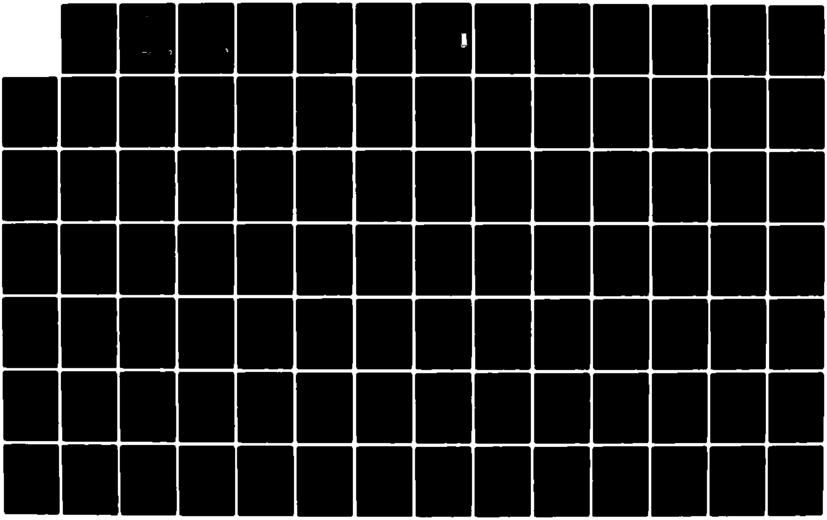
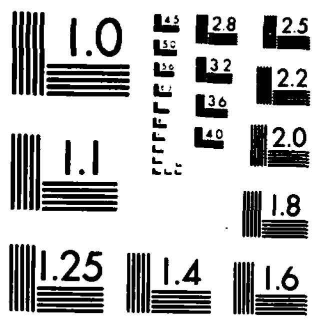
AD-A123 848 AIRFRAME RDT&E COST ESTIMATING: A JUSTIFICATION FOR AND 1/3
DEVELOPMENT OF UN..(U) AIR FORCE INST OF TECH
WRIGHT-PATTERSON AFB OH SCHOOL OF SYST..
UNCLASSIFIED C L BECK ET AL. SEP 82 AFIT-LSSR-56-82 F/G 1/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AIRFRAME RDT&E COST ESTIMATING:
A JUSTIFICATION FOR AND DEVELOPMENT
OF UNIQUE COST ESTIMATING RELATIONSHIPS
ACCORDING TO AIRCRAFT TYPE

Charles L. Beck, Jr., Captain, USAF
Dennis L. Pfeil, Major, USAF

LSSR 56-82

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (ATC)
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AIRFRAME RDT&E COST ESTIMATING:
A JUSTIFICATION FOR AND DEVELOPMENT
OF UNIQUE COST ESTIMATING RELATIONSHIPS
ACCORDING TO AIRCRAFT TYPE

Charles L. Beck, Jr., Captain, USAF
Dennis L. Pfeil, Major, USAF

LSSR 56-82

DISCLAIMER NOTICE

AFIT Control Number LSSR 56-82

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaires to: AFIT/LSH, Wright-Patterson AFB, Ohio 45433.

1. Did this research contribute to a current Air Force project?

   a. Yes   b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

   a. Yes   b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Can you estimate what this research would have cost if it had been accomplished under contract or if it had been done in-house in terms of manpower and/or dollars?

   a. Man-years ________ $ ________ (Contract).

   b. Man-years ________ $ ________ (In-house).

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3 above), what is your estimate of its significance?

   a. Highly Significant   b. Significant   c. Slightly Significant   d. Of No Significance

5. Comments:

________________________________ ________________________________
Name and Grade   Position

________________________________ ________________________________
Organization   Location

FOLD DOWN ON OUTSIDE - SEAL WITH TAPE

AFIT/ LSH
WRIGHT-PATTERSON AFB OH 45433

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE. $300

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 73236 WASHINGTON D.C.

POSTAGE WILL BE PAID BY ADDRESSEE

AFIT/ DAA
Wright-Patterson AFB OH 45433

FOLD IN

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER LSSR 56-82	2. GOVT ACCESSION NO. A123848	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AIRFRAME RDT&E COST ESTIMATING: A JUSTIFICATION FOR AND DEVELOPMENT OF UNIQUE COST ESTIMATING RELATIONSHIPS ACCORDING TO AIRCRAFT TYPE		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles L. Beck, Jr., Captain, USAF Dennis L. Pfeil, Major, USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS School of Systems and Logistics Air Force Institute of Technology, WPAFB, OH		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Department of Communication and Humanities AFIT/LSH, WPAFB, OH 45433		12. REPORT DATE September 1982 13. NUMBER OF PAGES 103
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES APPROVED FOR PUBLIC RELEASE: IAW AFR 190-17 LYNN E. WOLAVER 2 SEP 1982 Dean for Research and Professional Development AIR FORCE INSTITUTE OF TECHNOLOGY (ATC) WRIGHT-PATTERSON AFB, OH 45433		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) LIFE CYCLE COSTS AIRFRAME DEVELOPMENT COSTS COST ESTIMATING RELATIONSHIPS FACTOR ANALYSIS REGRESSION ANALYSIS		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Thesis Chairman: Theodore J. Novak, Jr., Lt Col, USAF		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Airframe RDT&E costs are invariably predicted by utilizing one general cost estimating relationship (CER) regardless of aircraft type (fighter, attack, or bomber/cargo). This practice results in inconsistent and often very significant inaccuracies in predicting weapon system development costs which may affect subsequent program funding. This thesis examines the utility of a unique CER for each aircraft type to be used for estimating airframe development costs. The methodology consisted of factor analysis and step-wise multiple regression analysis. Based on the results, the authors concluded that the unique CERs are consistently and significantly more accurate when estimating airframe RDT&E costs than the general CERs developed by former studies. The results of this study should be applicable to those organizations dealing with the procurement of aircraft airframes.

LSSR 56-82

AIRFRAME RDT&E COST ESTIMATING: A JUSTIFICATION FOR AND DEVELOPMENT OF UNIQUE COST ESTIMATING RELATIONSHIPS ACCORDING TO AIRCRAFT TYPE

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master in Science in Logistics Management

By

Charles L. Beck, Jr., BS
Captain, USAF

Dennis L. Pfeil, BA
Major, USAF

September 1982

Approved for public release;
distribution unlimited

This thesis, written by

Captain Charles L. Beck, Jr.

and

Major Dennis L. Pfeil

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfullment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

DATE: 29 September 1982

Theodore J. Novak Jr.
COMMITTEE CHAIRMAN

ACKNOWLEDGEMENTS

We are grateful to Lieutenant Colonel Ted Novak, Lieutenant Commander Joe Stewart, and Mr Roland Kankey for their helpful advice and guidance with this thesis. We are particularly appreciative of their willingness to allow us freedom of management while providing valuable direction. Several other faculty members provided valuable assistance for which we are extremely thankful.

A special note of thanks goes to our families for their support and understanding under often trying conditions. We sincerely congratulate and thank JoWilla Beck for her patience as a typist and performance of a job very well done!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The analysis of weapon system life cycle costs (LCC) is an integral part of the decision making process regarding Air Force systems acquisitions (10:1). Life cycle costs, when related to USAF aircraft, consist of all costs associated with the Research, Development, Test & Evaluation (RDT&E), Production, and Operation & Support (O&S) phases (10:11). Defense procurements in 1979 totaled almost $35 billion (3:12). Of that amount, approximately 45%, or almost $16 billion were expended on RDT&E programs (3:102). The RDT&E costs associated with the F-16 alone amounted to over $741 million over a six year period (6).

Although the use of life cycle cost analysis has been widespread it is not yet a finished and fully effective management tool. Many acquisition managers lack confidence in current LCC analysis techniques and are uncertain as to their efficiency. This uncertainty becomes significant when LCC analysis is used as an aid in economic tradeoff evaluations and in funding decisions demanding reliable, internally consistent estimates of absolute cost (10:1).

> Cost estimating capability is only as accurate as the information on which the estimates are based. On some large, complex development programs, the degree of accuracy surrounding an estimate may be -10% to +100% or more. Decision makers must be informed about the degree of accuracy so that they will not erroneously assume that an estimate is accurate to within plus or minus 10% [2:154].

Numerous cost models have been developed for each phase of a system's life cycle. However, the models pertaining to the RDT&E phase appear to be limited in their ability to accurately predict weapon system development costs. This thesis focuses on a shortcoming present in all cost models that have been examined by this thesis team. Most models place heavy emphasis on production and O&S phase costs, by using parameters identified through research of these two phases, to form the basis for the models' cost estimating relationships (CERs). When applied to aircraft, the research results in parametric equations unique to each aircraft type (fighter, attack, and cargo/bomber) for the production and O&S costs elements (i.e., the equation developed to estimate production cost elements for the F-15 would be different from that of the C-141). However, separate parametric equations based on aircraft type are not utilized to predict RDT&E costs. All existing models establish one CER equation that is used regardless of type aircraft for RDT&E cost estimates. That is, the models establish one algorithm for RDT&E that is used regardless of whether the aircraft is a fighter, attack, or cargo/bomber. Chapter II will examine and discuss selected algorithms in more detail.

Problem Statement

Airframe RDT&E costs are currently estimated by using one general CER in all existing models rather than a unique CER for each aircraft type. This practice may have substantial impact on the accuracy of RDT&E cost estimates and subsequent program funding.

Justification for Research

In the purview of acquisition managers, cost estimating techniques must be refined to more accurately predict weapon system costs. In this light, valid cost estimating techniques should be developed which reflect the unique cost characteristics for each aircraft type throughout each phase of the acquisition process. Common sense dictates that RDT&E cost equation for a small supersonic fighter aircraft, such as the F-16, should be different from the RDT&E cost equations associated with a large subsonic aircraft such as the C-5. Any attempt to estimate RDT&E costs for such dissimilar aircraft types using common and general CERs is likely to result in less accurate cost projections than could be obtained by using separate CERs for each aircraft type. As an example, a cost model developed by Grumman Corporation projected RDT&E costs with general CERs that had been developed using fighter, attack, and cargo airframe cost elements. The resulting estimates for airframes ranged from a 30% underestimate to a 20% overestimate (13:208).

The base model referred to throughout this thesis is the model initially developed by Grumman in 1976, as revised in 1980. This model is one of the most recently developed cost estimating tools and is based on data pertaining only to fairly recent procurements. The data base is available and has been verified for accuracy. Additionally, the Grumman model is useful for performing cost/design and performance trade-offs due to the airframe characteristics identified and included in the model as cost drivers. The Grumman model is reviewed in Chapter II of this thesis.

Purpose and Objective

This thesis is restricted to the development of algorithms that are structured for a single design type aircraft. An attempt to develop separate CERs by aircraft type for airframe RDT&E cost elements is based on logical cause and effect relationships between the dependent variables and independent variables. This logical relationship is supported by factor analysis and multiple regression analysis. The CERs that are developed are statistically compared with the base model in order to determine relative accuracv in predicting RDT&E costs.

Research Hypotheses

1) The initial research hypothesis proposed by this thesis is that a unique CER exists for each type of airframe (fighter, attack, cargo) for the RDT&E phase of the acquisition process.

2) The second hypothesis is that the unique CERs more accurately predict airframe RDT&E costs.

Scope

An attempt is made to develop CERs that pertain only to RDT&E airframe development costs. The CERs are developed based on data gathered on several fighter, attack and cargo aircraft, all in the "A" configuration. The analysis is limited to fighter, attack and cargo because of the limited and insufficient data available on all other aircraft configurations (trainer, bomber, etc.).

General Research Plan

This thesis research effort logically gathers data on all three types of airframe structures, groups the airframes by means of correlation of characteristics through the use of factor analysis, and develops an algorithm for the grouped data by using multiple regression analysis. The resulting CERs are then compared to CERs of the base model by using statistical tests of significance and measures of accuracy.

Support of the thesis hypotheses indicates that greater accuracy should be achieved by using specialized CERs. Improved cost estimates allow improved budgeting by DoD and Congress, and decrease the chances of cost overruns which may be viewed as politically unacceptable and ultimately may lead to cancellation of the program.

CHAPTER II

LITERATURE REVIEW

Introduction

A number of tools and techniques have been developed for use in estimating different categories of weapon system costs. For many years estimates of aircraft airframe costs were based primarily on weight. However, cost estimators have continuously searched for other aircraft characteristics that (1) will, in combination with weight, provide consistently accurate estimates, (2) are logically related to cost, and (3) can easily be determined prior to actual design and development, thus allowing for trade offs between cost and performance/physical characteristics (8:1).

Three of the most popular methods currently used for cost estimating are the analogy method, the engineered method, and the parametric method. The choice of which cost estimating method should be used is often governed by the time available for the estimating effort, the degree of system definition at the time of the analysis, the kind and amount of input data available, and the level of detail required (15:7.3).

Each of the three methods is described in the following paragraphs.

Analogy Method

When applying this method, estimated costs of the new items are derived from past costs of items that are at least similar in all important respects. The reasonableness of the quotations or prior prices must be established and an allowance made, through use of adjustment factors, for all differences between the proposed item and the past items used for comparison. Data used for making analogous estimates is normally taken from a library of catalogs and historical records of recent procurements, and includes information on the specification, schedule, and the contracting environment in which the item was procured (7:4, 5).

The need to rely on past procurements of similar items, based on the analyst's judgement, is one disadvantage to using the analogy method (15:7.5). A second disadvantage is that the adjustment factors used to account for differences are completely subjective. They are based solely on the analyst's judgement regarding the magnitude of the differences between the proposed item and the past items used for comparison. Additionally, analogy models tend to have limited usefulness with respect to design trade off applications since they ordinarily compute costs as a function of parameters such as mean time between failures and maintenance man-hours per flying hour. They do not relate costs directly to performance and design parameters and, therefore, cannot be used early in the conceptual phase of development when trade offs relating to performance/design parameters are usually made (1:24).

Engineered Cost Method

Estimations made by this method are based on an extensive knowledge of the system characteristics, requiring the cost analyst to have a detailed knowledge of the system, the production processes, and the production organization. A total project cost estimate is obtained by consolidating estimates from the various separate work segments (15:7.5).

If detailed cost data is available, the engineered cost method is preferred for making cost estimations (15:7.6). However, the required cost detail is not usually available early in the development process, particularly for DoD procurements, making this approach difficult to apply (15:7.5). Commonly, by the time detailed information is at hand many decisions have already been made and the choice among various initial alternative systems has been reduced to only a few (11:5-8). In addition, the engineered cost method is generally more costly and time consuming than other cost estimating techniques. One major defense firm has indicated that use of this method for estimating only airframe costs requires more than 4,000 separate estimates (15:7.6).

Parametric Cost Estimating

When applying parametric cost estimating techniques, the cost of a new item is based on physical and performance characteristics as well as costs of previously procured items (7:6). Through curve-fitting techniques, system cost is related to a combination of system parameters, such as physical dimensions, weight, maximum speed, etc. The relationships established, in the form of mathematical equations, are referred to as cost estimating relationships (CERs), which can be quite simple or very complex. Normally, the dependent variable in a CER is a cost element, such as engineering labor hours, while the independent variables are system parameters. CERs have been developed to reflect RDT&E, production, and/or operating and support (O&S) costs. They can be applied to individual segments of these costs or can reflect a composite of them all which results in a total system cost (11:5-6).

If detailed cost data is not available, parametric cost estimating is preferred over other methods for at least three reasons: (1) CERs can be developed and used early in the preliminary design stages of RDT&E to study the effects of varying parameters on system cost, thus allowing cost comparisions of different alternative designs; (2) the relationships developed can be used to obtain preliminary cost estimates before the details of design or O&S concepts are certain; (3) they require less input data than engineered models and can be more easily used for sensitivity or parametric analysis (1:26).

DoD is currently emphasizing the utilization of design to cost (DTC) techniques in all major weapon system acquisition programs. DTC calls for establishing weapon system cost parameters that can be translated into "design to" requirements. All R&D, production, and operating costs are directed to be principal design considerations. The focus is on practical trade offs weighing costs against system capability and program schedule requirements (16:2).

Of the three cost estimating techniques previously described, parametric cost estimating best lends itself to the implementation of DTC and its inherent trade offs between cost and physical/performance characteristics of a weapon system. In order for DTC to be effectively applied, it must be utilized early and throughout a development program. Early utilization of the engineered cost method is usually not possible due to the requirement for detailed cost data not yet available. The analogy method is also inappropriate for DTC application since the analogy models do not normally relate costs directly to performance and design parameters.

The remainder of this chapter reviews studies designed to develop parametric cost estimating models with emphasis on their application to airframe RDT&E costs.

Model Review

PRC 547-A, April 1967

One of the early attempts at estimating airframe development and production costs was undertaken by the Planning Research Corporation. The primary objective of the study was to develop suitable techniques for use in cost-effectiveness studies and evaluation of contractor proposals (14:vii).

The model, developed by use of multiple stepwise regression, consists of three distinct cost elements: direct manufacturing labor, manufacturing materials, and engineering and tooling (combined as one element). The sample included forty-one aircraft, both propeller driven and turbojet, dating as far back as 1940. The aircraft characteristics used as independent variables were speed, weight, and functions of these (e.g., speed squared) (14:II-2).

The cost estimating methodology involved deriving separate estimating equations for each cost element at production units 10, 30, 100, and 300. These estimates are then used to derive cost-quantity curves to enable cost estimation for any desired quantity (14:III-1). To illustrate, in order to estimate the cost of manufacturing labor for aircraft unit 1, four separate estimating equations were developed (one each for quantities 10, 30, 100, and 300). The estimated cost for manufacturing labor (expressed in average cost per airframe) is then plotted on logarithmic graph paper. A "best-fit" straight line is then drawn through the four points and extended back to the vertical axis to obtain an estimate of unit 1 (prototype) manufacturing labor costs. Thus, twelve equations were developed, four for each cost element, to derive three cost estimating curves.

The coefficients of determination (R^2) for the CERs derived for airframe unit 10 are listed below for each cost element:

Cost Element	R^2
Manufacturing Direct Labor	.8172
Manufacturing Materials	.8354
Tooling and Engineering	.8028

Although the R^2 values appear significant it should be remembered that these values apply only to the CERs developed for estimating the costs of airframe unit 10. It should not be assumed that the same coefficient of determination, an indication of regression line fit, is applicable to estimates made of airframe units other than 10, such as one or two, which might be prototype airframes. The study does not attempt to develop separate cost equations for prototype and production costs. Instead, the curve-fitting technique previously described results in "backing-in" to the cost of the early airframe units, irregardless of whether the units are prototype or production airframes.

One of the difficulties inherent in this study is the heterogeneity of the sample used to derive the CERs. There is no attempt to stratify the data according to aircraft type (cargo, fighter, attack, etc). The physical and performance characteristics of the sample aircraft, as well as the period of their development and production, differ widely.

Rand Studies

A number of studies relating to aircraft cost estimating relationships have been performed by the Rand Corporation. Two of the Rand studies which discuss airframe development costs are summarized in the following paragraphs.

R-761-PR, December 1971. This report presents separate CERs for the following cost elements pertaining to airframes: engineering, development support, flight test operations, tooling, manufacturing labor, manufacturing material, and quality control, as well as a separate set of equations for prototype development. The CERs are expressed as exponential equations derived by multiple regression techniques which relate costs or man-hours to aircraft physical and performance characteristics (9:1).

The equations were derived from historical data on twenty-nine post-World War II military aircraft, including cargo, tanker, fighter, bomber, and training aircraft, that were produced in quantity for operational military use. Most of the aircraft are turbojet, with a few propeller types included, and range in speed from low subsonic to Mach 2.2 (9:1). The majority of the cost and hour data used as dependent variables were obtained from the contractor. The aircraft physical and performance parameters (independent variables) found to be most useful for explaining variations in cost and man-hours are quantity, AMPR weight, and maximum airspeed at optimum altitude.

Of the twenty-nine aircraft included in the data base, fourteen were begun as prototype programs, with the remainder procured more or less under the concurrency method. The equations derived for prototype development (which approximates RDT&E) are:

Prototype Engineering (Total hours)

$$E_p = 8.634\,A^{.576}\,S^{.856}\,Q_p^{.960}$$

R^2 (unadjusted) = .65

Prototype Development Support (Total 1970 dollars)

$$D_p = .065\,A^{.366}\,S^{2.267}\,Q_p^{.485}$$

R^2 (unadjusted) = .88

Prototype Tooling (Total hours)

$$T_p = 57.335\,A^{.466}\,S^{.633}\,Q_p^{.482}$$

R^2(unadjusted) = .60

Prototype Manufacturing (Total hours)

$$L_p = .3019\,A^{1.118}\,S^{.410}\,Q_p^{1.366}$$

R^2 (unadjusted) = .98

Prototype Material (Total 1970 dollars)

$$M_p = 1.5\,A^{.585}\,S^{1.213}\,Q_p^{.622}$$

R^2 (unadjusted) = .64

Where A = AMPR weight (lb),

S = maximum speed (knots) at best altitude,

Q_p = protoype quantity (9:29)

Separate relationships were not derived for flight test costs or quality control costs relating to the RDT&E phase in this report. Additionally, CERs for manufacturing cost data were developed from the entire data set, including the concurrent procurements, and were not derived for the sole purpose of estimating prototype airframe costs.

This model received criticism from its users because of two perceived shortcomings: (1) the only two major explanatory variables were weight and speed; and (2) all aircraft were lumped together rather than treated as classes (e.g., fighter, attack, cargo, etc.). As a result of this criticism, Rand initiated a study in 1976 to produce a new estimating model.

R-1693-1-PA&E, February 1976. This study was sponsored by the Office of the Assistant Secretary of Defense as part of a research program focused on improved methods of estimating the development, procurement, and operating costs of new weapon systems. Generalized equations are presented for estimating development and production costs of aircraft, again primarily on the basis of weight and speed. A separate equation is provided for estimating prototype aircraft development costs.

Initially, 16 aircraft (including such antiquities as the B-47, F3D, F-84, F-86, and F-89) were used to derive prototype airframe estimating equations for each major cost element. The results were very poor statistically and it appeared that the equations were not reliable (8:50).

The six oldest aircraft were deleted from the sample and a second attempt was made at deriving a reliable estimating equation for each major cost element. As shown in the following table, the results were again statistically poor (8:50).

		Independent Variable					
		Weight		Speed		Quantity	
Cost Element	R^2	T-Ratio	LS*	T-Ratio	LS	T-Ratio	LS
Engineering Hours	.166	1.027	.66	.118	.09	---	---
Tooling Hours	.404	1.561	.84	-.334	.25	---	---
Manufacturing Hours	.590	3.175	.98	---	---	.62	.45
Manufacturing Material	.356	.793	.55	---	---	1.914	.90
Flight-test Cost	.189	.829	.57	1.274	.76	---	---

*Level of significance

An equation was then derived by combining the individual cost elements and dealing with total prototype program cost. The following equation was obtained:

$$TC_p = 1115.4\,(wt)^{.35}\,(N)^{.99}$$

$$R^2 = .75$$

$$F = 10.4$$

Where TC_p = total prototype program cost (1973 $)

wt = airframe unit weight (lb.)

N = number of prototypes

The problem with estimating prototype development costs, according to the report, is that there is little homogeneity among prototype programs (8:49). The samples used in this study were not limited to aircraft developed under a fly-before-buy concept. According to the authors,

> The problem is one of definition and of sample size. If we define a prototype program as one in which the first lot consists of 3 aircraft or less, we clearly will include programs in which preproduction costs are incurred in the first lot. If we define a prototype program as one in which no thought whatsoever is given to production considerations, our sample will dwindle to a very few aircraft...[8:49].

Although the equation developed to estimate total prototype program cost appears to approximate the cost of current prototype programs fairly well, "...this is clearly an area in which further research is required [8:5]".

Thus, no attempt was made to group the aircraft by type (attack, fighters, cargo, etc) when developing the prototype airframe cost equations. However, the study did explore stratification when developing CERs for cost elements other than prototype program costs. This attempt at grouping by type did not yield satisfactory statistical results.

FR-103-USN, September 1973

This report was prepared by J. Watson Noah Associates, Inc., for the Chief of Naval Operations, USN. The contract was originally awarded to examine aircraft R&D costs, and to derive CERs for their estimation. However, it became apparent very early in the effort that historical R&D costs would be very difficult to isolate with a significant degree of certainty. It was therefore decided that both R&D and production costs should be examined (12:iii).

The data base consisted of historical costs and characteristics of thirty-five airframes. Airframe costs were aggregated to include engineering, tooling and manufacturing labor, and materials costs (12:v). Although no attempt was made to develop separate equations for airframe RDT&E costs, the costs were divided into non-recurring and recurring costs. The non-recurring costs include much of what is commonly referred to as RDT&E costs and encompass the following costs:

1. Preliminary design effort for translating concepts and requirements into specifications as well as for modifications of existing systems.

2. Design engineering entailing the specification and preparation of the original set of detailed drawings for new systems as well as for major modifications of existing systems.
3. Tests, test spares, and mock ups regardless of when they occur during the program life.
4. All tooling, manufacturing, and procurement costs specifically incurred while performing development or tests, except for the manufacture of complete units during the development program.
5. The initial tools and all duplicate tools produced to permit the designed production rate for a program.
6. Training of service instructor personnel.
7. Initial technical data and manuals preparation (12:22, 23).

The CERs were developed by using multiple regression analysis and involved three major steps. First, a large number of variables in different combinations and functional forms were screened. An examination of conventional regression statistics (t-ratios, R^2, standard errors of estimate, etc.) resulted in the elimination of several candidate variables. The preferred CER was then developed and a prediction interval was computed. As a form of validation, the equation was used to predict known costs (based on known characteristics) for one or more aircraft which had been temporarily excluded from the data base. Provided these results proved satisfactory, all of the observations were included in the CER development and the coefficients were re-estimated (12:44, 45).

Screening of candidate variables which might drive airframe non-recurring costs resulted in selection of the following:

S = Maximum speed

A = AMPR weight

R = Ratio of gross take off weight to AMPR weight

T = Technology index

C = Complexity dummy

The technology index variable was included to help explain the evolutionary materials changes which have occurred in airframe manufacturing. The complexity dummy was included because the CERs developed seriously underestimated the costs of four aircraft (F-102, F-106, B-58, and F-111). The use of the dummy variable was justified for these aircraft on the basis that each had a major mission or performance parameter which required significantly new and complex technology (12:47, 48).

Regression analysis resulted in the following CER for predicting non-recurring airframe costs (12.66):

$$\text{Cost} = -5.945 + .00663S + .05138T - 1.4071R + 6.74926\,C$$

$N = 32$

$R^2 = .847$

No attempt was made to develop separate CERs for each element of airframe non-recurring total costs. The study did not address grouping the aircraft by type; instead, the entire sample was used to develop each CER.

Modular Life Cycle Cost Model (MLCCM), January 1980

This model was initially completed by Grumman Aerospace Corporation in October, 1976. The 1980 version is essentially the same except the model has been updated to include the most current data available.

The MLCCM is one of the most complete models yet developed with regard to the number and type of cost elements included. The model can be used to estimate airframe, engine, and avionics costs in the RDT&E, production, and O&S phases. Additionally, CERs are available for each aircraft type (fighter, attack, and cargo) for the production and O&S portions of this model.

The data base consists of cost elements and performance/physical characteristics from sixteen different aircraft, including such recent procurements as the F-15 and F-16. The cost elements used as dependent variables for the airframe RDT&E phase include: engineering labor, tooling labor, manufacturing and quality control (Q.C.) labor, manufacturing materials, and other direct charges. The following parameters are identified as major RDT&E airframe cost drivers and are used as the dependent variables: ultimate load factor (NZULT), maximum mach number (MAXMACH), total wetted area (TWTAREA), maximum takeoff gross weight (TOGWMAX), and number of prototype aircraft (PROTO) in the first buy (13:59-62). Both the dependent and independent variables are defined in Chapter 3 of this thesis.

Using regression analysis, the following CERs for airframe RDT&E costs were developed from a data base of 16 aircraft, including 8 fighters, 4 cargo, and 4 attack, all in the "A" configuration:

1. Total Engineering Labor (Manhours)

$$= 4.7561 \quad (PROTO)^{.1271} \quad (NZULT)^{1.7218} \quad (MAXMACH)^{.39856} \quad (TWTAREA)^{1.2588}$$

2. Total Tooling Labor (Manhours)

$$= 7.6038 \quad (PROTO)^{.32201} \quad (NZULT)^{1.2234} \quad (MAXMACH)^{.34498} \quad (TWTAREA)^{1.2137}$$

3. Total Other Direct Changes (1975 \$)

$$= (24.265 \times 10^{-6}) \ (PROTO)^{.48268} \ (NZULT)^{1.7087} \ (MAXMACH)^{.5161} \ (TWTAREA)^{1.2877}$$

4. First Airframe, Manufacturing Materials (1975 \$)

$$= (91.699 \times 10^{-6}) \ (PROTO)^{.13429} \ (NZULT)^{1.0623} \ (MAXMACH)^{.41612} \ (TOGWMAX)^{.83621}$$

5. First Airframe, Manufacturing and Q.C. Labor (1975 \$)

$$= (672.54 \times 10^{-6}) \ (PROTO)^{.0846} \ (NZULT)^{.88972} \ (MAXMACH)^{.99829} \ (TOGWMAX)^{.80029}$$

(13:60, 61)

Grumman did not include values for the coefficient of determination (R^2) in the report. Thus, it is difficult to determine how much of the variation in airframe RDT&E costs is explained by the parameters chosen as independent variables. Although the aircraft were stratified according to type for estimating the production and O&S costs, this was not done for the RDT&E phase. No rationale was presented that explained why the aircraft were not grouped by type when dealing with airframe RDT&E costs.

Summary

Five studies designed to develop parametric cost estimating models which accurately predict airframe costs have been discussed. The models described were developed as long ago as 1967 and as recently as 1976, with updates as recent as 1980. Each of the models addresses airframe RDT&E costs in varying degrees of detail. All of the models were developed by use of a multiple stepwise regression using data bases of varying sizes, including aircraft of late and early vintage. For all but the Grumman MLCCM, the primary airframe RDT&E cost drivers were identified as being only speed and weight. None of the studies grouped the aircraft by type (fighter, cargo, attack) when developing the CERs pertaining to airframe RDT&E costs.

Cost estimating relationships are used not only to estimate cost elements, but also to make cost comparisons between various alternative system designs through sensitivity analysis. The identification and inclusion of a greater number of cost drivers as independent variables makes sensitivity analysis a more viable tool when choosing between design alternatives. For example, alternative A may call for a design ultimate load factor of 11 g's while alternative B may require an ultimate load factor of 9 g's. If ultimate load factor is indeed a major cost driver (and thus an independent variable in the CER) then a cost performance trade-off analysis is possible using the CER. However, if the alternatives being compared do not have significant differences in weight (and weight and speed are the only independent variables) then a cost/performance trade-off analysis is not as easily performed.

The data base used in each study was very heterogenous in nature. That is, all aircraft are lumped together regardless of type as well as their period of development and production (the aircraft included in the Grumman MLCCM are more recent procurements). This heterogeneity makes the task of developing statistically strong CERs a difficult one.

This thesis focuses on grouping the aircraft by type when developing airframe RDT&E CERs. Chapter III contains the methodology of this thesis, including treatment of the data base, as well as the statistical methods used in the analysis.

CHAPTER III

METHODOLOGY

Basic Methodology

This section constructs the logical flow of tasks that must be accomplished to test the stated hypotheses that 1) a unique CER exists for each type of aircraft airframe for the RDT&E phase of the acquisition process, and 2) the unique CERs provide more accurate cost estimates than a single generalized CER. The data was researched and collected for each type of aircraft, but only for the "A" configuration of that aircraft. Some cost models have included the "A" configuration plus subsequent configurations, which provides for a larger data base but also skews the analysis towards those aircraft with more than the basic configuration involved in the data base. This practice can also significantly underestimate development time in terms of engineering hours, labor hours, and other direct costs. The data was then analyzed with the aid of factor analysis. The characteristics shown to be correlated by factor analysis indicate whether the different types of aircraft airframes should be regressed together or separately to obtain the regression equation. Based upon the results of the factor analysis, the variables were regressed using a step-wise regression. Prior to the regression analysis the variables were converted to logarithms to provide the optimum log-linear relationship. The first series of regressions were run without considering the possibility of multi-collinearity, and the resulting F-value was compared to the base model. Subsequent regressions were accomplished considering multi-colinearity and attempted to remove it by using interaction terms or by eliminating those variables that are highly correlated to variables already in the regression equation. The results of this thesis methodology were evaluated by comparing the F values and beta coefficients of both the thesis generated model and the base model. Additionally, tests were performed on the beta coefficients to determine the significance for all resulting regressions and the base model. The analysis also developed confidence intervals for all beta coefficients to explore the possibility of the beta value existing within the same significant range of values developed by the different models.

Data Base

Data are the key ingredients in any analysis. Accurate data are essential in the development of any model because the CERs are a direct reflection of the input parameters. The process of collecting data for cost analysis has been a difficult path to follow since most contracts fail to procure and document the detailed data necessary to conduct an analytical study. To further complicate the data collection, accounting practices differ from company to company, and even differ in the same company over a period of years. Additionally, strict definitions of terminology and methods of data collection must be used to ensure compatible data files.

The initial consideration for selection of data is that the data must logically be a determinate of what is estimated. Therefore, data used to estimate RDT&E costs for airframes should be factors of the structural complexity of aircraft design. Rand supports this logic somewhat in the selection of their model's independent variables, weight and speed, which are indicators of the structural design features of the aircraft. Furthermore, independent structural design engineers indicate that any airframe cost (RDT&E or Production) is driven by the performance, size and weight of the particular aircraft (4, 6). Grumman supports this logic in the development of their own cost model by developing CERs that use performance, size and weight as leading design parameters in estimating airframe costs.

The number of prototypes logically reflect the number of RDT&E manhours spent on tooling and manufacturing, and the dollars spent on RDT&E manufacturing materials. Additionally, the number of prototypes logically indicate the level of manufacturing facilities utilized in the initial production of an airframe assembly (4, 6).

The data used to develop this thesis were collected by Air Force Flight Dynamics Laboratory (FXB) over a period of several months from various sources, and were cross-checked by FXB with other sources to ensure accuracy and authenticity. Additionally, the Aeronautical System Division Comptroller's office provided further assurance of the data accuracy. The data utilized is a subset of that provided to Grumman Areospace Corporation and therefore provides an excellent standard for comparing study findings. The subset used pertains solely to aircraft airframes, whereas the Grumman study entailed a study of the total aircraft including avionics, engines, and aircraft structure. The following are definitions of the design parameters utilized by Grumman and this thesis for development of airframe structural CERs.

Independent Variables:

1. NZULT - Ultimate Load   Range: 3.75 to 12.75 (Number)

   Factor that indicates the environment in which the airframe will operate; a reflection of g-level necessary for operational efficiency. A high number indicates g-loads encountered by fighters and attack aircraft; whereas, a low number indicates the environment that is encountered by a cargo aircraft.

2. MAXMACH - Maximum Mach   Range: 0.54 to 2.30 (Ratio)

   Maxmach ratio relates the speed of the aircraft to the speed of sound. Additionally, it indicates increasing structural complexity which accompanies the high power levels and subsystem complexity necessary to achieve supersonic flight.

3. TWTAREA - Total Wetted Area   Range: 1200 to 32,900 (FT^2)

   Total wetted area relates to parasite drag, which in turn is a measure of the thrust required to attain a given mach number which relates to airframe strength. TWTAREA also directly measures the size of the airframe.

4. TOGMAX - Maximum Takeoff Gross Weight   Range: 24,500 to 764,000 (LB).

   Airframe weight relates to the cost of material and the labor to put it in place as well as the maximum takeoff gross weight.

5. PROTO - Number of Prototype Aircraft   Range: 2 to 42 Number in first buy

   Proto is simply the number of aircraft purchased under the research and design phase of the program. It significantly influences tooling, engineering, and manufacturing labor (10:62).

Dependent Variables:

1. ENG - Engineering Labor

   Includes all direct and overtime labor charges except premium pay, including off-site labor where applicable plus the systems engineering and program management required to design and analyze the airframe and provide liason for its construction.

2. TOOL - Tooling Labor

   Includes all direct and overtime labor charges except premium pay, including off-site labor where applicable, to provide tools to manufacture the airframe.

3. MANF - Manufacturing Hours

   Includes all direct and overtime labor charges except premium pay, including off-site labor where applicable to manufacture of airframe.

4. MANMAT - Manufacturing Materials

   Includes material to manufacture the airframes plus manufacturing and quality control, travel, relocation and premium pay; procured materials under termination; shipping charges; insurance on aircraft; applicable Government Furnished Equipment and Contractor Furnished Equipment material; and miscellaneous charges.

5. ODC - Other Direct Changes

   Includes Special Test Equipment; tooling materials; travel, relocation and premium pay for engineering and tooling labor. (10:60)

The data consists of independent and dependent variables gathered on 16 aircraft: 4 attack, 4 cargo, and 8 fighters. A complete listing of the data can be found in Appendix A.

Statistical Procedures

The procedures utilized during this research will be factor analysis and regression analysis. The following is a brief description of these analyses and the statistical implications.

Factor Analysis

Factor analysis is a multivariate technique to reduce a number of variables to a few interpretable constructs. Factor analysis is used primarily for grouping data on a statistical basis and empirical clustering of observations. Simply stated, factor analysis develops a few constructs for the total set of observed variables based on interrelationships. None of the variables are treated differently from the others, as opposed to multiple regression, in which one variable is considered the criterion (dependent) variable and all others the predictor (independent) variables. Factor analysis considers each of the observed variables as a dependent variable which is a function (construct) of some underlying, latent, and hypothetical factors. Conversely, each factor can be looked at as the dependent variable which is a function of the observed variables.

Factor analysis has some basic concepts and terminology. A factor is a linear combination of the observed variables. In other words,

$$F = a_1x_1 + a_2x_2 + a_3x_3 + \dots + a_nx_n$$

In this logic, the factor equates to the dependent variable (y) in multiple regression. The primary difference between factor analysis and multiple regression is that the total observed variables are grouped in a manner such that more than one factor is derived. Therefore, the following relationship may be developed using factor analysis

$$\begin{aligned} F_1 &= a_{11}x_1 + a_{21}x_2 + a_{31}x_3 \\ F_2 &= \qquad\qquad\qquad\qquad a_{42}x_4 + a_{52}x_5 \\ F_3 &= \qquad\qquad\qquad\qquad\qquad\qquad a_{63}x_6 + a_{73}x_7 \end{aligned}$$

The above analysis develops a three factor relationship derived by using seven variables. The first factor consists of three variables (x_1, x_2, x_3), the second (x_4, x_5) and the third (x_6, x_7). The important point to remember is that each factor has coefficients for all seven variables in the analysis but the coefficients may be zero or close to zero. Factor analysis also provides a predicted score, similar to a regression analysis estimate (y), for each individual factor developed, which is called a factor score. Therefore,

$$F_i = a_1x_{1i} + a_2x_{2i} + \dots + a_nx_{ni}$$

Thus, a primary difference between regression and factor analysis is that each observation will be assigned as many factor scores as there are factors and not just one score. The factor scores are summarized in a factor scores matrix for each sample (analysis). The factor score is correlated with the observed score for each variable, and summarized in a factor loadings matrix. Factor loading can be described as the correlation between the scores. If there are n variables and r factors, there will be a total of (n x r) factor loadings.

There are three useful techniques to describe the relationship represented by a factor loadings matrix. The first is the eigenvalue, which is mathematically identical to R^2 used in multiple regression. To obtain the eigenvalue, square the loadings of each factor and sum to get a "sum of squares" for each factor. Each eigenvalue summarizes a fraction of total variance. In order to obtain the variance explained by a particular factor, its corresponding factor score sum of square must be divided by the number of factors developed by the analysis. As an example, if the sum of squares equal 2.68 for factor number 3, and there are six factors in the factor loadings matrix, the variance explained by factor 3 would be 2.68/6 = .447 or 44.7% of the total variance is explained by this factor. The second technique is called communality (h^2), which represents the variance of each variable summarized by two factors. Simply stated communality is the percentage of total variance which is summarized in common factors. Common factors are those factors which are shared by at least two variables. All other factors are call unique factors. The third technique involves correlation prediction. Each factor loading represents a correlation between a variable and a factor. Therefore, the predicted correlation between two variables can be generated by multiplying their factor loadings on each factor and summing. As an example, if .68 and .59 are the factor loadings for the first factor, variables one and two, and .28 and .32 are the factor loadings for the second factor, variables one and two, then the correlation between variable one and two would equal (.68 x .59) + (.28 X .32) = .49.

Factor analysis is a multivariate statistical technique which can be described as a set of techniques. It is intended that the preceeding pages merely describe the basis of the procedures to be used in this thesis. Factor analysis is utilized to justify the development of separate cost equations for the airframes of fighters, attack and cargo. Conducting factor analysis on the performance characteristics of the airframe should result in a grouping of factors that correlate with at least two definite groups, fighter and cargo. If the above stated hypothesis can be statistically supported, then the development of a cost estimating equation for each different type of airframe during the RDT&E phase of an acquisition would appear justified. Additionally, if attack airframes do not appear statistically different from the fighter airframes, then one general equation can be developed for both types. Following the factor analysis portion of the research, the data is regressed to develop CERs for each dependent variable based on the factor loading groupings.

Regression Analysis

The regression procedure utilized in this thesis is a linear multiple regression. This means that the relationship between y (the dependent variable) and each one of the independent variables is linear when expressed in logarithms. Assuming linearity, and letting B_o (Beta) equal the y-intercept, B_1 equal the slope of the relationship between y and x_1, B_2 equal the slope between y and x_2 and so forth, until the list of independent variables is exhausted (represented by B_m x_m), plus an error term (e), yields the resulting regression equation:

$$y = c + B_1 x_{1i} + B_2 x_{2i} + \ . \ . \ . \ + B_m \ x_{mi} + e_i$$

The coefficients B_1, B_2, . . . B_n are called partial regression coefficients, since they indicate the influence of each independent variable on y with the influence of all other variables held constant.

There are seven important assumptions when using multiple regression. They are:

Assumption 1. The e_i are all independent of each of the m independent variables.

Assumption 2. The errors for all possible sets of given values x_1, x_2,.... x_m are normally distributed.

Assumption 3. The expected value of the error is zero for all possible sets of given values.

Assumption 4. The variance of the errors is constant for all possible sets of given values.

Assumption 5. Any two errors e_i and e_i are independent, therefore, the covariance is zero.

Assumption 6. None of the independent variables is an exact linear combination of the other independent variables.

Assumption 7. The number of observations (n) must exceed the number of independent variables (m) by at least two (i.e., n - m + 2) 5:411, 412 .

The procedures used in this thesis consist of log-linear step-wise regression. A statistical text book will provide a more detailed explanation of the regression procedures and statistical testing. However, the most important aspect of regression analysis testing which is pertinent to this thesis is explained. In order to understand regression and the testing for significance the following concepts must be understood: the sum of square total (SST or total variation) is equal to the sum of square error (SSE or unexplained variation) plus the sum of square regression (SSR or explained variation). This can be written as:

$$SST = SSE + SSR$$

$$\sum_{i=1}^{n} (y_i - \bar{y})^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 + \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2$$

Where:

$\bar{y}$ = the average value for y

y_i = the actual value for the i^{th} observation

$\hat{y}_i$ = the predicted value to the i^{th} observation

This relationship provides the basis for testing for the significance of the regression equation. The statistical tests used in this thesis are defined below. These tests indicate the "goodness of fit" of the model and establish relative error bounds on predictions.

Mean Squared Error (MSE) is an unbiased estimator of the model's variance, and is obtained by dividing SSE by the degrees of freedom.

$$MSE = \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{n-k} = \frac{SSE}{n-k}$$

Where:

y_i = dependent variable

$\hat{y}_i$ = regression estimate for y_i

n = number of observations

k = number of independent variables

k+1 = number of parameters estimated

SSE = sum of squares error.

A small mean squared error is desired and is indicative of a good estimate for y and a small degree of error. This can also be stated as such: a small MSE indicates that a significant portion of the variance between y_i and y_i is explained by the regression equation.

The Coefficient of Determination (R^2) measures how well the explanatory variables account for the variations in the actual cost data. The coefficient R^2 measures the proportion of total variance about the mean of y that is explained by the regression.

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2} = 1 - \frac{SSE}{SST} = \frac{SSR}{SST}$$

Where:

y_i = dependent variable

$\hat{y}_i$ = *regression estimate of* y_i

$\bar{y}$ = mean of dependent variable

SSR = sum of squares regression.

SST = sum of squares total

Ideally, the coefficient of determination can be written as:

$$R^2 = \frac{\text{Explained Variance}}{\text{Total Variance}}$$

The value of R^2 lies between zero and one and can be directly converted to the coefficient of correlation by taking the square-root of the value. This thesis uses R^2 since its interpretation can be better utilized than can the coefficient of correlation.

Another useful statistic is Students' t, which is used to determine the significance of an individual parameter, and is used in computing the confidence intervals and prediction intervals.

To test the significance of an individual coefficient (B_i) in the regression equation, a test is used which is similar to that for the slope in simple linear regression. The null hypothesis, $H_o : B_i = \emptyset$, means that the variable x_i has no linear relationship with y, holding the effect of the other independent variables constant. The best linear unbiased estimate of B_i is the sample partial regression coefficient b_i. Under the assumption that the error is normally distributed, the test for the null hypothesis follows the t-distribution with n - (k + 1) degrees of freedom

$$H_o : B_i = 0$$

Then:

$$t = \frac{b_i - 0}{S_{bi}}$$

Where:

H_o = Null hypothesis

B_i = Coefficient of the regression equation

b_i = Sample partial regression coefficient

S_{bi} = The amount of sampling error in the regression coefficient b; which can be written as:

$$S_{bi} = \frac{SSE}{n-(k+1)} \cdot \frac{1}{\sum_{i=1}^{n} (x_i - \bar{x})^2}$$

Where:

SSE	=	sum of squares error
n	=	number of observations
k+1	=	number of parameters estimated
k	=	number of independent variables
x_i	=	independent variable
$\bar{x}$	=	mean of independent variables

When the generated value for t exceeds the critical value of t (determined from a t-distribution table), then the null hypothesis of no significance is rejected.

To construct a confidence interval for B_i, the equation below is used.

$$b_i - t_{(a/2,\, n-2)} S_{bi} \leq B \leq b_i + t_{(a/2,\, n-2)} S_{bi}$$

Where:

a	=	level of significance
a/2	=	one half of the significance level (two-tailed test)

The t statistic is used to construct a confidence interval around the regression coefficients for comparison with the regression coefficients of the base model, and then to test for signficance using the base model as the null (H_o) hypothesis. This test can only be utilized for those portions of the regression equation that are similiar. If the regression equations differ not only in terms of B coefficients but also in terms of independent variables the F-test is used to compare the two models. In fact, model x will not be directly compared to model y but will be compared to the same basic hypothesis (H_o). This type of comparision will result in the comparison of the model by standarized statistical measures such as R^2 and the F-ratio.

The F-test is based upon the common null hypothesis that there is not a linear relationship at all in the population, i.e., that all B values are equal to zero.

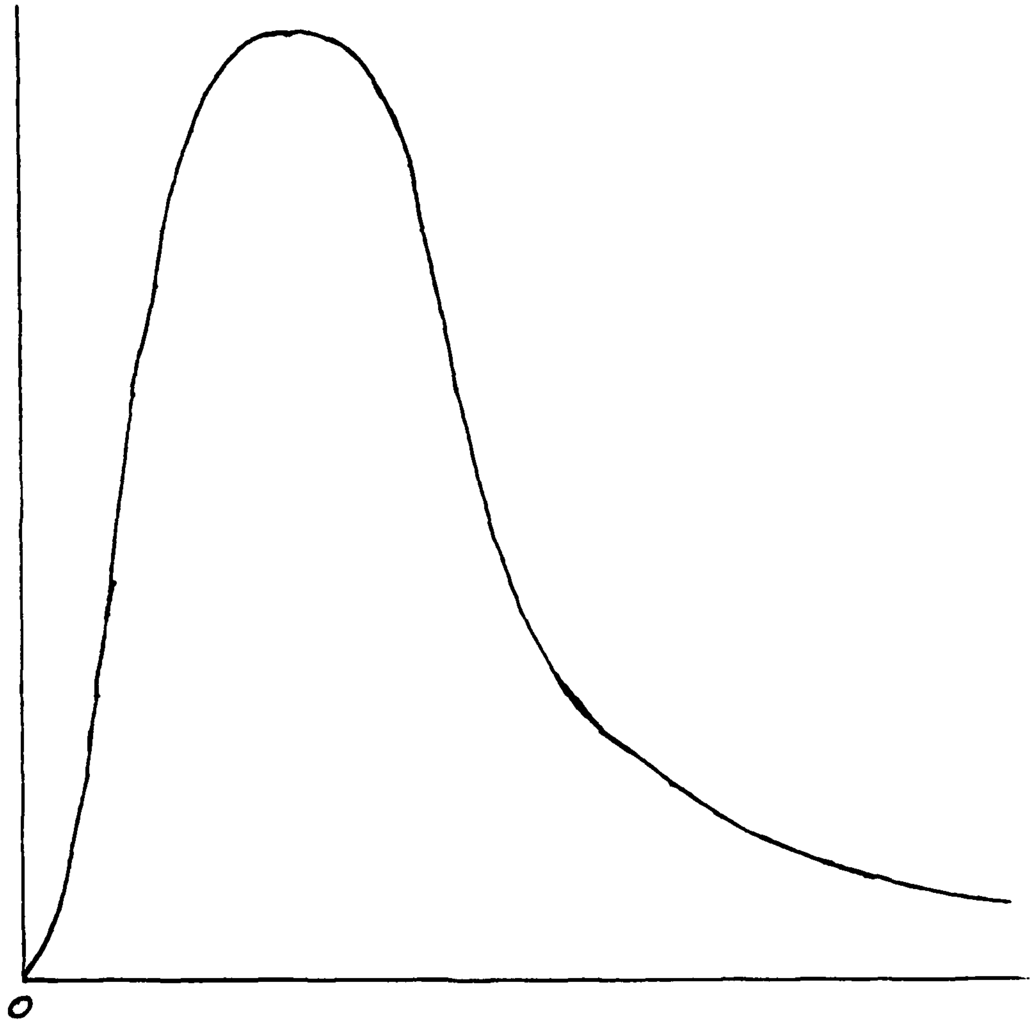
$$H_o : B_1 = B_2 = \ldots = B_m = \emptyset$$

If this hypothesis were true SSE would be large and SSR would be small. In order to obtain the F-ratio, the values for SSE and SSR are divided by their relative degree of freedom (d.f.). The resulting ratios are called the mean-square regression (MSR) and the mean-square error (MSE); the ratio of MSR to MSE follows the F-distribution and is the $F_{(CALC)}$ value.

The degrees of freedom associated with SSE is n-(k+1), because (k+1) parameters are being estimated. The degree of freedom for SSR is the number of independent variables. Therefore the appropriate statistical measurement to test the null hypothesis is the ratio of MSR to MSE, which follows the F-distribution with appropriate degrees of freedom (Figure 1). Therefore, the $H_o = B_1 = B_2 = \ldots = B_m = \emptyset$ is tested by:

$$F_{CALC} = \frac{SSR/k}{SSE/(n-k+1)} = \frac{MSR}{MSE}$$

To determine the significance of an individual coefficient (B_i), the t-test should be applied (assuming the error is normally distributed). This statistic is part of the computer output and verifies the significance of the coefficient. Additionally, the F-test is used to test the null hypothesis (no linear relationship) at the levels of signficance of 0.05 and 0.01. These results of the thesis generated model are then compared to the base model in an attempt to determine the relative accuracy and confidence in the regression equations.



The F-Distribution

Figure 1

Summary

This section provides the basic statistical background required to comprehend the analytical results presented in the following chapter. Chapter IV presents analysis of the data. The data analysis starts with a review of the data to determine whether the independent variables are logical estimators (cost drivers) of the dependent variables. Upon completion of the data review, the results and findings of the factor analysis are presented. The results are then used as inputs for the subsequent regression analysis. Once the regression results are examined, the equations are compared to the base model in order to determine which model more accurately estimates airframe RDT&E costs.

CHAPTER IV

ANALYSIS

The analysis in this chapter is presented in five distinct phases. First, the expected logical parametric relationships are developed for each dependent variable. Second, the airframe type groupings are developed based upon the results of the factor analysis. Third, the resulting airframe type groupings are regressed using both the dependent and independent variables for each group. Fourth, the expected logical parametric relationships are compared to the regression equations. Finally, the results of this regression are compared to the base model (Grumman MLCCM, 1980).

Parametric Relationships

Logical relationships between the dependent and independent variables must be developed to provide a basis for comparision to the subsequently developed regression equations before any analysis is accomplished. Development of these relationships serves several purposes. First, the development process serves as a crosscheck of the independent variables relationship with the dependent variables. Statistically, it is possible to have a good apparent predictor (independent variable) that is totally unrelated to what it accurately predicts (dependent variables). Therefore, the development of the logical relationship serves as a filtering process, eliminating those variables that are unrelated and retaining those variables that are logically related to the variable being estimated. Secondly, the relationships can be used as a basis of support for the subsequent regression equations. And finally, the development process serves as an instrument to support the validity of the analysis.

The major assumption contained in our parametric relationship analysis is that the variables defined by the base model are in fact cost drivers of the dependent variables. Based upon this assumption, the hypothesized order of entrance and relative importance of the independent variables are discussed in the following paragraphs, with the anticipated parametric relationship logically developed for each cost element.

The logical relationships presented below are for each of the dependent variables with each independent variable. It should be noted that the independent variables are listed in the order of expected influence on the dependent variable. In the development of relationships, the first one or two independent variables which enter the equation are expected to explain the major portion of the dependent/independent variable relationship. The order of entrance of the remaining three or four variables is exceedingly difficult to estimate without performing a statistical measure of correlation with the initial independent variables and the dependent variable (See Chapter III). In general, we expect the value of the dependent variables (measures of estimated airframe costs) to increase as the size, performance or number of prototype increase.

The variables are:

Independent	Dependent
NZULT - Ultimate Load Factor	ENG - Engineering Hours
MAXMACH - Maximum Mach	ODC - Other Direct Charges
TWTAREA - Total Wetted Area	MANMAT - Manufacturing Materials
TOGWMAX - Total Takeoff Weight	TOOL - Tooling Hours
PROTO - Number of Prototypes	MANF - Manufacturing Hours

Before proceeding with the parametric relationships it is important to review the definitions of both the independent and dependent variables presented in Chapter 3.

Engineering

Engineering relates to the direct and overtime labor hours required to design and analyze the airframe and provide liaison for its construction. In estimating this cost element it is logical to assume that three groups of independent variables would dominate the estimated regression equations. The three groups are represented by size (TOGWMAX and TWTAREA), complexity (MAXMACH and NZULT), and the number of prototypes (PROTO). One variable from each of these groups would logically enter the estimated regression equation before the second variable from either size or complexity would enter the equation. This stated relationship forms a basic rule for estimating the regression equations. However, this rule may be overridden when a particular dependent variable appears heavily skewed towards one of the groups. Based on this logic, the following represents the hypothesized regression equation for engineering hours.

ENG = Function (TOGWMAX, PROTO, NZULT, TWTAREA, MAXMACH).

There is a possibility that the grouped variables representing size and complexity are likely to exchange positions depending upon the correlation with the dependent variable. However, in estimating the regression equation for Engineering the rule pertaining to the groups appears to apply. Therefore, the order of entrance of the first three independent variables is likely to be one variable from each of the three groups since the engineering dependent variable, by definition, is correlated to size, complexity, and the number of prototypes.

Tooling

Tooling includes all direct and overtime labor charges, except premium pay, including off-site labor, to provide tools to manufacture the airframe. The tooling equation is likely to enter only one independent variable representing each of three dominant groups, before entering the second variable from any of the dominant groups defined above. Logically, tooling is signficantly correlated to the complexity and size of the airframe. This logic dictates that a factor representing size and complexity must be assigned the first and second positions in the estimated step-wise regression equation. The following is a prediction of the expected step-wise regression.

TOOL = Function (NZULT, TOGWMAX, PROTO, MAXMACH, TWTAREA).

There is a possibility that the grouped variables representing size and complexity are likely to exchange positions depending upon the correlation with the dependent variable.

Manufacturing and Quality Control

Manufacturing and Quality Control (QC) include all direct and overtime labor charges except premium pay, including off-site labor to manufacture the airframe. By definition, manufacturing and QC are directly related to the size and complexity of the airframe. In this case, the significance of PROTO would only be great if the number of prototypes is large. Therefore, it is expected that both variables from the groups representing complexity and size would enter the step-wise regression equation before PROTO.

The step-wise regression equation is expected to resemble the following hypothesized equation.

MANF = Function (NZULT, TOGWMAX, MAXMACH, TWTAREA, PROTO).

Again there is a possibility that the grouped variables can exchange locations within the estimated equation depending upon correlation with the dependent variable. Additionally, there is a possibility that the group representing size could enter both independent variables, before the group representing complexity, based upon correlation with manufacturing hours.

Manufacturing Materials

Manufacturing Materials includes the material used to manufacture the airframe plus other miscellaneous charges such as: QC, travel, relocation and premium pay, shipping charges, insurance, Government Furnished Equipment (GFE), and Contractor Furnished Equipment (CFE). Manufacturing materials is skewed towards the actual materials required to assemble the airframe. Therefore, it is logical to expect that the dominant groups are the number of prototypes and size. It is highly possible that both size variables can enter the step-wise regression equation before either variable representing complexity. The following is the hypothesized step-wise regression equation for manufacturing materials.

MANMAT = Function (PROTO, TOGWMAX, TWTAREA, NZULT, MAXMACH).

Furthermore, there is a possibility that the members of the groups may exchange places with each other in the hypothesized step-wise regression equation, or that one of the complexity variables can preceed one of the size variables. However, it is highly unlikely that any variable can displace the prototype variable.

Other Direct Charges

Other direct charges (ODC) include Special Test Equipment (STE), tooling materials, relocation and premium pay for engineering and tooling labor. Other direct charges are significantly related to the number of prototypes due to STE and other miscellaneous areas that arise during prototype construction. Additionally, ODC is related to engineering and tooling, so logically ODC is dependent upon the most significant estimator from engineering and tooling. The following is a hypothesized step-wise regression equation for ODC.

ODC = Function (PROTO, NZULT, TOGWMAX, MAXMACH, TWTAREA).

Once again, there is a possibility that fluctuations may occur between either the size and complexity groups, or between the variables within a group. However, it is unlikely that either group would place a variable ahead of the prototype variable in the ODC equation.

Factor Analysis

The purpose of factor analysis is to reduce a number of variables to a few interpretable constructs. The process described below is presented to provide an understanding of how the groupings are developed for the step-wise regession analysis.

The following analytical procedures are used: First the data are prepared. The data used are the structural characteristics of the airframe: 1) TOGWMAX, 2) TWTAREA, 3) NZULT, and 4) MAXMACH. Data are used for six different airframes within each airframe type.

Fighter	Attack	Cargo
F-4	A-3	C-2
F-6	A-4	C-130
F-14	A-5	C-133
F-15	A-6	C-135
F-16	A-7	C-141
F-102	A-10	C-5

Second, factor analysis is then performed on the data set, resulting in constraints that are used to develop logical groupings by airframe type for the step-wise regression. Third, the results are analyzed to determine whether the whole data set (Fighter, Attack, and Cargo) or a subset of the data set (Fighter alone, Attack alone, Cargo alone, or some combination) is to be used for the step-wise regression.

The initial factor analysis is run using the four structural design variables for each airframe. The factor run results in four factors being developed. Initial review of these factors shows that the first three factors support a communality among the data. However, the fourth factor exhibits a grouping of Fighter and Attack. This grouping is based upon the positive factor loadings for TWTAREA, NZULT, and TOGWMAX, while the cargo factor loadings tend to be negative (See Table 1).

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
2180=				
2190=	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
2200=				
2210= FTWT	.16100	.94929	.11259	.18324
2220= FNZU	.94518	-.30935	.04962	.04711
2230= FMXM	.52783	-.17676	.76819	.25106
2240= FTOG	.23308	.27608	.81393	.39679
2250= ATWT	.93478	.24220	-.11073	.17696
2260= ANZU	.02686	-.17045	.37197	.91205
2270= ANXM	.16827	.20212	-.94998	.16729
2280= ATOG	.80927	.48260	-.05008	.30939
2290= CTWT	.80712	-.05426	.36210	-.39787
2300= CNZU	.02968	.88575	-.10731	-.32512
2310= CMXM	.53389	-.71369	.37328	.02475
2320= CTOG	-.17313	-.04591	.08667	-.97999
2330=				

Table 1

Initial Factor Loadings

Further analysis of the factor run centers on the eigenvalue, communality (h^2), and the correlation between a variable and a factor (these techniques are presented in Chapter 3). Using the above table, the correlation between variables and factors are obtained. As an example, Fighter TWTAREA (FTWT) = .161 for Factor 1 and .94929 for Factor 2;

likewise, Fighter NZULT (FNZU) = .94518 for Factor 1 and - .3095 for Factor 2 and so on across the matrix. To obtain the correlation the formula would be:

(FTWT Factor 1 X FNZU Factor 1) + (FTWT Factor 2 X FNZU Factor 2) + (FTWT Factors X FNZU Factor 3) + (FTWT Factor 4 X FNZU Factor 4)

Therefore:

(.161 X .945) + (.949 X .309) + (.113 X .049) + (.183 X .049) + (.183 X .047) = -.127

Subsequent correlation generation is possible, but the overall result is presented in Table 2. The table is read across rows; the first line is read that Factor 1 is correlated to itself with a value of .80559. Factor 1 is correlated to Factor 2 negatively (-.08452), to Factor three positively (.46793), and to Factor 4 positively (.35345).

```
241Ø=
242Ø=                FACTOR  1   FACTOR  2   FACTOR  3   FACTOR  4
243Ø=
244Ø= FACTOR  1        .8Ø559     -.Ø8452      .46793      .35345
245Ø= FACTOR  2        .29493      .6675Ø     -.39612      .Ø5965
246Ø= FACTOR  3        .46641     -.19452     -.2Ø494     -.Ø3823
247Ø= FACTOR  4       -.21567      .44997      .76297     -.41Ø96
248Ø=1FACTOR ANALYSIS                       Ø3/22/82  14.42.32.
249Ø=
```

Table 2

Factor Score of the Initial Factor Analysis

The eigenvalues are presented in Table III. The table is read across the rows; therefore, FTWT on Factor 1 has an eigenvalue equal to 4.52772. This eigenvalue is then divided by the number of factors presented in the table, which is equal to 12 factors. This procedure indicates the percentage of total variance explained by FTWT through Factor 1. By reading down the cummulative percentage (CUM PCT) column it is apparent that only four factors are required to explain 100% of the data's variance. This table reinforces the fact that only four factors are presented in the Factor Matrix presented in Table 3.

VARIABLE	EST COMMUNALITY	FACTOR	EIGENVALUE	PCT	CUM PCT
FTWT	1.00000	1	4.52772	37.7	37.7
FNZU	1.00000	2	3.03168	25.3	63.0
FMXM	1.00000	3	2.25841	18.8	81.8
FTOC	1.00000	4	1.80523	15.0	96.9
ATWT	1.00000	5	.37704	3.1	100.0
ANZU	1.00000	6	.00000	.0	100.0
AMXM	1.00000	7	.00000	.0	100.0
ATOC	1.00000	8	.00000	.0	100.0
CTWT	1.00000	9	.00000	.0	100.0
CNZU	1.00000	10	-.00000	-.0	100.0
CMXM	1.00000	11	-.00000	-.0	100.0
CTOC	1.00000	12	-.00000	-.0	100.0

1FACTOR ANALYSIS 03/22/82 14.42.32.

Table 3

Factor Matrix for the Initial Factor Analysis

Communality is defined as the variance of each variable summarized by two factors, or simply, the percentage of total variation explained by common factors. The values for communality are presented in Table 4. The table is read across the rows; as an example, the communality value for FTWT is equal to .97332. This value expresses the fact that 97.332% of FTWT variance is explained by other factors utilized in the factor analysis run, or that FTWT only contributes 2.6% towards the 100% explained by the combination of all variables. The communality table shows all variables to have a communality of .90 or greater, which means that no single variable is the primary determinant of a Factor (Quartimax Rotation).

```
1930=
1940= VARIABLE      COMMUNALITY
1950=
1960= FTWT           .97332
1970= FNZU           .99374
1980= FMXM           .96299
1990= FTOG           .95047
2000= ATWT           .97605
2010= ANZU           .99997
2020= AMXM           .99962
2030= ATOG           .98605
2040= CTWT           .94380
2050= CNZU           .90265
2060= CMXM           .93434
2070= CTOG           .99998
2080=:FACTOR ANALYSIS
2090=
```

Table 4

Communality of the Initial Factor Analysis

Further investigations are required to ascertain whether there really exists a definite grouping of the fighter and attack airframe types. To resolve this issue, several artificial variables were created for each airframe type. The first is TWTAREA divided by TOGWMAX, and is used to represent a characteristic of the airframe size.

FF = Fighter TWTAREA ÷ Fighter TOGWMAX

AA = Attack TWTAREA ÷ Attack TOGWMAX

CC = Cargo TWTAREA ÷ Cargo TOGWMAX

The second is NZULT multiplied by MAXMACH, and is used to represent the performance and handling characteristics of the airframe.

FN = Fighter NZULT X Fighter MAXMACH

AN = Attack NZULT X Attack MAXMACH

CN = Cargo NZULT X Cargo MAXMACH

And finally, NZULT is divided by MAXMACH, and is used to represent a ratio of g-load environment to maximum mach.

FM = Fighter NZULT ÷ Fighter MAXMACH

AM = Attack NZULT ÷ Attack MAXMACH

CM = Cargo NZULT ÷ Cargo MAXMACH

Three more factor analyses are run using these artificial variables. The initial factor analysis run using FM, AM and CM results in only one factor being developed. However, this one factor tends to show more support for a fighter/cargo grouping, with both the values for CM and FM positive (Table 5).

```
1260=
1270=                  FACTOR  1
1280=
1290= FM                .42302
1300= NM               -.39671
1310= CM                .36107
1320=
```

Table 5

Factor Score of the Environment

In this particular case no correlations are developed because only one Factor exists. However, the eigenvalues for this run are presented in Table 6. Once again, the cumulative percentage is equal to 100, which indicates that the variables are explaining the total variance among themselves.

```
550=
560= VARIABLE          MEAN     STANDARD DEV     CASES
570=
580= FM              6.5272           2.7336         6
590= NM              8.6154           7.1015         6
600= CM              5.7018           1.8517         6
610=1FACTOR ANALYSIS                           03/22/82  15.34.38.
620=
```

Table 6

Factor Matrix of the Environment

The communality of these three artificial variables are presented in Table 7. The table indicates that although 100% of variation is explained, there is a possibility that significant differences exist for these three variables. The differences are recognized by the fact that the communality loadings are not extremely high (close to one), but are in the .60 to .80 range. Therefore, unexplained variance within the variables exists, and is possibly explained by other variables or artificial variables (Quartimax Rotation).

VARIABLE	COMMUNALITY
FM	.82159
NM	.72255
CM	.59858

Table 7

Cummunality of the Environment

The second factor analysis using FN, AN, and CN as the artificial variables results in two factors being developed. Once again, factor one tends to show a relationship for a fighter/cargo grouping. However, factor two shows the opposite relationship, supporting a fighter/attack grouping (Table 8).

	FACTOR 1	FACTOR 2
FN	.44647	.33338
AN	-.15728	.81002
CN	.70941	-.27094

Table 8

Factor Score of Performance

Correlation for the variables are developed from the above table and result in a positive correlation between fighter and attack (.00413), a negative correlation between cargo and attack (-.00124) and a negative correlation between fighter and cargo (-.05). The correlations indicate that there is little justification in grouping one airframe type with another.

The eigenvalues for this factor run are provided in Table 9. Again the cumulative percentage is equal to 100, with CN contributing the final 10.2 %. In analyzing, the communalities for FN, AN, and CN it is apparent that there is a relatively high communality between these three artificial variables. Which means 80% to 93% of the variance is explained by the two factors.

```
860=
870= VARIABLE EST COMMUNALITY  FACTOR  EIGENVALUE  PCT  CUM PCT
880=
890= FN            1.00000       1      1.65541  55.2    55.2
900= AN            1.00000       2      1.03741  34.6    89.8
910= CN            1.00000       3       .30718  10.2   100.0
920=1FACTOR ANALYSIS                             03/22/82  15.18.55.
930=
```

Table 9

Factor Matrix of Performance

The third factor analysis is run using FF, AA, and CC as the artificial variables and results in two factors being generated. Factor one shows a diverse range: AA highly positive, CC highly negative and FF approximately equal to zero (Table 10). Therefore, factor one tends to show support for three different groups, one for each one of the airframe types. Factor two shows support for grouping attack and cargo airframes, with a high positive factor loading for the fighters and extremely close negative factor loadings for the attack and cargo airframes.

```
1520=
1530=              FACTOR  1   FACTOR  2
1540=
1550= FF           -.01679      .96485
1560= AA            .58936     -.16798
1570= CC           -.56878     -.13599
1580=
```

Table 10

Factor Score of Size

Correlations for the variables are developed from the above table and result in positive correlation between fighter and attack (.00015), a negative correlation between cargo and attack (-.008), and a negative correlation between fighter and cargo (-.013). Again, the correlations indicate little support for grouping the airframe types.

The eigenvalues and communalities for the FF, AA, and CC are presented in Table 11. In reading both tables, it is apparent that the two factors that are developed explain a relatively high percentage of the variation of the artificial variables, but again indicate that a portion of the variation in each is not explained by either factor.

```
840=
850= VARIABLE EST COMMUNALITY  FACTOR  EIGENVALUE  PCT  CUM PCT
860=
870= FF           1.00000        1      1.50032  50.0   50.0
880= AA           1.00000        2      1.01807  33.9   83.9
890= CC           1.00000        3       .48161  16.1  100.0
900=1FACTOR ANALYSIS                           03/22/82  15.26.29.
910=
```

Table 11

Factor Matrix of Size

Factor Analysis Summary

Factor analysis supports grouping by airframe type, and thus, a separate CER for each airframe type must be developed. This conclusion is drawn on the basis of the four previously analyzed factor analysis runs. Each of the four runs indicate that there are fluctuations and variations internal to the airframe types. This is apparent in the factor loadings, where in one case the loadings would indicate a grouping and in another case it would support the opposite grouping. However, the most important of the decision criteria remains very consistent, that is the correlation between a variable and a factor. In every case identified there exists a correlation between the airframe types that is extremely close to zero. This overriding criteria indicates that a separate CER for each airframe type should be developed.

Regression Analysis

The regression procedures utilized in this chapter are identified in Chapter III, except for one point of clarification. The regression process is a multiple step-wise regression in lieu of merely a multiple regression. The difference is extremely important for the process of analyzing the regression analysis results. Pure multiple regression generates the same results (given the same data) as a step-wise regression. However, a step-wise regression generates a table, identifying the order in which the variables entered the regression equation. This is important in that the effects of each independent variable can be analyzed as it enters the regression equation.

The initial step-wise regression is accomplished using the same data base as the base model; however, the second step-wise regression utilizes two artificial variables, TT and MXNZ. The artificial variable TT is obtained by multiplying TOGWMAX by TWTAREA, and is used to represent the overall size and weight of an airframe (square foot pounds). The artificial variable MXNZ is obtained by mutliplying MAXMACH by NZULT, and is used to represent the total flying environment created when flying a high-g airframe at a high mach (synergistic effect of speed and load factor).

Initial Regression

The initial regression is accomplished using the data base identified in Appendix A. The data base consists of all 16 aircraft (8 fighters, 4 attack, and 4 cargo) and is utilized for comparison with the base model. The initial regression results in five equations being developed, one for each dependent variable (Engineering, Other direct charges (ODC), Manufacturing Materials, Manufacturing Labor, and Tooling). The following is the result of the initial regression analysis.

The initial dependent variable that is regressed is ODC, and results in the following regression equation being developed.

$$\mathrm{Ln(ODC)} = -10.3184 + (.5661\ \mathrm{Ln(PROTO)}) + (.8483\ \mathrm{Ln(TOGWMAX)}) + (1.1559\ \mathrm{Ln(NZULT)}) + (.212\ \mathrm{Ln(TWTAREA)}) + (.3503\ \mathrm{Ln(MAXMACH)})$$

The regression equation results in an R^2 value equal to .889, which means that the equation explains 88.9% of the variance of the ODC dependent variable. The calculated F = 16.025, with 5 and 10 degrees of freedom, and is significant to the .991 level of confidence. Additionally, the beta values computed from the regression form the following confidence intervals at the 95% confidence level (Table 12).

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95 PCT C.I.	
PROTO	.5661	.2545	.8776
TOGWMAX	.8483	.2974	1.3992
NZULT	1.1559	-.0072	2.3190
TWTAREA	.2120	-.1201	.5441
MAXMACH	.3503	-.2880	.9886
CONSTANT	-10.3184	-17.4998	-3.1371

Table 12

Initial Regression Equation Summary (ODC)

The estimated values generated by the regression analysis result in a regression line that predicts the actual values with a relatively high accuracy. None of the predicted values differ from the actual values by more than two standard deviations (Figure 2). In review of the residuals presented in Figure 2, the majority of the estimated values are close to the actual values with the exception of three outlying estimates (.4585 equals one standard deviation).

```
2740=
2750= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
2760=
2770=
2780= RESIDUAL PLOT.
2790=
2800=   Y VALUE    Y EST.  RESIDUAL -2SD             0.0              +2SD
2810=
2820=     2.605     2.950     -.145               .   I
2830=     2.476     2.254      .221                   I    .
2840=     3.575     4.410     -.834 .                 I
2850=     4.613     4.585      .028                   I.
2860=     6.208     5.775      .434                   I         .
2870=     3.466     3.307      .161                   I   .
2880=     4.711     4.577      .134                   I  .
2890=     4.281     4.857     -.577      .            I
2900=     4.847     4.711      .135                   I  .
2910=     2.931     2.808      .123                   I  .
2920=     5.371     5.211      .159                   I   .
2930=     4.551     5.267     -.717    .              I
2940=     5.301     5.131      .170                   I    .
2950=     5.165     4.965      .200                   I     .
2960=     5.312     5.083      .229                   I     .
2970=     5.901     5.623      .278                   I       .
2980=
2990= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
3000=          R INDICATES POINT OUT OF RANGE OF PLOT
3010=
3020=
3030= NUMBER OF CASES PLOTTED        16.
3040= NUMBER OF 2 S.D. OUTLIERS       0 OR      0 PERCENT OF THE TOTAL
3050=
3060= VON NEUMANN RATIO    2.43720         DURBIN-WATSON TEST    2.28488
3070=
3080= NUMBER OF POSITIVE RESIDUALS     12.
3090= NUMBER OF NEGATIVE RESIDUALS      4.
3100= NUMBER OF RUNS OF SIGNS           8.
3110=
```

Figure 2

Residuals of the Initial Regression (ODC)

The second dependent variable to be regressed is manufacturing materials, and results in the following equation being developed.

$$\mathrm{Ln(MANMAT)} = -8.1001 + (.1236\ \mathrm{Ln(PROTO)}) + (.8973\ \mathrm{Ln(TOGWMAX)}) + (1.172\ \mathrm{Ln(NZULT)}) + (.3120\ \mathrm{Ln(MAXMACH)}) + (-.0625\ \mathrm{Ln(TWTAREA)})$$

The regression equation results in an R^2 = .9164, or 91.64% of the variance of the manufacturing material dependent variable is explained by the five independent variables. The calculated F value is equal to 21.924 with 5 and 10 degrees of freedom and is significant at the .999 level of confidence. The computed beta values form the following confidence intervals at the 95% confidence level (Table XIII).

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95 PCT C.I.	
PROTO	.1236	-.0456	.2927
TOCWMAX	.8973	.5983	1.1964
NZULT	1.1172	.4858	1.7485
MAXMACH	.3120	-.0344	.6585
TWTAREA	-.0625	-.2427	.1178
CONSTANT	-8.1001	-11.9982	-4.2019

Table 13

Initial Regression Equation Summary (MANMAT)

The estimated values generated by the regression analysis result in a regression line that minimizes the sum of the squared errors in the regression (Figure 3). In review of the residuals the regression equation is able to predict the actual values with varying degrees of success (.2489 equals one standard deviation).

It is important to analyze the negative beta coefficient associated with TWTAREA in the MANMAT equation. The negative beta value is in contradiction to what is expected, that is, that as an independent data parameter increases so does the cost associated with that independent parameter. This situation might result from several factors: 1) it could be contained in the data set (existence of multicollinearity), 2) it could result from the bias contained in the regression analysis as a result of using logarithm and 3) the possibility that this independent variable's definition is incorrect (a zero line scatter indicated that this was not the case because the scattergram of the independent variable with the residuals appear to be random). It shou'd also be noted that some of the other regression equations in this Chapter also contain negative beta coefficients. This problem is addressed in Chapter V under recommendations for future research.

```
4760=
4770=   Y VALUE    Y EST.  RESIDUAL -2SD                0.0              +2SD
4780=
4790=     3.438     3.099     .339                        I              .     .
4800=     2.786     2.955    -.169                   .    I
4810=     3.908     4.055    -.147                    .   I
4820=     3.873     3.682     .192                        I      .
4830=     5.050     5.038     .011                        I.
4840=     3.288     3.272     .017                        I.
4850=     4.385     4.285     .099                        I   .
4860=     3.910     4.314    -.403          .             I
4870=     4.251     4.321    -.070                      . I
4880=     3.008     3.033    -.025                       .I
4890=     4.801     4.552     .249                        I        .
4900=     4.662     4.532     .131                        I    .
4910=     4.268     4.461    -.193                  .     I
4920=     3.857     3.785     .072                        I  .
4930=     3.731     4.019    -.289              .         I
4940=     5.246     5.060     .187                        I      .
4950=
4960= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
4970=          R INDICATES POINT OUT OF RANCE OF PLOT
4980=
4990=
5000= NUMBER OF CASES PLOTTED        16.
5010= NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL
5020=
5030= VON NEUMANN RATIO    2.40519         DURBIN-WATSON TEST    2.25487
5040=
5050= NUMBER OF POSITIVE RESIDUALS      9.
5060= NUMBER OF NECATIVE RESIDUALS      7.
5070= NUMBER OF RUNS OF SIGNS           9.
```

Figure 3

Residuals of the Initial Regression (MANMAT)

The third dependent variable that is regressed is manufacturing labor, and results in the following regression equation being developed.

$$\text{Ln(MANF)} = -7.1673 + (.8608\ \text{Ln(TOGWMAX)}) + (.9138\ \text{Ln(NZULT)}) + (.3261\ \text{Ln(MAXMACH)}) + (-.1041\ \text{Ln(TWTAREA)}) + (.0761\ \text{Ln(PROTO)})$$

The regression equation results in an R^2 = .8949, or 89.49% of the variance of the manufacturing labor dependent variable is explained by the independent variables. Additionally, the regression equation's F-value is equal to 17.038 which is significant at the .999 level of confidence. The computed beta values form the following confidence intervals at the 95% confidence level (Table 14).

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95 PCT C.I.	
TOGWMAX	.8608	.5486	1.1731
NZULT	.9138	.2545	1.5730
MAXMACH	.3261	-.0357	.6878
TWTAREA	-.1041	-.2923	.0841
PROTO	.0761	-.1004	.2527
CONSTANT	-7.1673	-11.2376	-3.0970

Table 14

Initial Regression Equation Summary (MANF)

The estimated values generated by the regression analysis result in a regression line that predicts the actual values with relatively high accuracy. However, there are some outlying predictions that are two standard deviations away from the regression equation, but one standard deviation is equal to only .2599 (Figure 4).

```
* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


RESIDUAL PLOT.

  Y VALUE    Y EST.  RESIDUAL -2SD              0.0             +2SD

    3.239     2.968      .271                   I         .
    2.526     2.757     -.231             .     I
    3.804     3.703      .102                   I   .
    3.246     3.215      .031                   I .
    4.727     4.695      .032                   I .
    3.118     3.080      .038                   I .
    4.078     4.060      .018                   I.
    3.738     4.038     -.300           .       I
    4.091     3.944      .147                   I     .
    2.803     2.798      .006                   I.
    4.412     4.172      .239                   I         .
    4.297     4.136      .162                   I      .
    3.608     4.069     -.460    .              I
    3.526     3.356      .170                   I      .
    3.336     3.639     -.303           .       I
    4.745     4.665      .080                   I   .

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
       R INDICATES POINT OUT OF RANGE OF PLOT


NUMBER OF CASES PLOTTED        16.
NUMBER OF 2 S.D. OUTLIERS       0 OR      0 PERCENT OF THE TOTAL

VON NEUMANN RATIO    3.00909          DURBIN-WATSON TEST    2.82102

NUMBER OF POSITIVE RESIDUALS     12.
NUMBER OF NEGATIVE RESIDUALS      4.
NUMBER OF RUNS OF SIGNS           9.
```

Figure 4

Residuals of the Initial Regression (MANF)

The fourth dependent variable to be regressed is tooling hours, and results in the following regression equation being developed.

$$\mathrm{Ln(TOOL)} = 16.7166 + (-4.0523\ \mathrm{Ln(NZULT)}) + (1.7124\ \mathrm{Ln(MAXMACH)}) + (-.8878\ \mathrm{Ln(TOGWMAX)}) + (.2988\ \mathrm{Ln(PROTO)}) + (.2972\ \mathrm{Ln(TWTAREA)})$$

The regression equation results in an R^2 = .5064, or 50.64% of the variance of the tooling dependent variable is explained by the independent variable. The calculated F-value is equal to 2.052 and is significant at the .884 level of confidence. The beta values form a wide confidence interval at the 95% confidence level (Table 15).

```
....
8190=
8200= COEFFICIENTS AND CONFIDENCE INTERVALS.
8210=
8220= VARIABLE        B              95 PCT C.I.
8230=
8240= NZULT        -4.0523     -7.4573     -.6473
8250= MAXMACH       1.7124      -.1561     3.5809
8260= TOCWMAX       -.8878     -2.5005      .7249
8270= PROTO          .2988      -.6133     1.2108
8280= TWTAREA        .2972      -.6749     1.2694
8290= CONSTANT     16.7166     -4.3063    37.7395
8300=
```

Table 15

Initial Regression Equation Summary (TOOL)

The estimated values generated by the regression analysis result in a regression line that minimizes the sum of the squared errors in the regression (Figure 5). The residual plot depicts the actuals in comparison with the estimated and must be interpreted correctly. Even though the actuals are within 1 to 1.5 standard deviations the actual standard deviation is larger for this regression analysis than those for the three previous regression analyses (1.3423 = one standard deviation).

```
8660= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
8670=
8680=
8690= RESIDUAL PLOT.
8700=
8710=   Y VALUE    Y EST.  RESIDUAL -2SD             0.0             +2SD
8720=
8730=     6.837     3.969     2.868                   I                R
8740=     -.302      .345     -.648              .    I
8750=      .703      .359      .344                   I .
8760=      .815     -.104      .920                   I     .
8770=     3.016     2.650      .366                   I .
8780=     1.411     2.639    -1.228         .         I
8790=     2.072     1.929      .142                   I .
8800=     1.609     3.165    -1.555      .            I
8810=     1.805     1.347      .458                   I  .
8820=      .285     1.215     -.930            .      I
8830=     1.844     2.111     -.267                 . I
8840=     1.690     2.003     -.313                .  I
8850=     1.221     1.664     -.443               .   I
8860=     2.087     1.456      .631                   I    .
8870=     1.690     2.964    -1.274         .         I
8880=     2.036     1.107      .929                   I      .
8890=
8900= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
8910=          R INDICATES POINT OUT OF RANGE OF PLOT
8920=
8930=
8940= NUMBER OF CASES PLOTTED        16.
8950= NUMBER OF 2 S.D. OUTLIERS       1. OR   6.25 PERCENT OF THE TOTAL
8960=
8970= VON NEUMANN RATIO    2.21191          DURBIN-WATSON TEST    2.07367
8980=
8990= NUMBER OF POSITIVE RESIDUALS      8.
9000= NUMBER OF NEGATIVE RESIDUALS      8.
9010= NUMBER OF RUNS OF SIGNS          11.
9020=
```

Figure 5

Residuals of the Initial Regression (TOOL)

The final dependent variable to be regressed is Engineering and results in the following regression equation.

$$\text{Ln(ENG)} = -11.745 + (.195\ \text{Ln(PROTO)}) + (.889\ \text{Ln(TOGWMAX)}) + (1.214\ \text{Ln(NZULT)}) + (.096\ \text{Ln(TWTAREA)}) + (.183\ \text{Ln(MAXMACH)})$$

The regression equation results in an R^2 = .8619 or 86.19% of the variance of the engineering dependent variable is explained by the independent variables. The calculated F-value is equal to 12.478 which is significant at the .999 level of confidence. The beta values form the following confidence interval at the 95% confidence level (Table 16).

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95 PCT C.I.	
PROTO	.1946	-.0471	.4363
TOGWMAX	.8889	.4615	1.3163
NZULT	1.2144	.3120	2.1167
TWTAREA	.0960	-.1617	.3536
MAXMACH	.1829	-.3123	.6781
CONSTANT	-11.7449	-17.3164	-6.1734

Table 16

Initial Regression Equation Summary (ENG)

The estimated values generated by the regression analysis result in a regression line that predicts the actual values with relatively high accuracy (Figure 6). Even though there are several actuals that are close to two standard deviations from the regression estimates the value of the standard deviation is small (.3557 = one standard deviation).

```
0630= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
0640=
0650=
0660= RESIDUAL PLOT.
0670=
0680=   Y VALUE    Y EST.  RESIDUAL -2SD               0.0              +2SD
0690=
0700=      .542      .833     -.291           .        I
0710=      .698      .570      .128                    I   .
0720=     1.647     1.924     -.277            .       I
0730=     1.716     1.996     -.280            .       I
0740=     3.466     3.193      .273                    I       .
0750=     1.459     1.228      .231                    I      .
0760=     1.681     2.084     -.203               .    I
0770=     2.245     2.340     -.095                 .  I
0780=     2.135     2.093      .043                    I .
0790=     1.004      .784      .220                    I      .
0800=     2.754     2.376      .377                    I          .
0810=     1.813     2.339     -.526      .             I
0820=     1.953     2.281     -.328          .         I
0830=     2.220     1.794      .426                    I           .
0840=     1.917     1.883      .034                    I.
0850=     3.045     2.776      .268                    I       .
0860=
0870= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
 10880=         R INDICATES POINT OUT OF RANGE OF PLOT
0890=
0900=
0910= NUMBER OF CASES PLOTTED        16.
0920= NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL
0930=
0940= VON NEUMANN RATIO    2.15324          DURBIN-WATSON TEST    2.01866
0950=
0960= NUMBER OF POSITIVE RESIDUALS      9.
0970= NUMBER OF NEGATIVE RESIDUALS      7.
0980= NUMBER OF RUNS OF SIGNS           8.
0990=
```

Figure 6

Residuals of the Initial Regression (ENG)

Second Regression

The second step-wise regression is accomplished utilizing the same data base as the initial regression. However, the second regression also utilizes the two artificial variables, TT and MXNZ. These artificial variables are used as interaction variables. The interaction variables are used to explain some of the variation of the dependent variable that is not already explained by the five independent variables and to control multi-collinearity. From this point forward the initial regression is called REG 1, and the second regression is called REG 2.

The basis of this section is the comparison of REG 1 with REG 2, in terms of equations, accuracy and significance. The confidence intervals and the residual plots are not presented in this section, but they are contained in Appendix C and D. Again, the analysis process is accomplished by regressing the dependent variable by independent variables. The first dependent variable to be regressed is ODC, and results in the following regression equation.

$$Ln(ODC) = 1.387 + (.626\ Ln(PROTO)) + (.11\ Ln(TT)) + (.688\ Ln(MXNZ) + (1.13\ Ln(NZULT)) + (-1.001\ Ln(TWTAREA)) + (-1.212\ Ln(MAXMACH)) + (-.288\ Ln(TOGWMAX))$$

The REG 2 regression equation generated an R^2 = .9022 and is significant at the .998 level of confidence. In comparison the REG 1 equation generated an R^2 = .889 at the .999 level of confidence. However, the standard deviation for REG 2 is .4812, where the standard deviation for REG 1 is .4585. The small difference of .0227 between standard deviations is not as significant as the 1.2% increase in explained variation, and therefore REG 2 is acceptable. Reviewing the statistics it appears that through the utilization of the artificial variables an increase in variation explained is possible, without a significant decrease in the level of signficance or a significant increase in the standard deviation.

The second dependent variable to be regressed is Manufacturing Materials, and results in the following regression equation.

Ln(MANMAT) = -18.2595 + (.0702 Ln(PROTO)) + (1.7978 Ln(TOGWMAX)) + (1.1434 Ln(NZULT)) + (-.2534 Ln(MXMZ)) + (-.0973 Ln(TT)) + (1.0158 Ln(TWTAREA)) + (.9362 Ln(MAXMACH))

The REG 2 regression equation generated an R^2 = .9360, and is significant at .999 level of confidence. In addition, REG 2 developed a standard deviation equal to .2435. REG 2 outperformed REG 1 in all three modes of measurement in this particular case. REG 1 generated an R^2 = .9164, a standard deviation equal to .2489, and was also significant at .999 level of confidence. Clearly, in attempting to estimate manufacturing materials REG 2 with artificial variables is the better regression equation.

The third dependent variable that is regressed is Manufacturing Labor, and results in the following regression equation. Note that only six independent variables are used in the equation, because the seventh variable influenced the degrees of freedom more than it added to the explanation of the dependent variable's variance. The decision to exclude the seventh variable is based upon the decrease in the level of significance and the resulting drop in the adjusted R^2 value.

Ln(MANF) = -7.949 + (1.216 Ln(TOGWMAX)) + (.941 Ln(NZULT)) + (.163 Ln(MAXNZ)) + (-.042 Ln(TT)) + (.054 Ln(PROTO)) + (.410 Ln(TWTAREA))

The REG 2 regression equation generates an R^2 = .899, a standard deviation equal to .2686, and is significant at .999 level of confidence. REG 1 generates an R^2 = .8949, a standard deviation equal to .2599, and is significant at .999 level of confidence. The comparison between REG 1 and REG 2 proves to be inconclusive. The reason is that the increase in explained variation is not highly significant, nor is the increase in the standard deviation. Therefore, either regression equation supplies the same results with the same degree of accuracy.

The fourth dependent variable to be regressed is Tooling Labor, and results in the following regression equation.

$$Ln(TOOL) = -31.150 + (-3.955\ Ln(NZULT)) + (9.757\ Ln(MAXMACH)) + (-3.592\ Ln(MAXNZ)) + (-.455\ Ln(TT)) + (.058\ Ln(PROTO)) + (5.115\ Ln(TWTAREA)) + (3.589\ Ln(TOGWMAX))$$

The REG 2 regression equation generates an R^2 = .6517, a standard deviation of 1.2606, and is signficant at .846 level of confidence. REG 2 outperforms REG 1 in two modes of measurement in the case dealing with the estimation of tooling. REG 1 generates an R^2 = .5064, a standard deviation equal to 1.3423, and is significant at .884 level of confidence. REG 2 provides nearly 15% more explanation of variance, and at the same time reduces the width of the standard deviation. In this particular case, the more accurate regression equation is REG 2 with artificial variables.

The final dependent variable to be regressed is Engineering, and generates the following regression equation.

$$\text{Ln(ENG)} = 2.521 + (.270\ \text{Ln(PROTO)}) + (-.376\ \text{Ln(TOGWMAX)}) + (1.177\ \text{Ln(NZULT)}) + (.137\ \text{Ln(TT)}) + (-1.469\ \text{Ln(TWTAREA)}) + (.356\ \text{Ln(MXMZ)}) + (-.695\ \text{Ln(MAXMACH)})$$

The REG 2 regression equation generates an $R^2 = .8931$, a standard deviation equal to .3498, and is significant at .998 level of confidence. REG 1 for Engineering generates an $R^2 = .8619$, a standard deviation equal to .3557, and is significant at .999 level of confidence. In analyzing the statistic measures, REG 2 generates a superior performance in the percentage of variance explained, and in a narrower standard deviation. Therefore, REG 2 is the better regression equation when estimating engineering hours for a combination of airframe types. The drop in the level of confidence of .002 is not very significant, when considering that the REG 2 equation is still above .99 level of confidence. Additionally, the increase in explained variation of over 3% more than outweighs the slight decrease in the confidence level.

Comparison of Parametric Relationships

This section provides a comparison of the hypothesized parametric relationships and the parametric relationships developed by REG 1. The purpose of this section is to strengthen both the hypothesized regression equations and the computer generated regression equations. When logic supports statistics the end result is a higher degree of confidence in the regression equations. The purpose of using REG 1 is that it does not use artificial variables, nor do the logically developed parametric relationships presented early in this Chapter. It is important to remember that the independent variables in the REG 1 regression equation are aligned in order of their entrance into the step-wise regression. Therefore, the independent variables are also in order of significance to the regression equation.

The first equation to be compared is Engineering hours. The following equations are first the estimated equation, and second the results of the REG 1 regression (without the beta coefficient values).

EST Eng = Function (TOGWMAX, PROTO, NZULT, TWTAREA, MAXMACH)

REG 1 Eng = Function (PROTO, TOGWMAX, NZULT, TWTAREA, MAXMACH)

The estimated regression equation and the REG 1 regression equation are extremely close in the order of entrance of the variables. Therefore, it is logical to accept the validity of REG 1. Because REG 1 executed the variable order extremely close to the hypothesized regression equation, the result adds strength and validity to both the hypothesized and REG 1 regression equations.

The following is a summarization of the four remaining equations. Note that the hypothesized and REG 1 equations are extremely close in order of entrance, and that the logic of one equation supports and validates the other equation.

EST TOOL = Function (NZULT, TOGWMAX, PROTO, MAXMACH, TWTAREA)

REG 1 TOOL = Function (NZULT, MAXMACH, TOGWMAX, PROTO, TWTAREA)

Performance characteristics dictate their importance by entering first and second in REG 1's regresson equation.

Est MANF = Function (NZULT, TOGWMAX, MAXMACH, TWTAREA, PROTO)

REG 1 MANF = Function (TOGWMAX, NZULT, MAXMACH, TWTAREA, PROTO)

As indicated, the independent variable TOGWMAX is more significant in the manufacturing equation than had been hypothesized.

EST MANMAT = Function (PROTO, TOGWMAX, TWTAR EA, NZULT, MAXMACH)

REG 1 MANMAT = Function (PROTO, TOGWMAX, NZULT, MAXMACH, TWTAREA)

The performance characteristics play a more important part in explaining variance of the dependent variable than originally thought. This may stem from the majority of the size characteristics being explained by TOGWMAX.

Est ODC = Function (PROTO, NZULT, TOGWMAX, MAXMACH, TWTAREA)

REG 1 ODC = Function (PROTO, TOGWMAX, NZULT, TWTAREA, MAXMACH)

The relative order of entrance of the independent variables remains the same, except the size characteristics enter before the performance characteristics. The order undoubtedly stems from the percentage of variance explained by TOGWMAX compared to NZULT.

Factor Grouping Regression

This section is based upon a regression analysis of the factor grouping. Therefore, the data base consists of only the eight fighter airframes. In the process of this analysis two regression runs are accomplished; one using the original five independent variables and another using the five independent variables plus two artificial variables (TT and MXNZ). The first factor group regression is called REG 3, and the second factor group regression with artificial variables is called REG 4. The results of each regression (equation, standard deviation, and significance level) are presented in this section. The actual printouts containing the beta coefficient confidence limits and the residual plots for REG 4 are available for review in Appendix E.

The initial dependent variable to be regressed is Other Direct Charges (ODC), and yields the following regression equations.

REG 3 $\text{Ln(ODC)} = -9.5736 + (.5919\ \text{Ln(PROTO)}) + (.9951\ \text{Ln(TOGWMAX)}) + (.9523\ \text{Ln(NZULT)})$

REG 4 $\text{Ln(ODC)} = -9.574 + (.592\ \text{Ln(PROTO)}) + (.995\ \text{Ln(TOGWMAX)}) + (.952\ \text{Ln(NZULT)})$

Both REG 3 and REG 4 yield about the same results with an R^2 = .8914, a standard deviation equal to .3907, and are significant at .979 level of confidence. The duplication of regression equations that are limited to three variables indicates that none of the other variables (two independent and two artificial) add to the variation being explained by PROTO, TOGWMAX AND NZULT (Figure 7).

```
2250= *********M U L T I P L E   R E G R E S S I O N*********
2260=
2270=
2280= RESIDUAL PLOT.
2290=
2300=   Y VALUE    Y EST.  RESIDUAL -2SD              0.0             +2SD
2310=
2320=     4.847     4.594      .253                   I     .
2330=     2.931     3.006     -.076                 . I
2340=     5.371     5.203      .167                   I   .
2350=     4.551     5.231     -.680     .             I
2360=     5.301     5.152      .149                   I  .
2370=     5.165     5.178     -.013                  .I
2380=     5.312     5.148      .164                   I   .
2390=     5.901     5.866      .035                   I.
2400=
2410= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
2420=        R INDICATES POINT OUT OF RANGE OF PLOT
2430=
```

Figure 7

Regression Analysis of REG 3 (ODC)

The second dependent variable to be regressed is Manufacturing materials, and yields the following regression equation.

REG 3 & REG 4 (Ln(MANMAT)) = -16.891 + (1.48 Ln(TOGWMAX)) + (1.457 Ln(NZULT)) + (.074 Ln(PROTO)) + (.214 Ln(TWTAREA)) + (-.168 Ln(MAXMACH))

Both REG 3 and REG 4 yield the same regression equations. REG 3 and REG 4 results in an R^2 = .9695, standard deviation equal to .1868, and are significant at .987 level of confidence. Note that all five original independent variables are in the equation, but neither of the artificial variables are able to reduce the unexplained variation (Figure 8).

```
4140= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
4150=
4160=
4170= RESIDUAL PLOT.
4180=
4190=   Y VALUE    Y EST.  RESIDUAL -2SD             0.0             +2SD
4200=
4210=     4.251     4.236     .016                   I.
4220=     3.008     2.997     .011                   I.
4230=     4.801     4.759     .041                   I .
4240=     4.662     4.503     .160                   I      .
4250=     4.268     4.522    -.254          .        I
4260=     3.857     3.819     .037                   I .
4270=     3.731     3.763    -.033                 . I
4280=     5.246     5.224     .022                   I .
4290=
4300= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
4310=         R INDICATES POINT OUT OF RANGE OF PLOT
4320=
```

Figure 8

Regression Analysis of REG 3 (MANMAT)

The third dependent variable to be regressed is Manufacturing hours, and yields the following regression equation. Note that both REG 3 and REG 4 are once again the same equation.

REG 3 & REG 4 (Ln(MANF) = -14.13 + (1.184 Ln(TOGWMAX)) + (1.608 Ln(NZULT)) + (.187 Ln(TWTAREA))

Both REG 3 and REG 4 result in an R^2 = .8804, a standard deviation equal to .2943, and are significant at .974 level of confidence. Note that only three of the independent variables are included in the regression equation. The regression equation is limited by choice of the authors, because if the other variables (MAXMACH and PROTO) are included in the equation, the R^2 only increases to .8828 while the standard deviation increases to .412 and the level of significance drops to a .732 level of confidence. In view of these circumstances the equation is limited to three independent variables (Figure 9).

```
6030= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
6040=
6050=
6060= RESIDUAL PLOT.
6070=
6080=   Y VALUE    Y EST.  RESIDUAL -2SD               0.0            +2SD
6090=
6100=     4.091     3.993      .098                    I .
6110=     2.803     2.798      .005                    I.
6120=     4.412     4.285      .126                    I  .
6130=     4.297     4.115      .182                    I   .
6140=     3.608     4.129     -.520          .         I
6150=     3.526     3.451      .076                    I .
6160=     3.336     3.363     -.027                   .I
6170=     4.745     4.685      .060                    I .
6180=
6190= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
6200=         R INDICATES POINT OUT OF RANGE OF PLOT
6210=
```

Figure 9

Regression Analysis of REG 3 (MANF)

The fourth variable to be regressed is tooling hours, and yields the following equation. Again, note that REG 3 and REG 4 result in the same regression equation.

REG 3 & REG 4 (Ln(TOOL)) = -6.489 + (.435 Ln(PROTO))
+ (1.641 Ln(NZULT)) + (.287 Ln(TOGWMAX))

Both REG 3 and REG 4 result in an R^2 = .8235, a standard deviation equal to .3265, and are significant at .945 level of confidence. Note that only three independent variables are included in the regression equation. Once again, the regression equation is limited to three independent variables, since with the addition of TWTAREA and MAXMACH, the R^2 only increases to .8311 while the standard deviation increases to .4516 and the level of significance drops to a .73 level of confidence (Figure 10).

```
7920= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
7930=
7940=
7950= RESIDUAL PLOT.
7960=
7970=   Y VALUE    Y EST.  RESIDUAL -2SD               0.0               +2SD
7980=                                                   ----------------
7990=     1.805     1.576      .229                     I    .
8000=      .285      .312    -.027                     .I
8010=     1.844     1.633      .211                     I   .
8020=     1.690     1.788    -.098                   .  I
8030=     1.221     1.754    -.533           .          I
8040=     2.087     2.012      .075                     I .
8050=     1.690     1.639      .051                     I .
8060=     2.036     1.945      .091                     I  .
8070=
8080= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
8090=          R INDICATES POINT OUT OF RANGE OF PLOT
8100=
```

Figure 10

Regression Analysis of REG 3 (TOOL)

The final dependent variable to be regressed is Engineering hours, and yields the following equation for both REG 3 and REG 4.

$$\text{REG 3 \& REG 4 } (\ln(\text{ENG})) = -11.829 + (1.265 \ln(\text{TOGWMAX})) + (.207 \ln(\text{PROTO})) + (-.405 \ln(\text{MAXMACH}))$$

Both REG 3 and REG 4 result in an R^2 = .7874, a standard deviation equal to .3769, and are significant at .922 level of confidence. Again, the authors chose to limit the regression equation to only three independent variables because of the huge drop in the level of confidence. If TWTAREA and NZULT are added to the regression equation the R^2 only increases to .8248, while the level of significant drops to a .718 level of confidence (Figure 11).

```
9810= * * * * * * * * * *M U L T I P L E   R E G R E S S I O N* * * * * * * * * *
9820=
9830=
9840= RESIDUAL PLOT.
9850=
9860=   Y VALUE    Y EST.  RESIDUAL -2SD             0.0             +2SD
9870=
9880=    2.135     1.830      .306                     I     .
9890=    1.004     1.061     -.056                   . I
9900=    2.754     2.516      .237                     I    .
9910=    1.813     2.217     -.404            .        I
9920=    1.953     2.306     -.353             .       I
9930=    2.220     2.173      .047                     I.
9940=    1.917     1.789      .128                     I .
9950=    3.045     2.949      .096                     I .
9960=                                               ---------
9970= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
9980=          R INDICATES POINT OUT OF RANGE OF PLOT
9990=
```

Figure 11

Regression Analysis of REG 3 (ENG)

Factor Grouping Summary

The results of the factor grouping regression is promising since several of the R^2 values increased significantly. However, in some cases there is a drop in R^2 value and in the significance level. The drop in R^2 value is not too significant because in all but one case the R^2 is still above

80% explained variation. The drop in level of confidence, which is based on the F-value, is not at all surprising. The reason the level of confidence drops is that the sample size is small (only eight data points). As the data base for fighter airframes increases, the level of confidence will increase accordingly, and the additional independent variables that are not in the proposed regression equations can be added later to increase the percent of explained variation.

Comparison of the Models

The following section presents a comparison of three models, REG 2, REG 3, and the base model (Grumman). The models are compared on the estimated values that are generated by each model's regression equations. The models are compared in tabular form, which lists the values generated by REG 2, REG 3, the base model, and the actuals. After examining the estimated values for each model, an R^2 is developed for the base model, REG 2 and REG 3.

Since the development of REG 3 was based on only fighter airframes, the comparison is limited to only the fighter portion of the data base. The comparison is made using all eight fighter airframe data points. The R^2 values are hand calculated values utilizing the R^2 formula presented in Chapter III. Additionally, all values presented in the table in this section are hand calculated values utilizing the equations identified with the base model in Chapter II, and the REG 2 and REG 3 regression equations developed earlier in Chapter IV.

Engineering Hours

The first dependent variable to be used as a point of comparison is Engineering hours. A summary of the estimated hours are displayed in Table 17. An initial comparison between the base model, REG 2 and REG 3, indicates that REG 3 is a better estimator of the actual values contained in the data base.

	REG 2	REG 3	BASE	ACTUAL
F-1	8.35	5.38	12.66	8.46
F-2	2.32	3.14	3.40	2.73
F-3	9.55	12.26	11.41	15.70
F-4	10.28	9.06	10.83	6.13
F-5	9.65	4.87	9.98	7.05
F-6	7.27	7.68	8.85	9.21
F-7	7.22	7.43	7.10	6.80
F-8	14.31	20.07	11.16	21.00

Table 17

Comparison of Engineering Estimates

The R^2 value for REG 3 = .8414 as compared to an R^2 = .3235 for the base model, and an R^2 = .5[illegible]3 for REG 2.

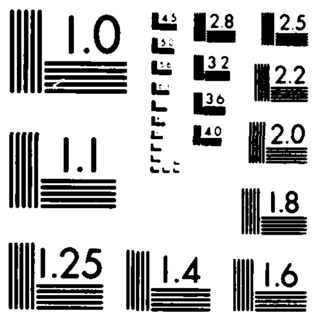
Tooling Hours

A summary of the estimated tooling hours are displayed in Table 18. The R^2 value generated for REG 3 is equal to .7813, REG 2 R^2 = .2209 and base model R^2 = .0915.

AD-A123 848 AIRFRAME RDT&E COST ESTIMATING: A JUSTIFICATION FOR AND DEVELOPMENT OF UN..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST..

2/3

UNCLASSIFIED C L BECK ET AL. SEP 82 AFIT-LSSR-56-82 F/G 1/3 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

	REG 2	REG 3	BASE	ACTUAL
F-1	1.80	4.90	5.49	6.08
F-2	3.00	1.38	1.48	1.33
F-3	13.00	4.67	4.67	6.32
F-4	5.87	5.98	6.04	5.42
F-5	4.77	4.85	5.44	3.39
F-6	2.55	7.14	5.67	8.06
F-7	16.10	5.47	5.17	5.42
F-8	5.49	7.42	2.57	7.65

Table 18

Comparison of Tooling Hours Estimates

Manufacturing Hours

A summary of the estimated hours for manufacturing are displayed in *Table 19. The generated* R^2 value for REG 3, REG 2 and the base model results in a REG 3 $R^2 = .9498$, REG 2 $R^2 = .866$ and base model $R^2 = .8469$.

	REG 2	REG 3	BASE	ACTUAL
F-1	51.50	55.74	56.19	59.8
F-2	16.00	16.84	16.29	16.5
F-3	68.17	72.75	70.98	82.4
F-4	63.10	61.89	68.26	73.5
F-5	58.00	30.16	62.46	36.9
F-6	26.40	29.34	29.58	34.0
F-7	36.50	29.00	41.52	28.1
F-8	111.05	106.45	102.65	115

Table 19

Comparison of Manufacturing Hours Estimates

Other Direct Charges

A summary of the estimated hours for ODC are presented in Table 20. The generated R^2 value for REG 3, REG 2 and the base model results in REG 3 $R^2 = .8680$, REG 2 $R^2 = .79$ and a base model $R^2 = .4338$.

	REG 2	REG 3	BASE	ACTUAL
F-1	126.97	98.89	173.20	127.35
F-2	17.10	20.20	27.17	18.70
F-3	164.70	181.81	193.22	215.07
F-4	200.00	186.97	203.32	94.70
F-5	171.40	172.77	174.22	200.00
F-6	164.40	177.32	211.01	175.00
F-7	170.37	172.08	171.63	202.80
F-8	243.20	352.80	77.98	365.40

Table 20

Comparison of ODC Estimates

Manufacturing Materials

A summary of the estimated hours for manufacturing materials is presented in Table 21. Once again REG 3 is utilized as the comparitor with the base model. The generated R^2 values for REG 3 equals .965, REG 2 R^2 equals .93 and the base model again cannot be calculated, which may be due to an error in the equation.

	REG 2	REG 3	BASE	ACTUAL
F-1	73.77	69.13	18.770	70.20
F-2	19.97	20.03	4.839	20.25
F-3	103.20	116.63	23.346	121.60
F-4	93.50	90.29	23.240	105.90
F-5	87.44	92.02	16.600	71.40
F-6	38.44	45.55	10.570	47.30
F-7	52.00	43.07	14.575	41.70
F-8	171.06	185.68	52.990	189.90

Table 21

Comparison of Manufacturing Materials Estimates

Verification

At this time, verification of the models developed in this thesis is not possible. The original research plan was to verify the models by attempting to predict the airframe RDT&E costs of the F-18 fighter aircraft. However, this thesis team was unable to collect the required cost data for the F-18 because of an ongoing "should-cost" study. This study made the release of cost data an extremely sensitive issue. Therefore, verification of the thesis generated CERs must be delayed until the necessary cost data is available.

Analysis Summary

The comparison of the three models points to the stated hypotheses in Chapter I that a unique CER exists for each type of airframe (fighter, attack, cargo) for the RDT&E phase of the acquisition process, and that the unique CER's will more accurately prodict RDT&E airframe costs. The comparison shows that in the area of fighters the best estimator is a CER equation designed specifically for fighter airframes. The REG 2 and base model are fair estimates of fighter airframe dependent variables, but lack the accuracy of the REG 3 equation. Both REG 2 and the base model prove less accurate in estimating fighter airframe costs because both models were developed using fighter, attack, and cargo airframe data. Therefore, REG 2 and the base model are gross estimator models and neither model can consistently estimate a value for fighter, attack, and cargo airframes with a high degree of accuracy. The purpose of REG 2 and the base model is to provide general estimates for a wide variety of airframes.

The REG 3 model, which is specifically designed for a particular airframe, shows consistent results when compared to the actual values. This development suggests promise for generating other specifically designed CER equations, in lieu of general CER equation.

PLEASE NOTE: Pages mis-numbered.

There is no page 85.

(note received with docu.)

CHAPTER V

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

The purpose of this thesis was to examine existing RDT&E airframe cost estimating models, and to compare the results of a base model with a thesis generated model. The intent was not to discredit any existing model, but to help pave the way to more accurate cost estimating.

Summary of Methodology and Findings

The methodology utilized in this thesis was first to examine the data base that was to be utilized during the statistical analysis. The data base was initially examined for accuracy and reliability and was found to be the most accurate and reliable available. Next the data was reviewed in terms of logic. The analysis consisted of developing expected logical relationships between the independent and dependent variables. The expected logical relationships were then compared to the computer generated regression equations, and were found to represent logical estimates of the dependent variables.

The first statistical procedure was factor analysis which was used to determine the airframe groupings to be utilized during the regression analysis. The factor analysis indicated that the regression grouping should consist of three distinct groups: one group for fighter, one for attack and one for cargo. The factor analysis developed these groupings based upon the independent parameters of NZULT, MAXMACH, TOGWMAX, and TWTAREA, which represented the size and performance features of the airframes.

Following the factor analysis a regression analysis was conducted on the full data for the fighter, attack, and cargo airframes. This initial regression analysis served as a point of comparison with the base model, and was called REG 1 (Regression analysis one). Next, a second regression analysis (REG 2) was conducted utilizing the full data for fighter, attack, and cargo, but interaction terms were added to the independent variable data set. This second regression analysis resulted in a higher statistical explanation of variance then did the REG 1 analysis. The third regression analysis (REG 3) was conducted utilizing only the data set for fighters. The data set was limited to fighters only based upon the results of the factor analysis. Additionally, a fourth regression analysis (REG 4) was conducted utilizing the fighter data set and interaction terms. Both REG 3 and REG 4 resulted in basically the same regression equations. Therefore, the interaction terms in REG 4 did not explain any more variance than did the initial independent variables.

After the regression analysis had been completed a comparison between the regression equations REG 2, REG 3, and the base model was conducted on the data set for fighters. This comparison was conducted on only the fighter airframes based upon the results of the factor analysis and the fact that REG 3 was based solely on the fighter data set. The comparison indicated that the REG 3 regression equation is a more accurate estimator of the actual fighter dependent variables than either the REG 2 model or the base model.

The statistical procedures support the hypotheses stated in Chapter I, that a unique cost estimating relationship (CER) exists for each airframe group (fighter, attack, and cargo) and that the unique CERs would result in more accurate cost estimating. This indicates that the development of separate CERs is necessary to more accurately estimate RDT&E airframe costs for the three groups.

Implications and Recommendations

The implications and recommendations of the research are summarized in four specific ideas. First, accumulate data to further refine the model generated by this thesis team (REG 3). The current REG 3 regression equations are in the state of infancy, and require firm support, so that the equations may become more accurate and verified by the passage of time and test.

Second, accumulate data to generate airframe specific regression equations for both attack and cargo airframes. With a data base of only four, both the attack and cargo data bases are in need of expansion. Once the data base has been developed, airframe specific regression equations may be developed that could possibly be more accurate than the general equations currently utilized to develop cost estimates.

Third, the RDT&E model should be used in conjunction with production and O&S cost models. Several existing models attempt to predict the life cycle cost of a system, but these models lean heavily on the production and O&S phases. While it is true that most of the actual costs occur during the production and O&S phases, most of the design decisions occur during the RDT&E phase of an acquisition. Therefore, Production and O&S models must be successfully meshed with an RDT&E model, so that the influence of a change during the RDT&E phase of a program can be observed in the Production and O&S phases. The process of meshing all three phases into one coherent model can provide the most accurate means in predicting life cycle costs.

And finally, the research initiated by this thesis needs to be expanded, especially dealing with the negative beta coefficients that surfaced in REG 1, REG 2, and somewhat in REG 3. This thesis team examined the relationship by accomplishing a zero line scattergram, in which the data appeared to be randomly distributed around the zero line. This issue was further examined by accomplishing a regression analysis on the data base using the arithmetic values for the independent and dependent variables. This regression analysis still produced negative beta coefficients. Therefore, this thesis team recommends that the data base be examined in detail in an attempt to divulge a latent problem inherent in the data base. This thesis team understands that every data set has some problems, and the data set utilized appears to be the best available. However, the problem of the negative beta coefficients must be examined from every angle.

This problem can possibly by rectified by accomplishing a regression analysis using the factor scores. This methodology would eliminate the multi-collinearity that is contained in the data base, but presents the problem of accurately defining what each factor actually represents in the "real world." The best methodology appears to be a combination of the methodology presented in this thesis accompanied by the aforementioned factor/regression methodology. This would allow for a complete explanation of the negative beta coefficients and perhaps lead to positive identification of the factors developed during the factor analysis.

Concluding Remarks

The analysis presented in this thesis represents an initial step in the development of more accurate cost estimating equations for airframe RDT&E costs. The statistical analysis indicates that separate CERs are the next logical step in developing models with increased accuracy in cost estimating. This logic is contrary to the procedures utilized in previous studies, but is supported by the results of factor analysis and regression analysis.

The accuracy of the CERs of the future are only limited by the inability to obtain verifiable data, and the inability to learn from the previously developed cost estimating equations.

APPENDICES

APPENDIX A

COST AND PERFORMANCE DATA

	NZULT	MAXMACH	TWTAREA	TOGWMAX	PROTO	ENG	ODC	MANMAT	TOOL	MANF
Attack	4.00	1.10	3692	73000	2	1.72	16.53	31.13	.932	25.5
	10.50	.93	1072	20000	1	2.01	11.89	16.22	.739	12.5
	9.75	.86	2180	60626	8	5.19	35.70	49.82	2.020	44.9
	11.00	.54	2600	50000	6	5.56	100.80	48.10	2.260	25.7
Cargo	3.75	.86	33712	769000	5	32.00	498.80	156.00	20.400	113.0
	3.90	.54	8797	124200	2	4.30	32.08	26.80	4.100	22.6
	3.75	.50	1470	286000	12	6.56	111.20	80.20	7.940	59.0
	3.75	.86	14312	323100	5	9.44	72.30	49.92	5.000	42.0
Fighter	12.75	2.40	2404	41910	7	8.46	127.30	70.20	6.080	59.8
	9.00	.95	2100	25000	2	2.73	18.74	20.25	1.330	16.5
	9.75	2.30	3105	72566	12	15.70	215.00	121.60	6.320	82.4
	11.00	2.50	2390	56000	16	6.13	94.70	105.90	5.420	73.5
	11.00	2.10	1456	33000	14	7.05	200.50	71.40	3.390	36.9
	10.50	1.00	2631	31276	42	9.21	175.00	47.30	8.060	34.0
	9.00	2.00	2230	39200	35	6.80	202.80	41.70	5.420	28.1
	11.00	2.20	1190	98850	18	21.00	365.40	189.90	7.660	115.0

APPENDIX B

FACTOR DATA

FTWTAREA	FNZULT	FMAXMACH	FTOGWMAX	ATWTAREA	ANUZLT	ATOGWMAX	ATOGWMAX	CTWTAREA	CNUZLT	CMAXMACH	CTOGWMAX
2404	12.75	2.40	41910	3692	4.00	1.10	73000	33712	3.75	.86	769000
2100	9.00	.95	25000	1072	1.05	.93	20000	8797	3.90	.54	124200
3105	9.75	2.30	72566	2180	9.75	.86	60626	14700	3.75	.50	286000
2390	11.00	2.50	56000	2600	11.00	.54	50000	14312	3.75	.86	323100
1456	11.00	2.10	33000	1703	10.50	.95	31873	11340	3.00	.88	300800
2631	10.50	1.00	31276	2959	7.50	1.80	62953	3729	3.90	.53	55000

APPENDIX C

REGRESSION REG 1

```
EDIT,=2,S
L,A
..

1
S
                                                              01/14/82  10.33.15. PAGE    1
              VOGELBACK COMPUTING CENTER
              NORTHWESTERN UNIVERSITY

              S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

              VERSION 8.0 -- JUNE 18, 1979




RUN NAME       INITIAL REGRESSION
VARIABLE LIST  NZULT,MAXMACH,TWTAREA,TOGWMAX,PROTO
               ENG,ODC,MANMAT,TOOL,MANF
VAR LABELS     NZULT  ULTIMATE LOAD FACTOR/
               MAXMACH  MAXIMUM MACH NUMBER/
               TWTAREA  TOTAL WETTED AREA/
               TOGWMAX  MAXIMUM TAKEOFF GROSS WEIGHT/
               PROTO  NUMBER OF PROTOTYPE AIRCRAFT/
               ENG  ENGINEERING HOURS/
               ODC  OTHER DIRECT COSTS/
               MANMAT  MANUFACTURING MATERIALS/
               TOOL  TOOLING/
               MANF  MANUFACTURING HOURS/
INPUT FORMAT   FREEFIELD
N OF CASES     UNKNOWN
COMPUTE        ENG=LN(ENG)
COMPUTE        ODC=LN(ODC)
COMPUTE        TOOL=LN(TOOL)
COMPUTE        MANMAT=LN(MANMAT)
COMPUTE        MANF=LN(MANF)
COMPUTE        TWTAREA=LN(TWTAREA)
COMPUTE        NZULT=LN(NZULT)
COMPUTE        MAXMACH=LN(MAXMACH)
COMPUTE        TOGWMAX=LN(TOGWMAX)
COMPUTE        PROTO=LN(PROTO)
REGRESSION     VARIABLES=ENG,NZULT,MAXMACH,TWTAREA
               TOGWMAX,PROTO,MANMAT,MANF,TOOL,ODC
               REGRESSION=ODC WITH NZULT,MAXMACH,TWTAREA
               TOGWMAX,PROTO(1)/RESID=0
               REGRESSION=MANMAT WITH NZULT,MAXMACH,TWTAREA
               TOGWMAX,PROTO(1)/RESID=0
               REGRESSION=MANF WITH NZULT,MAXMACH,TWTAREA
               TOGWMAX,PROTO(1)/RESID=0
               REGRESSION=TOOL WITH NZULT,MAXMACH,TWTAREA
               TOGWMAX,PROTO(1)/RESID=0
               REGRESSION=ENG WITH NZULT,MAXMACH,TWTAREA
               TOGWMAX,PROTO(1)/RESID=0
STATISTICS     ALL
READ INPUT DATA

00054600 CM NEEDED FOR REGRESSION



END OF FILE ON FILE FRO
AFTER READING     16 CASES FROM SUBFILE NONAME
1INITIAL REGRESSION                                 01/14/82  10.33.15.    PAGE    2
```

```
FILE - NONAME   (CREATED -  01/14/82)

**********MULTIPLE  REGRESSION**********


VARIABLE            MEAN     STANDARD DEV     CASES

ENG               1.9059             .7015        16
NZULT             2.0313             .4871        16
MAXMACH            .1526             .5718        16
TWTAREA           8.1946            1.0489        16
TOGWMAX          11.2327             .9843        16
PROTO             1.9800            1.0703        16
MANMAT            4.0290             .7029        16
MANF              3.7059             .6547        16
TOOL              1.8012            1.5599        16
ODC               4.4697            1.1239        16



CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.


NZULT           .00169
MAXMACH         .28700    .58154
TWTAREA         .29968   -.46350   -.43074
TOGWMAX         .56395   -.77487   -.31386    .56372
PROTO           .57072    .35360    .45298   -.19442    .00094
MANMAT          .86769    .05781    .43504    .11042    .52470    .59617
MANF            .85294   -.03609    .40219    .10082    .58418    .52753
TOOL           -.00627   -.40633    .07448    .16029    .33600    .00253
ODC             .91836    .12703    .39533    .20288    .41084    .75913

                ENG       NZULT     MAXMACH   TWTAREA   TOGWMAX   PROTO


MANF            .97334
TOOL            .19543    .23914
ODC             .85602    .70033    .06004

                MANMAT    MANF      TOOL


1INITIAL REGRESSION                        01/14/82  10.33.15.    PAGE    3

FILE - NONAME   (CREATED -  01/14/82)

**********MULTIPLE  REGRESSION**********

DEP. VAR... ODC         OTHER DIRECT COSTS

MEAN RESPONSE        4.46969      STD. DEV.       1.12392

VARIABLE(S) ENTERED ON STEP   1
PROTO       NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R     .7591 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .5763 REGRESSION     1.       10.919    10.919   19.040
STD DEV        .7573 RESIDUAL      14.        8.029      .573 SIG. .001
ADJ R SQUARE   .5460 COEFF OF VARIABILITY    16.9PCT

VARIABLE        B      S.E. B       F     SIG.      BETA  ELASTICITY
```

```
PROTO            .797      .183    19.040  .001       .75913    .35315
CONSTANT        2.891      .400    50.146  .000



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   2
TOGWMAX     MAXIMUM TAKEOFF GROSS WEIGHT

MULTIPLE R     .8628 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .7445 REGRESSION     2.       14.106     7.053    18.938
STD DEV        .6103 RESIDUAL      13.        4.842      .372 SIG. .000
ADJ R SQUARE   .7052 COEFF OF VARIABILITY    13.7PCT

VARIABLE           B       S.E. B        F      SIG.       BETA   ELASTICITY

PROTO            .797      .147    29.289  .000       .75874    .35297
TOGWMAX          .468      .160     8.558  .012       .41013   1.17688
CONSTANT       -2.368     1.828     1.679  .218
1INITIAL REGRESSION                         01/14/82  10.33.15.    PAGE    4

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ODC          OTHER DIRECT COSTS

VARIABLE(S) ENTERED ON STEP   3
NZULT        ULTIMATE LOAD FACTOR

MULTIPLE R     .9270 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8592 REGRESSION     3.       16.281     5.427    24.418
STD DEV        .4714 RESIDUAL      12.        2.667      .222 SIG. .000
ADJ R SQUARE   .8241 COEFF OF VARIABILITY    10.5PCT

VARIABLE           B       S.E. B        F      SIG.       BETA   ELASTICITY

PROTO            .556      .137    16.309  .002       .52945    .24630
TOGWMAX         1.041      .221    22.197  .001       .91179   2.61642
NZULT           1.493      .477     9.784  .009       .64714    .67864
CONSTANT      -11.359     3.202    12.581  .004



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   4
TWTAREA     TOTAL WETTED AREA

MULTIPLE R     .9340 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8724 REGRESSION     4.       16.531     4.133    18.810
STD DEV        .4687 RESIDUAL      11.        2.417      .220 SIG. .000
ADJ R SQUARE   .8261 COEFF OF VARIABILITY    10.5PCT

VARIABLE           B       S.E. B        F      SIG.       BETA   ELASTICITY

PROTO            .594      .141    17.717  .001       .56539    .26302
TOGWMAX          .929      .244    14.532  .003       .81339   2.33404
NZULT           1.442      .477     9.134  .012       .62400    .65530
TWTAREA          .154      .144     1.139  .309       .14392    .20273
CONSTANT      -11.331     3.184    12.663  .004
1INITIAL REGRESSION                         01/14/82  10.33.15.    PAGE    5

FILE - NONAME   (CREATED -  01/14/82)

```

```
----
* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ODC        OTHER DIRECT COSTS

VARIABLE(S) ENTERED ON STEP   5
MAXMACH     MAXIMUM MACH NUMBER

MULTIPLE R     .9429 ANOVA           DF   SUM SQUARES  MEAN SQ.      F
R SQUARE       .8890 REGRESSION      5.      16.846      3.369    16.025
STD DEV        .4585 RESIDUAL       10.       2.102       .210 SIC. .000
ADJ R SQUARE   .8336 COEFF OF VARIABILITY    10.3PCT

VARIABLE         B       S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .566      .140    16.388  .002       .53903    .25076
TOGWMAX         .848      .247    11.772  .006       .74291   2.13182
NZULT          1.156      .522     4.903  .051       .50094    .52533
TWTAREA         .212      .149     2.023  .185       .19784    .38867
MAXMACH         .350      .286     1.495  .249       .17823    .01196
CONSTANT     -10.318     3.223    10.249  .009


ALL VARIABLES ARE IN THE EQUATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B            95 PCT C.I.

PROTO           .5661        .2545      .8776
TOGWMAX         .8483        .2974     1.3992
NZULT          1.1559       -.0072     2.3190
TWTAREA         .2120       -.1201      .5441
MAXMACH         .3503       -.2880      .9886
CONSTANT     -10.3184     -17.4998    -3.1371


VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


NZULT           .27250
MAXMACH        -.06699     .08206
TWTAREA        -.01770     .01354     .02221
TOGWMAX         .10294    -.01885    -.01767     .06113
PROTO          -.03110    -.00648     .00382    -.01542     .01955

               NZULT     MAXMACH   TWTAREA   TOGWMAX   PROTO


1INITIAL REGRESSION                          01/14/02  10.33.15.    PAGE    6

FILE - NONAME   (CREATED -  01/14/02)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ODC        OTHER DIRECT COSTS


SUMMARY TABLE.

STEP VARIABLE E/R      F    MULT-R R-SQ CHANGE   R   OVERALL F  SIC.

  1  PROTO     E     19.040  .759  .576  .576  .759    19.040  .001
  2  TOGWMAX   E      8.530  .863  .744  .168  .411    18.930  .000
  3  NZULT     E      9.784  .927  .859  .115  .170    24.418  .000
```

```
   4  TWTAREA  E      1.139  .934  .872  .013  .203    16.810  .000
   5  MAIMACH  E      1.495  .943  .889  .017  .395    16.025  .000
1INITIAL REGRESSION                          01/14/82  10.33.15.    PAGE   7

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD                0.0              +2SD

     2.805     2.950     -.145                   .  I
     2.476     2.254      .221                      I   .
     3.575     4.410     -.834  .                   I
     4.613     4.585      .028                      I.
     6.200     5.775      .434                      I          .
     3.468     3.307      .161                      I  .
     4.711     4.577      .134                      I .
     4.281     4.857     -.577       .              I
     4.847     4.711      .135                      I .
     2.931     2.808      .123                      I .
     5.371     5.211      .159                      I  .
     4.551     5.267     -.717     .                I
     5.301     5.131      .170                      I  .
     5.165     4.965      .200                      I   .
     5.312     5.083      .229                      I   .
     5.901     5.623      .278                      I    .

 NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
             R INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED        16.
 NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    2.43720          DURBIN-WATSON TEST    2.28480

 NUMBER OF POSITIVE RESIDUALS     12.
 NUMBER OF NEGATIVE RESIDUALS      4.
 NUMBER OF RUNS OF SIGNS           8.

 NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
 USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                          01/14/82  10.33.15.    PAGE   8

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

 DEP. VAR... MANMAT     MANUFACTURING MATERIALS

 MEAN RESPONSE       4.02099      STD. DEV.        .70206

 VARIABLE(S) ENTERED ON STEP   1
 PROTO       NUMBER OF PROTOTYPE AIRCRAFT

 MULTIPLE R     .5962 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE       .3554 REGRESSION     1.      2.634     2.634     7.720
 STD DEV        .5841 RESIDUAL      14.      4.777      .341 SIG. .015
 ADJ R SQUARE   .3094 COEFF OF VARIABILITY   14.5PCT

 VARIABLE          B      S.E. B      F     SIG.      BETA   ELASTICITY

 PROTO           .392      .141    7.720   .015      .59617    .10741
```

```
CONSTANT        3.254      .315   106.754  .000

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   2
TOGWMAX     MAXIMUM TAKEOFF GROSS WEIGHT

MULTIPLE R     .7938 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .6301 REGRESSION     2.        4.670    2.335    11.074
STD DEV        .4592 RESIDUAL      13.        2.741     .211 SIG. .002
ADJ R SQUARE   .5732 COEFF OF VARIABILITY     11.4PCT

VARIABLE          B       S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .391       .111    12.472  .004       .59568    .19225
TOGWMAX         .374       .120     9.656  .008       .52414   1.04345
CONSTANT       -.950      1.375      .477  .502
1INITIAL REGRESSION                          01/14/82  10.33.15.    PAGE    9

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... MANMAT      MANUFACTURING MATERIALS

VARIABLE(S) ENTERED ON STEP   3
NZULT       ULTIMATE LOAD FACTOR

MULTIPLE R     .9297 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8643 REGRESSION     3.        6.405    2.135    25.479
STD DEV        .2895 RESIDUAL      12.        1.005     .084 SIG. .000
ADJ R SQUARE   .8304 COEFF OF VARIABILITY     7.2PCT

VARIABLE          B       S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .176       .084     4.360  .059       .26813    .08654
TOGWMAX         .806       .136    42.639  .000      1.24075   2.47009
NZULT          1.334       .293    20.710  .001       .92442    .67255
CONSTANT      -8.901      1.966    20.863  .001



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   4
MAXMACH     MAXIMUM MACH NUMBER

MULTIPLE R     .9547 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .9114 REGRESSION     4.        6.754    1.688    28.296
STD DEV        .2443 RESIDUAL      11.         .656     .060 SIG. .000
ADJ R SQUARE   .8792 COEFF OF VARIABILITY     6.1PCT

VARIABLE          B       S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .134       .073     3.363  .094       .20449    .06600
TOGWMAX         .840       .116    53.773  .000      1.18786   2.36320
NZULT          1.067       .271    15.535  .002       .73969    .53815
MAXMACH         .350       .145     5.850  .034       .20481    .01326
CONSTANT      -7.900      1.710    21.770  .001
1INITIAL REGRESSION                          01/14/82  10.33.15.    PAGE   10

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
```

```
DEP. VAR... MANMAT     MANUFACTURING MATERIALS

VARIABLE(S) ENTERED ON STEP   5
TWTAREA    TOTAL WETTED AREA

MULTIPLE R     .9573 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .9164 REGRESSION     5.       6.791     1.358    21.924
STD DEV        .2489 RESIDUAL      10.        .619      .062 SIG. .000
ADJ R SQUARE   .8746 COEFF OF VARIABILITY     6.2PCT

VARIABLE         B      S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .124      .076     2.650  .135      .18813     .06072
TOGWMAI         .897      .134    44.704  .000     1.25663    2.50170
NZULT          1.117      .283    15.544  .003      .77419     .56325
MAXMACH         .312      .155     4.027  .073      .25385     .01182
TWTAREA        -.062      .081      .596  .458     -.09321    -.12704
CONSTANT      -8.100     1.750    21.436  .001


ALL VARIABLES ARE IN THE EQUATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE         B           95 PCT C.I.

PROTO           .1236      -.0456     .2927
TOGWMAI         .8973       .5983    1.1964
NZULT          1.1172       .4858    1.7485
MAXMACH         .3120      -.0344     .6585
TWTAREA        -.0625      -.2427     .1178
CONSTANT      -8.1001    -11.9982   -4.2019


VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


NZULT           .08029
MAXMACH        -.01974     .02418
TWTAREA        -.00522     .00399     .00654
TOGWMAI         .03033    -.00555    -.00521     .01801
PROTO          -.00916    -.00191     .00113    -.00454     .00576

               NZULT     MAXMACH   TWTAREA   TOGWMAI   PROTO


1INITIAL REGRESSION                          01/14/82  10.33.15.    PAGE   11

FILE - NONAME    (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... MANMAT     MANUFACTURING MATERIALS


SUMMARY TABLE.

STEP VARIABLE E/R      F    MULT-R R-SQ CHANGE   R   OVERALL F  SIG.

  1  PROTO     E     7.720  .596  .355  .355  .596     7.720  .015
  2  TOGWMAI   E     9.656  .794  .630  .275  .525    11.074  .002
  3  NZULT     E    20.710  .930  .864  .234  .050    25.479  .000
  4  MAXMACH   E     5.050  .955  .911  .047  .435    28.296  .000
```

```
   5  TWTAREA   E       .596  .957  .916  .005  .110    21.924  .000
1INITIAL REGRESSION                              01/14/82  10.33.15.    PAGE  12

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD              0.0              +2SD

       3.438      3.099      .339                  I           .
       2.784      2.955     -.169             .    I
       3.908      4.055     -.147              .   I
       3.873      3.682      .192                  I     .
       5.050      5.038      .011                  I.
       3.288      3.272      .017                  I.
       4.385      4.285      .099                  I  .
       3.910      4.314     -.403    .             I
       4.251      4.321     -.070                . I
       3.008      3.033     -.025                 .I
       4.801      4.552      .249                  I        .
       4.662      4.532      .131                  I    .
       4.268      4.461     -.193           .      I
       3.857      3.785      .072                  I .
       3.731      4.019     -.289        .         I
       5.246      5.060      .187                  I     .

 NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
          R INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED         16.
 NUMBER OF 2 S.D. OUTLIERS         0 OR      0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    2.40519          DURBIN-WATSON TEST    2.25487

 NUMBER OF POSITIVE RESIDUALS        9.
 NUMBER OF NEGATIVE RESIDUALS        7.
 NUMBER OF RUNS OF SIGNS             9.

 NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
 USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                              01/14/82  10.33.15.    PAGE  13

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

 DEP. VAR... MANF      MANUFACTURING HOURS

 MEAN RESPONSE      3.70590      STD. DEV.        .65468

 VARIABLE(S) ENTERED ON STEP   1
 TOGWMAI    MAXIMUM TAKEOFF GROSS WEIGHT

 MULTIPLE R      .5842 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE        .3413 REGRESSION      1.       2.194     2.194    7.253
 STD DEV         .5500 RESIDUAL       14.       4.235      .303 SIG. .017
 ADJ R SQUARE   .2942 COEFF OF VARIABILITY    14.8PCT

 VARIABLE          B      S.E. B       F     SIG.       BETA   ELASTICITY

 TOGWMAI         .389      .144     7.253  .017      .58418   1.17770
 CONSTANT       -.658     1.626       .164  .692
```

```
5330=
5340=
5350=
5360= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
5370=
5380= VARIABLE(S) ENTERED ON STEP  2
5390= NZULT       ULTIMATE LOAD FACTOR
5400=
5410= MULTIPLE R     .8807 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
5420= R SQUARE       .7756 REGRESSION     2.       4.986     2.493    22.461
5430= STD DEV        .3332 RESIDUAL      13.       1.443      .111 SIG. .000
5440= ADJ R SQUARE   .7410 COEFF OF VARIABILITY     9.0PCT
5450=
5460= VARIABLE          B       S.E. B       F     SIG.      BETA   ELASTICITY
5470=
5480= TOCWMAX         .926       .138    44.847  .000     1.39201   2.00629
5490= NZULT          1.401       .279    25.156  .000     1.04254    .76809
5500= CONSTANT      -9.540      2.026    22.164  .000
5510=1INITIAL REGRESSION                         01/14/82  10.33.15.    PAGE  14
5520=
5530= FILE - NONAME   (CREATED -  01/14/82)
5540=
5550= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
5560=
5570= DEP. VAR... MANF        MANUFACTURING HOURS
5580=
5590= VARIABLE(S) ENTERED ON STEP  3
5600= MAXMACH     MAXIMUM MACH NUMBER
5610=
5620= MULTIPLE R     .9293 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
5630= R SQUARE       .8637 REGRESSION     3.       5.553     1.851    25.343
5640= STD DEV        .2702 RESIDUAL      12.        .876      .073 SIG. .000
5650= ADJ R SQUARE   .8296 COEFF OF VARIABILITY     7.3PCT
5660=
5670= VARIABLE          B       S.E. B       F     SIG.      BETA   ELASTICITY
5680=
5690= TOCWMAX         .840       .116    52.096  .000     1.26245   2.54509
5700= NZULT           .970       .274    12.509  .004      .72202    .53195
5710= MAXMACH         .433       .156     7.757  .016      .37853    .01785
5720= CONSTANT      -7.763      1.763    19.385  .001
5730=
5740=
5750=
5760= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
5770=
5780= VARIABLE(S) ENTERED ON STEP  4
5790= TWTAREA     TOTAL WETTED AREA
5800=
5810= MULTIPLE R     .9409 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
5820= R SQUARE       .8852 REGRESSION     4.       5.691     1.423    21.215
5830= STD DEV        .2590 RESIDUAL      11.        .738      .067 SIG. .000
5840= ADJ R SQUARE   .8435 COEFF OF VARIABILITY     7.0PCT
5850=
5860= VARIABLE          B       S.E. B       F     SIG.      BETA   ELASTICITY
5870=
5880= TOCWMAX         .921       .125    54.294  .000     1.30457   2.79127
5890= NZULT          1.035       .267    15.054  .003      .76997    .56727
5900= MAXMACH         .351       .160     4.842  .050      .30687    .01447
5910= TWTAREA        -.119       .083     2.067  .178     -.19062   -.26309
5920= CONSTANT      -7.019      1.690    21.402  .001
5930=1INITIAL REGRESSION                         01/14/82  10.33.15.    PAGE  15
5940=
5950= FILE - NONAME   (CREATED -  01/14/82)
5960=
5970= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
5980=
```

```
DEP. VAR... MANF       MANUFACTURING HOURS

VARIABLE(S) ENTERED ON STEP   5
PROTO       NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R     .9460 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8949 RECRESSION     5.       5.754     1.151    17.036
STD DEV        .2599 RESIDUAL      10.        .675      .068 SIG. .000
ADJ R SQUARE   .8424 COEFF OF VARIABILITY     7.0PCT

VARIABLE          B      S.E. B       F     SIG.       BETA   ELASTICITY

TOCUMAI        .861       .140    37.736  .000      1.29426   2.60922
NZULT          .914       .296     9.530  .011       .67985    .50088
MAIMACH        .326       .162     4.034  .072       .20481    .01343
TWTAREA       -.104       .084     1.519  .246     -.16678   -.23019
PROTO          .076       .079      .923  .359       .12448    .04068
CONSTANT     -7.167      1.827    15.394  .003


ALL VARIABLES ARE IN THE EQUATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE         B            95 PCT C.I.

TOCUMAX        .8608       .5486    1.1731
NZULT          .9138       .2545    1.5730
MAXMACH        .3261      -.0357     .6876
TWTAREA       -.1041      -.2923     .0841
PROTO          .0761      -.1004     .2527
CONSTANT     -7.1673    -11.2376   -3.0970


VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED RECRESSION COEFFICIENTS.


NZULT          .08754
MAXMACH       -.02152     .02636
TWTAREA       -.00569     .00435     .00714
TOCUMAX        .03307    -.00606    -.00568     .01964
PROTO         -.00999    -.00208     .00123    -.00495     .00628

                NZULT     MAXMACH    TWTAREA    TOCUMAX    PROTO


1INITIAL RECRESSION                          01/14/82  10.33.15.    PAGE   16

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E C R E S S I O N * * * * * * * * * *

DEP. VAR... MANF       MANUFACTURING HOURS


SUMMARY TABLE.

STEP VARIABLE E/R      F    MULT-R R-SQ CHANGE   R   OVERALL F  SIG.

  1  TOCUMAX   E     7.253  .584  .341  .341  .584    7.253  .017
  2  NZULT     E    25.156  .881  .776  .434 -.036   22.461  .000
  3  MAXMACH   E     7.757  .929  .864  .088  .402   25.343  .000
  4  TWTAREA   E     2.067  .941  .885  .022  .181   21.215  .000
  5  PROTO     E      .923  .946  .895  .010  .528   17.038  .000
```

```
6650=INITIAL REGRESSION                                    20 JAN 82  12.03.15    PAGE
6660=
6670= FILE - NONAME   (CREATED - 20/14/82)
6680=
6690= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
6700=
6710=
6720= RESIDUAL PLOT
6730=
6740=   Y VALUE    Y EST.  RESIDUAL -2SD              0.0                 +2SD
6750=
6760=     3.239     2.968     .271                     .               .
6770=     2.506     2.757    -.251              .      .
6780=     3.804     3.782     .022                     .    .
6790=     3.246     3.215     .031                     . .
6800=     4.707     4.695     .012                     . .
6810=     3.[illegible]     3.[illegible]     .[illegible]                     . .
6820=     4.075     4.046     .029                     . .
6830=     [illegible]     4.[illegible]    -.[illegible]        .            .
6840=     4.[illegible]     [illegible]     .[illegible]                     .      .
6850=     2.[illegible]     2.[illegible]     .[illegible]      *             . .
6860=     4.[illegible]     4.[illegible]     .[illegible]                     .
6870=     4.[illegible]     4.[illegible]     .[illegible]          .          .      .
6880=     3.[illegible]     4.[illegible]     -.[illegible]   .                .
6890=     3.50[illegible]     3.[illegible]     .[illegible]                     .      .
6900=     3.[illegible]     3.[illegible]    -.[illegible]          .          .
6910=     4.[illegible]     4.[illegible]     .[illegible]                     .  .
6920=
6930= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
6940=          R INDICATES POINT OUT OF RANGE OF PLOT
6950=
6960=
6970= NUMBER OF CASES PLOTTED        1[illegible]
6980= NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL
6990=
7000= VON NEUMANN RATIO    [illegible]          DURBIN-WATSON TEST    [illegible]
7010=
7020= NUMBER OF POSITIVE RESIDUALS    1[illegible].
7030= NUMBER OF NEGATIVE RESIDUALS     4.
7040= NUMBER OF RUNS OF SIGNS          [illegible].
7050=
7060= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
7070= USE A TABLE FOR EXPECTED VALUES.
7080=INITIAL REGRESSION                          20 JAN 82  12.03.15.    PAGE
7090=
7100= FILE - NONAME   (CREATED - 20/14/82)
7110=
7120= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
7130=
7140= DEP. VAR... TOOL      TOOLING
7150=
7160= MEAN RESPONSE        3.[illegible]       STD. DEV.       1.55994
7170=
7180= VARIABLE(S) ENTERED ON STEP   1
7190= NZULT      ULTIMATE LOAD FACTOR
7200=
7210= MULTIPLE R     .4863 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
7220= R SQUARE       .2365 REGRESSION     1.       8.633     8.633     4.3[illegible]
7230= STD DEV       1.4109 RESIDUAL      14.      27.869     1.991 SIG. .056
7240= ADJ R SQUARE  .1820 COEFF OF VARIABILITY    78.[illegible]PCT
7250=
7260= VARIABLE        B      S.E. B       F     SIG.      BETA  ELASTICITY
7270=
7280= NZULT        -1.556      .748     4.337  .056    -.46633  -1.75654
7290= CONSTANT      4.965     1.562    10.134  .007
7300=
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED IN STEP  2
MAXMACH    MAXIMUM MACH NUMBER

MULTIPLE R     [illegible] ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       [illegible] REGRESSION     [illegible]     [illegible]    [illegible]    [illegible]
STD DEV        [illegible] RESIDUAL       [illegible]     [illegible]    [illegible] SIG. [illegible]
ADJ R SQUARE   [illegible] COEFF OF VARIABILITY      [illegible]

VARIABLE         B        S.E. B        F      SIG.      BETA   ELASTICITY

NZULT         [illegible]   [illegible]   [illegible] [illegible]   [illegible] [illegible]
MAXMACH       [illegible]   [illegible]   [illegible] [illegible]   [illegible] [illegible]
CONSTANT      [illegible]   [illegible]   [illegible] [illegible]
INITIAL REGRESSION                               [illegible] [illegible]    PAGE [illegible]

FILE - NONAME   (CREATED - [illegible])

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

DEP. VAR.    [illegible]      [illegible]

VARIABLE(S) ENTERED IN STEP  3
TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT

MULTIPLE R     [illegible] ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .4642 REGRESSION     [illegible]     [illegible]    [illegible]    [illegible]
STD DEV        [illegible] RESIDUAL       [illegible]     [illegible]    [illegible] SIG. [illegible]
ADJ R SQUARE   [illegible] COEFF OF VARIABILITY      [illegible]

VARIABLE         B        S.E. B        F      SIG.      BETA   ELASTICITY

NZULT         [illegible]   [illegible]   7.893 .021    [illegible] [illegible]
MAXMACH       [illegible]   .719          5.225 .045    [illegible] [illegible]
TOGWMAX       -.457         .54[illegible]   .7[illegible] [illegible]    [illegible] [illegible]
CONSTANT      14.047        5.325         [illegible] [illegible]



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED IN STEP  4
PROTO      NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R     .6953 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .4835 REGRESSION     4.       17.647       4.412     2.574
STD DEV        1.3092 RESIDUAL      11.      18.554       1.714 SIG. .097
ADJ R SQUARE   .2956 COEFF OF VARIABILITY    72.7 PCT

VARIABLE         B        S.E. B        F      SIG.      BETA   ELASTICITY

NZULT         -3.815        1.451         6.911 .023    -1.19133 -4.30291
MAXMACH       1.531         .776          3.897 .074     .56133   .12974
TOGWMAX       -.651         .620          1.106 .316    -.41102 -4.06225
PROTO          .248         .392           .395 .541     .16990   .07222
CONSTANT      16.144        9.166         3.102 .106
INITIAL REGRESSION                              01/14/82  10.33.15.    PAGE  20

FILE - NONAME   (CREATED - 01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

[illegible]
```

```
6000= VARIABLE(S) ENTERED ON STEP  5
6000= TWTAREA    TOTAL WETTED AREA
6000=
6010= MULTIPLE R     .7116 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
6020= R SQUARE       .5064 REGRESSION     5.     [illegible]    [illegible]   2.052
6030= STD DEV        [illegible] RESIDUAL       10.    [illegible]    [illegible] SIG. .15[illegible]
6040= ADJ R SQUARE   .2596 COEFF OF VARIABILITY    [illegible]
6050=
6060= VARIABLE         B       S.E. B        F     SIG.      BETA   ELASTICITY
6070=
6080= NZULT        -4.052     [illegible]    7.2[illegible]  .024   [illegible]  [illegible]
6090= MAXMACH      [illegible]    [illegible]    4.[illegible]  [illegible]    [illegible]     .450[illegible]
6100= TOGWMAX      -.[illegible]    .[illegible]    .[illegible]  [illegible]   [illegible]  [illegible]
6110= PROTO        [illegible]    [illegible]    [illegible]  [illegible]   .284[illegible]  [illegible]
6120= TWTAREA      [illegible]    [illegible]    .4[illegible]  .5[illegible]   [illegible]  [illegible]
6130= CONSTANT     [illegible]    [illegible]    [illegible]  [illegible]
6140=
6150=
6160= ALL VARIABLES ARE IN THE EQUATION.
6170=
6180=
6190=
6200= COEFFICIENTS AND CONFIDENCE INTERVALS.
6210=
6220= VARIABLE         B           95 PCT C.I.
6230=
6240= NZULT        -4.05[illegible]    [illegible]    [illegible]
6250= MAXMACH      [illegible]    [illegible]    [illegible]
6260= TOGWMAX      [illegible]    -2.[illegible]    .[illegible]
6270= PROTO        [illegible]    [illegible]    [illegible]
6280= TWTAREA      [illegible]    -.[illegible]    [illegible]
6290= CONSTANT     [illegible]    [illegible]    [illegible]
6300=
6310=
6320= VARIANCE COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
6330=
6340=
6350= NZULT        [illegible]
6360= MAXMACH      [illegible]    [illegible]
6370= TWTAREA      [illegible]    [illegible]    .[illegible]
6380= TOGWMAX      [illegible]    [illegible]    [illegible]    [illegible]
6390= PROTO        -.[illegible]    -.0[illegible]    .0[illegible]    -.[illegible]    .[illegible]
6400=
6410=            NZULT    MAXMACH   TWTAREA   TOGWMAX   PROTO
6420=
6430=
6440=INITIAL REGRESSION                        [illegible]   PAGE  [illegible]
6450=
6460= FILE - NONAME   (CREATED - [illegible])
6470=
6480= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
6490=
6500= DEP. VAR... TOOL       TOOLING
6510=
6520=
6530= SUMMARY TABLE.
6540=
6550= STEP VARIABLE E/R      F   MULT-R R-SQ CHANGE   R   OVERALL F  SIG.
6560=
6570=   1  NZULT     E     4.337  .486  .237  .237 -.486     4.337  .056
6580=   2  MAXMACH   E     4.395  .655  .429  .19[illegible]  .074     4.892  .026
6590=   3  TOGWMAX   E      .793  .682  .465  .035  .336     3.474  .05[illegible]
6600=   4  PROTO     E      .398  .695  .483  .019  .003     2.574  .0[illegible]
6610=   5  TWTAREA   E      .464  .712  .506  .023  .[illegible]     2.052  .156
6620= INITIAL REGRESSION                   [illegible]           PAGE  [illegible]
```

```
FILE - NONAME   (CREATED - 01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


RESIDUAL PLOT.

  Y VALUE   Y EST.  RESIDUAL -2SD            0.0            +2SD

    [illegible]  [illegible]  [illegible]              :              R
   -[illegible]   [illegible]  -[illegible]         .    :
     .76[illegible]   .159    .[illegible]44            : .
     [illegible]   -[illegible]24   .[illegible]            :   .
    [illegible]   [illegible]   [illegible]            : .
    [illegible]   [illegible]  -[illegible]       .      :
    [illegible]   [illegible]   [illegible]            :.
    [illegible]   [illegible]  -[illegible]      .       :
    [illegible]   [illegible]    .45[illegible]            :  .
    [illegible]   [illegible]  -[illegible]         .    :
    [illegible]   [illegible]  -[illegible]           .  :
    [illegible]   [illegible]  -[illegible]           .  :
    [illegible]   [illegible]  -.44[illegible]            :
    [illegible]   [illegible]   [illegible]            :  .
    [illegible]   [illegible]  -[illegible]       .      :
    [illegible]   [illegible]   [illegible]            :   .

NOTE - + INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
       R INDICATES POINT OUT OF RANGE OF PLOT


NUMBER OF CASES PLOTTED        [illegible]
NUMBER OF 2 S.D. OUTLIERS      [illegible] OR  [illegible] PERCENT OF THE TOTAL

VON NEUMANN RATIO    [illegible]          DURBIN-WATSON TEST    [illegible]

NUMBER OF POSITIVE RESIDUALS      [illegible]
NUMBER OF NEGATIVE RESIDUALS      [illegible]
NUMBER OF RUNS OF SIGNS           [illegible]

NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
INITIAL REGRESSION                         01/14/82  10.33.[illegible]   PAGE  [illegible]

FILE - NONAME   (CREATED - 01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ENG       ENGINEERING HOURS

MEAN RESPONSE       1.90590     STD. DEV.      .[illegible]

VARIABLE(S) ENTERED ON STEP   1
PROTO      NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R    .5707 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .3257 REGRESSION     1.       2.984     2.964     6.763
STD DEV       .6642 RESIDUAL      14.       6.[illegible]77      .441 SIG. .021
ADJ R SQUARE  .2776 COEFF OF VARIABILITY   34.9PCT

VARIABLE       B      S.E. B       F     SIG.      BETA   ELASTICITY

PROTO         .417      .160    6.763  .021      .57072    .43[illegible]
CONSTANT     1.0[illegible]      .352    9.108  .009
```

```
9290=
9300= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
9310=
9320= VARIABLE(S) ENTERED ON STEP  2
9330= TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
9340=
9350= MULTIPLE R     .[illegible] ANOVA           DF  SUM SQUARES  MEAN SQ.       F
9360= R SQUARE       .[illegible] REGRESSION     [illegible]       [illegible]     [illegible]    [illegible]
9370= STD DEV        .50[illegible] RESIDUAL     [illegible]       [illegible]     [illegible] SIG. .00[illegible]
9380= ADJ R SQUARE  .55[illegible] COEFF OF VARIABILITY     [illegible]
9390=
9400= VARIABLE         B       S.E. B        F     SIG.       BETA   ELASTICITY
9410=
9420= PROTO           [illegible]      [illegible]    [illegible]  .024      [illegible]    [illegible]
9430= TOGWMAX         .[illegible]7      [illegible]    [illegible]  .00[illegible]      [illegible]    [illegible]
9440= CONSTANT      [illegible]     [illegible]    [illegible]  [illegible]
9450=INITIAL REGRESSION                          [illegible]  [illegible]    PAGE  [illegible]
9460=
9470= FILE - NONAME    (CREATED - [illegible])
9480=
9490= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
9500=
9510= DEP. VAR... ENG        ENGINEERING HOURS
9520=
9530= VARIABLE(S) ENTERED ON STEP  3
9540= NZULT      ULTIMATE LOAD FACTOR
9550=
9560= MULTIPLE R     .[illegible] ANOVA           DF  SUM SQUARES  MEAN SQ.       F
9570= R SQUARE       .[illegible] REGRESSION     [illegible]       [illegible]     [illegible]    [illegible]
9580= STD DEV        .[illegible] RESIDUAL       [illegible]       [illegible]     [illegible] SIG. .00[illegible]
9590= ADJ R SQUARE  .[illegible] COEFF OF VARIABILITY     [illegible]
9600=
9610= VARIABLE         B       S.E. B        F     SIG.       BETA   ELASTICITY
9620=
9630= PROTO           [illegible]      [illegible]    [illegible]  [illegible]      [illegible]    [illegible]
9640= TOGWMAX         [illegible]      [illegible]    37.4[illegible]  .000      [illegible]    [illegible]
9650= NZULT           [illegible]      [illegible]    [illegible]  .00[illegible]      [illegible]    [illegible]
9660= CONSTANT      [illegible]     2.[illegible]    [illegible]  .000
9670=
9680=
9690=
9700= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
9710=
9720= VARIABLE(S) ENTERED ON STEP  4
9730= TWTAREA    TOTAL WETTED AREA
9740=
9750= MULTIPLE R     .[illegible] ANOVA           DF  SUM SQUARES  MEAN SQ.       F
9760= R SQUARE       .[illegible] REGRESSION     4.        7.[illegible]     [illegible]    [illegible]
9770= STD DEV        .3505 RESIDUAL      [illegible]       [illegible]     .[illegible] SIG. .000
9780= ADJ R SQUARE  .7985 COEFF OF VARIABILITY     [illegible]
9790=
9800= VARIABLE         B       S.E. B        F     SIG.       BETA   ELASTICITY
9810=
9820= PROTO           .209      .105     3.9[illegible]  .07[illegible]      .2862[illegible]    [illegible]
9830= TOGWMAX         .[illegible]      .182    26.[illegible]  .000     [illegible]7248   5.46[illegible]
9840= NZULT          [illegible]      .357    14.6[illegible]  .00[illegible]      .84[illegible]   1.45[illegible]
9850= TWTAREA         .06[illegible]      .10[illegible]      .37[illegible]  .555      .06[illegible]    .25[illegible]
9860= CONSTANT     -12.2[illegible]     2.38[illegible]    26.576  .000
9870=INITIAL REGRESSION                          01/14/82  10.3[illegible]    PAGE  2[illegible]
9880=
9890= FILE - NONAME    (CREATED - 01/14/82)
9900=
9910= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
9920=
9930= DEP. VAR... ENG        ENGINEERING HOURS
9940=
```

```
0350= VARIABLE(S) ENTERED ON STEP   5
0360= MAXMACH     MAXIMUM MACH NUMBER
0370=
0380= MULTIPLE R     .9284 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
0390= R SQUARE       .8619 REGRESSION     5.       7.895      1.579    12.478
0400= STD DEV        .3557 RESIDUAL      10.       1.265       .127 SIG. .002
0410= ADJ R SQUARE  .7928 COEFF OF VARIABILITY    16.7PCT
0420=
0430= VARIABLE        B       S.E. B        F     SIG.       BETA   ELASTICITY
0440=
0450= PROTO          .195      .108     [illegible] .[illegible]   .26646   [illegible]
0460= TOGWMAX        .359      .1[illegible]    11.473 .00[illegible]    [illegible]   [illegible]
0470= NZULT         1.214      .465     6.991  .02[illegible]    .7[illegible]   1.0[illegible]
0480= TWTAREA        .096      .1[illegible]      .669 .426     .[illegible]   .4[illegible]
0490= MAXMACH        .1[illegible]      .1[illegible]      .677 .43[illegible]     .1[illegible]   .01464
0500= CONSTANT   -[illegible]     [illegible]    [illegible] .00[illegible]
0510=
0520=
0530= ALL VARIABLES ARE IN THE EQUATION.
0540=
0550=
0560=
0570= COEFFICIENTS AND CONFIDENCE INTERVALS.
0580=
0590= VARIABLE        B            95 PCT C.I.
0600=
0610= PROTO          .1946      -.0471      .4[illegible]
0620= TOGWMAX        .3[illegible]       .[illegible]     [illegible]
0630= NZULT         1.2144      .1[illegible]     2.[illegible]
0640= TWTAREA        .09[illegible]     -.[illegible]      .3[illegible]
0650= MAXMACH        .1[illegible]     -.[illegible]      .[illegible]
0660= CONSTANT    -[illegible]    -[illegible]   -[illegible]
0670=
0680=
0690= VARIANCE COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
0700=
0710=
0720= NZULT          .[illegible]
0730= MAXMACH       -.04[illegible]    .04[illegible]
0740= TWTAREA       -.01[illegible]    .00[illegible]    .01[illegible]
0750= TOGWMAX        .0[illegible]   -.0[illegible]   -.010[illegible]    .01675
0760= PROTO         -.0[illegible]   -.00390    .00[illegible]   -.0092[illegible]    .01[illegible]
0770=
0780=            NZULT    MAXMACH   TWTAREA   TOGWMAX   PROTO
0790=
0800=
0810= INITIAL REGRESSION                       01/14/82  10.33.15.    PAGE  [illegible]
0820=
0830= FILE - NONAME   (CREATED - 01/14/82)
0840=
0850= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * * *
0860=
0870= DEP. VAR... ENG        ENGINEERING HOURS
0880=
0890=
0900= SUMMARY TABLE.
0910=
0920= STEP VARIABLE E/R      F   MULT-R R-SQ CHANGE   R   OVERALL F  SIG.
0930=
0940=   1  PROTO     E     6.763  .571  .326  .326  .571     6.763  .021
0950=   2  TOGWMAX   E    11.565  .802  .643  .317  .564    1[illegible]  .001
0960=   3  NZULT     E    16.065  .921  .848  .204  .002    22.[illegible]  .000
0970=   4  TWTAREA   E      .371  .923  .853  .005  .300    15.895  .000
0980=   5  MAXMACH   E      .677  .928  .862  .009  .282    12.478  .002
0990= INITIAL REGRESSION                       01/14/82  10.33.15.    PAGE  [illegible]
1000=
```

```
FILE - NAME    CREATED - [illegible]

*********** MULTIPLE REGRESSION ***********


RESIDUAL PLOT.

  Y VALUE    Y EST.  RESIDUAL -2SD              0.0              +2SD

      .541      .831     -.291
      .595      .572      [illegible]
     1.647     1.924     -.277
     [illegible]  [illegible]  [illegible]
     1.466     [illegible]   .07[illegible]
     1.459     1.22[illegible]  [illegible]
     1.111     1.394     -.283
     2.045     2.146     -.0[illegible]5
     2.175     2.09[illegible]   .04[illegible]
     [illegible]  .794      [illegible]
     2.754     2.77[illegible]   .077
     [illegible]  [illegible]  -.526
     [illegible]  [illegible]  -.3[illegible]
     2.228     1.774      .40[illegible]
     [illegible]  [illegible]   .254
     3.045     2.77[illegible]   .2[illegible]

NOTE - * INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
       R INDICATES POINT OUT OF RANGE OF PLOT


NUMBER OF CASES PLOTTED        16.
NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

VON NEUMANN RATIO    [illegible]         DURBIN-WATSON TEST    [illegible]

NUMBER OF POSITIVE RESIDUALS      [illegible]
NUMBER OF NEGATIVE RESIDUALS      7.
NUMBER OF RUNS OF SIGNS           [illegible]

NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
INITIAL REGRESSION                       [illegible]  [illegible]    PAGE  [illegible]


CPU TIME REQUIRED..      .4[illegible] SECONDS



TOTAL CPU TIME USED..      .5640 SECONDS




RUN COMPLETED

NUMBER OF CONTROL CARDS READ  [illegible]
NUMBER OF ERRORS DETECTED      0
$
*EOR
[illegible]
[illegible]- LOGOUT
     [illegible] SEC.      [illegible] ADJ.
      49.57[illegible] SEC.      [illegible] ADJ.
[illegible]                        [illegible]
[illegible] TIME    [illegible] HRS.   59 MIN.
[illegible]
```

APPENDIX D

REGRESSION REG 2

```
MAND- E
MAND/TERMINAL MISMATCH
MMAND- EDITOR
..F,TAB=;,16
..GET,REG2,ID=DOZO
LE NAME REG2        HAS BEEN RETRIEVED
..GET,FA3,ID=DOZO
LE NAME FA3         HAS BEEN RETRIEVED
..REWIND,SPSS,FA3,REG2
..SPSS,D=FA3,I=REG2,LO=ABRV,L=W1,NR
```

```
..SS
```

```
 EDIT,W1,S
ES TRUNCATED- CH= 72 CHARS, LONGEST LINE WAS   75
..F,CH=132
..EDIT,W1,S
..L,A
```

```
 100=1
 110=S
 120=                                                  01/14/82  15.04.01. PAGE    1
 130=          VOGELBACK COMPUTING CENTER
 140=          NORTHWESTERN UNIVERSITY
 150=
 160=          S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
 170=
 180=          VERSION 8.0 -- JUNE 18, 1979
 190=
 200=
 210=
 220=
 230= RUN NAME        INITIAL REGRESSION
 240= VARIABLE LIST   NZULT,MAXMACH,TUTAREA,TOGWMAX,PROTO
 250=                 ENG,ODC,MANMAT,TOOL,MANF
 260= VAR LABELS      NZULT  ULTIMATE LOAD FACTOR/
 270=                 MAXMACH  MAXIMUM MACH NUMBER/
 280=                 TUTAREA  TOTAL WETTED AREA/
 290=                 TOGWMAX  MAXIMUM TAKEOFF GROSS WEIGHT/
 300=                 PROTO  NUMBER OF PROTOTYPE AIRCRAFT/
 310=                 ENG  ENGINEERING HOURS/
 320=                 ODC  OTHER DIRECT COSTS/
 330=                 MANMAT  MANUFACTURING MATERIALS/
 340=                 TOOL TOOLING/
 350=                 MANF  MANUFACTURING HOURS/
 360= INPUT FORMAT    FREEFIELD
 370= N OF CASES      UNKNOWN
 380= COMPUTE         ENG=LN(ENG)
 390= COMPUTE         ODC=LN(ODC)
 400= COMPUTE         TOOL=LN(TOOL)
 410= COMPUTE         MANMAT=LN(MANMAT)
```

```
COMPUTE        MANF=LN(MANF)
COMPUTE        TWTAREA=LN(TWTAREA)
COMPUTE        NZULT=LN(NZULT)
COMPUTE        MAXMACH=LN(MAXMACH)
COMPUTE        TOGWMAX=LN(TOGWMAX)
COMPUTE        MINZ=MAXMACH*NZULT
COMPUTE        TT=TOGWMAX*TWTAREA
COMPUTE        PROTO=LN(PROTO)
RECRESSION     VARIABLES=ENC,TOOL,MANF,MANMAT,ODC,MINZ,TT,PROTO
               TWTAREA,MAXMACH,NZULT,TOGWMAX
               REGRESSION=ODC WITH MINZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=TOOL WITH MINZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=MANF WITH MINZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=MANMAT WITH MINZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=ENC WITH MINZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
STATISTICS     ALL
READ INPUT DATA

00054700 CM NEEDED FOR REGRESSION



END OF FILE ON FILE FA3
AFTER READING     16 CASES FROM SUBFILE NONAME
1INITIAL REGRESSION                          01/14/82  15.04.01.   PAGE    2

FILE - NONAME   (CREATED - 01/14/82)

* * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *


VARIABLE           MEAN     STANDARD DEV     CASES

ENC              1.9059            .7815        16
TOOL             1.0012           1.5599        16
MANF             3.7059            .6547        16
MANMAT           4.0290            .7029        16
ODC              4.4497           1.1239        16
MINZ              .4618           1.2300        16
TT              92.5930          18.4092        16
PROTO            1.9000           1.0703        16
TWTAREA          8.1946           1.0409        16
MAXMACH           .1526            .5710        16
NZULT            2.0313            .4071        16
TOGWMAX         11.2327            .9043        16



CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.


TOOL          -.00627
MANF           .05294    .23914
MANMAT         .06769    .19543    .97334
ODC            .91036    .04004    .70033    .05602
MINZ           .32270    .04071    .45637    .47931    .42501
TT             .46476    .25258    .33153    .30665    .32059   -.40282
PROTO          [illegible]
```

```
TWTAREA        .29968    .16029    .10082    .11042    .20288   -.45168
MAXMACH        .28780    .07448    .40219    .43504    .39533    .98698*
NZULT          .00169   -.40633   -.03609    .05781    .12763    .52216
TOGWMAX        .56395    .33600    .58418    .52470    .41004   -.24212

               ENG       TOOL      MANF      MANMAT    ODC       MXNZ


PROTO         -.14620
TWTAREA        .92333*  -.19442
MAXMACH       -.41839    .45298   -.43074
NZULT         -.66253*   .35360   -.46350    .58154
TOGWMAX        .83309*   .00094    .56372   -.31386   -.77487*

               TT        PROTO     TWTAREA   MAXMACH   NZULT


1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE    3

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... ODC        OTHER DIRECT COSTS

 MEAN RESPONSE        4.46969      STD. DEV.       1.12392

 VARIABLE(S) ENTERED ON STEP   1
 PROTO       NUMBER OF PROTOTYPE AIRCRAFT

 MULTIPLE R    .7591 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE      .5763 REGRESSION     1.       10.919    10.919    19.040
 STD DEV       .7573 RESIDUAL      14.        8.029      .573 SIG. .001
 ADJ R SQUARE  .5460 COEFF OF VARIABILITY    16.9PCT

 VARIABLE        B        S.E. B        F      SIG.      BETA   ELASTICITY

 PROTO          .797       .183     19.040  .001      .75913    .35315
 CONSTANT      2.891       .400     50.146  .000



 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

 VARIABLE(S) ENTERED ON STEP   2
 TT

 MULTIPLE R    .8756 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE      .7666 REGRESSION     2.       14.526     7.263    21.350
 STD DEV       .5833 RESIDUAL      13.        4.422      .340 SIG. .000
 ADJ R SQUARE  .7307 COEFF OF VARIABILITY    13.0PCT

 VARIABLE        B        S.E. B        F      SIG.      BETA   ELASTICITY

 PROTO          .865       .142     36.975  .000      .82360    .30314
 TT             .027       .008     10.601  .006      .44100    .55534
 CONSTANT       .275       .863       .102  .755
1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE    4

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... ODC        OTHER DIRECT COSTS

 VARIABLE(S) ENTERED ON STEP   2
```

```
VARIABLE(S) ENTERED ON STEP 3
MXNZ

MULTIPLE R    .9161 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .8392 REGRESSION     3.      15.901     5.300    20.675
STD DEV       .5039 RESIDUAL      12.       3.047      .254 SIG. .000
ADJ R SQUARE  .7990 COEFF OF VARIABILITY    11.3PCT

VARIABLE         B      S.E. B       F     SIG.       BETA   ELASTICITY

PROTO          .722      .137    27.568  .000       .68717    .31967
TT             .034      .008    19.111  .001       .55337    .69684
MXNZ           .299      .128     5.417  .038       .32911    .03085
CONSTANT      -.212      .774      .075  .769



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP  4
NZULT       ULTIMATE LOAD FACTOR

MULTIPLE R    .9236 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .8530 REGRESSION     4.      16.162     4.041    15.953
STD DEV       .5033 RESIDUAL      11.       2.786      .253 SIG. .000
ADJ R SQUARE  .7995 COEFF OF VARIABILITY    11.3PCT

VARIABLE         B      S.E. B       F     SIG.       BETA   ELASTICITY

PROTO          .691      .141    24.139  .000       .65778    .30600
TT             .039      .010    17.005  .002       .64815    .81619
MXNZ           .264      .133     3.948  .072       .29057    .02724
NZULT          .399      .393     1.030  .332       .17293    .18135
CONSTANT     -1.478     1.468     1.014  .336
1INITIAL REGRESSION                            01/14/82  15.04.01.   PAGE    5

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ODC        OTHER DIRECT COSTS

VARIABLE(S) ENTERED ON STEP   5
TWTAREA    TOTAL WETTED AREA

MULTIPLE R    .9472 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .8972 REGRESSION     5.      16.999     3.400    17.446
STD DEV       .4414 RESIDUAL      10.       1.949      .195 SIG. .000
ADJ R SQUARE  .8457 COEFF OF VARIABILITY     9.9PCT

VARIABLE         B      S.E. B       F     SIG.       BETA   ELASTICITY

PROTO          .616      .129    22.920  .001       .58617    .27268
TT             .092      .027    11.097  .006      1.50030   1.09936
MXNZ           .144      .130     1.210  .296       .15810    .01483
NZULT         1.092      .480     5.170  .046       .47344    .49649
TWTAREA       -.041      .486     4.296  .065      -.70493  -1.54205
CONSTANT      -.632     1.351      .210  .630
1INITIAL REGRESSION                            01/14/82  15.04.01.   PAGE    6

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ODC        OTHER DIRECT COSTS

VARIABLE(S) ENTERED ON STEP   6
```

```
 MAXMACH    MAXIMUM MACH NUMBER

 MULTIPLE R    .9496 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE      .9018 REGRESSION     6.       17.087     2.848   13.770
 STD DEV       .4540 RESIDUAL       9.        1.861      .207 SIG. .000
 ADJ R SQUARE  .8363 COEFF OF VARIABILITY    10.2PCT

 VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY

 PROTO           .610      .133    21.149  .001      .58107     .27031
 TT              .087      .028     9.255  .014     1.42491    1.79435
 MINZ            .618      .741      .694  .426      .60071     .06381
 NZULT          1.155      .504     5.247  .048      .50063     .52500
 TWTAREA        -.739      .447     2.733  .133     -.68929   -1.35416
 MAXMACH       -1.045     1.607      .423  .532     -.53160    -.03567
 CONSTANT      -1.178     1.626      .525  .487
1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE    7

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... ODC         OTHER DIRECT COSTS

 VARIABLE(S) ENTERED ON STEP   7
 TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT

 MULTIPLE R    .9499 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE      .9022 REGRESSION     7.       17.096     2.442   10.547
 STD DEV       .4812 RESIDUAL       8.        1.853      .232 SIG. .002
 ADJ R SQUARE  .8167 COEFF OF VARIABILITY    10.8PCT

 VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY

 PROTO           .626      .162    15.010  .005      .59590     .27721
 TT              .110      .123      .798  .398     1.80754    2.27618
 MINZ            .688      .864      .634  .449      .75863     .07112
 NZULT          1.130      .549     4.238  .074      .48975     .51359
 TWTAREA       -1.001     1.423      .494  .502     -.93369   -1.83430
 MAXMACH       -1.212     1.905      .405  .542     -.61673    -.04139
 TOGWMAX        -.228     1.168      .038  .850     -.19963    -.57284
 CONSTANT       1.307    13.264      .011  .919


 ALL VARIABLES ARE IN THE EQUATION.



 COEFFICIENTS AND CONFIDENCE INTERVALS.

 VARIABLE         B            95 PCT C.I.

 PROTO          .6258        .2533     .9983
 TT             .1099       -.1737     .3934
 MINZ           .6883      -1.3043    2.6808
 NZULT         1.1301       -.1357    2.3959
 TWTAREA      -1.0005      -4.2824    2.2814
 MAXMACH      -1.2122      -5.6041    3.1797
 TOGWMAX       -.2279      -2.9223    2.4664
 CONSTANT      1.3075     -29.1990   31.9740


 VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


 MTU7          .7AAA3
```

```
TT              .03526    .01512
PROTO           .01847    .00830    .02609
TOCWMAX        -.42337   -.13930   -.09330   1.36514
TWTAREA        -.32900   -.17358   -.09115   1.56843   2.02548
MAXMACH       -1.62275   -.00823   -.05367   1.00210    .86771   3.62727
NZULT          -.00328   -.00412   -.03652    .15040    .02852   -.06323

                MINZ      TT        PROTO     TOCWMAX   TWTAREA   MAXMACH


NZULT           .30132

                NZULT


1INITIAL REGRESSION                             01/14/82  15.04.01.    PAGE    8

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

 DEP. VAR... ODC         OTHER DIRECT COSTS


 SUMMARY TABLE.

 STEP VARIABLE E/R      F    MULT-R R-SQ CHANGE   R    OVERALL F  SIC.

   1  PROTO     E     19.040  .759  .576  .576  .759    19.040  .001
   2  TT        E     10.601  .876  .767  .190  .321    21.350  .000
   3  MINZ      E      5.417  .916  .839  .073  .426    20.875  .000
   4  NZULT     E      1.030  .924  .853  .014  .128    15.953  .000
   5  TWTAREA   E      4.296  .947  .897  .044  .203    17.446  .000
   6  MAXMACH   E       .423  .950  .902  .005  .395    13.770  .000
   7  TOCWMAX   E       .030  .950  .902  .000  .411    10.547  .002
1INITIAL REGRESSION                             01/14/82  15.04.01.    PAGE    9

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD             0.0              +2SD

     2.805     2.699      .106                  I  .
     2.476     2.369      .106                  I  .
     3.575     4.309     -.734     .            I
     4.613     4.397      .216                  I     .
     6.208     5.939      .269                  I      .
     3.468     3.474     -.006                 .I
     4.711     4.553      .158                  I    .
     4.281     4.806     -.526          .       I
     4.047     4.044      .003                  .
     2.931     2.839      .0?2                  I .
     5.371     5.104      .267                  I      .
     4.551     5.304     -.753     .           .I
     5.301     5.144      .157                  I    .
     5.165     5.102      .063                  I .
     5.312     5.138      .174                  I    .
     5.901     5.494      .407                  I         .

 NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
        R INDICATES POINT OUT OF RANGE OF PLOT
```

```
NUMBER OF CASES PLOTTED          16.
NUMBER OF 2 S.D. OUTLIERS         0 OR      0 PERCENT OF THE TOTAL
VON NEUMANN RATIO    2.55766           DURBIN-WATSON TEST    2.39780
NUMBER OF POSITIVE RESIDUALS      12.
NUMBER OF NEGATIVE RESIDUALS       4.
NUMBER OF RUNS OF SIGNS            9.
NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                              01/14/82  15.04.01.    PAGE   10
FILE - NONAME    (CREATED -  01/14/82)
* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
DEP. VAR... TOOL        TOOLING
MEAN RESPONSE        1.80119      STD. DEV.       1.55994
VARIABLE(S) ENTERED ON STEP   1
NZULT      ULTIMATE LOAD FACTOR
MULTIPLE R     .4863 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .2365 REGRESSION     1.        8.633     8.633     4.337
STD DEV       1.4109 RESIDUAL      14.       27.866     1.991 SIG. .056
ADJ R SQUARE  .1820 COEFF OF VARIABILITY    78.3PCT
VARIABLE        B       S.E. B        F     SIG.       BETA   ELASTICITY
NZULT        -1.558      .748     4.337  .056     -.48633  -1.75654
CONSTANT      4.965     1.560    10.134  .007
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
VARIABLE(S) ENTERED ON STEP   2
MAXMACH    MAXIMUM MACH NUMBER
MULTIPLE R     .6553 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .4294 REGRESSION     2.       15.674     7.837     4.892
STD DEV       1.2657 RESIDUAL      13.       20.827     1.602 SIG. .026
ADJ R SQUARE  .3416 COEFF OF VARIABILITY    70.3PCT
VARIABLE        B       S.E. B        F     SIG.       BETA   ELASTICITY
NZULT        -2.563      .825     9.657  .008     -.80030  -2.89055
MAXMACH       1.473      .703     4.395  .056      .53989    .12478
CONSTANT      6.703     1.646    16.979  .001
1INITIAL REGRESSION                              01/14/82  15.04.01.    PAGE   11
FILE - NONAME    (CREATED -  01/14/82)
* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
DEP. VAR... TOOL        TOOLING
VARIABLE(S) ENTERED ON STEP   3
NINZ
MULTIPLE R     .7264 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .5276 REGRESSION     3.       19.250     6.419     4.467
STD DEV       1.1987 RESIDUAL      12.       17.743     1.437 SIG. .025
```

```
ADJ R SQUARE  .4095 COEFF OF VARIABILITY    66.6PCT

VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY

NZULT         -3.095      .851    13.238  .003    -.96642  -3.49056
MAXMACH        7.449     3.843     3.758  .076    2.73075    .63115
MXNZ          -2.672     1.692     2.494  .140   -2.12187   -.68509
CONSTANT       8.186     1.794    20.813  .001



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   4
TT

MULTIPLE R     .7386 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .5455 REGRESSION     4.       19.913     4.978     3.301
STD DEV       1.2280 RESIDUAL      11.       16.588     1.508 SIG. .052
ADJ R SQUARE  .3803 COEFF OF VARIABILITY    68.2PCT

VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY

NZULT         -3.512     1.077    10.639  .008   -1.09653  -3.96052
MAXMACH        7.941     4.007     3.928  .073    2.91104    .67282
MXNZ          -2.903     1.768     2.695  .129   -2.30534   -.74433
TT             -.015      .023      .434  .523    -.18274   -.79255
CONSTANT      10.491     3.952     7.048  .022
1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE   12

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... TOOL        TOOLING

VARIABLE(S) ENTERED ON STEP   5
PROTO       NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R     .7510 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .5640 REGRESSION     5.       20.585     4.117     2.587
STD DEV       1.2616 RESIDUAL      10.       15.916     1.592 SIG. .094
ADJ R SQUARE  .3459 COEFF OF VARIABILITY    70.0PCT

VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY

NZULT         -3.710     1.148    10.454  .009   -1.15857  -4.18459
MAXMACH        8.381     4.172     4.037  .072    3.07230    .71009
MXNZ          -3.174     1.864     2.900  .119   -2.52096   -.81394
TT             -.019      .025      .572  .467    -.21977   -.95317
PROTO           .232      .357      .422  .530     .15926    .25516
CONSTANT      10.703     4.085     6.969  .025
1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE   13

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... TOOL        TOOLING

VARIABLE(S) ENTERED ON STEP   6
TWTAREA     TOTAL WETTED AREA

MULTIPLE R     .7693 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .5919 REGRESSION     6.       21.604     3.601     2.175
STD DEV       1.2866 RESIDUAL       9.       14.897     1.655 SIG. .142
```

```
5040= ADJ R SQUARE  .3198 COEFF OF VARIABILITY   71.4PCT
5050=
5060= VARIABLE        B       S.E. B       F     SIG.       BETA    ELASTICITY
5070=
5080= MZULT        -4.351      1.427     9.300  .014    -1.35050  -4.90671
5090= MAIMACH       7.122      4.546     2.454  .152     2.61090    .60345
5100= MINZ         -2.479      2.097     1.398  .267    -1.96896   -.63572
5110= TT            -.079       .081      .953  .354     -.93196  -4.04207
5120= PROTO          .303       .375      .653  .440      .20810    .33343
5130= TWTAREA        .992      1.264      .616  .453      .66687   4.51229
5140= CONSTANT      9.250      4.601     4.042  .075
5150=1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE   14
5160=
5170= FILE - NCNAME   (CREATED -  01/14/82)
5180=
5190= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
5200=
5210= DEP. VAR... TOOL       TOOLING
5220=
5230= VARIABLE(S) ENTERED ON STEP   7
5240= TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
5250=
5260= MULTIPLE R      .8073 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
5270= R SQUARE        .6517 REGRESSION     7.      23.789     3.398     2.139
5280= STD DEV        1.2606 RESIDUAL       8.      12.712     1.589 SIG. .154
5290= ADJ R SQUARE    .3470 COEFF OF VARIABILITY    70.0PCT
5300=
5310= VARIABLE        B       S.E. B       F     SIG.       BETA    ELASTICITY
5320=
5330= MZULT        -3.955      1.438     7.567  .025    -1.23504  -4.46878
5340= MAIMACH       9.757      4.989     3.825  .086     3.57665    .82666
5350= MINZ         -3.592      2.263     2.519  .151    -2.85298   -.92112
5360= TT            -.445       .322     1.907  .205    -5.27264 -22.86837
5370= PROTO          .058       .423      .019  .894      .03981    .06378
5380= TWTAREA       5.115      3.728     1.883  .207     3.43938  23.27218
5390= TOGWMAX       3.589      3.061     1.375  .275     2.26463  22.38187
5400= CONSTANT    -31.150     34.746      .804  .396
5410=
5420=
5430= ALL VARIABLES ARE IN THE EQUATION.
5440=
5450=
5460=
5470= COEFFICIENTS AND CONFIDENCE INTERVALS.
5480=
5490= VARIABLE          B              95 PCT C.I.
5500=
5510= MZULT          -3.9554      -7.2713     -.6395
5520= MAIMACH         9.7571      -1.7477    21.2618
5530= MINZ           -3.5924      -8.8120     1.6272
5540= TT              -.4449      -1.1877      .2980
5550= PROTO            .0580       -.9177     1.0337
5560= TWTAREA         5.1153      -3.4818    13.7123
5570= TOGWMAX         3.5090      -3.4689    10.6469
5580= CONSTANT      -31.1502       -.1E+03    48.9747
5590=
5600=
5610= VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
5620=
5630=
5640= MINZ          5.12339
5650= TT             .24190     .10377
5660= PROTO          .12672     .05695     .17903
5670= TOGWMAX      -2.90517    -.95500    -.64024    9.36762
5680= TWTAREA      -2.26306   -1.19113    -.62550   10.76261   13.89889
5690= MAIMACH     -11.[illegible]   [illegible]   [illegible]   [illegible]   5.95427   [illegible]
```

```
NZULT          -.02254   -.02828   -.25063   1.03206    .19570   -.43389

                MINZ      TT        PROTO     TOGWMAX   TWTAREA   MAXMACH


NZULT          2.06765

                NZULT


1INITIAL RECRESSION                              01/14/82  15.04.01.    PAGE  15

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

 DEP. VAR... TOOL        TOOLING


 SUMMARY TABLE.

 STEP VARIABLE E/R      F    MULT-R R-SQ CHANGE   R    OVERALL F  SIG.

   1  NZULT     E     4.337  .486  .237  .237 -.486      4.337  .056
   2  MAXMACH   E     4.395  .655  .429  .193  .074      4.892  .026
   3  MINZ      E     2.494  .726  .528  .098  .069      4.467  .025
   4  TT        E      .434  .739  .546  .018  .253      3.301  .052
   5  PROTO     E      .422  .751  .564  .018  .003      2.587  .094
   6  TWTAREA   E      .616  .769  .592  .028  .160      2.175  .142
   7  TOGWMAX   E     1.375  .807  .652  .060  .336      2.139  .154
1INITIAL RECRESSION                              01/14/82  15.04.01.    PAGE  16

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD               0.0                 +2SD

     6.837     5.151     1.687                     I                .
     -.302     -.051     -.252                   . I
      .703      .912     -.209                   . I
      .815      .668      .148                     I .
     3.016     2.074      .941                     I       .
     1.411     1.672     -.261                  .  I
     2.072     1.930      .142                     I .
     1.609     3.436    -1.827       .             I
     1.005      .592     1.213                     I          .
      .285     1.117     -.832              .      I
       1.044     2.565     -.721              .      I
     1.690     1.770     -.080                    .I
     1.221     1.563     -.342                  .  I
     2.087      .937     1.150                     I          .
     1.690     2.779    -1.089            .        I
     2.036     1.704      .332                     I  .

 NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
          R INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED         16.
 NUMBER OF 2 S.D. OUTLIERS        0 OR       0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    2.78387          DURBIN-WATSON TEST    2.60000
```

```

NUMBER OF POSITIVE RESIDUALS      7.
NUMBER OF NEGATIVE RESIDUALS      9.
NUMBER OF RUNS OF SIGNS          11.

NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE   17

 FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * *M U L T I P L E   R E G R E S S I O N* * * * * * * * * *

 DEP. VAR... MANF         MANUFACTURING HOURS

 MEAN RESPONSE        3.70590     STD. DEV.        .65468

 VARIABLE(S) ENTERED ON STEP   1
 TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT

 MULTIPLE R     .5842 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE       .3413 RECRESSION     1.        2.194     2.194     7.253
 STD DEV        .5500 RESIDUAL      14.        4.235      .303 SIG. .017
 ADJ R SQUARE  .2942 COEFF OF VARIABILITY    14.8PCT

 VARIABLE        B       S.E. B       F      SIG.      BETA   ELASTICITY

 TOGWMAX        .389      .144     7.253  .017      .58418   1.17770
 CONSTANT      -.659     1.626      .164  .692



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

 VARIABLE(S) ENTERED ON STEP   2
 NZULT       ULTIMATE LOAD FACTOR

 MULTIPLE R     .8807 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE       .7756 REGRESSION     2.        4.986     2.493    22.461
 STD DEV        .3332 RESIDUAL      13.        1.443      .111 SIG. .000
 ADJ R SQUARE  .7410 COEFF OF VARIABILITY     9.0PCT

 VARIABLE        B       S.E. B       F      SIG.      BETA   ELASTICITY

 TOGWMAX        .926      .138    44.847  .000     1.39201   2.80629
 NZULT         1.401      .279    25.154  .000     1.04254    .76809
 CONSTANT     -9.540     2.026    22.164  .000
1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE   18

 FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * *M U L T I P L E   R E G R E S S I O N* * * * * * * * * *

 DEP. VAR... MANF         MANUFACTURING HOURS

 VARIABLE(S) ENTERED ON STEP   3
 NXNZ

 MULTIPLE R     .9324 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE       .8693 REGRESSION     3.        5.509     1.063    26.614
 STD DEV        .2644 RESIDUAL      12.         .840      .070 SIG. .000
 ADJ R SQUARE  .8367 COEFF OF VARIABILITY     7.1PCT

 VARIABLE        B       S.E. B       F      SIG.      BETA   ELASTICITY

 TOGWMAX        .824      .115    51.200  .000     1.23000   2.49754
```

```
NZULT            .977      .265    13.634  .003      .72724    .53579
MINZ             .199      .068     8.613  .012      .37659    .02480
CONSTANT       -7.627     1.736    19.297  .001



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   4
TT

MULTIPLE R      .9420 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE        .8873 REGRESSION     4.        5.704     1.426   21.647
STD DEV         .2567 RESIDUAL      11.         .725      .066 SIG. .000
ADJ R SQUARE    .8463 COEFF OF VARIABILITY     6.9PCT

VARIABLE          B        S.E. B      F      SIG.      BETA   ELASTICITY

TOCUMAI          .986      .166    35.389  .000     1.48248   2.98865
NZULT           1.047      .262    15.948  .002      .77867    .57368
MINZ             .159      .072     4.864  .050      .30163    .01987
TT              -.009      .007     1.751  .213     -.26635   -.23564
CONSTANT       -8.696     1.868    21.670  .001
1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   19

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

DEP. VAR... MANF        MANUFACTURING HOURS

VARIABLE(S) ENTERED ON STEP   5
PROTO       NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R      .9464 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE        .8957 REGRESSION     5.        5.758     1.152   17.168
STD DEV         .2590 RESIDUAL      10.         .671      .067 SIG. .000
ADJ R SQUARE    .8435 COEFF OF VARIABILITY     7.0PCT

VARIABLE          B        S.E. B      F      SIG.      BETA   ELASTICITY

TOCUMAI          .917      .184    24.773  .001     1.37849   2.77902
NZULT            .931      .294     9.995  .010      .69245    .51016
MINZ             .150      .074     4.110  .070      .28297    .01864
TT              -.008      .007     1.197  .300     -.22729   -.20108
PROTO            .071      .080      .803  .391      .11673    .03815
CONSTANT       -7.949     2.061    14.869  .003
1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   20

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

DEP. VAR... MANF        MANUFACTURING HOURS

VARIABLE(S) ENTERED ON STEP   6
TWTAREA     TOTAL WETTED AREA

MULTIPLE R      .9481 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE        .8990 REGRESSION     6.        5.780      .963   13.349
STD DEV         .2686 RESIDUAL       9.         .649      .072 SIG. .000
ADJ R SQUARE    .8316 COEFF OF VARIABILITY     7.2PCT

VARIABLE          B        S.E. B      F      SIG.      BETA   ELASTICITY

TOCUMAI         1.216      .582     4.361  .066     1.82951   3.686[illegible]
```

```
7680= NZULT           .941        .306      9.456  .013      .69977    .51555
7690= MINZ            .163        .000      4.112  .073      .30786    .02028
7700= TT             -.042        .064       .445  .522  -1.19733  -1.05928
7710= PROTO           .054        .009       .367  .560      .08789    .02872
7720= TWTAREA         .410        .753       .296  .600      .65600    .90553
7730= CONSTANT     -11.477       6.829      2.025  .127
7740=1INITIAL REGRESSION                           01/14/82  15.04.01.   PAGE   21
7750=
7760= FILE - NONAME   (CREATED -  01/14/82)
7770=
7780= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
7790=
7800= DEP. VAR... MANF          MANUFACTURING HOURS
7810=
7820= VARIABLE(S) ENTERED ON STEP   7
7830= MAXMACH     MAXIMUM MACH NUMBER
7840=
7850= MULTIPLE R     .9502 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
7860= R SQUARE       .9029 RECRESSION      7.       5.805      .829    10.623
7870= STD DEV        .2794 RESIDUAL        8.        .624      .078 SIG. .002
7880= ADJ R SQUARE  .8179 COEFF OF VARIABILITY     7.5PCT
7890=
7900= VARIABLE          B       S.E. B       F     SIG.      BETA   ELASTICITY
7910=
7920= TOGWMAX         1.309       .678      4.192  .075    2.00833   4.21006
7930= NZULT            .930       .319      8.509  .019     .69165    .5[illegible]57
7940= MINZ            -.117       .502       .055  .821    -.22169   -.0146[illegible]
7950= TT              -.058       .071       .651  .443  -1.62703  -1.43943
7960= PROTO            .045       .094       .225  .648     .07276    .02378
7970= TWTAREA          .559       .826       .458  .518     .89502   1.23642
7980= MAXMACH          .626      1.106       .320  .587     .54637    .02576
7990= CONSTANT      -13.162      7.701      2.921  .126
8000=
8010=
8020= ALL VARIABLES ARE IN THE EQUATION.
8030=
8040=
8050=
8060= COEFFICIENTS AND CONFIDENCE INTERVALS.
8070=
8080= VARIABLE          B            95 PCT C.I.
8090=
8100= TOGWMAX        1.3090       -.1753    2.9533
8110= NZULT           .9296        .1947    1.6644
8120= MINZ           -.1172      -1.2740    1.0397
8130= TT             -.0576       -.2223     .1070
8140= PROTO           .0445       -.1710     .2600
8150= TWTAREA         .5592      -1.3463    2.4646
8160= MAXMACH         .6255      -1.9244    3.1755
8170= CONSTANT     -13.1617     -30.9207    4.5973
8180=
8190=
8200= VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
8210=
8220=
8230= MINZ            .25169
8240= TT              .01109     .00510
8250= PROTO           .00623     .00290     .00079
8260= TOGWMAX       -.14272    -.04696    -.03145     .46010
8270= TWTAREA       -.11117    -.05051    -.03073     .52071     .60270
8280= MAXMACH       -.54702    -.02974    -.01009     .33701     .29250    1.22274
8290= NZULT         -.00111    -.00139    -.01231     .05070     .00961    -.02131
8300=
8310=                MINZ       TT        PROTO     TOGWMAX    TWTAREA    MAXMACH
8320=
8330=
```

```
....
 NZULT          .10157

              NZULT


1INITIAL REGRESSION                        01/14/82  15.04.01.   PAGE   22

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

 DEP. VAR... MANF         MANUFACTURING HOURS


 SUMMARY TABLE.

 STEP VARIABLE E/R      F   MULT-R R-SQ CHANGE   R   OVERALL F  SIC.

   1  TOGWMAI   E     7.253  .584  .341  .341  .584     7.253  .017
   2  NZULT     E    25.156  .881  .776  .434 -.036    22.461  .000
   3  MINZ      E     8.613  .932  .869  .094  .456    26.614  .000
   4  TT        E     1.751  .942  .887  .018  .332    21.647  .000
   5  PROTO     E      .003  .946  .896  .008  .528    17.168  .000
   6  TWTAREA   E      .296  .948  .899  .003  .101    13.349  .000
   7  MAINACH   E      .320  .950  .903  .004  .402    10.623  .002
1INITIAL REGRESSION                        01/14/82  15.04.01.   PAGE   23

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD              0.0              +2SD

     3.239     3.050      .189                     I     .
     2.526     2.675     -.149                .    I
     3.804     3.711      .093                     I  .
     3.246     3.311     -.064                   . I
     4.727     4.582      .146                     I    .
     3.118     3.080      .037                     I .
     4.078     4.101     -.024                    .I
     3.738     4.045     -.308          .          I
     4.091     3.941      .150                     I    .
     2.803     2.773      .030                     I .
     4.412     4.222      .190                     I     .
     4.297     4.143      .155                     I    .
     3.600     4.076     -.468     .               I
     3.526     3.275      .252                     I       .
     3.336     3.598     -.262            .        I
     4.745     4.710      .034                     I .

 NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
          R INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED        16.
 NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    3.15490          DURBIN-WATSON TEST    2.95700

 NUMBER OF POSITIVE RESIDUALS     10.
 NUMBER OF NEGATIVE RESIDUALS      6.
 NUMBER OF RUNS OF SIGNS          11.
```

```
9000= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
9010= USE A TABLE FOR EXPECTED VALUES.
9020=1INITIAL REGRESSION                        01/14/82  15.04.01.    PAGE   24
9030=
9040= FILE - NONAME   (CREATED -  01/14/82)
9050=
9060= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
9070=
9080= DEP. VAR... MANMAT     MANUFACTURING MATERIALS
9090=
9100= MEAN RESPONSE        4.02899      STD. DEV.        .70284
9110=
9120= VARIABLE(S) ENTERED ON STEP   1
9130= PROTO       NUMBER OF PROTOTYPE AIRCRAFT
9140=
9150= MULTIPLE R      .5962 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
9160= R SQUARE        .3554 REGRESSION      1.       2.634     2.634     7.720
9170= STD DEV         .5841 RESIDUAL       14.       4.777      .341 SIG. .015
9180= ADJ R SQUARE    .3094 COEFF OF VARIABILITY    14.5PCT
9190=
9200= VARIABLE          B       S.E. B        F      SIG.      BETA   ELASTICITY
9210=
9220= PROTO           .392      .141     7.720  .015       .59617    .19241
9230= CONSTANT       3.254      .315   106.754  .000
9240=
9250=
9260=
9270= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
9280=
9290= VARIABLE(S) ENTERED ON STEP   2
9300= TOGWMAX     MAXIMUM TAKEOFF GROSS WEIGHT
9310=
9320= MULTIPLE R      .7938 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
9330= R SQUARE        .6301 REGRESSION      2.       4.670     2.335    11.074
9340= STD DEV         .4592 RESIDUAL       13.       2.741      .211 SIG. .002
9350= ADJ R SQUARE    .5732 COEFF OF VARIABILITY    11.4PCT
9360=
9370= VARIABLE          B       S.E. B        F      SIG.      BETA   ELASTICITY
9380=
9390= PROTO           .391      .111    12.472  .004       .59568    .19225
9400= TOGWMAX         .374      .120     9.656  .008       .52414   1.04345
9410= CONSTANT       -.950     1.375      .477  .502
9420=1INITIAL REGRESSION                        01/14/82  15.04.01.    PAGE   25
9430=
9440= FILE - NONAME   (CREATED -  01/14/82)
9450=
9460= * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *
9470=
9480= DEP. VAR... MANMAT     MANUFACTURING MATERIALS
9490=
9500= VARIABLE(S) ENTERED ON STEP   3
9510= NZULT       ULTIMATE LOAD FACTOR
9520=
9530= MULTIPLE R      .9297 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
9540= R SQUARE        .8643 REGRESSION      3.       6.405     2.135    25.479
9550= STD DEV         .2895 RESIDUAL       12.       1.005      .084 SIG. .000
9560= ADJ R SQUARE    .8304 COEFF OF VARIABILITY     7.2PCT
9570=
9580= VARIABLE          B       S.E. B        F      SIG.      BETA   ELASTICITY
9590=
9600= PROTO           .176      .084     4.360  .059       .26813    .08654
9610= TOGWMAX         .886      .136    42.639  .000      1.24075   2.47009
9620= NZULT          1.334      .293    20.710  .001       .92442    .67255
9630= CONSTANT      -8.981     1.964    20.843  .001
9640=
9650=
```

```
****************************************
VARIABLE(S) ENTERED ON STEP   4
MINZ

MULTIPLE R     .9551 ANOVA          DF  SUM SQUARES  MEAN SQ.     F
R SQUARE       .9123 REGRESSION      4.       6.760     1.690    28.604
STD DEV        .2431 RESIDUAL       11.        .650      .059 SIG. .000
ADJ R SQUARE  .8804 COEFF OF VARIABILITY     6.0PCT

VARIABLE          B      S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .131      .073      3.226  .100       .19998    .06454
TOGWMAI         .839      .116     52.677  .000      1.17453   2.33825
NZULT          1.085      .266     16.611  .002       .75196    .54708
MINZ            .158      .064      6.017  .032       .27816    .01809
CONSTANT      -7.929     1.706     21.600  .001
1INITIAL REGRESSION                           01/14/82  15.04.01.    PAGE  26

FILE - NONAME   (CREATED -  01/14/82)

**********M U L T I P L E   R E G R E S S I O N**********

DEP. VAR... MANMAT     MANUFACTURING MATERIALS

VARIABLE(S) ENTERED ON STEP   5
TT

MULTIPLE R     .9574 ANOVA          DF  SUM SQUARES  MEAN SQ.     F
R SQUARE       .9167 REGRESSICN      5.       6.793     1.359    22.004
STD DEV        .2405 RESIDUAL       10.        .617      .062 SIG. .000
ADJ R SQUARE  .8750 COEFF OF VARIABILITY     6.2PCT

VARIABLE          B      S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .120      .076      2.451  .149       .18225    .05882
TOGWMAI         .934      .177     27.938  .000      1.30814   2.60424
NZULT          1.140      .282     16.209  .002       .78993    .57471
MINZ            .139      .071      3.851  .078       .24475    .01592
TT             -.005      .007       .527  .485      -.13475   -.11773
CONSTANT      -8.606     1.978     18.936  .001
1INITIAL REGRESSION                           01/14/82  15.04.01.    PAGE  27

FILE - NONAME   (CREATED -  01/14/82)

**********M U L T I P L E   R E G R E S S I O N**********

DEP. VAR... MANMAT     MANUFACTURING MATERIALS

VARIABLE(S) ENTERED ON STEP   6
TOTAREA     TOTAL WETTED AREA

MULTIPLE R     .9636 ANOVA          DF  SUM SQUARES  MEAN SQ.     F
R SQUARE       .9285 REGRESSION      6.       6.880     1.147    19.467
STD DEV        .2427 RESIDUAL        9.        .530      .059 SIG. .000
ADJ R SQUARE  .8808 COEFF OF VARIABILITY     6.0PCT

VARIABLE          B      S.E. B        F     SIG.       BETA   ELASTICITY

PROTO           .084      .080      1.097  .322       .12795    .04129
TOGWMAI        1.539      .526      8.557  .017      2.15545   4.29107
NZULT          1.160      .276     17.613  .002       .80378    .58473
MINZ            .165      .072      5.210  .048       .29162    .01897
TT             -.075      .057      1.604  .227     -1.96121  -1.71340
TOTAREA         [illegible]
```

```
 CONSTANT    -15.739     6.170     6.507  .031
1INITIAL REGRESSION                              01/14/82  15.04.01.    PAGE  28

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... MANMAT     MANUFACTURING MATERIALS

 VARIABLE(S) ENTERED ON STEP   7
 MAXMACH    MAXIMUM MACH NUMBER

 MULTIPLE R     .9675 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE       .9360 REGRESSION    7.       6.936       .991   16.717
 STD DEV        .2435 RESIDUAL      8.        .474       .059 SIG. .000
 ADJ R SQUARE   .8800 COEFF OF VARIABILITY     6.0PCT

 VARIABLE         B        S.E. B       F     SIG.      BETA   ELASTICITY

 PROTO           .070       .082      .737  .415     .10685     .03449
 TOGWMAX        1.798       .591     9.249  .016    2.51766    5.01216
 NZULT          1.143       .278    16.952  .003     .79239     .57650
 MINZ           -.253       .437      .336  .578    -.44659    -.02904
 TT             -.097       .062     2.447  .156   -2.56022   -2.23672
 TWTAREA        1.052       .720     2.134  .182    1.56951    2.13918
 MAXMACH         .936       .964      .944  .360     .76166     .03546
 CONSTANT     -18.259      6.711     7.403  .026


 ALL VARIABLES ARE IN THE EQUATION.



 COEFFICIENTS AND CONFIDENCE INTERVALS.

 VARIABLE         B            95 PCT C.I.

 PROTO           .0702       -.1183      .2586
 TOGWMAX        1.7978        .4346     3.1609
 NZULT          1.1434        .5030     1.7839
 MINZ           -.2534      -1.2615      .7547
 TT             -.0973       -.2408      .0461
 TWTAREA        1.0518       -.6086     2.7122
 MAXMACH         .9362      -1.2858     3.1582
 CONSTANT     -18.2595     -33.7346    -2.7844


 VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


 MINZ             .19111
 TT               .00903     .00387
 PROTO            .00473     .00212     .00668
 TOGWMAX         -.10037    -.03566    -.02308     .34943
 TWTAREA         -.00442    -.04443    -.02333     .40147     .51045
 MAXMACH         -.41537    -.02250    -.01374     .25450     .22211     .92846
 NZULT           -.00004    -.00105    -.00935     .03050     .00730    -.01619

                  MINZ       TT        PROTO     TOGWMAX    TWTAREA    MAXMACH


 NZULT            .07713

                  NZULT


```

```
1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   29

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... MANMAT     MANUFACTURING MATERIALS


 SUMMARY TABLE.

 STEP VARIABLE E/R      F   MULT-R R-SQ CHANGE   R   OVERALL F  SIG.

   1  PROTO     E      7.720  .596  .355  .355  .596     7.720  .015
   2  TOGWMAI   E      9.656  .794  .630  .275  .525    11.074  .002
   3  NZULT     E     20.710  .930  .864  .234  .058    25.479  .000
   4  MXNZ      E      6.017  .955  .912  .048  .479    28.604  .000
   5  TT        E       .527  .957  .917  .004  .307    22.004  .000
   6  TWTAREA   E      1.482  .964  .928  .012  .110    19.467  .000
   7  MAXMACH   E       .944  .967  .936  .008  .435    16.717  .000
1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   30

 FILE - NONAME   (CREATED -  01/14/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD                0.0              +2SD

      3.438     3.249      .189                      I       .
      2.786     2.822     -.036                    . I
      3.900     4.080     -.172              .       I
      3.873     3.844      .029                      I .
      5.050     4.853      .197                      I        .
      3.288     3.252      .036                      I .
      4.385     4.349      .035                      I .
      3.910     4.330     -.420     .                I
      4.251     4.301     -.049                   .  I
      3.000     2.994      .014                      I.
      4.801     4.637      .163                      I      .
      4.662     4.538      .125                      I     .
      4.268     4.471     -.203             .        I
      3.857     3.649      .207                      I        .
      3.731     3.952     -.222            .         I
      5.246     5.142      .104                      I    .

 NOTE - (+) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
          R INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED        16.
 NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    2.47045          DURBIN-WATSON TEST    2.32355

 NUMBER OF POSITIVE RESIDUALS     10.
 NUMBER OF NEGATIVE RESIDUALS      6.
 NUMBER OF RUNS OF SIGNS           9.

 NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
 USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   31

 FILE - NONAME   (CREATED -  01/14/82)
```

```
* * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

DEP. VAR... ENG          ENGINEERING HOURS

MEAN RESPONSE          1.90590       STD. DEV.          .78148

VARIABLE(S) ENTERED ON STEP   1
PROTO       NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R      .5707 ANOVA          DF   SUM SQUARES   MEAN SQ.        F
R SQUARE        .3257 REGRESSION      1.        2.984      2.984     6.763
STD DEV         .6642 RESIDUAL       14.        6.177       .441 SIG. .021
ADJ R SQUARE    .2776 COEFF OF VARIABILITY      34.9PCT

VARIABLE           B        S.E. B        F      SIG.       BETA   ELASTICITY

PROTO            .417        .160       6.763   .021       .57072     .43293
CONSTANT        1.081        .358       9.108   .009



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   2
TOGWMAX     MAXIMUM TAKEOFF GROSS WEIGHT

MULTIPLE R      .8020 ANOVA          DF   SUM SQUARES   MEAN SQ.        F
R SQUARE        .6432 REGRESSION      2.        5.892      2.946    11.715
STD DEV         .5015 RESIDUAL       13.        3.269       .251 SIG. .001
ADJ R SQUARE    .5883 COEFF OF VARIABILITY      26.3PCT

VARIABLE           B        S.E. B        F      SIG.       BETA   ELASTICITY

PROTO            .416        .121      11.844   .004       .57019     .43253
TOGWMAX          .447        .132      11.565   .005       .56342    2.63634
CONSTANT       -3.943       1.502       6.893   .021
1INITIAL REGRESSION                                01/14/82  15.04.01.    PAGE   32

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

DEP. VAR... ENG          ENGINEERING HOURS

VARIABLE(S) ENTERED ON STEP   3
NZULT        ULTIMATE LOAD FACTOR

MULTIPLE R      .9206 ANOVA          DF   SUM SQUARES   MEAN SQ.        F
R SQUARE        .8475 REGRESSION      3.        7.764      2.588    22.234
STD DEV         .3412 RESIDUAL       12.        1.397       .116 SIG. .000
ADJ R SQUARE    .8094 COEFF OF VARIABILITY      17.9PCT

VARIABLE           B        S.E. B        F      SIG.       BETA   ELASTICITY

PROTO            .193        .099       3.767   .076       .26419     .20041
TOGWMAX          .979        .160      37.466   .000      1.23200    5.76000
NZULT           1.384        .345      16.085   .002       .86360    1.47676
CONSTANT      -12.206       2.310      28.102   .000



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   4
TT
```

```
2300=
2310= MULTIPLE R     .9252 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
2320= R SQUARE       .8559 REGRESSION      4.       7.841     1.960    16.336
2330= STD DEV        .3464 RESIDUAL       11.       1.320      .120 SIG. .000
2340= ADJ R SQUARE   .8035 COEFF OF VARIABILITY    18.2PCT
2350=
2360= VARIABLE         B       S.E. B       F      SIG.      BETA   ELASTICITY
2370=
2380= PROTO           .217      .105      4.248  .064      .29749    .22567
2390= TOCWMAI         .851      .228     13.912  .003     1.07147   5.01359
2400= NZULT          1.350      .354     14.578  .003      .84143   1.43866
2410= TT              .007      .009       .640  .441      .17310    .35545
2420= CONSTANT     -11.499     2.550     20.337  .001
2430=1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   33
2440=
2450= FILE - NONAME   (CREATED -  01/14/82)
2460=
2470= + + + + + + + + + M U L T I P L E   R E G R E S S I O N + + + + + + + + +
2480=
2490= DEP. VAR... ENG         ENGINEERING HOURS
2500=
2510= VARIABLE(S) ENTERED ON STEP   5
2520= TWTAREA    TOTAL WETTED AREA
2530=
2540= MULTIPLE R     .9419 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
2550= R SQUARE       .8872 REGRESSION      5.       8.128     1.626    15.736
2560= STD DEV        .3214 RESIDUAL       10.       1.033      .103 SIG. .000
2570= ADJ R SQUARE   .8309 COEFF OF VARIABILITY    16.9PCT
2580=
2590= VARIABLE         B       S.E. B       F      SIG.      BETA   ELASTICITY
2600=
2610= PROTO           .271      .103      6.938  .025      .37177    .28201
2620= TOCWMAI        -.239      .687       .121  .735     -.30063  -1.40672
2630= NZULT          1.235      .335     13.569  .004      .76971   1.31622
2640= TT              .129      .074      3.000  .110     3.05294   6.26895
2650= TWTAREA       -1.431      .859      2.777  .127    -1.92067  -6.15289
2660= CONSTANT       1.320     8.048       .027  .873
2670=1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   34
2680=
2690= FILE - NONAME   (CREATED -  01/14/82)
2700=
2710= + + + + + + + + + M U L T I P L E   R E G R E S S I O N + + + + + + + + +
2720=
2730= DEP. VAR... ENG         ENGINEERING HOURS
2740=
2750= VARIABLE(S) ENTERED ON STEP   6
2760= MXNZ
2770=
2780= MULTIPLE R     .9433 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
2790= R SQUARE       .8898 REGRESSION      6.       8.151     1.358    12.100
2800= STD DEV        .3350 RESIDUAL        9.       1.010      .112 SIG. .001
2810= ADJ R SQUARE   .8163 COEFF OF VARIABILITY    17.6PCT
2820=
2830= VARIABLE         B       S.E. B       F      SIG.      BETA   ELASTICITY
2840=
2850= PROTO           .259      .111      5.403  .044      .35503    .26932
2860= TOCWMAI        -.104      .726       .064  .806     -.23139  -1.00271
2870= NZULT          1.165      .301      9.334  .014      .72634   1.24205
2880= TT              .120      .079      2.202  .165     2.83359   5.01854
2890= TWTAREA       -1.302      .939      1.926  .199    -1.74794  -5.59954
2900= MXNZ            .046      .100       .207  .660      .07216    .01103
2910= CONSTANT        .650     8.315       .004  .941
2920=1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   35
2930=
2940= FILE - NONAME   (CREATED -  01/14/82)
2950=
```

```
*********M U L T I P L E   R E G R E S S I O N*********

DEP. VAR... ENG        ENGINEERING HOURS

VARIABLE(S) ENTERED ON STEP   7
MAXMACH    MAXIMUM MACH NUMBER

MULTIPLE R     .9451 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8931 REGRESSION     7.       8.182     1.169     9.551
STD DEV        .3498 RESIDUAL       8.        .979      .122 SIG. .002
ADJ R SQUARE   .7996 COEFF OF VARIABILITY   18.4PCT

VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY

PROTO          .270       .117     5.269  .051     .36911    .28000
TOGWMAX       -.376       .849      .196  .670   -.47315  -2.21394
NZULT         1.177       .399     8.707  .018    .73389   1.25476
TT             .137       .089     2.337  .165    3.23341   6.63953
TWTAREA      -1.469      1.035     2.015  .194  -1.97181  -6.31414
MXNZ           .356       .628      .322  .586    .56489    .06635
MAXMACH       -.695      1.384      .252  .629   -.50838   -.05563
CONSTANT      2.521      9.642      .068  .800


ALL VARIABLES ARE IN THE EQUATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE        B            95 PCT C.I.

PROTO          .2695      -.0013      .5403
TOGWMAX       -.3756     -2.3343     1.5830
NZULT         1.1775       .2573     2.0976
TT             .1367      -.0695      .3428
TWTAREA      -1.4685     -3.8543      .9172
MXNZ           .3563     -1.0921     1.8048
MAXMACH       -.6948     -3.8874     2.4979
CONSTANT      2.5213    -19.7140    24.7565


VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


MXNZ          .39456
TT            .01863    .00799
PROTO         .00976    .00439    .01379
TOGWMAX      -.22373   -.07361   -.04931    .72141
TWTAREA      -.17428   -.09173   -.04017    .82883   1.07036
MAXMACH      -.05754   -.04662   -.02036    .52956    .45854   1.91683
NZULT        -.00174   -.00218   -.01930    .07940    .01507   -.03341

                MXNZ      TT       PROTO    TOGWMAX   TWTAREA   MAXMACH


NZULT         .15923

                NZULT


1INITIAL REGRESSION                         01/14/82  15.04.01.    PAGE   36

FILE - NONAME   (CREATED -  01/14/82)

*********M U L T I P L E   R E G R E S S I O N*********
```

```
DEP. VAR... ENG          ENGINEERING HOURS


SUMMARY TABLE.

STEP VARIABLE E/R       F    MULT-R R-SQ CHANGE   R    OVERALL F  SIG.

  1  PROTO     E      6.763  .571  .326  .326  .571     6.763  .021
  2  TOGWMAI   E     11.565  .802  .643  .317  .564    11.715  .001
  3  NZULT     E     16.085  .921  .848  .204  .002    22.234  .000
  4  TT        E       .640  .925  .856  .008  .465    16.336  .000
  5  TWTAREA   E      2.777  .942  .887  .031  .300    15.736  .000
  6  MINZ      E       .207  .943  .890  .003  .323    12.106  .001
  7  MAXMACH   E       .252  .945  .893  .003  .288     9.551  .002
1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE   37

FILE - NONAME   (CREATED -  01/14/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD               0.0               +2SD

     .542      .623     -.081                   . I
     .698      .756     -.058                    .I
    1.647     1.889     -.242              .      I
    1.716     1.768     -.052                    .I
    3.466     3.454      .012                     I.
    1.459     1.255      .203                     I     .
    1.881     1.995     -.114                  .  I
    2.245     2.317     -.072                   . I
    2.135     2.122      .013                     I.
    1.004      .840      .165                     I    .
    2.754     2.256      .497                     I              .
    1.813     2.331     -.518        .            I
    1.953     2.267     -.314              .      I
    2.220     1.984      .236                     I      .
    1.917     1.977     -.060                    .I
    3.045     2.661      .384                     I          .

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
        R INDICATES POINT OUT OF RANGE OF PLOT


NUMBER OF CASES PLOTTED        16.
NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

VON NEUMANN RATIO    2.19396          DURBIN-WATSON TEST    2.05684

NUMBER OF POSITIVE RESIDUALS      7.
NUMBER OF NEGATIVE RESIDUALS      9.
NUMBER OF RUNS OF SIGNS           8.

NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                          01/14/82  15.04.01.    PAGE   38


CPU TIME REQUIRED..      .6140 SECONDS


TOTAL CPU TIME USED........2110 SECONDS.
```

APPENDIX E

REGRESSION REG 3

```
1
S
                                                        01/15/82  10.25.57. PAGE    1
          VOGELBACK COMPUTING CENTER
          NORTHWESTERN UNIVERSITY

          S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

          VERSION 8.0 -- JUNE 13, 1979




 RUN NAME         INITIAL REGRESSION
 VARIABLE LIST    NZULT,MAXMACH,TWTAREA,TOGWMAX,PROTO
                  ENG,ODC,MANMAT,TOOL,MANF
 VAR LABELS       NZULT  ULTIMATE LOAD FACTOR/
                  MAXMACH  MAXIMUM MACH NUMBER/
                  TWTAREA  TOTAL WETTED AREA/
                  TOGWMAX  MAXIMUM TAKEOFF GROSS WEIGHT/
                  PROTO  NUMBER OF PROTOTYPE AIRCRAFT/
                  ENG  ENGINEERING HOURS/
                  ODC  OTHER DIRECT COSTS/
                  MANMAT  MANUFACTURING MATERIALS/
                  TOOL TOOLING/
                  MANF  MANUFACTURING HOURS/
 INPUT FORMAT     FREEFIELD
 N OF CASES       UNKNOWN
 COMPUTE          ENG=LN(ENG)
 COMPUTE          ODC=LN(ODC)
 COMPUTE          TOOL=LN(TOOL)
 COMPUTE          MANMAT=LN(MANMAT)
 COMPUTE          MANF=LN(MANF)
 COMPUTE          TWTAREA=LN(TWTAREA)
 COMPUTE          NZULT=LN(NZULT)
 COMPUTE          MAXMACH=LN(MAXMACH)
 COMPUTE          TOGWMAX=LN(TOGWMAX)
 COMPUTE          PROTO=LN(PROTO)
 REGRESSION       VARIABLES=ENG,NZULT,MAXMACH,TWTAREA
                  TOGWMAX,PROTO,MANMAT,MANF,TOOL,ODC
                  REGRESSION=ODC WITH NZULT,MAXMACH,TWTAREA
                  TOGWMAX,PROTO(1)/RESID=0
                  REGRESSION=MANMAT WITH NZULT,MAXMACH,TWTAREA
                  TOGWMAX,PROTO(1)/RESID=0
                  REGRESSION=MANF WITH NZULT,MAXMACH,TWTAREA
                  TOGWMAX,PROTO(1)/RESID=0
                  REGRESSION=TOOL WITH NZULT,MAXMACH,TWTAREA
                  TOGWMAX,PROTO(1)/RESID=0
                  REGRESSION=ENG WITH NZULT,MAXMACH,TWTAREA
                  TOGWMAX,PROTO(1)/RESID=0
 STATISTICS       ALL
 READ INPUT DATA

 00054600 CM NEEDED FOR REGRESSION



 END OF FILE ON FILE FAS
 AFTER READING       8 CASES FROM SUBFILE NONAME
1INITIAL REGRESSION                              01/15/82  10.25.57.    PAGE    2

 FILE - NONAME   (CREATED -  01/15/82)
```

```
* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


VARIABLE            MEAN     STANDARD DEV     CASES

ENG               2.1032             .6179        8
NZULT             2.3453             .1177        8
MAXMACH            .5996             .3926        8
TWTAREA           7.7125             .2803        8
TOGWMAX          10.7821             .4486        8
PROTO             2.5899             .9561        8
MANMAT            4.2281             .7000        8
MANF              3.8523             .6434        8
TOOL              1.5822             .5873        8
ODC               4.9222             .8963        8



CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.


NZULT          .35260
MAXMACH        .50225    .47114
TWTAREA       -.26277   -.10100   -.06349
TOGWMAX        .8148.    .33266    .75340   -.38334
PROTO          .52528    .06485    .21168    .02555    .28209
MANMAT         .85529    .31392    .75174   -.29381    .95456    .36699
MANF           .83728    .56065    .73582   -.26496    .89250    .28841
TOOL           .82333    .44755    .46011   -.03289    .52846    .79140
ODC            .67847    .33163    .56525   -.17724    .71774    .77999

                ENG      NZULT    MAXMACH   TWTAREA   TOGWMAX   PROTO


MANF           .97580
TOOL           .69164    .71111
ODC            .74026    .65829    .84538

               MANMAT    MANF      TOOL


INITIAL REGRESSION                              01/15/82  10.25.57.    PAGE   3

FILE - NONAME   (CREATED -  01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ODC          OTHER DIRECT COSTS

MEAN RESPONSE        4.92217      STD. DEV.        .89629

VARIABLE(S) ENTERED ON STEP   1
PROTO        NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R     .7800 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .6084 REGRESSION      1.       3.421     3.421     9.321
STD DEV        .6058 RESIDUAL        6.       2.202      .367 SIG. .022
ADJ R SQUARE   .5431 COEFF OF VARIABILITY    12.3PCT

VARIABLE          B       S.E. B       F     SIG.      BETA   ELASTICITY

PROTO           .731      .239      9.321  .022      .77999    .38473
```

```
CONSTAN           3.028        .656    11.299  .004



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   2
TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT

MULTIPLE R    .9368 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .8775 REGRESSION     2.       4.935     2.467    17.912
STD DEV       .3711 RESIDUAL       5.        .689      .138 SIG. .005
ADJ R SQUARE  .8285 COEFF OF VARIABILITY     7.5PCT

VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY

PROTO          .588      .153    14.793  .012      .62745    .30949
TOGWMAX       1.080      .326    10.997  .021      .54874   2.36671
CONSTANT     -8.151     3.426     5.798  .061
1INITIAL REGRESSION                        01/15/82  10.25.57.     PAGE    4

FILE - NONAME   (CREATED -  01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ODC          OTHER DIRECT COSTS

VARIABLE(S) ENTERED ON STEP   3
NZULT       ULTIMATE LOAD FACTOR

MULTIPLE R    .9441 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .8914 REGRESSION     3.       5.013     1.671    10.945
STD DEV       .3907 RESIDUAL       4.        .611      .153 SIG. .021
ADJ R SQUARE  .8100 COEFF OF VARIABILITY     7.9PCT

VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY

PROTO          .592      .161    13.502  .021      .63139    .31143
TOGWMAX        .995      .363     7.503  .052      .49804   2.17984
NZULT          .952     1.332      .511  .514      .12501    .45373
CONSTANT     -9.574     4.054     5.577  .078


F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE        B          95 PCT C.I.

PROTO          .5919       .1447    1.0391
TOGWMAX        .9951      -.0135    2.0038
NZULT          .9523     -2.7449    4.6494
CONSTANT     -9.5736    -20.8293    1.6820


VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


NZULT        1.77323
TOGWMAX      -.15886     .13199
PROTO         .00687   -.01620    .02595

             NZULT     TOGWMAX   PROTO

```

```
 INITIAL REGRESSION                       01/15/82  10.25.57.    PAGE    5

 FILE - NONAME   (CREATED -  01/15/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... ODC        OTHER DIRECT COSTS


 SUMMARY TABLE.

 STEP VARIABLE E/R      F   MULT-R R-SQ CHANGE   R   OVERALL F  SIG.

   1  PROTO     E      9.321  .780  .608  .608  .750     9.32.  .022
   2  TOGWMAX   E     10.987  .937  .878  .269  .718    17.912  .005
   3  NZULT     E       .511  .944  .891  .014  .332    10.945  .021
 INITIAL REGRESSION                       01/15/82  10.25.57.    PAGE    6

 FILE - NONAME   (CREATED -  01/15/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD                0.0               +2SD

     4.847     4.594      .253                      I     .
     2.931     3.006     -.076                    . I
     5.371     5.203      .167                      I   .
     4.551     5.231     -.680   .                  I
     5.301     5.152      .149                      I  .
     5.165     5.178     -.013                     .I
     5.312     5.148      .164                      I   .
     5.901     5.866      .035                      I.

 NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
          R INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED          8.
 NUMBER OF 2 S.D. OUTLIERS         0 OR      0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    3.08157          DURBIN-WATSON TEST    2.69636

 NUMBER OF POSITIVE RESIDUALS       5.
 NUMBER OF NEGATIVE RESIDUALS       3.
 NUMBER OF RUNS OF SIGNS            7.

 NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
 USE A TABLE FOR EXPECTED VALUES.
 INITIAL REGRESSION                       01/15/82  10.25.57.    PAGE    7

 FILE - NONAME   (CREATED -  01/15/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... MANMAT     MANUFACTURING MATERIALS

 MEAN RESPONSE         4.22007      STD. DEV.        .69998

 VARIABLE(S) ENTERED ON STEP   1
 TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT

 MULTIPLE R    .9544 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
```

```
2700= R SQUARE       .9112 REGRESSION      1.       [illegible]     [illegible]    [illegible]
2710= STD DEV        .2253 RESIDUAL        6.         .305      .051 SIG. .000
2720= ADJ R SQUARE   .8964 COEFF OF VARIABILITY      5.3PCT
2730=
2740= VARIABLE         B       S.E. B       F      SIG.       BETA   ELASTICITY
2750=
2760= TOGWMAX        1.490       .190    61.557  .000       .95456   3.79852
2770= CONSTANT     -11.832      2.049    33.362  .001
2780=
2790=
2800=
2810= + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + +
2820=
2830= VARIABLE(S) ENTERED ON STEP   2
2840= NZULT       ULTIMATE LOAD FACTOR
2850=
2860= MULTIPLE R     .9770 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
2870= R SQUARE       .9545 REGRESSION      2.       3.274      1.637    52.505
2880= STD DEV        .1766 RESIDUAL        5.        .156       .031 SIG. .002
2890= ADJ R SQUARE   .9364 COEFF OF VARIABILITY      4.2PCT
2900=
2910= VARIABLE         B       S.E. B       F      SIG.       BETA   ELASTICITY
2920=
2930= TOGWMAX        1.375       .158    75.952  .000       .85111   3.50622
2940= NZULT          1.314       .601     4.770  .081       .22031    .72867
2950= CONSTANT     -13.677      1.814    56.844  .001
2960=1INITIAL REGRESSION                         01/15/82  10.25.57.     PAGE    6
2970=
2980= FILE - NONAME   (CREATED -  01/15/82)
2990=
3000= + + + + + + + + + M U L T I P L E   R E G R E S S I O N + + + + + + + + +
3010=
3020= DEP. VAR... MANMAT     MANUFACTURING MATERIALS
3030=
3040= VARIABLE(S) ENTERED ON STEP   3
3050= PROTO       NUMBER OF PROTOTYPE AIRCRAFT
3060=
3070= MULTIPLE R     .9830 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
3080= R SQUARE       .9663 REGRESSION      3.       3.314      1.105    38.275
3090= STD DEV        .1699 RESIDUAL        4.        .115       .029 SIG. .002
3100= ADJ R SQUARE   .9411 COEFF OF VARIABILITY      4.0PCT
3110=
3120= VARIABLE         B       S.E. B       F      SIG.       BETA   ELASTICITY
3130=
3140= TOGWMAX        1.323       .158    70.157  .001       .84794   3.37423
3150= NZULT          1.336       .579     5.321  .082       .22450    .74095
3160= PROTO           .083       .070     1.401  .302       .11323    .05076
3170= CONSTANT     -13.385      1.763    57.659  .002
3180=
3190=
3200=
3210= + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + +
3220=
3230= VARIABLE(S) ENTERED ON STEP   4
3240= TWTAREA    TOTAL WETTED AREA
3250=
3260= MULTIPLE R     .9846 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
3270= R SQUARE       .9695 REGRESSION      4.       3.325       .831    23.810
3280= STD DEV        .1868 RESIDUAL        3.        .105       .035 SIG. .013
3290= ADJ R SQUARE   .9287 COEFF OF VARIABILITY      4.4PCT
3300=
3310= VARIABLE         B       S.E. B       F      SIG.       BETA   ELASTICITY
3320=
3330= TOGWMAX        1.365       .189    51.969  .006       .87466   3.48057
3340= NZULT          1.323       .637     4.311  .129       .22238    .73385
3350= PROTO           .076       .078      .959  .400       .10426    .04675
```

```
 TWTAREA        .153      .276      .307  .618       .06128    .27983
 CONSTANT    -14.969     3.452    18.799  .023
1INITIAL REGRESSION                          01/15/82  10.25.57.    PAGE    9

 FILE - NONAME   (CREATED -  01/15/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... MANMAT     MANUFACTURING MATERIALS

 VARIABLE(S) ENTERED ON STEP   5
 MAXMACH    MAXIMUM MACH NUMBER

 MULTIPLE R     .9861 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
 R SQUARE       .9723 REGRESSION     5.       3.335      .667    14.043
 STD DEV        .2179 RESIDUAL       2.        .095      .047 SIG. .068
 ADJ R SQUARE   .9031 COEFF OF VARIABILITY     5.2PCT

 VARIABLE        B        S.E. B        F     SIG.       BETA   ELASTICITY

 TOGWMAX       1.480       .336    19.341  .048       .94836   3.77387
 NZULT         1.457       .800     3.318  .210       .24489    .80813
 PROTO          .074       .091      .664  .501       .10131    .04543
 TWTAREA        .214       .349      .377  .602       .08590    .33125
 MAXMACH       -.168       .371      .205  .695     -.09413   -.02380
 CONSTANT    -16.891      5.850     8.337  .102


 ALL VARIABLES ARE IN THE EQUATION.



 COEFFICIENTS AND CONFIDENCE INTERVALS.

 VARIABLE        B           95 PCT C.I.

 TOGWMAX       1.4799       .0320    2.9277
 NZULT         1.4569     -1.9846    4.8984
 PROTO          .0742      -.3175     .4655
 TWTAREA        .2145     -1.2891    1.7181
 MAXMACH       -.1678     -1.7622    1.4265
 CONSTANT    -16.8986    -42.0602    8.2790


 VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


 NZULT          .63975
 MAXMACH      -.10954    .13730
 TWTAREA       .03158   -.05030    .12212
 TOGWMAX       .02331   -.09408    .06273    .11323
 PROTO         .00109    .00177   -.00510   -.00747    .00829

               NZULT    MAXMACH   TWTAREA   TOGWMAX   PROTO


1INITIAL REGRESSION                          01/15/82  10.25.57.    PAGE   10

 FILE - NONAME   (CREATED -  01/15/82)

 * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... MANMAT     MANUFACTURING MATERIALS


 SUMMARY TABLE.
```

```
 STEP VARIABLE E/R      F    MULT-R R-SQ CHANGE   R    OVERALL F  SIG.

   1  TOGWMAX   E     61.557  .955  .911  .911  .955    61.557  .000
   2  AZULT     E      4.770  .977  .955  .043  .514    52.503  .000
   3  PROTO     E      1.401  .983  .966  .012  .367    38.275  .002
   4  TWTAREA   E       .307  .985  .969  .003 -.294    23.810  .013
   5  MAXMACH   E       .205  .986  .972  .003  .752    14.041  .068
1INITIAL REGRESSION                           01/15/82  10.25.57.    PAGE   11

 FILE - NONAME    (CREATED -  01/15/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


 RESIDUAL PLOT.

   Y VALUE    Y EST.  RESIDUAL -2SD                0.0                +2SD

     4.251     4.236     .014                       I.
     3.008     2.997     .011                       I.
     4.801     4.759     .041                       I .
     4.662     4.503     .160                       I      .
     4.268     4.522    -.254             .         I
     3.857     3.819     .037                       I .
     3.731     3.763    -.033                      .I
     5.246     5.224     .022                       I .

 NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
           R INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED          8.
 NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    3.35490          DURBIN-WATSON TEST    2.93554

 NUMBER OF POSITIVE RESIDUALS      6.
 NUMBER OF NEGATIVE RESIDUALS      2.
 NUMBER OF RUNS OF SIGNS           5.

 NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
 USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                           01/15/82  10.25.57.    PAGE   12

 FILE - NONAME    (CREATED -  01/15/82)

 * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

 DEP. VAR... MANF       MANUFACTURING HOURS

 MEAN RESPONSE        3.85231      STD. DEV.        .64337

 VARIABLE(S) ENTERED ON STEP   1
 TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT

 MULTIPLE R    .8925 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
 R SQUARE      .7966 REGRESSION     1.       2.308     2.308   23.493
 STD DEV       .3134 RESIDUAL       6.        .589      .098 SIG. .003
 ADJ R SQUARE  .7627 COEFF OF VARIABILITY     8.1PCT

 VARIABLE        B      S.E. B       F     SIG.      BETA   ELASTICITY

 TOGWMAX       1.280      .264   23.493  .003      .89250   3.58272
 CONSTANT     -9.949     2.850   12.190  .013

```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
VARIABLE(S) ENTERED ON STEP   2
NZULT      ULTIMATE LOAD FACTOR
MULTIPLE R     .9353 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8748 REGRESSION     2.       2.535      1.267    17.465
STD DEV        .2694 RESIDUAL       5.        .363       .073 SIG. .006
ADJ R SQUARE   .8247 COEFF OF VARIABILITY     7.0PCT
VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY
TOGWMAX       1.139      .241    22.379  .005      .79384   3.18669
NZULT         1.622      .918     3.123  .137      .29657    .98725
CONSTANT    -12.227     2.767    19.520  .007
1INITIAL REGRESSION                            01/15/82  10.25.57.    PAGE  13
FILE - NONAME   (CREATED -  01/15/82)
* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
DEP. VAR... MANF         MANUFACTURING HOURS
VARIABLE(S) ENTERED ON STEP   3
TWTAREA    TOTAL WETTED AREA
MULTIPLE R     .9383 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8804 REGRESSION     3.       2.551       .850     9.816
STD DEV        .2943 RESIDUAL       4.        .346       .087 SIG. .026
ADJ R SQUARE   .7907 COEFF OF VARIABILITY     7.6PCT
VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY
TOGWMAX       1.184      .283    17.468  .014      .82582   3.31586
NZULT         1.608     1.003     2.571  .184      .29414    .97918
TWTAREA        .187      .430      .139  .687      .08132    .37361
CONSTANT    -14.130     5.324     7.043  .057
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
VARIABLE(S) ENTERED ON STEP   4
PROTO      NUMBER OF PROTOTYPE AIRCRAFT
MULTIPLE R     .9390 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8817 REGRESSION     4.       2.555       .639     5.591
STD DEV        .3380 RESIDUAL       3.        .343       .114 SIG. .094
ADJ R SQUARE   .7240 COEFF OF VARIABILITY     8.8PCT
VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY
TOGWMAX       1.165      .342    11.572  .042      .81227   3.26065
NZULT         1.616     1.153     1.966  .255      .29557    .98392
TWTAREA        .173      .499      .120  .752      .07529    .34592
PROTO          .026      .141      .033  .867      .03018    .01727
CONSTANT    -13.898     6.245     4.953  .112
1INITIAL REGRESSION                            01/15/82  10.25.57.    PAGE  14
FILE - NONAME   (CREATED -  01/15/82)
* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
DEP. VAR... MANF         MANUFACTURING HOURS
```

```

VARIABLE(S) ENTERED ON STEP   5
MAXMACH    MAXIMUM MACH NUMBER

MULTIPLE R     .9396 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8828 REGRESSION     5.       2.558       .512     3.013
STD DEV        .4120 RESIDUAL       2.        .340       .170 SIG. .268
ADJ R SQUARE   .5898 COEFF OF VARIABILITY    10.7PCT

VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY

TOGWMAX        1.230       .636     3.739  .193      .85779   3.44333
NZULT          1.692      1.512     1.252  .379      .30947   1.03028
TWTAREA         .208       .661      .099  .783      .09850    .41560
PROTO           .024       .172      .020  .900      .03435    .01645
MAXMACH        -.095       .701      .018  .904    -.05814   -.01483
CONSTANT     -14.989     11.060     1.837  .308


ALL VARIABLES ARE IN THE EQUATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE         B           95 PCT C.I.

TOGWMAX        1.2303     -1.5071    3.9677
NZULT          1.6922     -4.8145    8.1989
TWTAREA         .2077     -2.6351    3.0505
PROTO           .0245      -.7160     .7650
MAXMACH        -.0953     -3.1097    2.9191
CONSTANT     -14.9894    -62.5767   32.5980


VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


NZULT          2.28686
MAXMACH        -.39156    .49031
TWTAREA         .11289   -.17980     .43653
TOGWMAX         .08331   -.33631     .22423     .40476
PROTO           .00391    .00633    -.01822    -.02669     .02962

               NZULT     MAXMACH    TWTAREA    TOGWMAX    PROTO


1INITIAL REGRESSION                          01/15/82  10.25.57.    PAGE   15

FILE - NONAME   (CREATED -  01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... MANF        MANUFACTURING HOURS


SUMMARY TABLE.

STEP VARIABLE E/R      F    MULT-R R-SQ CHANGE   R   OVERALL F  SIG.

  1  TOGWMAX   E    23.493  .893  .797  .797  .893    23.493  .003
  2  NZULT     E     3.123  .935  .875  .078  .561    17.465  .006
  3  TWTAREA   E      .109  .938  .880  .006 -.265     9.816  .026
  4  PROTO     E      .033  .939  .882  .001  .288     5.591  .094
  5  MAXMACH   E      .018  .940  .883  .001  .736     3.013  .268
1INITIAL REGRESSION                          01/15/82  10.25.57.    PAGE   16
```

```
FILE - NONAME   (CREATED -  01/15/82)

* * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *


RESIDUAL PLOT.

  Y VALUE    Y EST.  RESIDUAL -2SD              0.0              +2SD

    4.091     3.993     .098                     I  .
    2.803     2.798     .005                     I.
    4.4.2     4.285     .126                     I   .
    4.297     4.115     .182                     I    .
    3.608     4.129    -.520          .          I
    3.526     3.451     .075                     I .
    3.336     3.363    -.027                    .I
    4.745     4.685     .060                     I .

NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
         R INDICATES POINT OUT OF RANGE OF PLOT


NUMBER OF CASES PLOTTED          8.
NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

VON NEUMANN RATIO    3.00567          DURBIN-WATSON TEST    2.62996

NUMBER OF POSITIVE RESIDUALS      6.
NUMBER OF NEGATIVE RESIDUALS      2.
NUMBER OF RUNS OF SIGNS           5.

NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                          01/15/82  10.25.57.    PAGE   17

FILE - NONAME   (CREATED -  01/15/82)

* * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * *

DEP. VAR... TOOL       TOOLING

MEAN RESPONSE        1.58223      STD. DEV.        .58735

VARIABLE(S) ENTERED ON STEP   1
PROTO      NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R    .7914 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .6263 RECRESSION     1.       1.512     1.512    10.056
STD DEV       .3878 RESIDUAL       6.        .902      .150 SIG. .019
ADJ R SQUARE  .5640 COEFF OF VARIABILITY    24.5PCT

VARIABLE       B      S.E. B      F     SIG.      BETA   ELASTICITY

PROTO         .486      .153    10.056  .019      .79140    .79578
CONSTANT      .323      .420      .592  .471



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   2
NZULT      ULTIMATE LOAD FACTOR

MULTIPLE R    .8854 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE      .7840 REGRESSION     2.       1.893      .947     9.072
```

```
6660= STD DEV       .3230 RESIDUAL       5.        .322      .064 SIG. .022
6670= ADJ R SQUARE  .6975 COEFF OF VARIABILITY    20.4PCT
6680=
6690= VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY
6700=
6710= PROTO           .470       .128    13.508  .014      .76559    .76983
6720= NZULT          1.986      1.040     3.649  .114      .39790   2.94413
6730= CONSTANT      -4.294      2.442     3.091  .139
6740=1INITIAL REGRESSION                          01/15/82  10.25.57.    PAGE   18
6750=
6760= FILE - NONAME   (CREATED -  01/15/82)
6770=
6780= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
6790=
6800= DEP. VAR... TOOL       TOOLING
6810=
6820= VARIABLE(S) ENTERED ON STEP   3
6830= TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
6840=
6850= MULTIPLE R    .9075 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
6860= R SQUARE      .8235 REGRESSION     3.       1.989       .663     6.222
6870= STD DEV       .3265 RESIDUAL       4.        .426       .107 SIG. .055
6880= ADJ R SQUARE  .6911 COEFF OF VARIABILITY    20.6PCT
6890=
6900= VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY
6910=
6920= PROTO           .435       .135    10.450  .032      .70820    .71212
6930= NZULT          1.641      1.113     2.174  .214      .32865   2.43174
6940= TOGWMAX         .287       .304      .895  .398      .21936   1.95723
6950= CONSTANT      -6.489      3.387     3.670  .128
6960=
6970=
6980=
6990= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
7000=
7010= VARIABLE(S) ENTERED ON STEP   4
7020= TWTAREA    TOTAL WETTED AREA
7030=
7040= MULTIPLE R    .9104 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
7050= R SQUARE      .8288 REGRESSION     4.       2.001       .500     3.630
7060= STD DEV       .3713 RESIDUAL       3.        .414       .138 SIG. .159
7070= ADJ R SQUARE  .6004 COEFF OF VARIABILITY    23.5PCT
7080=
7090= VARIABLE         B       S.E. B       F     SIG.      BETA   ELASTICITY
7100=
7110= PROTO           .428       .155     7.635  .070      .69655    .70041
7120= NZULT          1.627      1.265     1.651  .289      .32589   2.41136
7130= TOGWMAX         .333       .376      .782  .442      .25408   2.26708
7140= TWTAREA         .167       .549      .092  .781      .07963    .81318
7150= CONSTANT      -8.215      6.860     1.434  .317
7160=1INITIAL REGRESSION                          01/15/82  10.25.57.    PAGE   19
7170=
7180= FILE - NONAME   (CREATED -  01/15/82)
7190=
7200= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
7210=
7220= DEP. VAR... TOOL       TOOLING
7230=
7240= VARIABLE(S) ENTERED ON STEP   5
7250= MAXMACH    MAXIMUM MACH NUMBER
7260=
7270= MULTIPLE R    .9116 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
7280= R SQUARE      .8311 REGRESSION     5.       2.007       .401     1.968
7290= STD DEV       .4510 RESIDUAL       2.        .408       .204 SIG. .370
7300= ADJ R SQUARE  .4087 COEFF OF VARIABILITY    28.5PCT
7310=
```

```
VARIABLE           B       S.E. B         F     SIG.        BETA   ELASTICITY

PROTO            .426       .189      5.106   .152       .69388     .69773
NZULT           1.728      1.658      1.087   .407       .34621    2.56167
TOGWMAX          .420       .697       .362   .600       .32060    2.86262
TWTAREA          .213       .724       .087   .796       .10185    1.04016
MAXMACH         -.127       .768       .027   .884      -.08496    -.04817
CONSTANT       -9.671     12.123       .636   .509


ALL VARIABLES ARE IN THE EQUATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B            95 PCT C.I.

PROTO            .4263      -.3854     1.2379
NZULT           1.7282     -5.4037     8.8601
TOGWMAX          .4198     -2.5806     3.4202
TWTAREA          .2134     -2.9025     3.3293
MAXMACH         -.1271     -3.4311     3.1769
CONSTANT       -9.6706    -61.8302    42.4890


VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


NZULT         2.74741
MAXMACH       -.47042     .58966
TWTAREA        .13562    -.21601     .52444
TOGWMAX        .10009    -.40404     .25939     .46627
PROTO          .00469     .00760    -.02189    -.03206     .03558

               NZULT     MAXMACH    TWTAREA    TOGWMAX    PROTO


1INITIAL REGRESSION                          01/15/82  10.25.57.     PAGE   20

FILE - NONAME    (CREATED -  01/15/82)

* * * * * * * * * * M U L T I P L E    R E G R E S S I O N * * * * * * * * * *

DEP. VAR... TOOL         TOOLING


SUMMARY TABLE.

STEP VARIABLE E/R       F    MULT-R R-SQ CHANGE    R     OVERALL F  SIG.

  1  PROTO     E     10.056  .791  .626  .626  .791     10.056  .019
  2  NZULT     E      3.649  .885  .784  .158  .448      9.072  .022
  3  TOGWMAX   E       .895  .907  .823  .040  .528      6.220  .055
  4  TWTAREA   E       .092  .910  .829  .005 -.033      3.630  .159
  5  MAXMACH   E       .027  .912  .831  .002  .460      1.968  .370
1INITIAL REGRESSION                          01/15/82  10.25.57.     PAGE   21

FILE - NONAME    (CREATED -  01/15/82)

* * * * * * * * * * M U L T I P L E    R E G R E S S I O N * * * * * * * * * *


RESIDUAL PLOT.

   Y VALUE     Y EST.   RESIDUAL  -2SD              0.0                +2SD
----
```

```
7980=
7990=     1.805     1.576      .229                        I     .
8000=      .285      .312     -.027                       .I
8010=     1.844     1.633      .211                        I    .
8020=     1.690     1.788     -.098                      . I
8030=     1.221     1.754     -.533               .        I
8040=     2.087     2.012      .075                        I .
8050=     1.690     1.639      .051                        I .
8060=     2.036     1.945      .091                        I  .
8070=
8080= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
8090=         R INDICATES POINT OUT OF RANGE OF PLOT
8100=
8110=
8120= NUMBER OF CASES PLOTTED         8.
8130= NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL
8140=
8150= VON NEUMANN RATIO    2.18101          DURBIN-WATSON TEST    1.90840
8160=
8170= NUMBER OF POSITIVE RESIDUALS      5.
8180= NUMBER OF NEGATIVE RESIDUALS      3.
8190= NUMBER OF RUNS OF SIGNS           5.
8200=
8210= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
8220= USE A TABLE FOR EXPECTED VALUES.
8230=1INITIAL REGRESSION                           01/15/82  10.25.57.    PAGE   22
8240=
8250= FILE - NONAME   (CREATED - 01/15/82)
8260=
8270= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
8280=
8290= DEP. VAR... ENG        ENGINEERING HOURS
8300=
8310= MEAN RESPONSE        2.10516      STD. DEV.        .61793
8320=
8330= VARIABLE(S) ENTERED ON STEP   1
8340= TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
8350=
8360= MULTIPLE R    .8148 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
8370= R SQUARE      .6639 REGRESSION     1.       1.775     1.775    11.853
8380= STD DEV       .3869 RESIDUAL       6.        .898      .150 SIG. .014
8390= ADJ R SQUARE  .6079 COEFF OF VARIABILITY    18.4PCT
8400=
8410= VARIABLE       B      S.E. B       F     SIG.      BETA   ELASTICITY
8420=
8430= TOGWMAX       1.122      .326    11.853  .014      .81481   5.74873
8440= CONSTANT     -9.997     3.518     8.075  .029
8450=
8460=
8470=
8480= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
8490=
8500= VARIABLE(S) ENTERED ON STEP   2
8510= PROTO      NUMBER OF PROTOTYPE AIRCRAFT
8520=
8530= MULTIPLE R    .8711 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
8540= R SQUARE      .7587 REGRESSION     2.       2.028     1.014     7.862
8550= STD DEV       .3591 RESIDUAL       5.        .645      .129 SIG. .029
8560= ADJ R SQUARE  .6622 COEFF OF VARIABILITY    17.1PCT
  8570=
8580= VARIABLE       B      S.E. B       F     SIG.      BETA   ELASTICITY
8590=
8600= TOGWMAX        .998      .315    10.006  .025      .72426   5.10991
8610= PROTO          .207      .148     1.965  .220      .32097    .25521
8620= CONSTANT     -9.189     3.315     7.682  .039
8630=1INITIAL REGRESSION                           01/15/82  10.25.57.    PAGE   23
```

```
FILE - NONAME   (CREATED - 01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ENG        ENGINEERING HOURS

VARIABLE(S) ENTERED ON STEP   3
MAXMACH    MAXIMUM MACH NUMBER

MULTIPLE R     .8874 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
R SQUARE       .7874 REGRESSION      3.       2.105       .702     4.939
STD DEV        .3769 RESIDUAL        4.        .568       .142 SIG. .078
ADJ R SQUARE   .6280 COEFF OF VARIABILITY    17.5PCT

VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY

TOGWMAX       1.265      .492     6.612  .062      .91536   6.47931
PROTO          .207      .155     1.782  .253      .32073    .25501
MAXMACH       -.405      .552      .540  .503    -.25753   -.11547
CONSTANT    -11.829     5.002     5.593  .077



* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

VARIABLE(S) ENTERED ON STEP   4
NZULT       ULTIMATE LOAD FACTOR

MULTIPLE R     .9031 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
R SQUARE       .8156 REGRESSION      4.       2.180       .545     3.317
STD DEV        .4053 RESIDUAL        3.        .493       .164 SIG. .176
ADJ R SQUARE   .5697 COEFF OF VARIABILITY    19.3PCT

VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY

TOGWMAX       1.276      .529     5.812  .095      .92651   6.53679
PROTO          .211      .167     1.596  .296      .32665    .25972
MAXMACH       -.558      .635      .773  .444    -.35468   -.15902
NZULT         1.001     1.478      .458  .547      .19051   1.11463
CONSTANT    -14.214     6.431     4.885  .114
1INITIAL REGRESSION                        01/15/82  10.25.57.    PAGE   24

FILE - NONAME   (CREATED - 01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ENG        ENGINEERING HOURS

VARIABLE(S) ENTERED ON STEP   5
TWTAREA    TOTAL WETTED AREA

MULTIPLE R     .9082 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
R SQUARE       .8248 REGRESSION      5.       2.205       .441     1.883
STD DEV        .4839 RESIDUAL        2.        .468       .234 SIG. .382
ADJ R SQUARE   .3868 COEFF OF VARIABILITY    23.0PCT

VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY

TOGWMAX       1.406      .747     3.540  .201     1.02041   7.19928
PROTO          .201      .202      .985  .426      .31038    .24679
MAXMACH       -.662      .823      .648  .505    -.42057   -.18857
NZULT         1.066     1.776      .360  .609      .20291   1.18718
TWTAREA        .252      .776      .105  .776      .11425    .92257
CONSTANT    -17.614    12.988     1.839  .308
```

```
ALL VARIABLES ARE IN THE EQUATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE        B            95 PCT C.I.

TOGWMAX       1.4056     -1.8090    4.6202
PROTO          .2006      -.6690    1.0702
MAXMACH       -.6620     -4.2019    2.8778
NZULT         1.0656     -6.5753    8.7066
TWTAREA        .2518     -3.0865    3.5902
CONSTANT    -17.6144    -73.4972   38.2684

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

NZULT        3.15364
MAXMACH      -.53997    .67684
TWTAREA       .15568   -.24795    .60199
TOGWMAX       .11485   -.46378    .30922    .55817
PROTO         .00539    .00872   -.02513   -.03680    .04085

             NZULT     MAXMACH   TWTAREA   TOGWMAX   PROTO

1INITIAL REGRESSION                         01/15/82  10.25.57.    PAGE  25

FILE - NONAME   (CREATED -  01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... ENG        ENGINEERING HOURS


SUMMARY TABLE.

STEP VARIABLE E/R      F   MULT-R R-SQ CHANGE   R   OVERALL F  SIG.

  1  TOGWMAX   E    11.853  .815  .664  .664  .815    11.853  .014
  2  PROTO     E     1.965  .871  .759  .095  .525     7.862  .029
  3  MAXMACH   E      .540  .887  .787  .029  .502     4.939  .078
  4  NZULT     E      .458  .903  .816  .028  .353     3.317  .176
  5  TWTAREA   E      .105  .908  .825  .009 -.263     1.865  .382
1INITIAL REGRESSION                         01/15/82  10.25.57.    PAGE  26

FILE - NONAME   (CREATED -  01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


RESIDUAL PLOT.

  Y VALUE    Y EST.  RESIDUAL -2SD             0.0              +2SD

    2.135     1.830      .306                   I     .
    1.004     1.061     -.056                 . I
    2.754     2.516      .237                   I   .
    1.813     2.217     -.404           .       I
    1.953     2.306     -.353            .      I
    2.220     2.173      .047                   I.
    1.917     1.789      .128                   I  .
    3.045     2.949      .096                   I .
```

```
NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
       R INDICATES POINT OUT OF RANGE OF PLOT

NUMBER OF CASES PLOTTED          8.
NUMBER OF 2 S.D. OUTLIERS        0 OR     0 PERCENT OF THE TOTAL

VON NEUMANN RATIO    1.94889          DURBIN-WATSON TEST    1.70528

NUMBER OF POSITIVE RESIDUALS      5.
NUMBER OF NEGATIVE RESIDUALS      3.
NUMBER OF RUNS OF SIGNS           5.

NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
1INITIAL REGRESSION                       01/15/82  10.25.57.    PAGE   27


CPU TIME REQUIRED..      .3090 SECONDS



TOTAL CPU TIME USED..      .4770 SECONDS




RUN COMPLETED

NUMBER OF CONTROL CARDS READ  39
NUMBER OF ERRORS DETECTED      0
S
*EOR
..B
HAND- LOGOUT
      5.484 SEC.        4.469 ADJ.
      14.854 SEC.        4.396 ADJ.
US                       9.611
NNECT TIME    0 HRS.   38 MIN.
1/15/82  LOGGED OUT AT 10.54.14.
    <
```

APPENDIX F

REGRESSION REG 4

```
[illegible]
UR NAME TOLL         HAS BEEN RETRIEVED
[illegible]
[illegible] PROGRAM TALL NAME - [illegible]
[illegible]
UR NAME FAT          HAS BEEN RETRIEVED
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

                                                     [illegible] PAGE  1
           VOGELBACK COMPUTING CENTER
           NORTHWESTERN UNIVERSITY

           S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

           VERSION 8.0 -- JUNE 18, 1979




RUN NAME       INITIAL REGRESSION
VARIABLE LIST  NZULT,MAXMACH,TWTAREA,TOGWMAX,PROTO
               ENG,ODC,MANMAT,TOOL,MANF
VAR LABELS     NZULT ULTIMATE LOAD FACTOR/
               MAXMACH MAXIMUM MACH NUMBER/
               TWTAREA TOTAL WETTED AREA/
               TOGWMAX MAXIMUM TAKEOFF GROSS WEIGHT/
               PROTO NUMBER OF PROTOTYPE AIRCRAFT/
               ENG ENGINEERING HOURS/
               ODC OTHER DIRECT COSTS/
               MANMAT MANUFACTURING MATERIALS/
               TOOL TOOLING/
               MANF MANUFACTURING HOURS
INPUT FORMAT   FREEFIELD
N OF CASES     UNKNOWN
COMPUTE        ENG=LN(ENG)
COMPUTE        ODC=LN(ODC)
COMPUTE        TOOL=LN(TOOL)
COMPUTE        MANMAT=LN(MANMAT)
COMPUTE        MANF=LN(MANF)
COMPUTE        TWTAREA=LN(TWTAREA)
COMPUTE        NZULT=LN(NZULT)
COMPUTE        MAXMACH=LN(MAXMACH)
COMPUTE        TOGWMAX=LN(TOGWMAX)
COMPUTE        MXNZ=MAXMACH+NZULT
COMPUTE        TT=TOGWMAX+TWTAREA
COMPUTE        PROTO=LN(PROTO)
REGRESSION     VARIABLES=ENG,TOOL,MANF,MANMAT,ODC,MXNZ,TT,PROTO
               TWTAREA,MAXMACH,NZULT,TOGWMAX
               REGRESSION=ODC WITH MXNZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=TOOL WITH MXNZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=MANF WITH MXNZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=MANMAT WITH MXNZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
               REGRESSION=ENG WITH MXNZ,TT,PROTO,TOGWMAX,TWTAREA
               MAXMACH,NZULT(1)/RESID=0
STATISTICS     3
```

TEST INPUT DATA

0005470 CM NEEDED FOR REGRESSION

END OF FILE ON FILE F95
AFTER READING [illegible] CASES FROM SUBFILE NONAME
INITIAL REGRESSION 01/15/82 14.[illegible] PAGE [illegible]

FILE - NONAME (CREATED - 01/15/82)

* * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * * *

VARIABLE	MEAN	STANDARD DEV	CASES
ENG	[illegible]	[illegible]	[illegible]
TIOL	[illegible]	.5571	[illegible]
MANF	[illegible]	.6434	[illegible]
MANMAT	4.[illegible]	.7000	[illegible]
ODI	4.9200	[illegible]	[illegible]
MXNZ	[illegible]	.9427	[illegible]
TT	[illegible]	[illegible]	[illegible]
PROTO	[illegible]	[illegible]	[illegible]
TWTAREA	[illegible]	.2893	[illegible]
MAXMACH	.5996	.3926	[illegible]
NZULT	[illegible]	[illegible]	[illegible]
TOGWMAX	[illegible]	.4466	[illegible]

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	ENG	TIOL	MANF	MANMAT	ODI	MXNZ
TIOL	[illegible]					
MANF	.53723	[illegible]				
MANMAT	[illegible]	[illegible]	.97502			
ODI	[illegible]	.34[illegible]	[illegible]	.74025		
MXNZ	.47052	.45[illegible]	.7437[illegible]	.75[illegible]	.54[illegible]	
TT	[illegible]	.45[illegible]	.6000[illegible]	[illegible]	.50[illegible]	[illegible]
PROTO	[illegible]	.73148	.2884[illegible]	[illegible]	[illegible]	[illegible]
TWTAREA	-.2[illegible]	-.0[illegible]	-.2[illegible]	-.2[illegible]	[illegible]	[illegible]
MAXMACH	.50025	.4[illegible]	[illegible]	.75[illegible]	[illegible]	[illegible]
NZULT	[illegible]	.44755	[illegible]	[illegible]	[illegible]	[illegible]
TOGWMAX	[illegible]	.52846	.89250	.95456	[illegible]	.74[illegible]

	TT	PROTO	TWTAREA	MAXMACH	NZULT
PROTO	.27429				
TWTAREA	.50540	.02555			
MAXMACH	.65[illegible]	.21[illegible]	-.05[illegible]		
NZULT	.2[illegible]	.06455	-.10162	.47[illegible]	
TOGWMAX	.6038[illegible]	.25[illegible]	-.3[illegible]	.75540	.33266

INITIAL REGRESSION 01/15/82 14.[illegible] PAGE [illegible]

FILE - NONAME (CREATED - 01/15/82)

```
**********MULTIPLE REGRESSION**********

DEP. VAR... ODC        OTHER DIRECT COSTS

MEAN RESPONSE       4.91217      STD. DEV.       .89[illegible]

VARIABLE(S) ENTERED ON STEP   1
PROTO       NUMBER OF PROTOTYPE AIRCRAFT

MULTIPLE R     .7800 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .6084 REGRESSION     1.       [illegible]       [illegible]       [illegible]
STD DEV        .6056 RESIDUAL       6.       [illegible]       [illegible] SIG. .02[illegible]
ADJ R SQUARE   .54[illegible] COEFF OF VARIABILITY    [illegible]

VARIABLE         B       S.E. B        F      SIG.      BETA   ELASTICITY

PROTO           .7[illegible]       .2[illegible]      [illegible]  .02[illegible]      [illegible]     [illegible]
CONSTANT       [illegible]       [illegible]     [illegible]  .00[illegible]




**************************************************

VARIABLE(S) ENTERED ON STEP   2
TOGWMAX      MAXIMUM TAKEOFF GROSS WEIGHT

MULTIPLE R     .9[illegible] ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8[illegible] REGRESSION     2.       4.[illegible]       [illegible]     [illegible]
STD DEV        .37[illegible] RESIDUAL       5.       .[illegible]       [illegible] SIG. .[illegible]
ADJ R SQUARE   .[illegible] COEFF OF VARIABILITY      [illegible]

VARIABLE         B       S.E. B        F      SIG.      BETA   ELASTICITY

PROTO           .5[illegible]       .1[illegible]     [illegible]  .0[illegible]      .[illegible]   [illegible]
TOGWMAX        1.050      .[illegible]     [illegible]  .[illegible]      .5[illegible]   [illegible]
CONSTANT       -[illegible]     [illegible]     [illegible]  .0[illegible]
INITIAL REGRESSION                              0[illegible] [illegible]   PAGE  [illegible]

FILE - NONAME   (CREATED - 0[illegible])

**********MULTIPLE REGRESSION**********

DEP. VAR... ODC        OTHER DIRECT COSTS

VARIABLE(S) ENTERED ON STEP   3
NULT        ULTIMATE LOAD FACTOR

MULTIPLE R     .9441 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
R SQUARE       .8914 REGRESSION     3.       5.013      1.671     1[illegible]
STD DEV        .3907 RESIDUAL       4.       .61[illegible]      .15[illegible] SIG. .02[illegible]
ADJ R SQUARE   .8100 COEFF OF VARIABILITY     7.9PCT

VARIABLE         B       S.E. B        F      SIG.      BETA   ELASTICITY

PROTO           .592      .161     13.502  .021      .[illegible]     .3[illegible]
TOGWMAX         .995      .363      7.503  .052      .49[illegible]  [illegible]
NULT            .952     1.332       .51[illegible]  .514      .[illegible]     .45[illegible]
CONSTANT      -9.574     4.054      5.577  .078


F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.



COEFFICIENTS AND CONFIDENCE INTERVALS.
```

```
 VARIABLE        B              RE FIT C.I.

 FROTI          .5[illegible]      .1447    1.2[illegible]
 TOGWMAX        .[illegible]      -.2035    2.2[illegible]
 NZULT          .3[illegible]      -2.7449    4.4[illegible]
 CONSTANT     -4.5736    -28.3293     1.6528


 VARIANCE-COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


 FROTI          .02[illegible]
 TOGWMAX      -.01622    .0[illegible]
 NZULT          .22[illegible]   -.0[illegible]   .[illegible]

                FROTI      TOGWMAX    NZULT


INITIAL REGRESSION                            [illegible]        PAGE   [illegible]

 FILE - NONAME   (CREATED - [illegible])

**********M U L T I P L E   R E G R E S S I O N**********

 DEP. VAR. [illegible]        OTHER DIRECT COSTS


 SUMMARY TABLE

 STEP VARIABLE E/R      F    MULTR RSQ CHANGE  R   OVERALL F  SIG.

   1  FROTI     E      [illegible]  .780  .[illegible]  .[illegible]  .[illegible]    [illegible]  .[illegible]
   2  TOGWMAX   E      [illegible]  .[illegible]  .[illegible]  .[illegible]  .[illegible]    [illegible]  .[illegible]
   3  NZULT     E      [illegible]  .944  .[illegible]  .[illegible]  .[illegible]    12.945  .[illegible]
INITIAL REGRESSION                            [illegible]        PAGE   [illegible]

 FILE - NONAME   (CREATED - [illegible])

**********M U L T I P L E   R E G R E S S I O N**********


 RESIDUAL PLOT

    Y VALUE    Y EST.  RESIDUAL -[illegible]              0.0               +[illegible]

      4.[illegible]47     4.[illegible]     .2[illegible]                    :     .
      [illegible]     [illegible]     -.07[illegible]                  . :
      [illegible]     [illegible]     .[illegible]                    :   .
      4.[illegible]     [illegible]     -.[illegible]   .                :
      5.[illegible]     5.[illegible]     .[illegible]                    :  .
      5.[illegible]     5.[illegible]     -.0[illegible]                   .:
      5.[illegible]     5.146     .[illegible]4                    :  .
      5.[illegible]     5.[illegible]     .0[illegible]                    :.

 NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
          # INDICATES POINT OUT OF RANGE OF PLOT


 NUMBER OF CASES PLOTTED          8.
 NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

 VON NEUMANN RATIO    3.0[illegible]          DURBIN-WATSON TEST    [illegible]

 NUMBER OF POSITIVE RESIDUALS      5.
 NUMBER OF NEGATIVE RESIDUALS      3.
 NUMBER OF RUNS OF SIGNS           [illegible]
```

```
2610= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
2630= USE A TABLE FOR EXPECTED VALUES.
2640=INITIAL REGRESSION                    01/15/82  14.19.32.   PAGE   [illegible]
2650=
2660= FILE - NONAME   (CREATED - 01/15/82)
2670=
2680= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
2690=
2700= DEP. VAR... TOIL        TOOLING
2710=
2720= MEAN RESPONSE       [illegible]      STD. DEV.      [illegible]
2730=
2740= VARIABLE(S) ENTERED ON STEP   1
2750= PROTO      NUMBER OF PROTOTYPE AIRCRAFT
2760=
2770= MULTIPLE R    [illegible] ANOVA         DF  SUM SQUARES  MEAN SQ.      F
2780= R SQUARE      [illegible] REGRESSION    1.      [illegible]     [illegible]    [illegible]
2790= STD DEV       [illegible] RESIDUAL      [illegible]      .902        [illegible] SIG. [illegible]
2800= ADJ R SQUARE  .5646 COEFF OF VARIABILITY    [illegible] PCT
2810=
2820= VARIABLE       B      S.E. B       F     SIG.      BETA   ELASTICITY
2830=
2840= PROTO         .456      [illegible]    [illegible]  .015      [illegible]   [illegible]
2850= CONSTANT      .023      .422      .5[illegible]  .47[illegible]
2860=
2870=
2880=
2890= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
2900=
2910= VARIABLE(S) ENTERED ON STEP   2
2920= NZULT      ULTIMATE LOAD FACTOR
2930=
2940= MULTIPLE R    .88[illegible] ANOVA         DF  SUM SQUARES  MEAN SQ.      F
2950= R SQUARE      .7946 REGRESSION    2.      [illegible]      .947      [illegible]
2960= STD DEV       .[illegible] RESIDUAL      5.      .5[illegible]      .[illegible] SIG. .0[illegible]
2970= ADJ R SQUARE  .6975 COEFF OF VARIABILITY    [illegible] PCT
2980=
2990= VARIABLE       B      S.E. B       F     SIG.      BETA   ELASTICITY
3000=
3010= PROTO         .472      .[illegible]    [illegible]  .0[illegible]      .76[illegible]   .76[illegible]
3020= NZULT        1.[illegible]      [illegible]    [illegible]  [illegible]      .[illegible]98   [illegible]
3030= CONSTANT    -4.[illegible]     2.442     3.89[illegible]  .[illegible]
3040=INITIAL REGRESSION                    01/15/82  14.19.32.   PAGE   [illegible]
3050=
3060= FILE - NONAME   (CREATED - 01/15/82)
3070=
3080= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
3090=
3100= DEP. VAR... TOIL        TOOLING
3110=
3120= VARIABLE(S) ENTERED ON STEP   3
3130= TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
3140=
3150= MULTIPLE R    .9075 ANOVA         DF  SUM SQUARES  MEAN SQ.      F
3160= R SQUARE      .8235 REGRESSION    3.      [illegible].989      .66[illegible]     [illegible]
3170= STD DEV       .[illegible] RESIDUAL      4.      .42[illegible]      .107 SIG. .0[illegible]
3180= ADJ R SQUARE  .691[illegible] COEFF OF VARIABILITY    [illegible].5PCT
3190=
3200= VARIABLE       B      S.E. B       F     SIG.      BETA   ELASTICITY
3210=
3220= PROTO         .435      .[illegible]35    10.450  .03[illegible]      .78[illegible]   .7[illegible]
3230= NZULT        [illegible].64[illegible]     [illegible]     2.[illegible]74  .[illegible]      .[illegible]   [illegible]
3240= TOGWMAX       .287      .304       .895  .39[illegible]      .[illegible]   [illegible]
3250= CONSTANT    -[illegible].469     3.387     3.670  .12[illegible]
```

```
3270=
3280=
3290= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
3300=
3310= VARIABLE(S) ENTERED ON STEP  4
3320= TWTAREA    TOTAL WETTED AREA
3330=
3340= MULTIPLE R     .9104 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
3350= R SQUARE       .8288 REGRESSION     4.      2.001       .500    [illegible]
3360= STD DEV        .37[illegible] RESIDUAL       3.       .414      .138 SIG. [illegible]
3370= ADJ R SQUARE   .6004 COEFF OF VARIABILITY    21.5 PCT
3380=
3390= VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY
3400=
3410= PROTI          .428      .155     7.635  .070     .[illegible]   .[illegible]
3420= NZULT         1.[illegible]27     1.[illegible]     [illegible]  .[illegible]     .[illegible]   [illegible]
3430= TOGWMAX        .[illegible]       .[illegible]      .[illegible]  .442     .[illegible]   [illegible]
3440= TWTAREA        .[illegible]67      .54[illegible]      .[illegible]  .[illegible]     .[illegible]   [illegible]
3450= CONSTANT     -8.[illegible]     [illegible].[illegible]     [illegible].404  .[illegible]
3460= INITIAL REGRESSION                       [illegible]   [illegible]     PAGE    [illegible]
3470=
3480= FILE - NONAME  (CREATED - [illegible])
3490=
3500= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
3510=
3520= DEP. VAR... T[illegible]       T[illegible]
3530=
3540= VARIABLE(S) ENTERED ON STEP  5
3550= MAXMACH    MAXIMUM MACH NUMBER
3560=
3570= MULTIPLE R     .[illegible] ANOVA          DF  SUM SQUARES  MEAN SQ.      F
3580= R SQUARE       .[illegible] REGRESSION     5.      2.027       .[illegible]    [illegible]
3590= STD DEV        .4[illegible] RESIDUAL       2.       .388      .194 SIG. [illegible]
3600= ADJ R SQUARE   .4[illegible] COEFF OF VARIABILITY    2[illegible] PCT
3610=
3620= VARIABLE        B       S.E. B       F     SIG.      BETA   ELASTICITY
3630=
3640= PROTI          .42[illegible]      .[illegible]     [illegible]  .[illegible]     .6[illegible]   .6[illegible]
3650= NZULT         [illegible]     [illegible]     [illegible]  .4[illegible]     .[illegible]   [illegible]
3660= TOGWMAX        .420      .[illegible]      .[illegible]  .[illegible]     .[illegible]   [illegible]
3670= TWTAREA        .[illegible]      .724      .[illegible]  .[illegible]     .[illegible]   [illegible]
3680= MAXMACH       -.[illegible]      .7[illegible]      .027  .[illegible]    -.[illegible]  -.[illegible]
3690= CONSTANT     -9.[illegible]    [illegible]     .636  .[illegible]
3700=
3710=
3720= F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
3730=
3740=
3750=
3760= COEFFICIENTS AND CONFIDENCE INTERVALS.
3770=
3780= VARIABLE        B           95 PCT C.I.
3790=
3800= PROTI          .4263      -.3854     1.2379
3810= NZULT         1.7281     -5.4037     6.8681
3820= TOGWMAX        .4[illegible]     -2.5[illegible]     [illegible]
3830= TWTAREA        .2134     -2.9026     3.3293
3840= MAXMACH       -.[illegible]     -3.4[illegible]     [illegible]
3850= CONSTANT     -9.6706    -61.[illegible]    42.4898
3860=
3870=
3880= VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
3890=
3900=
3910= PROTI          .[illegible]
3920= TOGWMAX       [illegible]       [illegible]
```

```
TWTAREA       -.12133    .26717    .52444
MAXMACH        .02762   -.40402   -.10601    .55911
NCLUT          .00469    .0009     .13511   -.47041   1.74741

              PROTO    TOGWMAX   TWTAREA   MAXMACH   NCLUT

INITIAL REGRESSION                        01/15/82  14.19.38.     PAGE  19

FILE - NONAME    (CREATED - 01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *

DEP. VAR... TOIL        TOILING


SUMMARY TABLE

STEP VARIABLE E/R      F    MULT-R RSQ CHANGE   R   OVERALL F  SIG.

  1  PROTO     E    10.856  .791  .626  .626  .791    10.056  .019
  2  NCLUT     E     3.649  .855  .734  .108  .445     [illegible]  [illegible]
  3  TOGWMAX   E      .155  .857  .823  .049  .511     [illegible]  .155
  4  TWTAREA   E      .292  .912  .829  .027 -.212     [illegible]  [illegible]
  5  MAXMACH   E      .027  .912  .831  .002  .442     [illegible]  .376
INITIAL REGRESSION                        01/15/82  14.19.38.     PAGE  [illegible]

FILE - NONAME    (CREATED - 01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *


RESIDUAL PLOT

  Y VALUE    Y EST.  RESIDUAL -2SD            0.0              +2SD

    1.805     1.576     .229                    I    .
     .235      .312    -.077                   .I
    1.344     [illegible]  [illegible]          I   .
    1.498     1.755    -.257                  . I
    [illegible]  1.754  -.503              .    I
    2.087     2.011     .275                    I .
    1.498     1.639     .051                    I .
    2.036     1.945     .091                    I .

NOTE - (M) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
       R INDICATES POINT OUT OF RANGE OF PLOT


NUMBER OF CASES PLOTTED          8.
NUMBER OF 2 S.D. OUTLIERS        0 OR      0 PERCENT OF THE TOTAL

VON NEUMANN RATIO    2.18102          DURBIN-WATSON TEST    1.90842

NUMBER OF POSITIVE RESIDUALS      5.
NUMBER OF NEGATIVE RESIDUALS      3.
NUMBER OF RUNS OF SIGNS           5.

NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
INITIAL REGRESSION                        01/15/82  14.19.38.     PAGE  [illegible]

FILE - NONAME    (CREATED - 01/15/82)

* * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
```

```
4590= DEP. VAR... MANF      MANUFACTURING HOURS
4600=
4610= MEAN RESPONSE       3.85000     STD. DEV.        .64337
4620=
4630= VARIABLE(S) ENTERED ON STEP   1
4640= TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
4650=
4660= MULTIPLE R    .8925 ANOVA        DF  SUM SQUARES  MEAN SQ.      F
4670= R SQUARE      .7966 REGRESSION    1.       2.308      2.306    23.491
4680= STD DEV       .3134 RESIDUAL      6.        .589      .098 SIG. .003
4690= ADJ R SQUARE  .7627 COEFF OF VARIABILITY     8.1PCT
4700=
4710= VARIABLE       B      S.E. B       F      SIG.      BETA   ELASTICITY
4720=
4730= TOGWMAX       1.280     .264    23.491  .003      .89252   1.35371
4740= CONSTANT     -9.749    2.856    11.198  .015
4750=
4760=
4770=
4780= ++++++++++++++++++++++++++++++++++++++++
4790=
4800= VARIABLE S  ENTERED ON STEP   2
4810= NZULT      ULTIMATE LOAD FACTOR
4820=
4830= MULTIPLE R    .9350 ANOVA        DF  SUM SQUARES  MEAN SQ.      F
4840= R SQUARE      .8742 REGRESSION    2.       2.535      1.267    17.465
4850= STD DEV       .2694 RESIDUAL      5.        .363      .073 SIG. .006
4860= ADJ R SQUARE  .8240 COEFF OF VARIABILITY     7.0PCT
4870=
4880= VARIABLE       B      S.E. B       F      SIG.      BETA   ELASTICITY
4890=
4900= TOGWMAX       1.133     .241    22.073  .005      .79084   1.19868
4910= NZULT         1.622     .919     3.111  .137      .26457    .43703
4920= CONSTANT    -12.227    3.757    10.522  .023
4930=INITIAL REGRESSION                          8/15/82 14.19.32.    PAGE  12
4940=
4950= FILE - NONAME   (CREATED - 81 08 08)
4960=
4970= ++++++++++ M U L T I P L E   R E G R E S S I O N ++++++++++
4980=
4990= DEP. VAR... MANF       MANUFACTURING HOURS
5000=
5010= VARIABLE(S)  ENTERED ON STEP   3
5020= TWTAREA    TOTAL WETTED AREA
5030=
5040= MULTIPLE R    .9383 ANOVA        DF  SUM SQUARES  MEAN SQ.      F
5050= R SQUARE      .8804 REGRESSION    3.       2.551      .850     9.811
5060= STD DEV       .2943 RESIDUAL      4.        .346      .087 SIG. .025
5070= ADJ R SQUARE  .7907 COEFF OF VARIABILITY     7.6PCT
5080=
5090= VARIABLE       B      S.E. B       F      SIG.      BETA   ELASTICITY
5100=
5110= TOGWMAX       1.154     .253    17.466  .014      .80532   1.21586
5120= NZULT         1.605    1.003     2.571  .184      .26414    .43916
5130= TWTAREA        .167     .430      .159  .657      .08102    .07361
5140= CONSTANT    -14.138    5.324     7.042  .057
5150=
5160=
5170=
5180= ++++++++++++++++++++++++++++++++++++++++
5190=
5200= VARIABLE(S) ENTERED ON STEP   4
5210= PROTO      NUMBER OF PROTOTYPE AIRCRAFT
5220=
5230= MULTIPLE R    .9390 ANOVA        DF  SUM SQUARES  MEAN SQ.      F
5240= R SQUARE      .8817 REGRESSION    4          2.555        .6      5.59
```

```
[illegible]
5250= STD DEV.      .1160 RESIDUAL      3.      .041      .014 [illegible]
5260= ADJ R SQUARE  .7246 COEFF OF VARIABILITY    6.6 PCT
5270=
5280= VARIABLE         B      S.E. B        F     SIG.      BETA   ELASTICIT
5290=
5300= TOGWMAX       [illegible]    .342   [illegible].572  .041     .61227  [illegible]
5310= NZULT         [illegible]   [illegible]   [illegible]  .255     [illegible]  [illegible]
5320= TWTAREA        [illegible]    .499    [illegible]  .752     .27524  [illegible]
5330= PROTO          .022    [illegible]    .011  [illegible]   .015[illegible]  [illegible]
5340= CONSTANT   -[illegible]    [illegible].245   4.951  [illegible]
5350=INITIAL REGRESSION                     [illegible]    PAGE  14
5360=
5370= FILE - NONAME  (CREATED - [illegible])
5380=
5390= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
5400=
5410= DEP. VAR... MANF      MAN.FAIT.FIG.-HI FE
5420=
5430= VARIABLE(S) ENTERED ON STEP  5
5440= MAXMACH     MAXIMUM MACH NUMBER
5450=
5460= MULTIPLE R    [illegible] ANOVA         DF  SUM SQUARES  MEAN SQ.      F
5470= R SQUARE      .[illegible] REGRESSION    5.      1.551      .310    [illegible]
5480= STD DEV.      .4120 RESIDUAL      2.       .342      .170 SIG. [illegible]
5490= ADJ R SQUARE  .[illegible] COEFF OF VARIABILITY    10.[illegible]
5500=
5510= VARIABLE         B      S.E. B        F     SIG.      BETA   ELASTICIT
5520=
5530= TOGWMAX       [illegible]     [illegible]   [illegible]  [illegible]     [illegible]  [illegible]
5540= NZULT         [illegible]    [illegible]   [illegible]  [illegible]     [illegible]  [illegible]
5550= TWTAREA        [illegible]    [illegible]    .099  [illegible]     .2[illegible]  [illegible]
5560= PROTO          .024    [illegible]    [illegible]  .9[illegible]     .03[illegible]  [illegible]
5570= MAXMACH       -.0[illegible]    .781    [illegible]  .504    -.25[illegible]  -.01[illegible]
5580= CONSTANT   -14.9[illegible]  [illegible]   [illegible]  .[illegible]
5590=
5600=
5610= F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
5620=
5630=
5640=
5650= COEFFICIENTS AND CONFIDENCE INTERVALS.
5660=
5670= VARIABLE         B           95 PCT C.I.
5680=
5690= TOGWMAX       [illegible]   -[illegible]   [illegible]
5700= NZULT         [illegible]   -4.8145   [illegible]
5710= TWTAREA        .[illegible]77   -[illegible]   [illegible]
5720= PROTO          .0245    -.7160    .7650
5730= MAXMACH       -.0953   -[illegible]   [illegible]
5740= CONSTANT   -14.9894  -62.5767  32.5[illegible]
5750=
5760=
5770= VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
5780=
5790=
5800= PROTO          .02962
5810= TOGWMAX       -.02669   .40476
5820= TWTAREA       -.0[illegible]622   .22423   .43653
5830= MAXMACH        .00633  -.33631  -.17980   .49081
5840= NZULT          .00391   .08331   .11289  -.39156  2.25666
5850=
5860=             PROTO     TOGWMAX   TWTAREA   MAXMACH   NZULT
5870=
5880=
5890=INITIAL REGRESSION                     01/15/82  [illegible]    PAGE  15
5900=
```

```
FILE - NONAME   (CREATED - 01/15/82)
********** M U L T I P L E   R E G R E S S I O N **********
DEP. VAR... MANH      MANUFACTURING HOURS
SUMMARY TABLE.
STEP VARIABLE E/R      F   MULT-R R-SQ CHANGE  F   OVERALL F  SIG
  1  TOGWMAX   E    [illegible]  [illegible]  .797  .797  [illegible]   [illegible]  .003
  2  NULT      E    [illegible]  [illegible]  .875  .078  [illegible]   [illegible]  .006
  3  TWTAREA   E     [illegible]  [illegible]  [illegible]  [illegible]  [illegible]   [illegible]  [illegible]
  4  PRICE     E     .003  [illegible]  [illegible]  .001  [illegible]   [illegible]  [illegible]
  5  MAXMACH   E     .013  .948  .898  .001  .734   [illegible]  [illegible]
INITIAL REGRESSION                         01/15/82  14.[illegible]   PAGE  [illegible]
FILE - NONAME   (CREATED - 01/15/82)
********** M U L T I P L E   R E G R E S S I O N **********
RESIDUAL PLOT
   Y VALUE    Y EST.  RESIDUAL -2SD            0.0             +2SD
     4.[illegible]     [illegible]     .[illegible]                 I  .
     [illegible]     [illegible]     .[illegible]                 I.
     4.[illegible]     4.[illegible]     .[illegible]                 I   .
     4.[illegible]     4.[illegible]     .[illegible]                 I    .
     [illegible]     4.[illegible]    -.[illegible]        .        I
     [illegible]     [illegible]     .07[illegible]                 I.
     [illegible]     [illegible]    -.027                .I
     4.[illegible]     4.[illegible]     .020                 I.
NOTE - + INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
       R INDICATES POINT OUT OF RANGE OF PLOT
NUMBER OF CASES PLOTTED       8.
NUMBER OF 2 S.D. OUTLIERS       0 OR      0 PERCENT OF THE TOTAL
VON NEUMANN RATIO    [illegible]        DURBIN-WATSON TEST   [illegible]
NUMBER OF POSITIVE RESIDUALS     6.
NUMBER OF NEGATIVE RESIDUALS     2.
NUMBER OF RUNS OF SIGNS          5.
NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
USE A TABLE FOR EXPECTED VALUES.
INITIAL REGRESSION                         01/15/82  14.[illegible].30.   PAGE  17
FILE - NONAME   (CREATED - 01/15/82)
********** M U L T I P L E   R E G R E S S I O N **********
DEP. VAR... MANMAT     MANUFACTURING MATERIALS
MEAN RESPONSE        4.02807      STD. DEV.       .6[illegible]
VARIABLE(S) ENTERED ON STEP  1
TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
MULTIPLE R    .9546 ANOVA        DF  SUM SQUARES  MEAN SQ.     F
[illegible]
```

```
[illegible]
[illegible]= STD DEV         [illegible] RESIDUAL       [illegible]       [illegible]      [illegible]
[illegible]= ADJ R SQUARE  [illegible] COEFF OF VARIABILITY     [illegible]
[illegible]=
[illegible]= VARIABLE          B        S.E. B         F       SIG.        BETA   ELASTICITY
[illegible]=
[illegible]= TIGMAX         [illegible]      [illegible]    [illegible]  [illegible]      [illegible]  [illegible]
[illegible]= CONSTANT    [illegible]     [illegible]    [illegible]  [illegible]
[illegible]=
6650=
6660=
[illegible]= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
[illegible]=
6690= VARIABLE(S) ENTERED ON STEP   2
6700= NZULT        ULTIMATE LOAD FACTOR
6710=
6720= MULTIPLE R     [illegible] ANOVA          DF  SUM SQUARES  MEAN SQ.      F
[illegible]= R SQUARE       [illegible] REGRESSION      2.       [illegible]      [illegible]    [illegible]
[illegible]= STD DEV        [illegible] RESIDUAL        [illegible]       [illegible]      [illegible] SIG. [illegible]
[illegible]= ADJ R SQUARE  [illegible] COEFF OF VARIABILITY     [illegible]
[illegible]=
[illegible]= VARIABLE          B        S.E. B         F       SIG.        BETA   ELASTICITY
[illegible]=
[illegible]= TIGMAX         [illegible]      [illegible]    [illegible]  [illegible]      [illegible]  [illegible]
[illegible]= NZULT          [illegible]      [illegible]    [illegible]  [illegible]      [illegible]  [illegible]
[illegible]= CONSTANT    [illegible]     [illegible]    [illegible]  [illegible]
[illegible]=[illegible] REGRESSION                        [illegible]   PAGE  [illegible]
[illegible]=
[illegible]= FILE  NONAME    (CREATED  [illegible])
[illegible]=
[illegible]= * * * * * * * * * * *  M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
[illegible]=
[illegible]= DEP. VAR.. MANHAT    MANUFACTURING MATERIALS
[illegible]=
[illegible]= VARIABLE(S) ENTERED ON STEP   3
[illegible]= PROTO       NUMBER OF PROTOTYPE AIRCRAFT
[illegible]
[illegible]= MULTIPLE R     [illegible] ANOVA          DF  SUM SQUARES  MEAN SQ.      F
[illegible]= R SQUARE       [illegible] REGRESSION      3.       [illegible]      [illegible]    [illegible]
[illegible]= STD DEV        [illegible] RESIDUAL        4.       [illegible]      [illegible] SIG. [illegible]
[illegible]= ADJ R SQUARE  [illegible] COEFF OF VARIABILITY     [illegible]
[illegible]=
[illegible]= VARIABLE          B        S.E. B         F       SIG.        BETA   ELASTICITY
[illegible]=
7000= TIGMAX         [illegible]      [illegible]    [illegible]  [illegible]      [illegible]  [illegible]
7010= NZULT          [illegible]      [illegible]    [illegible]  [illegible]      [illegible]  [illegible]
7020= PROTO          [illegible]      [illegible]    [illegible]  [illegible]      [illegible]  [illegible]
7030= CONSTANT    [illegible]     [illegible]    [illegible]  [illegible]
7040=
7050=
7060=
7070= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
7080=
7090= VARIABLE(S) ENTERED ON STEP   4
7100= TWTAREA     TOTAL WETTED AREA
7110=
7120= MULTIPLE R     .9846 ANOVA          DF  SUM SQUARES  MEAN SQ.      F
7130= R SQUARE       .9695 REGRESSION      4.       3.025      [illegible]    [illegible]
7140= STD DEV        .1865 RESIDUAL        3.        .105      .035 SIG. [illegible]
7150= ADJ R SQUARE  .9287 COEFF OF VARIABILITY     4.4PCT
7160=
7170= VARIABLE          B        S.E. B         F       SIG.        BETA   ELASTICITY
7180=
7190= TIGMAX         1.365      .189    51.969  .006      .87466   3.42057
7200= NZULT          1.323      .637    4.3[illegible]  .1[illegible]      .22236    .7[illegible]
7210= PROTO           .076      .078      .959  .400      .0842[illegible]   .24[illegible]
[illegible]= TWTAREA        [illegible]      [illegible]    [illegible]  [illegible]      [illegible]  [illegible]
```

```
7220= CONSTANT    -[illegible]    [illegible]    [illegible]  [illegible]
7240=INITIAL REGRESSION                     [illegible]  [illegible]    PAGE  [illegible]
7250=
7260= FILE - NONAME   (CREATED - [illegible]/15/[illegible])
7270=
7280= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
7290=
7300= DEP. VAR... MANMAT     MANUFACTURING MATERIALS
7310=
7320= VARIABLE(S) ENTERED ON STEP  5
7330= MAXMACH    MAXIMUM MACH NUMBER
7340=
7350= MULTIPLE R    [illegible] ANOVA         DF  SUM SQUARES  MEAN SQ.     F
7360= R SQUARE      [illegible] REGRESSION     5.      [illegible]      [illegible]   [illegible]
7370= STD DEV       [illegible] RESIDUAL       [illegible]       [illegible]     [illegible]  [illegible]
7380= ADJ R SQUARE  [illegible] COEFF OF VARIABILITY     [illegible]
7390=
7400= VARIABLE       B      S.E. B       F      SIG.      BETA   ELASTICITY
7410=
7420= TOGWAX       [illegible]     [illegible]    [illegible] .[illegible]     [illegible]   [illegible]
7430= NZULT        [illegible]     [illegible]    [illegible] [illegible]     [illegible]   [illegible]
7440= PROTO        .[illegible]     .[illegible]    [illegible] [illegible]     [illegible]   [illegible]
7450= TWTAREA      [illegible]     .[illegible]    .[illegible] [illegible]     [illegible]   [illegible]
7460= MAXMACH      -[illegible]     [illegible]    [illegible] [illegible]    -[illegible]  -[illegible]
7470= CONSTANT     -[illegible]     [illegible]    [illegible] [illegible]
7480=
7490=
7500= F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
7510=
7520=
7530=
7540= COEFFICIENTS AND CONFIDENCE INTERVALS.
7550=
7560= VARIABLE       B           95 PCT C.I.
7570=
7580= TOGWAX       [illegible]      [illegible]    [illegible]
7590= NZULT        [illegible]     -[illegible]   -[illegible]
7600= PROTO        [illegible]     -[illegible]    [illegible]
7610= TWTAREA      [illegible]     -[illegible]    [illegible]
7620= MAXMACH      -[illegible]     -[illegible]    [illegible]
7630= CONSTANT     -[illegible]   -[illegible]    [illegible]
7640=
7650=
7660= VARIANCE COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.
7670=
7680=
7690= PROTO         .[illegible]
7700= TOGWAX       -.[illegible]    [illegible]
7710= TWTAREA      -.[illegible]   .[illegible]    [illegible]
7720= MAXMACH       .[illegible]   -.[illegible]  -.[illegible]    [illegible]
7730= NZULT         .[illegible]    .[illegible]    .03159   -.10974    .[illegible]
7740=
7750=             PROTO     TOGWAX   TWTAREA   MAXMACH   NZULT
7760=
7770=
7780=INITIAL REGRESSION                     [illegible]  [illegible]    PAGE  [illegible]
7790=
7800= FILE - NONAME   (CREATED - [illegible]/15/[illegible])
7810=
7820= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
7830=
7840= DEP. VAR... MANMAT     MANUFACTURING MATERIALS
7850=
7860=
7870= SUMMARY TABLE.
7880=
```

```
7990= STEP VARIABLE E/R       F   MULTR RSQ CHANGE   R   OVERALL F  SIG.
7920=
7930=   1  TOGWMAX   E    6..557  .955  .911  .911  .955    [illegible]  .000
7920=   2  NOLT      E    4.778   .977  .955  .043  .814    50.521  .000
7930=   3  PROTO     E    1.401   .983  .966  .011  .367    33.275  .001
7940=   4  TWTAREA   E     .387   .985  .969  .003 -.174    22.312  .013
7950=   5  MAXMACH   E     .205   .986  .972  .003  .752    14.841  .064
7960=INITIAL REGRESSION                        01/15/82  14.19.08.    PAGE  1.
7970=
7980= FILE - NONAME   (CREATED - 01/15 82)
7990=
8000= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
8010=
8020=
8030= RESIDUAL PLOT.
8040=
8050=   Y VALUE     EST.  RESIDUAL -2.0              0.0              +2.0
8060=
8070=    4.151    4.236     .046                       I.
8080=    3.002    2.997     .001                       I.
8090=    4.801    4.759     .041                       I .
8100=    4.551    4.503     .032                       I      .
8110=    4.262    4.501    -.284          .            I
8120=    3.557    3.519     .037                       I .
8130=    3.731    3.753    -.027                      .I
8140=    5.245    5.224     .001                       I .
8150=
8160= NOTE - (*) INDICATES ESTIMATE CALCULATED WITH MEANS SUBSTITUTED
8170=        (+) INDICATES POINT OUT OF RANGE OF PLOT
8180=
8190=
8200= NUMBER OF CASES PLOTTED          8.
8210= NUMBER OF 2 S.D. OUTLIERS         0 OR     0 PERCENT OF THE TOTAL
8220=
8230= VON NEUMANN RATIO    3.39496          DURBIN-WATSON TEST    2.95554
8240=
8250= NUMBER OF POSITIVE RESIDUALS       6.
8260= NUMBER OF NEGATIVE RESIDUALS       2.
8270= NUMBER OF RUNS OF SIGNS           5.
8280=
8290= NORMAL APPROXIMATION TO SIGN DISTRIBUTION IMPOSSIBLE.
8300= USE A TABLE FOR EXPECTED VALUES.
8310=INITIAL REGRESSION                        01/15 82  14.19.04.    PAGE  12
8320=
8330= FILE - NONAME   (CREATED - 01/15/82)
8340=
8350= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
8360=
8370= DEP. VAR... ENG        ENGINEERING HOURS
8380=
8390= MEAN RESPONSE       2.105.6      STD. DEV.       .6079[illegible]
8400=
8410= VARIABLE(S) ENTERED ON STEP   1
8420= TOGWMAX    MAXIMUM TAKEOFF GROSS WEIGHT
8430=
8440= MULTIPLE R    .8146 ANOVA         DF  SUM SQUARES  MEAN SQ.     F
8450= R SQUARE      .6639 REGRESSION    1.       1.775     1.775   11.853
8460= STD DEV       .3869 RESIDUAL      6.        .898      .150 SIG. .014
8470= ADJ R SQUARE  .6079 COEFF OF VARIABILITY    16.4PCT
8480=
8490= VARIABLE        B       S.E. B       F     SIG.     BETA   ELASTICITY
8500=
8510= TOGWMAX       1.122      .326   11.853  .014      .81461   5.74571
8520= CONSTANT     -9.997     3.518    8.075  .029
8530=
[illegible]
```

```
[illegible]
[illegible]= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
6570=
[illegible]= VARIABLE [illegible] ENTERED IN STEP [illegible]
[illegible]= PROTO      NUMBER OF PROTOTYPE AIRCRAFT
6600=
6610= MULTIPLE R    .87[illegible] ANOVA        DF  SUM SQUARES  MEAN SQ.     F
6620= R SQUARE      .7567 REGRESSION     [illegible]       [illegible]      [illegible]      [illegible]
6630= STD DEV       .35[illegible] RESIDUAL       [illegible]       [illegible]       [illegible] SIG. [illegible]
6640= ADJ R SQUARE  [illegible] COEFF OF VARIABILITY     [illegible]
[illegible]=
6660= VARIABLE        B      S.E. B       F     SIG.      BETA  ELASTICITY
6670=
6680= TOGWMAX         .998      [illegible]    [illegible] [illegible]     [illegible]   [illegible]
6690= PROTO           .227      .148     [illegible] [illegible]     [illegible]   [illegible]
6700= CONSTANT      -9.[illegible]     [illegible]     [illegible] [illegible]
6710=INITIAL REGRESSION                           [illegible]                PAGE  [illegible]
[illegible]=
[illegible]= FILE - NONAME   (CREATED - [illegible])
[illegible]=
[illegible]= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
6760=
[illegible]= DEP. VAR... ENG        ENGINEERING HOURS
[illegible]=
[illegible]= VARIABLE(S) ENTERED ON STEP [illegible]
6800= MAXMACH    MAXIMUM MACH NUMBER
[illegible]=
6820= MULTIPLE R    .8874 ANOVA        DF  SUM SQUARES  MEAN SQ.     F
[illegible]= R SQUARE      .7874 REGRESSION     [illegible]       [illegible]      .782     [illegible]
[illegible]= STD DEV       .3769 RESIDUAL       4        .568      [illegible] SIG. [illegible]
[illegible]= ADJ R SQUARE  .6280 COEFF OF VARIABILITY     [illegible]
[illegible]=
[illegible]= VARIABLE        B      S.E. B       F     SIG.      BETA  ELASTICITY
[illegible]=
[illegible]= TOGWMAX        [illegible]      .4[illegible]     [illegible] [illegible]     [illegible]   [illegible]
[illegible]= PROTO           .287      [illegible]     [illegible] [illegible]     [illegible]   [illegible]
[illegible]= MAXMACH        -.485      [illegible]     .548 .503    -[illegible]  -[illegible]
[illegible]= CONSTANT     -[illegible]     [illegible]     [illegible] .877
[illegible]=
  [illegible]=
6950=
[illegible]= * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
[illegible]=
[illegible]= VARIABLE(S) ENTERED ON STEP  4
[illegible]= NZULT      ULTIMATE LOAD FACTOR
9000=
9010= MULTIPLE R    .[illegible] ANOVA        DF  SUM SQUARES  MEAN SQ.     F
9020= R SQUARE      .[illegible] REGRESSION    4.       [illegible]      .547     [illegible]
9030= STD DEV       .4[illegible] RESIDUAL      [illegible]        .493      .164 SIG. .17[illegible]
9040= ADJ R SQUARE  .5697 COEFF OF VARIABILITY    19.[illegible]PCT
9050=
9060= VARIABLE        B      S.E. B       F     SIG.      BETA  ELASTICITY
9070=
9080= TOGWMAX        1.27[illegible]      .529     5.812 .095     .9[illegible]  6.5[illegible]
9090= PROTO          .2[illegible]      .167     1.596 .276     .3[illegible]5   .259[illegible]
9100= MAXMACH       -.556      .635      .773 .444   -.35468  -.15982
9110= NZULT         1.001     1.478      .458 .547     .1905[illegible]  [illegible]463
9120= CONSTANT     -14.214     [illegible]     4.885 .114
9130=INITIAL REGRESSION                      01/15/82  14.19.30.      PAGE  24
9140=
9150= FILE - NONAME   (CREATED - 01 15/82)
9160=
9170= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
9180=
9190= DEP. VAR... ENG        ENGINEERING HOURS
[illegible]=
```

```
9200= VARIABLE(S) ENTERED ON STEP 5
9210= TWTAREA   TOTAL WETTED AREA
9220=
9240= MULTIPLE R    .9082 ANOVA        DF  SUM SQUARES  MEAN SQ.      F
9250= R SQUARE      .8248 REGRESSION    5.      [illegible]     [illegible]     [illegible]
9260= STD DEV       .4839 RESIDUAL      [illegible]      .46[illegible]     .234 SIG. [illegible]
9270= ADJ R SQUARE  .[illegible] COEFF OF VARIABILITY    [illegible]
9280=
9290= VARIABLE       B      S.E. B       F     SIG      BETA   ELASTICITY
9300=
9310= TIGWMAX       [illegible]     [illegible]    [illegible]  [illegible]    [illegible]   [illegible]
9320= PROTO         [illegible]      [illegible]     .[illegible]  [illegible]    [illegible]   [illegible]
9330= MAXMACH       -[illegible]     .[illegible]     [illegible]  [illegible]    -[illegible]   -[illegible]
9340= NZULT         [illegible]      [illegible]     [illegible]  [illegible]    [illegible]   [illegible]
9350= TWTAREA       [illegible]      [illegible]     [illegible]  [illegible]    [illegible]   [illegible]
9360= CONSTANT     -[illegible]     [illegible]    [illegible]  [illegible]
9370=
9380=
9390= F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.
9400=
9410=
9420=
9430= COEFF LIMITS AND CONFIDENCE INTERVALS.
9440=
9450= VARIABLE       B          95 PCT C.I.
9460=
9470= TIGWMAX       [illegible]     -[illegible]   -[illegible]
9480= PROTO         [illegible]      [illegible]    [illegible]
9490= MAXMACH       -[illegible]    -[illegible]   [illegible]
9500= NZULT         [illegible]     -[illegible]   [illegible]
9510= TWTAREA       [illegible]     -[illegible]   [illegible]
9520= CONSTANT     -[illegible]    -[illegible]   [illegible]
9530=
9540=
9550= VARIANCE COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS
9560=
9570=
9580= PROTO        .04[illegible]
9590= TIGWMAX     -.0[illegible]   .[illegible]
9600= TWTAREA     -.0[illegible]   .0[illegible]   .[illegible]
9610= MAXMACH      .00[illegible]   -.[illegible]   -.[illegible]   .[illegible]
9620= NZULT        .00[illegible]   .[illegible]   .[illegible]   -.[illegible]   [illegible]
9630=
9640=           PROTO    TIGWMAX   TWTAREA   MAXMACH   NZULT
9650=
9660=
9670= CONDITIONAL REGRESSION                    0[illegible]/15/8[illegible]  [illegible]    PAGE  [illegible]
9680=
9690= FILE - NONAME   (CREATED - 0[illegible]/15/8[illegible])
9700=
9710= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
9720=
9730= DEP. VAR... ENG       ENGINEERING HOURS
9740=
9750=
9760= SUMMARY TABLE.
9770=
9780= STEP VARIABLE E/R      F   MULT R RSQ CHANGE   R   OVERALL F  SIG.
9790=
9800=   1  TIGWMAX   E    [illegible].853  .815  .6[illegible]4  .6[illegible]4  .[illegible]    [illegible]  .[illegible]
9810=   2  PROTO     E     1.765  .87[illegible]  .759  .095  .5[illegible]     7.[illegible]  .2[illegible]
9820=   3  MAXMACH   E      .540  .887  .787  .02[illegible]  .5[illegible]     4.[illegible]  .07[illegible]
9830=   4  NZULT     E      .45[illegible]  .90[illegible]  .[illegible]  .02[illegible]  .[illegible]     [illegible]  .[illegible]
9840=   5  TWTAREA   E      .105  .908  .825  .009 -.[illegible]     [illegible]  .[illegible]
9850= CONDITIONAL REGRESSION                    01/15/8[illegible]  [illegible]    PAGE  [illegible]
9860=
```

```
[illegible] FILE [illegible] NONAME [illegible] CREATED [illegible]
[illegible]=
[illegible]= * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * *
[illegible]=
[illegible]=
[illegible]= RESIDUAL PLOT
[illegible]=
[illegible]=    VALUE    Y EST.  RESIDUAL -[illegible]        0.0          +[illegible]
[illegible]=
[illegible]=    [illegible]
[illegible]=    [illegible]
[illegible]=    [illegible]
[illegible]=    [illegible]
[illegible]=    [illegible]
[illegible]=    [illegible]
[illegible]=    [illegible]
[illegible]=    [illegible]
[illegible]=
[illegible]= NOTE - [illegible] INDICATES ESTIMATE CALCULATED WITH MEAN [illegible]
[illegible]=        [illegible] INDICATES POINT OUT OF RANGE OF PLOT
[illegible]=
[illegible]=
[illegible]= NUMBER OF CASES PLOTTED   [illegible]
[illegible]= NUMBER OF [illegible] OUTLIERS   [illegible] OR   [illegible] PERCENT OF THE TOTAL
[illegible]=
[illegible]= VON NEUMANN RATIO  [illegible]     DURBIN-WATSON TEST  [illegible]
[illegible]=
[illegible]= NUMBER OF POSITIVE RESIDUALS   [illegible]
[illegible]= NUMBER OF NEGATIVE RESIDUALS   [illegible]
[illegible]= NUMBER OF RUNS OF SIGNS   [illegible]
[illegible]=
[illegible]= NORMAL APPROXIMATION TO SIGN DISTRIBUTION [illegible]
[illegible]= USE A TABLE FOR EXPECTED VALUES.
[illegible]= [illegible] REGRESSION        [illegible]   PAGE [illegible]
[illegible]=
[illegible]=
[illegible]= CPU TIME REQUIRED..   .[illegible] SECONDS
[illegible]=
[illegible]=
[illegible]=
[illegible]= TOTAL CPU TIME USED..   .[illegible] SECONDS
[illegible]=
[illegible]=
[illegible]=
[illegible]=
[illegible]= RUN COMPLETED
[illegible]=
[illegible]= NUMBER OF CONTROL CARDS READ  [illegible]
[illegible]= NUMBER OF ERRORS DETECTED   [illegible]
[illegible]=
0370=*EOR
..GET,FA4,[illegible]
LE NAME FA4      HAS BEEN RETRIEVED
..REWIND,SPSS,[illegible],FA4
..SPSS,[illegible]=FA4,[illegible]
[illegible] SPSS
LE QUOTA EXCEEDED
..RETURN,[illegible]
..[illegible]
```

APPENDIX G

FACTOR ANALYSIS INITIAL

```
180=          VERSION 8.0 -- JUNE [illegible]
190=
200=
210=
220=
230= RUN NAME       FACTOR ANALYSIS
240= VARIABLE LIST  FTWT,FNZU,FNIM,FTOC,ATWT,ANZU
250=                ANIM,ATOC,CTWT,CNZU,CNIM,CTOC
260=                FF,AA,CC,FN,AN,CN,FM,NM,CM
270= INPUT FORMAT   FREEFIELD
280= INPUT MEDIUM   DISK
290= N OF CASES     UNKNOWN
300= COMPUTE        FF=FTWT/FTOC
310= COMPUTE        AA=ATWT/ATOC
320= COMPUTE        CC=CTWT/CTOC
330= COMPUTE        FN=FNZU*FTWT
340= COMPUTE        AN=ANZU*ATWT
350= COMPUTE        CN=CNZU*CTWT
360= COMPUTE        FM=FNZU/FNIM
370= COMPUTE        NM=ANZU/ANIM
380= COMPUTE        CM=CNZU/CNIM
390= FACTOR         VARIABLES= FTWT TO CTOC/TYPE=PA1/
400=                ROTATE=QUARTIMAX/
410=                VARIABLES=FN,AN,CN/TYPE=PA1/
420=                ROTATE=QUARTIMAX/
430=                VARIABLES=FF,AA,CC/TYPE=PA1/
440=                ROTATE=QUARTIMAX/
450=                VARIABLES=FM,NM,CM/TYPE=PA1/
460=                ROTATE=QUARTIMAX/
470=                VARIABLES=FN,AN,CN,FM,NM,CM/TYPE=PA1/
480=                ROTATE=QUARTIMAX/
490= OPTION         8
500= STATISTICS     ALL
510= READ INPUT DATA
520=
530= 00053700 CM NEEDED FOR FACTOR
540=
550= END OF FILE ON FILE DA2
560= AFTER READING      6 CASES FROM SUBFILE NONAME
570=1FACTOR ANALYSIS                            03/22/82  14.42.32.    PAGE    2
580=
590= FILE - NONAME   (CREATED -  03/22/82)
600=
610=
620= VARIABLE          MEAN      STANDARD DEV     CASES
630=
640= FTWT         2347.6667        550.4917          6
650= FNZU           10.6667          1.2813          6
660= FNIM            1.8750           .7098          6
670= FTOC        43292.0000      17918.0191          6
680= ATWT         2354.3333        932.5905          6
690= ANZU            7.3000          3.9981          6
700= ANIM            1.0300           .4203          6
710= ATOC        49742.0000      20180.5157          6
720= CTWT        14431.6667      10272.9988          6
730= CNZU            3.6750           .3387          6
740= CNIM             .6950           .1087          6
750= CTOC       496050.0000     433179.0380          6
760=1FACTOR ANALYSIS                            03/22/82  14.42.32.    PAGE    3
770=
780= FILE - NONAME   (CREATED -  03/22/82)
790=
800=
810= CORRELATION COEFFICIENTS..
820=
830=
```

	FTWT	FNZU	FMXM	FTOC	ATWT
FTWT	1.00000	-.14019	.08111	.42760	.37509
FNZU	-.14019	1.00000	.58831	.21159	.62369
FMXM	.08111	.58831	1.00000	.75629	.38019
FTOC	.42760	.21159	.75629	1.00000	.29928
ATWT	.37509	.62369	.38019	.29928	1.00000
ANZU	.05247	.13909	.56014	.62256	.10314
AMXM	.14585	.05571	-.63091	-.61616	.33801
ATOC	.65877	.61835	.40378	.37758	.91539
CTWT	.08502	.76012	.65949	.25724	.59414
CNZU	.72298	-.24192	-.36498	.10455	.24491
CMXM	-.58684	.76536	.65162	.29808	.32891
CTOC	-.24049	-.19169	-.26180	-.37241	-.35672

	ANZU	AMXM	ATOC	CTWT	CNZU
FTWT	.05247	.14585	.65877	.08502	.72298
FNZU	.13909	.05571	.61835	.76012	-.24192
FMXM	.56014	-.63091	.40378	.65949	-.36498
FTOC	.62256	-.61616	.37758	.25724	.10455
ATWT	.10314	.33801	.91539	.59414	.24491
ANZU	1.00000	-.23061	.20372	-.19588	-.40842
AMXM	-.23061	1.00000	.33536	-.28106	.22547
ATOC	.20372	.33536	1.00000	.51375	.31942
CTWT	-.19588	-.28106	.51375	1.00000	-.00756
CNZU	-.40842	.22547	.31942	-.00756	1.00000
CMXM	.29592	-.40998	.04633	.53421	-.58445
CTOC	-.05836	-.28459	-.46924	.28519	.26201

	CMXM	CTOC
FTWT	-.58684	-.24049
FNZU	.76536	-.19169
FMXM	.65162	-.26180
FTOC	.29808	-.37241
ATWT	.32891	-.35672
ANZU	.29592	-.05836
AMXM	-.40998	-.28459
ATOC	.04633	-.46924
CTWT	.53421	.28519
CNZU	-.58445	.26201
CMXM	1.00000	-.05280

1FACTOR ANALYSIS 03/22/82 14.42.32. PAGE 4

FILE - NONAME (CREATED - 03/22/82)

	CMXM	CTOC
CTOC	-.05280	1.00000

1FACTOR ANALYSIS 03/22/82 14.42.32. PAGE 5

FILE - NONAME (CREATED - 03/22/82)

VARIABLE	EST COMMUNALITY	FACTOR	EIGENVALUE	PCT	CUM PCT
FTWT	1.00000	1	4.52772	37.7	37.7
FNZU	1.00000	2	3.03160	25.3	63.0
FMXM	1.00000	3	2.25841	18.8	81.8
FTOC	1.00000	4	1.80523	15.0	96.9
ATWT	1.00000	5	.37704	3.1	100.0
ANZU	1.00000	6	.00000	.0	100.0
AMXM	1.00000	7	.00000	.0	100.0
ATOC	1.00000	8	.00000	.0	100.0
CTWT	1.00000	9	.00000	.0	100.0
CNZU	1.00000	10	-.00000	-.0	100.0
CMXM	1.00000	11	-.00000	-.0	100.0
CTOC	1.00000	12	-.00000	-.0	100.0

1FACTOR ANALYSIS 03/22/82 14.42.32. PAGE 6

FILE - NONAME (CREATED - 03/22/82)

FACTOR MATRIX USING PRINCIPAL FACTOR, NO ITERATIONS

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FTWT	.16692	.83731	-.28623	.40303
FNZU	.82744	-.00645	.45135	-.32454
FMXM	.98835	-.28698	-.06731	.28956
FTOC	.68555	.00949	-.44440	.53190
ATWT	.74331	.54022	.26323	-.24983
ANZU	.53246	-.23288	-.79505	-.17350
AMXM	-.26693	.61125	.09363	-.73890
ATOC	.69707	.69563	.03449	-.12273
CTWT	.68360	.02381	.64630	.24130
CNZU	-.21608	.80025	.13606	.44390
CMXM	.67383	-.60805	.29059	-.16165
CTOC	-.44141	-.18368	.73188	.48554

VARIABLE	COMMUNALITY
FTWT	.97332
FNZU	.99374
FMXM	.96299
FTOC	.95047
ATWT	.97605
ANZU	.99997
AMXM	.99962
ATOC	.98605
CTWT	.94300
CNZU	.90265
CMXM	.93434
CTOC	.99998

1FACTOR ANALYSIS 03/22/82 14.42.32. PAGE 7

FILE - NONAME (CREATED - 03/22/82)

QUARTIMAX ROTATED FACTOR MATRIX
AFTER ROTATION WITH KAISER NORMALIZATION

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FTWT	.16100	.94929	.11259	.18324
FNZU	.94518	-.30935	.04962	.04711
FMXM	.52783	-.17676	.76819	.25106
FTOC	.23306	.27608	.81393	.39679
ATWT	.93478	.24220	-.11073	.17696
ANZU	.02686	-.17045	.37197	.91205
AMXM	.16827	.20212	-.94996	.16729
ATOC	.00927	.48260	-.05008	.30939
CTWT	.00712	-.05426	.36210	-.39787
CNZU	.02968	.88575	-.10731	-.32512
CMXM	.53389	-.71369	.37028	.02475
CTOC	-.17313	-.04591	.06667	-.97999

TRANSFORMATION MATRIX

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FACTOR 1	.80559	-.06452	.46793	.35345
FACTOR 2	.29493	.86750	-.39612	.05965
FACTOR 3	.46641	-.19452	-.20494	-.83823
FACTOR 4	-.21567	.44997	.76297	-.41096

1FACTOR ANALYSIS 03/22/82 14.42.32. PAGE 6

FILE - NONAME (CREATED - 03/22/82)

FACTOR SCORE COEFFICIENTS

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FTWT	.00390	.36159	.10416	.04399
FNZU	.27858	-.13706	-.09177	-.02917
FMXM	.07751	-.01901	.25961	.03019
FTOC	-.03242	.16078	.33474	.09756
ATWT	.26902	.05577	-.12324	.02782
ANZU	-.07138	-.05135	.08428	.37157
AMXM	.11958	-.01235	-.42825	.12465
ATOC	.21348	.15248	-.07385	.08324
CTWT	.22859	-.00147	.11087	-.24098
CNZU	.01448	.33195	.04837	-.15268
CMXM	.14004	-.25189	.05440	-.03042
CTOC	-.00327	.01367	.11718	-.42025

ERROR NUMBER.. 843. PROCESSING CEASES, ERROR SCAN CONTINUES.

CPU TIME REQUIRED.. .1530 SECONDS

- - - - - ERROR SUMMARY - - - - -

APPENDIX H

FACTOR ANALYSIS

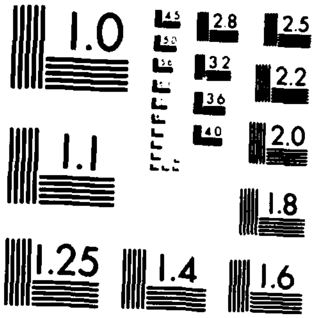
```
 100=RUN NAME       FACTOR ANALYSIS
110=VARIABLE LIST  FTWT,FNZU,FMIM,FTOG,ATWT,ANZU,
120=               AMIM,ATOG,CTWT,CNZU,CMIM,CTOG,
130=               FF,AA,CC,FN,AN,CN,FM,NM,CM
140=INPUT FORMAT   FREEFIELD
150=INPUT MEDIUM   DISK
160=N OF CASES     UNKNOWN
170=COMPUTE        FF=FTWT/FTOG
180=COMPUTE        AA=ATWT/ATOG
190=COMPUTE        CC=CTWT/CTOG
200=COMPUTE        FN=FNZU*FTWT
210=COMPUTE        AN=ANZU*ATWT
220=COMPUTE        CN=CNZU*CTWT
230=COMPUTE        FM=FNZU/FMIM
240=COMPUTE        NM=ANZU/AMIM
250=COMPUTE        CM=CNZU/CMIM
271=FACTOR         VARIABLES=FF,AA,CC/TYPE=PA1/
290=               ROTATE=QUARTIMAX/
300=               VARIABLES=FM,NM,CM/TYPE=PA1/
310=               ROTATE=QUARTIMAX/
320=               VARIABLES=FN,AN,CN,FM,NM,CM/TYPE=PA1
330=               ROTATE=QUARTIMAX/
340=OPTIONS        5
350=STATISTICS     ALL
360=READ INPUT DATA
..SAVE,FA1,N,0
..RETURN,A1
..REWIND,SPSS,DA2,FA1
..SPSS,D=DA2,I=FA1,LO=ABRV,L=W1,NR
PSS ERRORS
..EDIT,W1,S
.,A
..

  100=1
 110=S
 120=                                        03/22/82  15.26.29. PAGE    1
 130=         VOGELBACK COMPUTING CENTER
 140=         NORTHWESTERN UNIVERSITY
 150=
 160=         S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
 170=
 180=         VERSION 8.0 -- JUNE 18, 1979
 190=
 200=
 210=
 220=
 230= RUN NAME       FACTOR ANALYSIS
 240= VARIABLE LIST  FTWT,FNZU,FMIM,FTOG,ATWT,ANZU,
 250=                AMIM,ATOG,CTWT,CNZU,CMIM,CTOG,
 260=                FF,AA,CC,FN,AN,CN,FM,NM,CM
 270= INPUT FORMAT   FREEFIELD
 280= INPUT MEDIUM   DISK
 290= N OF CASES     UNKNOWN
 300= COMPUTE        FF=FTWT/FTOG
 310= COMPUTE        AA=ATWT/ATOG
 320= COMPUTE        CC=CTWT/CTOG
 330= COMPUTE        FN=FNZU*FTWT
 340= COMPUTE        AN=ANZU*ATWT
 350= COMPUTE        CN=CNZU*CTWT
 360= COMPUTE        FM=FNZU/FMIM
 370= COMPUTE        NM=ANZU/AMIM
 380= COMPUTE        CM=CNZU/CMIM
 390= FACTOR         VARIABLES=FF,AA,CC/TYPE=PA1/
 400=                ROTATE=QUARTIMAX/
```

AD-A123 848 AIRFRAME RDT&E COST ESTIMATING: A JUSTIFICATION FOR AND DEVELOPMENT OF UN..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. 3/3

UNCLASSIFIED C L BECK ET AL. SEP 82 AFIT-LSSR-56-82 F/G 1/3 NL

END
DATE
FILMED
3 83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

```
                    VARIABLES=FN,NM,CN/TYPE=PA1/
                    ROTATE=QUARTIMAX/
                    VARIABLES=FN,AN,CN,FN,NM,CN/TYPE=PA1/
                    ROTATE=QUARTIMAX/
 OPTIONS            5
 STATISTICS         ALL
 READ INPUT DATA

 000531OO CM NEEDED FOR FACTOR

 END OF FILE ON FILE DA2
 AFTER READING       6 CASES FROM SUBFILE NONAME
1FACTOR ANALYSIS                                    03/22/82  15.26.29.    PAGE    2

 FILE - NONAME    (CREATED -  03/22/82)


 VARIABLE             MEAN      STANDARD DEV      CASES

 FF                   .0597           .0208           6
 AA                   .0485           .0072           6
 CC                   .0420           .0200           6
1FACTOR ANALYSIS                                    03/22/82  15.26.29.    PAGE    3

 FILE - NONAME    (CREATED -  03/22/82)


 CORRELATION COEFFICIENTS..





                   FF           AA           CC

 FF              1.00000      -.03852      -.12345
 AA              -.03852      1.00000      -.49291
 CC              -.12345      -.49291      1.00000
1FACTOR ANALYSIS                                    03/22/82  15.26.29.    PAGE    4

 FILE - NONAME    (CREATED -  03/22/82)




 VARIABLE EST COMMUNALITY  FACTOR  EIGENVALUE  PCT  CUM PCT

 FF              1.00000        1      1.50032  50.0    50.0
 AA              1.00000        2      1.01007  33.9    83.9
 CC              1.00000        3       .48161  16.1   100.0
1FACTOR ANALYSIS                                    03/22/82  15.26.29.    PAGE    5

 FILE - NONAME    (CREATED -  03/22/82)


 FACTOR MATRIX USING  PRINCIPAL FACTOR, NO ITERATIONS




                 FACTOR  1   FACTOR  2

 FF                .14906      .97716
 AA                .04730     -.24225
 CC               -.07174     -.04740


```

```
 VARIABLE     COMMUNALITY

 FF            .97729
 AA            .77661
 CC            .76449
1FACTOR ANALYSIS                                   03/22/82  15.26.29.    PAGE    6

 FILE - NONAME   (CREATED -  03/22/82)


    QUARTIMAX ROTATED FACTOR MATRIX
 AFTER ROTATION WITH KAISER NORMALIZATION




                FACTOR  1   FACTOR  2

 FF              .03072      .98810
 AA              .87036     -.13812
 CC             -.85721     -.17229




 TRANSFORMATION MATRIX




                FACTOR  1   FACTOR  2

 FACTOR  1       .99268      .12081
 FACTOR  2      -.12081      .99268
1FACTOR ANALYSIS                                   03/22/82  15.26.29.    PAGE    7

 FILE - NONAME   (CREATED -  03/22/82)


 FACTOR SCORE COEFFICIENTS




                FACTOR  1   FACTOR  2

 FF             -.01679      .96405
 AA              .58936     -.16798
 CC             -.56078     -.13599

 ERROR NUMBER..  043. PROCESSING CEASES, ERROR SCAN CONTINUES.


 CPU TIME REQUIRED..      .0000 SECONDS




     - - - - -  ERROR SUMMARY  - - - - -




     ERROR NUMBER.. 043
     VARIABLE NAME ON SUBSEQUENT VARIABLES  LIST IS NOT
```

```
 300=OPTIONS        5
 310=STATISTICS     ALL
 320=READ INPUT DATA
..SAVE,FA1,N,O
..RN
 SUCH PROGRAM CALL NAME  -  RN
..RETURN,W1
..REWINF,SPSS,DA2,FA1
 SUCH PROGRAM CALL NAME  -  REWINF
..REWIND,SPSS,DA2,FA1
..SPSS,D=DA2,I=FAA1,LO=ABRV,L=W1,NR
 SPSS
..EDIT,W1,S
L;A
..

  100=1
 110=S
 120=                                          03/22/82  15.41.26. PAGE    1
 130=          VOGELBACK COMPUTING CENTER
 140=          NORTHWESTERN UNIVERSITY
 150=
 160=          S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
 170=
 180=          VERSION 8.0 -- JUNE 18, 1979
 190=
 200=
 210=
 220=
 230= RUN NAME       FACTOR ANALYSIS
 240= VARIABLE LIST  FTWT,FNZU,FNXM,FTOC,ATWT,ANZU,
 250=                ANXM,ATOC,CTWT,CNZU,CNXM,CTOC,
 260=                FF,AA,CC,FN,AN,CN,FM,NM,CM
 270= INPUT FORMAT   FREEFIELD
 280= INPUT MEDIUM   DISK
 290= N OF CASES     UNKNOWN
 300= COMPUTE        FF=FTWT/FTOC
 310= COMPUTE        AA=ATWT/ATOC
 320= COMPUTE        CC=CTWT/CTOC
 330= COMPUTE        FN=FNZU+FTWT
 340= COMPUTE        AN=ANZU+ATWT
 350= COMPUTE        CN=CNZU+CTWT
 360= COMPUTE        FM=FNZU/FNXM
 370= COMPUTE        NM=ANZU/ANXM
 380= COMPUTE        CM=CNZU/CNXM
 390= FACTOR         VARIABLES=FN,AN,CN,FM,NM,CM/TYPE=PA1/
 400=                ROTATE=QUARTIMAX/
 410= OPTIONS        5
 420= STATISTICS     ALL
 430= READ INPUT DATA
 440=
 450= 00053100 CM NEEDED FOR FACTOR
 460=
 470= END OF FILE ON FILE DA2
 480= AFTER READING      6 CASES FROM SUBFILE NONAME
 490=1FACTOR ANALYSIS                          03/22/82  15.41.26.    PAGE    2
 500=
 510= FILE - NONAME   (CREATED -  03/22/82)
 520=
 530=
 540= VARIABLE            MEAN     STANDARD DEV     CASES
 550=
 560= FN           24959.3750        6102.7190         6
 570= AN           17507.1000        9271.5710         6
 580= CN           53014.4000       30946.1497         6
```

FM	6.5272	2.7336	6
NM	8.6154	7.1015	6
CM	5.7010	1.8517	6

1FACTOR ANALYSIS 03/22/82 15.41.26. PAGE 3

FILE - NONAME (CREATED - 03/22/82)

CORRELATION COEFFICIENTS..

	FN	AN	CN	FM	NM
FN	1.00000	.43600	.51375	-.21144	.06217
AN	.43600	1.00000	-.03792	-.45135	.77403
CN	.51375	-.03792	1.00000	-.52386	-.06302
FM	-.21144	-.45135	-.52386	1.00000	-.70119
NM	.06217	.77403	-.06302	-.70119	1.00000
CM	.20044	-.27808	-.39962	.56038	-.43399

	CM
FN	.20044
AN	-.27808
CN	-.39982
FM	.56838
NM	-.43399
CM	1.00000

1FACTOR ANALYSIS 03/22/82 15.41.26. PAGE 4

FILE - NONAME (CREATED - 03/22/82)

VARIABLE	EST COMMUNALITY	FACTOR	EIGENVALUE	PCT	CUM PCT
FN	1.00000	1	2.79553	46.6	46.6
AN	1.00000	2	1.47425	24.6	71.2
CN	1.00000	3	1.29498	21.6	92.7
FM	1.00000	4	.37298	6.2	99.0
NM	1.00000	5	.06225	1.0	100.0
CM	1.00000	6	.00000	.0	100.0

1FACTOR ANALYSIS 03/22/82 15.41.26. PAGE 5

FILE - NONAME (CREATED - 03/22/82)

FACTOR MATRIX USING PRINCIPAL FACTOR, NO ITERATIONS

	FACTOR 1	FACTOR 2	FACTOR 3
FN	.34790	.70577	.50457
AN	.75406	-.16424	.56172
CN	.45051	.74968	-.47047
FM	-.09159	-.04903	.21299
NM	.82501	-.43043	.25461
CN	-.64663	.27041	.62554

```
VARIABLE     COMMUNALITY

FN              .99452
AN              .91232
CN              .99359
FM              .84277
NM              .93901
CM              .88256
1FACTOR ANALYSIS                                03/22/82  15.41.26.    PAGE    6

FILE - NONAME   (CREATED -  03/22/82)


    QUARTIMAX ROTATED FACTOR MATRIX
AFTER ROTATION WITH KAISER NORMALIZATION




               FACTOR  1   FACTOR  2   FACTOR  3

FN               .17585     -.14006      .97158
AN               .91629      .02940      .26810
CN              -.13973     -.89244      .42144
FM              -.60575      .68872     -.03883
NM               .95349     -.12661     -.11765
CM              -.36216      .71970      .48315




TRANSFORMATION MATRIX




               FACTOR  1   FACTOR  2   FACTOR  3

FACTOR  1        .80496     -.57935      .12002
FACTOR  2       -.40892     -.38537      .82721
FACTOR  3        .42991      .71822      .54711
1FACTOR ANALYSIS                                03/22/82  15.41.26.    PAGE    7

FILE - NONAME   (CREATED -  03/22/82)


FACTOR SCORE COEFFICIENTS




               FACTOR  1   FACTOR  2   FACTOR  3

FN               .05016      .00362      .67001
AN               .44940      .19004      .17973
CN              -.23210     -.55192      .24200
FM              -.17220      .31593      .02120
NM               .44392      .00460     -.10042
CM              -.05353      .41026      .20440
1FACTOR ANALYSIS                                03/22/82  15.41.26.    PAGE    8


```

```
1910= CPU TIME REQUIRED..      .0960 SECONDS
1920=
1930=
1940=
1950= TOTAL CPU TIME USED..      .1720 SECONDS
1960=
1970=
1980=
1990=
2000= RUN COMPLETED
2010=
2020= NUMBER OF CONTROL CARDS READ  21
2030= NUMBER OF ERRORS DETECTED      0
2040=S
2050=*EOR
..
```

```
1
S
                                                           03/22/82  15.18.55. PAGE    1
          VOGELBACK COMPUTING CENTER
          NORTHWESTERN UNIVERSITY

          S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

          VERSION 8.0 -- JUNE 18, 1979



 RUN NAME        FACTOR ANALYSIS
 VARIABLE LIST   FTWT,FNZU,FMIN,FTOC,ATWT,ANZU,
                 AMIN,ATOC,CTWT,CNZU,CMIN,CTOC,
                 FF,AA,CC,FN,AN,CN,FM,NM,CM
 INPUT FORMAT    FREEFIELD
 INPUT MEDIUM    DISK
 N OF CASES      UNKNOWN
 COMPUTE         FF=FTWT/FTOC
 COMPUTE         AA=ATWT/ATOC
 COMPUTE         CC=CTWT/CTOC
 COMPUTE         FN=FNZU*FTWT
 COMPUTE         AN=ANZU*ATWT
 COMPUTE         CN=CNZU*CTWT
 COMPUTE         FM=FNZU/FMIN
 COMPUTE         NM=ANZU/AMIN
 COMPUTE         CM=CNZU/CMIN
 FACTOR          VARIABLES=FN,AN,CN/TYPE=PA1/
                 ROTATE=QUARTIMAX/
                 VARIABLES=FF,AA,CC/TYPE=PA1/
                 ROTATE=QUARTIMAX/
                 VARIABLES=FM,NM,CM/TYPE=PA1/
                 ROTATE=QUARTIMAX/
                 VARIABLES=FN,AN,CN,FM,NM,CM/TYPE=PA1/
                 ROTATE=QUARTIMAX/
 OPTIONS         5
 STATISTICS      ALL
 READ INPUT DATA

 00053100 CM NEEDED FOR FACTOR

 END OF FILE ON FILE DA2
 AFTER READING       6 CASES FROM SUBFILE NONAME
1FACTOR ANALYSIS                                 03/22/82  15.18.55.    PAGE    2

 FILE - NONAME   (CREATED -  03/22/82)


 VARIABLE            MEAN      STANDARD DEV     CASES

 FN          24959.3750        6182.7198          6
 AN          17507.1000        9271.5718          6
 CN          53014.4000       30946.1497          6
1FACTOR ANALYSIS                                 03/22/82  15.18.55.    PAGE    3

 FILE - NONAME   (CREATED -  03/22/82)


 CORRELATION COEFFICIENTS..
```

```
                    FN         AN         CN

FN           1.00000     .43600     .51375
AN            .43600    1.00000    -.03792
CN            .51375    -.03792    1.00000
1FACTOR ANALYSIS                              03/22/82  15.10.55.    PAGE    4

 FILE - NONAME   (CREATED - 03/22/82)




 VARIABLE EST COMMUNALITY  FACTOR  EIGENVALUE  PCT  CUM PCT

 FN           1.00000        1      1.65541  55.2    55.2
 AN           1.00000        2      1.03741  34.6    89.8
 CN           1.00000        3       .30718  10.2   100.0
1FACTOR ANALYSIS                              03/22/82  15.10.55.    PAGE    5

 FILE - NONAME   (CREATED - 03/22/82)


 FACTOR MATRIX USING  PRINCIPAL FACTOR, NO ITERATIONS





                  FACTOR  1   FACTOR  2

 FN                .92228      .00938
 AN                .57363      .77688
 CN                .68976     -.65862




 VARIABLE     COMMUNALITY

 FN              .85068
 AN              .93259
 CN              .90955
1FACTOR ANALYSIS                              03/22/82  15.10.55.    PAGE    6

 FILE - NONAME   (CREATED - 03/22/82)


    QUARTIMAX ROTATED FACTOR MATRIX
 AFTER ROTATION WITH KAISER NORMALIZATION





                  FACTOR  1   FACTOR  2

 FN                .74235      .54735
 AN                .01048      .96565
 CN                .94475     -.13030




 TRANSFORMATION MATRIX


```

```
                FACTOR  1   FACTOR  2

FACTOR  1       .81086      .58523
FACTOR  2      -.58523      .81086
FACTOR ANALYSIS                                   03/22/82  15.18.55.    PAGE    7

FILE - NONAME   (CREATED -  03/22/82)


FACTOR SCORE COEFFICIENTS




                FACTOR  1   FACTOR  2

FN              .44647      .30038
AN             -.15720      .81082
CN              .70941     -.27094

ERROR NUMBER..  843. PROCESSING CEASES, ERROR SCAN CONTINUES.


CPU TIME REQUIRED..      .0860 SECONDS




     - - - - -  ERROR SUMMARY  - - - - -



     ERROR NUMBER.. 843
     VARIABLE NAME ON SUBSEQUENT VARIABLES  LIST IS NOT
     INCLUDED IN THE FIRST VARIABLES  LIST

TOTAL CPU TIME USED..      .1700 SECONDS




RUN COMPLETED

NUMBER OF CONTROL CARDS READ  27
NUMBER OF ERRORS DETECTED      1
S
..
```

```
..D,131
..L,A

 100=RUN NAME       FACTOR ANALYSIS
 110=VARIABLE LIST  FTWT,FNZU,FNIN,FTOC,ATWT,ANZU
 120=               ANIN,ATOC,CTWT,CNZU,CNIN,CTOC
 122-               FF,AA,CC,FN,AN,CN,FM,NM,CM
 140=INPUT FORMAT   FREEFIELD
 150=INPUT MEDIUM   DISK
 160=N OF CASES     UNKNOWN
 170=COMPUTE        FF=FTWT/FTOC
 180=COMPUTE        AA=ATWT/ATOC
 190=COMPUTE        CC=CTWT/CTOC
 200=COMPUTE        FN=FNZU*FTWT
 210=COMPUTE        AN=ANZU*ATWT
 220=COMPUTE        CN=CNZU*CTWT
 230=COMPUTE        FM=FNZU/FNIN
 240=COMPUTE        NM=ANZU/ANIN
 250=COMPUTE        CM=CNZU/CNIN
 260=FACTOR         VARIABLES= FTWT TO CTOC/TYPE=PA1/
 270=               ROTATE=QUARTIMAX/
 280=               VARIABLES=FN,AN,CN/TYPE=PA1/
 290=               ROTATE=QUARTIMAX/
 300=               VARIABLES=FF,AA,CC/TYPE=PA1/
 310=               ROTATE=QUARTIMAX/
 320=               VARIABLES=FM,NM,CM/TYPE=PA1/
 330=               ROTATE=QUARTIMAX/
 341=               VARIABLES=FN,AN,CN,FM,NM,CM/TYPE=PA1/
 350=               ROTATE=QUARTIMAX/
 360=OPTION         8
 370=STATISTICS     ALL
 380=READ INPUT DATA
..SAVE,FA2,N,O
..REPLACE,FA2,ID=D020
LE NAME FA2         HAS BEEN REPLACED
..EDIT,DA2,S
..L,A

 100=2404 12.75 2.4 41910 3692 4.0 1.1 73000 33712 3.75 .86 769000 0 0 0 0 0 0 0 0 0
 110=3105 9.75 2.3 56000 2100 9.75 .86 60626 14700 3.75 .5 286000 0 0 0 0 0 0 0 0 0
 120=2390 11 2.5 72566 2600 11 .54 50000 14312 3.75 .86 323100 0 0 0 0 0 0 0 0 0
 130=1456 11 2.1 33000 1703 10.5 .95 31873 11340 3.0 .88 300800 0 0 0 0 0 0 0 0 0
 140=2100 9.0 .95 25000 1072 1.05 .93 20000 8797 3.9 .54 1242400 0 0 0 0 0 0 0 0 0
 150=2631 10.5 1.0 31276 2959 7.5 1.0 62953 3729 3.9 .53 55000 0 0 0 0 0 0 0 0 0
..REWIND,SPSS,DA2,FA2
..FILES
OCAL FILES--
DA2       FA2       BCDOUT   $INPUT   $OUTPUT
SPSS
..SPSS,B=DA2,I=FA2,LO=ABRV,L=W1,NR
PSS ERRORS
..EDIT,W1,S
L,A
..

 100=1
 110=S
 120=                                          03/22/82  14.42.32. PAGE    1
 130=        VOGELBACK COMPUTING CENTER
 140=        NORTHWESTERN UNIVERSITY
 150=
 160=        S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
 170=
```

```
150=INPUT MEDIUM   DISK
160=N OF CASES     UNKNOWN
170=COMPUTE        FF=FTWT/FTOG
180=COMPUTE        AA=ATWT/ATOG
190=COMPUTE        CC=CTWT/CTOG
200=COMPUTE        FN=FNZU*FTWT
210=COMPUTE        AN=ANZU*ATWT
220=COMPUTE        CN=CNZU*CTWT
230=COMPUTE        FN=FNZU/FNIN
240=COMPUTE        NN=ANZU/ANIN
250=COMPUTE        CN=CNZU/CNIN
271=FACTOR         VARIABLES=FN,NN,CN/TYPE=PA1/
290=               ROTATE=QUARTIMAX/
300=               VARIABLES=FN,AN,CN,FN,NN,CN/TYPE=PA1/
310=               ROTATE=QUARTIMAX/
320=OPTIONS        5
330=STATISTICS     ALL
340=READ INPUT DATA
..SAVE,FA1,N,O
..RETURN,W1
..REWIND,SPSS,DA2,FA1
..SPSS,D-
D PARAMETER ON SPSS CALL
SPSS ERRORS
..SPSS,D=DA2,I=FA1,LO=ABRV,L=W1,NR
PSS ERRORS
..EDIT,W1,S
..
```

```
L,A

100=1
110=S
120=                                           03/22/82  15.34.38. PAGE    1
130=          VOGELBACK COMPUTING CENTER
140=          NORTHWESTERN UNIVERSITY
150=
160=          S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
170=
180=          VERSION 8.0 -- JUNE 18, 1979
190=
200=
210=
220=
230= RUN NAME        FACTOR ANALYSIS
240= VARIABLE LIST   FTWT,FNZU,FNIN,FTOG,ATWT,ANZU,
250=                 ANIN,ATOG,CTWT,CNZU,CNIN,CTOG,
260=                 FF,AA,CC,FN,AN,CN,FN,NN,CN
270= INPUT FORMAT    FREEFIELD
280= INPUT MEDIUM    DISK
290= N OF CASES      UNKNOWN
300= COMPUTE         FF=FTWT/FTOG
310= COMPUTE         AA=ATWT/ATOG
320= COMPUTE         CC=CTWT/CTOG
330= COMPUTE         FN=FNZU*FTWT
340= COMPUTE         AN=ANZU*ATWT
```

```
350= COMPUTE          CN=CNZU*CTWT
360= COMPUTE          FN=FNZU/FNIN
370= COMPUTE          NN=ANZU/ANIN
380= COMPUTE          CN=CNZU/CNIN
390= FACTOR           VARIABLES=FN,NN,CN/TYPE=PA1/
400=                  ROTATE=QUARTIMAX/
410=                  VARIABLES=FN,AN,CN,FN,NN,CN/TYPE=PA1/
420=                  ROTATE=QUARTIMAX/
430= OPTIONS          5
440= STATISTICS       ALL
450= READ INPUT DATA
460=
470= 00053100 CM NEEDED FOR FACTOR
480=
490= END OF FILE ON FILE DA2
500= AFTER READING      6 CASES FROM SUBFILE NONAME
510=1FACTOR ANALYSIS                                03/22/82  15.34.30.    PAGE   2
520=
530= FILE - NONAME   (CREATED -  03/22/82)
540=
550=
560= VARIABLE            MEAN     STANDARD DEV     CASES
570=
580= FN                6.5272          2.7336          6
590= NN                8.6154          7.1015          6
600= CN                5.7010          1.2517          6
610=1FACTOR ANALYSIS                                03/22/82  15.34.30.    PAGE   3
620=
630= FILE - NONAME   (CREATED -  03/22/82)
640=
650=
660= CORRELATION COEFFICIENTS..
670=
680=
690=
700=
710=                  FN          NN          CN
720=
730= FN             1.00000     -.70119      .56838
740= NN             -.70119     1.00000     -.43399
750= CN              .56838     -.43399     1.00000
760=1FACTOR ANALYSIS                                03/22/82  15.34.30.    PAGE   4
770=
780= FILE - NONAME   (CREATED -  03/22/82)
790=
800=
810=
820=
830= VARIABLE EST COMMUNALITY  FACTOR  EIGENVALUE  PCT  CUM PCT
840=
850= FN           1.00000         1       2.14271  71.4    71.4
860= NN           1.00000         2        .58267  19.4    90.8
870= CN           1.00000         3        .27462   9.2   100.0
880=1FACTOR ANALYSIS                                03/22/82  15.34.30.    PAGE   5
890=
900= FILE - NONAME   (CREATED -  03/22/82)
910=
920=
930= FACTOR MATRIX USING  PRINCIPAL FACTOR, NO ITERATIONS
940=
950=
960=
970=
980=                FACTOR  1
990=
1000= FN             .90642
```

```
 NM            -.85280
 CM             .77066




 VARIABLE     COMMUNALITY

 FM             .82159
 NM             .72255
 CM             .59858


 NUMBER OF FACTORS IS LESS THAN TWO
 PROCESSING CONTINUES BYPASSING ROTATION

1FACTOR ANALYSIS                              03/22/82  15.34.30.    PAGE    6

 FILE - NONAME   (CREATED -  03/22/82)


 FACTOR SCORE COEFFICIENTS




               FACTOR  1

 FM             .42302
 NM            -.39671
 CM             .36107

 ERROR NUMBER..  843. PROCESSING CEASES, ERROR SCAN CONTINUES.


 CPU TIME REQUIRED..      .0630 SECONDS





     - - - - -  ERROR SUMMARY  - - - - -



     ERROR NUMBER.. 843
     VARIABLE NAME ON SUBSEQUENT VARIABLES  LIST IS NOT
     INCLUDED IN THE FIRST VARIABLES  LIST

 TOTAL CPU TIME USED..      .1420 SECONDS




 RUN COMPLETED

 NUMBER OF CONTROL CARDS READ  23
 NUMBER OF ERRORS DETECTED      1
S
..
```

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. Collins, Captain Dwight E., USAF. "Analysis of Available Life Cycle Cost Models and Their Applications." Unpublished research report, unnumbered, Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost, ASD/ACL, Wright-Patterson AFB OH, June 1976.

2. Fox, J. Ronald. Arming America. Cambridge MA: Harvard University Press, 1974.

3. Gansler, Jacques S. The Defense Industry. Cambridge MA: The Massachusetts Institute of Technology Press, 1980.

4. Geese, William. Structural Engineer, Strategic Systems Program Office, Wright-Patterson AFB OH. Telephone interview conducted 28 January 1982.

5. Harnet, Donald L. Introduction to Statistical Methods. 2nd ed. Reading MA: Addison-Wesley Publishing Co., 1975.

6. Hosek, John. Price Analyst, Aeronautical Systems Division Pricing Office, Wright-Patterson AFB OH. Telephone interview conducted on 28 January 1982.

7. "Improved Cost Estimating Techniques." Unpublished technical report, LMI Task 70-18, Logistics Management Institute, Washington, December 1970. AD 738859.

8. Large, Joseph, P., Harry G. Campbell, and David Cates. "Parametric Equations for Estimating Aircraft Airframe Costs." Unpublished technical report, R-1693-1-PA&E, The Rand Corporation, Santa Monica CA, Feburary 1976. AD AO22086.

9. Levenson, G. S., H. E. Boren, Jr., D. P. Tihansky, and F. Timson. "Cost-Estimating Relationships for Aircraft Airframes." Unpublished research report, R-761-PR, The Rand Corporation, Santa Monica CA, December 1971.

10. Marks, Kenneth E., H. Garrison Massey, and Brent D. Bradley. "An Appraisal of Models Used in Life Cycle Cost Estimation for USAF Aircraft Systems." Unpublished research report, R-2287-AF, The Rand Corporation, Santa Monica CA, October 1978.

11. Menker, Lavern J. "Life Cycle Cost Analysis Guide." Unpublished cost analysis guide, unnumbered, Joint AFSC/AFLC Commanders' Working Group on Life Cycle Cost, ASD/ACL, Wright-Patterson AFB OH, June 1975.

12. Noah, J. W., J. M. Daniels, C. F. Day, and H. L. Eskew. "Estimating Aircraft Acquisition Costs by Parametric Methods." Unpublished technical report, FR-103-USN, J. Watson Noah Associates, Inc., Alexandria VA, Sepember 1973. AD 91344D.

13. Rachowitz, B. I., V. J. Pulito, and M. Izzi. "Modular Life Cycle Cost Model for Advanced Aircraft Systems Phase II (Volume I)." Unpublished technical report, AFFDL-TR-78-40, Grumman Aerospace Corporation, Bethpage NY, April 1978.

14. Sanchez, Luis R., and James A. DeiRossi. "Methods of Estimating Fixed-Wing Airframe Costs." Unpublished technical report, PRC-R-547A, Planning Research Corporation, Los Angeles, April 1967. AD 817670.

15. School of Systems and Logistics, Air Force Institute of Technology, Air University (ATC). Life Cycle Costing QMT-353. Wright-Patterson AFB OH.

16. U. S. Department of Defense. Design to Cost. DOD Directive 5000.28. Washington, Government Printing Office, 23 May 1975.

B. RELATED SOURCES

Bennett, Bruce R. "The Use of Parametric Cost Estimating Relationships as They Pertain to Aircraft Airframes; a New Perspective." Unpublished master's thesis. Unnumbered, Naval Postgraduate School, Monterey CA, March 1980. AD AO89525.

Bennett, Spencer, and David Bowers. An Introduction to Multivariate Techniques for Social and Behavioral Sciences. New York: John Wiley & Sons, 1976.

Boren, H. E., Jr. "A Computer Model for Estimating Development and Procurement Costs of Aircraft (DAPCA-III)." Unpublished technical report, R-1854-PR, The Rand Corporation, Santa Monica CA, March 1976. AD AO25276.

Carrier, J. M., and R. W. Smith. "Aircraft Airframe Cost Estimating Techniques." Unpublished technical report, RM-3375-PR, The Rand Corporation, Santa Monica CA, November 1962. AD 293863.

"Development Cost Estimating Survey." Unpublished technical report, unnumbered, Management Systems Corporation, Cambridge MA, June 1963. AD 408987.

Rachowitz, B. I., V. Pulito, and R. Penner. "Modular Life Cycle Cost Model for Advanced Aircraft Systems." Unpublished technical report, AFFDL-TR-76-123, Grumman Aerospace Corporation, Bethpage NY, October 1976.

Timson, F. S., and D. P. Tihansky. "Confidence in Estimated Airframe Costs: Uncertainty Assessment in Aggregate Predictions." Unpublished technical report, R-903-PR, The Rand Corporation, Santa Monica CA, October 1972.

MED

8