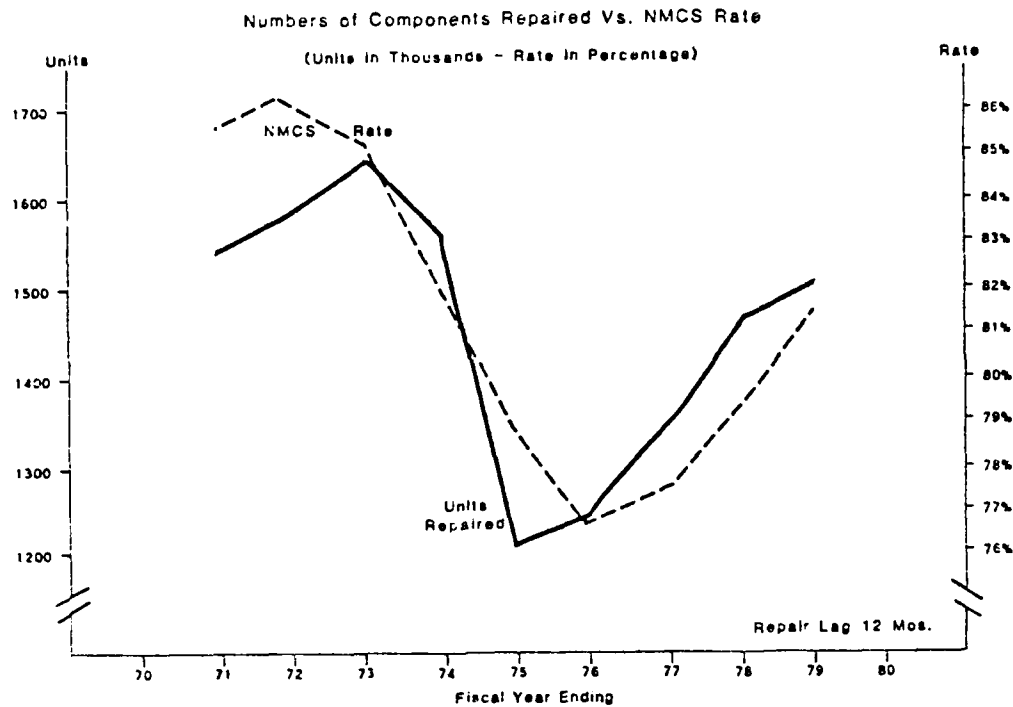


This chart depicts a comparison between the SMA rate and the NMCS rate. When the SMA rate is lagged twelve months, a very good correlation ($R^2=.92$) is achieved. This high correlation suggests that a change in SMA occurs approximately twelve months before a change in the NMCS rate.



This chart depicts the total components repaired, at the Intermediate Maintenance Activities (IMAs) as well as at the Depots, compared to the MC rates. Using linear and multiple regression analyses techniques, a poor correlation was found to exist with either the IMA or the Depot workload, (IMAs $R^2=.35$ and Depot $R^2=.49$; combined $R^2=.49$).

The validity of some of the component unit data used in this comparison is questionable since data was "derived" by dividing the total repair dollars by average cost to repair. Therefore this analysis may not be accurate. However, the fact that the number of units has such a poor correlation while the funding has such a high correlation suggests that the individual items being repaired, the cost per unit of repair and the complexity of aircraft and components may be a significant factor in the relationship between the repair program and operational readiness.

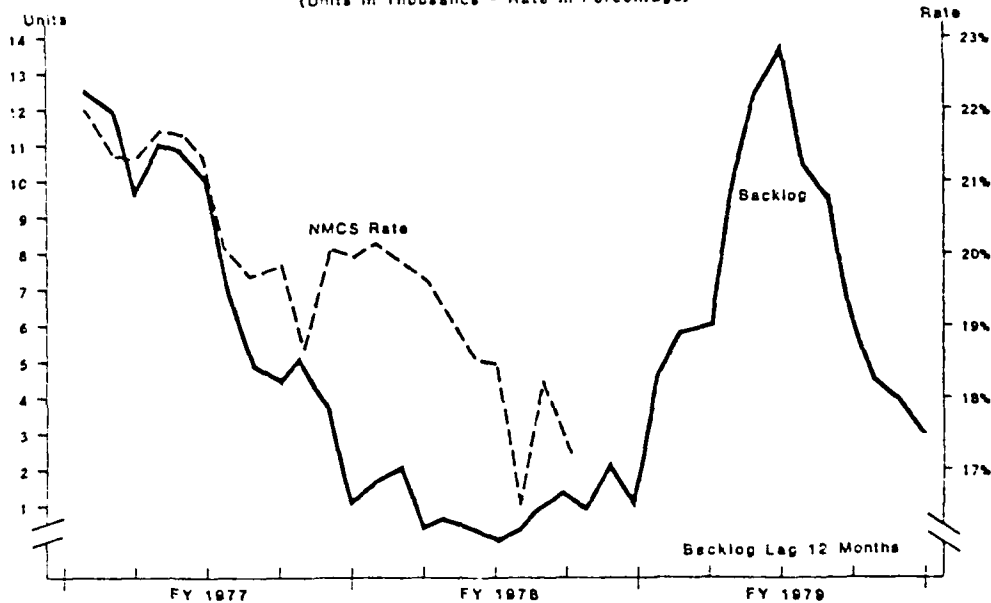


This chart depicts the total number of components repaired, at the Intermediate Maintenance Activities (IMAs), as well as at the Depots, compared to the NMCS rate. Using linear and multiple regression analyses techniques, a reasonably good correlation is indicated (IMAs $R^2=.62$, Depots $R^2=.74$; combined $R^2=.76$).

Again, the validity of some of the component unit data used in this comparison is questionable, since it was "derived". Therefore, any conclusions drawn should take this factor into consideration.

NARF Component Repair Backlog Vs. NMCS Rate

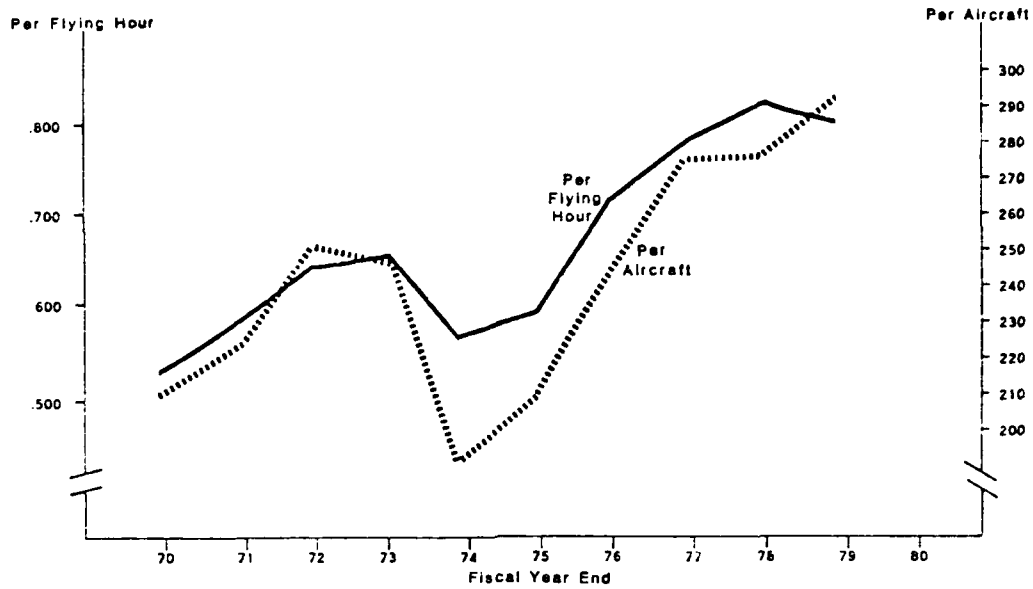
(Units in Thousands - Rate in Percentage)



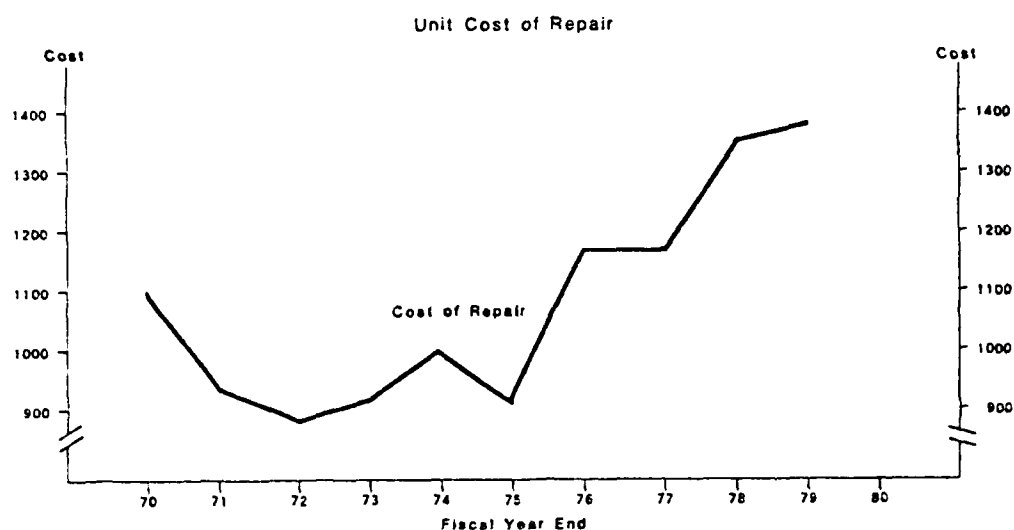
This chart depicts the numbers of components physically backlogged at the NARF's in a not-ready-for-issue (NRFI) condition compared to the NMCS rate. The Naval Aviation Logistics Center (NALC) compiles weekly statistics reported by each NARF of the number of NRFI components which are scheduled for repair but which have not been inducted for one reason or another, usually lack of funding, capacity, skill levels, etc. The data used in the above chart is a monthly average of the weekly reports and lagged by 12 months.

A linear regression analysis indicates a fair correlation ($R^2=.67$) and suggests that component backlog does impact on the NMCS rate.

NRFI Components Generated Per Flying Hour/Aircraft



This chart displays the increasing numbers of NRFI components being generated in support of the Naval Aviation program. The numbers of components per aircraft increased from 210 in Fiscal Year 1970 to 293 in Fiscal Year 1979, an increase of 40 percent. The numbers of components per flying hour increased from .527 in Fiscal Year 1970 to .804 in Fiscal Year 1979, an increase of 52 percent.



This chart depicts the increasing unit cost of repair for Fiscal Years 1970 through 1979 of units being repaired by the Depot. This does not include units or costs of repair at the Intermediate Maintenance Activities (IMA) since those costs were not available.

Unit costs have increased from \$1100 per unit in Fiscal Year 1970 to \$1370 per unit in Fiscal Year 1979, or a twenty-five percent increase.

CHAPTER V

FINDINGS

A. General

The comparisons discussed in the previous Chapter were accomplished through 350 different statistical calculations when considering the various iterations for "lag time". The results of these comparisons are categorized below based upon the coefficient of determination determined in the regression analyses performed.

o Very Good Relationships ($R^2 \geq .90$)

- oo Component Repair Funding and MC Rate. The best correlation ($R^2 \geq .90$) was achieved when the funding "lag time" of twelve months was used. Using only the last five years of data, the best correlation ($R^2 = .98$) was achieved when the "lag time" was between nine and eleven months.
- oo Component Repair/Procurement Funding and MC Rate. The best correlation ($R^2 = .95$) was achieved with multiple regression analysis when a funding "lag time" of eighteen to twenty-four months was used for procurement funding and repair funding was lagged ten to twelve months. Using only the last five years of data, the best correlation ($R^2 = .99$) was achieved when repair funding was lagged between eleven and fourteen months with procurement funding "lag time" being between eighteen and twenty-four months.
- oo Component Repair/Procurement Funding and SMA Rate. The best correlation ($R^2 = .94$) was achieved with multiple regression analysis when procurement funding was lagged between sixteen and seventeen months and no "lag time" for repair funding. While a zero repair funding "lag time" appears strange, it is suggested that in a "macro" sense, trends in the SMA rate are influenced more by procurement than repair. This suggestion is based also on the fact that there is little or no correlation between component repair funding and the SMA rate.
- oo Direct Maintenance Manhours per Flying Hour and NMCM Rate. There is an extremely good correlation ($R^2 = .95$) between DMMH/FH and the NMCM rate as would be intuitively believed.
- oo Aircraft Flying Hours and Component Repair Requirements. While a high correlation ($R^2 = .96$) exists between these two variables for the period of Fiscal Year 1974 through Fiscal Year 1979, it is a negative correlation, i.e., as flying hours decrease, component repair requirements increase and vice versa. Since the failure of a repairable component is usually dependent upon usage,

e.g., flying hours, the meaningfulness of the high negative correlation in this comparison is certainly questionable.

- oo SMA and NMCS Rates. This comparative analysis was really a determination of the relationship between two measures of performance in that both are dependent variables influenced by other variables and not each other. However, a very good correlation ($R^2=.92$) was achieved when the SMA rate was lagged twelve months relative to the NMCS rate.
- o Good Relationships ($R^2 \geq .75 < .90$)
 - oo Component Repair/Procurement Funding and NMCS Rate. A good correlation ($R^2=.82$) was determined using multiple regression analysis when procurement funding was lagged fifteen months and the "lag time" for repair funding was between nine and twelve months.
 - oo Average Flying Hours and NMCS Rate. A reasonably good correlation ($R^2=.83$) was determined to exist in this comparison. As indicated in Chapter IV, as flying hours have decreased in recent years, there is less incidence of inoperative aircraft because of the non-availability of components.
- o Questionable Relationships ($R^2 \geq .50 < .75$)
 - oo Aircraft Rework Program and MC Rate. When the total Aircraft Rework Program was compared to the MC Rate, the best correlation ($R^2=.69$) was achieved when funding was lagged three and four months. The meaningfulness of the correlation, however, is questionable since component repair appears to be the most significant factor as indicated on page 25.
 - oo Cannibalizations and MC Rate. The best correlation achieved in this comparison was $R^2=.53$; however, data was unavailable for the period of Fiscal Years 1974 through 1979.
 - oo Average Operating Aircraft and Component Repair Funding. The best correlation achieved in this comparison was $R^2=.66$ which is not considered to be meaningful.
 - oo Component Repair Funding and Time. This comparison was performed to determine if the funding profile for the repair of components might be a function of "time". However, the best correlation achieved with no "lag time" was $R^2=.53$, and with a "lag time" of twelve months the correlation $R^2=.37$ was achieved.
 - oo IMA Repaired Components and NMCS Rate. The best correlation ($R^2=.62$) was achieved with a twelve month "lag time". Intuitively, one would expect a higher correlation with no lagging at the IMA level; however,

the correlation was only $R^2=.31$. A graph on this comparison was not included in Chapter IV but the analysis is displayed in Appendix B.

- oo Depot Repaired Components and NMCS Rate. The best correlation ($R^2=.74$) was achieved with a twelve month "lag time". This correlation is most interesting since component repair funding of depot repair had very little correlation to the NMCS rate. A graph on this comparison was not included in Chapter IV but the analysis is displayed in Appendix B.
- oo NARF Component Backlog and NMCS Rate. This comparison is just the opposite of the preceding comparison, i.e., those components not repaired. The best correlation ($R^2=.67$) was achieved with a "lag time" of twelve months. Also, the data for this comparison was available for only October, 1976 through December, 1978.
- o No Apparent Relationships ($R^2<.50$)
 - oo The following comparisons revealed a coefficient of determination of below .50 and are considered insignificant in this study:
 - Component Repair Funding and NMCS Rate
 - Component Repair Funding and SMA Rate
 - Direct Maintenance Manhours/Flying Hours and MC Rate
 - Direct Maintenance Manhours/Flying Hours and NMCS Rate
 - Percent of Requirements Funded and MC Rate
 - Percent of Requirements Funded and NCMS Rate
 - Cannibalization and NMCS Rate
 - Airframe Rework Funding and Aircraft on Extension
 - Airframe Rework Funding and MC Rate
 - Aircraft Flying Hours and Component Repair Requirements and Funding
 - Aircraft Flying Hours and MC Rate
 - Aircraft Inventory and Component Repair Funding
 - Pilot Training Output and Component Repair Funding

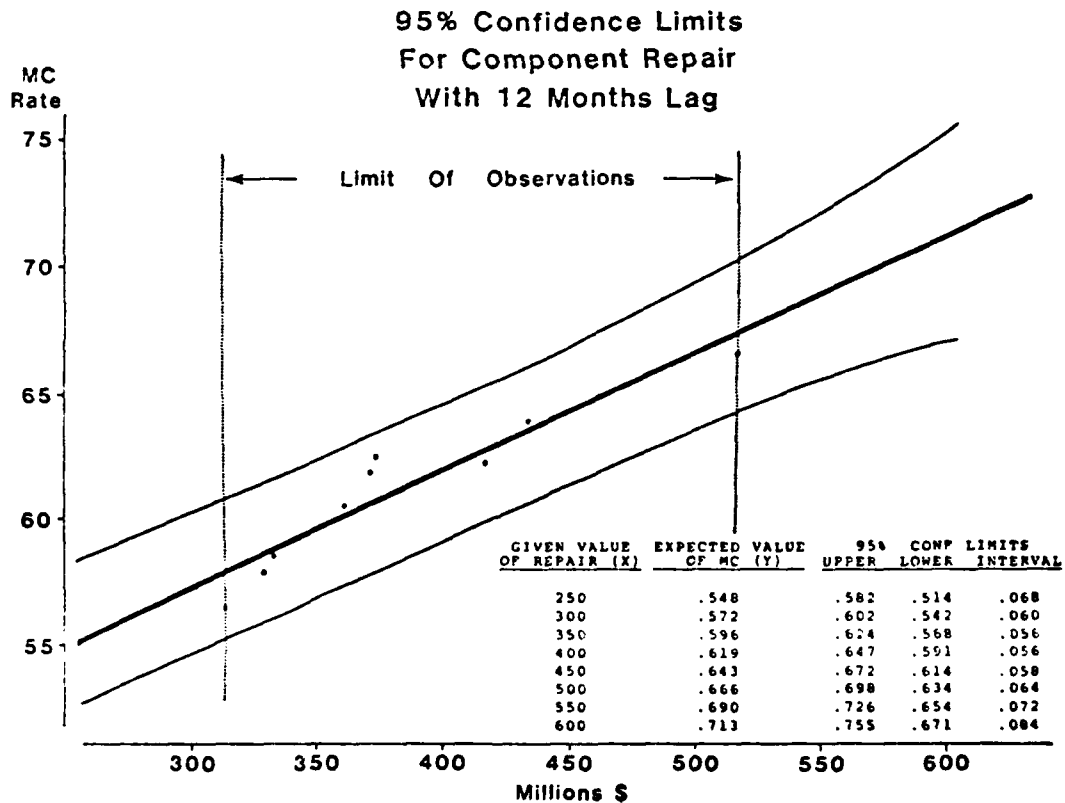
B. Measures of Effectiveness

The basic objective of this study was to identify a measure of effectiveness for the Aviation Component Repair Program in order to assess and evaluate funding requirements for the Program. Based upon the coefficients of determination derived from the numerous comparative analyses performed, any number of measures could be used to evaluate future funding requirements. For example, the multiple regression analysis of component repair and procurement funding compared to the MC rate

yields a very good correlation. A good correlation also exists when comparing DMMH/FH and component repair funding to the MC rate.

Notwithstanding these other good correlations, it is believed that the extremely good correlation ($R^2=.90$) that exists between component repair funding and the MC rate over the last nine years when funding is lagged twelve months is the measure of effectiveness most appropriate for evaluating this program.

By using the regression formula of MC rate = $.43 + .00047X$, where X is the planned funding profile, and the formula provided on page 11 for Confidence Levels, the Navy could also predict with a 95 percent confidence level, the MC rate range that could be expected to be achieved from a given level of component repair funding. The following chart illustrates this potential use of statistical predictive capabilities available to the Navy.



C. Commercial Versus In-House Repair

A multiple regression analysis of commercial and in-house repair compared to the MC rate is not significantly different than when comparing the total component repair program using simple linear regression. The best correlation using linear regression analysis appears to be when in-house repair funding is lagged ten months ($R^2=.92$) and commercial repair is lagged twelve months ($R^2=.56$). The best correlation using

linear regression analyses on the total component repair program is achieved when the funding is lagged twelve months ($R^2=.90$).

This analysis has been made based on the component repair program split of commercial and in-house repair using data for Fiscal Years 1970 through 1978 where the amount of commercial repair averaged about 30 percent. A significant change in this distribution could cause a distortion in any projection analysis since the cost of repair identified to commercial or inter-service work is approximately twice that identified to in-house effort. (In Fiscal Year 1979 commercial/inter-service repair cost \$2,337 per unit and in-house repair cost \$1,257 per unit).

D. Complexity

Although this study has concentrated primarily on component repair funding and the resultant measure of effectiveness at the "macro" level, there is every indication that the complexity of aircraft and components, and the changing nature of the component repair program, may have a far greater impact than is apparent at the "macro" level. The primary indicator of the increased complexity of the component repair program is the trend in not-ready-for-issue component being returned to the Depot. Since Fiscal Year 1975, the components returned by the IMA to the Depot for repair has increased steadily while workload at the IMA has increased slightly. This trend could be the result of more sophisticated weapon systems and/or a change in maintenance philosophy, e.g., modular replacement. Any analysis of the current program or projection of future requirements should take this important factor into consideration.

E. Related Issues

Although the basic finding of this analysis is that there is a very strong correlation between component repair funding and the MC rate, this finding has been derived by the use of empirical data over the past ten years and at the "macro" level. During the course of this study, it became apparent that there are several other factors which should be taken into consideration in any evaluation of either the component repair program or the resultant readiness indicators. The most significant of these are as follows:

- o The operational readiness rates for individual aircraft type, and of deployed and non-deployed aircraft, is such that there may be a significant relationship between the type of support provided these aircraft and resultant readiness which is not apparent at the "macro" level. Further, there may be potential trade-off possibilities between funding levels provided for the Aviation Consolidated Allowance List (AVCAL) and other funding support which could provide a direct and immediate impact on the MC rates.
- o Although the basic thrust of this study has been in component repair program, this program accounts for slightly less than half of the basic rework program in

support of naval aviation. While no significant relationships have been established within the scope of this study relating airframe, engine or support funding to the MC rate, it is logical to assume that such relationships do exist since these efforts are required to maintain an operating fleet of aircraft.

- o A new reporting system called Subsystem Capability and Impact Report (SCIR) is being implemented in the fleets for reporting the material readiness condition of aircraft. Although the impact of this new reporting system is not known, preliminary indicators are that readiness data may vary significantly from data currently being reported.

CHAPTER VI

CONCLUSIONS

A. Comparative Analyses

As a result of the comparative analyses performed during this study, the most significant conclusions reached are as follows:

- o A very good correlation exists between the funding levels of the Aviation Component Repair Program and the MC rate when funding is lagged by twelve months.
- o There is not a very good correlation between the funding levels of the Aviation Component Repair Program and either the NMCS or SMA rate.
- o When multiple regression analysis with both component repair and procurement funding is used, there is a very good correlation to the NMCS rate as well as the SMA rate.
- o It appears from this analysis that component repair funding is more of a determinant of the MC rate while component procurement funding is more of a determinant of the NMCS and SMA rate.

B. Measures of Effectiveness

While a number of very good correlations between independent and dependent variables were determined in this study, the most appropriate measure of effectiveness is considered to be the MC rate. The coefficient of determination derived from simple linear regression analysis of the component repair funding levels and the MC rate was extremely high when funding was lagged twelve months. By using the regression formula, $MC\ rate = .43 + .00047X$, where X equals the planned funding profile, the Navy can predict within a given range the MC rate to be acquired from a given funding profile. This statistical tool could be used to assess the reasonability of future component repair funding requirements as presented during the Program Objectives Memorandum review process.

C. Other Issues

While most of the efforts in this study related to determining an appropriate measure of effectiveness, the analysis performed revealed other issues which are considered important enough to mention below:

- o In analyzing the commercial and in-house segments of the component repair program, it was noted that the cost of repair at commercial activities has increased substantially more than the cost of repair at the Naval Air Rework Facilities. In Fiscal Year 1979, the cost of repair per

unit at a commercial activity was twice the cost of repair per unit at an in-house activity. This observation could be the result of the different types of components being repaired at these activities. However, since this study was performed at the "macro" level, such possibilities were not analyzed.

- o The number of aviation components being returned from the IMA to the Depot for repair has increased steadily since Fiscal Year 1975. During this same period, the number of components repaired at the IMA has increased slightly. This trend of increased workload for Depot repair would suggest the possibility of more complex weapon systems and/or a change in maintenance philosophy, e.g., modular replacement. The complexity issue is an important factor in the potential need for additional resources, but again any analysis of this issue was beyond the scope of this study. It is believed, however, that the complexity issue should be subjected to further analysis.
- o There are certain types of aircraft, and associated components, which have a greater degree of influence on readiness indicators as well as funding requirements. The extension of the analysis performed in this study to the "micro" level, i.e., type of weapon systems, would appear to be very appropriate. Such an analysis could also identify potential trade-offs between the funding levels for the Aviation Consolidated Allowance List and other funding support which may have a more immediate impact on readiness indicators.
- o This analysis evaluated funding levels in relationship to various readiness indicators such as MC, NMCS and NMCM which represent the Navy's current system of reporting aviation readiness. It was learned during the study that a new readiness reporting system is being implemented called SCIR. Since this reporting system may vary significantly from the previous system, its impact on using the MC rate as a measure of effectiveness in evaluating component repair funding requirements should be examined.

CHAPTER VII

RECOMMENDATIONS

Based upon the comparative analyses performed and the findings and conclusions enumerated in Chapters V and VI, the following recommendations are presented for consideration:

- o Utilization of the MC rate as the measure of effectiveness for assessing the Aviation Component Repair Program funding requirements considering a funding "lag time" of twelve months.
- o Alternatively, either the MC, NMCS or SMA rate could be used as a measure of effectiveness in evaluating the funding requirements for both repair and procurement of aviation repairables using multiple regression analysis and the appropriate "lag times" as identified in Chapter IV.
- o Based upon the findings of this study, develop a specific requirements determination methodology for the Aviation Component Repair Program for use in the Fiscal Year 1983 Program Objectives Memorandum and Budget review which it is understood will be combined based upon the recommendations of the Defense Management Resources Study.
- o Initiate an analysis of operational readiness and component repair funding by aircraft type to determine which weapon systems are most influential in terms of readiness and funding requirements.
- o Initiate an analysis to determine the causative factors of the dramatic increase in the cost-of-repair at commercial activities.
- o Initiate an analysis to determine the factors contributing to the increased number of components being repaired at the Depot level in terms of complexity and/or maintenance philosophy.
- o Initiate an analysis of deployed and non-deployed aircraft readiness and funding requirements with a view toward identifying potential trade-offs among the funding levels of the Aviation Consolidated Allowance List and other support funding which may have an immediate impact in aircraft readiness for deployed units.
- o Initiate an evaluation of the new SCIR reporting system to determine the impact it will have in assessing Aviation Component Repair Program funding requirements during the Fiscal Year 1983 Program Objectives Memorandum review process.

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