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TOTAL QUALITY MANAGEMENT ANALYSIS OF LAMPS MK I AVIATION MAINTENANCE DATA

A thesis presented to the Faculty of the U. S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

PATRICK J. GRAHAM, LCDR, USN
B. A., University of Colorado, Boulder, Colorado, 1980

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This study investigates the applications of aviation maintenance data used with the data analysis tools of Total Quality Management (TQM). This case study uses aviation maintenance data produced at HSL-37, NAS Barbers Pt, HI from Sep 1990 to August 1991. This study shows how aviation maintenance data from this squadron would be analyzed with TQM analysis tools used in the Shewart Cycle in TQM. It was designed to identify limits and shortfalls in data, and categories of data required that would be needed by the squadron in conducting TQM. It also provides a guide for TQM data analysis for naval aviation squadrons conducting TQM.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U. S. Army Command and General Staff College or any other governmental agency. (References to this thesis study should include the foregoing statement.)

ABSTRACT

TOTAL QUALITY MANAGEMENT ANALYSIS OF LAMPS MK I AVIATION MAINTENANCE DATA by LCDR Patrick J. Graham, USN, 156 pages.

This study investigates the applications of aviation maintenance data used with the data analysis tools of Total Quality Management (TQM). This is a case study using the aviation maintenance data produced at Helicopter Anti-Submarine (Light) Three Seven (HSL-37), NAS Barbers Pt, HI, from September 1990 to August 1991.

In 1991, the U. S. Navy began the process of implementing Total Quality Management developed by Dr. W. Edwards Deming. This study explores the sufficiency of the data produced by the squadron as measured by the results of TQM analysis tools.

This study shows how aviation maintenance data from this squadron would be analyzed with TQM analysis tools used in the Shewart Cycle in TQM. It was designed to identify limits and shortfalls in data, and categories of data required that would be needed by the squadron in conducting TQM. It also provides a guide for TQM data analysis for naval squadrons conducting TQM.

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TABLE OF CONTENTS

CHAPTER 1 1
Definitions. 7
Limitations and Delimitations
CHAPTER 2 12
CHAPTER 3 19
Chapter 3 Section I
Total Quality Management. 19
TQM Tools. 27
Chapter 3 Section II
Methodology 38
Chapter 3 Section III
LAMPS Maintenance and Flight Operations. 43
CHAPTER 4 54
Data Analysis
PIM Plan Stage
Data Analysis
PIM Do Stage 58
Check Phase 71
Analysis of FMC, MC, NMCS, NMCM,PMCS, and PMCM Data. 71
Analysis of Data Affecting Aircraft Status Categories. 81
CHAPTER 5 105
Did the data fit the TQM analysis tools? 105
Did the TQM analysis tools fit the data? 109
Recommendations 111
APPENDIX A
TQM Points, Deadly Diseases, and Obstacles 116
Appendix B
LAMPS Mk I Squadron Primer 119
Appendix C
Maintenance Data System Reports 124
Appendix D
Data 129
BIBLIOGRAPHY 153
Initial Distribution List 156

List of Tables

1. FMC/MC r and r^2 Values 69

2. Man-hours Percentage r and r^2 Values 86

3. Corrosion Control and Prevention versus FMC/MC Rates r and r^2 Values 87

4. Cannibalization per 100 Flight Hours r and r^2 Values 89

5. A799 per Month r and r^2 Values 91

6. Aircraft Age r and r^2 Values 95

List of Figures

1. Shewart Cycle 25
2. Process Improvement Model 40
3. Maintenance Flow Chart 57
4. Cause and Effect Diagram 59
5. Cause and Effect Diagram - Methods 81
6. Cause and Effect Diagram - Machinery 94
7. Cause and Effect Diagram - Manpower and Materials 102

CHAPTER 1

INTRODUCTION

This study determines if squadron aviation maintenance data is sufficient for TQM analysis. In achieving this goal, the study will:

1. Determine how well the aviation maintenance data fits the analysis tools of TQM.

2. Determine how well the analysis tools fit this data.

3. Develop an example of how to use the analysis tools with aviation maintenance data.

This thesis is a case study based on aviation maintenance data from September 1990 to August 1991 used by Helicopter Anti-Submarine Light Three Seven (HSL-37), a LAMPS Mk I squadron; the data analysis relates to aircraft readiness, applying Total Quality Management (TQM) analysis tools in the U. S. Navy's Total Quality Leadership.

In this study I will conduct TQM data analysis using the Navy Personnel Research and Development Center's Process Improvement Model (PIM). The Navy Personnel Research and Development Center developed this model around an elaboration of the Shewart cycle.[1] The research presented in Chapter 4 uses the PIM through a single iteration of the Shewart cycle. Utilizing the PIM to conduct the analysis, provides structure and focus for the analysis process. It will also include the three items previously mentioned in order to complete this study.

The actual analysis of the data is conducted in Chapter 4. In this chapter aviation maintenance data will be analyzed using the analysis tools of TQM. The benefit of following the PIM and Shewart cycle is twofold: It gives the analysis a framework in which to proceed. This framework provides an orderly progression of analyses for the data. The progression of analyses of the data is therefore more easily understood. It should also answer the first two items of data fitting the tools and tools fitting the data.

Secondly, using the PIM will demonstrate how the different analyses are related to the TQM process. This second benefit is crucial to relating the analysis tools to the actual implementation of TQM. By proceeding with the PIM for the analysis, this investigation can be used as an example for naval organizations. A discussion of the model is provided in Chapter 3.

The data used for the study is 12 months of aviation maintenance data that was produced by HSL-37. The data used was produced at the direction of higher commands to assist the squadron in analyzing its maintenance effectiveness.[2] The ultimate goal of squadron aviation maintenance is maximum aircraft readiness.[3] Therefore, the analysis of the data will also focus on aircraft readiness. The data is limited to the data the squadron produced in this one year period. This limits the amount of data, but it is the actual data used by the squadron and therefore closely reflects "fleet" conditions. However, categories of data that may be available from other sources, or that would be useful for this study, are not available.

The importance of this study is that it coincides with the Navy's recent full scale involvement in TQM. In 1991, the Chief of Naval Operations (CNO) announced in NAVOP 011/91 Navy wide implementation of TQM. In that message he stated the goals of this change are to improve efficiency, reduce accidents, and eliminate repetitive and unproductive tasks.[4]

The purpose of this study is to facilitate the implementation of TQM in the Navy. Change of this nature is normally resisted by large organizations. This investigation may help to reduce some of this natural resistance to change. By demonstrating how aspects of TQM can be applied to naval aviation squadrons, it can assist those who are leading the way to overcome the resistance to these changes. For this reason, this study will, where appropriate, discuss aspects of the Navy's program of TQM as it exists currently. The connection between the theory of TQM analysis tools reinforced by application provides a solid foundation for those who wish to use this as an example of how to conduct analyses in their own organizations.

In developing a TQM program the Navy changed the name of its program to Total Quality Leadership, TQL. This is to emphasize the role of the leader in all paygrades of the Navy.[5] According to CAPT Robert McLendon, the Navy's philosophy of TQL is the same as TQM expressed by Dr. Deming.[6] According to John L. Byron, USN, the only changes have been "minor word smithing."[7]

Dr. W. Edwards Deming developed TQM as a method to assist all organizations to operate more efficiently and produce the highest quality product possible. In his definition of product, Deming states that whether manufacturing or service based, government or private, all organizations are subject to the same managerial philosophies.[8] According to Deming, the techniques of TQM should be applicable to the U. S. Navy and all other Department of Defense Agencies.

TQM is not just a transformation of management methods. Deming describes it as much closer to a mutation with directed efforts.[9] The Department of Defense has said that TQM is a philosophy and a set of guiding principles that includes quantitative methods and human resources to improve the organization under an approach based on continuous improvement.[10]

Succinctly phrased by the Navy Personnel Research and Development Center: "This approach is based on a set of management practices and statistical measures that, when combined, can remove the causes of poor product quality and excessive cost."[11]

The aspects of TQM that will be studied here are: quantitative methods, technical tools, and statistical measures. These show that process and data analysis tools are an integral part of the TQM management process. The application of the quantitative methods of TQM involves using analysis tools. Workers at all levels and in separated phases of TQM use the tools as a method to help them understand how to improve the quality of their work.[12] How the tools are used throughout the improvement process may vary and therefore their results also may vary. The tools associated with TQM will be discussed in depth later but are identified here.

1) Flow Chart. A diagram to track a process from start to completion to assist in identification of the steps and pathways involved.

2) Cause and Effect Diagram (also known as an Ishikawa Diagram or a Fishbone Diagram). This diagram used to identify the causes, and basic relationships between causes, of an identified effect.

3) Check Sheet. A tally sheet used to record the number of times an event occurred during a certain period.

4) Run Chart. A chart used to display data graphically plotted as a system characteristic over time.

5) Control Chart. This is a specialized run chart that identifies the mean value for the data and has upper and or lower control limits identified on the chart.

6) Pareto Chart. A specialized bar chart used to identify proportionally small causes that are responsible for a proportionally high amount of effect on a system.

7) Histogram. A specialized bar chart used to show how groups of numerical data vary in frequency of occurrence.

8) Scatter Diagram. A chart used to show the amount of correlation between two categories of paired data.

Significance of this Study

In the future, the Navy, as well all the other military services, will be operating with fewer resources. The tight fiscal environment will require the Navy to become more efficient to accomplish its mission with fewer resources. In 1983, in its quest for improvement in quality and effectiveness, the U. S. Navy initiated an investigation into applications of Total Quality Management. This experimental beginning of the Navy's organizational scale implementation of TQM was at naval aviation depots.[13] The success of TQM at North Island Naval Aviation Depot in California was impressive. According to Navy officials commenting on Deming's methods, "application of his principles has reduced a one-year backlog of repairs to two weeks, while increasing the quality of the work."[14] The Navy selected aviation depots as trial organizations for TQM because they deal with manufacturing processes in a production environment very similar to that any manufacturing industry.[15] The mission of the depots is to repair and rework aircraft and their components and subsystems. The depot returns the aircraft parts and components to the fleet or supply system for reissue. Much of the work force consists of highly trained civilian technicians who work on a shift or hourly basis. The daily schedule of naval aviation depots is planned well in advance with few major changes. Based on the success of this experimental application of TQM, the Navy developed its own TQM program.

The mission of the Navy, according to the Chief of Naval Operations (CNO) in NAVOP 018/91, subject line: Navy-wide implementation of Total Quality Leadership

(TQL) "is to provide combat ready forces to support the requirements of the unified commanders."[16] The purpose of this message is to insure that all naval personnel know the mission of the Navy. It is important for this study to understand the mission of the Navy. The mission of the Navy translates to command goals at lower levels of command. Analysis of the data with the Shewart cycle is more focused when the analysis can be oriented towards a goal. For an HSL squadron, "the combat ready forces" consist of a fully mission capable (FMC) aircraft and a completely qualified aircrew. The maintenance performed in achieving an FMC helicopter produces data that covers many aspects of the maintenance process. It is the data produced by the maintenance processes that I have investigated. This aviation maintenance data that is used by the squadron to analyze and measure its maintenance readiness.

LAMPS squadrons perform their mission as individual detachments assigned to surface ships. The detachments operate almost independently of the squadron and are often thousands of miles away. Each detachment virtually functions as a one-helicopter squadron. Because detachments operate with minimum personnel, minimum equipment, and with only one helicopter, strengths and particularly weaknesses, in squadron management and organization, tend to be magnified in detachment operations. Therefore, implementation of TQL would have possibly an even greater impact on the performance of LAMPS detachments.

The naval organizations that have more recently implemented TQM are naval supply centers, shipyard facilities, and contract administration centers[17] whose structure and mission is similar to civilian industry. Deploying LAMPS detachments, and other operational units, offer a different challenge for TQM than logistics organizations.[18] There is a high turnover of personnel due to detachments operating on independent schedules. Job continuity and operational requirements impact the day to day operations of the squadron heavily. In the future, when TQM is implemented in deploying squadrons the challenges will be many. This study will help naval aviation squadrons in implementing TQM. It demonstrates how the quantitative analysis techniques of TQM can used with operational aviation maintenance data. This will give an example of how to tools can be applied to different types of aviation maintenance data and what kind of analysis can be performed. It should assist squadron personnel, at all levels of the organization, with familiarity of the analysis tools of TQM. In turn, this will assist in the implementation of TQM in the Navy in accordance with the CNO's stated goals.

Definitions.

The research question concerns the sufficiency of data. To decide what qualifies as "sufficient data" is a crucial factor in this study. Sufficient data should include the following aspects:

1) Sufficient data should include aspects of resources and production data of the process that are measurable and are identified by the TQM analysis process. The Navy measures resources as aircraft, parts, and manpower. Production is measured in mission capability status.

2) It should be applicable to TQM process evaluation. When the data is applied to the problem analysis tools associated with TQM it should reveal quantifiable levels of maintenance processes and trends for the resources and production measures identified by the first criterion.

Aviation Maintenance Definitions.

There are three levels of aircraft readiness categories:[19]

1) Fully Mission Capable (FMC). FMC is measured in hours per month. An FMC aircraft is an aircraft that has all its mission essential equipment functioning properly and has no malfunctions to it or to any of its systems or subsystems. The equipment, systems, and subsystems that are required to be fully operational are listed on the mission equipment essential list, Chief of Naval Operations Instruction 5442.4M (MESM). Naval Air Systems Command has determined a MESM for each aircraft based on its designed mission and installed mission equipment. An FMC aircraft can be tasked to accomplish any of its primary and/or secondary missions.

2) Partially Mission Capable (PMC). PMC is measured in hours per month. A PMC aircraft is an aircraft that has some unrepaired malfunctions in its systems, subsystems, or to any of its mission essential equipment. A PMC aircraft is able to fly, but has some degradation to its mission capability and may only accomplish some of its missions.

3) Not Mission Capable (NMC). NMC is measured in hours per month. An NMC aircraft is one that cannot be flown for safety of flight malfunctions. This aircraft can do none of its primary and/or secondary missions.

There is a fourth aircraft status category called Mission Capable (MC). The term MC is measured in hours and is used for data collection purposes. It is the sum of FMC hours and PMC hours.

Mathematically:[20]

PMC + FMC = MC

NMC + PMC + FMC = RRS (The total number of each month that the aircraft was in reporting status.)

For maintenance data purposes the categories of PMC and NMC are further stratified into PMC-S, PMC-M, NMC-S, and NMC-M.[21] These further clarifications of aircraft status are to indicate the primary reason for the PMC or NMC status. PMC-S and NMC-S indicate that a required part has been ordered from the supply system to replace a defective part or component, and has not yet been delivered. Therefore the reason for the degraded status is supply. PMC-M and NMC-M indicate that any required parts are on hand and the aircraft is awaiting maintenance to fix the system or subsystem that has malfunctioned.

Limitations and Delimitations:

Limitations.

1) The actual aviation maintenance data used is from HSL-37 from September 1990 to August 1991. The data was provided by the Maintenance Officer, HSL-37, specifically for this study. I have purposely limited the scope of the data. A full year of data should be sufficient to identify how the data could be used in TQM applications. The period of this data also covers a full range of squadron activities. During this time the data covers three detachments involved in Desert Shield, two of those detachments involved in combat operations in Desert Storm, one detachment deployed to the Persian Gulf after Desert Storm, one detachment deployed to the eastern Pacific Ocean for counter narcotics missions, numerous local deployment operations, and the training and readiness missions that occur at the squadron.

2) This is not all the aviation maintenance data available to the squadron, but it is the data HSL-37 publishes for its analysis in accordance with COMNAVAIRPAC and COMASWWINGPAC instructions. Additional data is available through the Maintenance Data System (MDS) that will be discussed in Chapter 3.

3) The actual application of the tools to the data is conducted by a team of individuals. In this study it is not possible for this to be done by a group.

Delimitations:

1) The focus of the data analysis uses aircraft readiness as an indicator of maintenance success. The goal of aviation maintenance is to provide an aircraft that can be flown safely with all its essential mission equipment fully operational. This focus of the data analysis facilitates both the understanding of the study and increases the adaptability of this study to "fleet" conditions.

2) The focus of this study to aviation maintenance data. In the actual implementation of TQM all facets of a squadron's operations would be incorporated. In a squadron there are other major factors besides aircraft readiness which impact the squadron's level of readiness. These areas, such as training, aircrew proficiency, operational commitments, and the level of personnel manning are all factors that impact readiness that will not be investigated.

3) This study is limited to LAMPS Mk I aviation maintenance data. It is not to suggest that findings will not be applicable to other types of squadrons. The data collection requirements for all naval aviation squadrons are directed by the NAMP. Therefore, the type and use of maintenance data collected in a LAMPS squadron is very similar to the type of maintenance data collected in squadrons throughout the Navy and Marine Corps. The results of this study may be a useful guide for other squadrons, regardless of the type of aircraft they fly.

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[1]Navy Personnel Research and Development Center, A Total Quality Management Improvement Model (San Diego, CA: 1988), 1.

[2]Chief of Naval Operations, Naval Aviation Maintenance Procedures, OPNAVINST 4790.2E Volume V (Wash D. C. 1989), 2-1.

[3]Commander Naval Air Forces Pacific Instruction 3501.1D.

[4]Chief of Naval Operations, NAVOP 011/91, NAVY-WIDE IMPLEMENTATION OF TOTAL QUALITY LEADERSHIP (TQL) (Wash D. C.) 1991.

[5]Ibid.

[6]Author's interview with CAPT Robert McLendon, USN, Commander in Chief Pacific Fleet Total Quality Leadership Team, September 1991.

[7]John L. Byron, CAPT, USN "Welcome to the Revolution," U. S. Naval Institute Proceedings (Oct. 1991): 30.

[8]W. Edwards Deming, Out of the Crisis (Cambridge, MA: Massachusetts Institute of Technology, 1986), p. xi.

[9]Ibid., ix.

[10]Defense Technical Information Center, Participant Guide for TQM Quantitative Methods Workshop (Alexandria, VA: Defense Logistics Agency, 1990), 1-3.

[11]Navy Personnel Research and Development Center, p. vii.

[12]Michael Brassard, The Memory Jogger: A Pocket Guide of Tools for Continuous Improvement (Methuen, MA: GOAL/QPC, 1988), 4.

[13]Navy Personnel Research and Development Center, p. v.

[14]Peter Gwynne, "The Reigning Guru of Quality Control," The World & I (February, 1989): 328-333.

[15]Byron, 31.

[16]Chief of Naval Operations, NAVOP 018/91, NAVY-WIDE IMPLEMENTATION OF TOTAL QUALITY LEADERSHIP (TQL) (Wash D. C.), 1991.

[17]Navy Personnel Research and Development Center, p. v.

[18]Byron, 30.

[19]Chief of Naval Operations, Naval Aviation Maintenance Procedures, OPNAVINST 4790.2E Volume V (Wash D. C. 1989).

[20]Chief of Naval Operations, OPNAVINST 4790.2E.

[21]Chief of Naval Operations, OPNAVINST 4790.2E.

CHAPTER 2

LITERATURE REVIEW

There is a range of literature on the subject of Total Quality Management and various aspects of quality and its relationships with business management. Some literature has been in print for more than thirty years and has been revised several times. Though the concept of TQM has recently surfaced as a new and great way to run a business, much of the original work for the basis of TQM is not new. Some publications were printed before World War II. More recently, there are many papers, articles and pamphlets that offer recent accounts of TQM applications.

For this research, the general topics of literature can be divided into the following categories: TQM books that cover the basic concepts of TQM, publications that describe TQM analysis tools and or critical analytical aspects therein, and government and corporate publications that are TQM "how to" and "how we did it" manuals and handbooks. Due to the recent popularity of Dr. Deming and TQM, there are many magazine articles from magazines that run the gamut of readership, from *U.S. News & World Report* to the *Whole Earth Review*.

TQM Sources

Two authoritative works on Dr. Deming's theory of TQM, Out of the Crisis by Dr. W. Edward Deming, and The Deming Management Method by Mary Walton seem the most widely read works on the theory of TQM. These two books cover the fundamentals and major concepts of TQM in depth. Dr. Deming's Out of the Crisis thoroughly explains the philosophy of TQM. It describes examples of TQM use and application for varied business organizations and differing situations. The Deming Management Method also details TQM, but also includes much more historical background on Dr. Deming. Knowing the historical background of Dr. Deming assists the reader in understanding TQM by explaining the origin of Dr. Deming's search for quality and scientific methods to achieve quality. The Deming Route to Quality and Productivity by William W. Scherkenbach is a shorter work that is focused on the 14 points of TQM. It highlights each of the 14 points and explains each in detail. Like Deming, Scherkenbach is a statistician and in his book adds to Deming's explanation of the connection between TQM and statistical analysis. What is Total Quality Control? The Japanese Way by Dr. Kaoru Ishikawa translated by David J. Lu offers the Japanese version of Total Quality Management. Dr. Ishikawa is credited by Juran [1] with the invention of one of the analysis tools, the cause and effect diagram. It concentrates on the role and involvement of management in the drive for quality. This book did not specifically address in-depth application of the analytical tools of TQM but does reinforce the importance of using data and analysis techniques to achieve quality.

TQM Analysis Sources

There are also many works that center on the detailed aspects of statistical analysis. Total Quality Control by Armand V. Feigenbaum and the Quality Control Handbook by Joseph M. Juran, have been sources for the mathematical aspects of the application of the tools of TQM. They have thorough and in-depth discussions of quality control statistical analysis. Both texts were originally printed in 1951 and have since been revised several times. Hitoshi Kume has published a book entitled Statistical Methods for Quality

Improvement. This recent book is a layman's handbook for the analysis tools of TQM. It provides straight forward explanations of the tools of TQM without getting mired down in the finer statistical points of the tools. All three of these books were very helpful in understanding the technical statistical methods involved with the application of TQM tools. Items such as the minimum recommended number of data points for histograms and the different methods of calculation that can be used for control chart limit lines were explained by these sources.

Fundamental Research Statistics for the Behavioral Sciences by John T. Roscoe and Statistics: The Essential for Research by Henry E. Klugh were used for background in statistical methods. These texts contain in-depth information on scatter diagrams and the Pearson Correlation Coefficient.

There are a variety of sources that explain the use of TQM analysis tools. The Air Force Reserve has reprinted a TQM pocket guide, The Memory Jogger, A Pocket Guide of Tools for Continuous Improvement. It was compiled and edited by GOAL/QPC (the Growth Opportunity Alliance of Greater Lawrence/Quality, Productivity, and Competitiveness). GOAL/QPC developed the pocket guide to assist its employees in using TQM analysis tools on a daily basis. It details when and where the analysis tools can be used and for what applications. Because of its shirt pocket size, it could be a very convenient guide for those who intend to use TQM analysis tools frequently.

TQM "How To" Sources

Xerox has published several manuals for the study of TQM. The USMG Partnership: The Way We Work produced by the United States Marketing Group, Quality Office, a division of Xerox, was designed to explain to new USMG employees and to other Xerox division employees their emphasis on quality. This publication explained the uses of problem identification and problem solving techniques of TQM. The Leadership Through Quality Training Programs, are a series of five training publications written by Xerox in conjunction with the National Technical Information Service. These are "quality" training manuals for Xerox employees. These manuals demonstrate the application of TQM in a real corporation. One manual, "*A Guide to Benchmarking in Xerox*," has thorough explanations of the applications of many tools of TQM. Being written for a wide range of employee comprehension skills, the explanations are clear and straight forward. The manual's thorough explanations of data and TQM analysis techniques were very useful for this study.

Department of Defense agencies have produced several publications dealing with TQM and its applications. The Navy Personnel Research and Development Center published A Total Quality Management Process Improvement Model. This manual was published after early work with TQM in naval aviation depots beginning in 1983. Lessons learned from these early applications of TQM were compiled into a model for application of TQM for other naval organizations to use. I have selected this model as a guide for applying the TQM analysis tools to the LAMPS aviation maintenance data. I selected this model for several reasons. First, it was developed and published by the U. S. Navy for use in the U. S. Navy. This model is being used currently in TQL implementation at naval shore based commands. By using this model, strong and weak points in the relationship between this model and this data may become evident. This would be helpful in actual TQM application situations. Secondly, it offers a framework of steps to be taken by an organization in the application of TQM. Many books do not present TQM in a "how to" format. They are much more a "what is TQM" approach. A Total Quality Management Process Improvement Model shows how the Shewart cycle is used in the conduct of TQM, and how the various TQM analysis tools fit into the Shewart cycle. Its coverage of analytical tools of TQM is brief, but more critically it explains where the tools fit into the Shewart cycle. This ultimately demonstrates how the analysis tools fit into the complete scheme of TQM.

The Defense Technical Information Center has published a training manual entitled Participant Guide for Total Quality Management (TQM) *Quantitative Methods Workshop*. Like the Xerox training manual, it is also a training manual, and helpful in explaining the use and application of the tools of TQM and the Shewart cycle. It was most helpful for basic understanding of TQM, the Shewart cycle, and the analysis tools of TQM. Because of its basic format and clear presentation, I strongly recommend this to anyone spearheading their organization's training program in the implementation of TQM.

The Air Force Logistics Command (AFLC) has published two manuals that deal with TQM. The first is The President's Award For Quality And Productivity Improvement 1991. This publication is an application for the President's Award for Quality and it highlights the AFLC's strong commitment to the principles of quality management. This manual re-emphasizes the importance of the role of data and measurement in the application of TQM. The other AFLC manual, Quality Leadership, is an instruction book for the application of TQM in the AFLC. The manual focuses on the role of management personnel in the search for higher quality. Its coverage of the analysis tools of TQM is good and helps to strengthen information from other sources.

U. S. Navy Instructions

In naval aviation maintenance there is a single source for almost all aspects of operations. The cornerstone for the Naval Aviation Maintenance Program (NAMP) is the Chief of Naval Operations Instruction 4790.2E, also known as OPNAVINST 4790.2E, the NAMP, or simply "The 4790". It governs all maintenance practices, all maintenance data collection, data analysis, and maintenance procedures for naval aviation programs. The data analysis section in the NAMP describes basic techniques for the analysis of data. However, the analysis techniques used are not related to any management decision making processes. The instruction simply cites examples and does not attempt to show how the analyses could be used in the improvement of quality. Another naval instruction that is referred to in aviation maintenance data collection is the Chief of Naval Operations Instruction 3710.6N. OPNAVINST 3710.6N governs the Naval Aircraft Flight Record System (NAVFLIRS). NAVFLIRS is the system that collects and records flight information that is used with the aviation maintenance data.

COMASWWINGPAC has generated two instructions pertaining to maintenance and material data collection and processing: COMASWWINGPAC Instruction 4790.9B, Aviation 3M Source Document Submission and Processing Procedures; and COMASWWINGPAC 4790.13B, Reporting Requirements of the Maintenance Data Collection Systems. These instructions do not specify more *stringent actions* than found in OPNAVINST 4790.2E. They cover local administrative and procedural aspects of aviation maintenance data collection and analysis as delineated in OPNAVINST 4790.2E. HSL-37 has published one instruction that concerns aviation data collection and analysis, HSL-37 Maintenance Instruction 17-91, 3-M Documentation Standardization. The purpose of this instruction is to establish standardization procedures for all squadron and detachment maintenance data collection. This instruction does not impact this study. However, the data accuracy of the data is critical to proper system data analysis. According to Messina "Data integrity is the most vital characteristic of any data collection system."[2] The integrity of the aviation maintenance data from a LAMPS squadron has the potential to be suspect. Detachments account for a large portion of the collected data, and operate independently, increasing the risk of collection of unstandardized data. This aspect of data collection is critical in conducting TQM. However, the integrity of the data is beyond the scope of this study and will not be challenged.

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[1]Joseph M. Juan, Quality Control Handbook (New York: McGraw-Hill Book Company, 1974), 20-16.

[2]William S. Messina, Statistical Quality Control for Manufacturing Managers (New York: John Wiley and Sons, 1987), 1.

CHAPTER 3

TOTAL QUALITY MANAGEMENT, AVIATION MAINTENANCE DATA, AND THE U. S. NAVY'S TOTAL QUALITY MANAGEMENT PROCESS IMPROVEMENT MODEL

This chapter will explain fundamentals of the concepts required to understand the research. Included will be a description of TQM, TQM analysis tools, and tool applications. A description of the methodology by which the research will be conducted will follow. This will entail a description of the method used to conduct the application of the analysis tools associated with TQM. Finally, I will discuss the LAMPS aviation maintenance and data collection systems that provide the data that will be the focus of application of the TQM analysis tools.

Chapter 3 Section I: Total Quality Management.

To understand the importance of the application of the tools of TQM requires a thorough discussion of TQM. TQM is based on the idea that quality should be designed into every facet of an organization. Dr. Deming has developed guidelines to assist in achieving the transition from current management methods to a quality oriented organization. They are known as the 14 points, the deadly diseases, and some obstacles.[1] (See Appendix A for a list of the points, diseases, and obstacles.) Deming states that "The 14 points are the basis for transformation of American industry."[2] They delineate broad and specific actions for management to conduct throughout their organizations. The deadly diseases[3] are characteristics of management techniques that cripple the ability of an organization to be a quality centered organization and interfere with the transition to TQM. There are many obstacles identified by Dr. Deming[4]. Obstacles are characterized as attitudes, institutional prejudices, and beliefs that interfere with transformation of the system. The obstacles are similar to the deadly diseases, but are problems that are easier to cure than the deadly diseases.

The common theme that runs throughout Dr. Deming's 14 points, deadly diseases, and obstacles is that management must be the force behind the move to quality. The leadership of the organization must involve all personnel in the organization in the transformation to quality. The target of the transformation is the system. Finally, it is the customer that establishes the definition of quality. The Navy Personnel Development and Research Center has synthesized the contents of the 14 points, deadly diseases, and obstacles and to come up with critical concepts of TQM.[5]

1. Quality is defined by customers' requirements.
2. Top management has direct responsibility for quality improvement.
3. Increased quality comes from systematic analysis and improvement of work processes.
4. Quality improvement is a continuous effort and conducted throughout the organization.

Concept 1: Quality Defined

The definition of quality, who defines quality, and how do you measure it is an important aspect of TQM. TQM says that the customer defines quality. If the customer is dissatisfied with the product or service he will find another supplier. In LAMPS aviation maintenance, who is the customer? In aviation maintenance, as with any process, there may be many customers. The helicopter crews are the customers of the Maintenance Department. Maintenance crews are the customer of the parts supply system and the design engineers. In the operational environment, the ship and battlegroup are the customers of the services provided by the LAMPS detachments.

In a LAMPS squadron, quality is measured by the ability of the aircrew and the helicopter to complete its mission. To the aircrew, quality may mean a 100% FMC status for their aircraft. To the aviation mechanic who works on the helicopter, quality may mean how much work he must perform to sustain the helicopter in a 100% FMC status. Quality to the budget planner may be measured in the required cost to maintain the helicopter in a 100% FMC status.

On a broad sense, the command requesting the services of a LAMPS detachment is the customer of the LAMPS detachment. The battlegroup or surface command tasking the LAMPS detachment requires a certain level of quality from the detachment. Their definition of quality may be a ready aircrew and FMC aircraft available for tasking 24 hours a day. To achieve this goal a squadron or detachment will have two major areas of concentration. One area is the level of aircrew qualification and training. The other is the ability to maintain a LAMPS aircraft in an FMC status for the most amount of time possible. Data from the processes involved with the second area, maintenance of an FMC aircraft, will be the focus of this report.

An important aspect of quality is its quantifiability. Each customer's definition of quality may be different, but they all have a way to measure the quality they are looking for. Customers measure quality by comparing it to a standard or compare it to another source. Sometimes that personal standard may be no more than a feeling, but is still a standard. In naval aviation maintenance, the standards are tangible and measurable. They may be measured in dollars, maintenance man-hour time, flight time, or levels of readiness. We can therefore measure the quality we are striving to achieve.

The requirement to measure the quality of a process is critical to TQM.[6] You have to be able to measure a process to determine what level of quality exists currently. The measurements are the data from the processes. To improve a process you must first know at what level the process is currently operating. As stated by Michael Brassard in his pocket guide for TQM tools, "You don't know how much better you are if you don't know where you were before the change."[7] By knowing at what level of quality the process is operating, it will tell you where you must start to improve the process. Knowing the level of quality in the process also will aid in telling you where you want the process to be. You also need to measure changes in the level of quality to observe if changes made to the process are having the desired effect. You will not know if changes to the process have made it worse if you cannot measure the process. The data recorded by measurements can be used in the application of TQL tools. The goal of data analysis is to determine at what level a process is operating. By measuring and recording the right information, there are many aspects of a process that can be analyzed and diagnosed.

Concept 2: The Role of Top Management.

The common theme that runs throughout TQM is that management must be the force behind the move to quality.[8] To accomplish the transition, competent leadership absolutely committed to the transformation is required. TQM proponents estimate that up to 85 percent of quality improvement is under direct control of management.[9] This proportion of the change cannot be remedied by hourly employees. It is therefore the role of management to lead the transformation from current operational methods through the transition to becoming a quality centered organization. The current design of most organizations will not allow for the worker to be the motive behind the transition.[10] Therefore the change must be lead by management.

Concept 3: Systematic Analysis of the Work Process

Systematic analysis of the work processes is a major concept of TQM. It requires decisions to be based on factual evidence. The goal of TQM is to apply scientific methods in support of business applications. According to the dictionary scientific method is "A method of research in which a problem is identified, relevant data gathered, a hypothesis formulated, and the hypothesis empirically tested."[11] It is this method of problem identification, data gathering, and hypotheses formulating and testing, which the principles of TQM puts into practical applications for businesses. The scientific method is designed to search for empirical knowledge. TQM was developed to solve practical problems. TQM uses the Shewart cycle to translate the systematic approach of scientific method to organizational problem identification and analysis.

The Shewart Cycle

Of Deming's 14 points of TQM, point 14: "Put everybody in the company to work to accomplish the transformation,"[12] describes a methodology. The crux of point 14 is that it is essential that everybody in the organization be involved in the implementation of TQM. The following question becomes crucial. What is everyone supposed to do? The 14 points do not set up committees or action teams or set ground rules for proceeding with the transition. Deming found his answer to that question in the Shewart Cycle. In Japan it is called the Deming Cycle because he was the individual that introduced it to Japan.[13]

The Shewart cycle, also known as the Plan Do Check Act, or PDCA cycle, is the means of implementing TQM. Dr. Walter A. Shewart, a colleague of Dr. Deming, developed the Shewart cycle in the 1930's. The Shewart cycle, like the scientific method, does not rely on experience or accepted authority as the basis of fact.[14] It relies on the analysis of facts and data to figure out solutions to problems. The Shewart cycle is a process whose goal is to translate scientific method into applications that can be used by organizations to investigate their processes using a scientific methodology. The steps of the cycle- - Plan, Do, Check, Act - - represent phases of the problem solving process.[15] Certain activities are conducted in each phase giving structure to the problem analysis and solution procedure.[16] The Shewart cycle designates teams of personnel that are involved and activities that should occur in each step of the cycle. According to the Department of Defense, "The real value of of the PDCA approach is that it encourages practical problem analysis by people who are knowledgeable about a given process."[17] The different steps of the cycle have different TQM analysis tools that are associated with that step. This is not to imply that specific tools are only used at certain steps, but that the activity involved with that step lends itself to utilize tools with recognized strengths.

The Shewart Cycle divides the stratagem management should adopt in implementation of TQM into the following steps:[18]

Step 1. Plan

Step 2. Do

Step 3. Check

Step 4. Act:

Step 5. Repeat step 1.

Step 6. Repeat step 2.

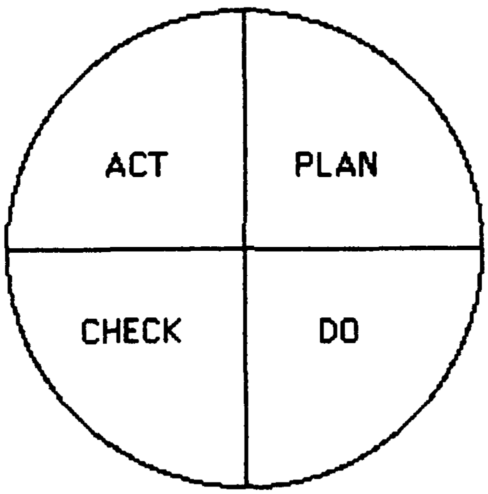

Figure 1. The Shewart Cycle

Step 1: The Plan Phase.

This phase involves identification of the goals and significant processes for the organization. In this phase customer definitions of quality should be determined for the organization. Phase 1 involves an assessment of how the organization is operating currently compared with how it is supposed to operate. Some problem identification occurs at this time, but there should be no changes introduced at this phase.[19] Upper level management personnel that have been formed into an Executive Steering Committee (ESC) normally conducts this step. Assisting the ESC will be a Quality Management Board (QMB)."[20]

Step 2: The Do Phase.

This phase involves the identification of problems and identification of the causes of quality in the process. According to the DOD, this phase is where "Operational definitions are developed in great detail so that there is minimum ambiguity when taking process measurements."[21] This is also when a scheme for data collection and actual data collection of the identified causes is developed.[22] This step is normally completed by QMBs and Process Action Teams (PATs). PATs are made up of supervisors and hourly wage personnel who are selected for their in-depth knowledge and experience in the area being investigated.[23]

Step 3: The Check Phase.

This is where analysis of the data occurs. This phase uses many of the TQM tools referred to earlier. QMBs and PATs are tasked with the analysis of the data that has been collected. It is possible that results of the analysis of the data during this phase may lead back to the Plan and Do steps. According to the PIM, a majority of the analysis using the tools of TQM occurs during this phase.[24]

Step 4: The Act Phase.

This involves the development of recommendations and implementation strategies that will be used to improve the quality of the process. The focus of this phase shifts back to

ESCs and QMBs. This is the level where the power to implement changes as results of the Check Phase. The changes are evaluated as to their effects on the process. The final task of the Act Phase is to publish the results as reports and briefings for the personnel involved in the Plan phase so the cycle may continue.

Concept 4. Quality Improvement is a Continuous Effort.

Once changes have been implemented in the Act Phase the cycle is continued with the Plan Phase to pursue continuous improvement.[25] It is this cyclical aspect of this type of improvement that is the strength of TQM. Changes in the process may be small with each iteration of the cycle. However, if the entire organization is dedicated to the task, quality will improve.

TQM Tools.

A critical concept and goal of ESC's, QMB's and PAT's is to esatblish a forum for communication for the people who should be making decisions.[26] The proper communication between and inside these functional groups is crucial to the overall success of the organization. As mentioned earlier, a strength of the use of the TQM analysis tools is their ability to facilitate communications. They portray graphically the characteristics of the data being investigated. They are easy to comprehend by a group with minimal inspection and reveal aspects of complex data that may not otherwise be apparent. The tools are easy to construct and do not involve difficult mathematics.[27]

The eight analysis tools that were previously mentioned are used to assist with problem identification and analysis in all phases of the Shewart cycle. The concept behind the use of these tools is to provide a structured problem identification and solving process that utilizes graphical techniques. The strengths of graphical techniques are that they are readily understood, they let you know where in the problem solving process you are, allow for simple identification of the problem and its variations, can tell you the relative importance of problems areas, and finally, graphical techniques allow you to evaluate the impact of corrective changes applied to a problem.[28]

The tools are not necessarily connected to a certain phase of the Shewart cycle, but their uses fit into different stages of the cycle. The tools associated with TQL can be separated into two major categories: problem identification and problem analysis.[29] Problem identification and problem analysis are closely associated with the Plan and Do phases of the Shewart cycle. These categories are not mutually exclusive and some tools fit into both categories. Flow charts, cause and effect diagrams, check sheets, Pareto charts, and run charts can be used for problem identification. Pareto charts, run charts, histograms, scatter diagrams, and control charts can all be used for problem analysis.

Problem identification tools do just that. They give indications when the system is not operating at its highest capability and show that a problem exists. Problem analysis tools assist in locating the effect of the problem. This is not necessarily the same as the cause of the problem. To find the cause of a problem may require more in-depth study and more iterations of the Shewart cycle.

Flow Chart.

The flow chart is a method of graphically describing how a process works, or how the process is supposed to work. Standard symbols used in construction of the flow chart and are found in many TQM books. According to Brassard, "A flow chart is a pictorial representation showing all the steps of a process."[30] The primary focus of this tool is to show how the different steps in a process are interrelated. The Navy Personnel Research and Development Center states that "In many traditional organizations, managers and employees are encouraged to specialize in those activities and operations they perform."[31]

For the members of the different teams; ESCs, QMBs, and PATs, a flow diagram will explain the structure of a process to individuals who may not be knowledgeable with that process.

When beginning construction of a flow chart the major steps of the process should be charted first. The flow chart of the major process steps is called a macro flow chart.[32] The advantages of a macro flow chart are that it displays only the major steps of a process and does not get in-depthly involved with the detailed procedures in the process. It makes the chart easier to understand for those who are not familiar with the process. After creating the macro flow chart then a micro flow chart can be made for each step in the process. The micro flow chart will detail the exact steps of each process. An extremely complex process may require the use of several layers of micro flow charts to adequately describe the process.[33]

Cause and Effect Diagram.

The cause and effect diagram, also called the Ishikawa Diagram or the fishbone diagram, is used to relate various possible causes to an effect or problem. It is called the Ishikawa Diagram after its inventor Kaoru Ishikawa, a pioneer in quality control. The name fishbone diagram comes from its fish-like skeletal appearance when completed.[34] The Navy PIM states "The purpose of conducting cause-and-effect analysis is to identify the variables that appear to have a major influence on the process results."[35] Normally a team would be responsible for building the diagram.[36] There are several different types of group techniques that are used to construct the diagrams. Each method involves different ways of soliciting possible causes from the team.[37] There are no strict rules concerning the number of and the titles of categories. However, a widely accepted categorization developed by Dr. Ishikawa is "Methods, Manpower, Material, and Machinery -- or the four

Ms."[38] For administrative or service organizations the causes can be grouped into equipment, policies, procedures, and people.[39] After the possible causes of an effect are recorded, the team then determines which causes should be given high priority for further analysis.

Check Sheet.

Check sheets are data collection tools that assist in problem identification. They are the best way to record the occurrence of an identified event or several types of events. The categories are usually an event or several different events recorded over a designated period. The purpose of the check sheet is twofold: 1) to facilitate data gathering and 2) to properly arrange data for ease in further use.[40] This type of chart can answer the question "How many times did this happen today?" In aviation maintenance a check sheet could be used to count the number of helicopters that required maintenance before take off even though they had been already certified safe for flight by a qualified plane captain. By counting the number of times maintenance was required may identify that there are certain strengths or weaknesses in the squadron's plane captain program. When using a check sheet there are several steps that must be followed. The most basic is the definition of an event or simply, what defines a mark on the check sheet. Secondly, they must agree upon the length of the period during which the data is being collected. Is it on a daily basis, every shift, or maybe a weekly period?[41]

Check sheets can also be used to record the frequency of an event in the structure of a histogram.[42] By constructing the check sheet to record specific categories of events in appropriate blocks, the appearance of the check sheet will take on the form of a histogram.

The data gathered from a check sheet should be graphically displayed to realize the full benefit of the data. The data from a check sheet can be easily used to construct run charts or histograms.[43]

Run Chart.

According to GOAL, "A run chart is a line graph that shows data plotted over time."[44] The purpose of a run chart is to make the presentation of the data, from a check sheet for example, clearer and easier to comprehend.[45] The number of "events" is normally presented on the vertical axis and the time interval is shown across the horizontal axis. Often the chart also will have the average of the data represented on the chart. This tool can be used to:

- Summarize large amounts of data.
- Display trends within observation points over a specific period of time.
- Monitor a process to see if the long range average is changing.
- Show the effects of corrective action, a *before* and *after* chart.[46]

Run charts are a particularly useful tool because of their simplicity of construction and readability.[47]

Pareto Diagram

The Pareto chart was named after the 19th century Italian sociologist and economist, Vilfredo Pareto.[48] The Pareto chart combines the graphical presentation of the bar chart with the percentage type data of a pie chart. The strength of a Pareto chart is that it readily shows the leading causes of an effect.[49] It displays its data in vertical bars like a bar graph, but the height of the bars represents a percent of the total and not a quantitative amount as with a bar graph.[50] Its effect is that of unrolling a pie chart.[51] On the vertical axis are percentages. The horizontal axis, like a bar chart, will have nominal categories. The nominal categories should be arranged with the largest percentage value on the left and sequentially decreasing to the right.[52] This arrangement of categories will allow the user to see how much each category contributes to the effect in question. The Pareto principle says that 20% of the causes produce 80% of the results. The other 80% of the causes produce only 20% of the results.[53] In other words, 20% of your effort will produce 80% of your work; 80% of your sales will come from 20% of your sales force; 80% of your problems will come from 20% of your problem categories; etc. A Pareto chart assists in identification of the 80% and the 20%.

Histogram

The histogram, also known as a frequency distribution, is a vertical bar graph that shows the distribution of continuous data. Histograms present a snapshot of the variation by graphically portraying the spread of measurements and the number of measurements in specified ranges.[54] It is similar in appearance to a bar chart. It is used to display variable data that is from one category. Like the bar chart, the vertical axis is a quantitative scale. However, instead of nominal categories on the horizontal axis, there are numerical categories. These categories are called numerical ranges.[55] These ranges represent the spread of the value of the quantitative data. Histograms are very useful when the variation of the data around a central value is the focus of the presentation. The histogram can display two types of variability: peakedness and skewedness.[56] Peakedness is used to describe the height of the graph, or lack of height of the graph. A histogram with a short base and tall height is considered peaked and indicates a narrow range of variability. A histogram with a wide base and short height is considered less peaked and indicates a wide range of variability. Skewedness refers to the point in the range of data the greatest frequency of measurement occurs. The peak may be skewed to the right or left. A histogram that shows high frequencies of data at either end of the data range is skewed. Histograms that show high frequencies of data at or near the center of the data range are normal.[57] The amount of variation of a process is a major concern for many organizations. Therefore, the histogram could be a very useful tool. However, as Juran cautions, "Analyses of histograms to draw conclusions beyond the sample data should be based on at least 50 measurements."[58]

Scatter Diagram

The scatter diagram is used to determine if there is a relationship between two sets of paired, variable data. This is to show a trend between two variables over time, or to investigate a possible cause and effect relationship.[59] A scatter diagram does not prove that one variable causes another to change, but it can demonstrate the strength of the relationship between two variables.[60] This type of presentation of *data can* be useful in problem solving because it can identify areas that have an effect on the problem in question. It illustrates relationships about the variables that might have been difficult to observe.[61] The data must be measured as sets of data.[62] A data point on one axis must be paired and plotted with its partner on the other axis. To determine if there is a correlation between the height and weight of people we cannot just take a list of heights and plot them against a list of weights. Each person's height and weight must be plotted as a set. If we can determine a correlation between two variables in our data, then we can use the measure of one variable to predict the other. If a scatter diagram shows that the two variables have no correlation, that is to say that changing one w[illegible]t effect the other, we can look for other variables to compare. If the points tend to form a line then the a correlation is said to exist. Correlation can be of varying degree and have a positive or negative slope.[63] Data points that tend to form a well defined line are highly correlated. Data points that form a random pattern are said to have no correlation. Data that forms a pattern between a line and randomness have a mild or unclear correlation.[64]

Formulae have been developed to calculate the relative amount of correlation from the data. This number is called the Pearson product moment correlation coefficient and is the most common measure of the degree of relationship between variables.[65] It is a dimensionless number between 1 and -1. The formula to calculate the coefficient of correlation, r, is:[66]

$$r = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{n}}{\sqrt{\left(\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right)\left(\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right)}}$$

In this equation, x and y represent the paired data in question. Negative values for r indicate that the variables are negatively related. Positive values for r indicate that the variables are positively related.[67]

Plainly stated, the more the data points tend to form a straight line, the closer the value of r, the coefficient of correlation, will be to 1 or -1. This is a number developed to measure the amount of correlation of data.

The value of the coefficient is meaningful when the variables are linearly related.[68] If the relationship between the two variables is other than linear, the value for r will underestimate the relationship.[69] For this reason, it is important to draw the scatter diagram to visually check the relationship between the variables.[70]

A second useful number is the coefficient of determination and is equal to the correlation coefficient squared, or r^2. The coefficient of determination is the amount that one variable is influenced by the other variable. For example, if r = .80 then the variables would be positively correlated. In this case, $r^2 = .64$. This means that 64% of the variation in the values of y can be attributed to variation in the values of x.[71]

The meaning of the absolute value of r and r^2 to the data are beyond the scope of this study. However, the relative values of r and r^2 for data where the x values stay the same and are compared to different sets of y values will be important. By comparing the relative values of r and r^2, relative amounts of correlation and determination will tell which variables have more impact on the value of variables in question.

No more than a general inference can be made concerning the absolute value of the Pearson correlation coefficient.[72] An r value of .70 may be very strong for some data and very weak for other data. The significance of the value of the Pearson correlation coefficient is directly related to the sample size.[73] In this study, relative values for r and r^2 are used to show relative affects of several variables on a separate category of data. This comparison is valid because the sample sizes of the different variables are the same.[74]

Scatter diagrams may be very helpful in LAMPS maintenance data analysis. First, because scatter diagrams may reveal areas that are related to each other that have yet to be suspected. Secondly, much of the data recorded in aviation maintenance is recorded in groups, making it usable for scatter diagrams.[75]

<u>Control Chart</u>

Dr. Shewart, of Shewart cycle fame, originally developed this chart to show distinctions between common and special causes of variation.[76] Control charts display the value of a characteristic over time the same way as a run chart does. However, control charts are more complex and are used to show a more in-depth analytical aspect of the data. Feigenbaum defines it as "A graphical method for evaluating whether a process is or is not in a 'state of statistical control.'"[77] Along with the data plotted on the chart are upper and lower control limits. Not all processes require both upper and lower control limits to be depicted. Processes whose production concerns a *minimum* or *maximum* value may only require an upper control limit or a lower control limit. Common sense dictates that in a process whose goal is a maximum or minimum value the control limit line in the direction of the goal is not required. The concept of statistical control will be addressed later in this chapter with the discussion of common and special causes of variation. Juran describes a control chart as a graphic comparison of process performance data to computed control limits drawn as limit lines on the chart.[78] The primary function of a control chart is to discover the causes of variation in a process.[79] Control charts are used as a basis for judging the significance of the variation of the measurements.

The upper and lower control limits are lines that have a calculated value relating to the data. Juran[80] identifies eight different methods for calculating the upper and lower control limits. The differences in formulae are dependent upon the type of data and the object of the analysis. These formulae were developed to draw a dividing line to provide an economic balance between searching too often for special causes when none exist and not often enough when they do.[81]

The NAMP[82] uses the following method to calculate the limit lines:

Upper control limit = mean + 3 times the square root of the mean

Lower control limit = mean - 3 times the square root of the mean

The Defense Technical Information Center publishes the following equations[83]:

Upper control limit = mean + 3 times the standard deviation

Lower control limit = mean - 3 times the standard deviation

Whereas these two methods are simple mathematically, they do not appear other texts on statistical quality control cited in this study.

The upper and lower control limits are plotted on the chart with the data points and the mean value. When the data points consistently fall between the upper and lower control limits the system is operating with a predictable amount of variation and is said to be in statistical control. This means that the system is not suffering from special causes of variation and that the analysis has predictive value. When the data points fall above and or below the upper and lower control limits, the system is not operating on a predictable basis, and the amount of variation from the mean is being caused by a special cause of variation.[84]

Common and Special Causes of Variation

All systems, even the most precise, do not have the exact results time after time. The outcome will be different almost every time, even if only by fractional amounts. But, with proper measurement of the system, we can mathematically determine average results for the system. From this we can also determine trends or runs[85]: local differences in the value of the average. Runs in the system will cause the average to differ from its historic value over time and may indicate a shift in the parameters of the process. For this reason, mean values and runs are important in the statistical analysis of the data.[86]

The amount that each data point differs from the average is known as variation. It is the cause of variation in a system that is very important. Dr. Deming has used the concept developed by Dr. Shewart of the two major causes of system variation, special causes and common causes.[87]

Special causes of variation are causes that come from outside the system. They affect the process but are not part of the system. Special causes may produce similar variation of data as seen in common causes or they may be responsible for larger anomalies in data.[88] They will be the causes of variation responsible for runs. Eliminating special causes of variation will allow the system to be in statistical control.[89]

Common causes of variation belong to the system.[90] They have been designed into the system. They will cause variation of data uniformly around the mean. The magnitude of the variation from the mean is a measure of the consistency designed into the system. Reducing common causes of variation improves the quality of the system.[91] A system that has only common causes of variation is in a state of statistical control. According to Dr. Deming, "A system that is in statistical control has a definable identity and a definable capability."[92] It is the identity and capability of a system that can be improved.

The statistical stability of a process is very important to TQM.[93] The system must be in a state of statistical control for these measurements to be of valid, predictive use. As Dr. Deming states, "The system must be stable before statistical analysis would have a predictive value."[94] When a system is statistically stable, the data allows a decreased requirement for inspections used to insure quality. However, a process not in statistical control can still benefit from statistical analysis. The trends it produces can point to the fact that special causes have an impact on the system. This will lead to the beginning of problem solving techniques used in TQM.

Chapter 3 Section II: Methodology

The application of the data to the tools will be accomplished using the Navy Personnel Research and Development Center's, A Total Quality Management Process Improvement Model. (Hereinafter it will be referred to as the PIM.) The Navy developed the PIM based on the fundamentals of TQM to be used by naval industrial organizations as a way to improve quality and productivity[35]. The model itself uses a TQM tool, the flow chart, to explain its use. (See Figure 2) The PIM, as shown in Figure 2, was designed using the Shewart cycle as its structure.[96] According to the PIM the majority of the data analysis is conducted during the middle steps of the Shewart cycle.[97] The following section will describe the PIM and how the analysis of the data using the PIM will proceed.

The Process Improvement Model - PIM

As earlier stated, the PIM was developed for the implementation of TQM at naval facilities. It was designed using the Shewart cycle as a framework. In the four steps of the Shewart cycle - - Plan, Do, Check, Act - - the Navy has broken each cycle step into smaller steps.[98] This facilitates the implementation of TQM by making the PIM the link between TQM theory and TQM application.[99]

PIM Plan Phase.

The PIM Plan Phase consists of three steps: 1) State Goal, 2) Describe Flow Processes, and 3) Define Desired Changes in Outcomes.

State Goal. In this step the goal of the organization is determined by the ESC. The goal should be both relevant and measurable.[100] Relevant means that the goal should have clear impact on the mission of the organization. Measurable goals can be verified by data. In this study I will determine the goal based on the squadron's mission. The mission is to provide FMC aircraft and fully qualified aircrew for assignment. For the maintenance side, this equates to maximum amount of FMC aircraft status time.

Describe Flow Processes. In this step the QMB constructs a flowchart to identify the system in question. Construction of the flow chart allows the process to be evaluated for gaps, disconnects, or other organizational problems. In the analysis phase I will construct a flow chart that depicts the LAMPS aviation maintenance procedures. In real world situations a more detailed flow chart would be to the advantage of its users.

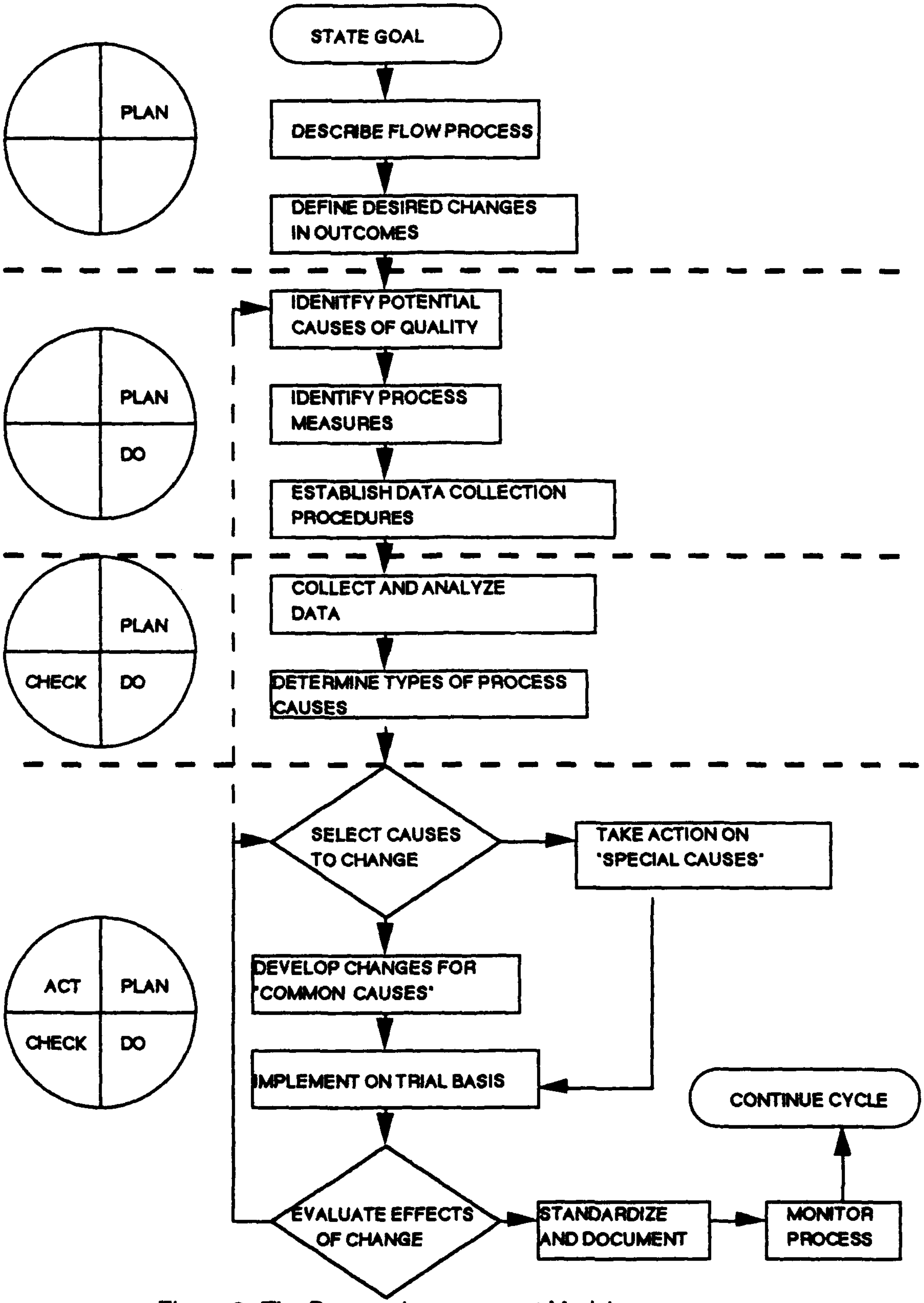

Figure 2. The Process Improvement Model

Define Desired Changes in Outcomes. There are three types of information required for this step: outcome, output, and process[101]. Outcome is the information the ESC uses to identify major organizational goals. The ESC and the QMB decide how the requirements of the outcome translate to specific process outputs. Then the QMB's and the PAT's identify process variables that have the greatest impact on the output quality of the process.

PIM Do Phase.

This phase also has three steps: 1) Identify potential causes of quality, 2) Identify process measures, and 3) Establish data collection procedures.

Identifying Potential Causes of Quality. This is defining and describing the process as it now exists. This "baseline information"[102] is in the form of data, flow charts, and cause and effect diagrams. The flow charts and cause and effect diagrams are used to organize the data and process steps into a graphic portrayal that is understood by everyone involved. Scatter diagrams can be used here[103] to identify variables that are and are not related to the outcomes from the Plan Phase. I will construct scatter diagrams to determine if a relationship exists between FMC and other categories of data. If the data is appropriate for analysis with scatter diagrams, the scatter diagrams should show either positive or negative correlation between the FMC data and another data category.

Identification of Process Measures. This is deciding how the measuring of process variables will occur. Data measurements for aviation maintenance process variables will be discussed at the end of this chapter. For this application, the decision of measuring process variables was done when the data was compiled at the squadron. This study will be working within the confines of the measures available with the data on hand.

Establishing Data Collection Procedures. In this step the PAT will decide how it will collect the data. A Pareto chart can be used in this phase by the PAT to determine which areas of the process should receive concentration.[104] By using the Pareto chart analysis on baseline data the PAT can save time and resources by only collecting data from the areas that of the most concern. I will use Pareto charts to identify the highest percentage of mission capability status times. Appropriate data should show what the major causes of non-FMC status time are.

PIM Check Phase.

This phase is divided into two steps: 1) Collecting and analyzing data, and 2) Determining the types of process causes.

Collecting and analyzing data. The data is collected and analyzed using the tools of TQM. This involves the use of histograms, control charts, run charts, and scatter diagrams. The determination of the types of process causes is referred to common and special causes of variation. The differentiation of these two types of variation is beyond the goal of this study and will not be conducted. In this phase, if the data are appropriate for TQM analysis tools, then the data should point to areas that impact, positively or negatively, the squadron's FMC status rates, monthly flight hours, and man hour usage.

Determining the types of process causes. The second step is to determine types of process causes. This involves using control charts to differentiate between common and special causes of variance. Variance of data that is between the control limits is being affected by common causes. Variance of data that falls outside the upper and or lower control limits may be the result of special causes.[105] To determine the exact cause of the variance requires detailed system knowledge that is brought to this step by QMBs and PATs and is beyond the scope of this study.

PIM Act Phase

This phase of the cycle is where the QMBs and the PATs develop and implement changes for the process based on the information from the Check Phase. These functions are beyond the scope of the data analysis.

For the actual analysis, I will apply the tools used in TQM as part of the Shewart cycle as described in the PIM to the available data. Herein lies a limit of this study. According to the PIM the PDCA cycle of TQM, ESCs, QMBs, and PATs are used to execute the various steps of problem identification, data collection, and data analysis.[106] The interaction of the members of these teams is all a part of the TQM process.[107]

Chapter 3 Section III: LAMPS Maintenance and Flight Operations.

This section will explain how LAMPS aviation maintenance is conducted and documented. Understanding the maintenance processes will be important during the Plan Phase of the application of the TQM tools. Thorough knowledge of the data collection system used in aviation maintenance is critical in the Do Phase of the application of the TQM tools. This discussion is general information to help the reader gain a broad understanding of Naval aviation maintenance procedures. It is not intended as a step by step authoritative explanation of maintenance procedures.

Aircraft Maintenance Operations

Between 4 and 8 hours before scheduled launch time, a plane captain will perform a daily or turn around inspection, associated documentation, and note any discrepancies he has discovered. The daily and turn around inspections are to insure the helicopter is ready for the flight. Discrepancies are written on a Visual Information and Display System/Maintenance Action Form (VIDS/MAF). The VIDS/MAF is submitted to

Maintenance Control where tasking to the appropriate squadron maintenance work center for corrective action is accomplished. Once the daily or turn around inspection is completed and the discrepancies are corrected, Maintenance Control releases the aircraft to the aircrew for pre-flight. Downing discrepancies, discrepancies involving safety of flight items, found by the aircrew during pre-flight inspection must be corrected prior to launch. Discrepancies in required mission equipment will also be corrected before launch. These discrepancies are recorded on a VIDS/MAF and submitted to maintenance control. Discrepancies that are not safety-of-flight items may or may not be corrected before the flight at the discretion of the Helicopter Aircraft Commander (HAC). After the mission is complete, the aircrew preforms a post-flight inspection. Discrepancies discovered during the post-flight inspection, during the flight, or ones discovered during the pre-flight are recorded on VIDS/MAFs for Maintenance Control to process as mentioned before.

In addition to maintenance performed in direct support of the flight schedule, there are other types of maintenance performed including two major aircraft inspection cycles. Each aircraft has components that must be replaced at designated flight hour intervals. This high time component maintenance replacement action is completed and documented with the use of VIDS/MAFs. The two inspection cycles are flight hour and calendar based. The flight hour phase inspection cycle requires maintenance and inspections performed at regular flight hour intervals. The calendar inspection requires maintenance and inspections performed at prescribed calendar intervals. Tasking for the inspections, and discrepancies found during both inspections are also recorded on VIDS/MAFs.

Cannibalization and "A-799" discrepancies are also recorded on the VIDS/MAF. Cannibalization is removing a good part from one aircraft to replace a faulty part on another aircraft. High frequency of cannibalization may suggest a supply problem, a part reliability problem, or other problems with the system in question. "A-799" discrepancies are those where the maintenance worker could not find the reported discrepancy with the system or subsystem in question. "A-799" is the maintenance action code for this case. A high number of "A-799" discrepancies leads to high amounts of wasted maintenance man-hours and may indicate that more training on discrepancy detection is warranted in the unit. It may also indicate that an intermittent problem may exist in a system.

When maintenance has been completed, the maintenance worker will complete the appropriate blocks on the VIDS/MAF. Entries of time required for job completion, maintenance action taken to correct the discrepancy, repair parts required, system or subsystem affected, and other pertinent data, are all part of the procedure. It is these hand written entries on the VIDS/MAF that the DSF transcribes into the data for the Maintenance Data System (MDS).

Maintenance Data System.

The MDS program is part of the Navy Maintenance and Material Management System (3-M). According to the NAMP

> The MDS is a management information system designed to provide statistical data for use at all management levels relative to:
> a. Equipment maintainability and reliability.
> b. Equipment configuration, including alteration and technical directive (TD) status.
> c. Equipment mission capability and utilization.
> d. Material usage.
> e. Material non-availability
> f. Maintenance and material processing times.
> g. Weapon system and maintenance material costing.[108]

According to the NAMP, the MDS

> is designed so that each worker, when performing a job, converts a narrative description of the job into codes and enter coded information on standard forms or source documents. These source documents are collected and transmitted to a Data Services Facility (DSF) where the information is converted to machine records.[109]

> The Maintenance Data System is designed to accumulate factual data pertaining to all phases of maintenance. The function of the analysis is to examine the data contained in these reports and determine what affect the conditions indicated may have on the maintenance effort. Analysis will show favorable and unfavorable conditions in the maintenance scheme.[110]

Aviation maintenance data is entered into the MDS through two sources: VIDS/MAFs and NAVFLIRs. The VIDS/MAF is the paperwork heart of aviation maintenance system. The VIDS/MAF is a multi-copy form used to record all aspects of maintenance performed on aircraft and maintenance support equipment. The VIDS/MAF system documents all maintenance tasked, all maintenance currently in work, and all maintenance complete. The VIDS/MAF system was developed to track and record aviation maintenance that has been performed, maintenance is currently in work, and maintenance that has been tasked. VIDS/MAFs are 5 copy forms for use in the maintenance department. Two copies are distributed to the work center or detachment, one for the Visual Information Display System board and one for a back up file. One copy is given to maintenance control for work verification information. One copy is placed in the aircraft discrepancy book to be reviewed by aircrew personnel before each flight. The final copy is delivered to the Quality Control division for final check for correctness. The entries on the VIDS/MAF come from the actual personnel doing the maintenance. They are verified by work center supervisors before being completed.

VIDS/MAFs are also the data collection heart of aviation maintenance. Most of the maintenance data collected in Naval aviation comes from VIDS/MAFs or is derived using data input from VIDS/MAFs. It is the source of all operational category hours: fully mission capable (FMC), mission capable (MC), and not mission capable (NMC); maintenance status data: not mission capable for maintenance-scheduled (NMCM-S), not mission capable for maintenance-unscheduled (NMCM-U), not mission capable for supply (NMCS), partially mission capable for maintenance (PMCM), and partially mission capable for supply (PMCM). In addition to aircraft hours, the VIDS/MAFs also record man-hour usage for each job that is tasked and completed.

Designated entries on the VIDS/MAF are for the subsystem capability impact reporting system (SCIR). According to a LAMPS squadron SCIR instruction pamphlet "SCIR is used to monitor mission capability of selected systems and subsystems. Mission capability tells the maintenance manager just how well his equipment is doing and if there are any problems with a subsystem."[111]

VIDS/MAFs record a specific work unit code (WUC) for each job. According to the NAMP "The WUC is a one, three, five, or seven character or alpha-numeric code. It identifies a system, subsystem, set, major component, repairable sub-assembly, or part of an end item being worked on."[112]

The other major source of data is the Naval Aircraft Flight Record (NAVFLIR). It provides flight information data from the "yellow sheet." The yellow sheet is the official flight record that the aircrew completes after each flight. The NAVFLIR system is currently being replaced by a computer system to ease data transcription and to reduce the data error rate from NAVFLIRs. Maintenance data and flight information from NAVFLIRs are combined to form the products of the MDS.

Squadrons are supported by a data service facility (DSF). The mission of the DSF is to compile the raw data from the VIDS/MAFs and the NAVFLIRs. Once compiled, the data is returned to the squadron as monthly maintenance summary consisting of the Maintenance Data Reports. See Appendix C for a list of MDS reports.

From the MDRs, squadrons produce a monthly Maintenance and Material Management (3-M) summary. According to the NAMP the analysis of data

> Involves the detailed study, or examination of, the accumulated data. There is no restriction as to who may do an analysis. The intent of the detailed study of the accumulated data is the same, that is, (1) to determine if a problem actually exists, (2) to identify the factors contributing to the problem, (3) to list possible conclusions, and (4) to suggest possible alternative courses of action.[113]

The MDS contains all the maintenance and readiness data generated at the local level. Each month, squadrons are required to compile selected entries of the data to produce a Monthly Maintenance Summary (MMS). According to the NAMP, "The monthly maintenance summary provides a coordinated combination of MDS reports to highlight specific problem areas and improve overall maintenance management."[114] The NAMP has 10 charts and data summaries provided for squadrons as example reports that can be included in the 3-M Summary. This is the data analysis conducted at the user level. See Appendix D.

The Squadron Monthly Maintenance and Material Management (3-M) Summary. Each month the squadron Maintenance Department produces the 3-M report. The intent of the report is to assist the Maintenance Department in evaluating the effectiveness of the their maintenance programs. See Appendix F for a sample 3-M Summary. The data in the 3-M Monthly Maintenance Summary is a monthly snapshot of the Maintenance Department. This data is to provide a history of the effectiveness of the maintenance department.

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[1]W. Edwards Deming, Out of the Crisis (Cambridge, MA: Massachusetts Institute of Technology, 1986), 23.

[2]Ibid.

[3]Ibid. 97.

[4]Ibid. 126.

[5] Navy Personnel Research and Development Center, A Total Quality Management Improvement Model (San Diego, CA: 1988), p. vii.

[6]Mary Walton, The Deming Management Method (New York: Dodd, Mead, 1986), 96.

[7] Michael Brassard, The Memory Jogger: A Pocket Guide of Tools for Continuous Improvement (Methuen, MA: GOAL/QPC, 1988), 21.

[8]Walton, 66.

[9]Navy Personnel Research and Development Center, p. vii.

[10]Walton, 66.

[11]The Random House College Dictionary Revised Edition (New York: Random House Inc., 1988), 1179.

[12]Walton, 86.

[13]Ibid.

[14]Defense Technical Information Center, Participant Guide for TQM Quantitative Methods Workshop (Alexandria, VA: Defense Logistics Agency, 1990), 2-4.

[15]Defense Technical Information Center, 2-5.

[16]Ibid. 2-13.

[17]Ibid. 2-6.

[18]Walton, 87.

[19]Defense Technical Information Center, 2-16.

[20]Navy Personnel Research and Development Center, 6.

[21]Defense Technical Information Center, 2-25.

[22]Navy Personnel Research and Development Center, 17.

[23]Ibid. 6.

[24]Ibid. 20.

[25]Ibid. 1.

[26]Ibid. 5.

[27]Walton, 97.

[28]Brassard, 4.

[29]Brassard, 5.

[30]Brassard, 9.

[31]Navy Personnel Research and Development Center, 9.

[32]Defense Technical Information Center, 4-13.

[33]Ibid. 4-14.

[34]Ibid. 4-23.

[35]Navy Personnel Research and Development Center,17.

[36]Defense Technical Information Center, 4-24.

[37]Ibid. 4-23.

[38]Kaoru Ishikawa, Guide to Quality Control (Tokyo: Asian Productivity Organization,1982), 18.

[39]Brassard, 27.

[40]Hitoshi Kume, Statistical Methods for Quality Improvement (Tokyo: 3A Corporation, 1989), 18.

[41]Defense Technical Information Center, 5-8.

[42]Kume, 20.

[43]Ibid.

[44]Defense Technical Information Center, 6-3.

[45]Ibid. 6-4.

[46]Ibid.

[47]Brassard, 30.

[48]Kume, 18.

[49]Brassard, 17.

[50]Xerox Corporation. Leadership Trough Quality Training Programs: A Guide to Benchmarking in Xerox (Rochester, NY: 1990), p. C-30.

[51]Ibid.

[52]Defense Technical Information Center, 5-21.

[53]Ibid. 5-13.

[54]Ibid. 5-30.

[55]Ibid.

[56]Ibid. 5-32.

[57]Brassard, 17.

[58]Joseph M. Juan, Quality Control Handbook (New York: McGraw-Hill Book Company, 1974), 22-6.

[59]Defense Technical Information Center, 5-32.

[60]Brassard, 44.

[61]Henry E. Klugh, Statistics: The Essentials for Research 2nd ed. (New York: John Wiley & Sons, Inc., 1974), 70.

[62]Kume, 44.

[63]Defense Technical Information Center, 5-53.

[64]Ibid. 5-54.

[65]Klugh, 70.

[66]Kume, 74.

[67]Ibid.

[68]Klugh, 74.

[69]Ibid. 75.

[70]Ibid.

[71]John T. Roscoe, Fundamental Research Statistics for the Behavioral Sciences 2nd ed. (New York: Holt, Rinehart, and Winston, Inc., 1975), 102.

[72]Ibid. 101.

[73]Ibid.

[74]Ibid.

[75]Chief of Naval Operations, OPNAVINST 4790.2E.

[76]Kume, 92.

[77]Armand V. Feigenbaum, Total Quality Control (New York: McGraw-Hill Book Company, 1983), 396.

[78]Juran, 23-2.

[79]Ibid.

[80]Ibid. Chap. 23.

[81]Walton, 115.

[82]Chief of Naval Operations, OPNAVINST 4790.2E. 4-4.

[83]Defense Technical Information Center, 6-26.

[84]Juran, 23-3.

[85]Eugene L. Grant, and Richard S. Leavenworth, Statistical Quality Control (New York: McGraw-Hill Book Company, 1980), 91.

[86]Ibid. 91.

[87]Deming, 310.

[88]Donald J. Wheeler and David S. Chambers. Understanding Statistical Process Control (Knoxville, TN: Statistical Process Controls, Inc., 1986), 10.

[89]Juran, 23-3.

[90]Wheeler and Chambers, 9.

[91]Walton, 115.

[92]Deming, 321.

[93]Ibid. 312.

[94]Ibid.

[95]Navy Personnel Research and Development Center, 1.

[96]Ibid. p. vii.

[97]Ibid. 4.

[98]Ibid. 1.

[99]Ibid. 5.

[100]Ibid. 7.

[101]Ibid. 11.

[102]Ibid.

[103]Ibid. 17.

[104]Ibid. 18.

[105]Walton, 115.

[106]Navy Personnel Research and Development Center, 5.

[107]Ibid.

[108]Chief of Naval Operations, OPNAVINST 4790.2E. 2-1.

[109]Ibid. 2-3.

[110]Ibid. 4-1.

[111]HSL-37 SCIR Data Pamphlet.

[112]Chief of Naval Operations, OPNAVINST 4790.2E. 2-7.

[113]Ibid. 4-2.

[114]Ibid.

CHAPTER 4

ANALYSIS OF THE AVIATION MAINTENANCE DATA

The LAMPS aviation maintenance data is compiled by the squadron as discussed in Chapter 3. An example 3-M Monthly Maintenance Summary is shown in appendix F. The analysis will proceed by using the steps in the PIM as discussed in Chapter Three. At each step I will show how the data is used with the various tools in each step.

Data Analysis: PIM Plan Stage:

Step 1) State the Organization's Goal. Ordinarily, the ESC would meet to establish the goal for the organization. The goal should be relevant and measurable. [1] For LAMPS aviation maintenance, the goal could be expressed by different methods FMC or PMC rates, flight hours, or even maintenance man-hour per flight hour. Commander Naval Air Forces Pacific Instruction 3501.1D (COMNAVAIRPACINST 3501.1D) states minimum requirements for maintenance readiness. This instruction states that the maintenance goal should be to achieve FMC and MC rates at 54% and 71% respectively. It is possible that an organization may already be exceeding goals set by a higher command. The goals that are established by the ESC should be the best ones for that organization. These goals may use the same criteria or ones that are determined to be more appropriate.

For clarification, FMC and MC percentage rates are calculated by dividing the number of hours that the aircraft was in the mission category status (FMC or MC) by the number of hours that the aircraft was in a reporting status (RRS). The following equations are presented for clarification:[2]

$$RRS = FMC+PMCS+PMCM+NMCS+NMCM,$$

$$MC = FMC+PMCS+PMCM$$

The squadron may set goals in many different areas. In order to focus the analysis phase of this study, I will use the COMNAVAIRPAC guidelines as the maintenance goal. As will be shown later in this chapter, conducting the aviation data analysis with a defined goal will keep the analysis pointed in a single direction. Therefore, the goal for the maintenance is to equal or surpass the COMNAVAIRPAC aircraft availability guidelines.

GOAL: Maintain FMC above 54% and MC above 71% for all aircraft.

Step 2) Describe Process Flow. Although there are many processes that make up LAMPS aviation maintenance I will use the overall maintenance process as described in Chapter 3 as the basis for the flow diagram. (See Figure 3.) This is a macro flow chart as described in Chapter 3. On this macro flow chart are many sub-processes that could be used to construct micro flow charts. For example: At the top of the flow chart diagram is the step "D & T." "D &T" is a daily and turn around inspection and is completed by a plane captain prior to each flight. If it were determined that the aircraft daily and turn around program was weak evidenced by a high number of aircraft gripes written before takeoff, the squadron could investigate that sin[illegible]r process using the PIM. For this step the participants could construct a micro flow chart for the daily and turn around program. Constructing a micro flow chart may convey specific problem areas in the Daily and Turn Around Inspection program. For this study, there will be no micro flow charts constructed. My personal knowledge of the Daily and Turn Around Inspection program is not thorough enough to construct a micro flow chart. This flow chart allows all personnel to see how and where maintenance evolutions affect aircraft readiness. On this chart I have outlined areas that correspond to the different aircraft status categories: NMCM, NMCS, PMCM, and PMCS. If analysis determines that one of these categories is a major contributor to non-FMC hours, then micro flow charts for each major step should be constructed.[3]

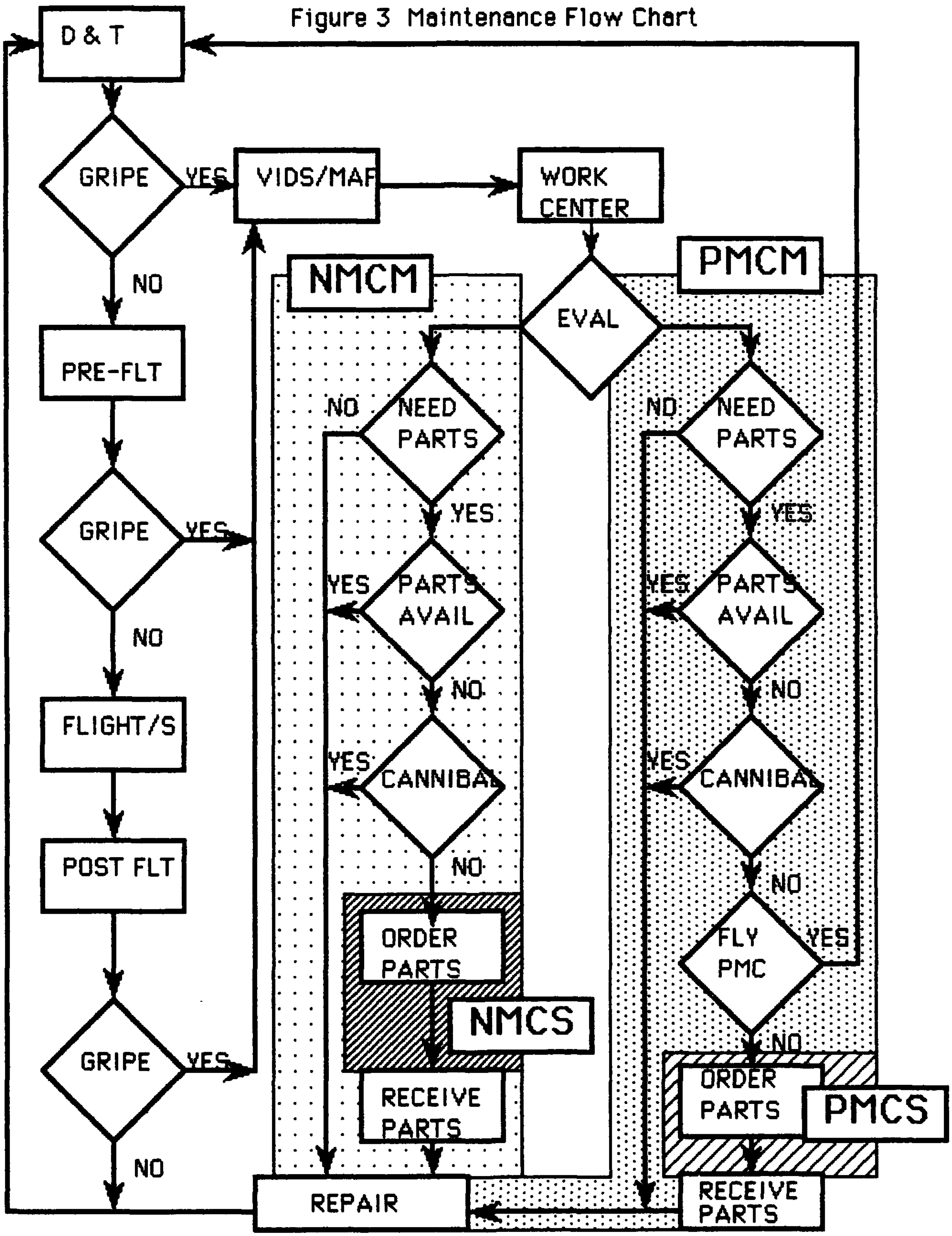
Step 3) Define Desired Change in Outcomes. This step concerns delineating quantitative amounts of change that will be used in the following phase; the Act Phase. As stated in Chapter 3, there are three categories of information that will be needed to effect quality change: outcome, output, and process.

The PIM defines outcome as"the customer's evaluation of the product or service."[4] In other words, how the customer measures the service. For this application, this would be the FMC and MC rates achieved by the squadron as delineated by COMNAVAIRPACINST 3501.1D.

Output is the information that describes objective characteristics of a product, process, or service.[5] The output information would be all of the categories: RRS, FMC, MC, PMCS, PMCM, NMCS, and NMCS hours. These are the specifications the maintenance squadron would use to determine the FMC and MC rates.

Process information is used to describe the resources and operations required to develop a product, process, or service.[6] In this study the process information is the rest of the supporting data compiled in the 3-M Monthly Maintenance Report. This includes the measurements of the processes and resources used to achieve the status categories used for output information. See Appendix F for a sample 3-M Monthly Maintenance Report.

Figure 3 Maintenance Flow Chart



Data Analysis: PIM Do Stage

Step 1) Identify the Potential Causes of Quality. The Ishikawa diagram, or fishbone diagram, is used for identification of potential causes of quality.[7] I have chosen the category of aircraft status to be the effect. This includes all of the possible statuses of FMC, PMCS, PMCM, NMCS, and NMCM. (See Figure 4.) This diagram was constructed using the 4 M's categories of manpower, methods, materials and machinery.[8] This diagram should include anything that may impact the quality of output.[9] This phase is conducted by a team. I have attempted to include as many aspects of the maintenance process as possible, just as a team would. The items of the Ishikawa diagram should cover all aspects of the effect. On this chart I have used all of the categories of maintenance data that are part of the 3-M Monthly Summary. Also included are aspects that may effect the the maintenance status of the helicopter that but that are not measured or have related data collected.

As stated in chapter three the major causes can be separated into the Four M's: manpower, methods, materials, and machinery. Other categories may be used. There are no set rules for categories. As stated by Brassard "You may use any major category that emerges or helps people think creatively."[10]

The Ishikawa diagram shows that there are many things that may impact aircraft status. As stated earlier, there are identified causes that do not have collected data. Areas such as the level of training of maintenance personnel and their maintenance experience, are ones that should be investigated in actual applications. However, due to a lack of data, it cannot be done here. This is an area where sufficient data has not been collected by the Maintenance Data System for TQM analysis.

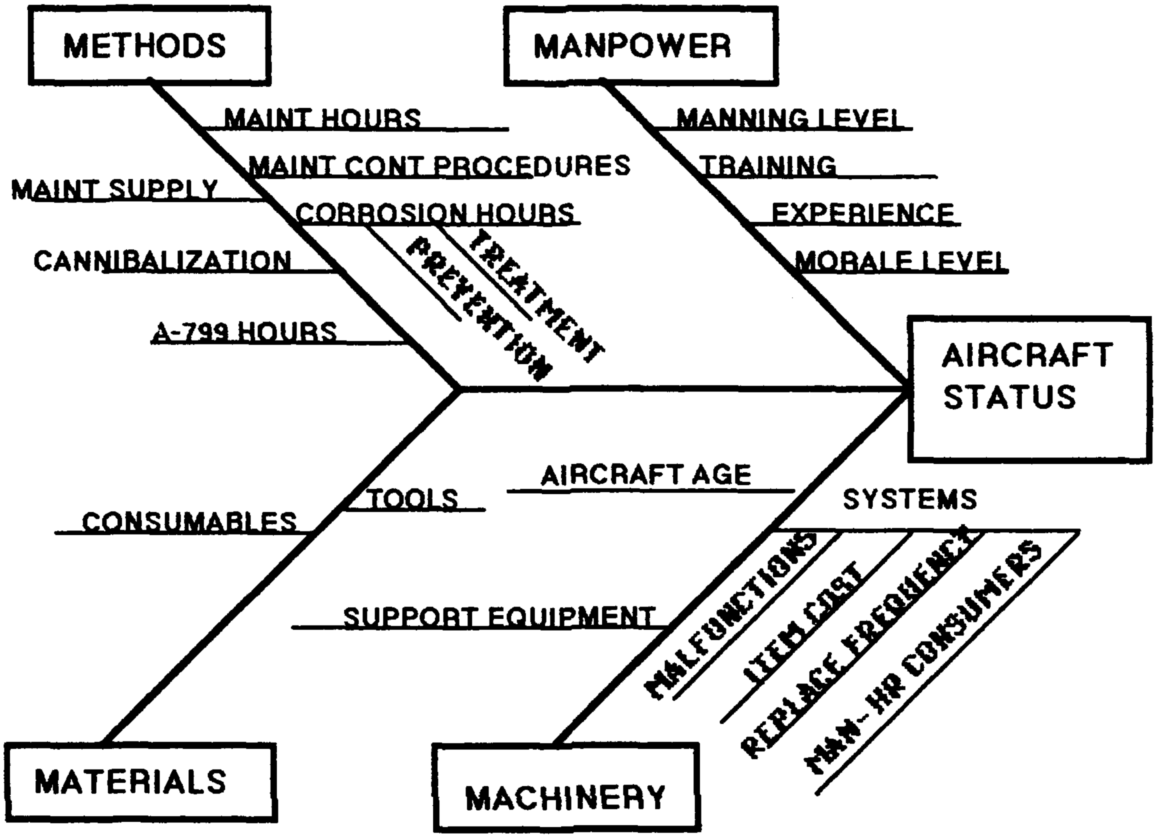


Figure 4. Cause and Effect Diagram

The next step is to construct scatter diagrams and Pareto charts using the available data to see how the factors identified on the Ishikawa diagram relate to FMC rates.[11] The best way to determine which reporting status besides FMC accounts for the most hours, is to construct a Pareto chart using the totals from the Monthly Maintenance Summaries.

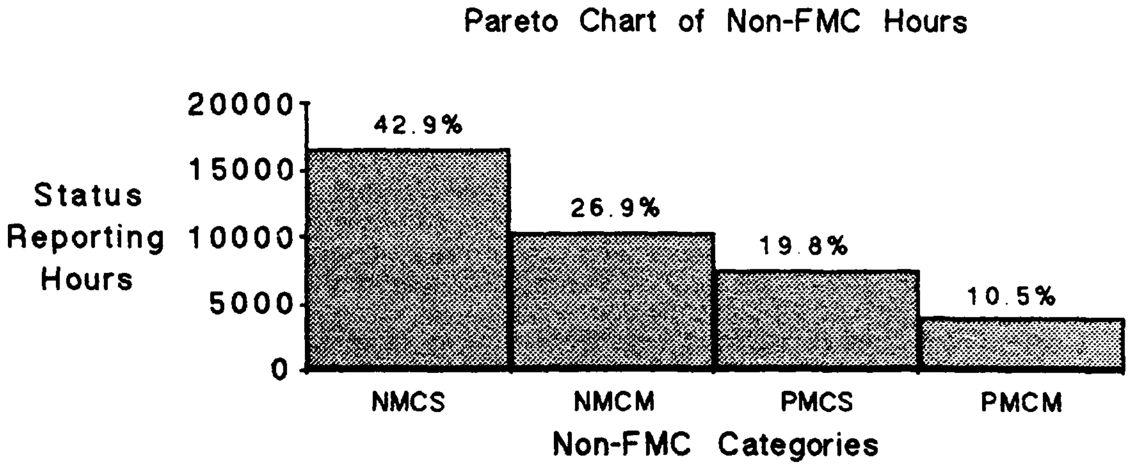


Chart 1.

Chart 1 shows that NMCS hours account for 42.9% of the non-FMC hours, PMCS accounts for 19.8% of the non-FMC hours. Therefore, non-FMC hours due to supply related causes account for 62.7% of the total hours. The chart also shows that of the 37.3% represented by maintenance categories, NMCM and PMCM, that 72% of that time is represented by the NMCM category. This initial Pareto chart has pointed to two areas that can be focused upon by the TQM teams.

As stated earlier, now that the highest categories of non-FMC time are known, the team should return to the flow charts and construct micro flow charts for the steps involved. One such micro flow chart to investigate NMCS time could be the process used to initiate and complete a requisition for a required part.

The next step is to construct scatter diagrams with the separate categories to evaluate the relationship between FMC and the other aircraft status categories, PMCS, PMCM, NMCS, and NMCM. The scatter diagrams should identify possible relationships between FMC and the other status categories. The preceding Pareto chart, Chart 1, has already demonstrated that NMCS is the largest non-FMC category. Scatter diagrams FMC data versus the other aircraft status categories should confirm this relationship. In evaluating the results of these scatter diagrams, it will be important to compare the Pearson correlation coefficients and the coefficients of determination for the data. These numbers will help to evaluate the relative amount of correlation between FMC hours and the other categories. These charts were constructed using the number of FMC and non-FMC hours per month as data pairs. Therefore each of these scatter diagrams will have twelve data points representing each month. The different scatter diagrams all have the same population size. This fits the criteria set forth by Roscoe[12] of using r and r2 as meaningful relative quantities. At the end of the scatter diagrams there is a table of coefficients of correlation and determination, r and r^2. The coefficients were calculated using the formula in Chapter 3.

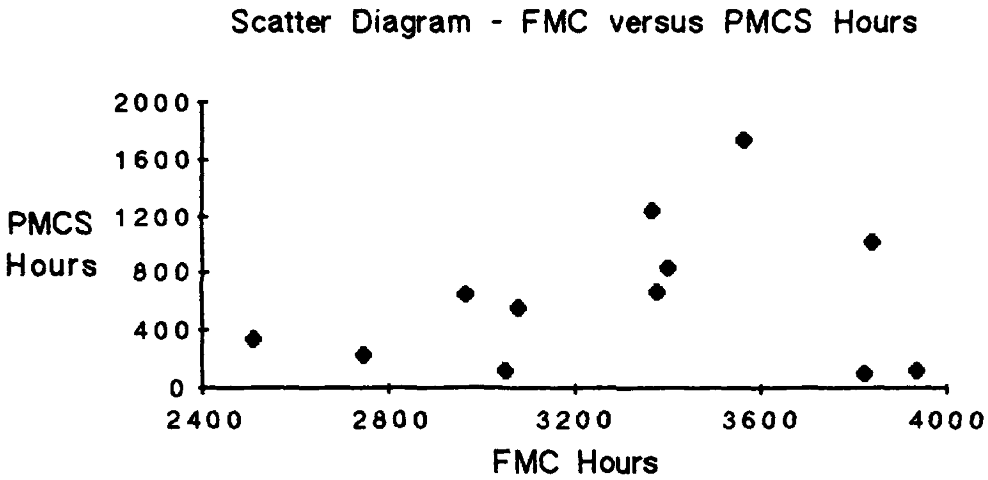


Chart 2.

This chart demonstrates a weak positive correlation between FMC hours and PMCS hours. In this chart r= .220 and r^2= .048. It suggests that the number of FMC hours is only weakly related to the number of PMCS hours.

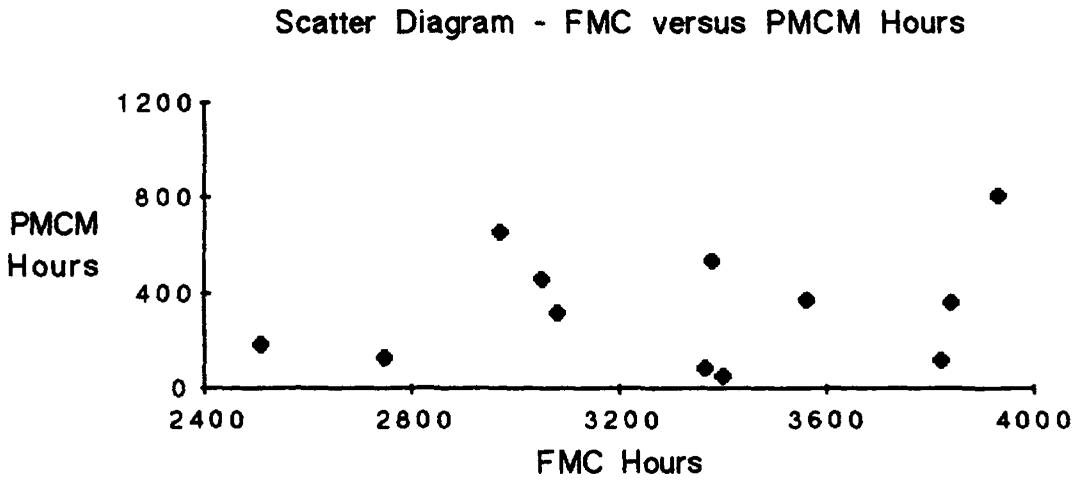


Chart 3.

Chart 3 demonstrates a mild positive correlation between FMC hours and PMC hours. In this chart r= .238 and r^2= .057. It suggests that the number of FMC hours is only mildly related to the number of PMCM hours.

So for both PMC categories there appears to be no strong correlation with FMC time. This agrees with the Pareto chart of this data, Chart 1. That chart shows that less than 30% of the *non*-FMC time is PMC time. Because the Pareto chart and the scatter diagrams show no strong nor even moderate effects, the PMC status would not be the area to focus impriovement efforts.

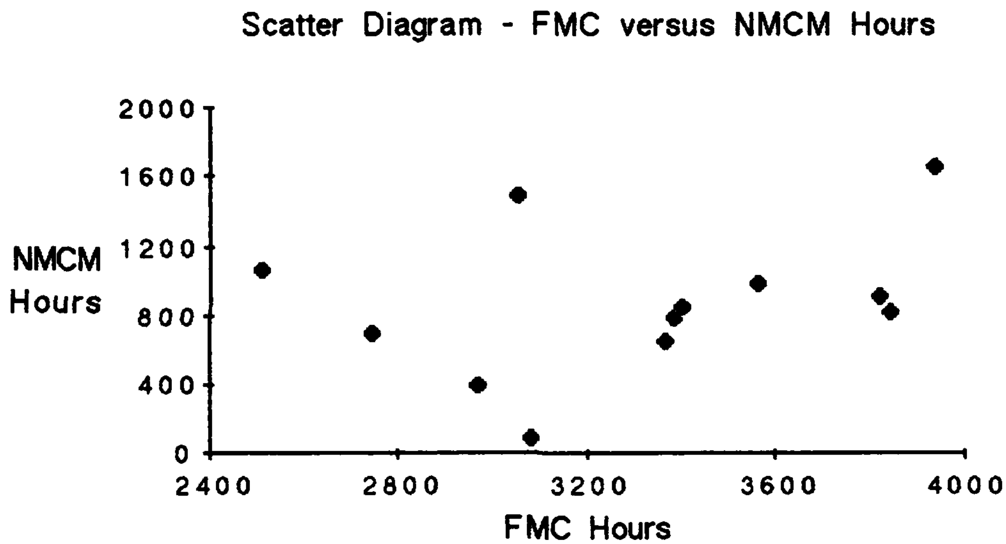


Chart 4

Chart 4 demonstrates a mild positive correlation between FMC hours and NMCM hours. In this chart r= .298 and r^2= .087. It suggests that the number of FMC hours is only mildly related to the number of NMCM hours.

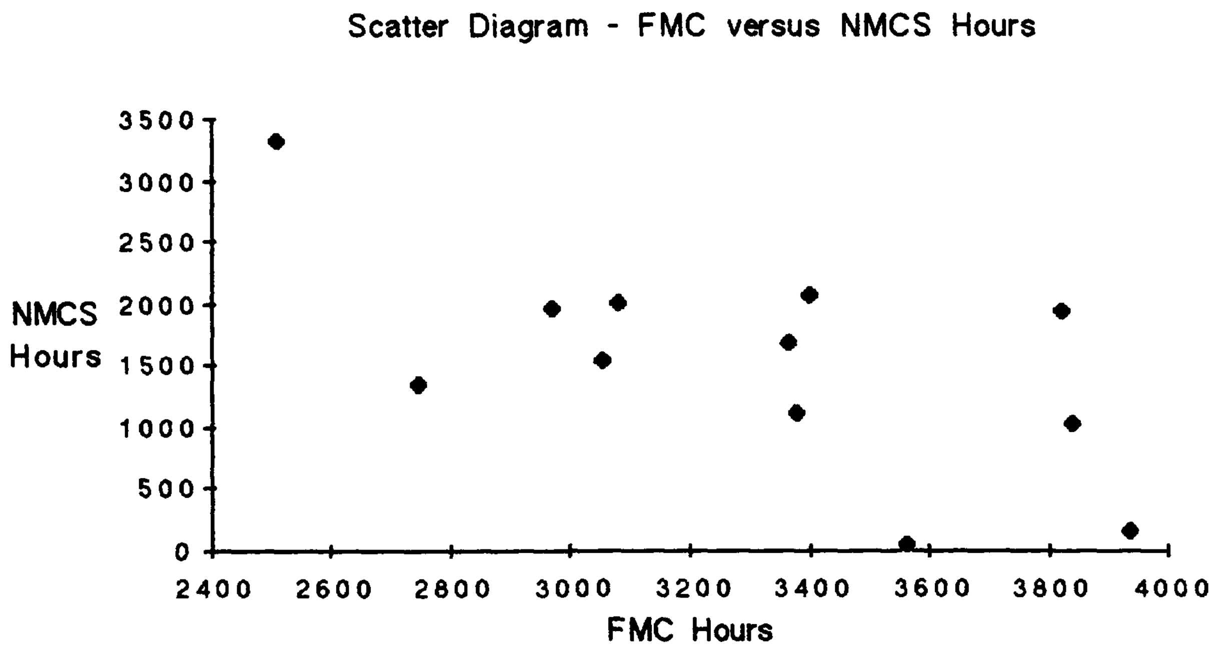


Chart 5

Chart 5 demonstrates a moderate negative correlation between FMC hours and NMCS hours. In this chart r= -.653 and r^2= .426 It suggests that the number of FMC hours is negatively influenced by the number of NMCS hours. The coefficient of correlation for NMCS is almost three times as high as the other categories. This does not mean that the influence of NMCS hours is three as much as the other categories, but a significance difference in values would indicate that the category of NMCS should receive the highest priority for investigation of the four.

The two scatter diagrams of NMC status also agree with the data in Chart 1, the Pareto chart. When comparing the r and r^2 values, it is clear which status area is impacting FMC time the greatest amount. By itself, and according to its coefficient of determination, NMCS time accounts for almost half of the impact on FMC time. This would be a logical area for further investigation. It could be helpful for the squadron to return to the macro maintenance flow diagram for more detailed work. The area shaded for NMCS time has only one process included: Order Parts. A micro flow diagram of this process could reveal supply problems in or possibly outside the squadron.

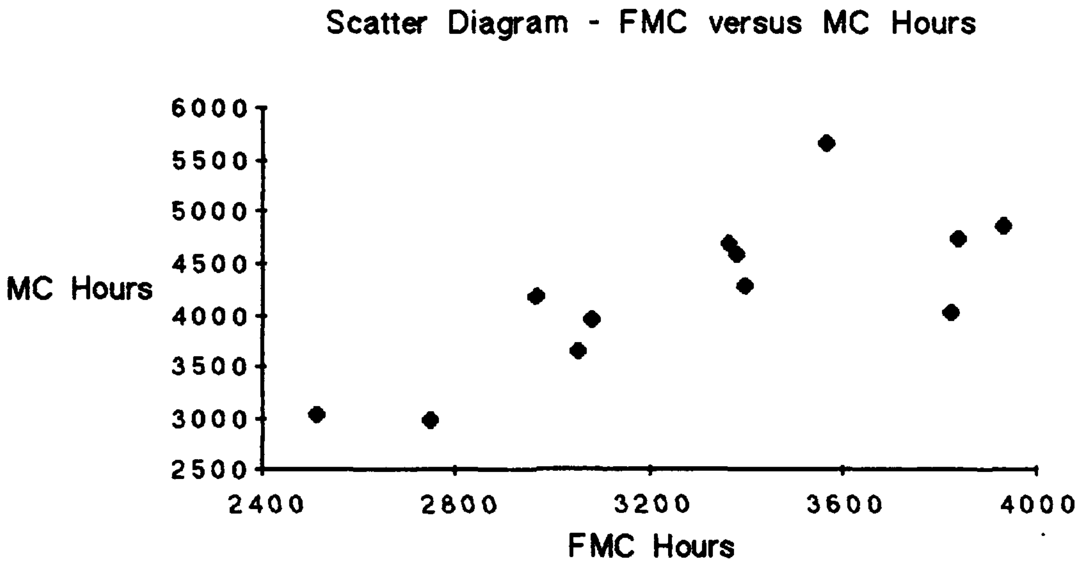


Chart 6

This chart demonstrates a very moderate positive correlation between FMC hours and MC hours. In this chart r= .760 and r^2= .578 It suggests that a high number of FMC hours will positively influence the number of MC hours. This inference may not be correct however. A detailed investigation of the two status times, FMC and MC, is required before any relationship can be proven.

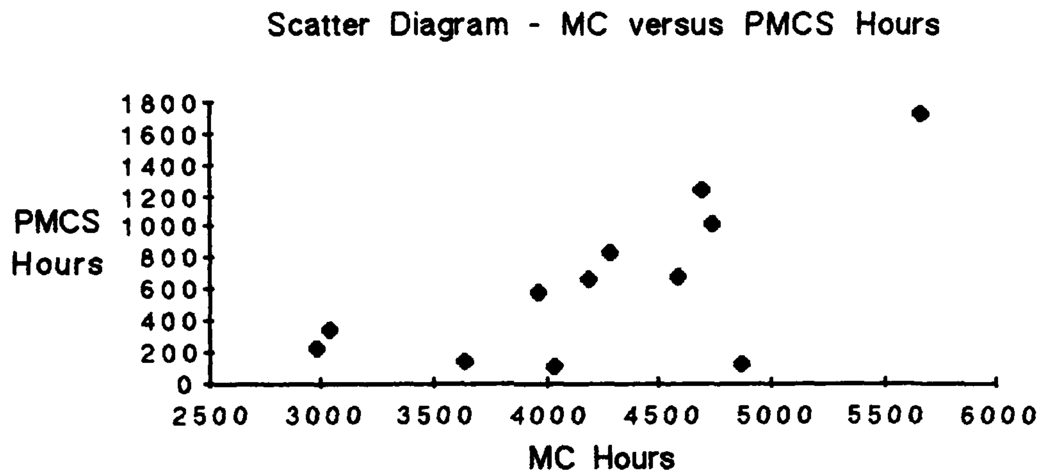


Chart 7

Chart 8 demonstrates a moderately strong positive correlation between MC hours and PMCS hours. In this chart r= .706 and r^2= .499. It suggests that the number of MC hours is positively related to the number of PMCS hours.

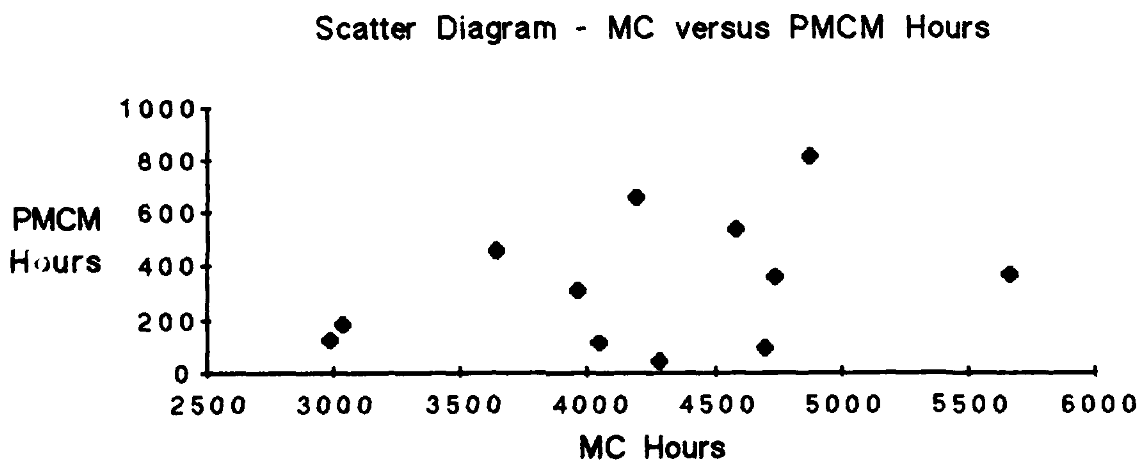


Chart 8

Chart 9 demonstrates a weak positive correlation between MC hours and PMCM hours. In this chart r= .346 and r^2= .120. It suggests that the number of MC hours is slightly positively related to the number of PMCM hours.

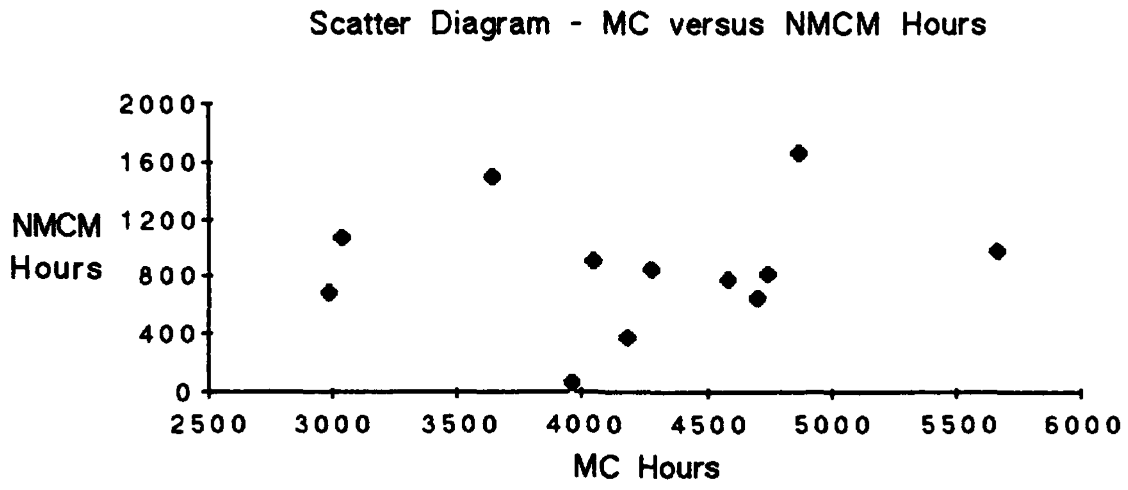


Chart 9

Chart 10 demonstrates an extremely weak positive correlation between MC hours and NMCM hours. In this chart r= .098 and r^2= .010. It suggests that the number of MC hours is only weakly related to the number of NMCM hours.

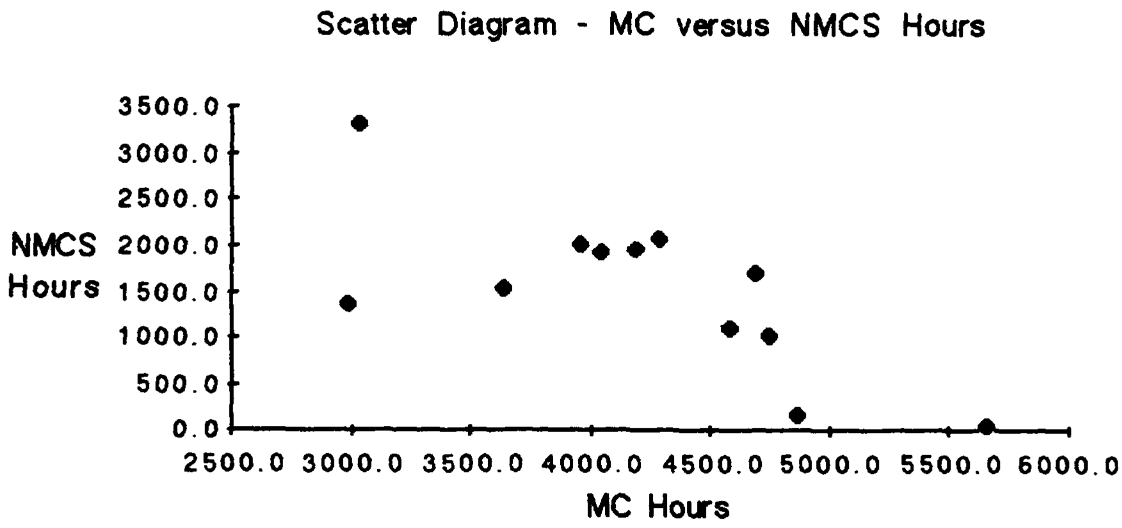


Chart 10

Chart 7 demonstrates a strong negative correlation between MC hours and NMCS hours. In this chart r= -.727 and r^2= .529 It suggests that the number of MC hours is negatively influenced by the number of NMCS hours by a noticeable amount.

The preceding four charts of MC versus the other status categories indicates that time awaiting supply, NMCS and PMCS, have the largest effect on MC time. NMCS has a large negative impact on MC time. It also has a large effect on FMC time. This would indicate that the squadron may need to address problems with the supply system to be able to improve its FMC and MC percentages.

The nine preceding scatter diagrams show the amount of correlation between FMC and MC hours and the other categories of aircraft status. Since the purpose of this phase is to decide priorities of effort it is helpful to compare all of their correlation and determination coefficients, r and r^2 data.

		PMCS	PMCM	NMCM	NMCS	MC
FMC	r	.220	.238	.093	-.653	.760
	r^2	.048	.057	.087	.426	.578
MC	r	.706	.346	.098	-.727	1.00
	r^2	.499	.120	.010	.529	1.00

Table 1

For both categories, FMC and MC, the table shows the largest negative values of r is NMCS. This is in agreement with the Pareto chart as to the category with the greatest impact on FMC status. This category, because of its relatively large values, should be the one to receive the highest priority. It is interesting to note that NMCM has a positive coefficient of correlation for both categories. Ideally, as the amount of time an aircraft is NMC increases, for any reason, the amount of FMC time should decrease. Due to the low correlation and determination coefficients and being contrary to reasonable thought, it is reasonable to believe there may be other factors that affect FMC and MC status.

Step 2) Identify Process Measures. The process measures for LAMPS aviation maintenance data that are being used in this study are identified in OPNAVINST 4790.2E, the NAMP. It is not possible to attempt to identify new process measures for this study. However, for all of the areas identified on the Ishikawa Diagram that do not have data collected, a data collection scheme should be constructed.

Step 3) Establish Data Collection Procedures. The data being used is collected from VIDS/MAFs, SCIR documentation, and NAVFLIRs. In the PIM, it states five questions that should be addressed in this stage[13]:

1. What process information will be collected?
2. How will the data be collected?
3. Who will collect the information?
4. Where will the data be collected?
5. When will the data be collected?

For this study, because the data have already been collected, the answers to these questions are directed by OPNAVINST 4790.2E, the NAMP. However, it has been shown that there will be data needed that is not part of the MDS as directed by the NAMP. When developing the data collection scheme all of these questions should receive thorough attention. For the previcus example of detachment maintenance personnel experience, the answers to the preceding five questions should be decided before collecting data for this phase.

The next operation in this step is to perform a Pareto analysis of baseline data.[14] The goal of this operation is to determine which causes identified on the Ishikawa diagram in the Do Phase, Step 1: Identify Potential Causes of Quality. It has already been demonstrated through a Pareto char: which of the non- FMC aircraft reporting status categories consumes the most time. Now, the leading contributor of NMCS time should be determined through the use of a Pareto chart. However, the data contains no details on NMCS hours. The information is not included in the Maintenance Data Reports as part of the Maintenance Data System.[15] Data that could be used for this part should be available from the aviation supply system.

Check Phase

Step 1) Collect and Analyze Data. In this phase the data is summarized using graphic methods. This includes all the TQM analysis tools previously addressed in Chapter Three. For the actual data analysis, first I will demonstrate how the aircraft status category data can be used with various TQM analysis tools. Second, I will analyze the items shown on the secondary bones of the Ishikawa diagram with the various TQM analysis tools. This will demonstrate how the data may be used in conjunction with different tools and conversely the suitability of the data to the tools.

Analysis of FMC, MC, NMCS, NMCM,PMCS, and PMCM Data.

Run Charts. A logical place to begin analysis is with run charts. Run charts, because of their time-related aspect, show a history and current status of the system involved.[16] Since FMC and MC percentages are the specified COMNAVAIRPAC goals, they will be the first charts to construct. This chart shows a history of how well the squadron has, or has not, met the COMNAVAIRPAC goals. This chart indicates that the minimums for FMC and MC have not been met on a regular basis.

Run Chart of FMC and MC Percentages

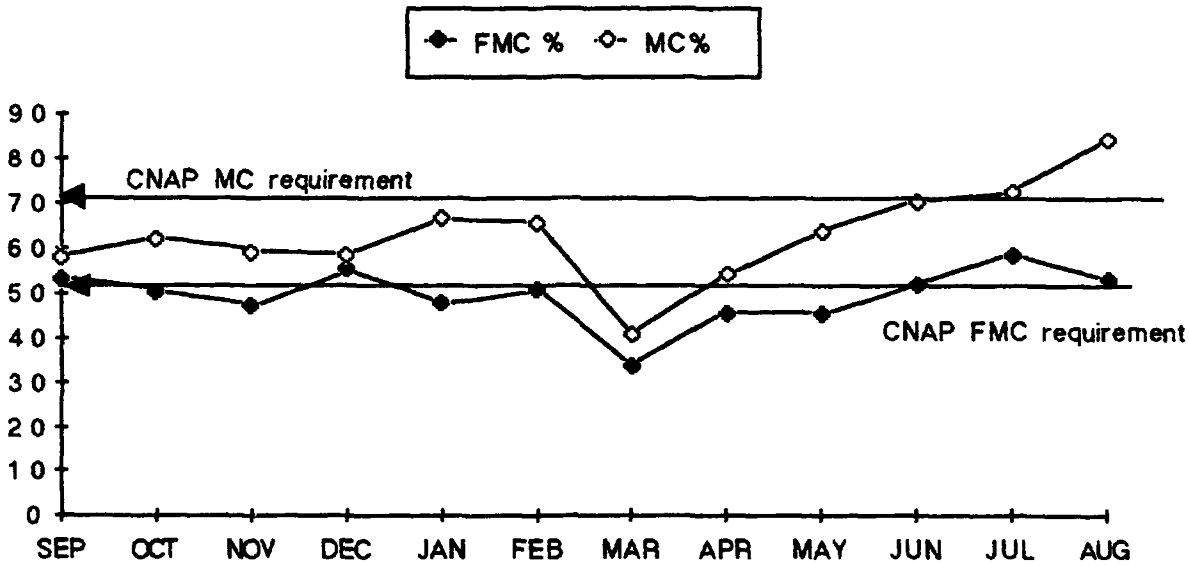


Chart 11

This run chart, Chart 11, is easily read at a glance and shows several things. The squadron has seldom attained its goal in FMC percentage and rarely made its goal in MC percentage. This chart gives the history of FMC and MC percentage and shows that it has been improving. Has there been a recent change in maintenance procedures to account for the increase? Or did outside factors have an impact? Maybe the release of additional transport aircraft from Desert Storm duties has increased the supply systems responsiveness? These are the questions that could be addressed as the analysis continues.

In the same way that FMC and MC can be tracked by a run chart so can NMCS, NMCM, PMCS, and PMCM. These may identify seasonal problems or success in the status of the aircraft.

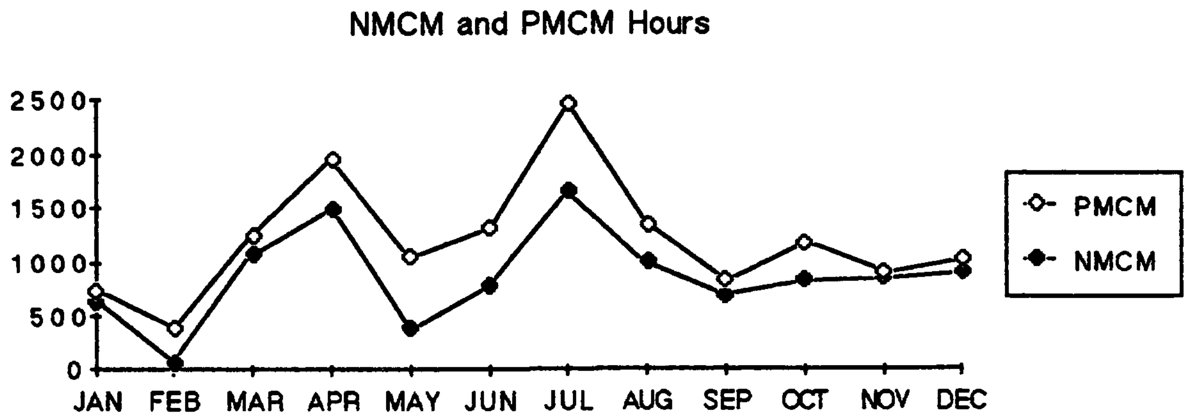


Chart 12

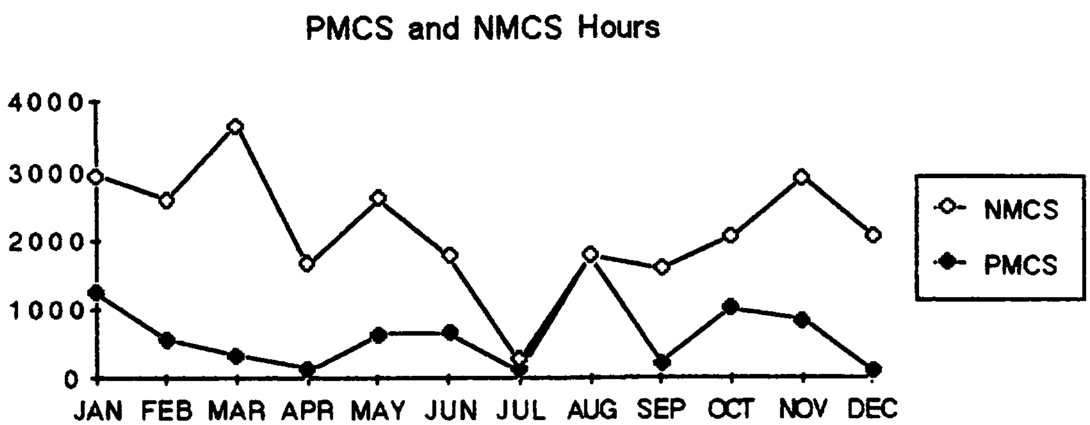


Chart 13

Maintenance or part supply problems can be tracked and identified using run charts. For example, from personal experience I know the peak in NMCS hours in March was due to a shortage in trim strut actuators. Defective actuators had been identified to be from a second contract supplier and were removed from the helicopters and the supply system.

The original contractors actuators were in short supply therefore causing a high amount of NMCS time. (Note: Had the Navy used a single source of supply, TQM point 8, as extolled by Deming[17], this problem may not have occurred.)

The 3-M Monthly Report contains five run charts or similar graphic representations that use data from FMC and MC percentages, aircraft utilization, A-799 trends, cannibalization trends, and man-hour documentation. See appendix F.

Histograms. Histograms are snapshots of a system used to display variation around a central value.[18] It is ideal for processes whose goal is to produce at a predetermined value.[19] Almost all the data presented by the squadron monthly report is from a system whose goal is to maximize or minimize certain characteristics. However, one category of data, man-hours per flight hour by aircraft, was reported for the last seven months of the period. Using this data to construct a histogram demonstrates how the data can be used for this type of tool.

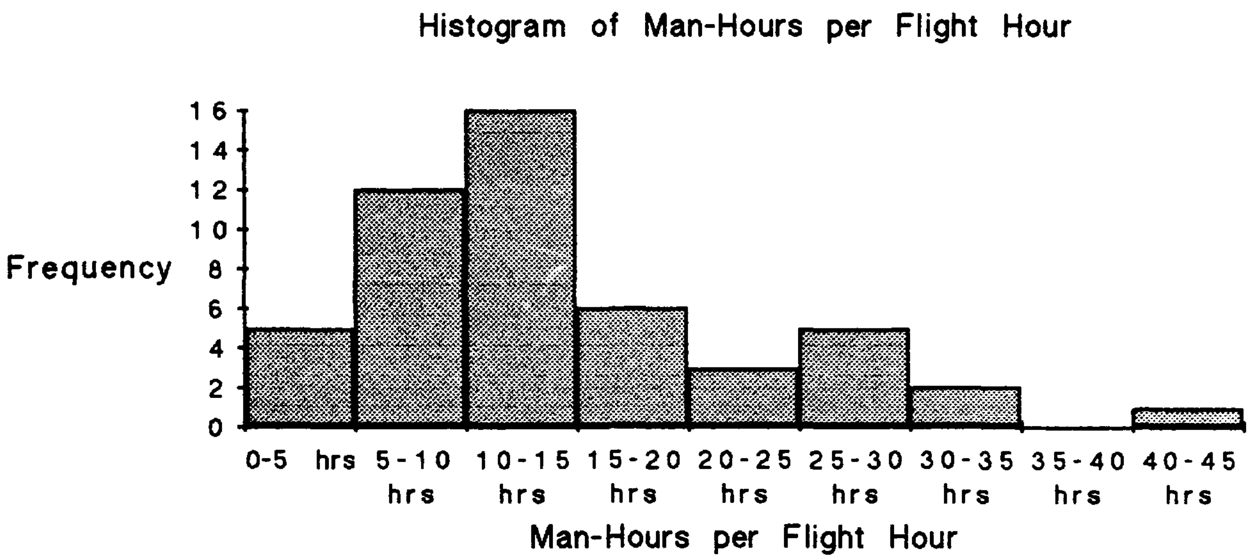


Chart 14

This histogram demonstrates that there is a tendency for one flight hour to require ten to fifteen man-hours. Given this information, maintenance planners could estimate the workload and personnel required to fly a certain number of hours. This histogram does not include all the data. There are six data entries that would not fit on this chart. They are so far to the right of the page it would take over 13 feet of paper to the right to represent all of these data. One data entry is as high as 1600 man-hours. Three of the entries, 1600 man-hours per flight hour, 945 man-hours per flight hour, and 76 man-hours per flight hour, originated from the same aircraft, and were omitted because they were off the scale.

Control Charts. Control chart use is described in the current edition of the NAMP.[20] The control chart can be used to predict how a process should perform under stable conditions.[21] The 3-M Monthly Maintenance Report has a run chart of the monthly FMC and MC percentages. This data can be used to construct control charts for FMC and MC percentages.

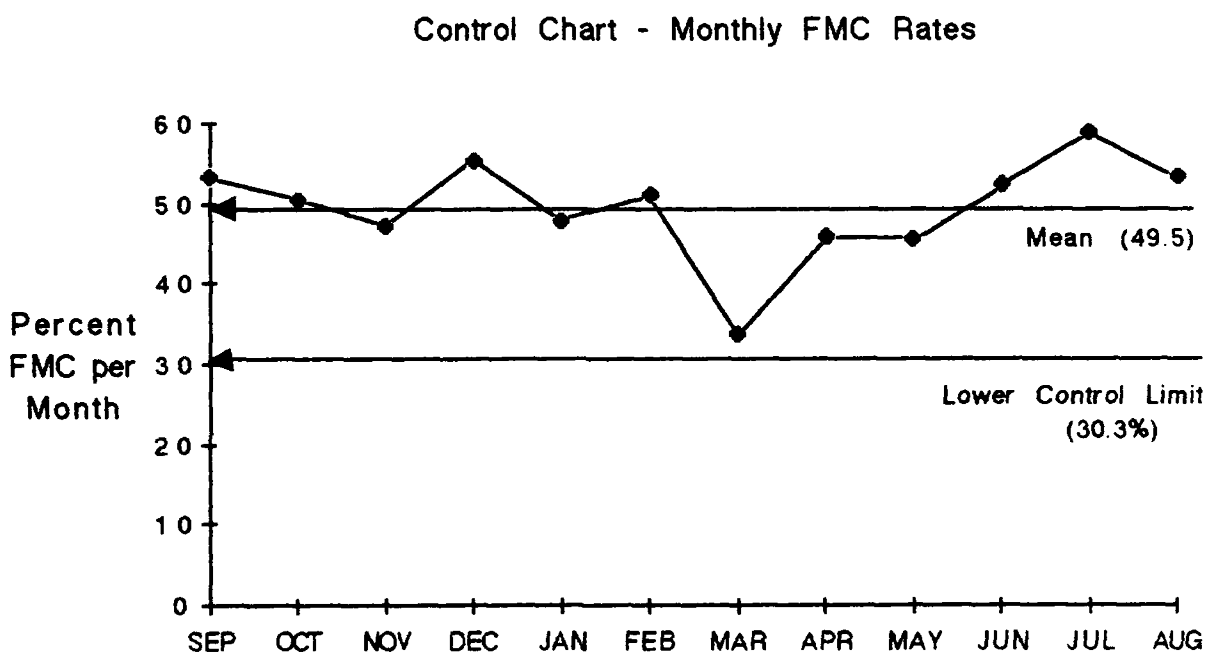


Chart 15

This control chart shows that even though the squadron has rarely achieved prescribed MC monthly rates it has no data points that are below the lower control limit (LCL). This indicates that MC time is not being impacted on by special causes of variation and that the variation it does show is due to common causes. These common causes are built into the maintenance system. It has already been shown that supply procedures, though not directly a squadron program are included in the common causes of variation. If the supply procedures alone were changed the data may show an increase. This chart could reflect this kind of change. The same can be said for the following control chart of monthly MC rates.

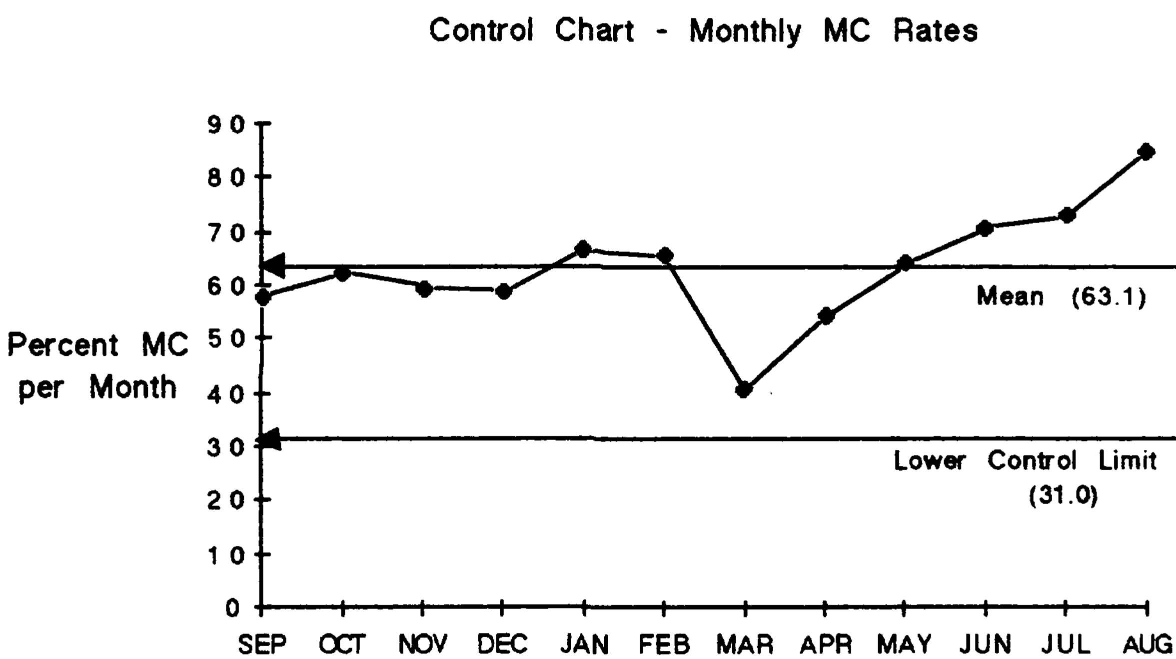


Chart 16

Note that the preceding two charts have no upper control limit lines. As previously discussed, the upper control limit lines were not depicted. They are not of concern because the goal in each case is maximization of either FMC or MC rate. The lower control limit was calculated using the second formula presented in Chapter 3. In all cases none of the data points fall below the lower control limit lines. These charts are telling us that the processes are stable and the system is not being affected by special causes of variance. However, neither the FMC or the MC line averages are above the minimums set by COMNAVAIRPAC. Hence, it is a stable system that is operating below its goals suffering from common causes of variation.

The following control charts, 17-20, will be addressed collectively after Chart 20.

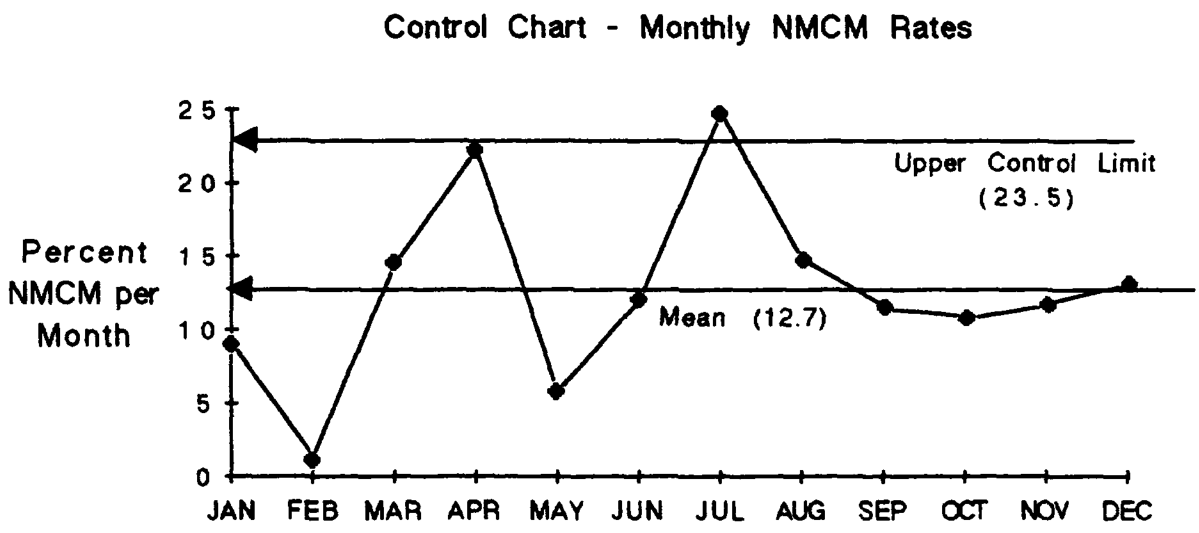


Chart 17

Control Chart - Monthly NMCS Rates

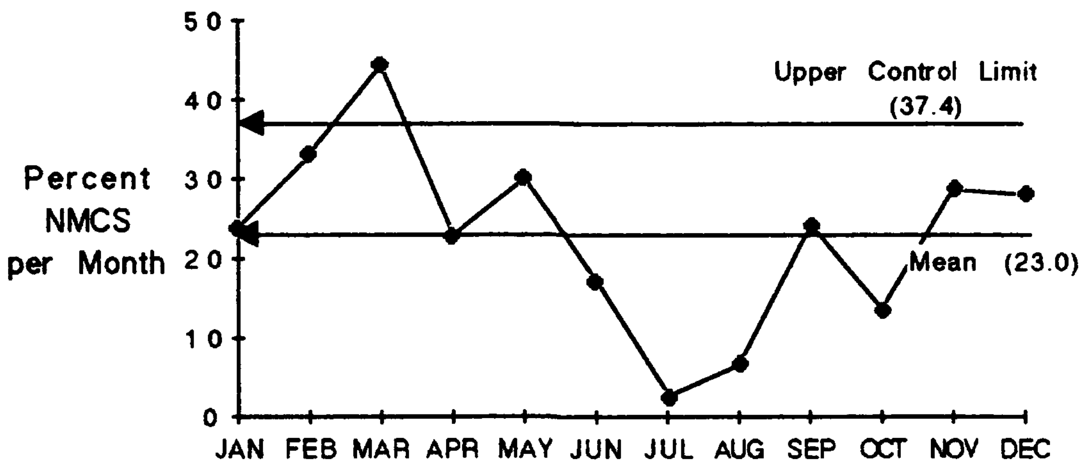


Chart 18

Control Chart - Monthly PMCM Rates

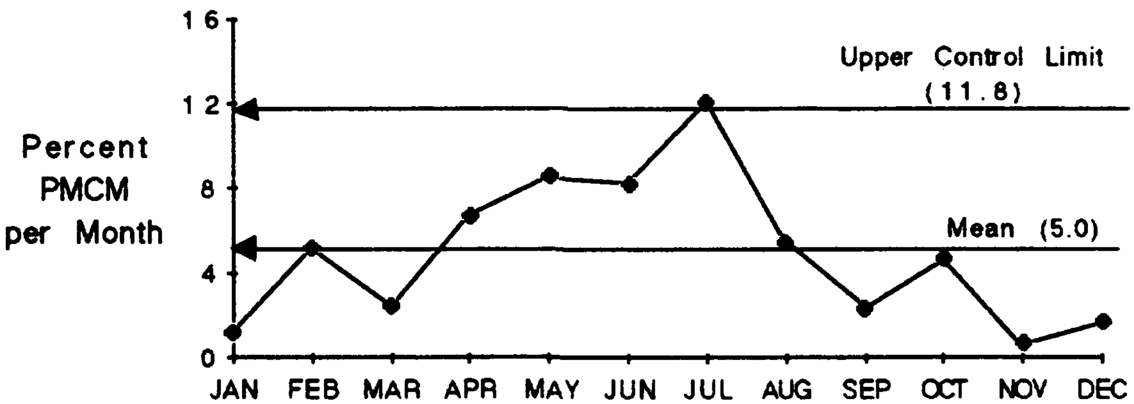


Chart 19

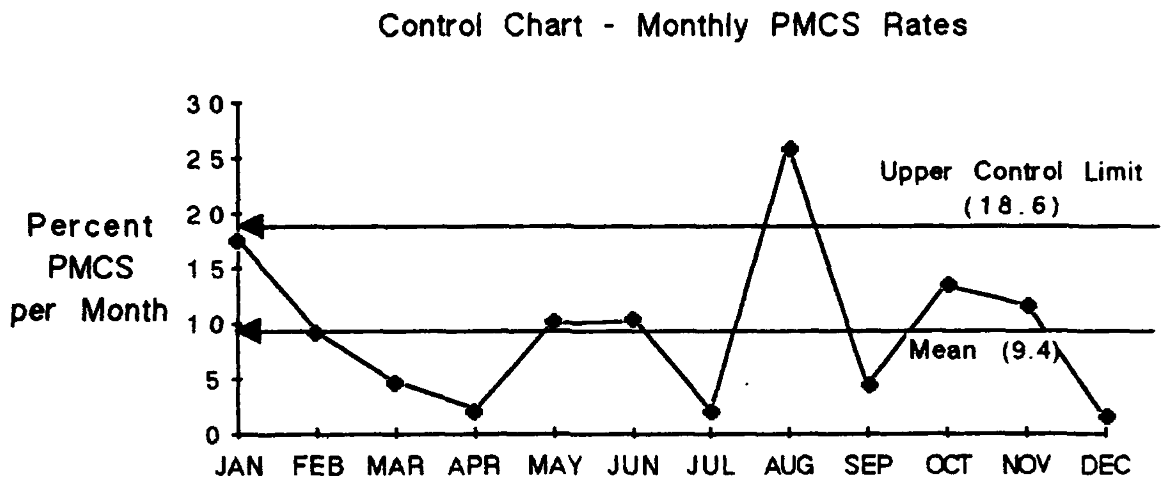


Chart 20

These control charts, Charts 17-20, have only the upper control limit lines because, similarly with FMC and MC control charts, the minimum values are not a concern. The upper control limits were calculated by the formula[22]:

UCL = mean + 3 x standard deviation

Constructing these control charts allows the TQM team to evaluate the process for the types of process causes. In each of these four control charts, there was one data point that was beyond the upper control limit line. Both NMCM and PMCM were above the line in the month of July. The team conducting the data analysis should have the expertise to identify those two points as common causes or special causes of variation. The data for these categories points to the processes as being stable[23].

Scatter Diagrams. Scatter diagram analysis of the aircraft status categories was conducted previously in the Do Phase. Other scatter diagrams will be presented later.

Analysis of Data Affecting Aircraft Status Categories.

By comparing the 4 M's on the Cause and Effect Diagram - - Manpower, Methods, Materials, and Machinery - - and the data from the 3-M Monthly Maintenance Report, it shows that the data does not contain any entries for causes in the Manpower and Materials sections. This lack of data will be addressed later. The investigation therefore will focus on the remaining two sections: Methods and Machinery. The Methods section is the equivalent of aviation maintenance processes. The Machinery section focuses on the aircraft and aircraft systems. I will first use the TQM tools to analyze the data in the methods section. Then I will do the same with the data in the machinery section.

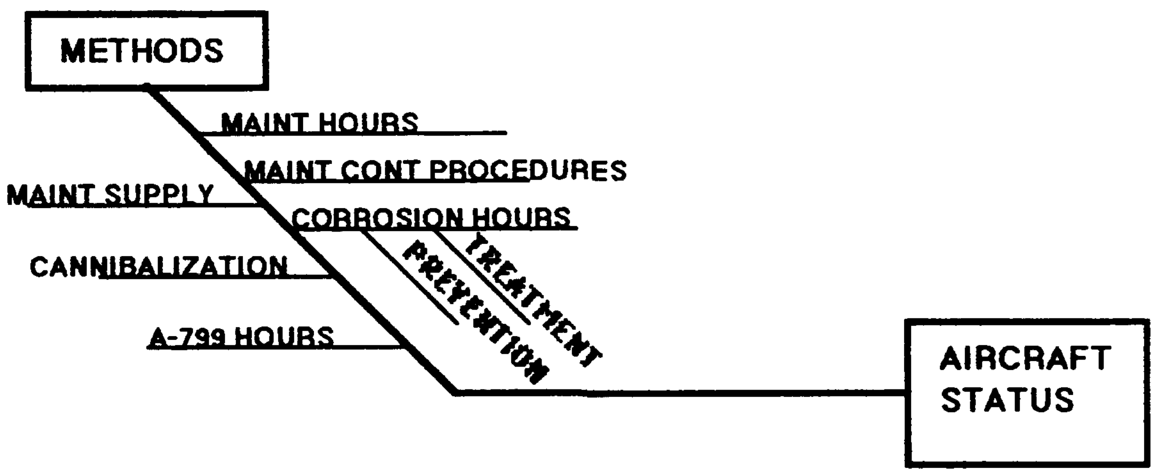


Figure 5. Methods Bone of the Cause and Effect Diagram

Analysis of the Items on the Methods Bone. The items listed in the methods section (See Figure 5.) all have run charts constructed in the 3-M Monthly Maintenance Report. (See Appendix D.) There is no need to duplicate this. I will concentrate on using scatter diagrams to discover any positive or negative correlations between FMC and these items. After that, I will use control charts to demonstrate trends and to show where common and special causes of variation exist.

Maintenance Man-hour Usage

The item "maintenance hours" is the time spent doing actual maintenance. Comparing man-hour percentages and aircraft status time in scatter diagrams will show the amount of correlation between man-hours and aircraft status. Man-hour percentage is the number of man-hours used divided by the number of man-hours available in a reporting period.[24] If man-hours show a strong positive correlation with FMC and MC time, it would indicate that the work procedures are effective and impact status hours. If the correlation is weak or possibly negative than an evaluation work processes would be in order.

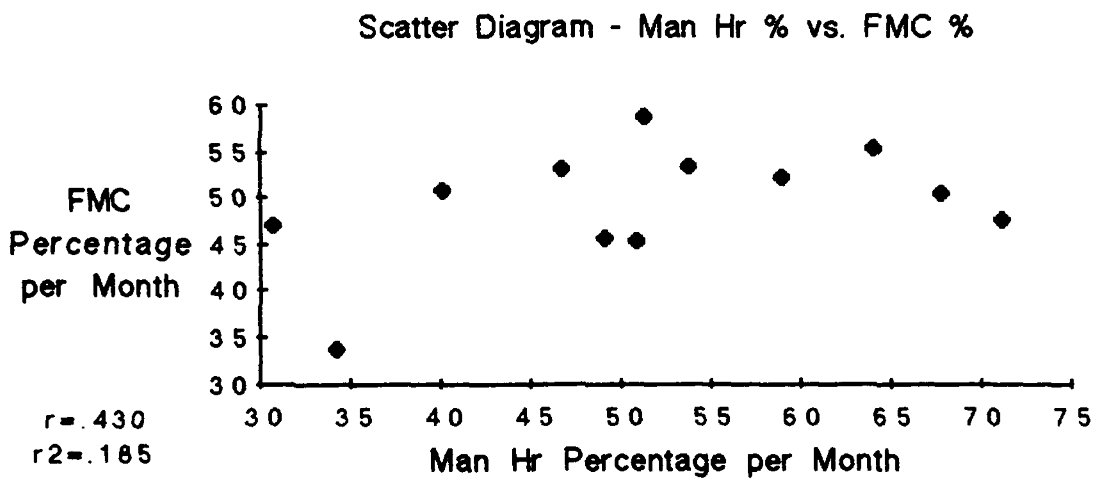


Chart 21

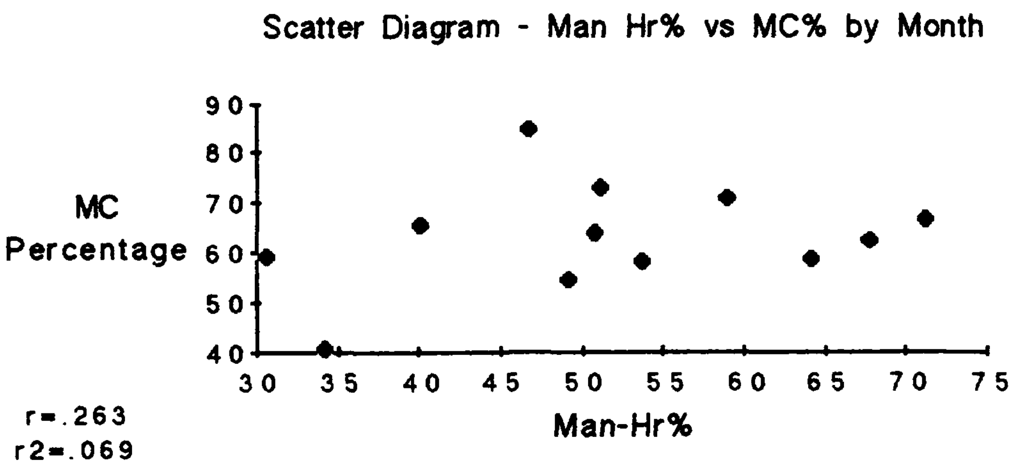


Chart 22

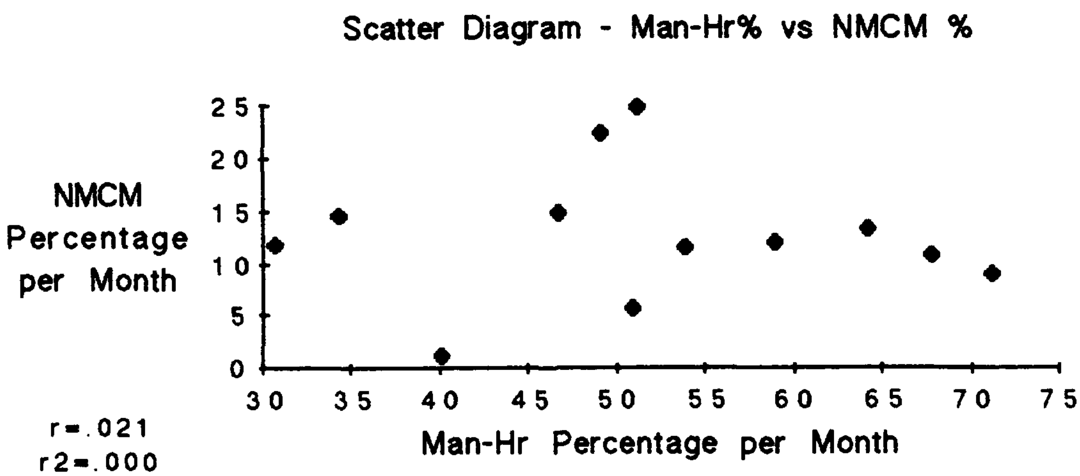


Chart 23

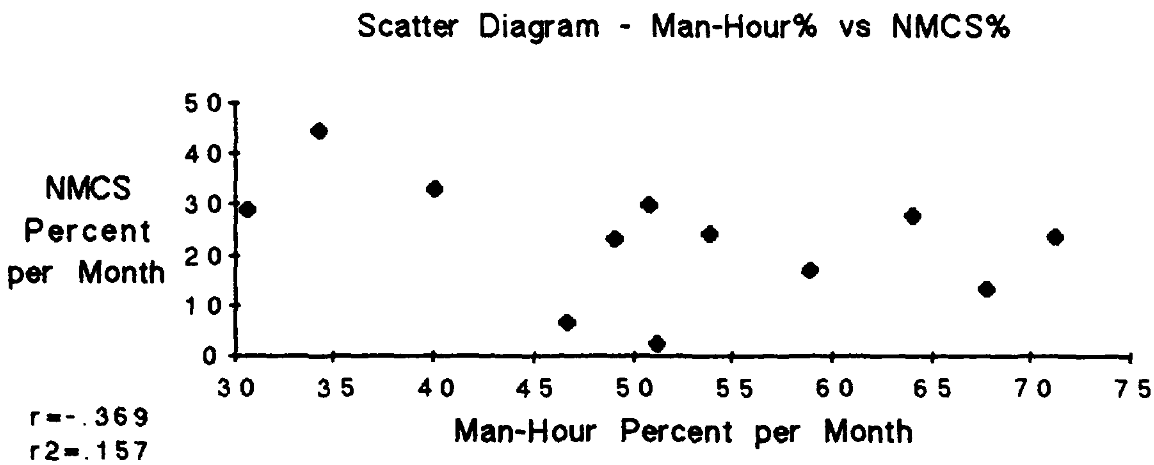


Chart 24

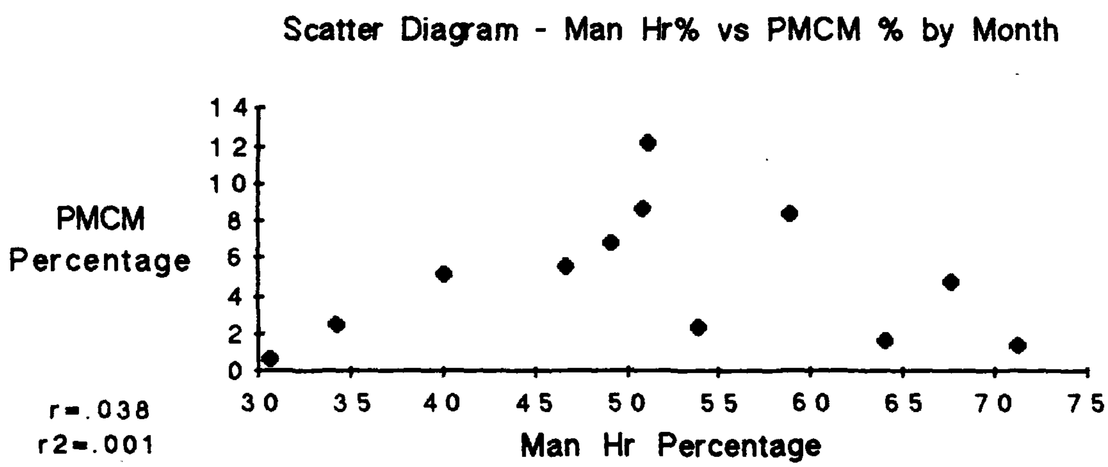


Chart 25

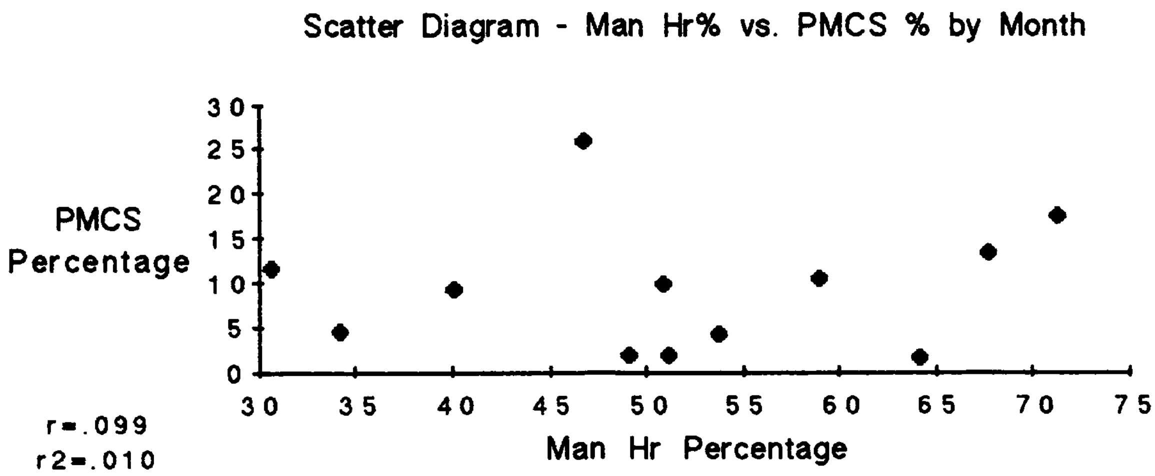


Chart 26

Of these six scatter diagrams, only the FMC (Chart 21) and NMCS (Chart 24) categories show moderate positive and lightly moderate negative correlations respectively. The proof of this is in examining the coefficients of correlation in Table 2. It makes sense that the more work done on an aircraft (a higher man-hour percentage) would correlate with higher FMC rates. The connection between NMCS percentage and man-hour percentage may be less strait forward. A possible explanation is that less work is done on an aircraft (low man-hour percentages) the more time the aircraft is awaiting parts (high NMCS percentages) These scatter diagrams and r and r^2 values show how man-hour data and aircraft status data can be analyzed to see if they are related. Constructing a table of correlation coefficients will allow a comparison of man-hour percentages and aircraft status. (See Table 2.)

Man-hour Percentage

	FMC	MC	PMCS	PMCM	NMCM	NMCS
r	.430	.263	.099	.038	.021	-.369
r^2	.185	.069	.010	.001	.000	.157

Table 2

Corrosion Maintenance.

A second area of recorded maintenance man-hour expenditure is corrosion maintenance. There are two type of corrosion maintenance; preventative and treatment. Comparison of these two categories of corrosion maintenance with FMC and MC time could establish a correlation between the two.

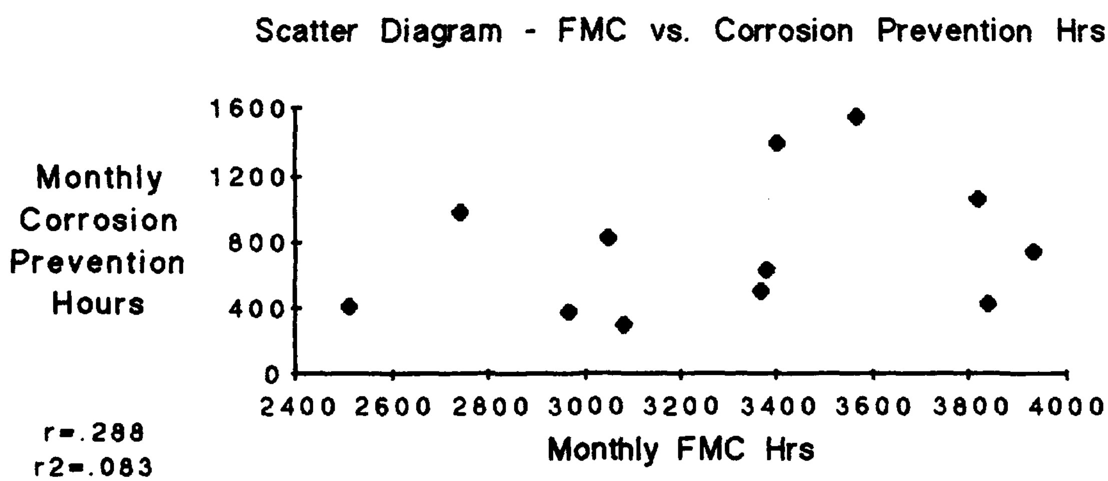


Chart 27

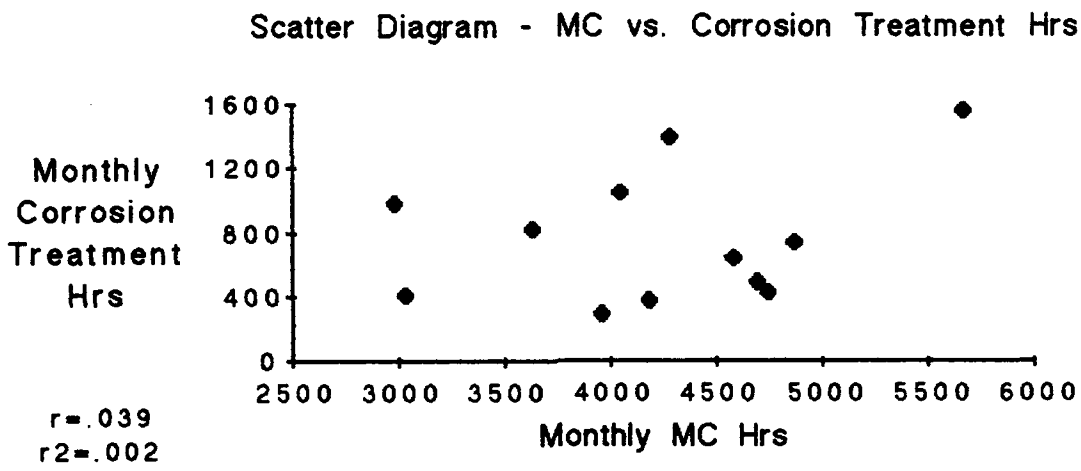


Chart 28

	Corrosion Prevention		Corrosion Treatment	
	FMC	MC	FMC	MC
r	.288	.289	.190	.039
r^2	.083	.089	.036	.002

Table 3

Table 3 shows that corrosion prevention has a mild positive correlation with both FMC and MC hours. This type of comparison could be used to show cause for a continued corrosion prevention program. Likewise, corrosion treatment showing a small correlation would indicate several things. First, that corrosion is not a major problem in the squadron because the correlation between FMC, MC and corrosion treatment is low. Second, its possible that the corrosion prevention program is good enough to remove major impact of corrosion treatment. Finally it could indicate that the corrosion is not a problem anyway.

Cannibalization

From this data, a scatter diagram can be constructed to determine if cannibalization trends affect aircraft status. These diagrams could reveal any positive or negative relationships between the cannibalization and aircraft status. Cannibalization is discouraged because of it is a catalyst for other problems. Cannibalization generally requires twice the labor as a part replacement because the part must first be removed from another aircraft. Parts may be damaged during removal or installation. Critical parts may experience multiple cannibalizations which could drastically reduce their operating life and only exacerbate the problem. Some cannibalization actions require other parts to be removed to facilitate installation. This increases problems for others systems besides the one for which the cannibalization is occurring.

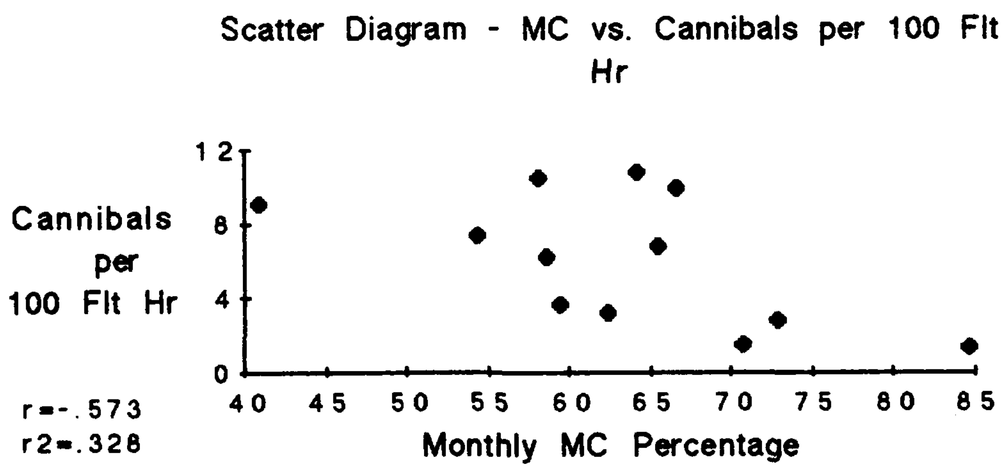


Chart 29

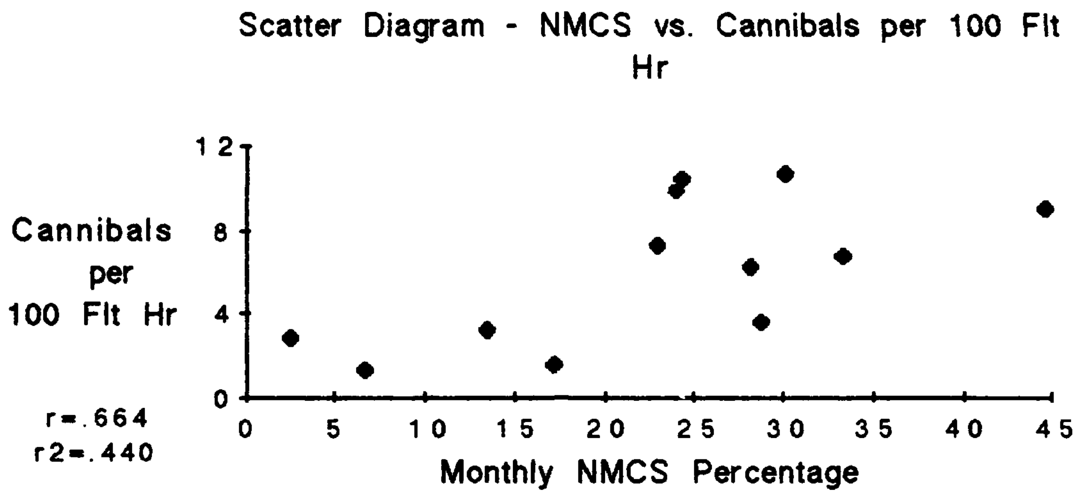


Chart 30

Cannibalization - Number of Items per 100 Flight Hours

	FMC	MC	PMCS	PMCM	NMCM	NMCS
r	-.469	-.573	-.315	-.324	-.331	.664
r^2	.220	.328	.099	.105	.110	.440

Table 4

These two scatter diagrams, charts 29 and 30, are representative of the group of scatter diagrams. They demonstrate unique relationships between cannibalization and aircraft status. Table 4 shows the values of the correlation and determination coefficients. The TQM teams working with these diagrams and the table of coefficients could be able to see the effects of cannibalization on aircraft status. Since cannibalization is a function of aviation supply and parts availability, this may have exposed an additional reason to examine the supply problems. It is important to remember that the scatter diagrams do not prove a causal relationship exists. As stated by the Department of Defense, scatter diagrams can be used to test the strength of the relationship between two variables, but it cannot be used to prove that one variable causes another.[25] It takes more study than just a scatter diagram of the process to confirm a causal relationship.

It could be helpful to construct a control chart of the cannibalization trend. This will show if the cannibalization process is operating within limits.

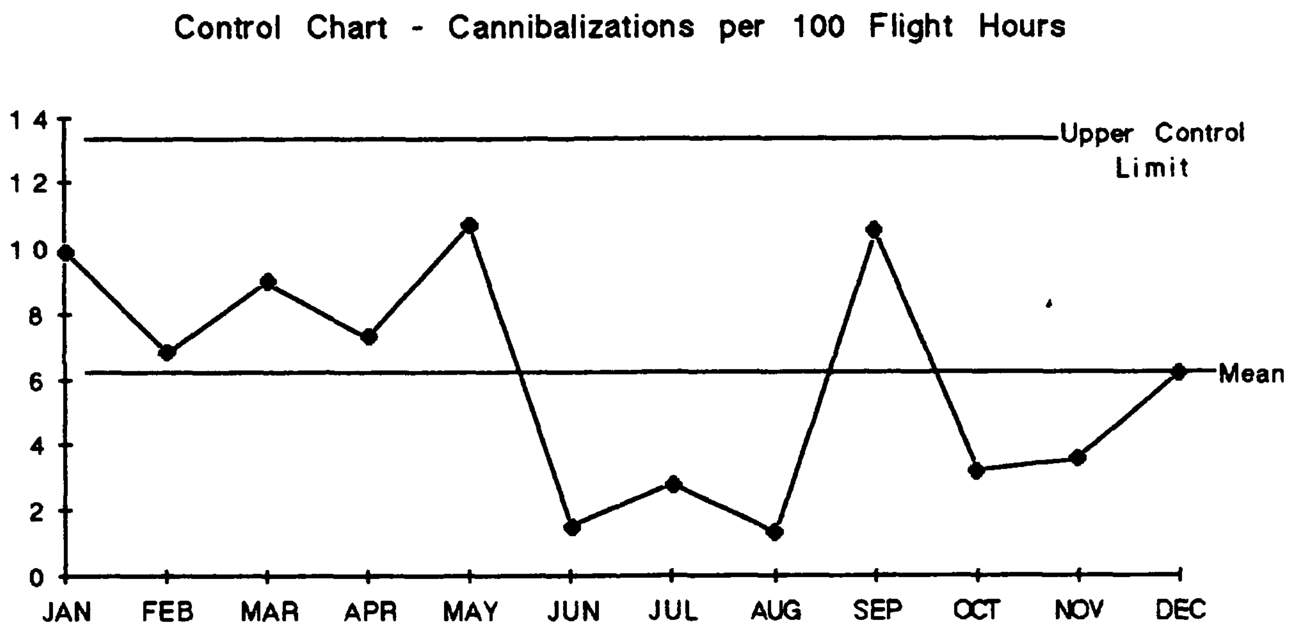


Chart 31

The upper control line was calculated using the formula from the NAMP.[26] This chart demonstrates that the system is operating with no special causes of variation influencing it. Therefore, the process variation is a function of the system design. Improvement in the systems ·nd processes that lead to cannibalization could show improvement for the squadron. This again points to the supply system as a possible place to invest effort to begin changes.

A-799 Maintenance

The A-799 maintenance time expended should be evaluated in a similar method as the cannibalization program. By constructing scatter charts of the relationship between numbers of A-799 and aircraft status categories we can see if any correlation exists. Examination of the r and r^2 data generates the following table:

r and r^2 Values for A-799 VIDS/MAFs Percentage

	FMC	MC	PMCS	PMCM	NMCM	NMCS
r	.244	-.157	.281	-.571	-.278	.247
r^2	.059	.025	.079	.326	.077	.061

Table 5

Table 5 shows that as A-799's increase the amount of NMCM and PMCM time will decrease. The largest absolute r value shows a moderate, negative correlation between A-799 and PMCM. Overall, the disparity of negative and positive values for r could tend to weaken any possible true causal relationship between A-799 and aircraft status. More data taken over several years could be used to see if these values hold up.

Control Chart - A-799 Percentage

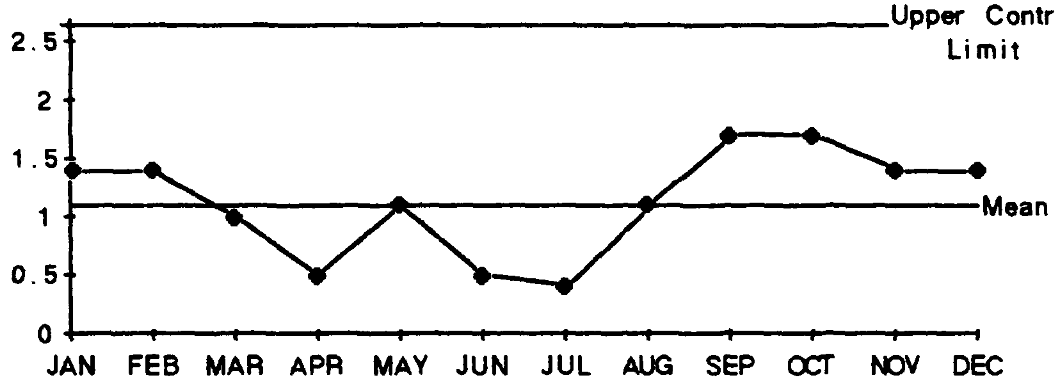


Chart 32

The upper control line was calculated using the formula from the NAMP.[27] The A-799 control chart shows a system that has been operating completely below the upper control limit. Like cannibalization, this system is not suffering from special causes of variation. Therefore, the cause of variation is designed into the process. The overall effect of A-799 levels may not effect aircraft status significantly. Therefore, this area may be not a priority for further investigation.

Man-hours Per Flight Hour

The data that was used to construct the histogram for man-hours per flight hour, Chart 14 in the previous section, can also be used to construct a control chart.

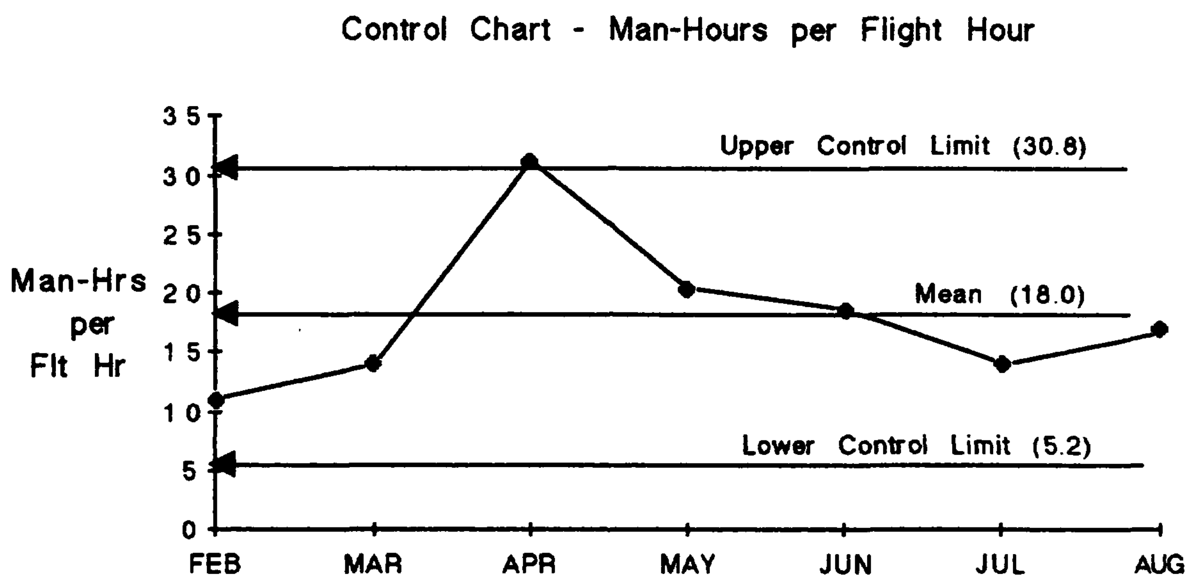


Chart 33

On this control chart, Chart 33, both upper and lower control limits were calculated. A goal may be to reduce man-hours per flight hours to a minimum and therefor not be concerned about a lower control limit line. However, experience dictates that there is a level where man-hours per flight hour becomes a safety of flight concern. The histogram of this data, Chart 14, showed a central tendency for man-hours per month. Constructing a control chart with the same data shows that the process, with the exception of one point, appears to be operating with only common causes of variance. The peak in the data occurred in the month of April. Examining the April maintenance data shows it was during this month that there was a 1600 man-hours per flight hour data point. This is the same data point that could not be displayed on the histogram of man-hours per flight hour. The cause of this large anomaly, with proper research, could be attributed to special causes of variance.[28]

Analysis of the Items on the Machinery Bone. The analysis of the machinery section will not have as many separate analyses. Identified on that section are aircraft age, system malfunctions and system high man-hour consumers.

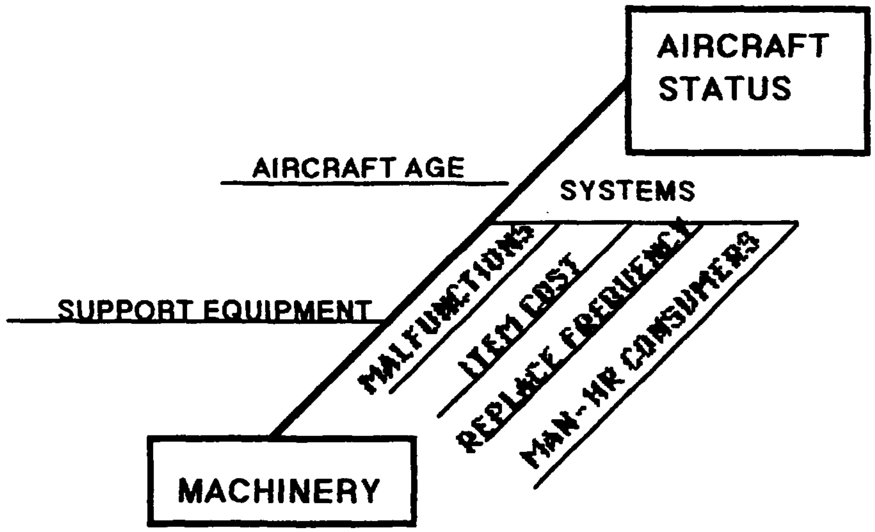


Figure 6. Cause and Effect Machinery Bone

Aircraft Age

The LAMPS community has a varied range of ages of aircraft. There is an unsupported belief in LAMPS squadrons that newer aircraft are easier to maintain and fly more than older aircraft. The aircraft can be identified as to relative age by their bureau numbers. These six digit numbers are assigned sequentially to all naval aircraft upon fleet acceptance. With this information it can be determined that four of the ten aircraft used in this investigation were manufactured in the middle 1960's. The next four were manufactured in the early 1980's. The last two with the highest bureau numbers were less than two years old at the beginning of the data reporting period.

Scatter Diagrams can be used to discern the effects of aircraft age on aircraft status. Comparing aircraft age with FMC, MC, NMCM, NMCS, PMCM, and PMCS times we may be able to judge if fleet confidence in newer aircraft is warranted. Translating the age of each aircraft to a quantitative value required using a number value to represent each aircraft. Because the exact age of each aircraft could not be determined without thorough research into their logbooks I used a rank ordered scale. I numbered the aircraft 1 through 10 from oldest to youngest. Common algebraic sense dictates that making the quantitative value between each aircraft equal allows the calculation of r to be useful. See Table 6. However, common algebraic sense also dictates that this would not be a valid method to calculate the slope of the regression line or any of its intercept points. The coefficient values for FMC and MC show strong positive correlation. Likewise, the coefficient values for NMCM and NMCS show strong negative correlation. PMCS and PMCM show very little correlation to aircraft age.

r and r^2 Values for Aircraft Age

	FMC	MC	PMCS	PMCM	NMCM	NMCS
r	.875	.812	-.117	.139	-.649	-.720
r^2	.766	.659	.014	.019	.421	.518

Table 6

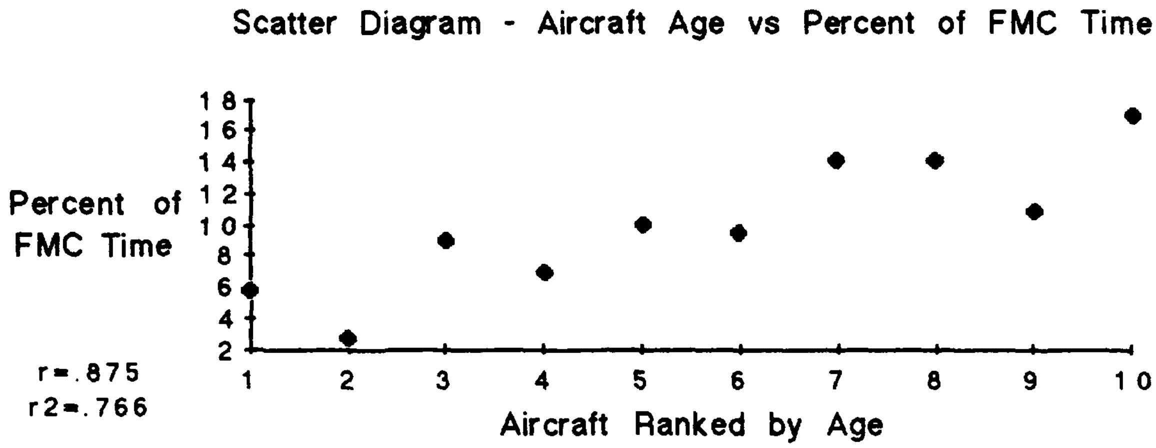


Chart 34

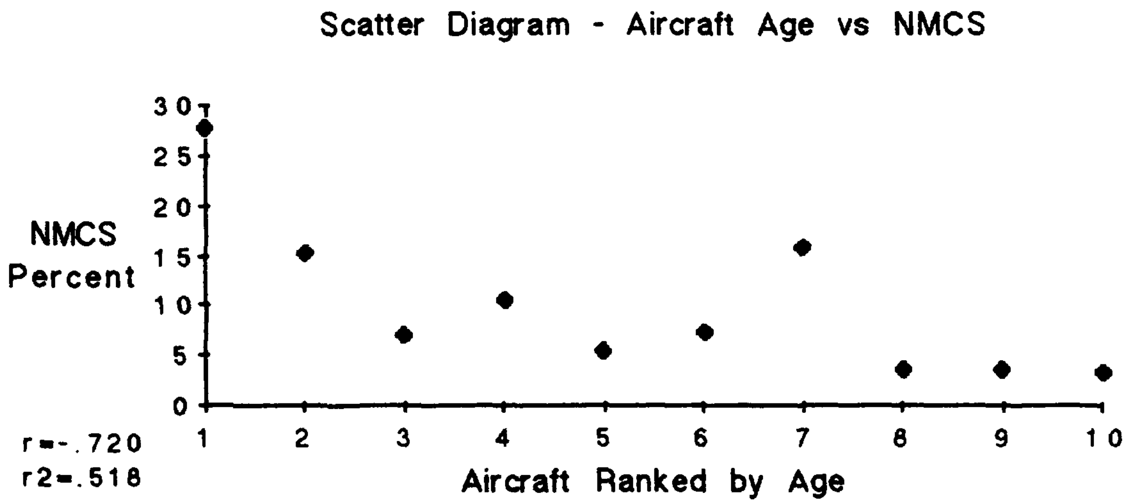


Chart 35

The table of coefficients and the scatter diagrams all indicate that there is a strong relationship between aircraft age and maintenance status.

Again, it is important to remember that the scatter diagrams only measure the strength of the relationship and do not prove a causal relationship. The relationship between aircraft age and status is an area that could require in-depth investigation to determine the existence of a causal relationship.

Aircraft Systems

The second area of discussion, from the machinery leg of the cause and effect diagram, is aircraft systems. Under the category of systems are malfunctions, man-hour consumers, system replacement frequency, and system cost. Data is presented in the monthly report that addresses malfunction type and man-hour consumers. Data for system reliability and cost is available in the MDS and supply system[29] but is not part of this data.

The monthly report lists the "High Five" entries for both categories by system: the high five occurring malfunctions and the high five man-hour consumers. A "High Five" list is also compiled for cannibalization items. Cannibalization man-hours were addressed earlier. This discussion will focus on the systems that were subject to cannibalization.

Pareto charts can be used to determine which system or systems are major contributors to the high five lists. By using a year's worth of data for the Pareto charts, it is possible to determine which systems are costing the squadron the most in terms of man-hours. It may also be possible to identify systems that are prone to failure. The following Pareto charts are constructed with this data.

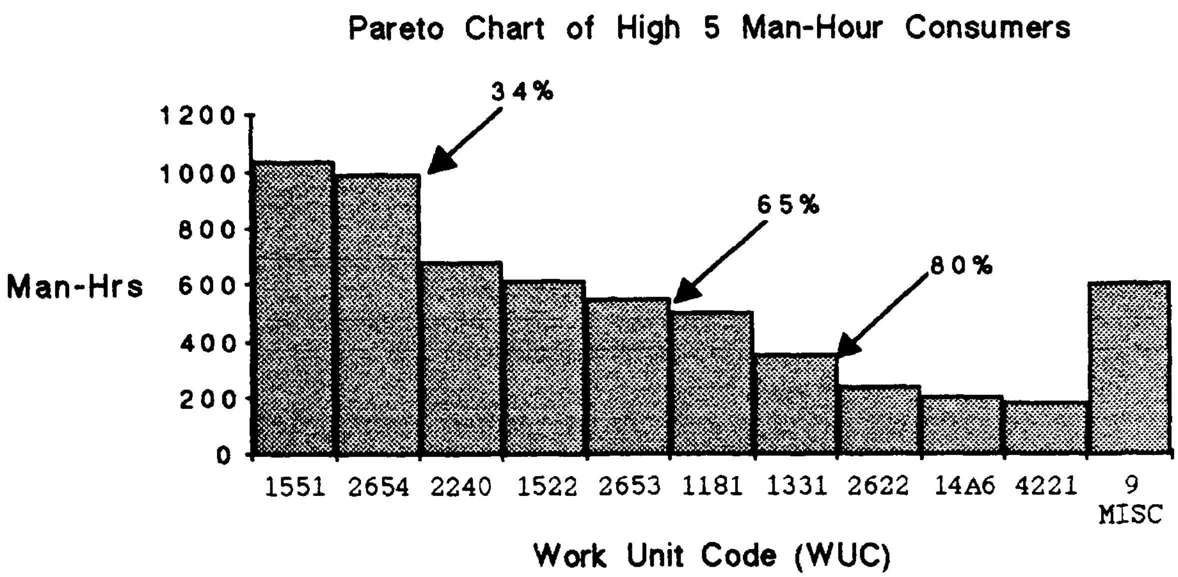


Chart 36

This Pareto chart, Chart 36, shows that there are 7 WUCs that comprise 80% percent of the man-hours consumed. There are another 12 WUCs that make up the rest of the man-hour consumers.

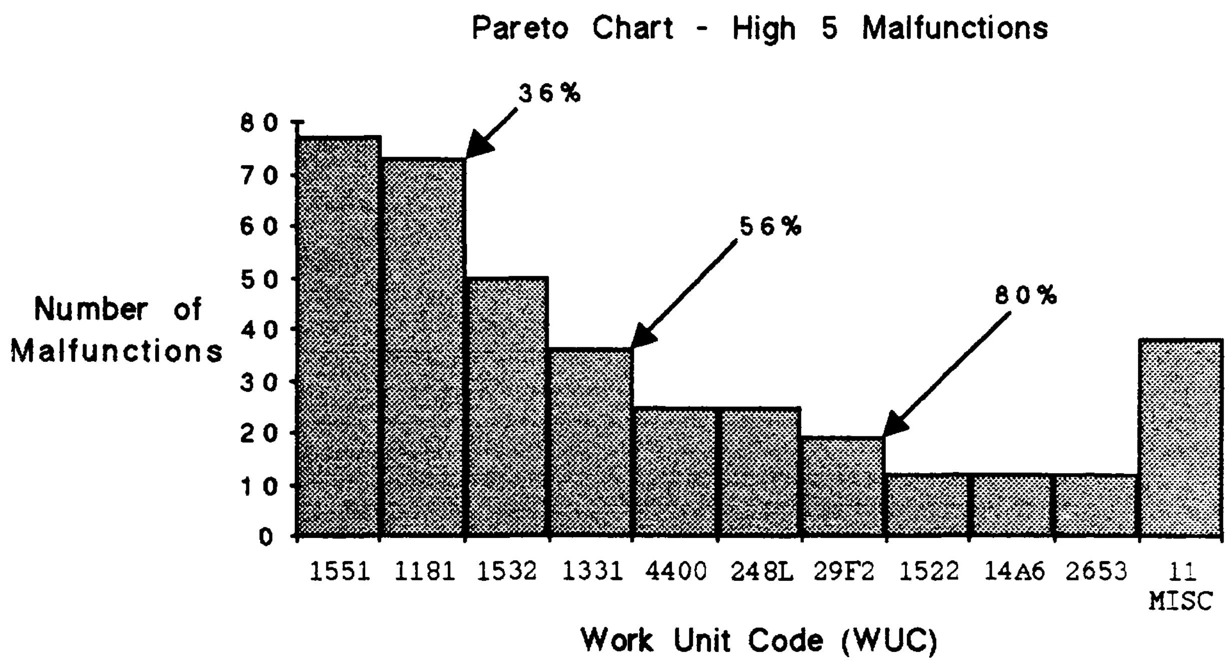


Chart 37

This Pareto Chart also shows that there are 7 WUCs that comprise 80% of the malfunctions. Fourteen other WUCs comprise the remaining 20% of the categories.

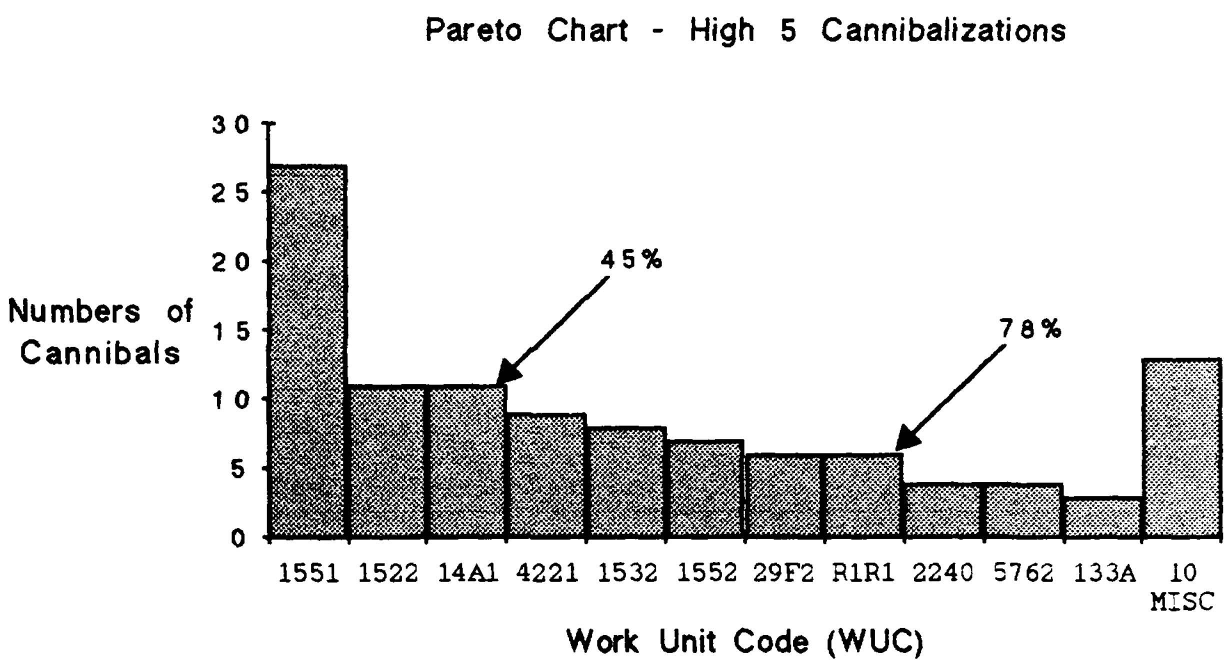


Chart 38

This Pareto chart shows that there are 8 WUCs that are responsible for 78% of the systems cannibalized. There are 13 remaining that make up the remaining 22%.

The three charts represent different facets of system problems. The "High Five" malfunction Pareto chart identifies systems that are less reliable than the others. The "High Five" man-hour consumer Pareto chart identifies systems that require more labor than the other systems. Finally, the "High Five" cannibalization Pareto chart identifies systems that are difficult to get replacements for and therefore must be cannibalized.

None of the Pareto charts appear to display a classic 80-20 relationship as discussed in Chapter Three. The charts have identified 7 or 8 WUCs that are responsible for the bulk of the problems. However, if all three charts are compared, several systems begin to stand out. One system, the main rotor assembly, WUC 1551, is at the top of all three charts. There are 5 systems that made it into at least two Pareto charts. This shows that these that made it into at least two Pareto charts. This shows that these systems are causing an inordinate share of the problems. Systems that appear in two, or all three, of the Pareto charts should be seen as less reliable, labor intensive, and in short supply. These are the systems that should receive higher command attention to resolve the problems.

Analysis of the Items on the Manpower and Materials Bones

The discussion of the analysis of the two sections, Materials and Machinery, is done together is because there is no data to analyze for either section. (See Figure 7.) The items on these two bones - - manning level, training, experience, morale level, consumables, and tools - - do not have any data recorded on them in the 3-M Monthly Maintenance Summary. (See Appendix D.)

On the Manpower section, manning level and training are tracked by the squadron, but not part of any data analysis program for maintenance.[30] These are factors that can affect the quality of aircraft maintenance and therefore affect aircraft status.

The Materials section of the Cause and Effect Diagram has a similar story. Consumables is the name for a collective group of items that are used on a daily basis. This includes the oils, grease, hydraulic fluid, cleaning fluids, paints, etc. These items may have an impact on aircraft readiness but no data in the MDS is collected on them.[31] There are other types of consumables. Items such as washers, cotter keys, safety wire, etc. can all be called hardware consumables. These items may also have an effect on aircraft status. Material failure of these items could have a crucial impact on the status of the aircraft. These items are not part of the MDS.[32] The tools that are used by the maintenance technicians can be as critical to aircraft status as the maintenance personnel.

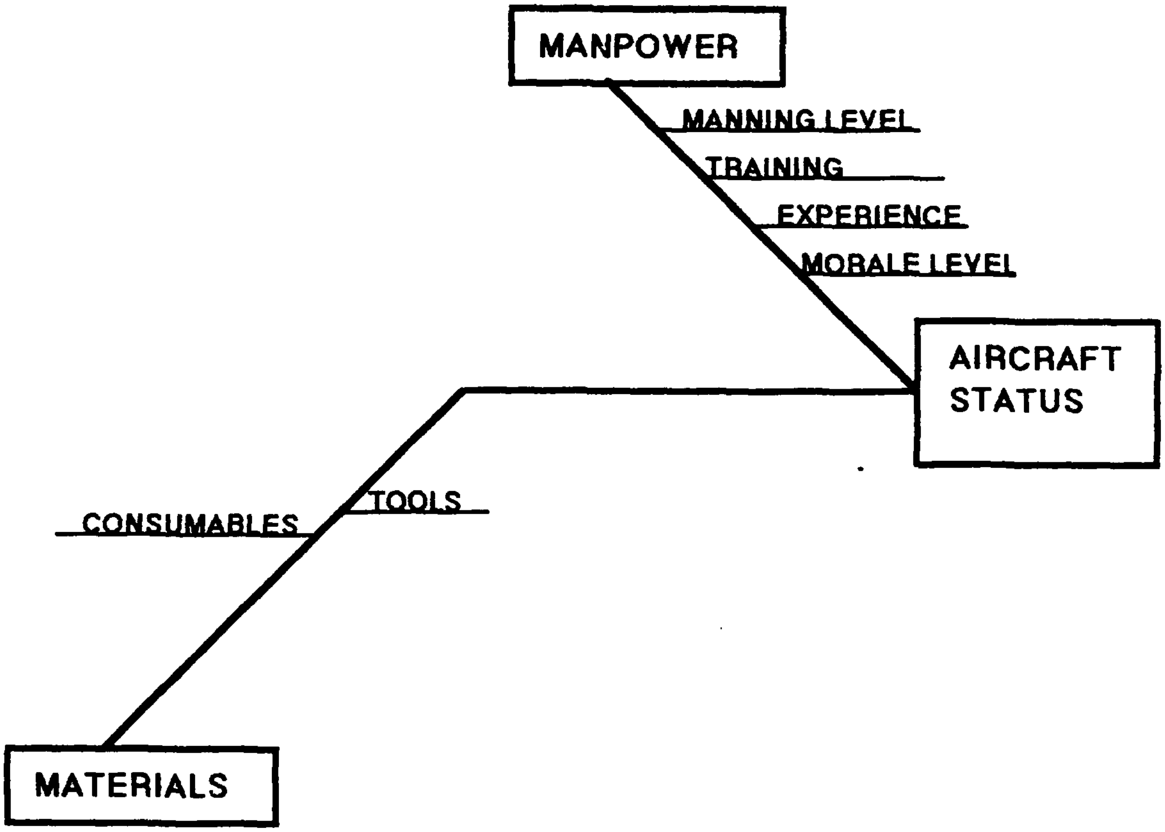


Figure 7. Cause and Effect Manpower and Materials Bone

<u>Step 2) Determine Types of Process Causes</u>.

This step is where the cause of a problem is determined to be either attributed to common causes or special causes. QMBs and PATs will determine the cause in order to approach the problem with a proper solution. This function involves interpretation of the graphic analyses constructed with the TQM analysis tools. This interpretation of the data is outside the limits of this investigation and will not be done.

[1]Navy Personnel Research and Development Center, A Total Quality Management Improvement Model (San Diego, CA: 1988), 7.

[2]Chief of Naval Operations, Naval Aviation Maintenance Procedures, OPNAVINST 4790.2E Volume V (Wash D. C. 1989).

[3]Defense Technical Information Center, Participant Guide for TQM Quantitative Methods Workshop (Alexandria, VA: Defense Logistics Agency, 1990), 4-14.

[4]Navy Personnel Research and Development Center, 9.

[5]Ibid. 10.

[6]Ibid.

[7]Kaoru Ishikawa, Guide to Quality Control. (Tokyo: Asian Productivity Organization, 1982), 18.

[8]Michael Brassard, The Memory Jogger: A Pocket Guide of Tools for Continuous Improvement (Methuen, MA: GOAL/QPC, 1988), 24

[9]Defense Technical Information Center, 4-2.

[10]Brassard, 24.

[11]Navy Personnel Research and Development Center, 18.

[12]John T. Roscoe, Fundamental Research Statistics for the Behavioral Sciences. 2nd ed. (New York: Holt, Rinehart, and Winston, Inc., 1975), 101.

[13]Navy Personnel Research and Development Center, 17.

[14]Ibid. 18.

[15]Chief of Naval Operations, OPNAVINST 4790.2E. 3-1through 3-66.

[16]Brassard, 30.

[17]Mary Walton, The Deming Management Method (New York: Dodd, Mead, 1986), 62.

[18]Navy Personnel Research and Development Center, 20.

[19]Joseph M. Juan, Quality Control Handbook (New York: McGraw-Hill Book Company, 1974), 22-6.

[20]Chief of Naval Operations, OPNAVINST 4790.2E, 4-3.

[21]Navy Personnel Research and Development Center, 20.

[22]Defense Technical Information Center, 6-26.

[23]Walton, 115.

[24]Chief of Naval Operations, OPNAVINST 4790.2E.

[25]Defense Technical Information Center, 5-49.

[26]Chief of Naval Operations, OPNAVINST 4790.2E, 4-4.

[27]Ibid.

[28]Defense Technical Information Center, 6-23.

Chief of Naval Operations, OPNAVINST 4790.2E, 3-39.

[30]Ibid.

[31]Ibid. Chap 3.

[32]Ibid.

.c. CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The overall conclusion is that the data available is not sufficient to conduct data analysis with the TQM analysis tools. Whereas the data in the 3-M Summary is useful and very applicable to the tools, it does not cover the range of areas that is needed for complete analysis.

This study addresses three areas: First, to determine if the aviation maintenance data fit well with the tools. Second to determine if the tools fit the data. The final area of this study was to develop an example for TQM analysis applications to aviation organizations.

.c2. Did the data fit the TQM analysis tools?.

The data had several areas where it was incomplete and was not sufficient to support analysis by TQM analysis tools. During the analysis in Chapter 4, there were several areas in the Ishikawa diagram that could not be analyzed. The data was not recorded in these areas. Sufficient data should include all aspects of resources and production data of the process that are measurable and identified by the TQM analysis process. The resources in this study are the aircraft, the materials, and the man power. These three correspond with three of the major areas on the Ishikawa diagram; Machinery, Materials, and Manpower. (See Figure 4.) The remaining area on the Ishikawa diagram, Methods, represents how the resources were used in the aviation maintenance processes. The production data is the data that focuses on aircraft status, particularly FMC and MC data. Aircraft status is the "effect" listed on the Ishikawa diagram.

In the initial step of the Do Phase: Identification of potential causes of quality, a flow chart and a cause and effect diagram where constructed. The construction of the flow chart did not require the use of the data provided in the 3-M Summary. However, it identified how the data is interrelated in the processes of LAMPS aviation maintenance. It creates a graphic presentation of how critical processes intermesh in the overall maintenance process.

The construction of the Ishikawa diagram was crucial in identification of the potential causes quality for the maintenance processes. The data categories reported in the 3-M Summary assisted in nominating items for the secondary bones of the "fishbone diagram." By using the suggested major categories of Manpower, Methods, Materials, and Machinery[1], it is possible to address many areas of concern of the maintenance processes.

The construction of the Ishikawa diagram shows many areas in aviation maintenance that affect aircraft status. By comparing the items on the Ishikawa diagram with the data from the 3-M Summary it became obvious that the 3-M Summary does not include all the data it should. The following areas were not included in the 3-M Summary: manning level, personnel training, personnel experience, morale level, maintenance control, maintenance supply, consumables, tools, and support equipment.

It was stated in Chapter 4 that there was no data for either the manpower leg or the materials leg. These two legs account for most of the areas that have no data to support them. The focus of this data is strongly slanted to the collection of data on physical hardware. The data is very weak in areas that involve measurements outside this realm.

Data on certain items of the manpower leg are available in the squadron. The maintenance manning level is watched very closely by the squadron and the wing. Navy-wide decreased manning causes all commands to closely monitor and track their fair share allowance of personnel. The manning level could have a strong impact on maintenance production. In the detachment environment, manning is even more critical. For the implementation of TQM this data should be used in analysis of the data from the organization.

The 3-M Summary does not contain data for two areas from the Manpower section: personnel training and experience. These two areas, though not the same, may be grouped together under the heading of expertise. The level of expertise in the Maintenance Department could effect aircraft maintenance quality and therefore aircraft status. Whereas it could require data to determine which area, personnel training or experience, would have more effect on aircraft status, it is not possible to determine it now from the data available from the MDS.[2]

The final area under the Manpower leg is morale level. The effects of personal attitudes and morale in the work place are difficult to measure. Like the other aspects of the Manpower leg they are not covered by the MDS.[3] The level of morale may be a by product when other organizational aspects are going well. Examining Deming's 14 points (See Appendix A) reveals that many of his ideas could improve morale in the work place.

The Materials leg of the Ishikawa diagram did not have any data from the MDS for analysis with TQM tools. Materials in a LAMPS squadron are oil, grease, common nuts and bolts, cleaning fluids, paint, etc. These items are lumped together in a group called consumables. The nature of the impact of consumables is largely unknown. There are no provisions in the MDS to collect any data that would address characteristics of these materials[4]. This is an area where the team conducting the TQM analysis could concentrate effort to decide to what extent they will evaluate the effects of materials.

Data for tools was also not included in the MDS.[5] The tools used in aviation maintenance could be as important as the people. The correct tools in proper working condition can directly affect aircraft status. The effect of this area will not be measured by the current system. The data for one item of the machinery leg, support equipment, also was not available. This area, like tools could have an impact on aircraft status.

Specific aircraft are included as part of the format for data collection in the NAMP.[6] Therefore, most aspects of the data as it dealt with individual aircraft were available in the 3-M Summary. Much of the aircraft system data is reported through SCIR reports in the NAMP.[7] The replacement data and man-hour data for the different systems are completely documented by the MDS[8]. The 3-M Summary report does not include system costs. However, in the present fiscal environment it would seem inconceivable that this information is not tracked. This data is recorded by several commands in the administrative chain of command and in the aviation supply system and is available at the squadron. System replacement frequency, while not presented in the 3-M Summary is available at the squadron through the MDS[9]. This data would be more useful at aviation engineering facilities than at the squadron. In the operational environment, the cost of a part is not considered when replacements are required. It is at the purchasing and designing levels were this cost is important.

Using the Ishikawa diagram as meter to identify aviation data requirements has shown that there are many areas on the Ishikawa diagram that do not have data to support them in the 3-M Summary. Therefore, the data is lacking in the range of categories it addresses. For this reason, the data is not sufficient for complete TQM data analysis. The categories that are lacking are areas that could represent major impacts on aircraft status. However, without data to support or refute this statement, the actual effects of these areas cannot be measured. Use of the Ishikawa diagram has shown that the data used by

LAMPS squadrons to evaluate maintenance is not sufficient in range of categories to conduct analysis with the tools of TQM.

The categories of Manpower and Materials had no data represented in the 3-M Summary. The Maintenance Data System is focused on the collection of data directly involved with equipment maintainability, reliability, capability, and utilization.[10] By design, the MDS does not collect data on manpower categories. However, complete data is critical to thorough analysis of the potential causes of maintenance quality. The effect of these areas on the aviation maintenance processes cannot be determined without the input of information from these areas.

Did the TQM analysis tools fit the data?.

The TQM analysis tools used in this investigation worked well with the data from the squadron. The data used by HSL-37 in the monthly 3-M Summary is applicable to the TQM process evaluation. Analysis of the data revealed quantifiable levels of maintenance processes and trends. The evidence of this is found in the Check Phase of the Shewart cycle.

The majority of the analysis occurred in the "collect and analyze data" step. In this step the items identified on the Ishikawa diagram were analyzed with the TQM analysis tools. The data and the tools were able to graphically portray quantifiable levels of maintenance productivity. The type of data collected for the 3-M Summary is well organized. Scatter diagrams, Pareto charts, run charts, control charts and a histogram were constructed, used and interpreted.

The organized format of the data allowed for maximum use of scatter diagrams. It was possible to demonstrate data relationships between FMC and MC and most all the other categories of data entries. The Pearson correlation coefficient, r, and the coefficient of determination, r^2, were easily calculated and could be used to measure relative effects on other variables. These scatter diagrams could be where the start of further investigation could begin to identify the causes of quality in the organization. The squadron could use this information as the basis for an investigation into actual cause and effect relationships. This is an important aspect of improving the level of quality in a process. Scatter diagrams can be used to show if a change made to the system results in a change in outcome.[11]

Pareto charts require that one set of data be nominal data.[12] Therefore the use of Pareto charts was limited to only a few situations. However, in these situations, it was valuable. The three Pareto Charts show that the main rotor system is in the top spot for all three measurements of subsystem malfunctions: frequency, man-hours, and number of cannibalizations. This may be a new information to personnel in the field of aviation maintenance. Pareto charts also provided proof that supply problems accounted for a large portion of aircraft status problems. With this information, the squadron could request additional support from its chain of command for assistance in this area. The squadron could be able to prove that its isolated geographic location (Hawaii) may be affecting its supply channels.

The use of run charts in naval aviation maintenance is common in the NAMP.[13] However, despite explanations of control charts in the NAMP,[14] the current use and understanding of control charts is at a much lower level. Deming says that a properly understood control chart "is a guide to constant improvement."[15] In this data, this critical data analysis tool was not used. (See Appendix D.) In this study, control charts were used to demonstrate the possible existence special and common causes of variation in many of the maintenance processes.

The data from aviation maintenance processes is not as easily used for the construction of histograms as much as the other TQM analysis tools. As previously stated much of the data from aviation maintenance represents areas where maximums or minimums are the goals. This data is well suited to the other analysis tools. Histograms show the nature of variation around a central value.[16] Nonetheless, a histogram proved valuable in the graphic presentation of man-hour per flight hour figures. Histograms should be used for analysis of this data where they are applicable.

The data that is available from the MDS fits the TQM analysis tools quite well. Much of its strength may lie in its organization. The data was easy to manipulate with computer assistance for construction of many charts and diagrams.

The third goal was to develop an example of how the TQM analysis tools could be used to analyze aviation maintenance data. This investigation has been successful in this area. It was able to demonstrate the use of the tools with different areas of aviation maintenance data. This study could not have addressed all the uses of all the tools with all the data. However, it has shown how the tools can be used to relate data to aircraft readiness. Following this example could assist a squadron maintenance department in its own data analysis.

Recommendations

The recommendations of this study will be directed to improving the Naval Aviation Maintenance Program, the NAMP, and expanding data collection procedures. The NAMP Chapter 4, Maintenance Data System Analysis, is the guide for aviation data analysis.[17] This chapter should be rewritten to include where and when to use TQM data analysis tools and procedures. The NAMP is the source for aviation maintenance procedures and guidelines. Incorporating the TQM analysis tools and techniques into an existing chapter on data analysis would make the transition to the use of these tools smoother. However, the NAMP is not the best location for an in-depth explanation of the TQM analysis tools.

There will be many people who will possibly use the analysis tools that are not in aviation maintenance. A separate instruction for TQM data analysis tools could be written to explain the correct use of the tools. The NAMP would be responsible for directing specific applications of the tools.

This opens the door for a subject of further study. Follow on investigations could involve the rewriting of the NAMP, vol V, Chapter 4, to include the proper application of TQM analysis tools.

A conclusion of this study is that the collection of data required for use in TQM analysis of aviation maintenance data is incomplete. The analysis showed that there is no data on maintenance personnel, support equipment, tools, and consumables. Personal experience suggests that the effect of maintenance personnel is the first of these four areas to concentrate on. Having lead detachments with great maintenance experience and detachments with little maintenance experience has shown me that people make the largest difference. This is also, in many ways, the crux of TQM. Examining Deming's 14 Points shows that a majority are oriented on dealing with people.[18] Therefore, if the Navy is going to evaluate fully the maintenance process, its need to determine a method for measuring the impact of the personnel on aviation maintenance.

To gather baseline data could begin as simply as comparing similar squadrons by readiness and maintenance personnel variables. The maintenance personnel variables could include time in service, actual time in maintenance positions, time in current aircraft maintenance, and level of formal maintenance training. It would be possible to convert most of these categories into numerical values by measuring the time in years. For example, the number of years the person has in the Navy, plus the number of years in maintenance positions, plus the number of years in current aircraft could be added to calculate a maintenance experience number. To add emphasis to one category in favor of another, any one of these categories could be weighted. Using this data, squadrons could be compared on the basis of personnel experience and aircraft readiness status. Detachments of a single squadron could be compared to determine if a correlation existed between personnel experience and readiness. To include formal maintenance personnel training into this analysis could be done by assigning a numerical value to each level of formal maintenance training attended.

This is an area of furthe. study that could prove to be valuable to the fleet. If a study determined that maintenance personnel experience affected aircraft readiness then training of personnel could be improved to attempt to develop experience in the classroom.

Another recommendation is that those using the analytical tools be well trained in the uses of the analytical tools. Deming recommends that everyone using the analysis tools be trained by an instructor with a minimum a master's degree in statistics or extensive work experience.[19] For this reason this study can only serve as an example of how to use the tools. Competent training should be provided for everyone responsible for any amount data analysis.

A recommendation for the Navy from this study is to improve process data collection. Successful TQM is a way of communicating factual information within a functional team of workers. The reliability of the information, or data, that the teams depend on will directly affect the success of the changes they recommend. The old phrase, "Garbage in. . garbage out," will have strong meaning when working with TQM analysis tools. The conclusions and recommendations derived from data analysis can be no better than the information used for the basis their development.

Personnel using the TQM analysis tools should be well versed in their uses, and just as importantly, of their limitations. For example, a scatter diagram may be interpreted differently by different individuals. Even the interpretation of the value of the coefficients of correlation and determination could be different. It is important that the personnel analyzing the data be knowledgeable in the proper use of the analysis tools. A second example is the calculation of lower and upper control lines for control charts. As stated in Chapter 3, there are many different methods to calculate the limit lines. The methods used depend on the situation and the type of data represented. Using an incorrect method could hide the existence of special causes of variation or, conversely, indicate the existence of special causes of variation where none exist. Either of these could cause problems in the organization's quest for improvement.

There is ample room for the application of basic computer data analysis software programs to assist in the development and analysis of aviation maintenance data. The charts presented in this study were all constructed from a basic spreadsheet software application. Readily available, existing software for data analysis could be used as a convenient tool to enhance maintenance data analysis. These programs can be used to generate run charts, control charts, scatter diagrams, and Pareto charts. Simple computer calculations can also be used to determine coefficients of correlation and determination for scatter diagrams. This is basic technology that should be exploited to it fullest.

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[1]Michael Brassard, The Memory Jogger: A Pocket Guide of Tools for Continuous Improvement, (Methuen, MA: GOAL/QPC, 1988), 24.

[2]Chief of Naval Operations, Naval Aviation Maintenance Procedures, OPNAVINST 4790.2E Volume V, (Wash D. C. 1989), chap 3.

[3]Chief of Naval Operations, Naval Aviation Maintenance Procedures, OPNAVINST 4790.2E Volume V, (Wash D. C. 1989), chap 2.

[4]Ibid.

[5]Ibid.

[6] Chief of Naval Operations, OPNAVINST 4790.2E, chap 2.

[7] Ibid. 3-39, 3-48.

[8] Ibid. chap 2.

[9] Ibid. 3-39.

[10] Chief of Naval Operations, OPNAVINST 4790.2E, 2-1.

[11] Navy Personnel Research and Development Center, 20.

[12] Navy Personnel Research and Development Center, 19.

[13] Chief of Naval Operations, OPNAVINST 4790.2E, chap 4.

[14] Chief of Naval Operations, OPNAVINST 4790.2E, 4-3.

[15] Mary Walton, The Deming Management Method (New York: Dodd, Mead, 1986), 113.

[16] Hitoshi Kume, Statistical Methods for Quality Improvement, (Tokyo: 3A Corporation, 1989), 38.

[17] Chief of Naval Operations, OPNAVINST 4790.2E, 4-1.

[18] Walton, 113.

[19] Ibid. 97.

APPENDIX A: TQM Points, Deadly Diseases, and Obstacles

The 14 points

1. Create a constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs

2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.

6. Institute training on the job.

7. Institute leadership (Points 8 and 12). The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial

relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.

12a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual or merit rating and of management by objective.

13. Institute a vigorous program of education and self-improvement.

14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

The Deadly Diseases

1. Lack of constancy of purpose to plan product and service that will have a market and keep the company in business, and provide jobs.

2. Emphasis on short-term profits: short-term thinking (just the opposite from constancy of purpose to stay in business), fed by fear of unfriendly takeover, and by push from bankers and owners for dividends.

3. Evaluation of performance, merit rating, or annual review.

4. Mobility of management; job hopping.

5. Management by use only of visible figures, with little or no consideration of figures that are unknown or unknowable.

6. Excessive Medical costs

7. Excessive costs of liability, swelled by lawyers that work on contingency fee.

<u>Obstacles</u>

There are many obstacles identified by Dr. Deming. The obstacles are similar to the deadly diseases, but are problems that are easier to cure than the deadly diseases. Obstacles are characterized as attitudes, institutional prejudices, and beliefs that interfere with transformation of the system. Some of the more pertinent ones are mentioned here.

- Hope for instant pudding.

- The supposition that solving problems, automation, gadgets, and new machinery will transform industry.

- "Our problems are different."

- Poor teaching of statistical methods in industry.

- "Our troubles lie entirely in the work force."

- The supposition that it is only necessary to meet specifications.

- "Anyone that comes to try to help us must understand all about our business."

Appendix B: LAMPS Mk I Squadron Primer

The LAMPS Squadron.

LAMPS helicopter squadrons are officially called Helicopter Anti-Submarine-Light (HSL) Squadrons. The mission of the squadron is to deploy mission ready LAMPS detachments in support of maritime operations. There are two types of LAMPS squadrons: LAMPS MK I, flying the older SH-2F Seasprite and LAMPS MK III, flying the newer SH-60B Seahawk. Their roles and missions are very similar. I will orient my discussion towards the LAMPS MK I, but, as previously stated, there would be few changes in concepts for LAMPS MK III squadrons. The squadron mission is to deploy LAMPS detachments in frigates, destroyers, and cruisers to support these ships in the execution of their missions. These ships may be operating independently, in concert with other ships, or with a complete carrier battlegroup. Almost all operational flying is conducted by detachments while assigned to ships. However, approximately one third of the flying is conducted ashore at the squadron. These flights consist of training, aircrew proficiency, and support for other commands. LAMPS primary mission is anti-submarine warfare. There are also a number of secondary missions which LAMPS helicopters perform: Surface Ship Surveillance and Control (SSSC), Over-the-Horizon Targeting (OTH-T), Search and Rescue (SAR), Logistics/Vertical Replenishment (VERTREP), Naval Gunfire Spotting (NGFS), and Utility Missions. Other missions areas such as Counter Narcotics Surveillance and Anti-Mine Warfare have recently been added to the previous list of secondary missions. During a deployment, a LAMPS detachment is expected to be proficient at its primary mission and all of its secondary missions.

LAMPS detachments.

A LAMPS detachment consists of one helicopter and the aircrew and maintenance personnel required to operate the helicopter. With only one helicopter it is critical to the success of the detachment and the supported surface ships to maintain the highest readiness possible. HSL squadrons, when fully supported, will have the manpower and maintenance equipment to deploy 10 detachments. Normally a squadron will only have 80 to 90 per cent of their authorized allowances on hand to complete their tasking. At any one time a squadron may have as many as seven detachments deployed.

A detachment is normally established in the squadron at least 6 months or more before its scheduled deployment date. All mission and maintenance requirements for aircrew and maintenance personnel are to be completed in this time period. The mission and maintenance requirements are established at the functional wing and squadron levels to cover all aspects of readiness for the detachment.

A deployment may last anywhere from 3 to 8 months. The ship may be in company with a carrier battlegroup (CVBG), surface ships only, (Surface Action Group, SAG), or engaged in independent operations. There may be many days in port or only a few.

Detachment Manning.

HSL dets consist of 4 officers, 1 chief petty officer (CPO, E-7/8), and typically 12 enlisted men (E-2 through E-6). The Officer in Charge (OIC), is normally a senior lieutenant (LT, O-3) or a junior lieutenant commander (LCDR, O-4). The other officers will be LT's and/or lieutenants junior grade (LTJG, O-2).

The OIC will be on his second or third sea tour and normally have completed at least one previous LAMPS cruise. He was most likely the detachment maintenance officer on one of these cruises. His most recent tour may vary the entire range of possibilities. He may have been flying LAMPS aircraft on sea or shore duty, or have come from a non-flying billet. At this point in his career the typical OIC has had very little formal leadership training. His leadership and management style is most likely a compilation of his experiences.

The other three officers are all normally first tour pilots and fill the following billets: maintenance officer, operations officer, and administration officer. The maintenance officer will have been on at least one other deployment, but the other two pilots normally have little or no cruise experience.

Detachments are manned with two full aircrews. An aircrew consists of one Helicopter Aircraft Commander (HAC), one Helicopter 2nd Pilot (H2P), and one aircrewman (AW). The aircrewman an E-3 to E-6 and is the operator for most of the mission related equipment. The OIC and the maintenance officer are normally HAC's. The Operations Officer and Administration Officer are H2P's. The two HAC's will also have earned the designation as Functional Check Flight (FCF) Pilots. This designation permits the pilots to be the aircraft commander for post maintenance check flights where additional aviation and maintenance expertise in the aircraft is required.

The detachment CPO is a key position. His job is to direct the maintenance effort to keep the detachment's aircraft in working condition. He is the expert on all aviation maintenance matters and is the "Foreman" of the detachment. Typically chief petty officers have a LAMPS background and are well versed in the maintenance requirements of LAMPS detachment operations. The CPO sets the standards for quality in maintenance and maintenance data verification. The accuracy of aviation maintenance data input to the system will directly impact the reliability of the data and its analysis.

The 12 enlisted men comprise the entire maintenance effort for the detachment. The senior enlisted man is normally selected for the position as Leading Petty Officer. He may be from any of the five maintenance rates required on a LAMPS detachment. The five aviation maintenance rates - - Aviation Machinist Mate, AD; Aviation Structural Mechanic, AM; Aviation Electrician, AE; Aviation Anti-Submarine Warfare Equipment Technician, AX; and Aviation Maintenance Yeoman, AZ- - are represented by nine of the enlisted men. The remaining two enlisted men have the rating of Helicopter Aircrewmen, AW(H). They operate the inflight mission equipment and are also trained as rescue swimmers. They can be used for some routine maintenance functions but do not fulfill a dedicated maintenance position.

AIRCREW:

2 Helicopter Aircraft Commanders (HAC): O-3 or O-4

2 Helicopter 2nd Pilots (H2P): O-2 or O-3

2 Aircrewmen (AW): E-3 to E-6

MAINT CREW:

1 CPO: E7-E8, may be of any of 4 rates AD, AE, AMH, AX

1 LPO: E-6, may be of any of 6 rates AD, AE, AM, AX, AW, AZ

2 Engine mechanics (AD): E-2 to E-6

2 Metalsmiths (AM): E-2 to E-6

2 Electricians (AE): E-2 to E-6

2 Mission Equipment Technicians: E-2 to E-6

1 Aviation Maintenance Yeoman: E-4 to E-6

Maintenance Proficiency Designations.

There are two levels of maintenance proficiency that may be achieved by the maintenance workers: Collateral Duty Inspector (CDI) and Quality Assurance

Representative (QAR). The title of Quality Assurance Representative is not related to TQM. The qualification as QAR is strictly a level of capability based on maintenance expertise and experience. CDI's and QAR's both inspect maintenance performed by other workers to insure correct procedures have been followed. To be designated as a CDI, a maintenance worker must have completed the proper Personal Qualification Standard (PQS) book and a written examination. To become a QAR requires the maintenance man to be a qualified CDI, complete the PQS book for QAR, pass a written examination, and pass an oral board. CDI's inspect maintenance tasks required for normal maintenance operations, but not critical for safety of flight items. QAR's inspect items that are critical to safety of flight. A complex maintenance evolution may have many steps or phases that require CDI or QAR inspection. A typical detachment may have 3 or 4 personnel qualified as CDI's and 1 or 2 qualified as QAR's. Normally the senior man in each rate is a CDI and the LPO and CPO are QAR's.

Before each flight a qualified plane captain is required to perform a Daily or Turn Around Inspection. Daily or Turn Around Inspections are checks to insure the aircraft is safe for flight. To be designated a plane captain requires completion of the appropriate PQS book, a written examination, and an oral board. A maintenance worker's designation as plane captain is normally the first step in designation as a CDI and QAR. However, there is no requirement to be designated a plane captain before becoming a CDI or QAR.

Appendix C: Maintenance Data System Reports

NAVFLIRS-1. Monthly Aircraft Utilization Report. This report summarizes, by bureau/serial number, total mission requirement (TMR) hours with mission name, shipboard and field landings, total flight hours and flights, and total shipboard flight hours and flights.

NAVFLIRS-2. Monthly Aircraft Mission Report. This report summarizes, by TMR, the number of missions, hours flown, and the average duration in each mission category.

NAVFLIRS-3. Monthly Individual Flight Activity Report. This report details, by individual, the specific flight activity performed during the period.

NAVFLIRS-4. Monthly Aircraft Logistics Data Report. This report summarizes the flight hours, distance, confirmed/opportune payloads, and configuration data for each aircraft by bureau number.

MDR-2. Monthly Production Report. This report provides maintenance work center supervisors with statistical data pertaining to his work center. It will provide data on the following:

- Troublesome subsystems indicated by a large number of repeat discrepancies by bureau number

- Man-hours for each subsystem

- Possible lack of training or test equipment indicated by the numbers A-799s or cannibalization actions for a subsystem.

- Days/man-hours required to complete a joo.

- Repetitive parts problems for a given subsystem

- Efficiency of inspection procedures evaluated by comparing when discovered code totals to total numbers of discrepancies.

MDR-3. Job Control Number Consolidation (JCN) Report. JCN consolidation reports all maintenance and technical directive compliance for the month. This report allows supervisory personnel to have a comprehensive record of all maintenance performed their maintenance. This report includes identification of:

- The components worked on.

- The maintenance performed.

- Description of the malfunction

- Man-hours used

- Failed parts

- Date of job origination and completion by job control number.

- Defects found in parts removed for rework.

- Items removed for rework without sufficient cause (no defect found at rework facility).

MDR-4-1. Technical Directive Compliance Report. Used to track Technical Directives (TD) compliance by:

- TD identification

- Aircraft Bureau/Serial Number

- Man-hours used in TD compliance

- Work centers involved in TD compliance

MDR-4-2. Intermediate Technical Directive Compliance Report. Only concerns maintenance facilities above the level of a squadron.

MDR-5. Maintenance Action by Bureau/Serial Number Report. Consolidates maintenance action to provide a history of maintenance action by bureau/serial number in man-hours. Typical uses include identification of cost in man-hours for scheduled and unscheduled maintenance to support a single aircraft or aircraft subsystem or identification of troublesome systems or subsystems by tallying numbers of discrepancies.

MDR-6 Maintenance Action by System and Component Report. This report is used to:

- Identify troublesome systems/components indicated by excessive man-hours or numbers of discrepancies.

- Determine the cost in man-hours for a system or components.

- Identify repeat failure items to establish cause of failures, ie. maintenance, structural, or design.

MDR-7. Component Repair/Beyond Capability of Maintenance Report. Used at maintenance levels above the squadron.

MDR-8. Failed Parts/Parts Required Report. Used to identify:

- Total number of parts used in repair

- Parts that have experienced high awaiting parts time.

MDR-9. Repair Cycle Data Report. Used at maintenance levels above the squadron.

MDR-10. Foreign Object Damage (FOD) Report. Used to measure maintenance effort in man-hours, components replaced, and or components condemned attributable to FOD.

MDR-11 Corrosion Control/Treatment Report. Records man-hours spent on corrective corrosion treatment. Indicates success of corrosion prevention program.

MDR-12 No Defect Report. Records the maintenance expended where there is no malfunction. It identifies:

- Numbers of malfunctions that were either non-existent or could not be duplicated.

- Man-hours used in cannibalization.

- Man-hours used in removing and installing items with no malfunction to facilitate other maintenance.

- Items removed and installed due to scheduled removal or scheduled maintenance.

- Items removed and installed for TD compliance.

- Items removed as part of a matched system.

MDR-13. When Malfunction Was Discovered Report. Shows the maintenance action taken by category of each when discovered code. Used to determine:

- How many abort malfunctions were caused by mechanical failures, what caused them, if they were discovered before or during flight, and whether they could have been eliminated by better inspections.

- The identification of items processed and man-hours expended for an acceptance check evolution.

- The number of malfunctions discovered during functional check flights.

SCIR-3 Monthly Equipment Discrepancy and Utilization Report. This report is designed to show, by bureau number, the total number discrepancy hours limiting the equipment from performing its assigned mission or function.

SCIR-4. Monthly Equipment Capability Report. This report is designed to reflect equipment capability to perform its assigned mission.

SCIR-5-1. Monthly Equipment Mission Capability Summary Report. This report displays SCIR hours by mission category and awaiting maintenance (AWM) hours by reason codes for a given WUC.

SCIR-5-2. Monthly Equipment Mission Capability Bureau/Serial Summary Report. This report displays SCIR hours by mission category and awaiting maintenance (AWM) hours by reason codes for a given bureau/serial number.

SCIR-5-3. Monthly Mission and Maintenance Data Detail by Bureau/Serial Report. This report shows the mission capability and maintenance data for each VIDS/MAF for given WUC and bureau/serial number.

Appendix D: Data

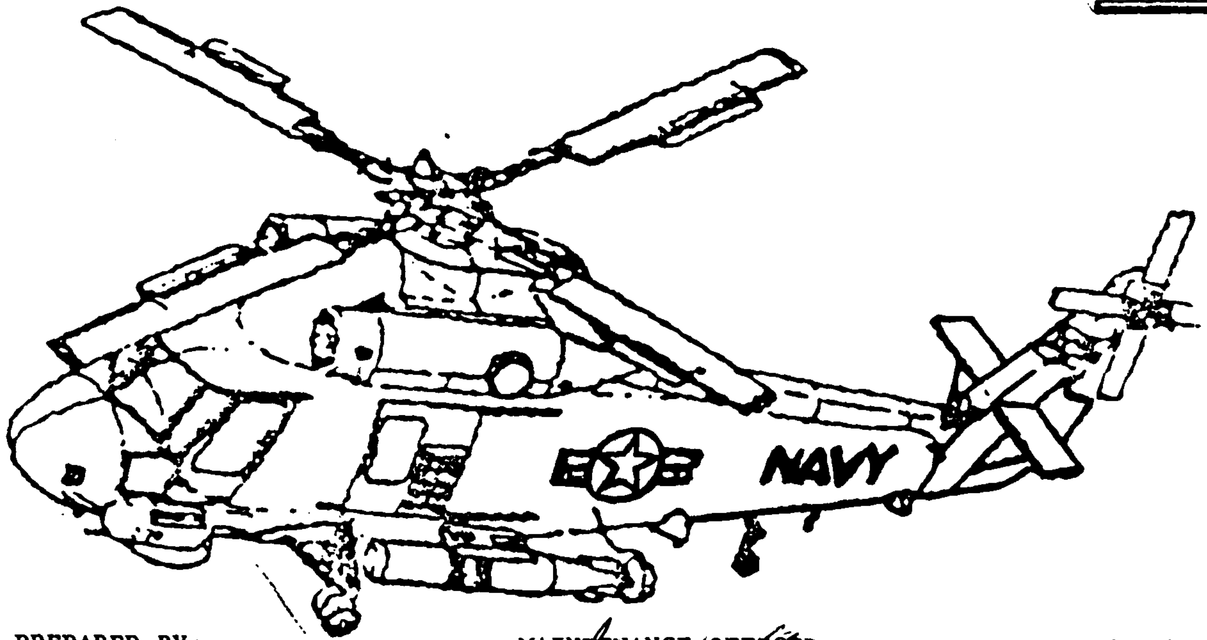
The following pages include a copy of the 3-M Summary from August 1991. The pages of tabular data are summarizations of categories of data from the period studied, September 1990 to August 1991.

In-depth scrutiny of the data has revealed that it has minor, but obvious, errors. There are repeated data entries from one month to another of phenomena that are too improbable to happen same way two months in a row. There are occurrences of numbers that have been obviously transposed from one column to another column. In actual application of the tools of TQM the accuracy of the data is extremely important. Errant data could lead to errant decisions made on identification of problems and their solutions.

3-M SUMMARY

HELANTISUBRON LIGHT THREE SEVEN

AUGUST 1991



PREPARED BY:
A. L. MCCARTNEY
AZ2 USN

MAINTENANCE OFFICER:
R. M. DRUFFEL
LCDR USN

COMMANDING OFFICER:
for D. C. TAYLOR
CDR USN

MONTH: AUGUST 1991

1. HSL-37 SHORE BASED AT NAS BARBERS PT HI REPORTING 9.0 AIRCRAFT.

2. OVERALL SQUADRON MISSION CAPABILITY 84.6 UP 11.8% FROM JULY AND FULL MISSION CAPABILITY 53.2 DOWN 5.6% FROM JULY.

3. TOTAL AVERAGE AIRCRAFT 8.8, AIRCRAFT UTILIZATION FOR AUGUST 91 69.0% .

4. CANNIBALIZATION RATE FOR JULY 91 WAS 5.2 MANHOURS PER FLIGHT HOUR AND 1.3 ITEMS PER 100 F.T. HOURS.

5. HSL-37 PERFORMED 714.8 HOURS OF CORROSION PREVENTION, DOWN 113.7 HRS AND 1559.4 HOURS OF CORROSION TREATMENT, UP 856.3 HRS FROM JULY.

6. DETS 6 LATE IN MAIL.

MONTH : AUGUST 19[illegible]

DISTRIBUTION OF HOURS IN RRS BY BUREAU NUMBER

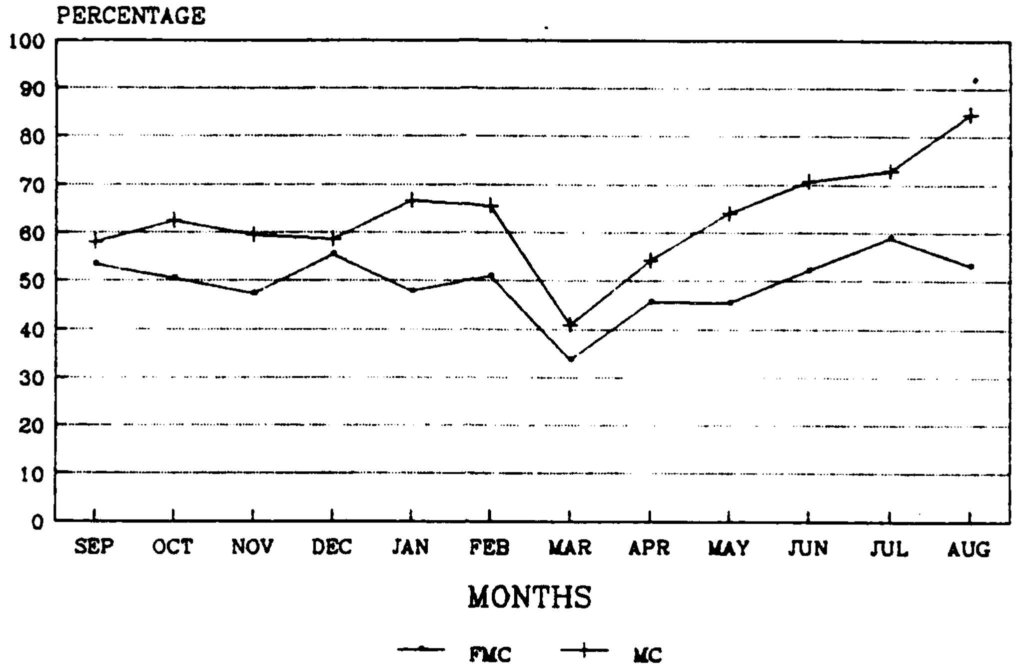
BUREAU NUMBER	HRS RRS	HRS MC	HRS FMC	NMCM-S	NMCM-U	NMCS	PMCM	PMCS	FLT HRS	FLTS
149766	744.0	0.0	0.0	0.0	744.0	0.0	0.0	0.0	0.0	0
150157	744.0	744.0	744.0	0.0	0.0	0.0	0.0	0.0	97.5	46
150158	744.0	720.0	648.0	0.0	24.0	0.0	72.0	0.0	89.5	49
150169	744.0	626.0	437.0	0.0	78.0	40.0	183.0	6.0	71.9	38
161906	744.0	706.8	0.0	0.0	37.2	0.0	98.8	608.0	60.1	26
161908	744.0	734.0	113.0	0.0	10.0	0.0	4.0	17.0	90.0	39
161645	744.0	743.0	743.0	0.0	1.0	0.0	0.0	0.0	42.8	18
162582	744.0	654.7	554.7	0.0	89.3	0.0	0.0	0.0	75.6	39
163211	744.0	734.0	22[illegible].0	0.0	5.0	5.0	8.0	502.0	85.6	34
TOTAL	6696.0	5662.5	356[illegible].7	0.0	938.5	45.0	365.8	1733.0	607.0	201
PERCENT		84.6	53.2	0.0	14.9	0.3	5.5	25.9		

SOURCE: SCIR-3
NAVFLIRS
R & T.

REMARKS:

AIRCRAFT READINESS HISTORY

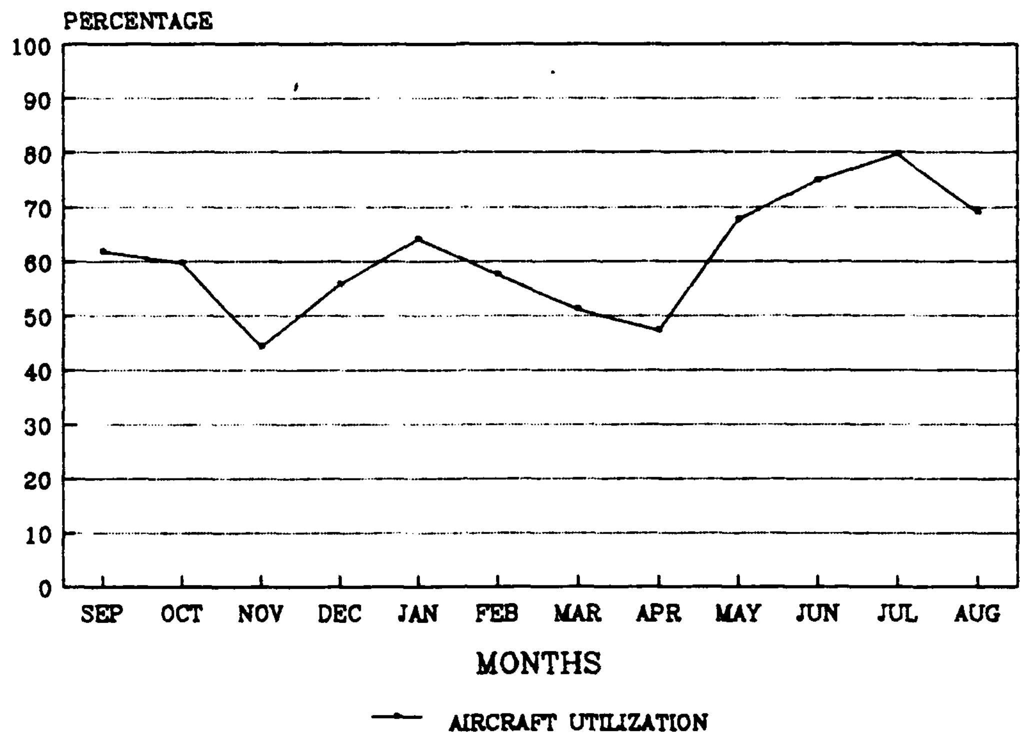
MISSION/FULL MISSION CAPABLE %



MONTH	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
MC	[illegible]	[illegible]	59.4	58.6	66.6	65.5	[illegible]	54.3	64.1	70.7	72.3	84.6
FMC	53.3	50.5	47.2	55.4	47.8	50.9	33.7	45.7	45.4	52.2	58.8	53.2
NMCM-S	[illegible]	[illegible]	0.0	0.6	0.3	0.0	[illegible]	2.4	0.0	[illegible]	[illegible]	0.0
NMCM-U	11.5	[illegible]	11.8	13.2	9.1	1.3	14.5	22.3	5.6	12.1	14.3	14.8
NMCS	24.3	13.5	28.9	28.1	24.0	33.3	44.6	23.0	30.1	17.2	2.5	6.7
PMCM	2.4	4.7	0.7	1.7	1.3	[illegible]	2.5	[illegible]	9.6	8.3	12.1	5.5
PMCS	4.4	17.4	11.6	1.5	17.5	9.2	4.6	2.0	10.0	10.4	1.9	25.9

SOURCE: SCI9-3

AIRCRAFT UTILIZATION



MONTH	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
AC UTIL.	61.8	59.6	44.2	55.6	64.0	57.5	51.0	47.2	67.7	74.9	79.8	69.0
TOTAL FLT HRS.	506.6	608.3	442.4	517.2	608.4	517.9	500.8	439.2	504.8	573.3	717.8	607.0
TOTAL FLIGHTS	267	311	203	244	273	255	239	201	224	288	322	201
AVG NO AC	9.2	10.2	10.0	9.3	9.5	9.0	10.3	9.3	8.0	9.0	9.0	8.8

SOURCE: 3CIR-3
NAVFLIRS-1

MONTH: AUGUST 1991

AIRCRAFT MAINTENANCE DATA

HIGH FIVE A-799 (NO DEFECT) ITEMS:

WUC	NOMENCLATURE	ITEMS
42821	AC/DC POWER AIRCRAFT WIRING	1
155[illegible]20	PITCH CONTROL BEAM ASSEMBLY	1
42000	ELEC PWR SPLY/DISTR/LIGHTING SYS	1
62X10	VHF COMMUNICATIONS ASSOC. EQUIPMENT	1
71Y943C	WIRING RELATED CMPNT	1

HIGH FIVE CANNABILIZATION ITEMS:

WUC	NOMENCLATURE	ITEMS	MHRS
14A4132	LATERAL SERIES BOOST ACTUATOR	1	17.0
13391	PARKING BRAKE CONTROL ASS.	1	6.2
15516	MAIN ROTOR DAMPER ASS.	1	6.0
5762110	VERTICAL GYROSCOPE	1	3.6
15322	BLADE TRACK ACCELEROMETER	1	3.4

HIGH FIVE MANHOUR CONSUMERS:

WUC	NOMENCLATURE	ITEMS	MHRS
26221	GEARBOX	1	76.4
29E25	BELLMOUTH ASSEMBLY	1	72.0
22400	T-55 ENGINE	1	67.5
1181950	CABIN FLOOR/COPILOTS LWR DOOR TRACKS	2	67.2
26224	LUBE SCAVENGE PUMP	2	61.0

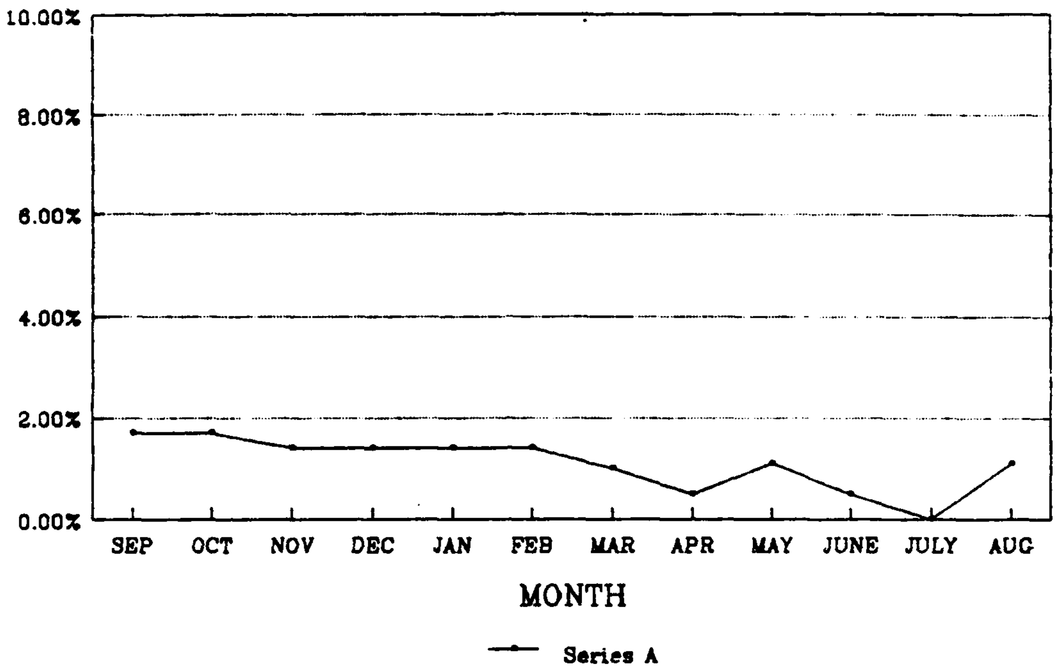
HIGH FIVE MALFUNCTION:

WUC	NOMENCLATURE	ITEMS	MHRS
13315	WHEEL/TIRE ASSEMBLY	7	60.2
651E400	LN66HP RECEIVER/TRANSMITTER	5	29.8
1551F	FOLDING PIN CAP	5	12.3
1E51Y00	FLAP ASSEMBLY	4	22.3
1131PB0	CABIN FLOOR/COPILOTS DOOR TRACKS	4	50.6

SOURCE: MDR-12
MDR-6

A–799 TREND CHART

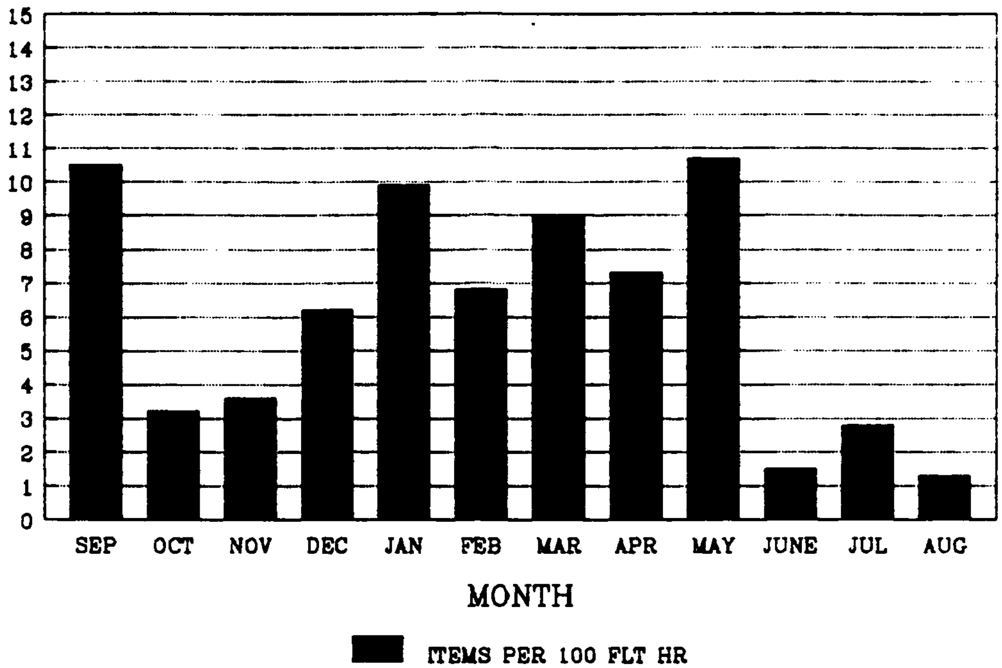
% PERCENTAGE %



MONTH	ITEMS PROCESS	TOTAL A-799 ITEMS	PERCENTAGE
SEPTEMBER	793	14	1.7%
OCTOBER	799	14	1.7%
NOVEMBER	659	9	1.4%
DECEMBER	1527	22	1.4%
JANUARY	1238	17	1.4%
FEBRUARY	79[illegible]	11	1.4%
MARCH	858	9	1.0%
APRIL	1699	9	0.5%
MAY	964	11	1.1%
JUNE	1280	7	0.5%
JULY	1422	7	0.01%
AUGUST	1308	14	1.1%

SOURCE: MDR-12
MDR-2

CANNIBALIZATION TREND CHART
ITEMS PER 100 FLIGHT HOURS



MONTH	ITEMS CANN.	FLIGHT HOURS	TOTAL MAN HOURS	MANHOURS PER ITEM	ITEMS PER 100 FLIGHT HOURS
SEPTEMBER	53	506.6	449.7	8.5	10.5
OCTOBER	20	608.3	103.8	5.2	3.3
NOVEMBER	16	442.1	126.3	7.9	3.6
DECEMBER	32	517.2	225.4	7.0	6.2
JANUARY	60	608.4	629.5	10.5	9.9
FEBRUARY	37	554.7	277.9	7.5	6.8
MARCH	45	500.8	239.3	5.3	9.0
APRIL	32	439.2	150.4	4.7	7.3
MAY	54	504.9	1090.9	20.2	10.7
JUNE	10	677.5	181.0	18.1	1.5
JULY	20	717.8	146.3	7.3	2.8
AUGUST	27	607.0	41.9	5.2	[illegible]

LIST OF ITEMS

SOURCE: MDR-12

MONTH: AUGUST 1991

CORROSION PREVENTION & TREATMENT REPORT

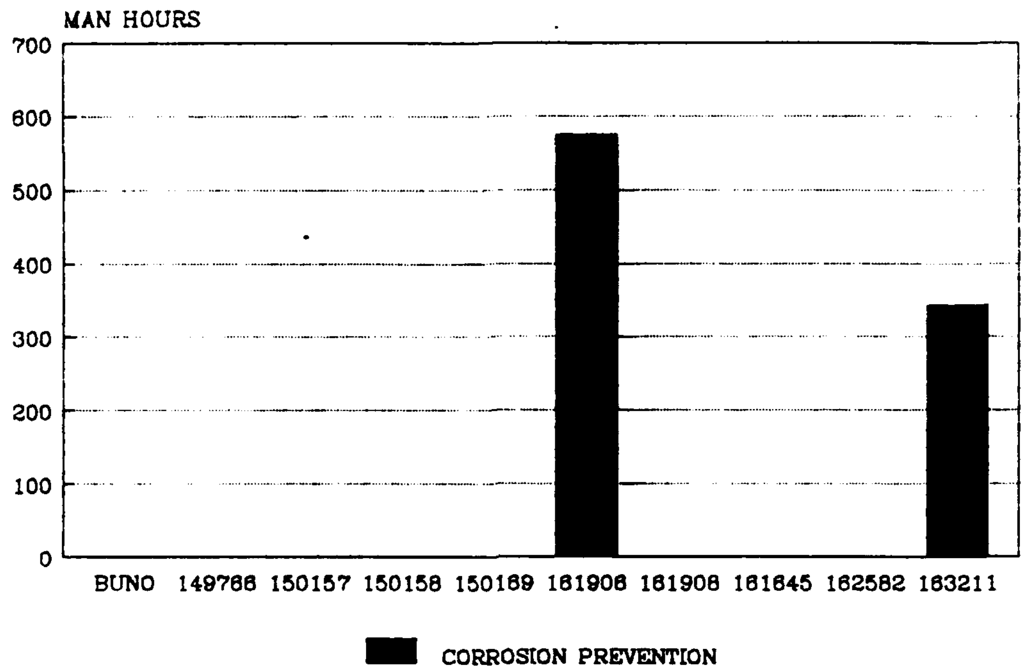
BUNO	SAF/MAF ITEMS	SAF/MAF MHRS	MAT ITEMS	MAT MHRS
149766	[illegible]	[illegible]	[illegible]	[illegible]
150157	[illegible]	[illegible]	[illegible]	[illegible]
150158	0	[illegible]	14	44.9
150169	0	0.0	8	[illegible]
161906	32	374.0	49	[illegible]
161908	0	0.0	50	143.2
161645	0	0.0	96	356.7
162582	0	0.0	0	0.0
163211	26	342.8	170	403.9
TOTALS:	60	916.8	389	1559.4

SOURCE: MDR-11

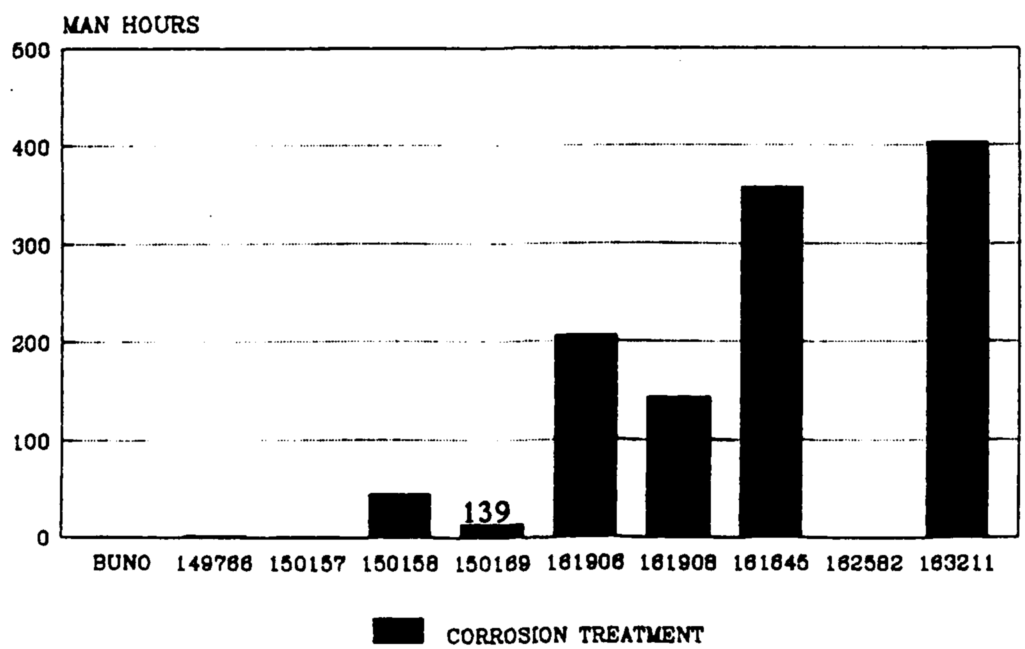
REMARKS: DETS 6 LATE IN MAIL.

CORROSION CONTROL CHARTS

PREVENTION



TREATMENT



SOURCE: MDR-11

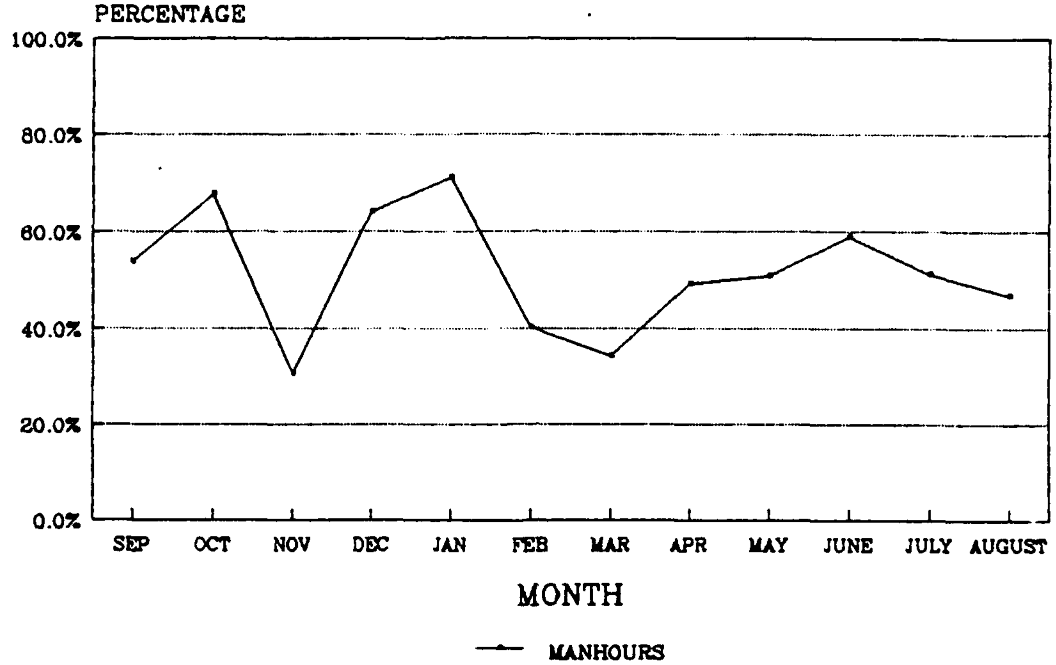
MAINTENANCE MAN-HOURS BY BUREAU NUMBER

BUREAU NUMBER	FLIGHT HOURS	TRANS/ ACCEPT	SPECIAL INSPECT	PHASE/CALENDAR INSPECTION LOOK	FIX	COND INSP.	UNSCH MAINT	TDC	OTHER	TOTAL	MMH/FH
149766	0.0	0.0	63.4	0.0	0.0	0.0	136.3	0.0	0.0	199.7	0.0
150157	87.5	0.0	[illegible]	0.0	0.0	16.0	409.9	0.0	481.3	1120.2	12.8
150158	89.5	0.0	264.5	213.7	22.4	0.0	265.8	0.0	492.3	1258.7	14.1
150169	71.9	0.0	258.9	0.0	0.0	5.0	415.[illegible]	0.0	395.5	1074.5	14.9
161906	60.1	0.0	907.4	118.1	11.6	7.0	288.[illegible]	0.0	330.6	1655.9	27.6
161908	90.0	0.0	422.7	247.0	34.6	0.0	492.4	0.0	495.0	1681.7	18.7
161645	42.8	0.0	487.5	159.0	3.0	0.0	16.3	0.0	235.4	898.1	21.0
162582	79.6	0.0	13.6	229.5	17.6	0.0	73.7	0.0	437.8	772.2	9.7
163211	85.6	0.0	706.7	0.0	0.0	0.0	402.2	0.0	470.8	1597.7	18.5
TOTAL	607.0	0.0	3334.2	967.3	89.2	24.0	2489.2	0.0	3338.7	102[illegible].7	16.9

SOURCE: MDR-[illegible]
MDR-5
MDR-6
NAVFLIRS

REMARKS: DET 6 LATE IN MAIL

MANHOUR DOCUMENTATION
FOR AUGUST 1991



MONTH	TOTAL HOURS AVAILABLE	TOTAL HOURS USED	PERCENTAGE
SEPTEMBER	22290.0	11987.7	53.8%
OCTOBER	26610.0	18034.3	67.7%
NOVEMBER	15624.0	4782.6	30.6%
DECEMBER	11406.0	7314.0	64.1%
JANUARY	13932.0	9919.3	71.2%
FEBRUARY	13791.0	5519.6	40.1%
MARCH	16579.0	5671.0	34.2%
APRIL	10299.5	20986.0	49.1%
MAY	17112.0	8696.4	50.8%
JUNE	14800.0	8711.4	58.9%
JULY	13988.0	7156.5	51.2%
AUGUST	14665.0	6842.5	46.7%

SOURCE: MDR-2

MANHOUR MAINTENANCE DOCUMENTATION

AUGUST 1991

WORKCENTER	500 LABOR USED	500 LABOR AVAILABLE	PERSONNEL	PERCENTAGE
HOMEGUARD	1,779.1	5,527.0	39	31.9 %
DET ONE	0.0	0.0	0	0.0 %
DET THREE	426.3	1,408.0	8	30.3 %
DET FIVE	1213.9	1,408.0	8	86.2 %
DET SIX	9.0	1,728.0	8	5.2 %
DET SEVEN	1331.5	1,728.0	8	77.0 %
DET NINE	1391.5	1,408.0	8	98.8 %
DET TEN	691.3	1,408.0	8	49.1 %
TOTAL	6,842.5	14,665.0	87	46.7 %

SOURCE: MDR-2

REMARKS: DETS 3,5,7 LATE IN MAIL.

READINESS REPORT BY ORGANIZATION

	HG	DET 1	DET 3	DET 5	DET 6	DET 7	DET 9	DET 10
PERCENT FULL MISSION CAPABLE	62.4	0.0	67.0	50.0	88.0	0.0	29.9	44.8
PERCENT MISSION CAPABLE	65.6	0.0	67.0	98.0	88.8	95.0	98.1	53.5
PERCENT NOT MISSION CAPABLE SUPPLY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERCENT NMC MAINT SCHEDULED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PERCENT NMC MAINT UNSCHEDULED	34.4	0.0	33.0	2.0	12.0	5.0	1.9	46.5
AIRCRAFT UTILIZATION	59.0	0.0	42.8	90.0	79.6	60.1	85.6	71.9
DIRECT MAINT. MHRS PER FLT HRS.	10.1	0.0	10.0	13.5	1.1	22.2	16.3	9.6
TOTAL CORROSION CONTROL MHRS	48.0	0.0	356.7	143.2	0.0	279.5	745.8	14.0

SOURCE: SCIR 3
MDR-11
NAVFLIRS

AIRCRAFT READINESS HOURS BY AIRCRAFT

AIRCRAFT BUNO 149761

MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS UNSC	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	427.3	70.2	13.7	136.6	180.1	374.5	39.1	32	26	40.7	0	0
FEB	672.0	192.0	25.2	192.0	0.0	480.0	0.0	0.0	17	2	1.9	0	0
MAR	744.0	0.0	0.0	0.0	0.0	744.0	0.0	0.0	0	0	0	4	21.3
APR	720.0	0.0	0.0	0.0	0.0	720.0	0.0	0.0	0	0	0	81	694.5
MAY	744.0	0.0	0.0	0.0	0.0	744.0	0.0	0.0	0	13	47	0	0
JUN	720.0	615.2	83.3	215.5	42.8	62.0	363.7	0.0	41	7	15.5	0	0
JUL	744.0	595.2	76.2	471.0	148.8	0.0	124.2	0.0	40	20	20.3	11	1
AUG	744.0	0.0	0.0	0.0	744.0	0.0	0.0	0.0	0	1	2.1	0	0
SEP	720.0	274.0	35.7	159.0	92.0	353.0	102.0	13.0	17	8	59.2	32	194.4
OCT	744.0	434.0	20.5	114.0	83.0	113.0	424.0	10.0	15	24	35.1	55	242.8
NOV	720.0	275.8	1.7	138.0	0.0	445.0	137.0	0.0	3	2	41.8	0	0
DEC	744.0	426.0	40.9	422.0	67.0	251.0	1.0	3.0	22	25	36.4	19	171
TOTAL	8760	3239.5	353.7	1725.2	1314.2	4092.1	1526.4	65.1	187	128	300	202	1325

AIRCRAFT BUNO 150157

MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	23.0	0.3	0.0	322.0	399.0	0.0	23.0	2	7	145.3	0	0
FEB	672.0	362.9	24.0	174.7	0.0	309.1	0.0	188.2	18	0	0	0	0
MAR	744.0	14.0	0.0	0.0	235.0	495.0	14.0	0.0	0	13	226.2	4	20
APR	720.0	58.0	2.9	0.0	443.0	203.0	47.0	11.0	3	84	270	462	1463
MAY	744.0	341.1	16.4	0.0	0.0	402.9	159.6	181.5	10	6	77.4	0	0
JUN	720.0	0.0	0.0	0.0	0.0	720.0	0.0	0.0	0	5	14.4	0	0
JUL	744.0	48.4	0.8	48.4	695.6	0.0	0.0	0.0	1	12	26.3	0	0
AUG	744.0	744.0	87.5	744.0	0.0	0.0	0.0	0.0	46	1	1	0	0
NOV	720.0	595.0	70.0	219.0	0.0	125.0	376.0	0.0	34	0	0	0	0
DEC	744.0	0.0	0.0	0.0	0.0	744.0	0.0	0.0	0	1	1	9	16.5
TOTAL	7296.0	2186.4	201.9	1186.1	1695.6	3398.0	596.6	403.7	114	129	761.6	475	1500

AIRCRAFT READINESS HOURS BY AIRCRAFT

AIRCRAFT BUNO 150158

MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	674.9	114.4	409.4	69.1	0.0	257.2	8.3	50	13	16.7	49	1344
FEB	672.0	470.4	75.0	463.7	0.0	201.6	0.0	6.7	34	13	46.4	0	0
MAR	744.0	320.4	40.5	224.2	178.1	245.5	1.1	95.1	21	48	69.4	0	0
APR	720.0	561.6	97.0	561.6	23.0	135.4	0.0	0.0	40	14	18.2	0	0
MAY	744.0	490.6	65.1	327.9	0.0	253.4	158.8	3.9	26	18	19	84	761
JUN	720.0	440.9	59.7	0.0	176.8	100.3	270.9	172.0	29	10	42.8	0	0
JUL	744.0	575.9	124.1	503.7	0.0	168.1	0.0	72.2	58	21	29.2	0	0
AUG	744.0	720.0	89.5	648.0	24.0	0.0	0.0	72.0	49	14	44.9	0	0
SEP	264.0	24.0	36.5	24.0	176.0	64.0	0.0	0.0	18	2	8.504	41	296.4
OCT	744.0	295.0	36.5	229.0	249.0	200.0	63.0	3.0	18	3	18	68	476.1
NOV	720.0	659.0	60.7	638.0	54.0	7.0	9.0	12.0	23	0	0	22	42.5
DEC	223.0	0.0	11.6	0.0	0.0	223.0	0.0	0.0	5	14	1939	0	0
TOTAL	7783	5232.7	810.6	4029.5	950	1598.3	760	445.2	371	170	2252	264	2920

AIRCRAFT BUNO 150158

MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	654.0	89.9	2.4	89.9	24.0	540.1	0.0	0.0	3	30	61	0	0
FEB	582.0	126.0	0.0	0.0	0.0	456.0	126.0	0.0	0	0	0	3	54
MAR	744.0	110.0	23.0	0.0	313.0	321.0	80.0	31.0	15	7	31.1	21	378
APR	720.0	190.0	34.3	0.0	455.0	75.0	37.0	153.0	20	38	71.8	1	210
MAY	584.0	391.0	49.5	391.0	37.0	156.0	0.0	0.0	14	4	15	0	0
JUN	720.0	256.0	54.0	170.0	379.0	85.0	0.0	86.0	29	43	110.6	20	496
JUL	744.0	616.2	64.8	593.0	128.0	0.0	0.0	23.1	38	54	160.4	84	482
AUG	744.0	626.0	71.9	437.0	78.0	40.0	6.0	183.0	38	8	14	0	0
SEP	720.0	696.0	41.1	696.0	8.0	16.0	0.0	0.0	20	7	31.5	21	77.7
OCT	744.0	457.0	4.1	200.0	22.0	257.0	0.0	0.0	20	8	17.6	98	782.4
NOV	720.0	317.0	41.1	252.0	289.0	114.0	34.0	31.0	22	0	0	3	22
DEC	720.0	373.0	50.9	307.0	69.0	278.0	21.0	45.0	22	26	73.2	9	239
TOTAL	8396.0	4248.1	437.1	3135.9	1802.0	2338.1	304.0	552.1	241	225	586.2	260	2741

AIRCRAFT READINESS HOURS BY AIRCRAFT

AIRCRAFT BUNO 161906

MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS UNSC	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	725.4	80.8	678.5	0.0	18.6	0.0	46.9	30	81	32	77	0
FEB	672.0	585.3	82.2	571.2	0.0	86.7	14.1	0.0	44	8	18.6	12	233.4
MAR	744.0	144.8	70.0	144.8	121.4	477.8	0.0	0.0	30	3	2	9	277.4
APR	720.0	354.2	78.8	170.6	365.8	0.0	0.0	183.6	35	42	101.2	4	80
MAY	744.0	675.6	79.1	312.5	68.4	0.0	0.0	363.1	35	25	28.6	1	24
JUN	720.0	520.7	91.3	520.7	136.8	62.5	0.0	0.0	39	67	196.8	37	627.5
JUL	744.0	685.2	80.0	361.6	58.8	0.0	0.0	323.6	32	25	42.7	20	265.5
AUG	744.0	706.8	60.1	0.0	37.2	0.0	608.0	98.8	26	49	205.5	32	574
SEP	720.0	502.0	10.6	380.0	44.0	174.0	14.0	108.0	4	116	40.2	105	427.6
OCT	744.0	33.0	10.6	33.0	100.0	157.0	264.0	26.0	7	1	7	6	800.5
NOV	720.0	668.5	31.4	668.5	21.5	30.0	0.0	0.0	18	0	0	16	26.3
DEC	744.0	400.0	7.4	295.0	206.0	138.0	60.0	45.0	6	8	202.4	1	26.8
TOTAL	8760.0	6001.5	682.3	4136.4	1159.9	1144.6	960.1	1195.0	306	425	877	320	3363

AIRCRAFT BUNO 161908

MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	456.0	159.9	0.0	159.9	14.8	281.3	0.0	0.0	0	61	99.5	0	0
FEB	672.0	384.0	8.8	72.0	0.0	288.0	216.0	96.0	5	28	180.9	0	0
MAR	744.0	414.4	76.3	241.0	59.1	270.5	146.6	26.8	36	15	36.5	7	79.5
APR	720.0	458.2	60.9	327.0	131.7	130.1	44.2	87.0	34	11	29.3	83	719.5
MAY	736.0	700.0	90.2	664.0	28.0	8.0	23.0	13.0	38	9	11.2	0	0
JUN	720.0	693.0	100.0	413.0	22.0	5.0	3.0	277.0	38	34	37.1	0	0
JUL	744.0	617.5	110.0	260.4	126.5	0.0	0.0	357.1	42	3	6.5	0	0
AUG	744.0	734.0	90.0	113.0	10.0	0.0	617.0	4.0	39	50	143.2	0	0
SEP	720.0	608.0	110.9	608.0	0.0	0.0	110.0	2.0	45	0	0	0	0
OCT	744.0	678.0	110.9	676.0	65.0	1.0	0.0	2.0	45	29	50.2	0	0
NOV	720.0	122.0	9.9	122.0	0.0	598.0	0.0	0.0	6	0	0	0	0
DEC	744.0	562.0	12.9	562.0	176.0	6.0	0.0	0.0	10.0	315	341.6	0.0	0.0
TOTAL	8464.0	6131	780.8	4218.3	633.1	1587.9	1159.8	864.9	338	555	936	90	799

AIRCRAFT READINESS HOURS BY AIRCRAFT

AIRCRAFT BUNO 161643

161643 MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	566.9	70.0	493.9	38.5	138.6	60.0	13.0	38	18	54.3	33	774
FEB	90.0	64.0	13.2	64.0	24.0	2.0	0.0	0.0	5	9	19.6	19	342
MAR	744.0	137.0	31.5	99.0	140.0	467.0	10.0	28.0	18	8	37	6	54
APR	202.0	99.0	3.7	97.0	25.0	78.0	1.0	1.0	2	11	32.9	49	191.1
SEP	720.0	242.0	0.5	242.0	203.0	275.0	0.0	0.0	1	0	0	0	0
OCT	744.0	246.0	0.5	246.0	232.0	266.0	0.0	0.0	1	104	281.3	91	427
NOV	720.0	0.0	0.0	0.0	360.0	360.0	0.0	0.0	0	80	120.3	0	0
DEC	744.0	307.0	3.4	280.0	245.0	188.0	16.0	11.0	10	25	224.5	9	129.4
TOTAL	4708.0	8354.9	916.5	6302.2	2076.6	3368.5	1246.8	917.9	423	1125	2048	297	2717

AIRCRAFT BUNO 161645

MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	704.0	21.9	207.8	16.5	0.0	491.0	5.2	12	0	0	0	0
FEB	672.0	483.8	67.4	268.8	0.0	188.2	215.0	0.0	27	7	21.7	0	0
MAR	744.0	738.0	100.0	652.0	4.0	2.0	84.0	2.0	40	0	0	0	0
APR	720.0	629.0	85.6	629.0	25.0	66.0	0.0	0.0	31	87	109.4	0	0
MAY	744.0	342.2	70.6	342.0	0.0	401.8	0.0	0.0	29	43	124.8	0	0
JUN	720.0	624.0	145.2	624.0	19.0	77.0	0.0	0.0	63	22	47.2	7	137
JUL	744.0	714.7	142.0	714.2	2.2	0.0	0.0	27.5	54	96	193	1	10
AUG	744.0	743.0	42.8	743.0	1.0	0.0	0.0	0.0	18	96	356.7	0	0
SEP	560.0	433.0	92.5	433.0	110.0	17.0	0.0	0.0	54	94	715	77	696.4
OCT	688.0	658.0	92.5	523.0	24.0	0.0	22.0	112.0	55	10	13.1	58	388.9
NOV	720.0	593.0	68.2	571.0	126.0	1.0	16.0	6.0	30	44	53.3	0	0
DEC	744.0	647.0	75.0	641.0	73.0	24.0	3.0	3.0	35	76.0	86.8	0.0	0.0
TOTAL	8544.0	7309.7	1003.7	6348.8	400.7	777.0	831.0	155.7	448	575	1721.0	143	1232.3

AIRCRAFT READINESS HOURS BY AIRCRAFT

AIRCRAFT BUNO 162582

162582 MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	603.6	100.0	603.6	2.6	137.8	0.0	0.0	45	0	0	0	0
FEB	672.0	672.0	110.0	0.0	0.0	0.0	0.0	0.0	49	0	0	0	0
MAR	744.0	425.1	75.9	417.5	22.8	296.1	5.3	2.3	42	0	0	0	0
APR	720.0	638.0	8.0	638.0	2.0	80.0	0.0	0.0	4	35	84.8	0	0
MAY	744.0	535.7	49.5	467.2	208.0	0.0	59.5	0.0	26	29	24	0	0
JUN	720.0	717.8	50.0	691.2	2.2	0.0	26.6	0.0	14	71	405.5	63	494
JUL	744.0	260.4	21.1	260.4	483.6	0.0	0.0	0.0	13	26	33.6	0	0
AUG	744.0	654.7	79.6	654.7	89.3	0.0	0.0	0.0	39	0	0	0	0
OCT	744.0	744.0	100.0	744.0	0.0	0.0	0.0	0.0	54	0	0	0	0
NOV	720.0	411.0	61.4	411.0	0.0	309.0	0.0	0.0	28	0	0	0	0
DEC	744.0	603.0	137.3	594.0	53.0	88.0	2.0	7.0	53	45	37.6	0	0
TOTAL	8040.0	6265.3	792.8	5481.6	863.5	910.9	93.4	9.3	367	206	585.5	63	494

AIRCRAFT BUNO 163211

163211 MONTH	HRS RRS	HRS MC	FLT HRS	HRS FMC	HRS NMCM	HRS NMCS	HRS PMCS	HRS PMCM	FLTS NO	MAF NO	MAF M-HRS	SAF NO	SAF M-HRS
JAN	744.0	720.0	148.4	710.1	22.0	2.0	8.3	1.6	61	0	0	0	0
FEB	672.0	618.3	112.1	602.8	53.8	0.0	0.0	15.5	56	0	0	C	0
MAR	744.0	731.4	84.0	731.4	12.6	0.0	0.0	0.0	37	0	0	0	0
APR	720.0	649.0	68.0	649.0	21.0	50.0	20.0	19.0	32	22	103.1	1	5
MAY	744.0	706.8	81.4	453.8	37.2	0.0	253.0	0.0	39	17	31.4	14	252
JUN	720.0	716.0	90.0	709.0	4.0	0.0	7.0	0.0	35	18	65.6	25	438
JUL	744.0	729.1	98.8	721.7	14.9	0.0	0.0	7.4	44	83	191.1	16	272
AUG	744.0	734.0	85.6	224.0	5.0	5.0	502.0	8.0	34	170	403	26	342.8
SEP	720.0	206.0	68.3	202.0	61.0	453.0	2.0	2.0	37	16	101.7	72	504.2
OCT	744.0	672.0	68.3	228.0	40.0	32.0	243.0	200.0	37	2	5	88	554.9
NOV	720.0	639.0	100.0	379.0	0.0	81.0	260.0	0.0	39	0	0	0	0
DEC	744.0	720.0	177.8	720.0	24.0	0.0	0.0	0.0	81	16	29.8	0	0
TOTAL	8760.0	7841.6	1182.7	6330.8	295.5	623.0	1295.3	253.5	532	344	930.7	242	2369

YEARLY TOTAL: "HIGH 5" CANNIBALIZATIONS

WUC	NOMENCLATURE	ITEMS	ITEMS %	% TOT	M-HRS
1551	MAIN ROTOR SYSTEM	27	24.8	24.8	500.7
1522	MAIN ROTOR FLIGHT CONTRO	11	10.1	34.9	56.2
14A1	CONTROL STRUTS	11	10.1	45.0	53.9
4221	GENERATORS	9	8.3	53.2	91.3
1532	FLIGHT CONTROLS	8	7.3	60.6	64.9
1552	MAIN ROTOR FLT CONTROLS	7	6.4	67.0	55.0
29F2	AIR FRAME ELECTICAL SYS	6	5.5	72.5	46.1
R1R1	AVIONICS	6	5.5	78.0	43.5
2240	T-58 ENGINE	4	3.7	81.7	150.7
5762	ASE ELECTICAL SYSTEM	4	3.7	85.3	18.2
133A	SHOCK STRUT	3	2.8	88.1	29.3
2654	COMBINING GEAR BOX	2	1.8	89.9	210.0
2653	MAIN GEAR BOX	2	1.8	91.7	54.0
2246	ENGINE FUEL SYSTEM	2	1.8	93.6	8.0
1333	LANDING GEAR HYDRAULICS	1	0.9	94.5	41.4
2651	MAIN DRIVE SHAFT	1	0.9	95.4	37.0
14A6	FLT CONTROL: AZIMUTH	1	0.9	96.3	22.0
14A4	FLT CONTROLS: HYDRAULIC	1	0.9	97.2	17.0
1181	AIR FRAME	1	0.9	98.2	10.4
1339	MAIN LNDG GEAR BRAKES	1	0.9	99.1	6.2
2622	AIR FRAME COMPONENTS	1	0.9	100.0	6.0
	TOTAL	109			

YEARLY TOTAL: "HIGH 5" A-799s

WUC	NOMENCLATURE	ITEMS	ITEMS %	% TOTAL
5762	ASE ELECTICAL SYSTEM	8	11.1	11.1
4400	LIGHTING SYSTEM	6	8.3	19.4
1532	MAIN ROTOR TRACK	5	6.9	26.4
6418	ICS	4	5.6	31.9
7244	NAVIGATION EQUIPT	4	5.6	37.5
14A1	CYCLIC FLIGHT CONTROLS	3	4.2	41.7
2900	AIR FRAME ELECTICAL SYS	3	4.2	45.8
632Z	COMM EQUIPT	3	4.2	50.0
651E	MISSION EQUIPT	3	4.2	54.2
1331	LANDING GEAR	2	2.8	56.9
2240	ENGINES	2	2.8	59.7
2652	TAIL ROTOR DRIVE	2	2.8	62.5
4221	ELECTRICAL COMPONENTS	2	2.8	65.3
14A3	DIR CONTROL SYSTEM	2	2.8	68.1
723B	NAVIGATION EQUIPT	2	2.8	70.8
723C	AIRFRAME ELECT EQUIPT	2	2.8	73.6
765K	ESM EQUIPT	2	2.8	76.4
1400	FLT CONTOLS	1	1.4	77.8
1551	MAIN ROTOR SYSTEM	1	1.4	79.2
2241	ENGINE COMPONENTS	1	1.4	80.6
2246	FUEL LINES	1	1.4	81.9
2653	MAIN GEAR BOX ASSEMBLY	1	1.4	83.3
4200	ELECTICAL POWER SUPPLY	1	1.4	84.7
4282	ELECTRICAL WIRING	1	1.4	86.1
4911	RESCUE HOIST SYSTEM	1	1.4	87.5
4961	CAUTION PANNEL	1	1.4	88.9
5426	DATA LINK SYSTEM	1	1.4	90.3
6322	RADIO COMPONENTS	1	1.4	91.7
7116	NAVIGATION AIRFRAME COMP	1	1.4	93.1
7439	RAWS	1	1.4	94.4
14A2	COLLECTIVE FLT CONTROLS	1	1.4	95.8
62X1	VHF COMM EQUIPT	1	1.4	97.2
71Y9	WIRING EQUIPT	1	1.4	98.6
75R1	SONOBUOY EQUIPT	1	1.4	100.0
TOTAL		72		

FROM THE DATA: 132 A799'S WERE REPORTED
BUT NOT IDENTIFIED BY WUC IN THE MMS

YEARLY TOTAL: "HIGH 5" MAN-HOUR CONSUMERS

WUC	NOMENCLATURE	MAN-HRS	MAN-HR%	% TOTAL	ITEMS
1551	MAIN ROTOR SYSTEM	1037.3	17.4	17.4	38
2654	COMBINING GEAR BOX ASSY	995.1	16.7	34.0	10
2240	ENGINES	678.8	11.4	45.4	10
1522	TAIL ROTOR BLADES	619.1	10.4	55.8	40
2653	MAIN GEAR BOX ASSEMBLY	552.0	9.2	65.0	9
1181	AIRFRAME	504.1	8.4	73.4	11
1331	MAIN MOUNT	351.4	5.9	79.3	5
2622	ACCESSORY COMPONENTS	243.3	4.1	83.4	7
14A6	FLIGHT CONTROL SYSTEM	202.0	3.4	86.8	7
4221	ELECTRICAL COMPONENTS	185.5	3.1	89.9	1
1532	MAIN ROTOR BLADE TRACK	118.9	2.0	91.9	50
751L	AIRFRAME MISSION EQUIPT	97.0	1.6	93.5	1
29F2	ENGINE ACCESSORY EQUIPT	72.0	1.2	94.7	1
7700	PHOTO/RECON EQUIP	67.0	1.1	95.8	9
723C	AIRFRAME ELECT EQUIPT	57.0	1.0	96.8	1
2246	ENGINE FUEL SYSTEM	55.4	0.9	97.7	1
4400	LIGHTING SYSTEM	53.7	0.9	98.6	21
14A4	ASE HYDRAULIC SYSTEM	50.0	0.8	99.5	1
5762	ASE ELECTRICAL SYSTEM	32.8	0.5	100.0	6
TOTALS		5972.4			229

YEARLY TOTAL: "HIGH 5" MALFUNCTIONS

WUC	NOMENCLATURE	ITEMS	% TOTALS	PERCENT	MAN-HRS
1551	MAIN ROTOR SYSTEM	77	20.2	20.2	377.1
1181	AIRFRAME	73	39.3	19.1	162.2
1532	MAIN ROTOR TRACK	50	52.4	13.1	118.9
1331	LANDING GEAR	36	61.8	9.4	166.9
4400	LIGHTING SYSTEM	25	68.3	6.5	66.4
248L	INTERIOR LIGHTING	25	74.9	6.5	31.9
29F2	ENGINE ACCESSORY EQUIPT	19	79.8	5.0	71.5
1522	TAIL ROTOR SYSTEM	12	83.0	3.1	169.4
14A6	FLIGHT CONTROLS	12	86.1	3.1	133.0
2653	MAIN GEAR BOX ASSEMBLY	12	89.3	3.1	46.3
651F	MISSION EQUIPT	5	90.6	1.3	29.8
7244	NAVIGATION EQUIPT	5	91.9	1.3	22.7
74R5	RESCUE EQUIPTMENT	5	93.2	1.3	6.3
632Z	COMM EQUIPT	4	94.2	1.0	19.4
14A1	COCKPIT FLIGHT CONTROLS	4	95.3	1.0	17.8
4282	ELECTRICAL WIRING	3	96.1	0.8	35.6
2622	ACCESSORY COMPONENTS	3	96.9	0.8	31.6
4622	FUEL SYSTEM	3	97.6	0.8	24.5
428Q	FUEL/OIL SYS WIRING	3	98.4	0.8	17.4
229E	ENGINE ELECTICAL SYS	3	99.2	0.8	11.6
2246	FUEL LINES	3	100.0	0.8	3.0
	TOTAL	382			1563.3

BIBLIOGRAPHY

Books

Brassard, Michael. The Memory Jogger: A Pocket Guide of Tools for Continuous Improvement. Methuen, MA: GOAL/QPC, 1988.

Brassard, Michael. The Memory Jogger Plus+. Methuen, MA: GOAL/QPC, 1989.

Crosby, Philip B. Quality is Free. New York: McGraw-Hill, 1979.

Deming, W. Edwards. Out of the Crisis. Cambridge, MA: Massachusetts Institute of Technology, 1986.

Feigenbaum, Armand V. Total Quality Control, New York: McGraw-Hill Book Company, 1983.

Gabor, Andrea. The Man Who Discovered Quality. New York: Random House, Inc., 1990.

Grant, Eugene L. and Richard S. Leavenworth. Statistical Quality Control. New York: McGraw-Hill Book Company, 1980.

Ishikawa, K. Guide to Quality Control. Tokyo: Asian Productivity Organization, 1982.

Ishikawa, K. and David J. Lu. What is Total Quality Control? The Japanese Way. Englewood Cliffs, N. J.: Prentice-Hall, 1985.

Juran, Joseph M. Quality Control Handbook. New York: McGraw-Hill, 1974.

Klugh, Henry E. Statistics: The Essentials for Research. 2nd ed. New York: John Wiley & Sons, Inc., 1974.

Kume Hitoshi, Statistical Methods for Quality Improvement. Tokyo: 3A Corporation, 1989.

Mann, N. R. The Keys to Excellence: The Story of the Deming Philosophy. Los Angeles: Prestwick Books, 1987.

Messina, William S. Statistical Quality Control for Manufacturing Managers. New York: John Wiley and Sons, 1987.

Ott, Ellis R. Process Quality Control: Troubleshooting and Interpretation of Data. New York: McGraw-Hill Book Company, 1975.

Roscoe, John T. Fundamental Research Statistics for the Behavioral Sciences. 2nd ed. New York: Holt, Rinehart, and Winston, Inc., 1975.

Scherkenbach, W. W. The Deming Route to Quality and Productivity: Roadmaps and Roadblocks. Washington, D. C.: CEEPRESS, 1986.

USMG Quality Office. USMG Partnership: The Way We Work. Rochester, NY: USMG Quality Office, 1988.

Walton, Mary. Deming Management at Work. New York: G. P. Putnam's Sons, 1990.

Walton, Mary. The Deming Management Method. New York: Dodd, Mead, 1986.

Western Electric Company. Statistical Quality Control. Indianapolis: Western Electric Co., Inc., 1985.

Wheeler, Donald J. and David S. Chambers. Understanding Statistical Process Control. Knoxville, TN: Statistical Process Controls, Inc., 1986.

Xerox Corporation. Leadership Trough Quality Training Programs: A Guide to Benchmarking in Xerox. Rochester, NY: 1990.

Government Documents

Chief of Naval Operations. Naval Aviation Maintenance Procedures, OPNAVINST 4790.2E Volume V. Wash D. C. 1991.

Chief of Naval Operations. NAVOP 011/91, NAVY-WIDE IMPLEMENTATION OF TOTAL QUALITY LEADERSHIP (TQL). Wash D. C., 1991.

Chief of Naval Operations. NAVOP 018/91, NAVY-WIDE IMPLEMENTATION OF TOTAL QUALITY LEADERSHIP (TQL). Wash D. C., 1991.

Commander Anti-Submarine Wing Pacific. COMASWWINGPAC Instruction 4790.13B. North Island NAS, CA: 1988.

Commander Anti-Submarine Wing Pacific. COMASWWINGPAC Instruction 4790.9B. North Island NAS, CA: 1989.

Defense Technical Information Center. Participant Guide for TQM Quantitative Methods Workshop. Alexandria, VA: Defense Logistics Agency, 1990.

Defense Technical Information Center. Total Quality Management: Getting Started. Alexandria, VA: Defense Logistics Agency, 1990.

Helicopter Anti-Submarine (Light) Three Seven. Maintenance Instruction No. 17-91. Barbers PT, NAS, HI: 1991.

Helicopter Anti-Submarine (Light) Three Seven. "Subsystem Capability Impact Reporting System (SCIR)" undated.

Navy Personnel Research and Development Center. A Total Quality Management Improvement Model. San Diego, CA: 1988.

United States Air Force Logistics Command. Quality Leadership. Wright-Patterson AFB, OH: 1989.

United States Air Force Logistics Command. Application for The President's Award for Quality and Productivity Improvement 1991. Wright-Patterson AFB, OH: 1991.

Periodicals and Articles

Byron, John L. "Welcome to the Revolution," U. S. Naval Institute Proceedings Oct. 1991: 30-35.

Eddingfield, L. E. and J. G. Stavridis. "A Measure of Success," U. S. Naval Institute Proceedings Feb. 1992: 80-81.

Gabor, Andrea. "The leading light of quality." U. S. News & World Report 28 Nov. 1988:53-56.

Gwynne, Peter. "The Reigning Guru of Quality Control," The World and I Feb 1989: 328-333.

Kleiner, Art. "What's Going on in Corporations," Whole Earth Review Fall 1991: 126-129.

Moneymaker, Patrick D. "TQL Goes to Sea," U. S. Naval Institute Proceedings Jan. 1992: 91-92.

Mumford, Robert E. "The 'Navy Way' Can Change," U. S. Naval Institute Proceedings Naval Review, May 1991: 110-113.

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