UNCLASSIFIED

AD NUMBER
AD378370
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution: Further dissemination only as directed by Director of Supersonic Transport Development, Federal Aviation Agency, Washington, DC; Sep 1966.
AUTHORITY
FAA ltr, 10 Oct 1972; FAA ltr, 10 Oct 1972

THIS PAGE IS UNCLASSIFIED

AD378370

CONFIDENTIAL

PWA FP 66-100
SEPTEMBER 1966
C28-6C 2360.

(6)

ENGINE PROPOSAL FOR PHASE III OF THE SUPERSONIC TRANSPORT DEVELOPMENT PROGRAM.

VOLUME V. MANAGEMENT AND MANUFACTURING (4) (5)

(11) Sep 66 (14) PWA-FP-66-100-Vol-5

(12) 441 p.

(15) FA-SS-66-8

DDC
RECEIVED
JAN 20 1967

(COMPETITIVE DATA)

PREPARED FOR
FEDERAL AVIATION AGENCY
OFFICE OF SUPERSONIC TRANSPORT DEVELOPMENT
WASHINGTON, D. C.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18 U. S. C., SECTIONS 793 AND 794. ITS TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

FAA SECURITY CONTROL
NO. 67216

Pratt & Whitney Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION
FLORIDA RESEARCH AND DEVELOPMENT CENTER

(401355)

DECLASSIFIED AFTER 12 YEARS. DOD DIR. 5200.10

CONFIDENTIAL

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE
ORIGINAL MAY BE SEEN IN DDC HEADQUARTERS

Printed in the United States of America

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

All distribution of this document is controlled. In addition to security requirements which apply to this document and must be met, it may be further distributed by the holder only with specific prior approval of:

Director of Supersonic Transport Development
Federal Aviation Agency
Washington, D. C. 20553

The distribution of this report is limited because it contains technology identifiable with items excluded from export by the Department of State (U. S. Export Control Act of 1949, as amended).

PAGES NOT FILMED ARE BLANK.

CONTENTS

REPORT AND SECTION		PAGE
A	MASTER PROGRAM PLAN	
I	PHILOSOPHY	VA - 1
	A. Program Management Philosophy	VA - 1
	B. Design Philosophy	VA - 2
	C. Manufacturing Philosophy	VA - 3
	D. Tooling Philosophy	VA - 4
II	DESCRIPTION OF PHASES OF THE SST PROGRAM	VA - 5
	A. Phase I and Phase II	VA - 5
	B. Transition From Phase II-C to Phase III	VA - 5
	C. Phase III	VA - 5
	D. Transition From Phase III to Phase IV	VA - 6
	E. Phase IV	VA - 6
	F. Transition From Phase IV to Phase V	VA - 7
	G. Phase V	VA - 7
III	JTF17 PROGRAM MANAGEMENT	VA - 7
	A. Organization	VA - 7
	B. Master Milestone Chart	VA - 7
	C. Cost and Schedule Control	VA - 11
IV	FRDC MANAGEMENT COMMITTEE	VA - 11
V	FAA REVIEWS	VA - 12
VI	AIRLINE REVIEW BOARD	VA - 12
VII	SUBORDINATE MANAGEMENT PLANS	VA - 13
	A. Facilities Plan	VA - 13
	B. Configuration Management Plan	VA - 13
	C. Data Management Plan	VA - 13
	D. Detail Work Plan	VA - 13
	E. Product Support Plan	VA - 14
	F. Integrated Test Plan	VA - 14
	G. Manufacturing Plan	VA - 14
	H. JTF17 Program Room	VA - 14
VIII	REPORTING TO FAA	VA - 15
	Exhibit A Descriptions of Reports to FAA	VA - 15
B	FACILITIES PROGRAM	VB - 1
I	INTRODUCTION	VB - 1
	A. Objective	VB - 1
	B. Organization and Procedures	VB - 2
	C. Status of Facilities	VB - 3
II	FACILITIES FOR PHASE III AND IV	VB - 7
	A. Office, Manufacturing, Assembly, and Inspection Facilities	VB - 7
	B. Engine and Component Test Facilities Description	VB - 10
	C. Supporting Laboratory Facilities	VB - 40
	FACILITIES FOR PHASE V	VB - 49
	A. Description of Facilities	VB - 50
	B. Modernization Program	VB - 60
	C. Expansion of Production Capacity	VB - 60
	D. Facility Requirements for the JTF17 Engine Program	VB - 61
IV	FACILITIES COST SUMMARY	VB - 65
	A. Development Facilities	VB - 104
	B. Delivery Facilities	VB - 104

CONTENTS (Continued)

REPORT AND SECTION		PAGE
C	CONFIGURATION MANAGEMENT PLAN	VC - 1
I	SCOPE AND OBJECTIVES	VC - 1
II	ORGANIZATION	VC - 5
III	BASELINE CONTROL-ENGINE DEVELOPMENT PHASE	VC - 9
	A. Development Engine Configuration	VC - 10
	B. Development Engine Accountability	VC - 15
IV	BASELINE CONTROL-ENGINE DELIVERY PHASE (PROTOTYPE AND PRODUCTION)	VC - 17
	A. Initial Delivery Engine Configuration	VC - 17
	B. Configuration Change Control Procedure	VC - 17
	C. Part and Assembly Number Control Procedures	VC - 26
	D. JTF17 Engine Changes Requiring FAA Approval	VC - 27
	E. Engineering Change Processing	VC - 28
	F. Delivery Engine Accountability	VC - 28
V	ENGINE CONFIGURATION AND AIRFRAME COMPATIBILITY	VC - 31
	A. Phase III Prototype Engine Configuration Compatibility Procedures	VC - 31
	B. Production Engine Configuration Compatibility Procedure	VC - 33
VI	SUBCONTRACT VENDOR COMPONENT CONFIGURATION CONTROL	VC - 35
	A. Delivery Engine Component Configuration	VC - 35
	B. Configuration Change Control Procedure	VC - 36
VII	JTF17 CONFIGURATION MANAGEMENT WORK PLAN	VC - 39
	A. Prepare and Issue JTF17 Engine Model and Performance Specification	VC - 39
	B. Establish JTF17 Engine Design (Prototype and Production)	VC - 39
	C. P&WA JTF17 Engine Design Review	VC - 39
	D. JTF17 Engine Engineering Design Review (Prototype and Production)	VC - 39
	E. Establish JTF17 Prototype Engine Configuration	VC - 39
	F. JTF17 Engine Mockups (Prototype and Production)	VC - 40
	G. JTF17 Engine Mockup Review (Prototype and Production)	VC - 40
	H. Control of JTF17 Prototype Engine Configuration	VC - 40
	I. Establishment of JTF17 Production Engine Configuration	VC - 40
	J. Control of JTF17 Production Engine Configuration	VC - 40
	K. Implementation of Engineering Change Control Procedures	VC - 41
	L. Airframe/Engine Configuration Coordination Meeting	VC - 41
	M. JTF17 Engine Certification Test – Pre-Test and Post-Test Reviews	VC - 41
	N. JTF17 Engine Post 100-Hour Flight Test Review	VC - 41
	O. Airframe Manufacturer Review Meetings	VC - 41
D	DATA MANAGEMENT PLAN	VD - 1
I	OBJECTIVE	VD - 1
II	ORGANIZATION	VD - 1
	A. Functions and Responsibility	VD - 2
	B. Relationship to Chief, Data Management	VD - 2
III	DATA CENTER OPERATION	VD - 3
IV	LIBRARY	VD - 6

CONTENTS (Continued)

REPORT AND SECTION		PAGE
V	DATA REQUIREMENTS DOCUMENT	VD - 7
	A. Reporting to the FAA	VD -
VI	DATA LIST	VD - 9
VII	DATA ACCESSION LIST	VD - 9
	Appendix A Data Requirements Document	VD - 10
	Appendix B Airframe Contractor Data	VD - 18
E	SUBCONTRACTING PROGRAM	
I	INTRODUCTION	VE - 1
II	ORGANIZATION	VE - 1
III	PURCHASING PRODUCT MATERIAL	VE - 2
	A. Product Assurance in Purchased Material	VE - 3
	B. Ensuring On-Schedule Procurement	VE - 3
	C. Selection of Type of Contract	VE - 3
	D. Vendor Selection	VE - 4
	E. Value Analysis in Purchasing	VE - 4
	F. Special Patent Provisions and Data Rights Provisions	VE - 4
IV	MAKE-OR-BUY DECISIONS	VE - 5
F	COST AND SCHEDULE CONTROL PROGRAM	
I	INTRODUCTION	VF - 1
II	COST PLANNING AND CONTROL SYSTEM	VF - 3
	A. Organization and Responsibilities	VF - 3
	B. Program Objectives	VF - 3
	C. Developing Cost Estimates	VF - 5
	D. Initiation of the Program	VF - 6
	E. Cost Segregation and Budget Determination	VF - 7
	F. Cost Collection System	VF - 9
	G. Cost Reporting and Control	VF - 13
	H. Summary	VF - 19
III	SCHEDULE PLANNING AND CONTROL SYSTEM	VF - 21
	A. Method of Operating and Organization Responsibilities Part/Time	21
	B. System Implementation	VF - 21
	C. System Functions and Capabilities	VF - 21
	D. Part Organization	VF - 23
	E. Part Experience	VF - 25
	F. Additional Schedule Plans and Controls	VF - 25
G	MANUFACTURING PROGRAM	
I	OBJECTIVES	VG - 1
II	MAJOR MILESTONES	VG - 3
III	MAJOR RESPONSIBILITIES	VG - 9
	A. Florida Research and Development Center	VG - 9
	B. Connecticut Operations	VG - 9
IV	MANUFACTURING ORGANIZATIONS AND GENERAL FACILITIES	VG - 11
	A. FRDC Development	VG - 11
	B. FRDC Manufacturing Organization for Phase III Prototype Delivery	VG - 23

go to page VI

CONTENTS (Continued)

REPORT AND SECTION		PAGE
	C. FRDC Manufacturing Organization for Phases III and IV Product Support	VG - 23
	D. Connecticut Operations Manufacturing Organization, Phase V	VG - 24
V	PRODUCTION CONTROL, MATERIALS CONTROL AND PROCUREMENT	VG - 35
	A. Production Control at FRDC (Phases III, IV and V)	VG - 35
	B. Materials Control at FRDC	VG - 40
	C. Production Control, Connecticut Operations	VG - 41
	D. Material Control, Connecticut Operations	VG - 45
	E. Procurement, FRDC and Connecticut Operations	VG - 46
VI	PLANS FOR MEETING MANUFACTURING MILESTONES	VG - 47
	A. Development	VG - 47
	B. Pre-PTS and Prototype Delivery	VG - 49
	C. Product Support at FRDC	VG - 50
	D. Production – Phase V	VG - 51
VII	PRODUCIBILITY	VG - 53
	A. General	VG - 53
	B. Producibility Prior to Design Release	VG - 53
	C. Producibility Achieved After Drawing Release	VG - 54
	D. Producibility – Materials, Processes, and Advanced Technology	VG - 55
	E. Producibility – Equipment	VG - 55
VIII	MANUFACTURING RESEARCH AND DEVELOPMENT OF NEW TECHNIQUES	VG - 57
IX	SUBCONTRACTOR REQUIREMENTS IN SUPPORT OF THE PROTOTYPE AND PRODUCTION PROGRAM COMPONENT PROCUREMENT	VG - 59
	A. Vendor Selection of Subcontractor – Developed Components	VG - 59
	B. Scheduling of Subcontractor – Developed Components	VG - 59
	C. Configuration Control of Subcontractor Designed Components	VG - 59
	D. Other Engine Hardware Subcontracted	VG - 59
	E. Subcontractor Requirements	VG - 60
X	TOOLING	VG - 61
	A. Tooling Philosophy	VG - 61
	B. Development Construction Tooling	VG - 61
	C. Prototype Construction Tooling	VG - 63
	D. Production, Phase V, Tooling	VG - 65
	E. Tool Data Section	VG - 67
	F. Inspection Gages	VG - 72
XI	MATERIAL FLOW	VG - 75
	A. Shop Areas – Florida Research and Development Center	VG - 75
	B. Engine Assembly – Florida Research and Development Center	VG - 75
	C. Shop Areas – Connecticut Operations	VG - 75
	D. Engine Assembly – Connecticut Operations	VG - 77
	E. Engine Test – Connecticut Operations	VG - 77
	Appendix A Manufacturing Facilities and Techniques	VG - 79

CONTENTS (Continued)

REPORT AND SECTION			PAGE
H	DETAIL WORK PLAN		VH - 1
I	ORGANIZATION		
	I	INTRODUCTION	VI - 1
	II	ORGANIZATION – FLORIDA RESEARCH AND DEVELOPMENT CENTER	VI - 5
	III	JTF17 PROGRAM MANAGEMENT	VI - 11
	IV	COMMUNICATIONS	VI - 35
	V	SUPPORTING FUNCTIONS	VI - 37
		Appendix A Selected SST Personnel Summary	VI - 39
		Appendix B Design and Development Personnel	VI - 43
		Appendix C Work Breakdown Structure vs Functional Responsibility	VI - 47
J	RESOURCES		
	I	INTRODUCTION	VJ - 1
	II	DEVELOPMENT (FRDC)	VJ - 1
		A. Manpower Requirements (Total)	VJ - 3
		B. Technical Manpower	VJ - 3
		C. Hourly and Nontechnical Salary Manpower	VJ - 4
		D. Employee Skills Training	VJ - 6
		E. Plant Capacity and Facilities	VJ - 7
	III	PRODUCTION (EAST HARTFORD)	VJ - 11
		A. Manpower	VJ - 11
		B. Production Capacity	VJ - 16
		C. Facilities Requirements	VJ - 16
K	COMPANY COMPETENCE		
	I	SUMMARY	VK - 1
		A. Commercial Experience	VK - 1
		B. Supersonic Cruise Experience	VK - 1
		C. Military Gas Turbine Experience	VK - 1
		D. Aircraft Powerplant Resources	VK - 2
		E. Record in Meeting Commitments	VK - 2
		F. Financial Capability	VK - 2
	II	SUPPORTING DOCUMENTATION	VK - 5
		A. Commercial Experience	VK - 5
		B. Supersonic Cruise Experience	VK - 17
		C. Military Gas Turbine Experience	VK - 22
		D. Aircraft Powerplant Resources	VK - 28
		E. Record in Meeting Commitments	VK - 33
		F. Financial Capability	VK - 44

REPORT A
MASTER PROGRAM PLAN

SECTION I
PHILOSOPHY

A. PROGRAM MANAGEMENT PHILOSOPHY

Pratt & Whitney Aircraft's management philosophy for the SST Program will be responsive to the vital interests of the airlines, who must find the United States Supersonic Transport a safe, reliable, and economically attractive addition to their fleets; the airframe contractor, who must assume systems responsibility for the major goals of the program; and the Federal Aviation Agency, who by reason of commitment of large government appropriations, must be concerned with program decisions involving contract cost, certain critical performance criteria, and key program milestones.

The JTF17 Program Management will direct the design and development effort to meet contract requirements. The Engine Model Specification requirements are stated primarily as performance levels so that the program management may exercise complete control over the design, development, and support elements of the program. In conducting the program to obtain the required performance levels, Program Management will have the responsibility for the control of costs and schedules.

In recognition of the airlines' role, Pratt & Whitney Aircraft will encourage the airlines to state their desires throughout the SST design, development, and production phases so that configuration decisions in particular will be influenced by the airlines to the maximum practical degree. In addition to the traditional P&WA/airline contacts, the airlines will be asked to participate formally in program reviews for the purpose of influencing the design, safety, reliability, maintainability, and performance aspects of the program. It is contemplated that airline cooperation will make the airline industry committees an important and effective voice for the SST program. Accordingly, the contribution of these committees will be actively sought.

In recognition of the airframe contractor's role, P&WA has negotiated an SST Airframe/Engine Compatibility Agreement with the airframe contractor which sets forth the coordinated engine/airframe interface plan. The agreement recognizes that the airframe contractor will have total system responsibility and defines the division of responsibilities for Phase III, including cost responsibility. In implementing the Compatibility Agreement, Program Management will strive to see that no element of necessary work is overlooked and that minimum duplication of effort exists between the airframe contractor and P&WA. Program Management will also initiate additional elements of work beyond those called for by the negotiated agreements whenever such work provides increased assurance of achieving SST system performance requirements or permits the attainment of higher SST system performance goals. These additional elements of work will be coordinated with the airframe contractor.

In recognition of the Government's role, P&WA will provide the FAA with overall visibility into the Phase III effort with a series of manage-

ment and product assurance plans. P&WA will submit proposed changes affecting major performance criteria (Category I changes) to the FAA for approval and will also describe for the FAA all other changes (Category II changes) as part of the product configuration control for which P&WA assumes complete responsibility. P&WA will submit for approval all program changes affecting contract cost and schedules and will also describe for the FAA other detail cost and schedule activity as part of the program cost and schedule control for which P&WA assumes complete responsibility.

The Program Manager is responsible for the implementation and management of the Phase III SST Program, as described in the program plans. The Program Manager will have responsibility for updating the program plans or generating new plans to meet changing program requirements. Copies of updated plans will be supplied to the FAA in accordance with the Data List of the Data Management Plan (See Volume V, Report D).

B. DESIGN PHILOSOPHY

The JTF17 engine design completed in Phase II-C has evolved from the firm base of Pratt & Whitney Aircraft's experience in high Mach number flight and commercial airline service. The design will meet the objectives of providing a safe, reliable, and economically attractive powerplant with maximum noise control. The same objectives will guide the continuing design efforts of Phase III and the follow-on phases.

The design objectives, as well as the design requirements, criteria, and approach (described in detail in Volume III of this proposal), reflect Pratt & Whitney Aircraft's experience in both commercial airline service, and in military operation at Mach 3 and above. Current programs including the TF30 engine for the F-111 and the JT9D engine for the Boeing 747, which are in development, and the J58 engine for the SR-71 will provide, in the period prior to certification of the JTF17 engine for commercial service, additional operating experience which, in terms of engine flight hours, will exceed P&WA's industry-leading total as of this date. Program Management will make use of this constantly growing reservoir of experience to refine the engine design during the development period.

P&WA design philosophy may be expressed as a requirement to "design for production." This requirement demands that, from the outset, prototype (FTS) engine design must meet production engine standards of safety, reliability, maintainability, and value. It has been recognized that in the very early stages of design, the design objectives and major design decisions can themselves limit the inherent safety, reliability, maintainability, performance, and noise control which can be achieved for a given state-of-the-art. The detail design choices have been based upon a background of experience which indicates the JTF17 design will achieve the performance objectives, minimize cost, and provide for essential engine growth. Changes in the design dictated by the Phase III development program will be evaluated in keeping with this philosophy.

Wherever practical, the JTF17 engine design makes use of component configurations, maintenance and overhaul concepts, and materials with which the airlines are familiar. Thus, design standards for common types

of parts have been established based on previous experience. When a new approach was required, it was carefully reviewed by technical experts for basic feasibility, analyzed for potential failure modes, subjected to special feasibility testing and value engineering considerations.

Because of the importance of previous experience in the conception and layout of new designs and to provide the necessary standardization and control during all phases of design, it is P&WA's policy to provide a complete in-house design capability. The design capability consists of a comprehensive team of engineers, draftsmen, and design specialists capable in all aspects of engine design and analysis. The members of the FRDC design group are experienced in high temperature engine design, have worked together as a team, and understand the requirements of both experimental and production programs.

C. MANUFACTURING PHILOSOPHY

The P&WA manufacturing philosophy recognizes that manufacturing quality requirements for engine parts must keep pace with the increasing performance requirements of advanced systems. Thus the heart of P&WA's manufacturing capability lies in the range and variety of production operations, in demanding quality assurance standards, and in the existing and proven procedures to control the simultaneous production of many engine models and associated spare parts.

P&WA recognizes three requisites to the production of quality commercial powerplants. The first is an experienced, skilled, and ably supervised work force. The second is modern and versatile machine tools and facilities. The third is a dynamic organization for the continual development and application of advanced manufacturing methods. (The facilities and manufacturing capability are further described in Volume V, Reports B and G. See also Manufacturing, S-996, dated June, 1966.)

P&WA has developed and will continue to use for the SST production program a part- and process-oriented manufacturing organization. Under this policy, similar parts, such as discs for all engine models, are assigned to the same work area within the Production Department. The facilities for specialized processes, such as heat treat or plating, are also centralized in a single work area. This organization has the ability to organize and retain specialized skills and know-how, thereby providing economy and flexibility in operation and permitting the implementation of additional engine programs without extensive facility reorganization.

Production of the ground test and prototype (FTS) engines for the Phase III flight test program will be accomplished by the Florida Research and Development Center (FRDC). The Center's manufacturing team has qualified for the SST effort as a result of experience on the J58 supersonic turbine engine and in the Phase II-C demonstration engine program. FRDC and its subcontractors have experience in all phases of manufacturing and

overhaul support of flight test engines.

Connecticut operations will phase in, as it has on other engine programs undertaken at FRDC, and will manufacture, acceptance test, and deliver the later Phase V production engines. In these later phases, the JTF17 Production Manager under the direction of the JTF17 Program Manager will have the responsibility for meeting the engine and spares production schedules. This type of Production Manager organization offers the advantage of utilizing an established and functioning production control system while at the same time providing the emphasis, direct control, and time saving communication inherent in a program-oriented system. P&WA has successfully used this system on the J58 and RL10 engine programs. The program management and engineering development of both these engines was conducted at FRDC, with production at the Connecticut operations.

Pratt & Whitney Aircraft will continue to encourage and support a strong subcontractor base for manufacturing of development and production engine parts. Make or Buy decisions will be based on optimum value as the fundamental consideration. The determination of optimum value is based on consideration of quality, schedule, and cost.

D. TOOLING PHILOSOPHY

The philosophy guiding the selection of manufacturing processes and the design of tooling at P&WA is directed toward providing the optimum trade-off between labor costs and tooling costs. The selection of tooling is based on anticipated rates of production and is modified to reflect risks of obsolescence due to changes in part design or changes in process. To provide the flexibility necessary during development, minimum tooling and semi-production methods utilizing universal machines are used for parts having a high probability of change. Refined tooling is provided for parts for which the design has stabilized or when justified by production volume. Tooling procured during Phase III of the SST Program will generally be of minimum sophistication in view of the limited procurement planned for the prototype engines and in anticipation of the need for rapid incorporation of development changes.

P&WA maintains, as a matter of policy, the capability of designing, fabricating, and maintaining all types of nonproprietary special tooling required for fabrication of engine parts. These facilities are used to provide urgently needed tooling, help tools, master models, and complex tools that subcontractors do not have the capability of making. Subcontractors provide most of the balance of the tooling requirements. Maintenance of a broad subcontractor base for both design and fabrication of tooling allows a wide distribution of peak loads and provides the basis for competitive bids. Traditionally, 60% of tool design and 50% of tool fabrication and maintenance have been subcontracted. The tool "make or buy" decision will be based on an evaluation of tool room work load, tool complexity, schedule requirements, and cost.

SECTION II
DESCRIPTION OF PHASES OF THE SST PROGRAM

A. PHASE I AND PHASE II

Phase I, the initial Proposal Phase, and Phase II, the Competitive Design Phase, have culminated in Phase II-C in which the competing engine manufacturers initiated a development test program that will accumulate a minimum of 100 test hours by December 31, 1966. As part of the effort in Phase II-C, the engine contractors have submitted definitive proposals for Phase III.

B. TRANSITION FROM PHASE II-C TO PHASE III

Following evaluation by the government and the airlines, the FAA will award Phase III contracts to the selected contractors by January 1, 1967. It is anticipated that the FAA will have also accepted the contractor's proposals for the procurement of certain long lead time items and will have provided funds by September 30, 19[illegible]. The basic program schedule in P&WA's Phase III proposal is predicated on these government actions.

C. PHASE III

In Phase III, the Prototype Construction and Flight Test Phase, the airframe manufacturer will complete his detail design and construct two pre-production prototype aircraft and fly these aircraft for a minimum of 100 hours of flight test. P&WA will perform the work as specifically defined in the Work Statement of the Phase III contract. This work will include effort generally in accordance with the following summary.

1. Perform design, manufacture, assembly, and test of development engines leading to the completion of the FTS test
2. Conduct a comprehensive component test program in support of the engine development program
3. Manufacture and deliver the required number of ground test and flight test engines and support the engines through the SST prototype aircraft 100-hour flight test program
4. Provide a firm set of production specifications with the warrantees and guarantees to be offered to airline customers and establish a firm schedule for the delivery of certificated production engines
5. Prepare a proposal for the follow-on program.

Though defined as a distinct segment of the SST Program for contracting purposes, Phase III is recognized as an integral element of a continuous development process by which a United States SST can be type-certificated for passenger service in the 1974 time period. Accordingly, in addition to FTS completion, P&WA's Phase III development program will demonstrate engine performance and durability characteristics such as to give reasonable assurance of the successful completion of the Engine Type Certification requirements in Phase IV.

D. TRANSITION FROM PHASE III TO PHASE IV

As part of its Phase III effort, P&WA will provide to the airframe contractor a firm Engine Model Specification including guarantees for the production engine and a firm schedule for certificated production engine deliveries and will propose to the airlines a firm set of warrantees for the production engines in initial commercial operation. The timing for providing the specifications and schedules will be coordinated with the airframe contractor who will be providing specifications and schedules for the SST airplane as part of his total system responsibility.

Phase III will end when the airframe contractor has completed a minimum of 100 hours of flight test and such specific demonstrations as will be defined in his Phase III contract on the two prototype aircraft. P&WA will have previously completed an FTS and delivered FTS engines and spares support to the airframe contractor.

The initiation of a firm Phase IV Program will require that certain events be accomplished in addition to the planned activities noted above for Phase III. The following must be accomplished:

1. P&WA and the airframe contractor must, not later than 24 months prior to the programmed completion date of Phase III, propose financial plans applicable to the future phases of the SST Program for government approval.
2. The Government must negotiate and give its approval, not to be unreasonably withheld or delayed, to a firm financial plan for Phase IV.
3. The airframe contractor must make a firm proposal to the airlines for the sale of SST aircraft.
4. The airlines must place firm orders for SST aircraft including the necessary installation and spare engines with the manufacturers.

Since the initiation of Phase IV will be dependent on major decisions and subsequent implementing actions by the government, the airframe contractor, and the airlines, P&WA cannot implement its Phase IV program independently. Careful coordination between the Government, the contractors, and the airlines will be required to protect the estimated Phase IV engine certification date which is predicted on the initiation of Phase IV design and long lead time procurement activities 12 months prior to the programmed completion date for Phase III.

E. PHASE IV

In Phase IV, the Production Development and Certification Phase, the airframe manufacturer will continue flight testing the prototype aircraft, initiate major structural tests of the production design, refine the aircraft design to incorporate improvements and/or changes as required for production aircraft, construct aircraft to the production design, conduct flight tests and obtain type certification. Pratt & Whitney Aircraft will continue development of the JTF17 engine as a commercial airline engine, refine the engine design to incorporate improvements and/or changes as required for the production aircraft, obtain type certification of the

production engine, and support the production aircraft flight test program through aircraft type certification. Pratt & Whitney Aircraft will also support the flight test program conducted by the airframe contractor on the prototype aircraft which will initially utilize FTS engines furnished under the Phase III contract, but which may ultimately require production engines.

F. TRANSITION FROM PHASE IV TO PHASE V

Phase IV will end when the airframe contractor obtains type certification for the production SST airplane. Phase V will already have been initiated by Pratt & Whitney Aircraft as necessary to provide certificated production engines for the airframe contractors certification flight test program and early production. Providing financial plans negotiated during Phase III are complete with regard to financial support and recoupment provisions, and the airlines have made firm commitments which offer reasonable assurance of a successful program, no action will be required by the Government to initiate Phase V.

G. PHASE V

It is expected that Phase V, the Production Phase, will correspond in all respects to a normal commercial program. Pratt & Whitney Aircraft will initiate production of JTF17 engines to be delivered to the airframe contractor for installation in production airplanes and to the customer airlines for spares. Spares parts production and other commercial airline support activities, including training and provisioning will be fully activated.

Pratt & Whitney Aircraft will conduct a vigorous post certification development program which commercial experience has shown is essential to assure the extension of major inspection periods, TBO periods, and engine parts life. These extensions are required if the SST is to achieve its optimum earning potential.

SECTION III
JTF17 PROGRAM MANAGEMENT

A. ORGANIZATION

The P&WA Program Management for the JTF17 Phase III development program is shown in figure 1. The Program Manager has overall responsibility for the design, development, manufacturing, and product support of the engine and for meeting cost, schedule, and performance requirements. The Program Management organization is staffed by experienced personnel selected for both their management and technical abilities. (The organization is described with resume's of key personnel in Volume V, Report I.)

B. MASTER MILESTONE CHART (See figures 2 and 3.)

The master milestone chart displays the schedule for the major events and program effort during Phase III. Overall visibility is provided by including the major program events which will occur in Phases IV and V. This is in recognition of the continuous nature of the development program as described in Paragraph B of this plan.

JTF17 Program Management

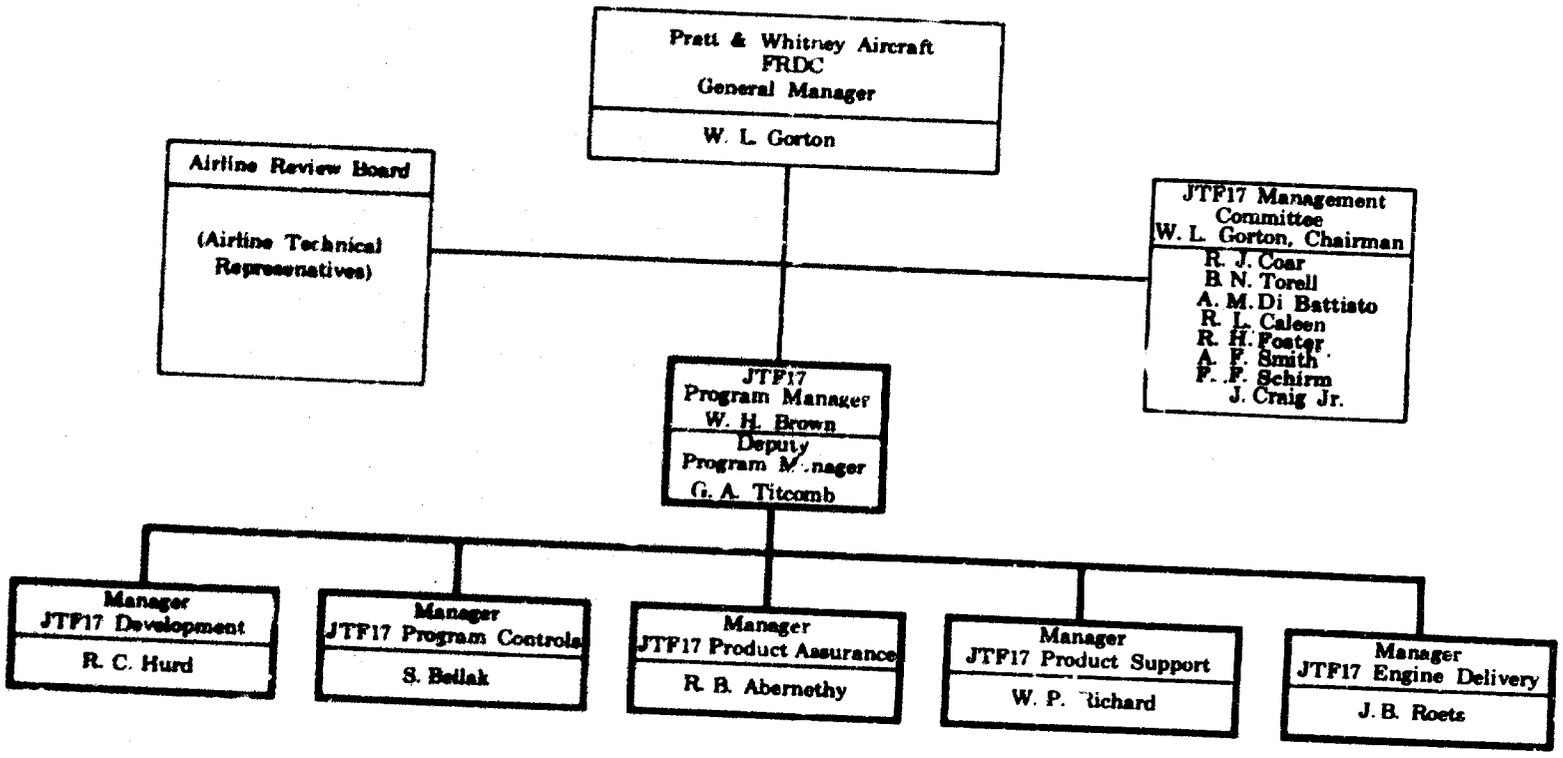
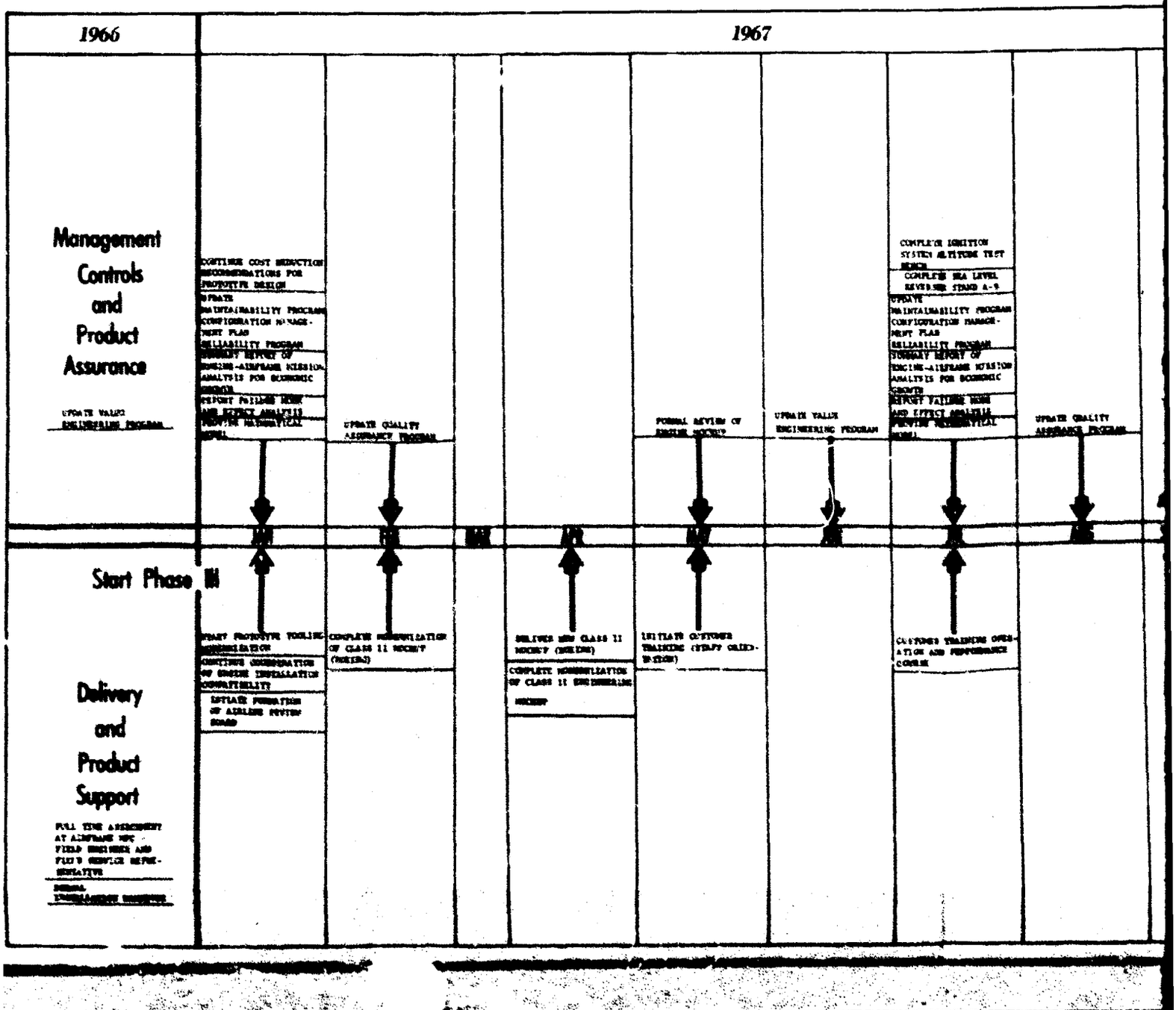
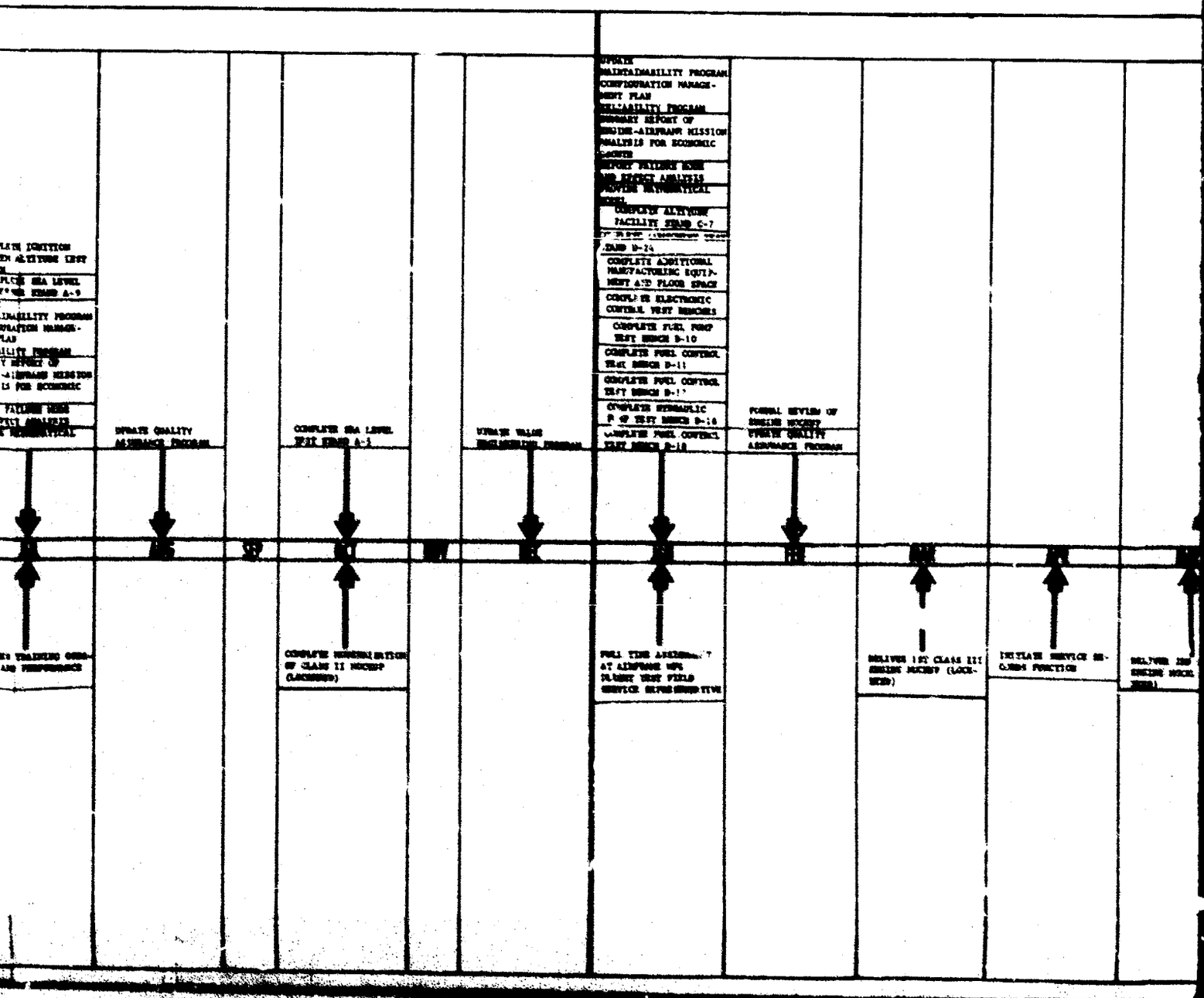


Figure 1.

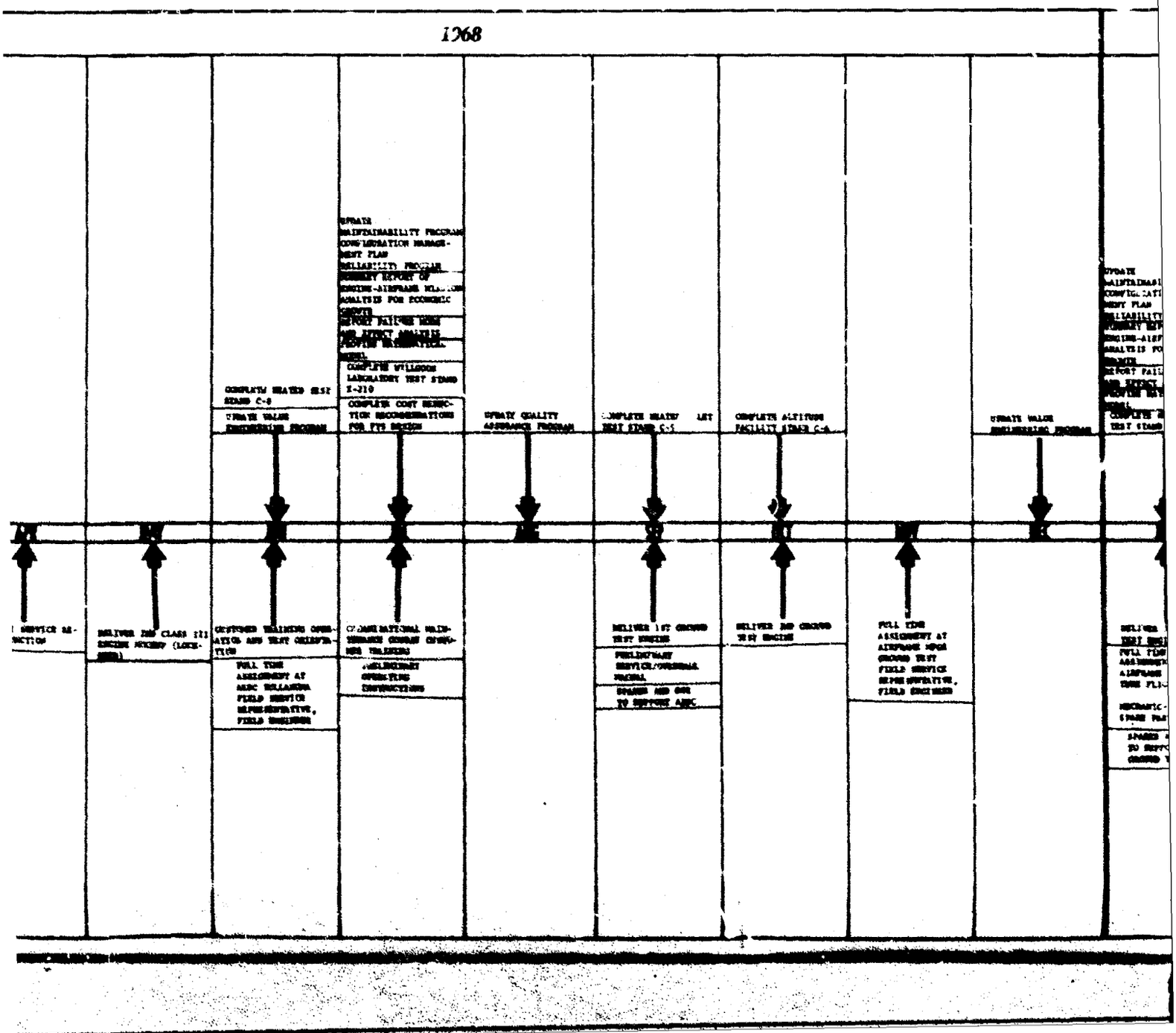

1966
1967
Management Controls and Product Assurance
UPDATE VALUE ENGINEERING PROGRAM
CONTINUE COST REDUCTION RECOMMENDATIONS FOR PRODUCTIVE DESIGN
UPDATE MAINTAINABILITY PROGRAM
CONFIGURATION MANAGEMENT PLAN
RELIABILITY PROGRAM
SUMMARY REPORT OF ENGINE-AIRFRAME MISSION ANALYSIS FOR ECONOMIC GROWTH
REPORT FAILURE MODE AND EFFECT ANALYSIS PRODUCTIVE MECHANICAL MODEL
UPDATE QUALITY ASSURANCE PROGRAM
FORMAL REVIEW OF ENGINE MOCKUP
UPDATE VALUE ENGINEERING PROGRAM
COMPLETE IGNITION SYSTEM ALTITUDE TEST BENCH
COMPLETE SEA LEVEL REVERSER STAND A-5
UPDATE MAINTAINABILITY PROGRAM
CONFIGURATION MANAGEMENT PLAN
RELIABILITY PROGRAM
SUMMARY REPORT OF ENGINE-AIRFRAME MISSION ANALYSIS FOR ECONOMIC GROWTH
REPORT FAILURE MODE AND EFFECT ANALYSIS PRODUCTIVE MECHANICAL MODEL
UPDATE QUALITY ASSURANCE PROGRAM
Start Phase III
Delivery and Product Support
FULL TIME ASSIGNMENT AT AIRFRAME MFG. FIELD ENGINEER AND FIELD SERVICE REPRESENTATIVE
SPARE ENGINEERING SUPPORT
START PRODUCTIVE TOOLING
CONTINUE INCORPORATION OF ENGINE INSTALLATION COMPATIBILITY
INITIATE FORMATION OF AIRLINE USERS BOARD
COMPLETE NOMENCLATURE OF CLASS II MOCK/T (PHASE2)
DELIVER NEW CLASS II MOCK/T (ENGINE)
COMPLETE NOMENCLATURE OF CLASS II ENGINEERING MOCKUP
INITIATE CUSTOMER TRAINING (STAFF ORIENTATION)
CUSTOMER TRAINING OPERATION AND PERFORMANCE COURSE

MANAGEMENT MASTER MILE

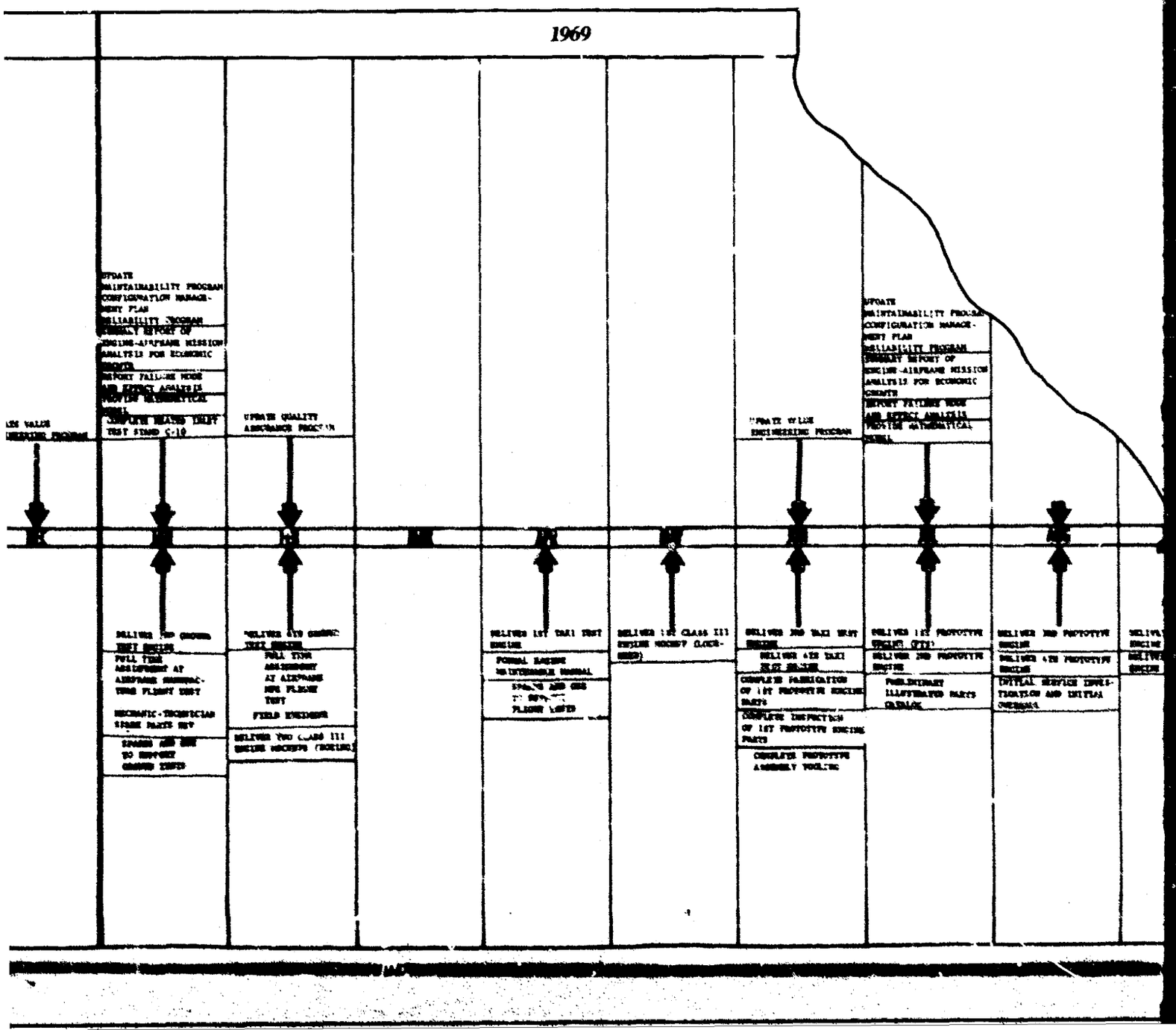


3

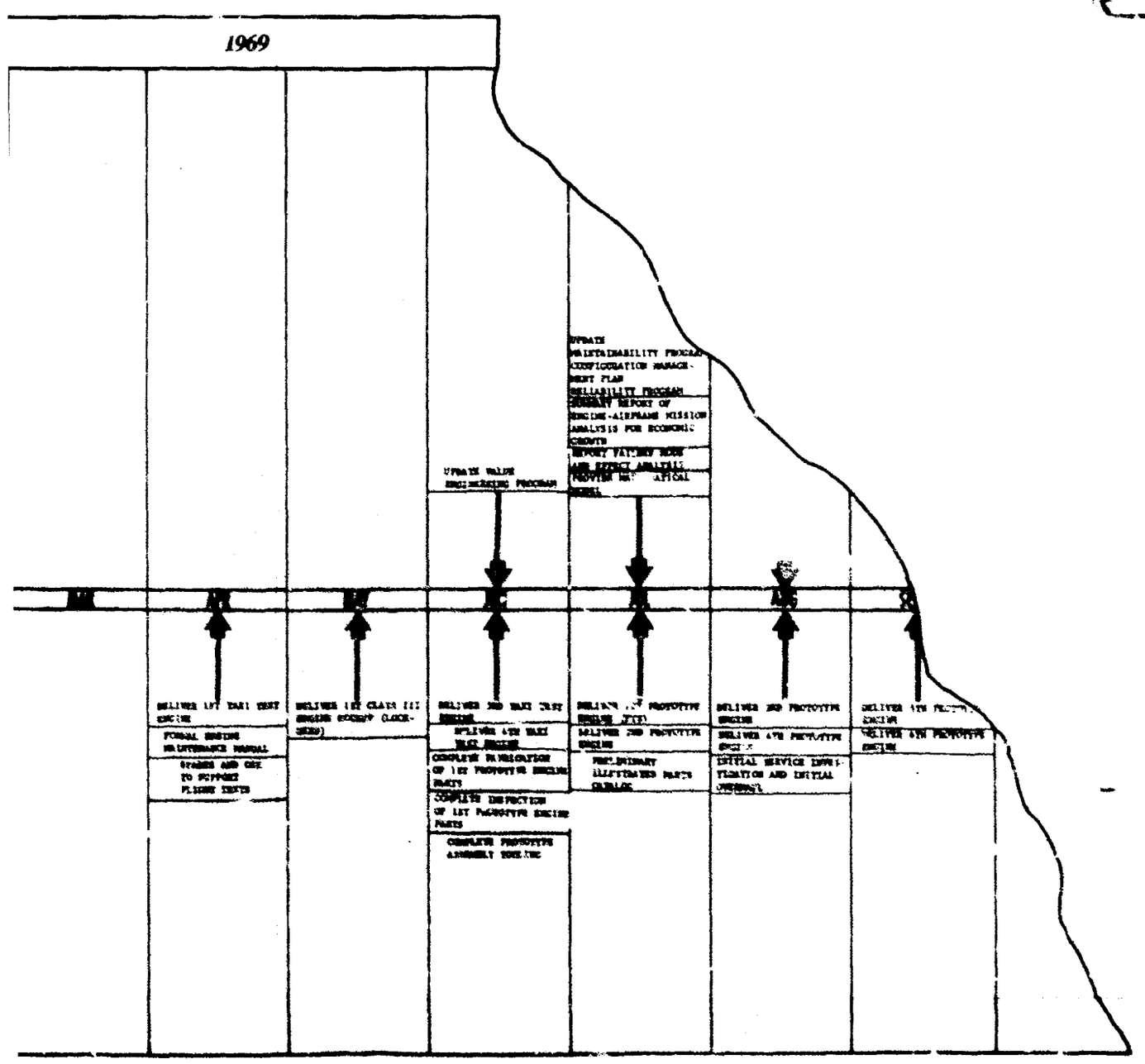
MASTER MILESTONE CHART

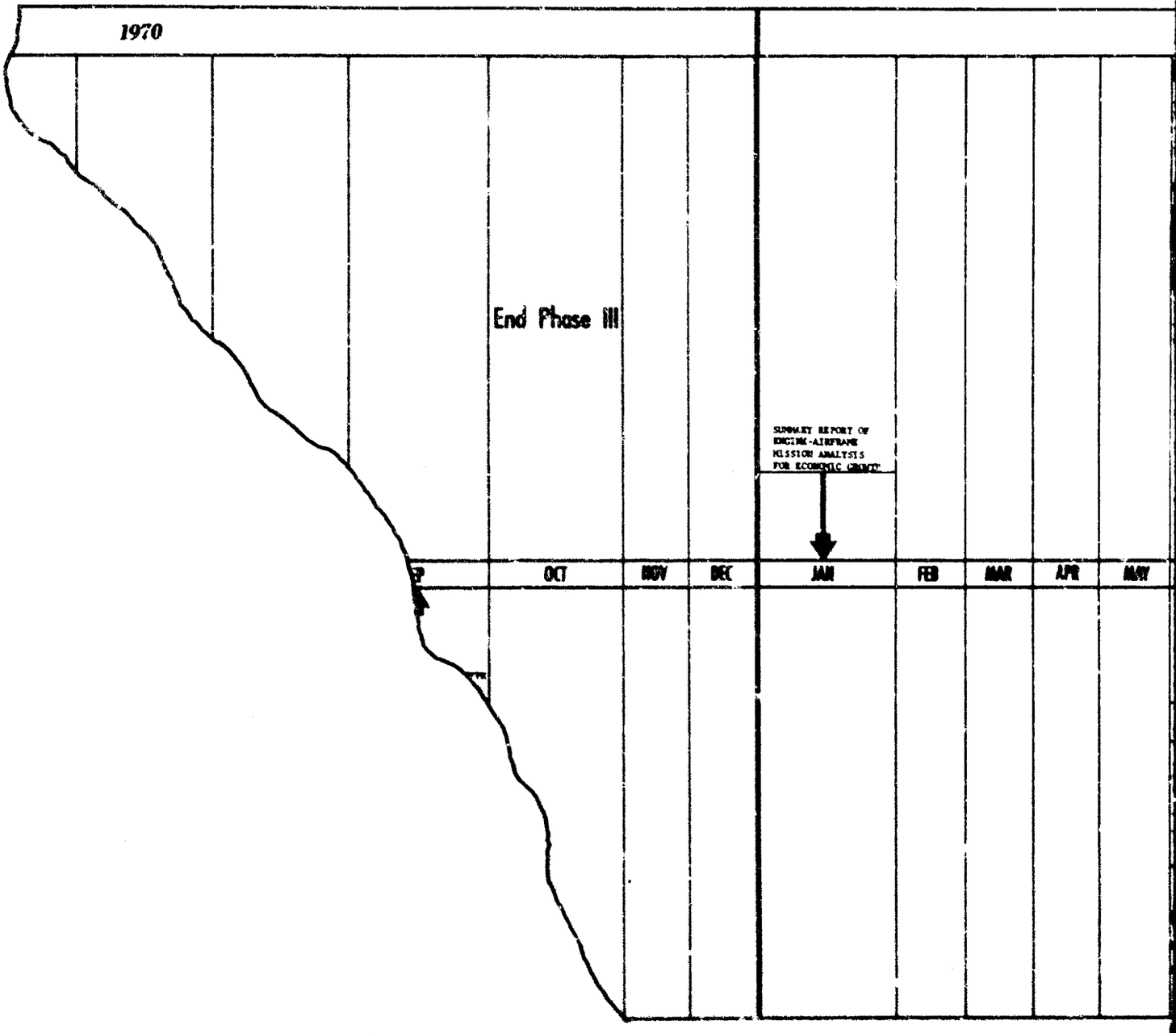


4


1969
UPDATE MAINTAINABILITY PROGRAM
CONFIGURATION MANAGEMENT PLAN
UPDATE QUALITY ASSURANCE PROGRAM
UPDATE WORK ENGINEERING PROGRAM
UPDATE MAINTAINABILITY PROGRAM
CONFIGURATION MANAGEMENT PLAN
FULL TIME ASSIGNMENT AT AIRFRAME
FIELD ENGINEER
FORMAL ENGINE MAINTENANCE MANUAL
PRELIMINARY ILLUSTRATED PARTS CATALOG
INITIAL SERVICE INVESTIGATION AND INITIAL OVERHAUL

5


1969
UPDATE
MAINTAINABILITY PROGRAM
CONFIGURATION MANAGEMENT PLAN
RELIABILITY PROGRAM
UPDATE VALUE ENGINEERING PROGRAM
DELIVER 1ST CLASS III ENGINE ASSEMBLY (LOCKHEED)
DELIVER 1ST FLIGHT TEST ENGINE
FORMAL ENGINE MAINTENANCE MANUAL
DELIVER 2ND FLIGHT TEST ENGINE
DELIVER 4TH FLIGHT TEST ENGINE
COMPLETE INVESTIGATION OF 1ST PROTOTYPE ENGINE PARTS
COMPLETE INSPECTION OF 1ST PROTOTYPE ENGINE PARTS
COMPLETE PROTOTYPE ASSEMBLY ENGINE
DELIVER 2ND PROTOTYPE ENGINE
DELIVER 4TH PROTOTYPE ENGINE
PRELIMINARY ILLUSTRATED PARTS CATALOG
DELIVER 2ND PROTOTYPE ENGINE
DELIVER 4TH PROTOTYPE ENGINE
INITIAL SERVICE INVESTIGATION AND INITIAL
DELIVER 4TH PROTOTYPE ENGINE


1970
End Phase III
SUMMARY REPORT OF
ENGINE-AIRFRAME
MISSION ANALYSIS
FOR ECONOMIC GROWTH
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY

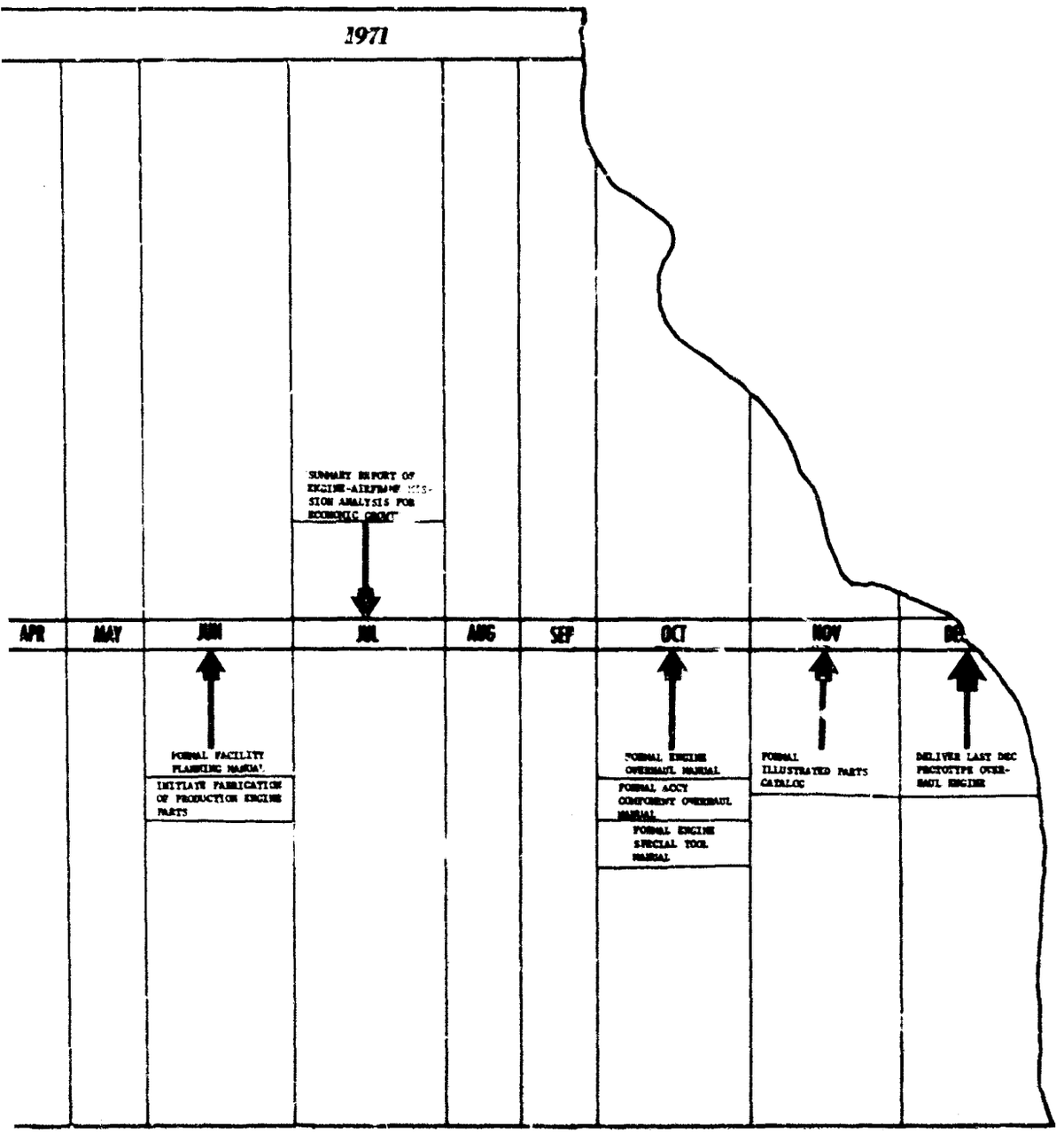

1971
SUMMARY REPORT OF ENGINE-AIRFRAME MISSION ANALYSIS FOR ECONOMIC CHOICE
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
FORMAL FACILITY PLANNING MANUAL
INITIATE FABRICATION OF PRODUCTION ENGINE PARTS
FORMAL ENGINE OVERHAUL MANUAL
FORMAL ACCY COMPONENT OVERHAUL MANUAL
FORMAL ENGINE SPECIAL TOOL MANUAL
FORMAL ILLUSTRATED PARTS CATALOG
DELIVER LAST DEC PROTOTYPE OVERHAUL ENGINE

Figure 3

662608
FD 17895

VA-9

production engine, and support the production aircraft flight test program through aircraft type certification. Pratt & Whitney Aircraft will also support the flight test program conducted by the airframe contractor on the prototype aircraft which will initially utilize FTS engines furnished under the Phase III contract, but which may ultimately require production engines.

F. TRANSITION FROM PHASE IV TO PHASE V

Phase IV will end when the airframe contractor obtains type certification for the production SST airplane. Phase V will already have been initiated by Pratt & Whitney Aircraft as necessary to provide certificated production engines for the airframe contractors certification flight test program and early production. Providing financial plans negotiated during Phase III are complete with regard to financial support and recoupment provisions, and the airlines have made firm commitments which offer reasonable assurance of a successful program, no action will be required by the Government to initiate Phase V.

G. PHASE V

It is expected that Phase V, the Production Phase, will correspond in all respects to a normal commercial program. Pratt & Whitney Aircraft will initiate production of JTF17 engines to be delivered to the airframe contractor for installation in production airplanes and to the customer airlines for spares. Spares parts production and other commercial airline support activities, including training and provisioning will be fully activated.

Pratt & Whitney Aircraft will conduct a vigorous post certification development program which commercial experience has shown is essential to assure the extension of major inspection periods, TBO periods, and engine parts life. These extensions are required if the SST is to achieve its optimum earning potential.

SECTION III
JTF17 PROGRAM MANAGEMENT

A. ORGANIZATION

The P&WA Program Management for the JTF17 Phase III development program is shown in figure 1. The Program Manager has overall responsibility for the design, development, manufacturing, and product support of the engine and for meeting cost, schedule, and performance requirements. The Program Management organization is staffed by experienced personnel selected for both their management and technical abilities. (The organization is described with resume's of key personnel in Volume V, Report I.)

B. MASTER MILESTONE CHART (See figures 2 and 3.)

The master milestone chart displays the schedule for the major events and program effort during Phase III. Overall visibility is provided by including the major program events which will occur in Phases IV and V. This is in recognition of the continuous nature of the development program as described in Paragraph B of this plan.

JTF17 Program Management

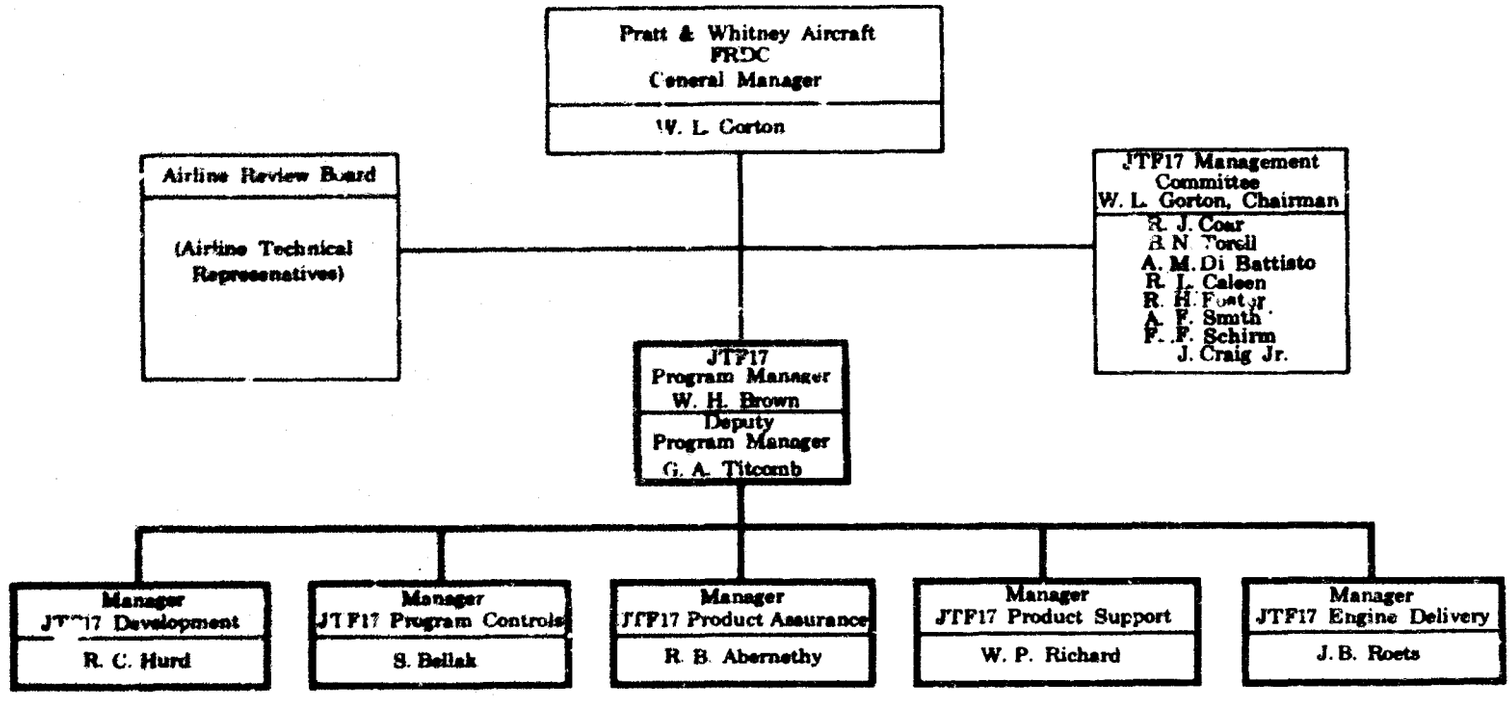
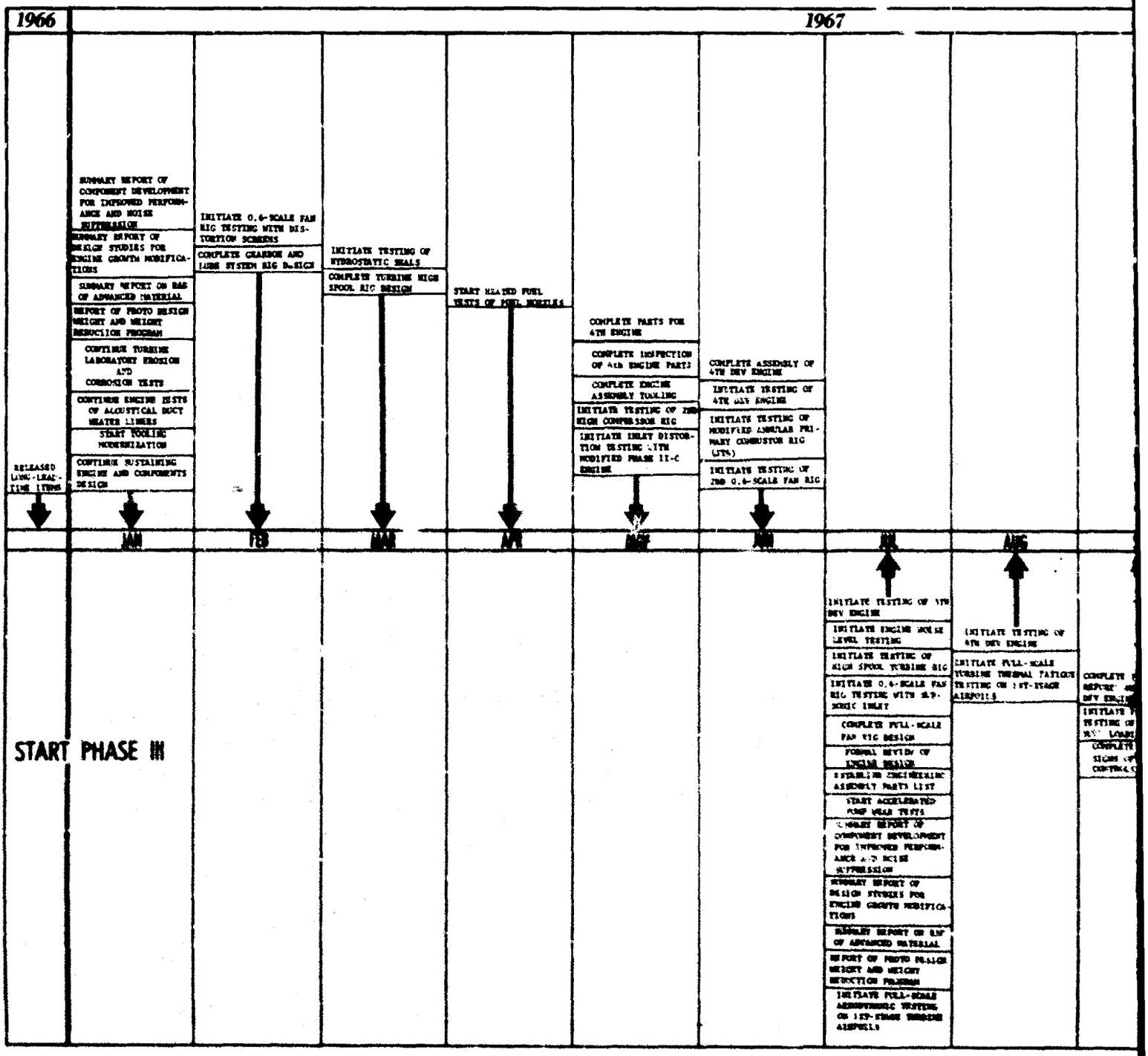


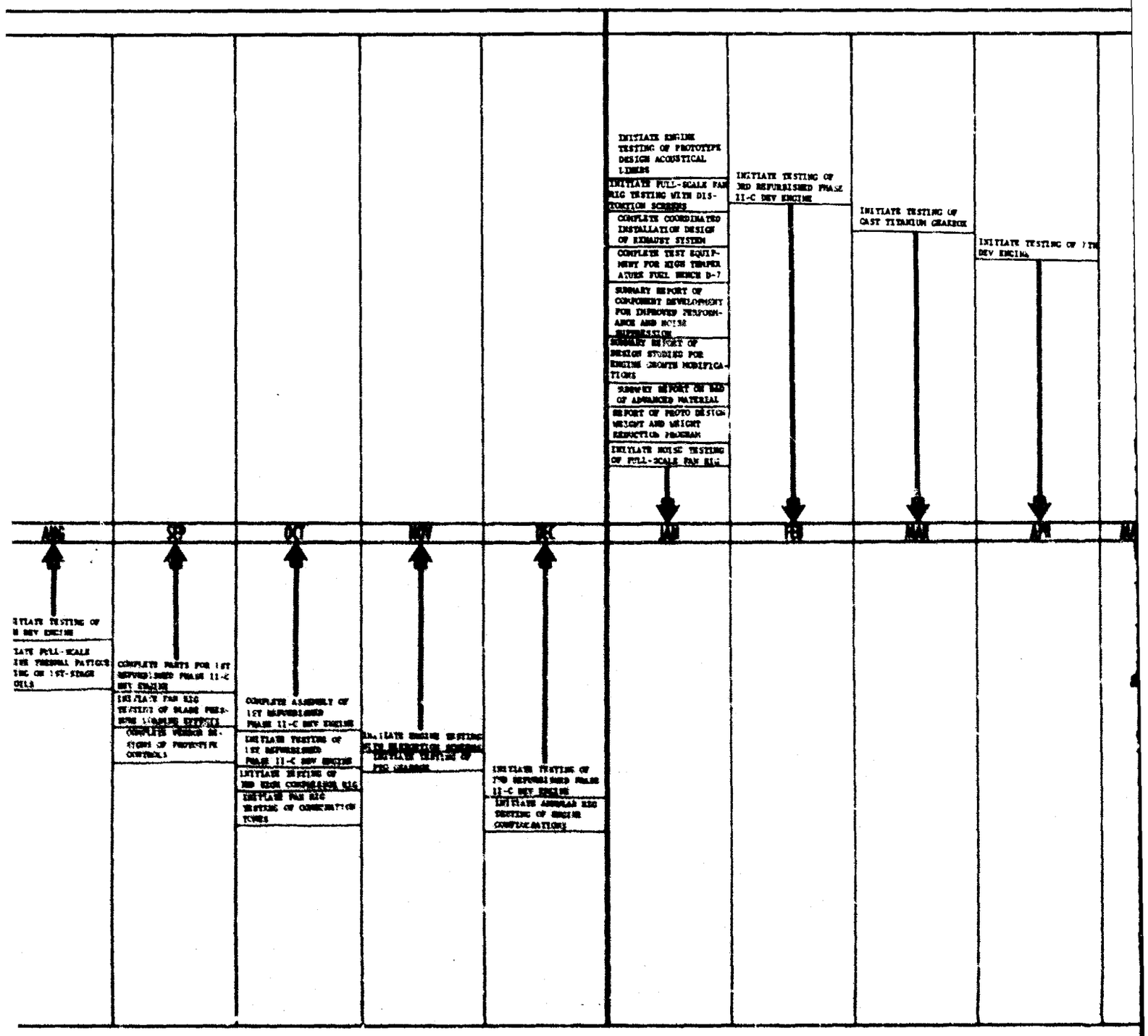
Figure 1.

FD 17700


1966
1967
RELEASED LONG-LEAD-TIME ITEMS
SUMMARY REPORT OF COMPONENT DEVELOPMENT FOR IMPROVED PERFORMANCE AND NOISE SUPPRESSION
SUMMARY REPORT OF DESIGN STUDIES FOR ENGINE GROWTH MODIFICATIONS
SUMMARY REPORT ON USE OF ADVANCED MATERIAL
REPORT OF PHOTO DESIGN WEIGHT AND WEIGHT REDUCTION PROGRAM
CONTINUE TURBINE LABORATORY EROSION AND CORROSION TESTS
CONTINUE ENGINE TESTS OF ACOUSTICAL DUCT HEATER LINERS
START TOOLING MODERNIZATION
CONTINUE SUSTAINING ENGINE AND COMPONENTS DESIGN
JAN
INITIATE 0.6-SCALE FAN RIG TESTING WITH DISTORTION SCREENS
COMPLETE GEARBOX AND LUBE SYSTEM RIG DESIGN
FEB
INITIATE TESTING OF HYDROSTATIC SEALS
COMPLETE TURBINE HIGH SPOOL RIG DESIGN
MAR
START HEATED FUEL TESTS OF FUEL NOZZLES
APR
COMPLETE PARTS FOR 4TH ENGINE
COMPLETE INSPECTION OF 4th ENGINE PARTS
COMPLETE ENGINE ASSEMBLY TOOLING
INITIATE TESTING OF 2ND HIGH COMPRESSOR RIG
INITIATE INLET DISTORTION TESTING WITH MODIFIED PHASE II-C ENGINE
MAY
COMPLETE ASSEMBLY OF 4TH DEV ENGINE
INITIATE TESTING OF 4TH DEV ENGINE
INITIATE TESTING OF MODIFIED ANNULAR PRIMARY COMBUSTOR RIG (JT9)
INITIATE TESTING OF 2ND 0.6-SCALE FAN RIG
JUN
JUL
INITIATE TESTING OF 4TH DEV ENGINE
INITIATE FULL-SCALE TURBINE THERMAL FATIGUE TESTING ON 1ST-STAGE AIRFOILS
AUG
START PHASE III
INITIATE TESTING OF 5TH DEV ENGINE
INITIATE ENGINE NOISE LEVEL TESTING
INITIATE TESTING OF HIGH SPOOL TURBINE RIG
INITIATE 0.6-SCALE FAN RIG TESTING WITH SONIC INLET
COMPLETE FULL-SCALE FAN VIG DESIGN
FORMAL REVIEW OF ENGINE DESIGN
ESTABLISH ENGINEERING ASSEMBLY PARTS LIST
START ACCELERATED PUMP WEAR TESTS
SUMMARY REPORT OF COMPONENT DEVELOPMENT FOR IMPROVED PERFORMANCE AND NOISE SUPPRESSION
SUMMARY REPORT OF DESIGN STUDIES FOR ENGINE GROWTH MODIFICATIONS
SUMMARY REPORT ON USE OF ADVANCED MATERIAL
REPORT OF PHOTO DESIGN WEIGHT AND WEIGHT REDUCTION PROGRAM
INITIATE FULL-SCALE AERODYNAMIC TESTING ON 1ST-STAGE TURBINE AIRFOILS

MANAGEMENT MASTER MILESTONE CH

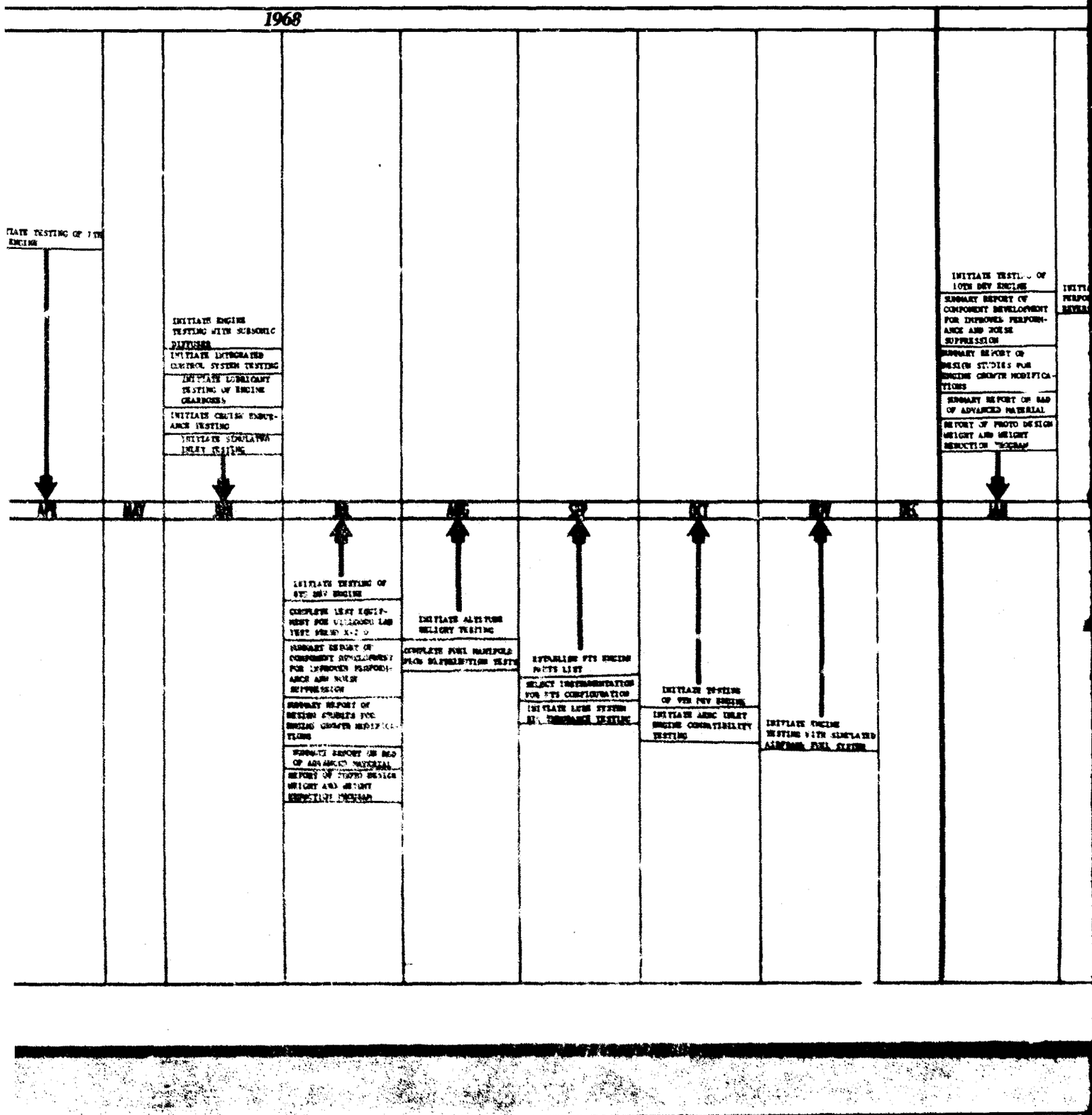
Engine and Component Development

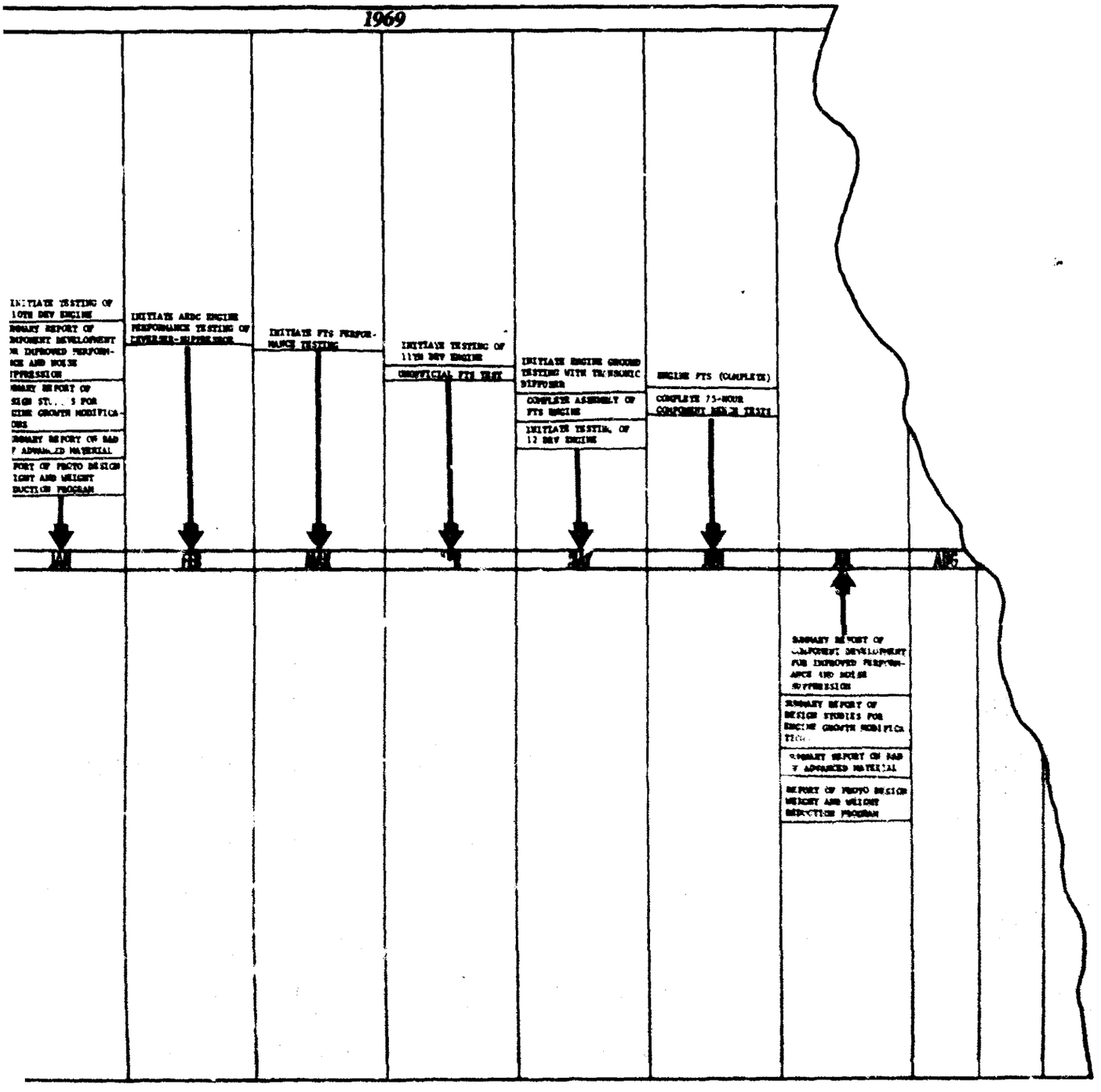


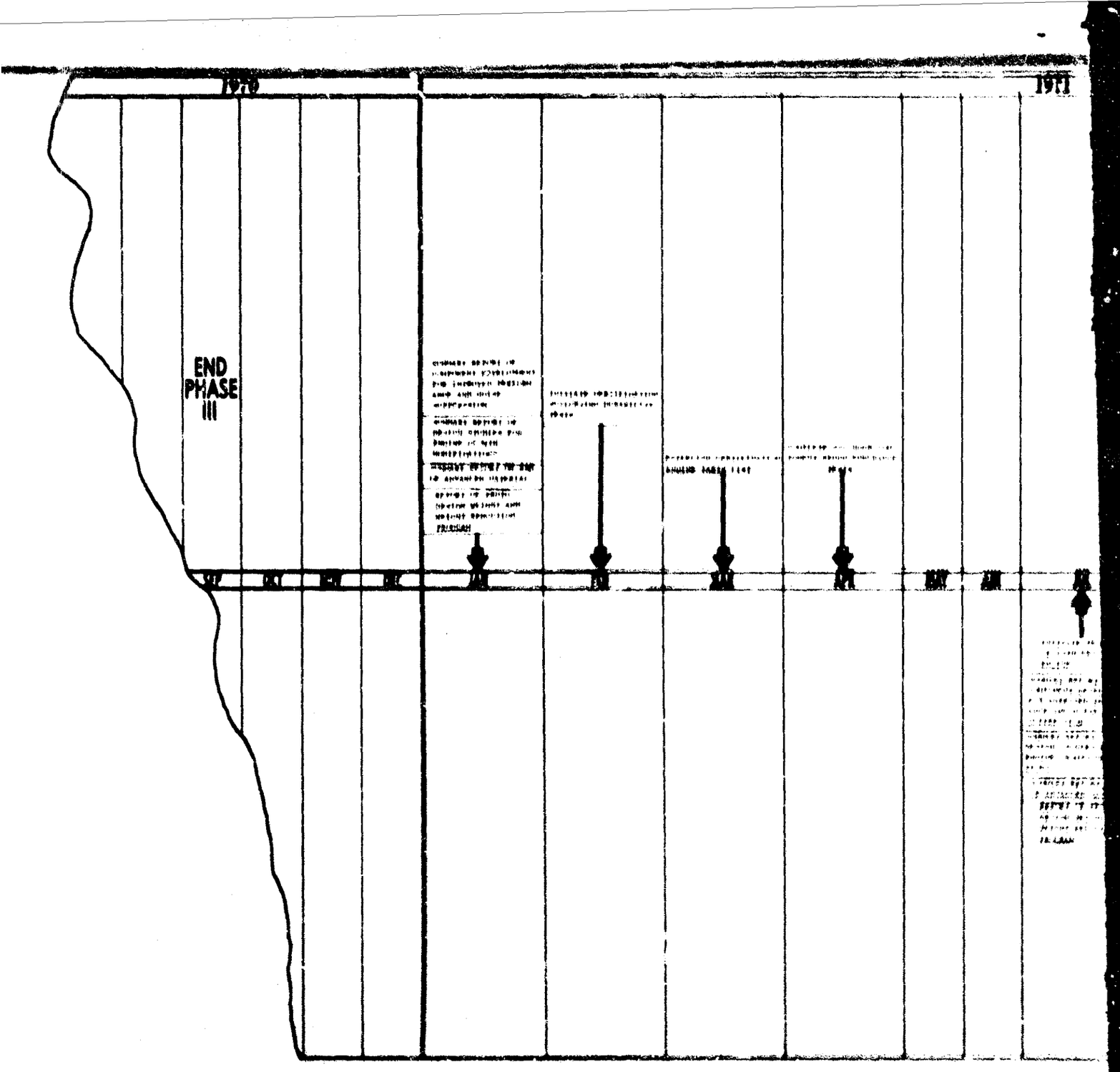
3

LESTONE CHART

Development




1969
INITIATE TESTING OF 10TH DEV ENGINE
SUMMARY REPORT OF COMPONENT DEVELOPMENT FOR IMPROVED PERFORMANCE AND NOISE SUPPRESSION
SUMMARY REPORT OF DESIGN STUDIES FOR ENGINE GROWTH MODIFICATIONS
SUMMARY REPORT OF R&D OF ADVANCED MATERIAL
REPORT OF PHOTO DESIGN WEIGHT AND WEIGHT REDUCTION PROGRAM
INITIATE ARDC ENGINE PERFORMANCE TESTING OF REVERSER-SUPPRESSOR
INITIATE FTS PERFORMANCE TESTING
INITIATE TESTING OF 11TH DEV ENGINE
UNOFFICIAL FTS TEST
INITIATE ENGINE GROUND TESTING WITH TRANSONIC DIFFUSER
COMPLETE ASSEMBLY OF FTS ENGINE
INITIATE TESTING OF 12 DEV ENGINE
ENGINE FTS (COMPLETE)
COMPLETE 75-HOUR COMPONENT DESIGN TESTS
SUMMARY REPORT OF COMPONENT DEVELOPMENT FOR IMPROVED PERFORMANCE AND NOISE SUPPRESSION
SUMMARY REPORT OF DESIGN STUDIES FOR ENGINE GROWTH MODIFICATIONS
SUMMARY REPORT OF R&D OF ADVANCED MATERIAL
REPORT OF PHOTO DESIGN WEIGHT AND WEIGHT REDUCTION PROGRAM


1970
1971
END
PHASE
III

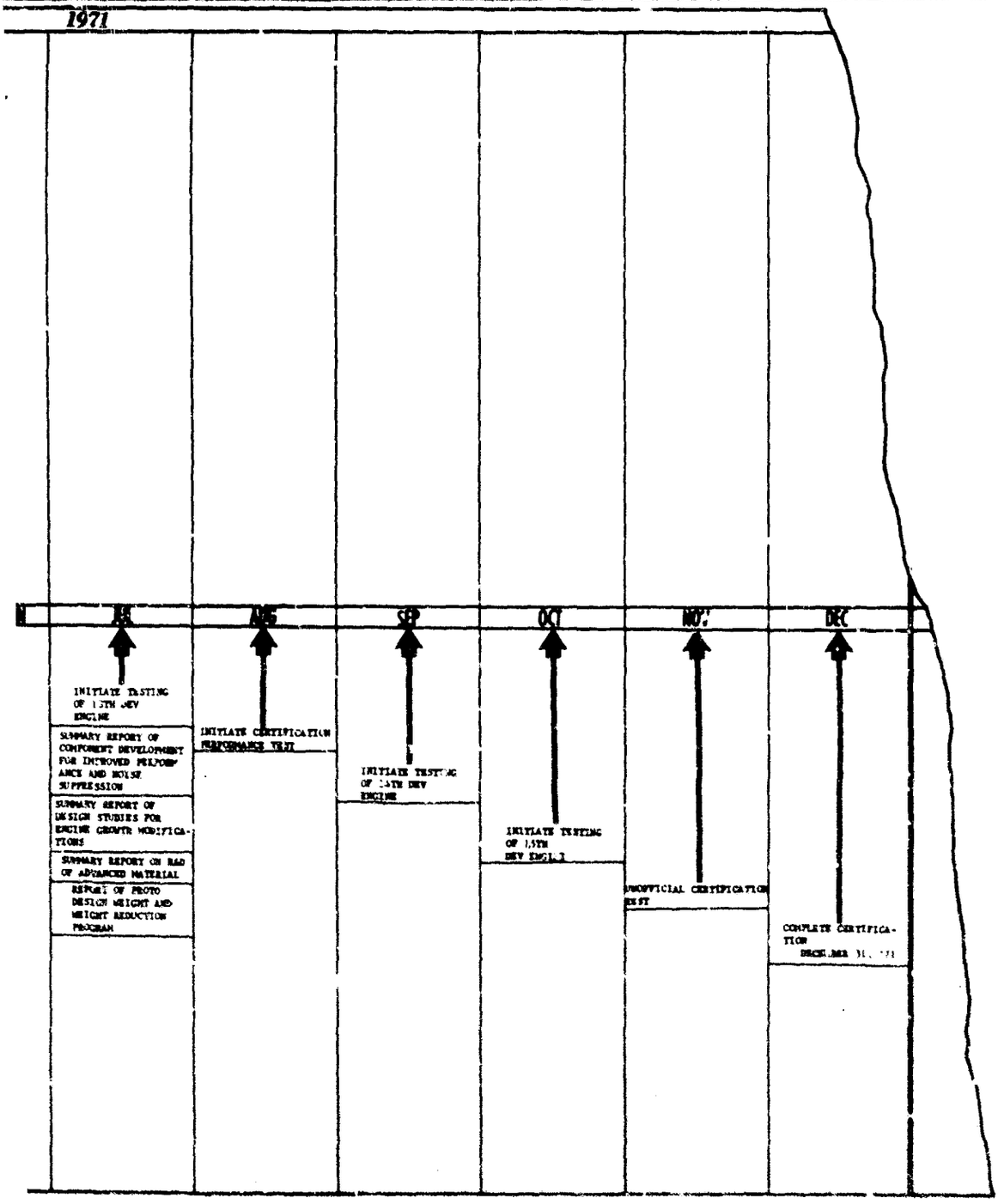

1971
AUG
SEP
OCT
NOV
DEC
INITIATE TESTING OF 1.5TH DEV ENGINE
SUMMARY REPORT OF COMPONENT DEVELOPMENT FOR IMPROVED PERFORMANCE AND NOISE SUPPRESSION
SUMMARY REPORT OF DESIGN STUDIES FOR ENGINE GROWTH MODIFICATIONS
SUMMARY REPORT ON R&D OF ADVANCED MATERIAL
REPORT OF PHOTO DESIGN WEIGHT AND WEIGHT REDUCTION PROGRAM
INITIATE CERTIFICATION PERFORMANCE TEST
INITIATE TESTING OF 1.5TH DEV ENGINE
INITIATE TESTING OF 1.5TH DEV ENGINE
UNOFFICIAL CERTIFICATION TEST
COMPLETE CERTIFICATION



Figure 2

662608
FD 17897

The master milestone chart will not be used as a substitute for the schedule controls. These controls are described in the Schedule Planning and Control System, Volume V, Report F. The Program Manager will use the charts to gain an overview of the complete program, thereby permitting a rapid appraisal of the major upcoming events as well as those which have been completed.

C. COST AND SCHEDULE CONTROL

The control of schedule will be by means of a Schedule Planning and Control System (described in Volume V, Report F) and supplemented by daily and weekly written reports that will detail the status of all major component rig and development engine test programs, engine deliveries and product support activities.

The schedule system will use PERT/Time for schedule planning, reporting, and management control.

The control of cost will be by means of a Cost Planning and Control System (described in Volume V, Report F).

SECTION IV
FRDC MANAGEMENT COMMITTEE

A Management Committee at the FRDC will provide, for the Center's management, the required direct contact with JTF17 Engine Program in Phase III.

The members of the Committee will be:

- W. L. Gorton, General Manager, Chairman
- R. J. Coar, Engineering Manager
- B. N. Torell, Chief Engineer
- A. F. Smith, Chief Engineering Operations
- R. L. Caleen, Chief, Field Operations
- J. Craig, Jr., Asst. Sales Manager
- A. M. DiBattista, Purchasing Manager
- R. H. Foster, Department Controller
- F. F. Schirm, Personnel Manager

The JTF17 Program Manager and the JTF17 Deputy Program Manager will serve as Committee members in a reporting function.

The Committee will meet under the chairmanship of the FRDC General Manager to receive an oral report from the JTF17 Program Manager. The Manager's report will cover the areas of design, development, manufacturing, and product support and will also include progress in meeting the cost, schedule, and performance requirements for all of which the Program Manager bears the responsibility. The Program Manager will call upon the Managers responsible for JTF17 Development, Program Controls, Product Assurance, Product Support, and Engine Delivery to assist in making his report.

The Program Manager will review major program problems, provide his planned course of action along with any alternatives, and report on their

final successful solution. The Chairman will assign responsibilities, resolve conflicts, and establish schedules to support the Program Manager's recommendations for meeting program requirements or solving problems. On occasion the Chairman may direct program changes or problem solutions if they are required in his judgment to meet overall program objectives. The Deputy Program Manager will serve as secretary and, as directed by the Chairman, will maintain a list of problems including the assigned responsibilities and schedules for corrective action. As solutions are obtained, the problems will be dropped from the list. Thus at all times, the list will serve as part of the agenda for the FRDC Management Committee Meetings.

Though meetings will normally be held weekly, special meetings will be called by the General Manager or Program Manager as program developments require. By the operation of the Management Committee, FRDC management will be kept fully informed of program problems and requirements for management support.

SECTION V
FAA REVIEWS

Management reviews will be held for the FAA at which JTF17 Program Management will present oral reports on program progress and review major technical problems including plans for their solution. The schedule for these reviews will be coordinated with the FAA in Phase III.

These reviews will provide overall program visibility to the FAA and assist the FAA in correlating the data received via P&WA Phase III program reports.

SECTION VI
AIRLINE REVIEW BOARD

The airlines have recognized that they should work directly and closely with the airframe and engine contractors during the design and development programs. To achieve the maximum effectiveness, they have organized industry committees and endeavored to reach a common position on policy and planning regarding technical questions. One committee, known as the Airline Supersonic Transport Committee with Mr. W. C. Mentzer as Chairman, has already contributed substantially to the SST program in Phase II-C.

Pratt & Whitney Aircraft recognizes the importance of airline inputs to the Phase III program and will plan specific program reviews for the airlines who will be invited to serve as an airline review board. The schedule for these reviews will be coordinated with the airlines.

The reviews, to be conducted by JTF17 Program Management, will cover policy and planning aspects of major technical questions as well as reports on program progress. It is expected that the reviews will generate a need for more detailed discussions in certain clearly defined areas. Accordingly, additional meetings will be scheduled at that time, between airline and P&WA specialists or among airline, P&WA, and airframe contractor specialists.

In all the reviews and meetings, P&WA will maintain a record of airline suggestions and recommendations. The airlines will be formally notified of the acceptance or the reasons for rejection of any suggestion or recommendation. In the event of a rejection, P&WA management will entertain any appeal or review desired by an individual airline, again providing formal notification of acceptance or the reasons for rejection.

SECTION VII
SUBORDINATE MANAGEMENT PLANS

The Master Program Plan is supplemented by the subordinate plans described in this section. Each of these subordinate plans contains for a specific area of the program effort an objective directly related to Phase III performance requirements, an organization with assigned responsibilities, detail requirements, description of work and procedures, management reporting requirements, and schedules as appropriate. The following describes the areas of program effort to which each plan is applicable.

A. FACILITIES PLAN

The Facilities Plan (See Volume V, Report B) details the planned modifications or additions for JTF17 sea level and altitude test stands, component test stands, and manufacturing capability.

B. CONFIGURATION MANAGEMENT PLAN

The Configuration Management Plan (see Volume V, Report C) describes how P&WA will control the JTF17 engine and GSE configuration. It also contains the configuration inspection and review plan and describes the Major Program Reviews with the Government/Airlines/Airframe contractor, as well as the P&WA Design Reviews. The airframe/engine liaison is also described.

C. DATA MANAGEMENT PLAN

P&WA plans to generate, collect, store, and disseminate significant technical, financial, and managerial data to facilitate JTF17 program monitoring and decision making. The Data Management Plan describes the procedures and the documents which will be provided to the FAA, airframe manufacturer, and airlines.

D. DETAIL WORK PLAN

The Detail Work Plan quantifies tasks, establishes schedules, and assigns responsibility for discrete items of work in relation to the work breakdown structure. The major elements of the plan are a program management network, an event dictionary, and activity descriptions.

The Detail Work Plan presents the total design, development, prototype (FTS) delivery, and support of the JTF17 engine during Phase III.

The development program is patterned after previous commercial and high Mach number engine programs, as well as the work required in Phase II-C to build three demonstrator engines.

E. PRODUCT SUPPORT PLAN

The Product Support Plan brings together in one comprehensive plan the interdependent, yet individual, requirements of the basic product support elements for the Phase III ground and flight tests and shows how this experience will be utilized to prepare for the support of the engine in Phase IV and scheduled airline operation.

These elements include:

1. Phase III maintenance and overhaul
2. Field personnel
3. Spares
4. Technical publications
5. Training and training equipment
6. Ground support equipment
7. Data

The effort expended to obtain airline recommendations during Phase II-C and how these efforts will be continued and expanded in Phase III and beyond is discussed.

F. INTEGRATED TEST PLAN

The Integrated Test Plan details the many and varied component and full-scale engine tests. The direction, procedures, and control necessary to achieve program performance requirements are shown. The automatic data collection system, analysis procedures, and the integration of reliability, maintainability, and safety are discussed.

G. MANUFACTURING PLAN

The Manufacturing Program subdivides into two categories. The first pertains to the manufacture and delivery of the prototype (FTS) engines for Phase III, and the second to the manufacture and delivery of the production engines in Phase V. The prototype engines will be manufactured at the FRDC facilities and the production engines at the main manufacturing facilities in Connecticut. This method has been successfully employed with other FRDC developed engines. The Manufacturing Plan covers this method.

The Plan details the Phase III objectives and describes how the experience gained in building the Phase II-C demonstrator engines and engine mockups has united in formulating the Phase III plan.

H. JTF17 PROGRAM ROOM

Program Management meetings will be held in the JTF17 Program Room. Certain charts will be displayed in this room so that they can be readily referred to during the meeting. It is planned to have the data

manager and his files adjacent to the meeting room to provide ease of reference.

The charts intended for display will be made available to the FAA for the FAA Control Room. They include:

1. JTF17 program organization
2. Program management pert chart
3. Master milestone chart
4. Engine sectional breakdown
5. Work breakdown structure
6. Installation drawing

These same charts will also be made available to the airframe contractor.

In addition to the charts in the JTF17 Program Room, P&WA will provide the FAA with copies of other charts used for managerial control and presentation.

SECTION VIII
REPORTING TO FAA

During Phase III, reports and data will be submitted to the FAA in accordance with the schedule and quantity shown on the Data List Exhibit 1 of the Phase III contract.

From this list the following data will comprise the management reports from P&WA to the FAA. Brief descriptions are contained in Exhibit A.

	Phase III Submittal	
Report	Initial	Frequency
Cost Status Report	February 1967	Monthly
Schedule Status Report	February 1967	Monthly
High Risk Area Report	February 1967	Two Months
Progress Report including Data Ascension List as an appendix	March 1967	Two Months
Cost Baseline Report	September 1967	Annual
Annual Report	January 1968	Annual
Final Report, Phase III		Conclusion
Flash Failure Report	As Generated	

The Master Program Plan will also be updated and transmitted to the FAA on July 1967 and thereafter at 6-month intervals.

EXHIBIT A
DESCRIPTION OF REPORTS TO FAA

1. Progress Report

The Progress Report will reduce to writing the program accomplishments in relation to the Detailed Work Plan tasks and in accordance with

the Work Breakdown structure. It will contain as an appendix a Data Accession List which will provide a listing of the documentation which has been completed during the reporting period.

2. Cost Status Report

The Cost Status Report is described in the Cost Planning and Control System Volume V, Report F.

3. Schedule Status Report

The Schedule Status Report is described in the Schedule Planning and Control System Volume V, Report F.

4. Cost Baseline Report

This report provides estimates of the contractors cost for the total SST development and production program. The data will provide a basis for cost control in Phase III and will provide cost estimates necessary for the evaluation of SST airline economics.

5. Annual Report

The Annual Report will summarize significant progress and the expenditure of resources during the year and provide an appraisal of progress with respect to the total development program.

6. Final Report

The Final Report will summarize the results of the Phase III development program and assess its impact on the total development program.

7. High Risk Area Report

The High Risk Area Report will present a compilation of the areas or items where the contractor feels the development risk is highest or the outcome is most uncertain. The report will be in narrative form, discussing the area or item, the potential impact, and any Work Breakdown Structure elements involved.

8. Flash Failure Report

The Flash Failure Report will notify the FAA promptly of failures in test hardware having a major impact on the program and provide a description of the test hardware, test conditions, type of failure, preliminary analysis and proposed corrective action. Notification will be by TWX. Where the preliminary analysis and proposed corrective action are not immediately available they will be provided on an expedited basis in a followup TWX.

REPORT B
FACILITIES PROGRAM
SECTION I
INTRODUCTION

A. FACILITY STATUS

The purpose of this Report is to present the detailed facility information for Phases III, IV, and V of the Supersonic Transport Development Program. It incorporates both the facilities acquisition and utilization plan and all associated descriptive and substantiating data.

Following the Company's original SST proposal, a detailed study was made of the anticipated facility requirements. These requirements were then compared to existing facilities, with consideration given to conflicts with other programs. From this basic information, requirements for additional facilities or modifications to existing facilities were determined. Finally, costs and schedules were estimated for facility and equipment modifications and additions planned for the SST Program. Orders are ready to be placed for long lead time items.

All of the facilities described in this document exist now or will be acquired or placed in use during Phase III. A distinction has been made between development facilities and those required for prototype and overhaul delivery activities since testing, manufacturing, and assembly techniques and controls will differ. No additional facilities are required for Phase IV; those acquired during Phase III will continue to be used. All of the Connecticut manufacturing and test facilities described in this document will be in existence and can be used for Phase V of the SST Program. Phases III and IV of the SST Program will be carried on principally at the Florida Research and Development Center, with some specialized testing and support provided by the Connecticut facilities. Production of JTF17 engines in Phase V will be accomplished at the Connecticut plants, with development continuing in Florida.

FRDC facilities now include 1,150,000 square feet of floor space. Manufacturing, assembly, and inspection tools number 473 major items. The turbojet test areas contain 54 stands with capabilities ranging from full-scale engine and rig testing to small component calibration. Supporting these activities are a Materials Development Laboratory, a Computing Laboratory, and an Instrument Laboratory. For Phases III and IV, of the SST Program, the floor space will be expanded by 96,000 square feet. A limited number of major manufacturing tools will be added and eight new test stands will be constructed. The Materials Development and Instrument Laboratories will add some new equipment. The Computer Laboratory capabilities are now in process of improvement by replacement of several existing IBM systems with newer models. The Connecticut facilities to be used for Phases III and IV include the Andrew Willgoos Turbine Laboratory, consisting of 14 test stands; the United Aircraft Research Laboratories Wind Tunnel; and the Advanced Materials Development Laboratory.

Four plants, all company-owned and in Connecticut, will be used for Phase V of the SST Program. They contain 7,897,600 square feet of floor space and approximately 4000 production machine tools.

By letter dated 13 July 1966, sent via the FAA, the Contractor has requested the Air Force to make available water capacity from Air Force Plant No. 74 for use in performing engine and component cooling operations under Phase III. Plant No. 74 is located adjacent to the Florida Research and Development Center. Raw water is supplied to Plant No. 74 through a Government-owned 21-inch pipeline from the St. Lucie Canal. The details concerning the use of this Government facility are described in the letter referred to above.

B. ORGANIZATION AND PROCEDURES

A Senior Facilities Engineer, reporting administratively to the Chief, Facilities, has the responsibility for the coordination and acquisition of all facilities. The facilities consist of two major categories: test facilities and manufacturing and support facilities. Under the Senior Facilities Engineer, facilities engineers are responsible for the design, procurement, and construction of major portions of the facilities. Each facilities engineer has at his disposal personnel from the Facilities Engineering Department to perform each of the above functions. This organization is broken into technical functional categories so that each aspect is treated by competent and experienced engineers. In the design phase, a design leader will direct the activities of structural, mechanical, and electrical design engineers. Upon completion of design, the facilities engineer will initiate procurement through a procurement coordinator who is responsible for all procurement activities from initiation through receipt and acceptance of material. Installation and construction will be supervised by mechanical, civil, architectural, and electrical engineers under the direction of the facilities engineer. The budgetary control shall be the responsibility of the individual facilities engineers. Cost information will be provided by a Cost Control Section.

The Senior Facilities Engineer receives requests for facilities directly from the JTF17 Program Managers, the Chief, Experimental Manufacturing, and the managers of each supporting laboratory.

Figure 1 describes the organization responsible for the acquisition of all facilities.

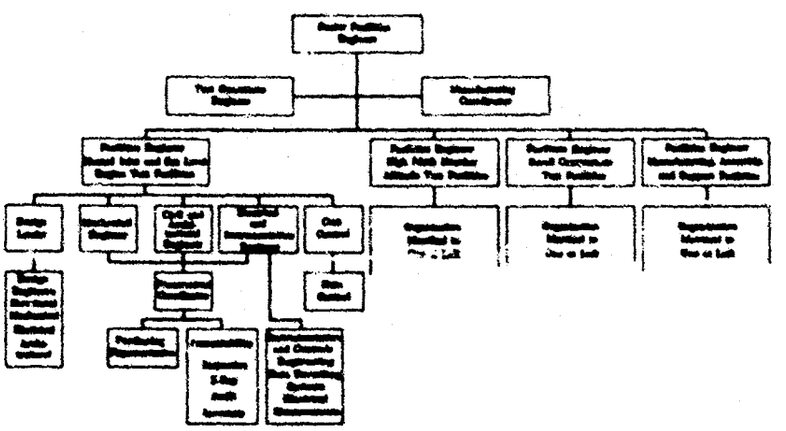


Figure 1. Functional Organization Chart - JTF17A Engine Facilities FD 17670 VB

C. FACILITIES PLAN

The design, procurement, construction, and checkout schedules for all facilities to be acquired for Phases III and IV are shown in figures 2 through 5. These schedules are predicated on the requirements shown in the Integrated Test Plan, Volume III, Report E, Sections I, II, and III.

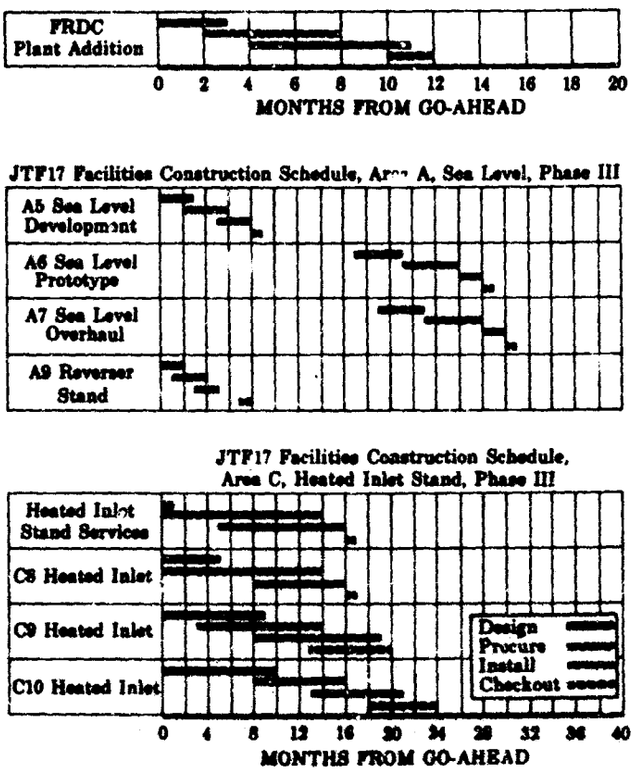


Figure 2. Phase III Facilities Construction Schedules - FRDC Plant Additions and JTF17 Areas A and C Test Equipment

FD 17658
VB

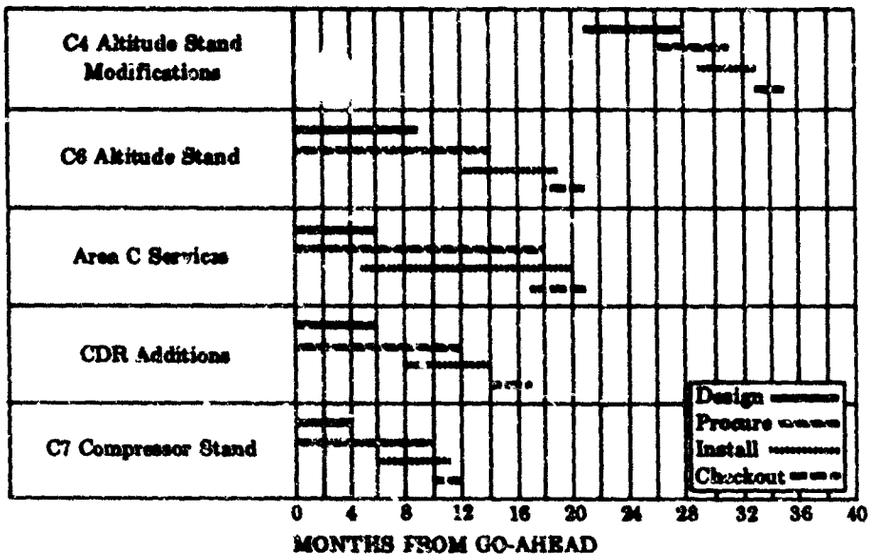


Figure 3. Phase III Facilities Construction Schedules - JTF17 Area C Test Equipment

FD 17659
VB

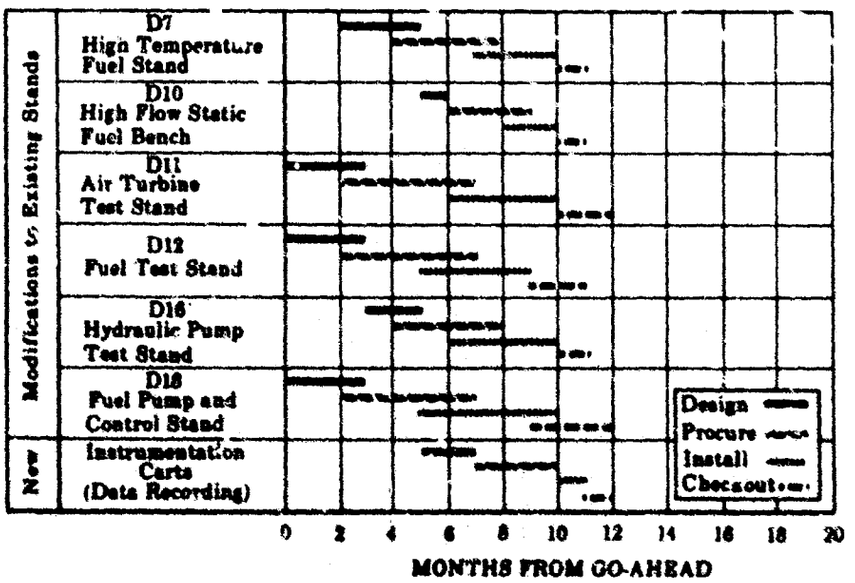


Figure 4. Phase III Facilities Construction Schedule - JTF17 Area D Modifications to Existing Test Equipment

FD 17660
VB

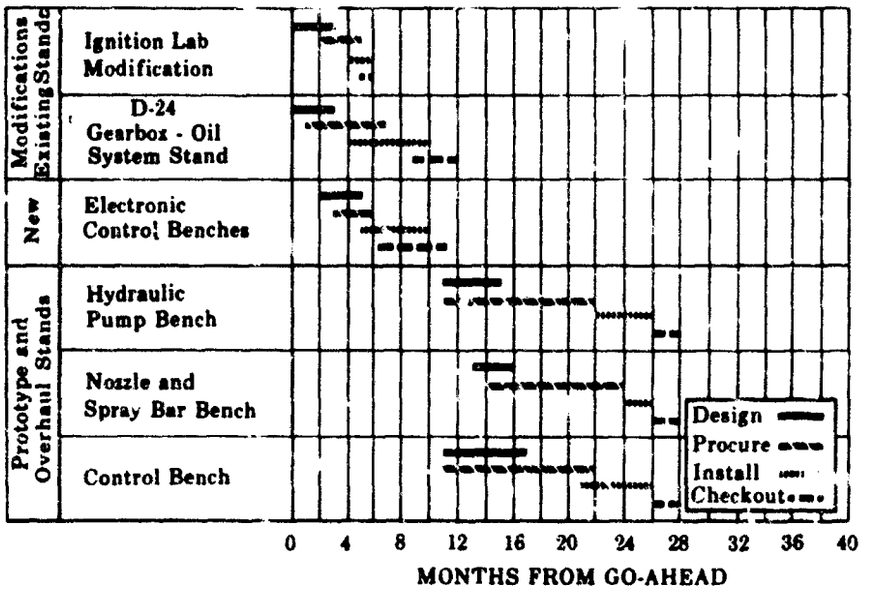


Figure 5. Phase III Facilities Construction Schedule - JTF17 Area D Test Equipment

FD 17661
VB

SECTION II
FACILITIES FOR PHASES III AND IV

A. OFFICE, MANUFACTURING, ASSEMBLY, AND INSPECTION FACILITIES SUMMARY

1. Office Facilities

The existing Florida Research and Development Center engineering and administrative office facilities cover 200,000 square feet of floor area. The main office building covers 150,000 square feet. (See figure 6.)

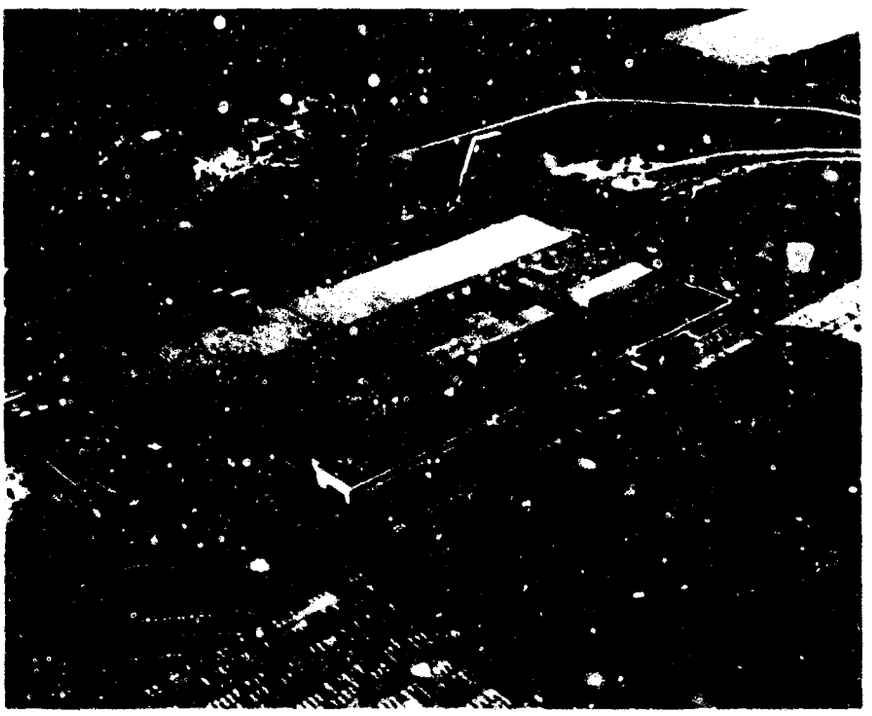


Figure 6. FRDC Engineering and Administrative Office Facilities — FE 13329 VB

The managers of each department are located in offices central to their departments. The SST Engine Program Manager is located in the Program Management Area on the second floor of the office building. (See figure 7.)

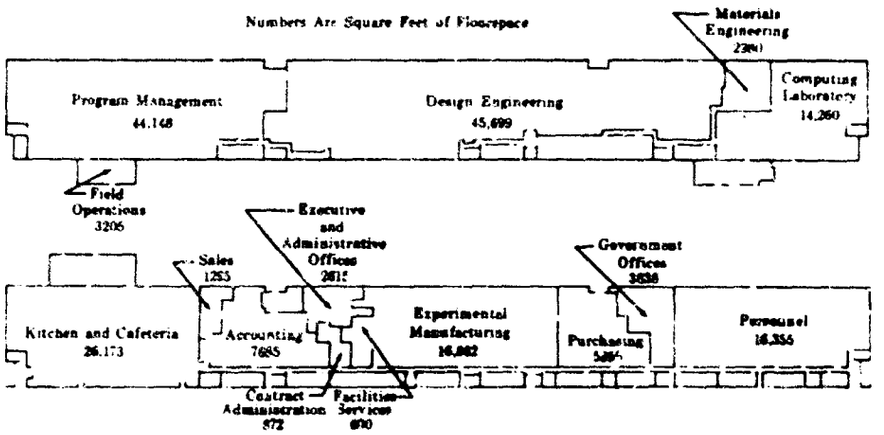


Figure 7. Existing Office Facilities FD 17671
VB

2. Manufacturing, Assembly, and Inspection Facilities

FRDC currently has 326,000 square feet of floor space allocated to its Experimental Shops, Experimental Assembly, and supporting departments, as shown in figure 8. Ninety-six thousand square feet of floor space will be added to support the SST Program. (See figure 9.)

a. Manufacturing Facilities

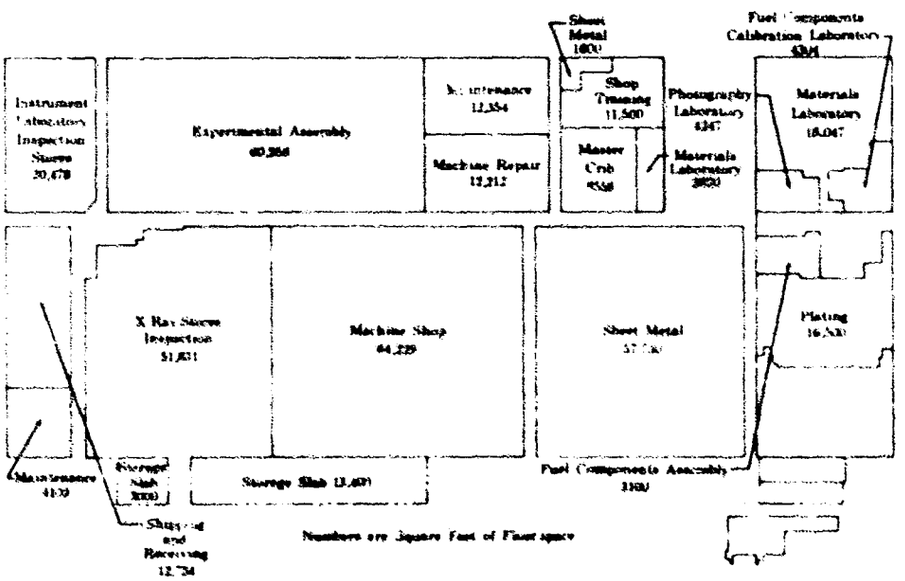


Figure 8. Existing Facilities FD 17673
VB

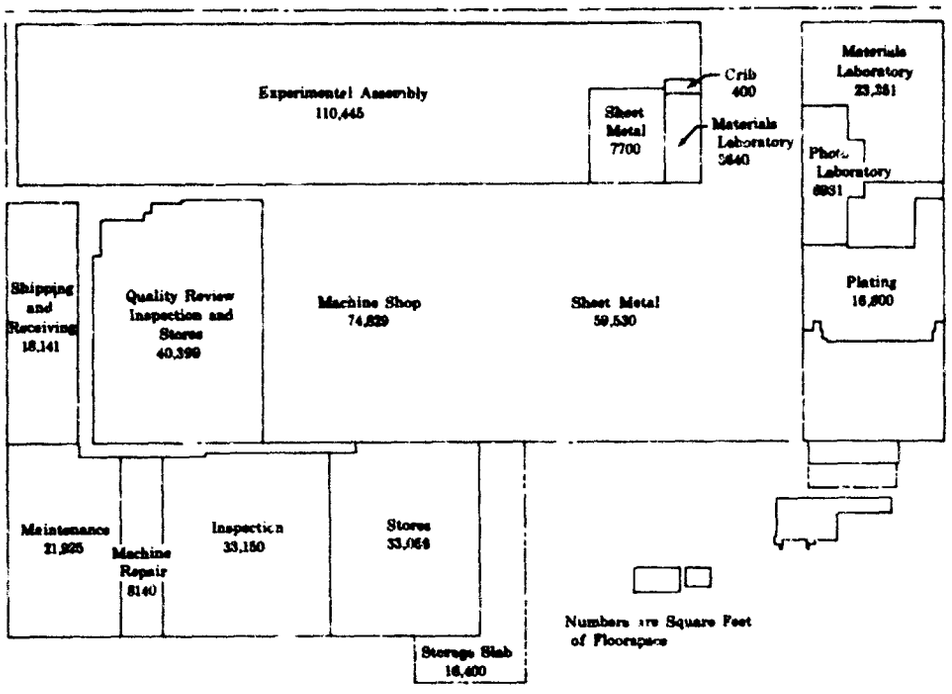


Figure 9. Expanded Facilities FD 17674
VB

The Experimental Shops, composed of the Machine Shop, Sheet Metal Fabrication and Welding Shops, Tube Forming and Tube Assembly Shops, Tool Room, Pattern Shop, and supporting stores, total 265,000 square feet. Thirty-two thousand square feet will be added to the Experimental Shops area for the JTF17 Program.

b. Experimental Assembly Facilities

The Assembly Facilities, including mockup room and components assembly, consist of a completely air-conditioned area covering 61,000 square feet of floor area.

The Experimental Assembly space available will total 80,700 square feet after the expansion for the JTF17 Program. The new Delivery Assembly floor will total 29,800 square feet of floor area.

c. Inspection and Quality Engineering Facilities

The Inspection and Quality Engineering Department is subdivided into the following ten major areas:

1. Delivery Inspection
2. Development Inspection
3. Shop Inspection
4. Gage Standards
5. Log-In and Records
6. Assembly Inspection
7. Nondestructive Test
8. Radiographic Inspection
9. Quality Review
10. Inspection Methods.

These areas contain 28,000 thousand square feet of floor space. In the expanded manufacturing facility, 14,800 square feet will be added to the inspection area. As indicated, development and delivery inspection have been separated to provide different quality standards and techniques for the two categories.

d. Manufacturing, Assembly, and Inspection Equipment

The existing manufacturing, assembly, and inspection equipment at Pratt & Whitney Aircraft and prospective subcontractors, and that to be procured and installed to support the SST engine program, are shown in Section IV on tables IV-1 through IV-7; IV-18 through IV-26; and IV-29 through IV-32.

B. ENGINE AND COMPONENT TEST FACILITIES DESCRIPTION

The test facilities required for the JTF17 Engine Test Program include sea level, heated inlet, and altitude stands; compressor and burner rig stands; and small component and rig stands. A tabulation of the test stands to be used in whole or in part for the JTF17 Program are shown in Section IV on tables IV-8 through IV-11; table IV-27; and tables IV-33 and IV-34. The sea level stands are required for general engine development testing, sea level calibrations, thrust measurement evaluations, specific fuel consumption programs, and inlet distortion testing; plus general engine control development, sound programs, and reverser-suppressor development. Heated inlet stands will provide for testing the engine at elevated inlet temperature and for endurance-type testing. Altitude stands will simulate altitude and Mach number conditions operating over the full range of the engine map. Compressor rig stands will provide for individual testing of the high and low full-scale compressors at atmospheric and heated inlet conditions. Development testing of turbine blades and vanes as well as segmented annular burners and burner hardware will be done on burner stands with temperature capabilities up to 2500°F. Small component and rig stands are necessary for the development testing of ignition systems, bearings, seals, gearboxes, actuators, and various fuel system components, including main engine fuel control, duct heater controls, hydraulic pumps, exhaust nozzle controls, scavenge pumps, main engine oil pumps, fuel nozzles, spraybars, and electronic engine controls.

The majority of the JTF17 engine and component testing will be done at FRDC. Existing test facilities include seven sea level test stands, of which two are heated inlet, and one burner stand located in Test Area A. Area C, the High Mach Number Laboratory, contains two burner stands, one compressor stand, and two altitude stands; and also other services (compressor-exhausters, cooling water systems, air heaters, etc.) that provide simulated altitude and high Mach number environmental conditions. In the Small Components Test Facility, Area D, there are 42 component and rig test benches. Jet fuel is supplied to all facilities from a fuel "farm" consisting of storage tanks, pumps, and distribution piping.

During the SST Phase II-C Program (JTF17 Demonstration), the J58 project shared two sea level test stands with the JTF17 Program. In order to conduct a major dual engine development program, it will be necessary to convert one additional sea level stand for JTF17 development testing with 100% utilization. It will also be necessary to utilize the two coexistent sea level test stands 100% of the time for the JTF17. One additional sea level test facility will be required for sound and ejector/reverser test programs, and will be utilized 100% by the JTF17 Program. Two existing sea level test stands will be converted during the latter portion of Phase III for specific sea level delivery engine testing. The existing burner stand in the sea level area will be 25 to 30% utilized by the JTF17 Program. One existing heated inlet stand will be utilized 35% of available stand time at sea level conditions for engine burner rig testing.

The High Mach Number Laboratory will be expanded by adding one additional altitude stand for high-altitude development work to be utilized 100% by the JTF17 Program. The present coexistent altitude test stand will be fully converted for the JTF17 Program and utilized approximately 80% of the time for JTF17 testing. One additional compressor stand will be constructed for operation independent of the high-altitude facility, and will be utilized 100% by the JTF17 Program for high and low compressor testing. The existing high compressor stand will be utilized 50% of available stand time for JTF17 high compressor testing. Additional air and cooling water services will be procured and installed to meet the heated air inlet and exhaust cooling water requirements necessary to accommodate the JTF17 engine air flows and temperatures. Additional cooling water will be obtained from Air Force Plant No. 74 as mentioned in Section I.

Three new heated inlet stands will be constructed to provide high air flows and temperatures to the JTF17 Engine for long-time endurance requirements at heated inlet conditions.

Additional altitude testing will be done in Stand X-210 at P&WA's Andrew Willgoos Laboratory in East Hartford, Connecticut. Between the Florida and Connecticut facilities, the entire JTF17 flight envelope can be simulated.

In the Small Components Test Facility, 11 of the existing 42 rig and component test benches will require modifications for fuel control testing; general purpose fuel system component testing; hydraulic pump, fuel pump, gearbox, seal and bearing testing; and environmental testing of the systems. These benches will be utilized 100% of the time for the JTF17 Program. In addition to the 11 modified benches, two new electronic fuel control stands will be constructed for general control development work, and will be utilized 100% of the time for the JTF17 Program. The 15 existing benches will be utilized 60 to 70% of the available bench time on the JTF17 Program. Additional new benches will be provided for delivery engine component testing.

Figure 10 depicts the utilization of the major test facilities by the J58 and JTF17 and other programs from the start of Phase III through engine certification.

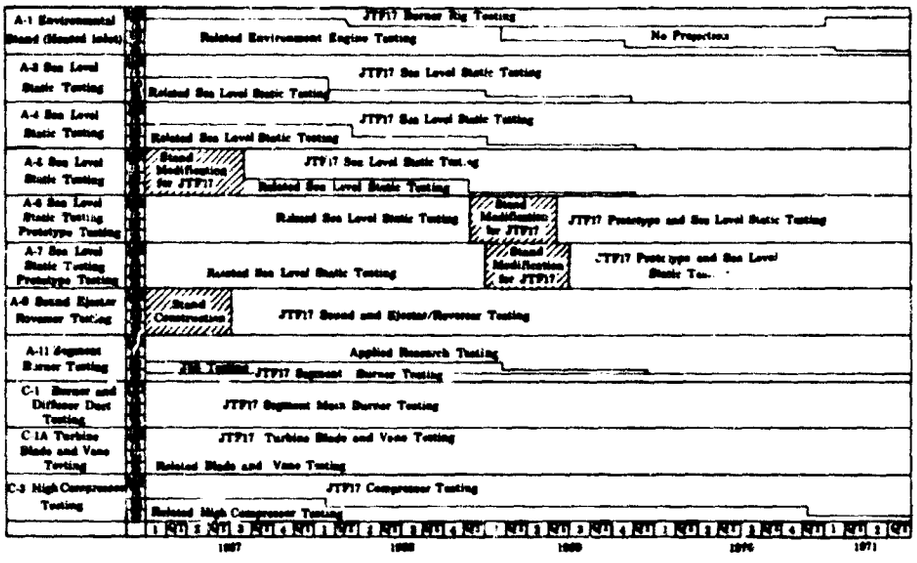


Figure 10. Projected JTF17 Test Stands Occupancy (Sheet 1 of 2) FD 17662 VB

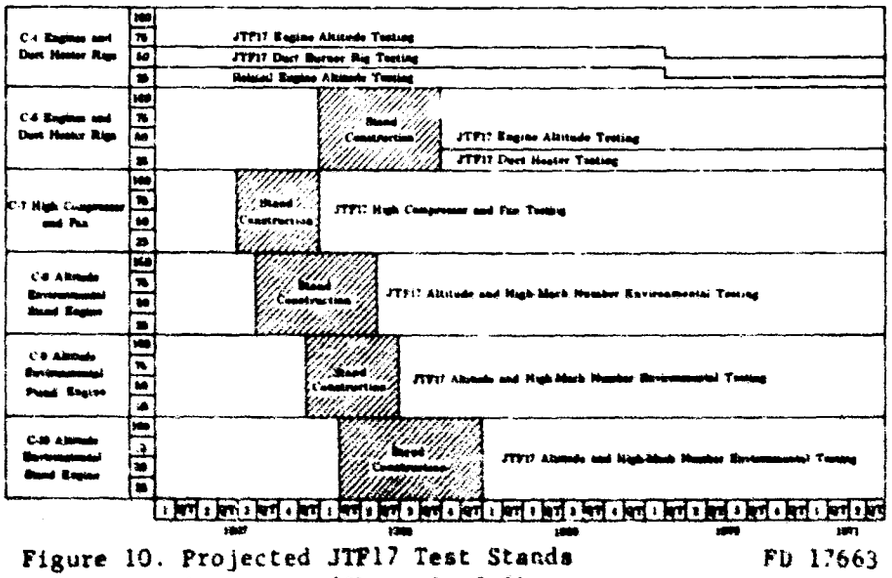


Figure 10. Projected JTF17 Test Stands Occupancy (Sheet 2 of 2) FD 17663 VB

Expansion of the "fuel farm" will consist of adding two 1,000,000-gallon storage tanks and additional distribution systems from the farm to the test areas, with the necessary pump capacity to service the JTF17 Program. Additional data acquisition and other instrumentation systems, such as disaster monitoring, transient recording, and manual instrumentation, will be installed in all test areas for the JTF17 Program.

Table II-1 indicates the number of test hours projected for the peak year of the SST Phase III Program, and the number of stands required to meet the peak effort. Both JTF17 and other engine-required test hours are shown, along with the average number of test hours per stand per year, based on previous history. From these figures, the number of stands required for the combined programs and, therefore, the number of stands that must be added, has been determined.

Table II-1. Projected Peak Year Test Hours and Test Equipment Required

Type of Test Hours	Engine Hours* *During peak	JTF17 Hours* year	Total Combined Hours*	Hrs. Stds. Yr.	Stds. Req.	Existing Stds	New Stands Req'd.	Remarks
Sea Level	930	5,200	6,130	745	8.0	7.0	A-9	(Sea Level Sound & Ejector/ Reverser Stand)
Heated Inlet and Altitude Test Stands	770	2,600	3,370	425	8.0	4.0	C-6 C-8,9,10	(Alt. Stand) (Heated Inlet Stands Simultaneous Operation of any 2 of 3)
Compressor Test	250	1,550	1,800	600	2.8	1.0	C-7	(Independent Operation)
Major Fuel Components	10,600	18,360	28,360	1800	15.5	31	2	(Plus Modification to 9 Benches for 100% JTF17 Utilization)
Oil System Simulator	0	2,400	2,400	685	1.0	0	1	(Required for Development of Engine Oil System)
Rigs and Sub-Components	12,500	34,400	46,900	3860	12.0	11		(Existing Benches to be Utilized 90% for JTF17 Program)
Unitized Control Bench, Hydraulic Pump Bench, Nozzle and Spray Bar Bench						0		(Required for Calibration and Component Calibration Scheduling of JTF17 Prototype Engine Components)

Figure 11 shows the proposed additions and modifications to the Turbojet Engine and Components Test Facilities for adaptation for the JTF17. The following paragraphs describe these changes, including each test area's resulting capabilities.

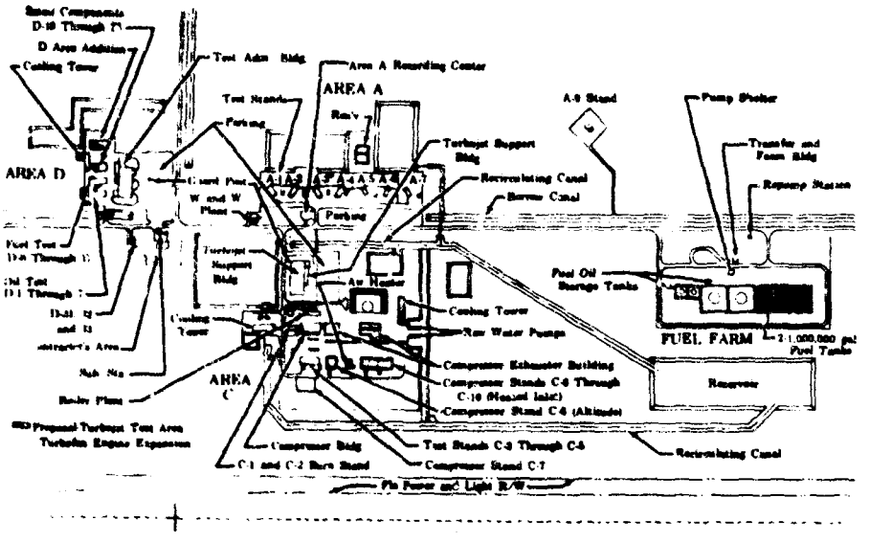


Figure 11. Turbojet Test Facilities FD 17675 VB

1. Sea Level Engine Calibration and Endurance Test Facilities

a. SST Program Requirements

Six Sea Level Engine Test Stands and one Burner Stand are required to conduct the SST Program. Five existing FRDC engine stands will be available and capable, with modifications, of testing the JTF17 engine. These stands are A-3, A-4, A-5, A-6, and A-7. One new stand, A-9, will be built. The A-11 Burner Stand will be capable of JTF17 combustor testing. (See figure 12 for an aerial view of Area A.)



Figure 12. Aerial View of Area A PC 13339
VB

b. Existing Test Stands Descriptions

(1) A-3 and A-4 Test Stands

(a) General Description

Sea level calibration and endurance testing of full-scale engines is accomplished on stands A-3 and A-4. Each stand consists of an engine mount and thrust measuring system, fuel supply system, and a control room provided with engine monitoring and controls. Performance data is collected through a data acquisition system. The stands have already been modified for JTF17 testing as part of the SST Phase II-C Program. Figure 13 shows the A-3 stand with a JTF17 engine installed.

(b) Modification and Additions Required

Additional data system capability will be added consisting of:

1. 100 steady-state pressure channels
2. 4 flow and speed channels



Figure 13. A-3 Test Stand

FE 61389
VB

(c) Test Stand Capabilities

The thrust block thrust stand and measuring system are capable of withstanding 80,000 pounds of thrust.

(d) Instrumentation

A centrally located data acquisition system is provided with the capability of recording the following:

1. 300 steady state pressure channels
2. 40 transient pressure and thrust channels
3. 16 temperature channels
4. 10 flow and speed channels
5. 12 vibration channels

Figure 14 shows the data acquisition system used to record data from A-3 and A-4 test stands. The data acquisition system can be used to record data in two basic modes, steady-state and transient. In the steady-state mode, 10 readings are taken from each channel, and the average of these ten readings is used to define steady state performance. In the transient mode, all, or a selected portion of, the channels are sampled at a high sample rate for the duration of the transient. The transient mode has been used on engine test programs to study control system response, starting characteristics, surge line definition, and simulated mission cycles.

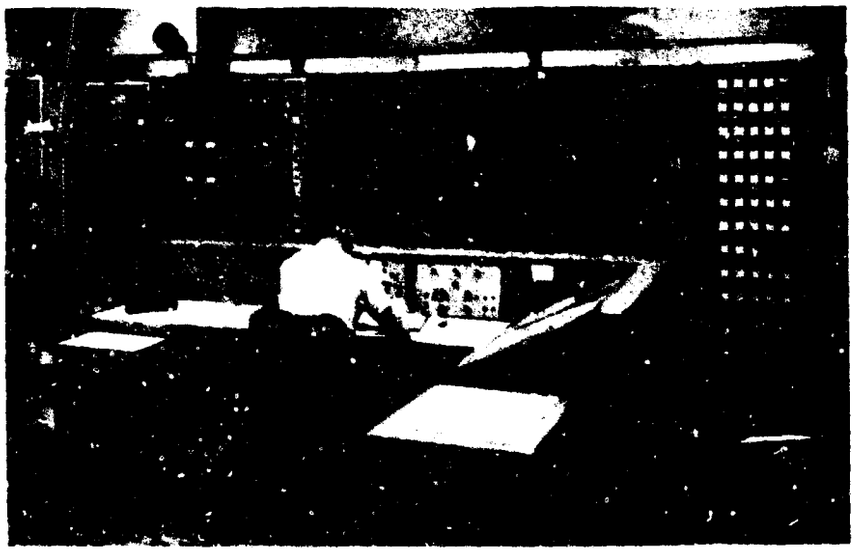


Figure 14. Data Acquisition System FC 12346
VB

A general purpose digital computer (figure 15) is provided to make computed results available to the test engineer while the test is in progress. This computer is integrated with both Areas A and C data recording systems. The computer converts the raw digital data into engineering units, and then solves performance analysis equations and the condensed results are transmitted to printers located in the control rooms. Typical calculations include air flow, corrected fuel weight flow, Mach number simulated altitude, thrust specific fuel consumption, and component efficiencies. Typical elapsed time between recording a point and having condensed data available to the test engineer is 2 minutes. Complete data reduction is also performed by the computer and tabulated on a high speed printer for more complete data analysis.

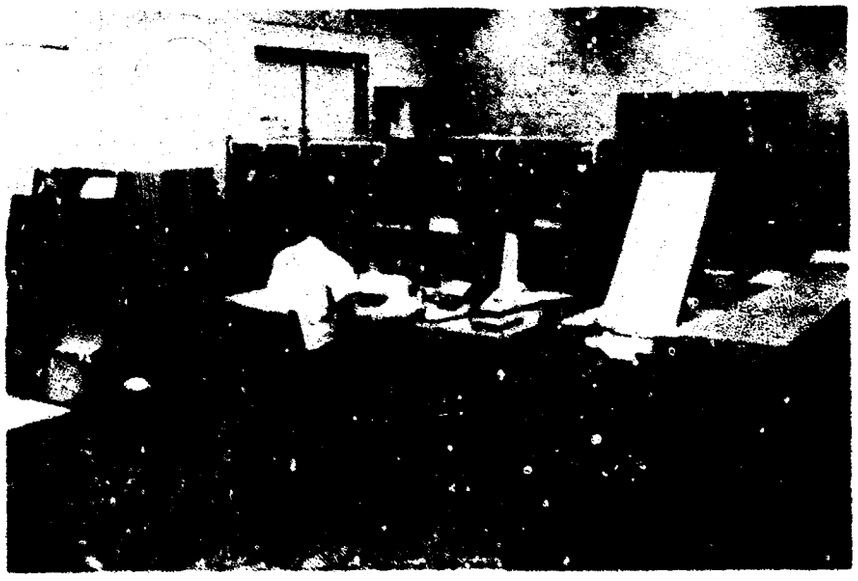


Figure 15. General Purpose Digital Computer FC 12347
VB

Continuous monitoring equipment, consisting of 11 channels that are fed into a magnetic tape recorder/reproducer system is provided. The channels are as follows:

1. 3 pressure channels
2. 1 temperature channel
3. 1 vibration channel
4. 3 flow speed channels
5. 3 position channels

Three separate fuel systems, each capable of supplying 120,000 pounds per hour of jet fuel at ambient temperature at pressures up to 100 psig, are available.

A compressed air system which is capable of delivering air at a rate of 6 pounds per second at 80 psig for engine starting and motoring, is available.

(2) A-5 Test Stand

(a) General Description

A-5 is a sea level calibration and endurance stand for full-scale engine testing.

(b) Modifications and Additions

An increased-flow fuel filter, duct reverser and supports, inlet screen and dolly, 80,000 pounds thrust platform assembly, engine thrust mount, and concrete thrust block set on piling, concrete pads behind engine exhaust, engine transport trailer, and additional data recording system components will be added. The existing fuel package will be modified for increased flow.

(c) Resulting Test Stand Capabilities

The capabilities will be the same as those of A-3 and A-4.

(3) A-6 and A-7 Test Stands

(a) General Description

A-6 and A-7 are sea level calibration and endurance stands for full-scale engine testing. They will be modified specifically for delivery engine testing.

(b) Modifications and Additions

An increased flow fuel filter, duct reverser and supports, inlet screen and dolly, supports, 80,000 pounds thrust platform assembly, engine thrust mount, and concrete thrust block set on piling, concrete pads behind engine exhaust, engine transport trailer, and a 14-channel strain gauge system will be provided at both stands.

For A-7 only, continuous monitoring equipment, a 40-manometer tube bank and a 400 cycle M-G set will be added.

(c) Resulting Test Stand Capabilities

The thrust block, thrust stand and measuring system will be capable of withstanding 80,000 pounds of thrust.

The following instrumentation will be provided:

1. 56 channels of transient recording capability with portable equipment
2. Control Room instrumentation for observation of pressure, temperature and flow (manometers, pressure gages, digital readouts and potentiometers).
3. Continuous monitoring equipment of 18 channels fed into a magnetic tape recorder/reproducer system.

Three separate fuel systems, each capable of supplying 120,000 pounds per hour of jet fuel at ambient temperature and pressures to 100 psig, are available.

A compressed air system that is capable of delivering air at a rate of 6 pounds per second at 80 psig for engine starting and motoring, is available.

(4) ...-11 Burner Stand

(a) General Description

This stand is capable of burner rig, afterburner spraybar rig, and turbine rig testing. Inlet air is ducted to the rig from a JT3 engine exhaust.

(b) Test Stand Capabilities

1. Fuel flow of 2000 pounds per hour at 500°F
2. Airflow
   a. 160 pounds per second at 900°F, vitiated
   b. 9 pounds per second at 450°F and 120 psig, nonvitiated (JT3 bleeds)

c. New Sea Level Test Stand Description

(1) A-9 Test Stand

(a) General Description

A-9 stand will be a sea level facility suitable for testing the thrust reversers of the SST engine. In addition, it will be used for engine noise level determination, utilizing truck-mounted sound equipment operating on a road parallel to the axis of the engine.

(b) Equipment Required

The stand will consist of a control room, engine thrust stand and mounts, engine monitoring instrumentation, fuel and starter air systems, and sound measuring instrumentation.

d. Fuel Storage and Distribution System (Fuel Farm)

(1) General Description

A jet fuel storage area is located east of Areas A and C. A distribution system carries fuel to each test area.

(2) Modifications and Additions Required

Two new 1,000,000 gallon jet fuel storage tank systems, six new pumps, each with a pumping capacity of 650 gpm, and two new ten-inch distribution lines, including filters and valves, to Areas A and C will be provided.

(3) Resulting Capabilities

1. Fuel storage tanks totaling 3,300,000 gallons
2. Nine pumps, each with a 225 gpm capacity at a head of 296 feet
3. Six pumps, each with 650 gpm capacity at a head of 296 feet
4. Three six inch and two ten inch pipe lines distribute the fuel to Areas A and C.

e. Compressed Air Supply and Distribution System

(1) General Description

A compressed air system is located in Area A for engine starting and motoring. No modifications or additions are planned for the system. Its capabilities are:

1. Delivery of two pounds per second with four reciprocal machines operating
2. A total volumetric capacity of 3000 cubic feet is provided by seven air receivers
3. Delivery of six pounds per second of compressed air at 80 psig over short periods for jet engine starting and motoring.

2. Heated Inlet Engine Calibration and Endurance Test Facilities

a. SST Program Requirements

Three new heated inlet test stands will be required for the SST engine program to endurance test engines at cruise conditions. These stands will be designated C-8, C-9 and C-10.

b. General Description

The stands will be interconnected to the service facilities so that any two stands may be operated simultaneously. Ram air will be provided by compressors, driven by FT4A-2 drives. The pressure and temperature of the air supplied will simulate that required at cruise conditions. Fan air discharge, because of its higher total pressure, will be discharged to atmosphere. Engine air will be cooled by spray water, ducted to a scrubber to reduce the temperature and thence to exhausters, driven by FT4A-2 drives, exhausting the air to atmosphere. The engine will be shrouded and heated, and a fuel system will be provided to simulate actual temperature conditions encountered in flight. Provisions will be made for testing with simulated engine inlet distortion. The major components of each heated inlet stand will be an inlet duct and plenum, and engine shroud and mounts, exhaust ejector-diffuser, a fan air exhaust collector, a heated fuel system, and engine and stand instrumentation. Two control room buildings will be provided for the three stands.

A independent data acquisition system will be provided to make the following measurements from C-8, C-9 and C-10 test stands:

1. 80 steady-state pressure channels
2. 40 transient pressure and thrust channels
3. 100 temperature channels
4. 10 flow and speed channels.

The system will record from one test stand at a time, but will be able to switch from one stand to another in a matter of seconds. Included is a tie-in to the existing computer in Area A providing Control Room display of critical performance parameters while testing is in progress.

The heated inlet stand services consist of four 200,000 SCFM compressors driven by two FT4A-2 drives. Each set is capable of supplying the ram air required by one heated inlet stand and therefore two stands can be run simultaneously. The exhauster system will consist of four 200,000 SCFM compressors driven by one FT4A-2 drive. Two compressors will exhaust the engine air from each stand to atmosphere. Scrubbers will cool and exhaust gases and remove moisture from them. The Area C cooling tower system will supply the necessary cooling water.

c. Resulting Test Capabilities

1. Fuel flow of 70,000 pounds per hour at 55 psig heated to 300°F or 120,000 pounds per hour at ambinet (sea level)
2. Ram airflow: 515 pounds per second at 51 inches of mercury, absolute (Hga)
3. Exhaust airflow: 123 pounds per second at 10 inches Hga
4. Temperature air: Temperatures up to 500°F

A diagram of the facility is shown in figure 16. The heated inlet facility envelope is shown in figure 17.

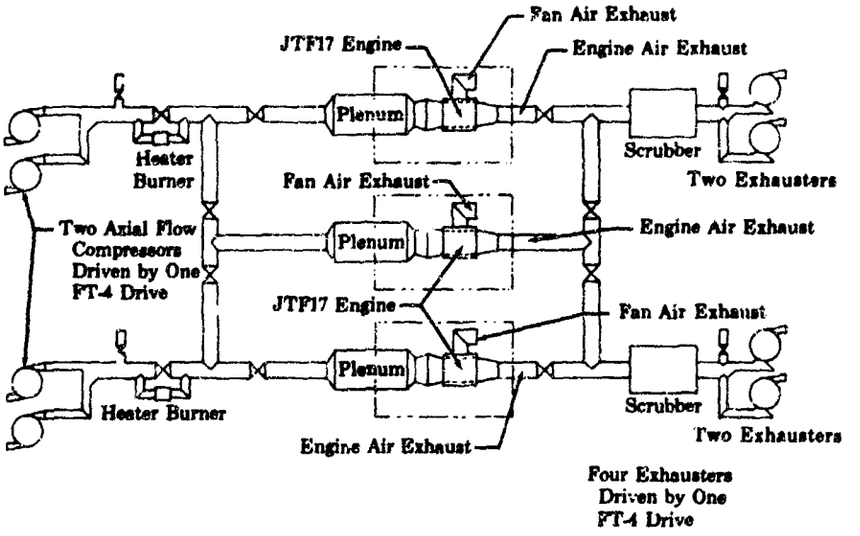


Figure 16. Heated Inlet Stands - C-8, C-9, and C-10 FD 17677 VB

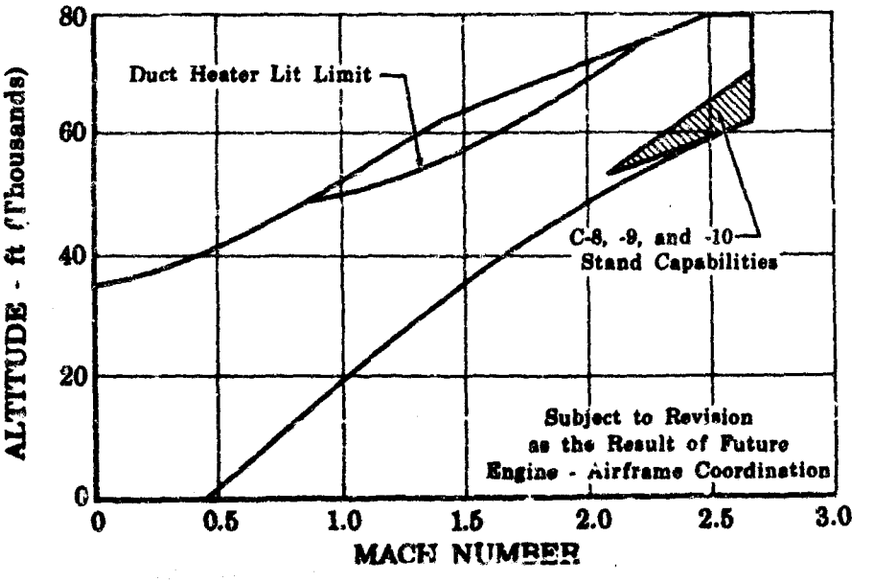


Figure 17. C-8, C-9, and C-10 Test Stand Capabilities FD 17678 VB

3. Simulated Altitude and High Mach Number Engine Test Facilities

a. SST Program Requirements

Two Simulated Altitude and High Mach Number Engine Test Stands are necessary to conduct the testing required. In this facility, flight conditions can be simulated over an engine flight envelope. One existing test stand, C-4, will be available after modification for testing the JTF17 engine. One new test stand, C-6, will be constructed. Both C-4 and C-6 stands will be connected to Area C services.

b. Existing Test Stand Description

(1) C-4 Test Stand

(a) General Description

The C-4 test stand provides simulated Mach number conditions of pressure, temperature, and air-weight flow for full-scale engine testing. (See figure 18 for C-4 stand with JTF17 engine mounted.)

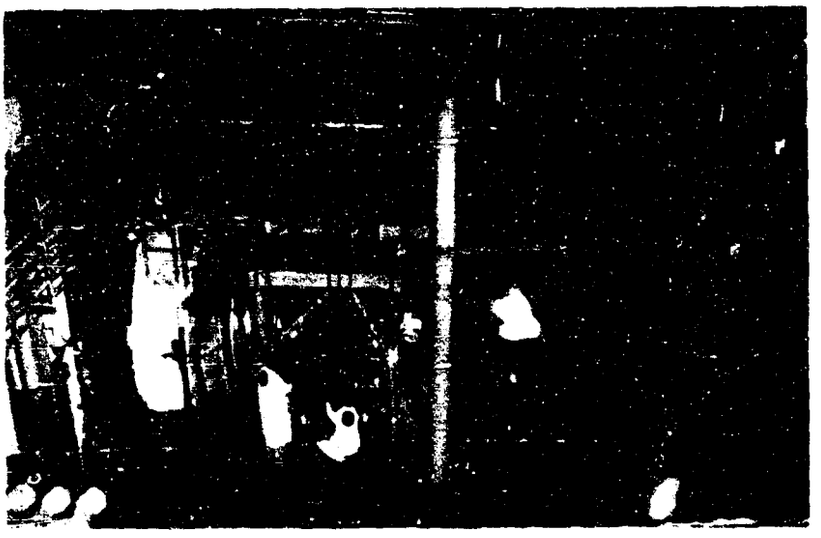


Figure 18. C-4 Test Stand with a JTF17A Engine Installed FAE 61153 VB

(b) Modifications and Additions Required

1. Modify stand plenum chamber ducting and valves to supply air to a turbofan-type engine
2. Connect fuel system into new fuel heater
3. Provide engine shroud and ejector diffuser
4. Provide increased stand instrumentation and data acquisition
5. Rework existing fire protection and detection systems.

(c) esulting Test Stand Capabilities

1. Fuel flow of 150,000 pounds per hour at 55 psig and 300°F heated conditions
2. Ram airflow: 1240 pounds per second at 500°F and 150 inches Hga atmospheric intake
3. Exhaust airflow
   a. 300 pounds per second at 12 inches Hga
   b. 625 pounds per second at 22 inches Hga
   c. Atmospheric exhaust

(d) Data Acquisition System (See figure 19.)

A centrally located data acquisition system is provided with the capability of recording the following:

1. 320 steady-state pressure channels
2. 180 temperature channels
3. 40 transient pressure channels
4. 10 flow and speed channels

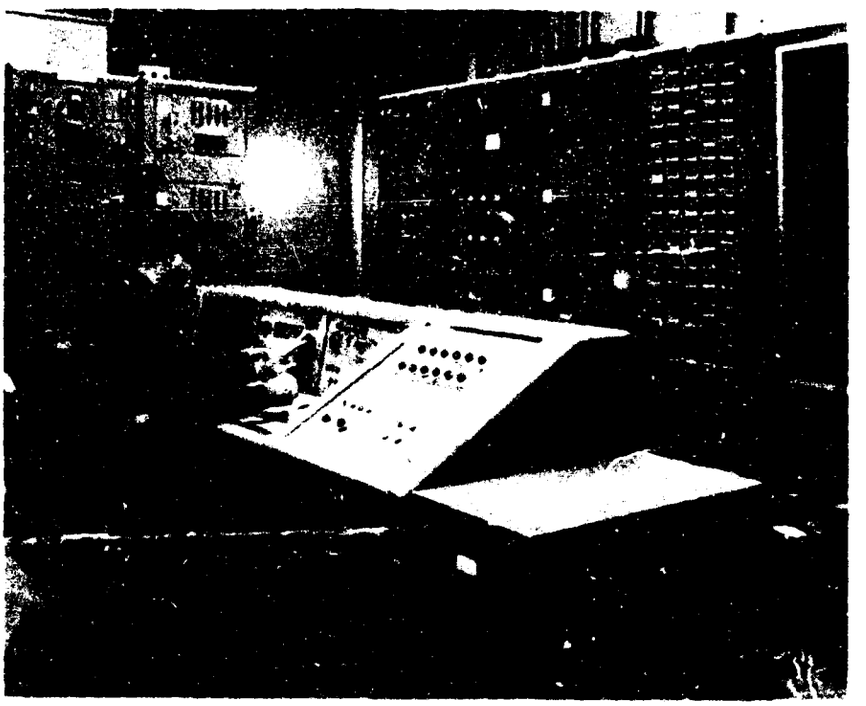


Figure 19. Data Acquisition System - C-4 Test Stand FC 12348 VB

The data acquisition system can be used to record data in two basic modes; steady-state and transient. In the steady-state mode, 10 readings are taken from each channel and the average of these 10 readings is used to define steady-state performance. In the transient mode, all or a selected portion of the channels are sampled at a high sample rate for the duration of the transient. The transient mode has been used on engine test programs to study control system response, starting characteristics, surge line definition, and simulated mission cycles.

A general purpose digital computer (figure 15) is provided to make computed results available to the test engineer while the test is in progress. This computer is integrated with both the Area A and Area C data recording systems. The computer converts the raw digital data into engineering units, and then solves performance analysis equations and the condensed results are transmitted to printers located in the control rooms. Typical calculations include air flow, corrected fuel weight flow, Mach number simulated altitude, thrust specific fuel consumption, and component

efficiencies. Typical elapsed time between recording a point and having condensed data available to the test engineer is 2 minutes. Complete data reduction is also performed by the computer and tabulated on a high-speed printer for more complete data analysis.

c. New Test Stand Description

(1) C-6 Test Stand

(a) General Description

C-6 will provide simulated high Mach number conditions of pressure, temperature, and air-weight flows for full-scale engine testing. The major components will be control room building, test stand structure including crane and engine bedplate, engine shroud and engine ejector-diffuser, air and gas ducting, engine plenum section, control valves and controls, heated fuel system consisting of heater and distribution system, fire protection and detection system, control room and stand instrumentation connections to existing data acquisition system and mechanical and electrical installation of all equipment. The C-6 facility flight envelope is shown on figure 20.

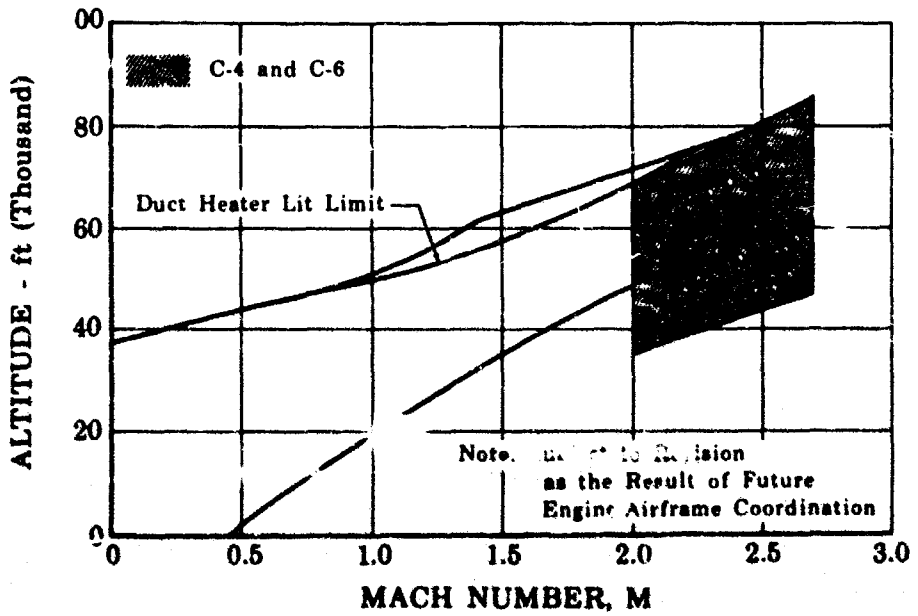


Figure 20. C-4 and C-6 Test Stand Capability FD 17680 VE

(b) Resulting Test Stand Capabilities

The test stand capabilities will be the same as C-4. A diagram of C-6 facilities is shown on figure 21.

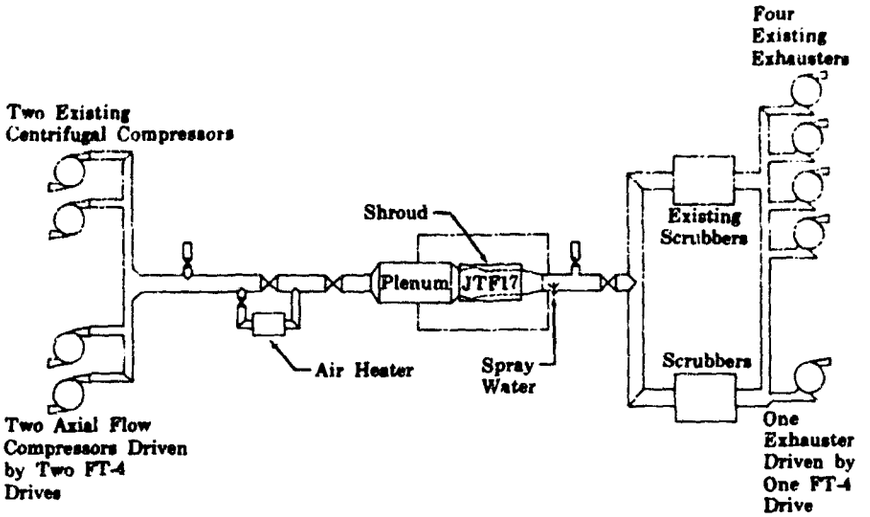


Figure 21. Altitude Test Stand C-6 FD 17681
VB

(2) Engine Altitude Test Stand X-210

This test stand, which is located at The Andrew Willgoos Turbine Laboratory in East Hartford, Connecticut, is a duct-connected engine test stand. It is currently the largest in the Laboratory and is designed to utilize the entire compressor and exhauster capacity. This stand will be used for that part of the JTF17 engine development testing requiring refrigerated air. The X-210 test capabilities map is shown on figure 22.

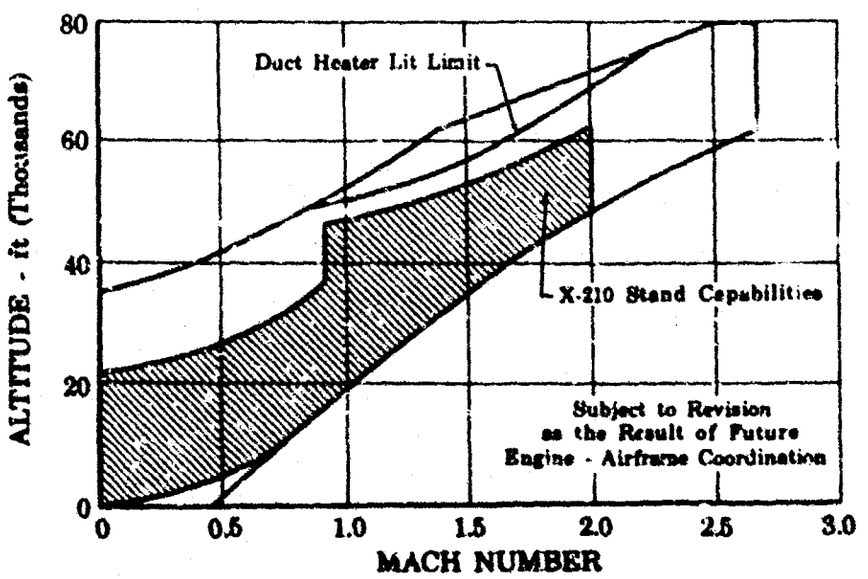


Figure 22. X-210 Test Stand Capabilities FD 17682
VB

(1) Test Stand Capabilities

1. Maximum altitude: 90,000 feet
2. Maximum refrigerated air: 450 pounds per second at -10°F
3. Fuel supply capability: 60,000 pounds per hour from -65 to 165°F

4. Simulated Altitude and High Mach Number Component Test Facilities

a. Fan and Compressor Facilities

(1) SST Program Requirements

Two full-scale fan and compressor test stands are required. One existing stand, C-3, will be used for JTF17 high compressor rig testing on a "share" basis with the J58 program. One additional stand, C-7, will be constructed for full time testing of either the JTF17 high or low compressor. Both stands will utilize the compressor-exhauster capabilities of the Area C service facilities.

(2) Existing Test Stand Description and Capabilities

Test stand C-3 provides simulated high Mach number conditions of pressure, temperature, and airflow for compressor testing. No modifications are required or planned for this stand. Its capabilities are:

1. Ram airflow:
   a. 400 pounds per second at 105 inches Hga
   b. 500 pounds per second at 60 inches Hga
   c. Throttled atmospheric intake
2. Exhaust airflow:
   a. 20 pounds per second at 1.5 inches Hga
   b. 250 pounds per second at 22 inches Hga
   c. Atmospheric exhaust
3. Air temperature: 250 pounds per second at 700°F
4. Steam turbine drive delivering 24,000 hp at 8500 rpm to test compressor
5. Instrumentation: Centrally located Automatic Data Acquisition and processing equipment with:
   a. 180 temperature channels
   b. 200 steady-state pressure channels
   c. 40 transient pressure channels and 9 speed or flow channel
6. Data system produces computed performance parameters in the control room while testing is in progress

7. Similar channels to the above are also reproduced in the control room for test personnel observation.

(3) New Test Stand Description

Test stand C-7 will provide simulated high Mach number conditions of pressure, temperature, and airflow for full-scale fan or high pressure compressor testing. The major components will be a control room building, stand structure, compressor and turbine bedplates, control room and test stand instrumentation, air and gas ducting, inlet section, control valves and controls, test compressor mounts, exhaust collectors, inlet adapter, test compressor drive equipment, and mechanical and electrical installation of all equipment. Data acquisition equipment will be provided and connected to the existing Area C data system.

(4) New Test Stand Capabilities

1. Max airflow:

   a. 400 pounds per second at 120 inches Hga
   b. 500 pounds per second at 60 inches Hga
   c. Throttled atmospheric intake

2. Exhaust airflow

   a. 20 pounds per second at 1.5 inches Hga
   b. 250 pounds per second at 23 inches Hga
   c. Throttled atmospheric exhaust

3. Air temperature: 700°F at 250 pounds per second at 120 inches Hga

4. Gas turbine drive, delivering 52,500 hp at 9000 rpm

5. Data acquisition system:

   a. 160 steady-state pressure channels
   b. 100 temperature channels
   c. 100 transient pressure channels (40 convertible to temperature)
   d. 9 flow and speed channels.

A diagram of the C-7 facility is shown on figure 23.

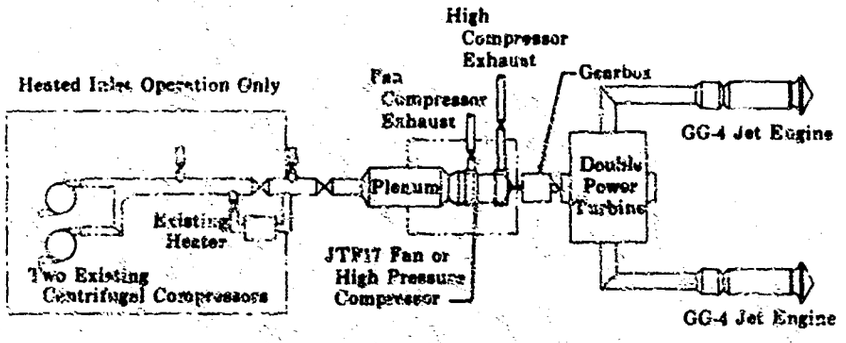


Figure 23. C-7 Compressor Test Stand

FD 17684
VB

b. Turbine and Burner Facilities

(1) SST Program Requirements

Two test stands are required for turbine component testing. These stands are required to investigate and develop turbine blade and vane materials and configurations. Two existing FRDC test stands, C-1 and C-2, will be available for this testing. Each stand is connected to the Area C service facilities.

(2) Stand Description and Capabilities

C-1 and C-2 each provide simulated operating conditions of temperature, pressure, and air-weight flow for turbine blade and vane testing. No modifications are required or planned for these stands. Their present capabilities are:

1. Ram airflow:

   a. 8 pounds per second at 63 inches Hga
   b. 100 pounds per second at 120 inches Hga
   c. 24 pounds per second at 180 inches Hga

2. Exhaust airflow: 15 pounds per second at 4.2 inches Hga

3. Air temperatures:

   a. 20 pounds per second at 900°F nonvitiated
   b. 120 pounds per second at 350°F nonvitiated
   c. 20 pounds per second at 2500°F vitiated

4. Jet fuel: 5000 pounds per hour at ambient temperature to 500°F and 500 psig

5. Instrumentation:

   a. Thirty - 100-inch manometer tubes
   b. Forty-three - temperature channels (0-2400°F)
   c. Forty-seven - temperature channels (0-1200°F)

6. Data recording:

   a. 80 temperature channels
   b. 40 pressure channels
   c. 5000 measurements per second.

5. Simulated Altitude and High Mach Number Service Facilities

a. SST Program Requirements

Area C test stands require additional ram and exhaust flow capacity, inlet air heating, and exhaust gas cooling capacity.

b. Existing Facility Description

Compressor-exhauster units, scrubbers, ejectors, and air heater provide simulated altitude and Mach number conditions for engine and component testing in Area C. (See figure 24.)

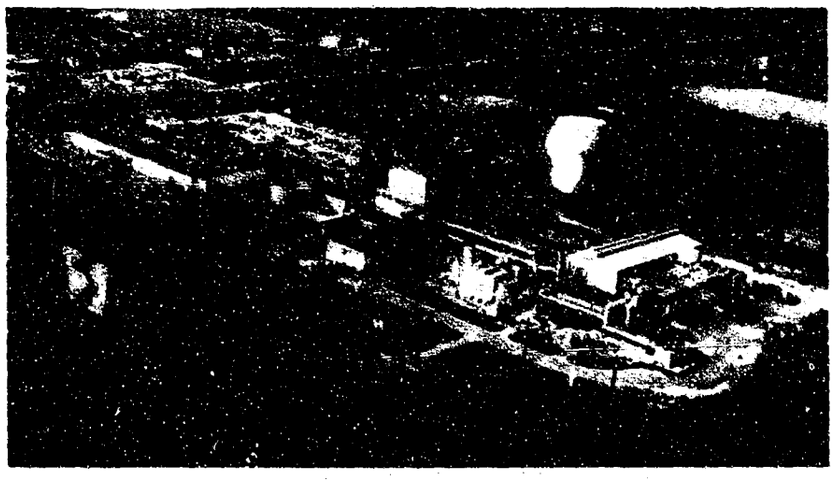


Figure 24. Test Area C FC 13296 VB

c. Modifications and Additions

The major modifications will consist of new site work and a building for compressor-exhauster machinery; new FT4A-7 jet engine drive units and axial flow compressor-exhausters; air and exhaust gas ducting, valves and scrubbers; electrical services, including transformers, substation and feeds; utilities services; one new air heater; and a cooling and exhaust scrubbing water system, including a cooling tower.

d. Resulting Service Capabilities

1. Ram airflow: 1240 pounds per second at 105 inches Hga
2. Exhaust airflow:
   a. 300 pounds per second at 12 inches Hga
   b. 625 pounds per second at 22 inches Hga
3. Air temperatures: up to 500°F.

6. Small Components Test Facilities

a. SST Program Requirements

Twenty-eight small component stands and benches are required for development testing. They will be necessary for testing complete control systems and subcomponents; ignition systems; such mechanical components as oil pumps, gearboxes, bearings, and seal systems; and other engine auxiliary equipment. Two new electronic control benches will be built. The remaining 26 required stands and benches exist at FRDC in Area D, and will be available for JTF17 component testing.

b. Existing Facilities (Nonmodified)

A photograph of Area D is shown in figure 25. The following paragraphs describe the test facilities that will be available for the JTF17 test program without modification.

(1) D-1 Stand

(a) General Description

This stand is for testing bearing compartment seals of various types.



Figure 25. Test Area D

FC 4617
VB

(b) Present Stand Capabilities

1. Drive:

a. Gasoline engine; 125-hp, with gearbox output speed variable to 11,000 rpm maximum

b. "Varidrive," 15-hp; one output pad speed range 1100 to 5500 rpm; the other, 2400 to 12,000 rpm

2. Oil system: 22 gpm at 100 psi, design temperature 1000°F maximum
3. High-temperature air: 1000°F at 375 psi, or 1500°F at 150 psi, 0.33 pounds per second
4. Altitude exhaust: 0.3 pound per second airflow at 2 inches mercury absolute.

(2) D-3 Stand

(a) General Description

This stand is for testing engine oil pumps and bearing rigs.

(b) Present Stand Capabilities

1. Drive
   a. "Varidrive"; 60-hp; output drive speed range 2350 to 11,600 rpm
   b. Two "Varidrives;" 7-1/2-hp, 1000 to 5000 rpm variable speed output
2. Oil system: 22 gpm at 100 psi; design temperature 1000°F maximum
3. High-temperature air system: 1000°F at 375 psi or 1500°F at 150 psi, 0.33 pound per second.

(3) D-4 Stand

(a) General Description

This stand is for testing bearing compartment seal rigs.

(b) Present Stand Capabilities

1. Drive: Gasoline engine; 125-hp, with gearbox output speed variable to 11,000 rpm maximum
2. Oil system: 22 gpm at 100 psi, design temperature 1000°F maximum
3. High-temperature air: 1000°F at 375 psi, or 1500°F at 150 psi; 0.33 lb per second
4. Altitude exhaust: 0.3 lb per second airflow at 2 inches mercury absolute.

(4) D-9 Stand

(a) General Description

This stand is a low-flow, static test bench for testing valves, filters, spray manifolds, etc.

(b) Present Stand Capabilities

Fuel supply is 40,000 pounds per hour at 1000 psi and 150°F maximum, open or closed loop.

(5) D-13 Stand

(a) General Description

This stand incorporates hydraulic circuits and an actuator loading device for testing exhaust nozzle control systems.

(b) Present Stand Capabilities

Fuel supply is 50 gpm at 3000 psi and 100°F.

(6) D-14 Stand

(a) General Description

This stand is for calibrating high-flow fuel flowmeters, and is of the stand-pipe type.

(b) Present Stand Capabilities

Fuel supply is 200,000 pounds per hour, 100° to 200°F.

(7) D-15 Stand

(a) General Description

This stand is for calibrating low-flow fuel and oil flowmeters, and is of the weigh-scale type.

(b) Present Stand Capabilities

Fuel supply is 30 to 12,000 pounds per hour, 100° to 350°F temperature

(8) D-17 Stand

(a) General Description

This stand is for testing hydraulic actuators and starter bleed valves.

(b) Present Stand Capabilities

1. Fuel supply: 10 gpm at 0 to 5000 psi and 150°F maximum from a variable volume pump
2. Air supply: 1.5 lb per second at 1200°F and 375 psi.

(9) D-20 Stand

(a) General Description

This stand is an air turbine pump and control stand.

(b) Present Stand Capabilities

1. Fuel supply: 120,000 lb per hour at 1000 psi and 100°F
2. Air supply: 4.2 lb per second at 375 psi and 400°F maximum.

(10) D-23 Stand

(a) General Description

This stand is for testing fuel-oil heat exchangers and other lubrication system components.

(b) Present Stand Capabilities

Heat transfer fluid system has 8,000,000 Btu per hour capacity at 720°F.

(11) D-23A Stand

(a) General Description

This is a heat transfer stand and utilizes a high-temperature oil system in conjunction with portable low-horse-power variable speed drives.

(b) Present Stand Capabilities

Heat transfer fluid system, at 720°F, has an 8.000,000 Btu per hour capacity.

(12) D-31 Stand

(a) General Description

The purpose of this stand is to test gearboxes and drive systems at room temperature, under load.

(b) Present Stand Capabilities

This stand has a 350 hp dc variable-speed drive; several gearboxes are available.

(13) D-32 Stand

(a) General Description

This facility is an ignition system test stand for simulated engine operation of both chemical and electrical ignition systems. It is in an isolated location, which includes a burn-off area for chemical ignition fluids.

(b) Present Stand Capabilities

1. Air supply: Two 75 hp centrifugal blowers furnish 5 lb per second of air at 2 psig
2. Fuel system: 1000-gallon supply tank
3. Electric power: 23 volt dc and 110-volt, 400-cycle ac.

(14) DM-42 Stand

(a) General Description

This stand is for calibrating individual fuel spray nozzles.

(b) Present Stand Capabilities

1. Fuel supply: 4000 lb per hour at 1000 psi and 80°F
2. Spray chamber: Viewing port with adjustable protractor.

(15) DM-49 Stand

(a) General Description

This stand is for testing starter bleed valves at room temperature.

(b) Present Stand Capabilities

Air supply is 2 pounds per second at 125°F and 125 psi.

c. Existing Facilities (Modified)

The following paragraphs describe the modified test facilities that will be available for the JTF17 test program.

(1) D-7 Stand

(a) General Description

This stand is a high-temperature fuel system test stand for testing fuel pumps and controls, complete systems, system response, and heat rejection.

(b) Modifications and Additions Required

Increase air supply by modifying the supply system and adding an air heater; change gears in drive system; add new rig mounts.

(c) Resulting Stand Capabilities

1. Drive: 400-hp dc motor, regulated variable speed through operating range of full-scale engine rig
2. Fuel system supply: 350 gpm at 60 psi and 300°F, 15 gpm at 650°F open-loop system.
3. Fuel system capacity: 350 gpm at 1000 psi and 350°F test pump discharge
4. Air supply: 8.4 pounds per second at 110 psi up to 1100°F
5. Heat transfer fluid: 750°F, 500,000 Btu per hour
6. Test chamber: Available in several configurations to test components or systems in an inert atmosphere at temperatures from 400° to 1200°F.

(2) D-10 Stand

(a) General Description

This stand is a high-flow, static test bench for testing fuel system components and air turbine-driven pumps and controls.

(b) Modifications and Additions Required

Increase air supply by modifying the air supply system.

(c) Resulting Stand Capabilities

1. Fuel supply: 100,000 pounds per hour at 1000 psi and 150°F maximum, either open- or closed-loop with either clean or contaminated fuel
2. Air supply: 8.4 pounds per second at 110 psi and 400°F.

(3) D-11 Stand

(a) General Description

This stand is a general purpose stand for testing both shaft-driven and air turbine-driven fuel pumps and controls.

(b) Modifications and Additions Required

For fuel control testing:

1. Increase air supply by modifying the air supply system
2. Add a high-pressure boost pump
3. Add two loading rigs for hydraulic actuators
4. Add circuitry for electronic fuel controls
5. Add fluid circuits and instrumentation for unitized system.

(c) Resulting Stand Capabilities

1. Drive: 250 hp dc motor; variable-speed; gearbox output to 5500 rpm maximum
2. Air supply: 8.4 lb per second at 110 p.i and 400°F
3. Fuel system capacity: Up to 100,000 pounds per hour test pump discharge at 1000 psi and 250°F maximum; closed-loop system
4. Altitude exhaust: Fuel supply tank to 60,000 ft on open-loop system.

(4) D-12 Stand

(a) General Description

This is a general purpose fuel test stand for shaft driven pumps and controls.

(b) Modifications and Additions Required

For fuel control testing:

1. Add an air supply and a high-pressure boost pump
2. Change gear ratios in drive system
3. Add two loading rigs for hydraulic actuators
4. Add electronic and fluid circuits and instrumentation.

(c) Resulting Stand Capabilities

1. Drive: 400 hp DC motor; variable-speed, dual-pad gearbox, output to 5000 rpm and 16,000 rpm
2. Air supply: 8.4 pounds per second at 110 psi and 400°F
3. Fuel system capacity: 120,000 pounds per hour test pump discharge at 1000 psi and 250°F maximum, closed-loop system
4. Altitude exhaust: Fuel supply tank to 60,000 ft on an open-loop system.

(5) D-16 Stand

(a) General Description

This is a hydraulic pump test stand

(b) Modifications and Additions Required

For testing large capacity hydraulic pumps, increase the system flow capacity; change gear ratio of drive system.

(c) Resulting Stand Capabilities

1. Drive: 150 hp eddy-current clutch; gearbox output speed variable to 5500 rpm maximum

2. Fuel system capacity: 120 gpm at 3000 psi and 350°F maximum boost pump pressure of 125 psi

3. Test chamber: Inert atmosphere at 400° to 1200°F.

(6) D-18 Stand

(a) General Description

This is a general purpose fuel pump and control stand.

(b) Modifications and Additions Required

For fuel control testing:

1. Add an air supply and a high-pressure boost pump
2. Add two loading rigs for hydraulic actuators
3. Add electronic and fluidic circuits and instrumentation
4. Install a 250 hp dc drive and change gears.

(c) Resulting Stand Capabilities

1. Drive: 250 hp dc motor

2. Fuel system supply: 120,000 pounds per hour at 1000 psi, and 100°F and 12,000 pounds per hour at 3000 psi

3. Air supply: 8.4 pounds per second at 110 psi and 400°F.

(7) D-24 Stand

(a) General Description

The purpose of the stand is to conduct sea level and altitude testing of engine accessory gearboxes, oil systems, and auxiliary mechanical systems.

(b) Modifications Required

1. Provide a 1500 hp eddy-current clutch drive to meet JTF17 accessory power requirements

2. Provide a new 1500 hp drive gearbox

3. Provide a 400 hp variable-speed drive and gearbox to drive the second rotor of the rig

4. Provide an increase in substation capacity to handle the above load.

(c) Resulting Stand Capabilities

1. Drive: One 1500 hp eddy-current clutch drive, variable-speed; one gearbox, variable-speed; and one 400 hp variable-speed drive and gearbox

2. Test chambers: Rig-mounted, inert gas atmosphere at temperatures of 400° to 1200°F

3. Air supply: 6.0 pounds per second at temperatures up to 1100°F and pressure to 100 psi

4. Altitude exhaust: 4.2 pounds per second airflow at 4 inches Hga

(8) Ignition Lab

(a) General Description

The FRDC Ignition Lab provides for electrical and environmental tests on ignition systems and components, and is also equipped for maintenance of these items.

(b) Present Capabilities

1. G-3 Bench

   a. Test chamber - Main: 20 by 20 by 20 feet
      Ignitor: 5 by 5 inch diameter

   b. Temperature range - -200° to +250°F

   c. Vacuum range - Main: 1-micron Hga to atmospheric
      Ignitor: 1-micron Hga to 400 psia

2. G-16 Bench

   a. Pressure - 1000 psia maximum (nitrogen)

   b. Vacuum - Bell jar

   c. Power - 28-volt dc, variable voltage

3. G-17 Bench

   a. Pressure - 1000 psi maximum (nitrogen)

   b. Vacuum - Bell jar

   c. Power - 28-volt dc, variable voltage

4. G-18 Bench power - High voltage, 0 to 30 KV

(c) Modifications Required

1. A new ignition system power supply for the above benches

2. A new high-temperature ignition test oven with a provision for testing ignition cooling systems.

d. New Facilities and Equipment Required

The following paragraphs describe the new test facilities and equipment required for the JTF17 test program.

(1) Electronic Fuel Control Stands

(a) General Description

Two electronic fuel control stands are required to support the program. Each will be suitable for calibrating, reprograming, and maintaining vernier and airflow computers by simulating inputs, measuring vernier outputs, simulating output loads, and accomplishing troubleshooting.

(b) Equipment To Be Provided and Resulting Capabilities

1. Air supply: A clean, dry supply of 100°F, 125-psi air
2. Electric power:
   a. 3-phase, 400-cycle, 208/115 volt
   b. Single-phase, 110-volt, 60-cycle
   c. 28-volt dc
3. Cooling system: A small recirculating system will be provided for cooling test units
4. Input simulators and load simulators: To simulate inputs and loads
5. Electronic test equipment: Digital equipment to perform computer programing, test equipment for general troubleshooting, and interconnecting harnesses and plumbing.

(2) Data Recording Carts

(a) General Description

Four mobile recording carts are required to support the program. The carts will be used to monitor and record the transient and/or frequency response of the various engine components. Each cart will operate independently, and more than one cart may be used on one stand, as required.

The following equipment is to be provided on each cart:

1. One recording oscillograph
2. Three digital-to-analog converters
3. One bridge balance network
4. One power supply

(3) Delivery Component Stands

New control, hydraulic pump, nozzle, and spraybar benches will be provided to accomplish calibration testing of JTF17 delivery engine components.

C. SUPPORTING LABORATORY FACILITIES

Several laboratories are required to support the JTF17 engine and component development program. These laboratories are the Materials Development Laboratory, the Materials Control Laboratory, the Computer Laboratory, and the Instrument Laboratory.

1. Materials Development and Materials Control Laboratories

The Materials Development Laboratory is divided into three sections: the metallurgy section, the applied mechanics section, and the chemistry section. The Laboratory's function is to develop materials and processes for current and advanced engines, to evaluate existing and advanced engine component designs, and to perform engine failure analyses in support of the Project and Design Engineering departments.

The Materials Control Laboratory is responsible for assuring that contract materials and parts conform to the material, chemical, and metallurgical requirements established by Project and Design Engineering drawings and specifications. The Laboratory consists of three groups: technical and clerical control, materials testing, and X-ray and metallurgical process control.

The existing equipment and that to be acquired for the above laboratories is listed in Section IV, tables IV-13, IV-14, and IV-35 through IV-37.

2. Computer Laboratory Facilities

The Computer Laboratory supports propulsion research and development programs with technical and mathematical analyses, applied digital programming, analog simulation, and computer solution of engineering, scientific, and related problems. Support is also provided for management operation and control programs, computer programing research, and computer system development.

Two IBM System 360, Model 50 computers provide the primary computing capability for engineering and scientific calculations. These two computers will be replaced by a larger IBM System 360, Model 65 in late 1966. An IBM 1410 computer with remote feedback processes turbojet test data on-line. This computer will be replaced in mid-1967 by an IBM System 360, Model 40 to provide an increased capability. Smaller scale and less complex calculations are performed on three IBM 1620 computers located in the Engineering and Design Departments. These computers will be replaced early in 1967 by three IBM 1130 computers to provide increased capability and more economical operation. An IBM 1410 computer prepares management information and control reports. An IBM System 360, Model 30 provides off-line input/output capability and capacity for small scale maintenance routines and 1401 computer emulation. Each of two Benson-Lehner automatic plotters can plot up to 300 points per minute from magnetic tape. These plotters also have curve line drawing capability. A Beckman/Berkeley EASE 2133 Repetitive Analog Computer System solves high order, complex differential equations. This system, which can simulate all components required for turbojet or rocket engine transient and steady-state studies, consists of two control consoles, each having 3600-hole problem boards, a time scale, itinerative control capabilities, and interconsole slaving. Within the system there are 324 operational amplifiers, 80 high accuracy electronic multipliers, 48 diode-function generators, 48 servo-set diode function generators, and 448 coefficient potentiometers.

A summary of the equipment described below is presented in Section IV, tables IV-12 and IV-28.

a. IBM System 360, Model 65 (See figure 26.)



Figure 26. IBM System 360, Model 65 FC 13426 VB

(1) Configuration

The Model 65 has 512K bits of storage; four Model 2404 tape drives (8 tapes); sixteen Model 2311 disk storage drives; four Model 1403 N1 printers; two Model 2540 card readers/punches; one Model 2302 4-disk storage unit; one Model 2860 3-selector channel; one Model 2870 multiplexor channel; and one Model 2365 2-processor storage.

(2) Processing Unit

This unit features a general and floating point register implemented in high speed internal circuitry, 200-nanosecond read-only storage for control of the processing unit, 8-bit parallel data flow, and instruction overlap for increased speed.

(3) Core Storage

Core storage consists of a 750-nanosecond storage cycle with 8-bit access and double words that are two-way interleaved for improved sequential access.

(4) Instruction Overlap Devices

The Model 65 has additional storage provided by a Model 2301 drum with a capacity of 4 million bits and a data transfer rate of 1.2 million bits per second.

(5) Channels

The Model 2860 selector channel unit with three channels and the two selector subchannels on the Model 2870 multiplex channel permit the simultaneous operation of five high speed instruction overlap devices concurrent with main program execution. The Model 2870 with multiplex channels permits the concurrent operation of all printers and card reader/punches, which are overlapped with selector channel and processing unit operation.

(6) Computations

Computations performed by the IBM System 360 include engineering analysis in the following areas: stress and vibrations; heat transfer; compressor, turbine, and pump design; combustion instability; flight analysis; controls; design automation; numerical analysis; statistical analysis (PERT, simulation, reliability, operations research, information retrieval); combustion performance and thermodynamics; engine and component theoretical performance; and on-line engine and component test data reduction and performance.

b. IBM System 360, Model 40 (See figure 27.)



Figure 27. IBM System 360, Model 40 FC 13423
VB

(1) Configuration

The Model 40 has 128K bits of storage; two Model 2415 tape drives; three Model 2311 disk drives; one Model 1403 N1 printer; one Model 2501 B1 card reader; one Model 2520 B3 card punch; and one Model 2701 data adapter unit for interfacing to teleprinters and the data acquisition system.

(2) Processing Unit

This unit has a storage cycle time of 2.5 microseconds with 2-bit access, 625 nanosecond read-only storage for control of the processing unit and instruction overlap functions, and 625 nanosecond local storage for general and floating point registers.

(3) Instruction Overlap Devices

Model 2415 tapes have a data transfer rate of 15,000 bits per second; the Model 1403 N1 printer can print up to eleven hundred 132 character lines per minute; the Model 2501 is a serial card reader using a light sensing mechanism which permits operation at 600 cards per minute; and the Model 2520 punches at the rate of 300 cards per minute. With the parallel data adapter feature, the Model 2701 is the interface between the CSC millisadic acquisition system and the Model 40.

(4) Channels

Two selector channels allow simultaneous operation of tape and disk to be overlapped with computing operations. The printer, reader, punch, and Model 2701 are all attached to the multiplex channel.

(5) Functions

This system reduces recorded test data to engineering units and computes performance parameters. Results are teletyped on-line to test stand control at an average of 300 character messages in less than one minute from time of data acquisitions, thus enabling the test conductor to monitor a test run in almost real time. On-line data acquisition is an invaluable aide to engineering analysis of turbojet and turbofan propulsion unit testing.

c. IBM 1130

Three IBM 1130 computers are available in Design, Project Engineering, and Experimental Engineering to perform engineering calculations that do not require large scale, high speed processing systems. These computers provide the engineer with fast, accurate answers to simpler problems at a considerable saving of time and labor over previous methods employing manually operated calculating equipment. The IBM 1130 computer is shown in figure 28.



Figure 28. IBM 1130 Computer FC 13425
VB

d. IBM 1410 (Business Applications) (See figure 29.)

An IBM 1410 solid state digital computer with simultaneous input/output computer capability and large core and tape storage is used to process data required for effective management control of plant operations. This system is utilized in daily processing of information necessary for distribution of labor and material charges, inventory control, procurement, inspection of parts and assemblies, job scheduling, status and cost information, parts availability, bills of materials, maintenance and tool control, and test facility scheduling and control.



Figure 29. IBM 1410 FC 8633
VB

e. IBM System 360, Model 30 (See figure 30.)

(1) Configuration

The Model 30 has 32K bits of storage; two Model 2402 1 tape drives; two Model 1403 N1 printers; and one Model 2540 card reader/punch.

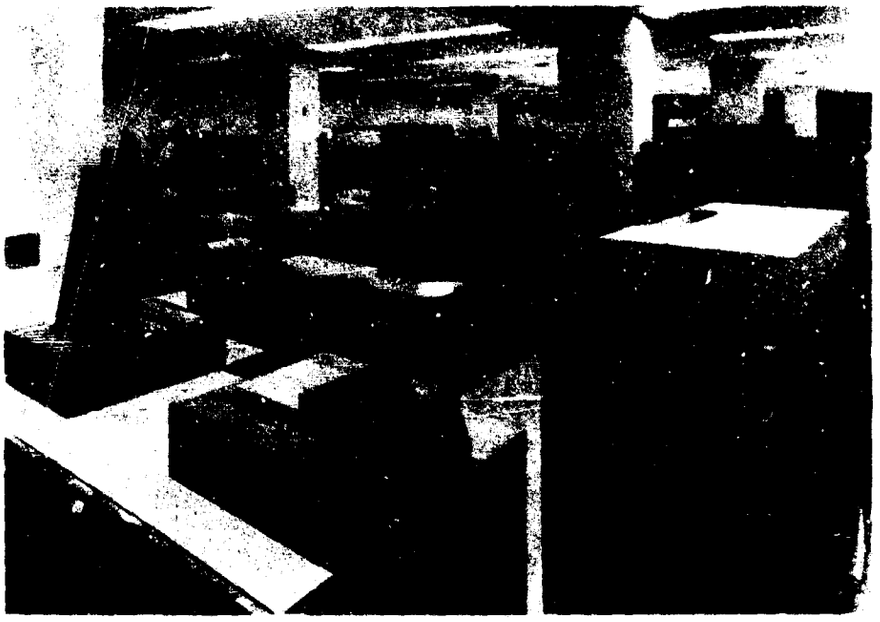


Figure 30. IBM System 360, Model 30 FC 13424 VB

(2) Processing Unit

This unit has a storage cycle time of 1.5 microseconds with 1-bit access, 750 nanosecond read-only storage for control of the processing unit and instruction overlap functions, and 750 nanosecond local storage for general and floating point registers.

(3) Instruction Overlap Devices

The Model 2402 1 tapes have a data transfer rate of 30,000 bits per second; the Model 1403 N1 printers can print up to eleven hundred 132-character lines per minute; and the Model 2540 card unit reads up to 1000 cards per minute and punches up to 300 cards per minute.

(4) Channels

The tapes are connected to a selector channel and the printers and card reader/punch are attached to the multiplex channel so that up to five instruction overlap operations may be in progress simultaneously, all overlapped with computing operations.

(5) Functions

The Model 30 performs the input/output functions required by the Model 1410 computer. The two high speed printers and one card reader provide printing at 2200 lines per minute and card reading at 1000 cards per minute. In addition, the Model 30 provides support and maintenance capabilities and emulation of Model 1410 computer processing. The Model 30 is an invaluable tool for performance of utility and test functions.

f. Benson-Lehner Plotter (See figure 31.)

Two automatic Benson-Lehner magnetic tape electro-plotter systems provide a wide variety of plots and graphs. Line plotting capability of up to six inches per second and point plotting up to 300 points per minute are achieved with a maximum absolute deviation of ±0.017 inch. The plot tapes are automatically written on the IBM System 360, Model 50 computer while data is being processed, thus eliminating the costly time delays of hand plotting.

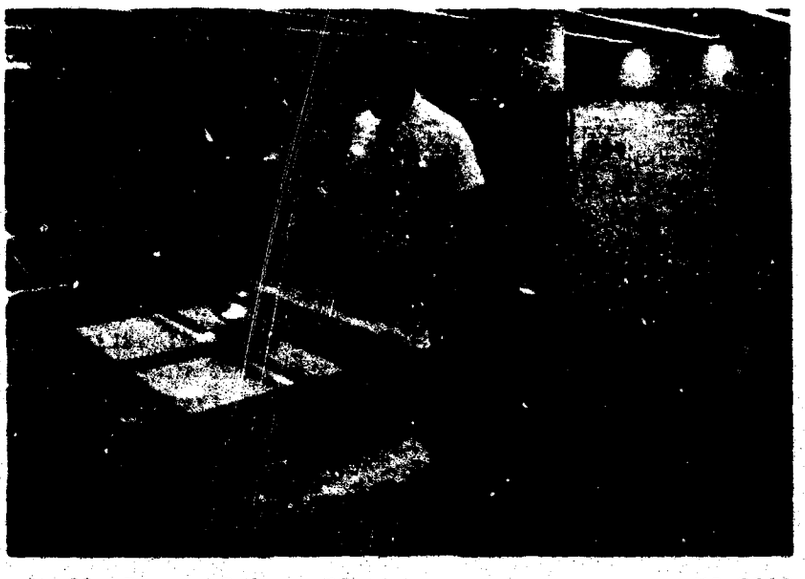


Figure 31. Benson-Lehner Plotter FC 8632
VB

g. Beckman 2133 (See figure 32.)

The FRDC Computer Laboratory has two Beckman Instruments Model 2133 large scale general purpose electronic analog computers, one Comcor, Inc. automatic tape set function generator system, and complete maintenance and calibration facilities. The 540 dc operational amplifiers plus a full complement of nonlinear equipment (typified by ninety-six 10-segment arbitrary function generators) can be used for solution of a large problem or of a number of less complex problems. Problem setup and checkout is automated through use of a Beckman digital input/output translator system, an IBM Model 1620 digital computer, a separate automatic paper tape control, and logic for function generator settings. Recent analog

simulations include air breathing jet engine transient analysis, hydraulic control analysis, stress analysis, heat transfer studies, and pump and bearing design analysis.



Figure 32. Beckman 2133 Analog Computer FC 5262
VB

3. Instrument Laboratory

The Instrument Laboratory is equipped and staffed to develop, maintain, and calibrate all types of precision instruments required for propulsion system, component development, and performance measurements. The calibration facilities are all National Bureau of Standards traceable. A total area of 12,000 square feet is devoted to electronic instrument development and construction, instrument welding and machining, maintenance of standards for calibration, and maintenance and calibration of a variety of instruments. Equipment is available for measuring and recording fuel flow, thrust, speed, pressure, vibration stress, chemical composition, heat transfer, and other variables associated with power plant evaluation. Humidity, vacuum and temperature chambers and vibration excitation equipment are available for environmental testing of small mechanical and electronic components. An additional area of 3500 square feet is located in other buildings on the plant site for data acquisition system maintenance and strain gage development and application. The major equipment existing in the laboratory is shown in Section IV, tables IV-15 through IV-17.

SECTION III
FACILITIES FOR PHASE V

Pratt & Whitney Aircraft facilities have evolved over 16 years of gas turbine engine production and are well suited for the development and production of the JTF17 engine. This is indicated by past production performance, existing facilities, planned engine programs, and future facilities plans.

This section discusses P&WA production facilities and describes production facilities utilization. Current floorspace and machine tool inventories are compared with future requirements for those years preceding and including the JTF17 engine program.

Four manufacturing facilities of Pratt & Whitney Aircraft, all company-owned and all in Connecticut, will be involved in the production of JTF17 engines. The layouts of these plants, discussed in this section, reflect the rearrangement to be completed prior to the beginning of the JTF17 production engine program. The four Connecticut facilities contain 7,897,600 square feet of floorspace and approximately 4000 production machine tools. Major machine tools at the Connecticut plants are listed in Section IV on table IV-18. The production facilities arrangements for the four manufacturing facilities are shown in table III-1.

Table III-1. Production Facilities Arrangements

Plant	Part Manufactured	Floorspace, sq ft
East Hartford		
Area I	Gears, gearshafts, and couplings	142,816
Area II	A variety of small machined details	122,097
Area III	Fan ducts, transition ducts, and heatshield assembly	143,757
Area IV	Fuel manifolds, compressor cases, and thrust reversers	237,852
Area V	Diffuser case assembly and intermediate case assembly	166,688
Area VI	Sheet metal details	221,337
Area XII	Inlet guide vanes, inlet guide vane assembly, and fan exit case	125,218
Area XIV	Vane and shroud assembly, and compressor and turbine shrouds	123,219
D-96	Semi-production (machining)	87,526
D-97	Semi-production (sheet metal forming and welding)	68,543
Area VIII	Engine assembly	222,412
Area VIII	Engine test	247,934
	East Hartford Plant:	1,907,399

Table III-1. Production Facilities Arrangements (Continued)

Plant	Part Manufactured	Floorspace, sq ft
North Haven		
Area XXI	Compressor and turbine disks, and fuel nozzle body	174,223
Area XXII	Compressor shafts, hubs, and spacers	133,800
Area XXIII	Turbine rotor blades and vanes	154,903
Area XXIV	Turbine cases, and large rings	158,751
	North Haven Plant:	621,677
Southington		
Area XXXV	Turbine exhaust case, diffuser case, and fan case	104,043
Area XXXVII	Gearbox housings, and supports	109,048
	Southington Plant:	213,091
Middletown		
Area XLII	High and low compressor shaft	50,459
Area XL	Turbine exhaust case assembly combustion chamber assembly and combustion chamber liners	98,108
Semi-Production Machining		26,661
	Middletown Plant:	175,228
	Total all four plants :	2,917,395

A. DESCRIPTION OF FACILITIES

1. East Hartford Complex

The East Hartford complex covers 1066 acres and is composed of the main administration offices of the United Aircraft Corporation and the Pratt & Whitney Aircraft Division; the Pratt & Whitney Aircraft main plant; the new materials center and assembly floor; the Andrew Willgoos Turbine Laboratory; Rentschler Airfield (private); the airport laboratory; and the United Aircraft Corporation Research Laboratory. An aerial view of the East Hartford complex is shown in figure 33, and the layout of the East Hartford complex is shown in figure 34.



Figure 33. East Hartford Complex Z 24989
VB

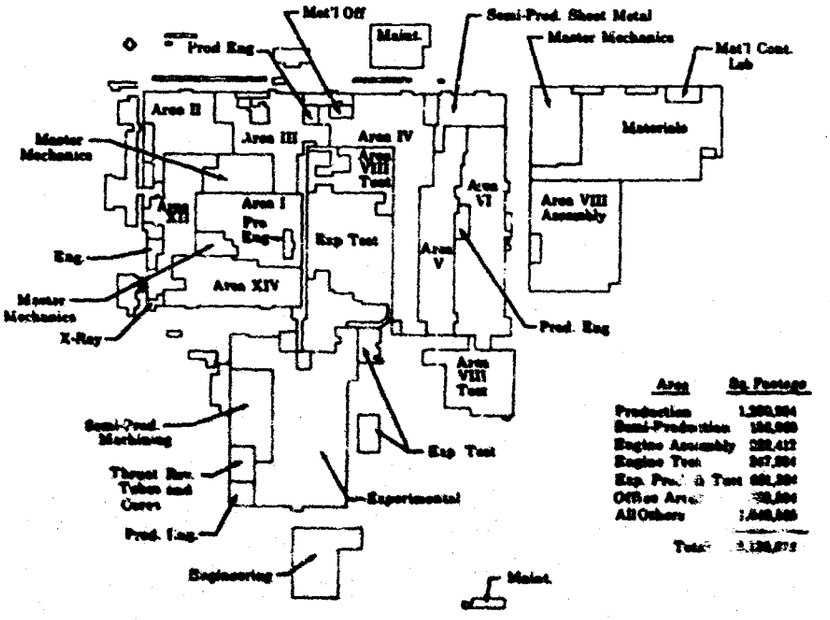


Figure 34. Layout of Main Plant at East Hartford FD 17688
VB

The new materials center, consisting of 433,000 square feet of floor-space, provides the latest in materials handling techniques and equipment. This center is a centralized facility that receives and dispatches materials to the shop and assembly floor, thereby expediting all phases of material handling and work flow for the JTF17 engine and current engine programs.

The new assembly floor, consisting of 222,412 square feet of floorspace, is ideally suited for the assembly of JTF17 production engines. Proximity to the materials center allows efficient flow of finished parts and assemblies to production assembly lines. Figure 35 shows two assembly lines on the assembly floor. A layout of the production assembly floor is shown in figure 36.

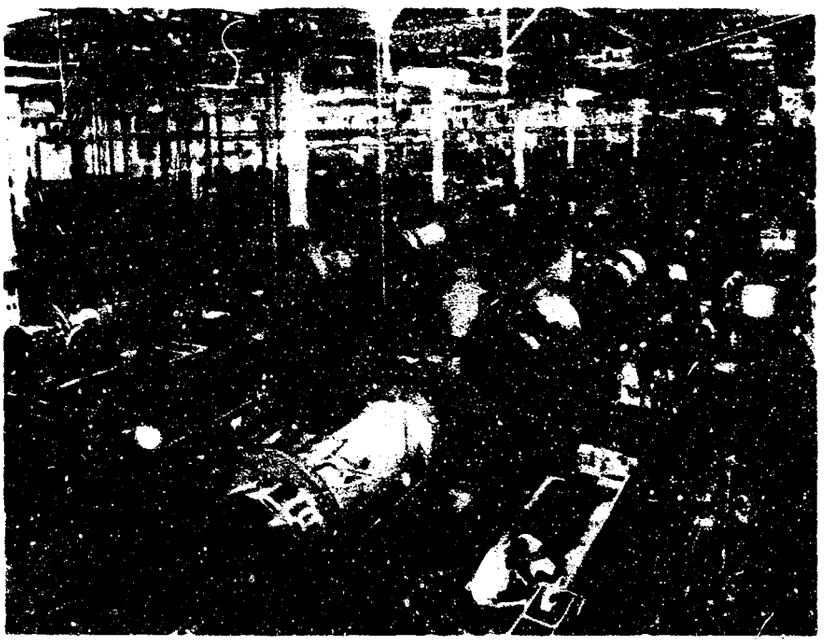


Figure 35. Production Assembly H 59011 VB

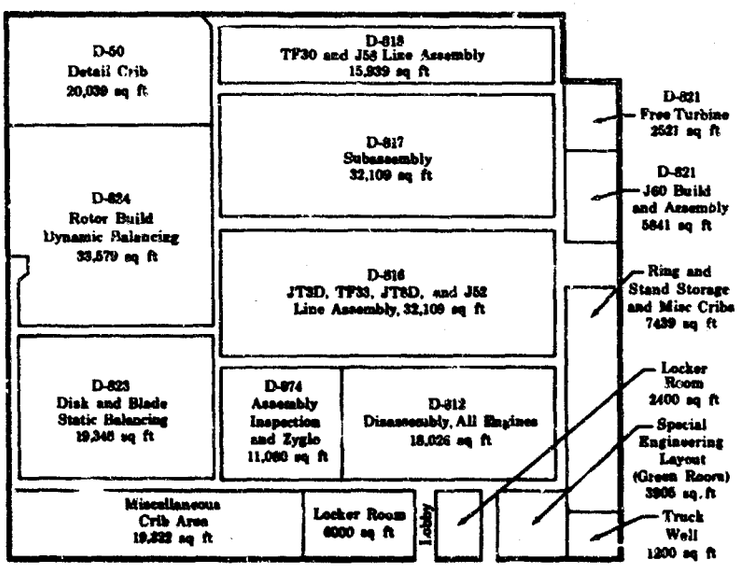


Figure 36. Production Assembly Floor Layout FD 17689 VB

2. North Haven Plant

The North Haven, Connecticut plant, which is situated on approximately 162 acres, contains facilities for production and the Advanced Materials Research and Development Laboratory. The production facility, occupying 621,677 square feet, is primarily engaged in producing rotating parts, turbine cases, and turbine vanes. The Advanced Materials Research and Development Laboratory is devoted to the research and development of materials with unique properties required for advanced engines. Figure 37 is an aerial view of the plant, and figure 38 shows the layout of the facilities.

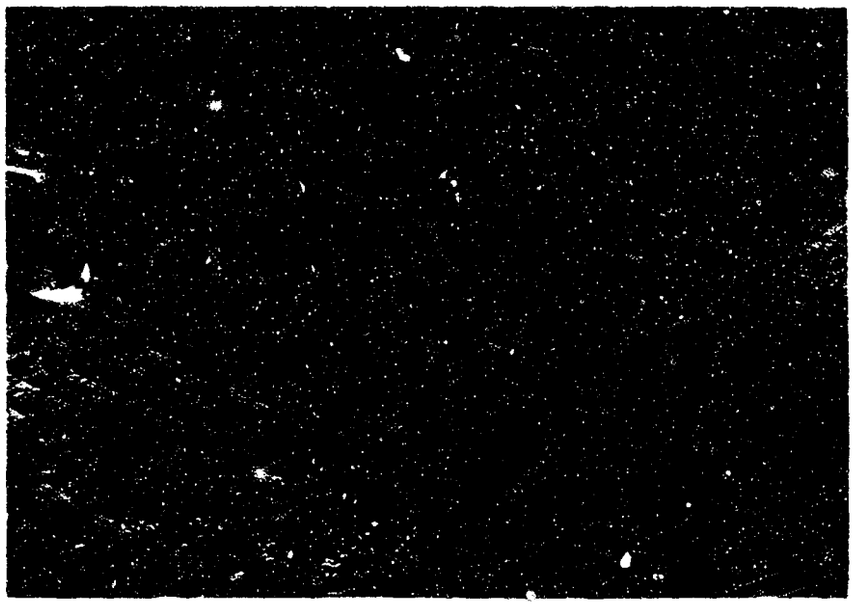


Figure 37. North Haven Plant CN 5803
VB

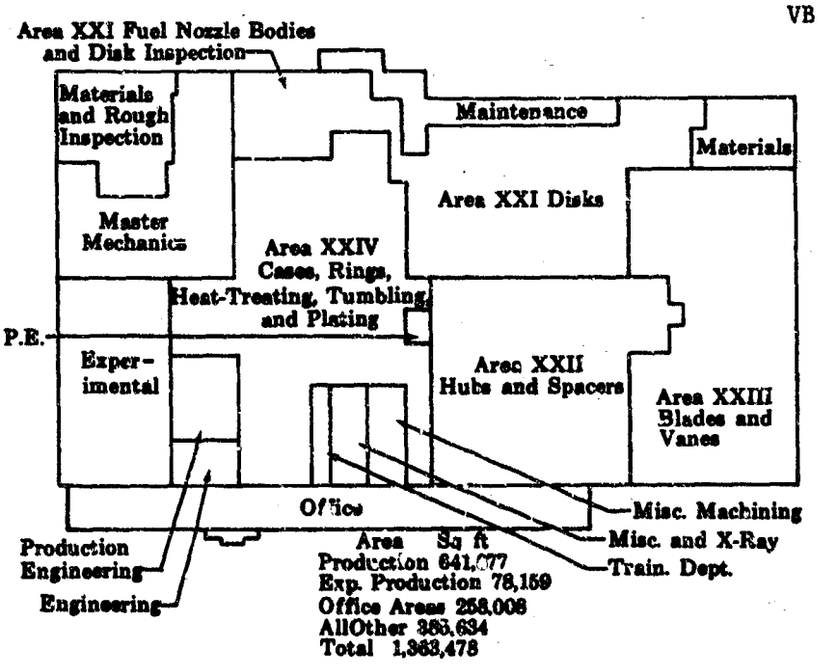


Figure 38. North Haven Plant Layout FD 17690
VB

3. Southington Plant

The plant at Southington, Connecticut contains 664,647 square feet of floorspace for the production of turned forged rings and machined gearbox housings and for engine overhauling. An aerial view of the plant, which is situated on a 40-acre tract, is shown in figure 39. Figure 40 shows the layout of the Southington plant.

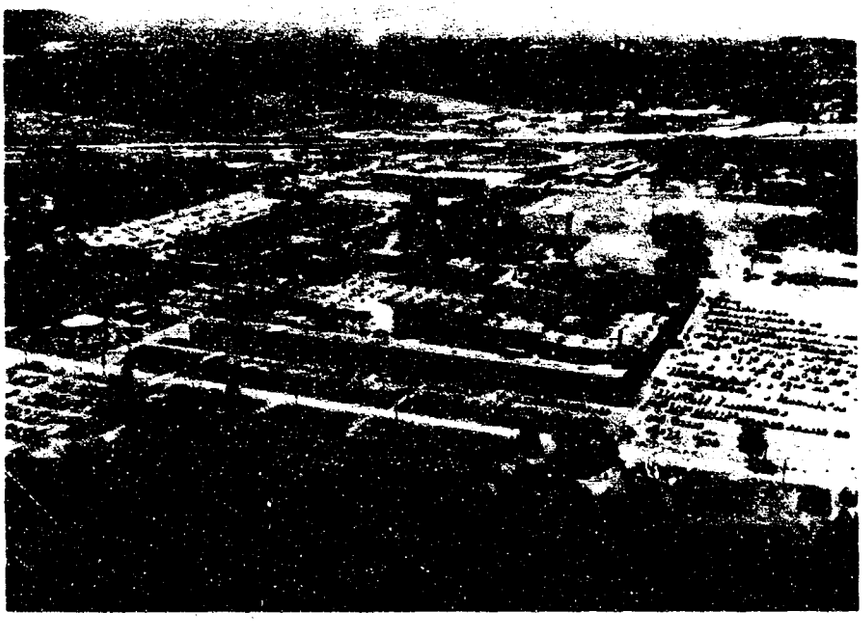
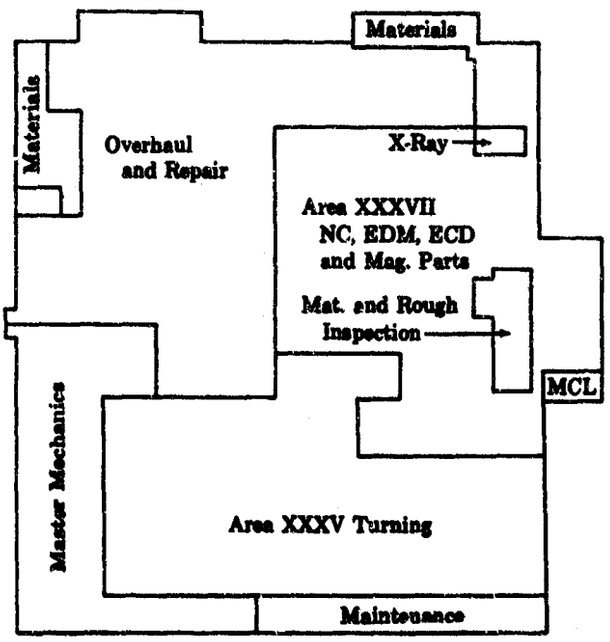


Figure 39. Southington Plant

Z 24986
VB



Area	sq ft
Production	213,091
Overhaul and Repair	136,386
Office Area	38,079
All Other	277,091
Total	684,647

Figure 40. Southington Plant Layout

FD 17691
VB

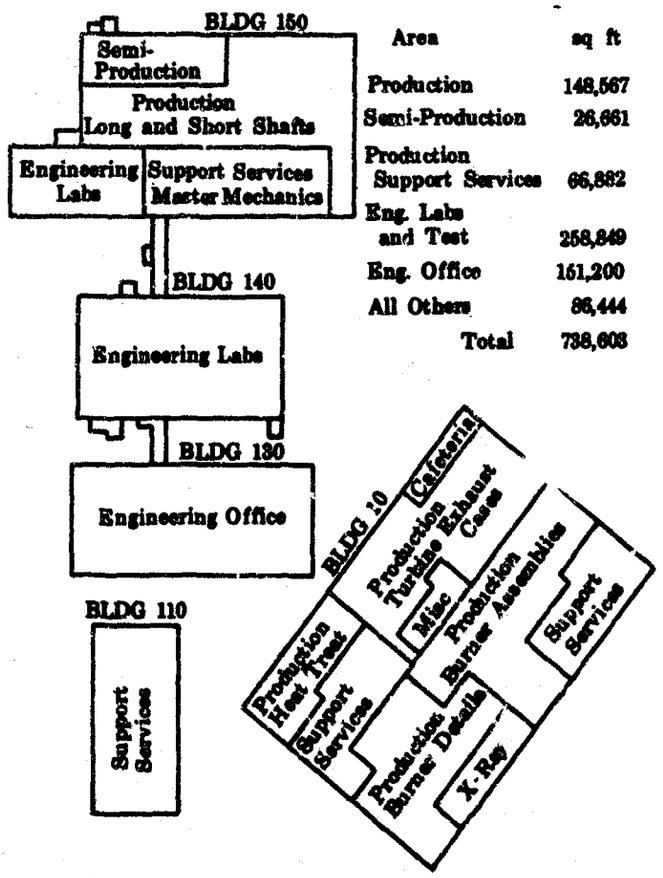
4. Middletown Plant

The Middletown, Connecticut plant, which is a recent P&WA acquisition, contains approximately 148,000 square feet that will be devoted to the production of long and short shafts, burner can details and assemblies, and turbine exhaust assemblies. An aerial view of the plant, situated on 1000 acres of company-owned land, is shown in figure 41. Figure 42 shows the layout of the Middletown plant.



Figure 41. Middletown Plant

CN 1849
VB



Area	sq ft
Production	148,567
Semi-Production	26,661
Production Support Services	66,882
Eng. Labs and Test	258,849
Eng. Office	151,200
All Others	86,444
Total	738,603

Figure 42. Middletown Plant Layout

FD 17692
VB

5. Leased Facilities

a. Summary of Leased Facilities

In addition to company-owned facilities, Pratt & Whitney Aircraft leases other Connecticut facilities. Leasing such facilities provides P&WA with additional floorspace, capacity, and flexibility without increasing fixed cost. Leased facilities that will be of primary significance to the JTF17 program are discussed in the following paragraphs. A complete listing of leased facilities is presented in table III-2.

Table III-2. Summary of Leased Facilities

Facility	Use	Floorspace, sq ft
1. Airkaman, Incorporated, Bradley Field, Windsor Locks, Conn.	Flight testing, storage, and maintenance of experimental aircraft and engines	9,800
2. Arawana Mills, Inc., Southington, Conn.	Overhaul and repair manufacturing	208,000
3. Barridon Corporation, Hartford, Conn.	Temporary storage	39,000
4. Cheney Brothers, Inc., Manchester, Conn.	Experimental parts, test rings, and fixture storage	37,912
5. Colt Park Operating Corporation, Hartford, Conn.	Office space	29,500
6. Connecticut General Life Insurance Co., Wethersfield, Conn.	Service training school for military, commercial, and civilian personnel; provisioning meetings by spare parts section	33,000
7. Connecticut, State of, Bradley Field, Windsor Locks, Conn.	Test and sound control installation	11.1 acres
8. Eagle Lock Corporation, Terryville, Conn.	Storage for overhaul and repair equipment and material	192,000
9. Kolodney Manufacturing Company, Hartford, Conn.	Storage for stationery supplies, records, and research department reports	21,000
10. Manchester Properties, Inc., Elm Street Ext., Manchester, Conn.	Storage, dormant parts packing and shipping supplies, rough storage, and bin stock	223,466
11. Manchester Properties, Inc., Hall Court, Manchester, Conn.	Experimental foundry, material development lab and storage, and production jigs, fixtures, and die storage	65,992

Table III-2. Summary of Leased Facilities (Continued)

Facility	Use	Floorspace, sq ft
12. D.H. Overmyer Warehouse Co., East Hartford, Conn.	Storage of fixtures	40,000
13. Hartford Properties, Hartford, Conn.	Shop skills training	46,710
14. Realty Nominee, Inc., 460 Capital Avenue, Hartford, Conn.	Storage of general office furniture and machines, and records center	13,147
15. United Bank & Trust Co., New Hartford, Conn.	Storage of records	288
16. Roger Sherman Warehouse, East Hartford, Conn.	Storage of machinery accessories and related production equipment	63,232
17. Shepard-Pola, Inc., South Windsor, Conn.	Office space and manufacturing facility (Powercel Systems)	136,564
18. The 115 Park Ave., Corp., East Hartford, Conn.	Storage of equipment, supplies and UAC show exhibits	50,000
19. Utility Industries Co., South Windsor, Conn.	Office space, plant layout, parts storage, shop supplies, and standard tool storage	136,200
	Total Area of Leased Facilities	1,345,811 sq ft and 11.1 acres

b. Utilities Industries Building

The utilities industries building in South Windsor, Connecticut houses the technical manual publications group, the plant layout department spare parts sales department, and the engine mockup group. The building also provides spare parts storage space. An aerial view of the plant is shown in figure 43, and the plant floor plan is shown in figure 44.



Figure 43. Utilities Industries Building FC 13360
VB

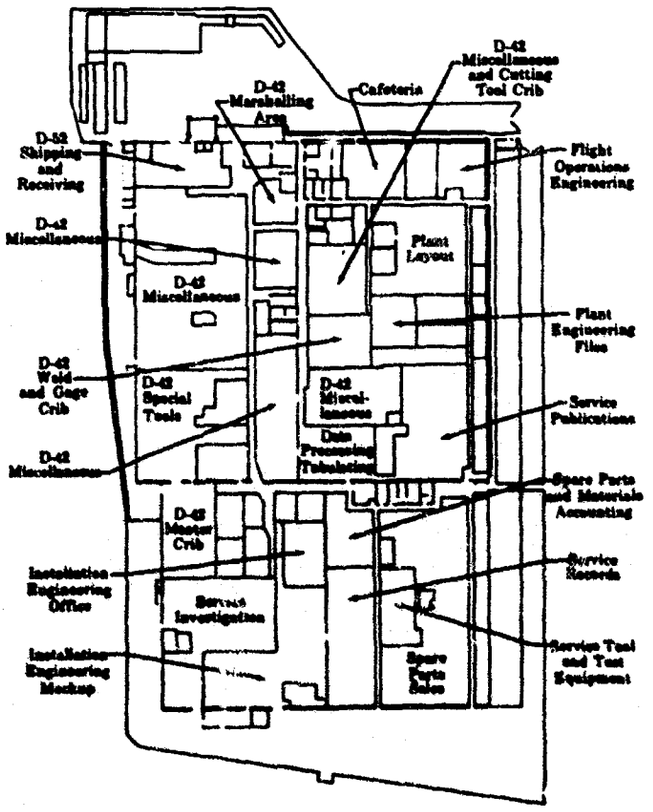


Figure 44. Utilities Industries Building Layout FD 17693
VB

c. Overhaul and Repair

A leased facility in Southington, Connecticut is used for engine overhaul and repair to supplement the company-owned Southington facility. The facility provides 206,106 square feet of floorspace. The plant floor plan is shown in figure 45.

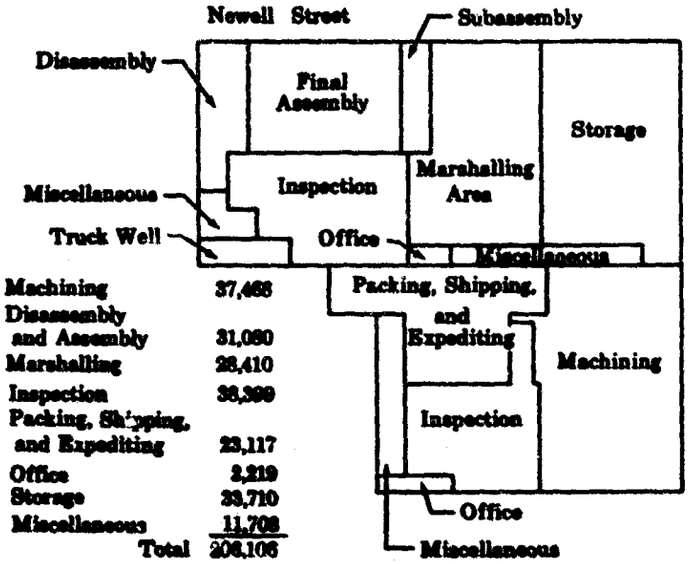


Figure 45. Layout of Leased Overha . and Repair Facilities at Southington

FD 17694
VB

d. Service School

The P&WA Service School in Wethersfield, Connecticut provides training in the operation and maintenance of P&WA engines for military, commercial, and civilian customers. The school has 23,891 square feet of floorspace, as shown in figure 46.

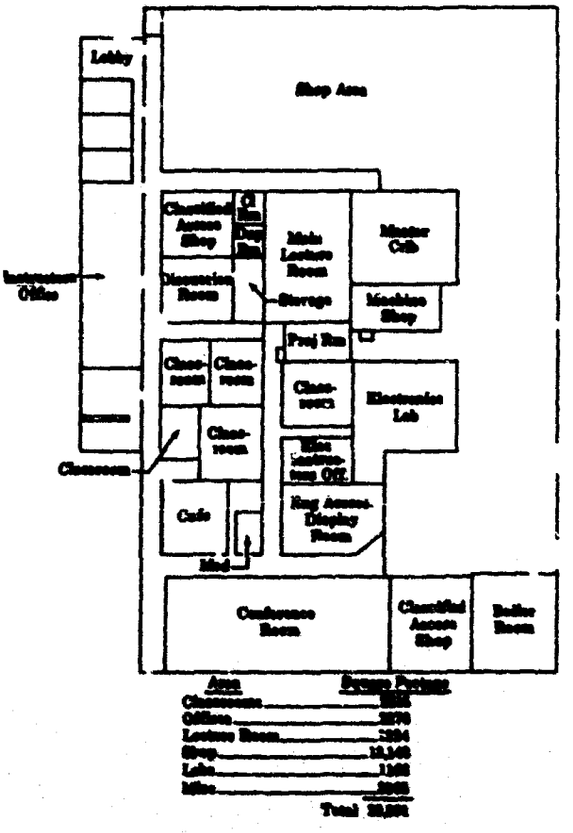


Figure 46. Layout of Service School at Wethersfield

FD 17695
VB

B. MODERNIZATION PROGRAM

A company-financed machine modernization and replacement program is conducted at Pratt & Whitney Aircraft on a continuing basis. New types of machines are continually evaluated for use to assure increased capacity and reduced manufacturing costs consistent with quality and performance requirements. A modernization budget of $12,000,000 for capital improvement has been approved for 1966, and budgets of $12,000,000 per year are planned for the years 1967 through 1969.

Numerically-controlled machine tools have been used in production at Pratt & Whitney Aircraft for eight years. In that time, the inventory of both point-to-point and continuous path machines has steadily increased to 148, with 52 still on order. The use of numerically-controlled machines eliminates the need for elaborate jigs and fixtures, machines with excellent repeatability and consistent accuracy, lowers tool costs, increases productivity, reduces scrap, shortens leadtimes, and improves quality.

C. EXPANSION OF PRODUCTION CAPACITY

During the last 1-1/2 years, Pratt & Whitney Aircraft has conducted an extensive program to expand production capacity. The expansion is in

response to the rapid rise in requirements experienced for the last two years and to the rates of production forecast for the next several years. The expansion program has included the modernization of existing facilities, procurement of additional machines, increased use of leased facilities, construction of additional buildings, purchase of a government-owned facility, and expansion of the subcontracting base.

Since October 1964, the company has appropriated $113,000,000 for machines and related production equipment to modernize and to expand production capacity. These appropriations have resulted in orders for 1083 additional machines and 410 major items of related capital equipment.

More than $64,000,000 has been appropriated for captial additions and modernization of buildings since the last quarter of 1964. Construction of a new materials center, a new assembly floor, and a three-story office building has added more than 1.1 million square feet in East Hartford this year. The recent acquisition of the Middletown Plant has provided an additional 294,000 square feet suitable for production and support operations. Floorspace has been further increased in expanding the use of leased facilities. An additional 346,900 square feet have been leased since the beginning of 1965.

D. FACILITY REQUIREMENTS FOR THE JTF17 ENGINE PROGRAM

A detailed analysis of production facility requirements has been conducted for the years encompassing the JTF17 production engine program. This forecast is based on a schedule of project engine and spare parts business through 1977. The Long Range Machine Load Computer Forecasting System was used to assist in the facilities analysis. The system consists of a series of computer programs developed by Pratt & Whitney Aircraft to predict the effect of future business on the requirements for machine tool and floor space.

1. Machine Requirements

The forecast of total requirements for production machines for the years 1968 to 1977 is shown on table III-3. This figure includes a listing of machines presently in production and those currently on order. It is significant to note that the requirements for machine tools will increase for the next few years. This increase in requirements is presently being translated into an increase in available machine tools. The peak requirements for machine tools occur in 1969, prior to the time that effects of JTF17 engine production are anticipated; thus adequate production capacity will be available because of the decline in requirements for other engine programs.

Machine tool requirements for the JTF17 engine program are shown on table III-4. Requirements for the year 1976 were chosen for table III-4 since 1976 is the year during which the peak production rate of eighteen JTF17 engines per month is anticipated. Table III-4 shows the percent of the total load attributed to JTF17 requirements for each category of machines. The analysis of requirements for the JTF17 engine program is based on detailed information from master planning summaries of operations. These planning summaries, developed for the majority of JTF17 parts to be manufactured in-house, provide an accurate basis for facilities forecasting.

Table III-3. Machine Requirements, 1968 Through 1977

Type of Machine	Present Inventory*	Machine Required To Meet Anticipated Schedule (Including JTF17 Engine) 1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Horizontal boring	18	12	17	18	18	16	16	16	15	17	14
Vertical turning and boring	323	300	335	326	312	276	283	279	270	295	274
Precision boring	89	72	98	95	92	84	87	86	84	87	87
Jig boring	121	122	116	111	105	86	93	93	92	95	90
Broaching	28	21	18	18	18	18	18	18	18	18	18
Drilling	530	417	415	412	407	359	376	372	365	378	397
Gear cutting	231	144	150	145	126	112	114	113	112	117	117
Grinding	714	674	688	657	613	578	629	628	626	632	626
Horizontal lathe	423	398	427	417	399	351	348	348	340	362	319
Milling	427	410	474	462	446	389	440	392	373	430	397
ECM-EDM	36	40	49	46	42	45	46	46	47	49	47
Miscellaneous types	470	363	383	379	376	348	367	364	357	375	362
Sheet metal forming	231	198	207	199	192	187	193	192	192	201	199
Welding	440	359	393	385	372	312	377	370	355	354	341
Totals	4081	3530	3770	3670	3518	3161	3387	3317	3246	3410	3288

*Inventory figures include machines currently on order.

Table III-4. Machine Requirements, JTF17 Engine Production

Type of Machine	Percent of Total Load in 1976 Resulting from JTF17 Engine Production at Projected Rate of 18 per Month.
Horizontal boring	23
Vertical turning and boring	26
Precision boring	26
Jig boring	24
Broaching	23
Drilling	21
Gear cutting	23
Grinding	21
Horizontal lathes	17
Milling	29
ECM-EDM	28
Miscellaneous machines	22
Sheet metal forming	21

2. Floorspace Requirements

Production machining floorspace will be adequate for the JTF17 program and other concurrent programs throughout the period affected by JTF17 production. The analysis of machine requirements indicates that the floorspace provided for the peak production years of 1968 and 1969 will satisfy the requirements of the mid-1970's.

3. Test Cell Requirements

The analysis of test cell requirements has been based on the projected schedule of engine production. The planned utilization of test cells is shown on figure 47. All test cells shown on this figure are currently in use except cells 109 to 116. These new cells are planned for use with the new generation of high thrust engines. Their design allows for rapid conversion so that a minimum of time and expense will be required to convert these cells for use in the JTF17 program. Appropriations have been approved for the construction of the first four new test cells. The additional cells will be built as required.

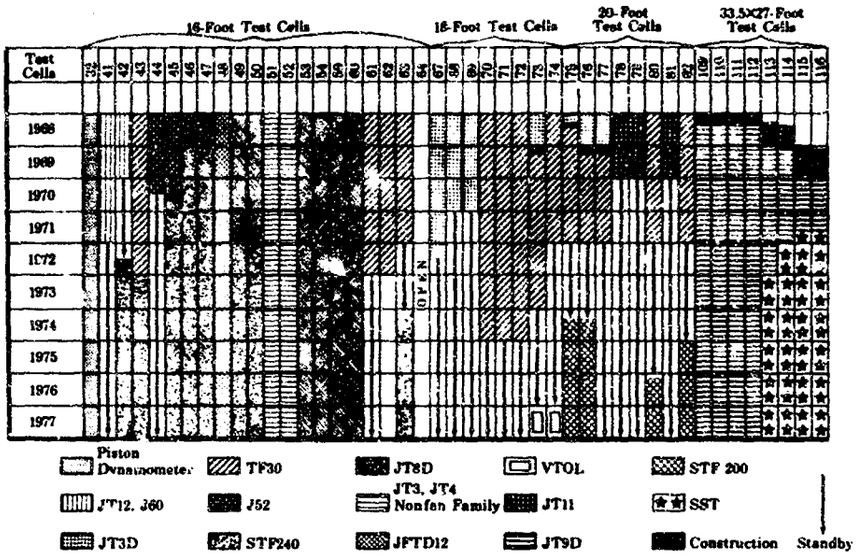


Figure 47. Test Cell Utilization

FD 17696
VB

SECTION IV
SUBSTANTIATING DATA

Tables IV-1 through IV-38 describe the facilities to be used in Phases III, IV, and V. The tables include the following:

1. Government facilities presently installed at the plants
2. A description of Pratt & Whitney Aircraft owned major facilities presently at the plants
3. A list of additional facilities to be acquired by Pratt & Whitney Aircraft for the JTF17 Program.

No additional Government-owned facilities will be required for Phases III, IV, or V. The additional company facilities cost summary is presented in table IV-38.

Table IV-1. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
Phase III Manufacturing Facilities						
7 Spot Welders to 400 KVA	FRDC	Existing		Yes	See Manufacturing Plan, Volume V, Report G for justification and use of equipment.	As required
3 Seam Welders to 300 KVA	FRDC	Existing		Yes	" " "	As required
1 Resistance, Metal Gathering 100 KVA	FRDC	Existing		Yes	" " "	As required
12 Fusion Welding Booths Fully Equipped	FRDC	Existing		Yes	" " "	As required
10 Automatic Welding Positioners to 84 inches	FRDC	Existing		Yes	" " "	As required
2 Electronic Induction Heaters (brazing) to 100 KW	FRDC	Existing		Yes	" " "	As required
1 Electron Beam Welder 8 KVA, 150 KV	FRDC	Existing		Yes	" " "	As required
2 Hydroforms to 26 inch Diameter Blank	FRDC	Existing		Yes	" " "	As required

Table IV-2. Government-Owned Facilities (Existing)

(Contract NOw 66-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
3 Hydraulic Presses to 1600 tons	FRDC	Existing		Yes	See Manufacturing Plan, Volume V, Report G for justification and use of equipment	As required
1 Radial Draw Former 100-inch Diameter, 30-inch Sheet Width	FRDC	Existing		Yes	" " "	As required
3 Vane Piercing Presses	FRDC	Existing		Yes	" " "	As required
1 Drop Hammer 48 x 48 inch Working Surface with 7000-lb Ram	FRDC	Existing		Yes	" " "	As required
1 Horn Press 32-ton	FRDC	Existing		Yes	" " "	As required
3 Inclinable Presses to 70 ton	FRDC	Existing		Yes	" " "	As required
2 Manual Presses	FRDC	Existing		Yes	" " "	As required
15 Punch and Shear Machines	FRDC	Existing		Yes	" " "	As required
14 Jig Borers to 84-inch Dia	FRDC	Existing		Yes	" " "	As required
9 Horizontal Boring Mills	FRDC	Existing		Yes	" " "	As required

Table IV-3. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
2 Horizontal Broaching Machines 180-inch Stroke, 50 ton	FRDC	Existing		Yes	See Manufacturing Plan, Volume V, Report G for justification and use of equipment	As required
3 Vertical Broaching Machines 100-inch Stroke, 50 ton	FRDC	Existing		Yes	" " "	As required
22 Drill and Tap Machines	FRDC	Existing		Yes	" " "	As required
26 Gear Machines to 36-inch Diameter	FRDC	Existing		Yes	" " "	As required
88 Grinding Machines (Surface, OD and ID)	FRDC	Existing		Yes	" " "	As required
68 Lathes (Vertical, Horizontal, Turret and Spin)	FRDC	Existing		Yes	" " "	As required
74 Milling Machines (Vertical, Horizontal, Universal, and Duplicating)	FRDC	Existing		Yes	" " "	As required
2 Shapers, 24-inch Stroke	FRDC	Existing		Yes	" " "	As required

Table IV-4. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
8 Lap and Hone Units to 11-inch Diameter	FRDC	Existing		Yes	See Manufacturing Plan, Volume V, Report G for justification and use of equipment	As required
8 Electrical Discharge Machines to 56-inch Diameter	FRDC	Existing		Yes	" " "	As required
22 Furnaces to 135 x 96 x 85 inch 2600°F Plating Facility	FRDC	Existing		Yes	" " "	As required
			Phase III Assembly Facilities			
43 Hoists to 5 ton	FRDC	Existing		Yes	" " "	As required
4 6-ton Levelators, 96-inch Diameter	FRDC	Existing		Yes	" " "	As required
6 5-ton Levelators, 72-inch Diameter	FRDC	Existing		Yes	" " "	As required
5 Cleaning Tanks to 7 x 8 x 11 ft	FRDC	Existing		Yes	" " "	As required
2 Vapor Blast Cabinets	FRDC	Existing		Yes	" " "	As required

Table IV-5. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
3 Varsol Spray Booths	FRDC	Existing		Yes	See Manufacturing Plan, Volume V, Report G for justification and use of equipment	As required
3 Ultrasonic Degreasers	FRDC	Existing		Yes	" " "	As required
2 Standard Degreasers	FRDC	Existing		Yes	" " "	As required
6 Surface Plates to 6 x 8 foot	FRDC	Existing		Yes	" " "	As required
8 Balancing Machines to 66 in. Diameter, 120 in. long up to 4200 lbs	FRDC	Existing		Yes	" " "	As required
7 Arbor Presses to 24 in.	FRDC	Existing		Yes	" " "	As required
1 75-Ton Hydraulic Press	FRDC	Existing		Yes	" " "	As required
2 Lathes to 16-inch diameter	FRDC	Existing		Yes	" " "	As required
7 Ovens to 1250°F	FRDC	Existing		Yes	" " "	As required
1 Deep Freeze to -190°	FRDC	Existing		Yes	" " "	As required

Table IV-6. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
2 Water Pressure Test Tanks	FRDC	Existing		Yes	See Manufacturing Plan, Volume V, Report G for justification and use of equipment	As required
2 Oil Flow Benches	FRDC	Existing		Yes	" " "	As required
1 Hydrostatic Test Bench, 0-10,000 psig	FRDC	Existing		Yes	" " "	As required
Phase III Inspection Facilities						
6 Air Gages	FRDC	Existing		Yes	" " "	As required
4 Dividing Heads	FRDC	Existing		Yes	" " "	As required
6 Comparators	FRDC	Existing		Yes	" " "	As required
9 Hardness Testors	FRDC	Existing		Yes	" " "	As required
4 Measuring Machines	FRDC	Existing		Yes	" " "	As required
6 Microscopes	FRDC	Existing		Yes	" " "	As required
7 Optical Comparators	FRDC	Existing		Yes	" " "	As required

Table IV-7. Government-Owned Facilities (Existing)

(Contract NO. 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
10 Rotary tables to 84 inch	FRDC	Existing		Yes	See Manufacturing Plan Volume V, Report G, for justification and use of equipment	As required
5 Sonic Detector Surface Plates to 8 x 12 ft	FRDC	Existing		Yes	" " "	As required
2 Fluorescent Penetrant Lines	FRDC	Existing		Yes	" " "	As required
2 Magnetic Particle Units	FRDC	Existing		Yes	" " "	As required
1 Sonic Tube Line	FRDC	Existing		Yes	" " "	As required
1 Sonic Inspection Tank	FRDC	Existing		Yes	" " "	As required
1 Spectrograph	FRDC	Existing		Yes	" " "	As required
3 24-inch Rotary Tables MAS8-5017(F)	FRDC	Existing		Yes	" " "	As required

Table IV-8. Government-Owned Facilities (Existing)

(Contract NOw 6400-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
Phase III - Sea Level Engine Calibration and Endurance Test Facilities						
Sea Level Test Stand, A-3	FRDC	Existing		Yes	Sea Level Calibration Testing	As required
Sea Level Test Stand, A-4	FRDC	Existing		Yes	Sea Level Calibration Testing	As required
Burner Stand, A-11	FRDC	Existing		Yes	Burner and Component Tests	As required
Data Acquisition Equipment	FRDC	Existing		Yes	Acquire and Record Data from Sea Level Test Stands	As required
Phase III - Simulated Altitude and High Mach Number Engine Test Facilities						
Burner and Turbine Component Test Stand, C-1	FRDC	Existing		Yes	Burner and Component Tests	As required
Burner and Turbine Component Test Stand, C-2	FRDC	Existing		Yes	Burner and Component Tests	As required
Data Acquisition Equipment	FRDC	Existing		Yes	Acquire and Record Data from Altitude Simulation Test Stands	As required
Altitude Simulation Engine Test Stand, C-4	FRDC	Existing		Yes	Engine Altitude Tests	As required

Table IV-9. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
Altitude and High Mach Number Simulation Services	FRDC	Existing		Yes	Provides Services for Altitude and High Mach Number Conditions at Test Stands	As required
			Phase III Small Component Test Facilities			
D-7 High Temperature Fuel System Mockup	FRDC	Existing		Yes	Full-Scale Fuel System Mockup Tests	As required
D-9 Low Flow Static	FRDC	Existing		Yes	Small Fuel Components Tests	As required
D-10 High Flow Static and Air Turbine Pump	FRDC	Existing		Yes	Duct Heater Pump and Control Tests	As required
D-11 General Purpose Fuel Pump and Control	FRDC	Existing		Yes	Unitized Fuel Control Tests	As required
D-12 General Purpose Fuel Pump and Control	FRDC	Existing		Yes	Unitized Fuel Control Tests	As required
D-13 Fuel Control	FRDC	Existing		Yes	Exhaust Nozzle Control Tests	As required
D-14 Fuel Flowmeter Calibration	FRDC	Existing		Yes	Flowmeter Calibration Tests	As required
D-15 Fuel and Oil Flowmeter Calibration	FRDC	Existing		Yes	Flowmeter Calibration Tests	As required

Table IV-10. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
D-16 Hydraulic Pump	FRDC	Existing		Yes	Hydraulic Pump Tests	As required
D-17 Hydraulic Actuator	FRDC	Existing		Yes	Hydraulic Actuator Tests	As required
D-18 General Purpose Fuel Pump and Control	FRDC	Existing		Yes	Unitized Fuel Control Tests	As required
D-20 Air Turbine Pump and Control	FRDC	Existing		Yes	Duct Heater Pump and Control Tests	As required
D-23 Fuel/Oil Coolers and Oil Flow	FRDC	Existing		Yes	Fuel/Oil Coolers Tests	As required
DM-42 Fuel Nozzle Calibration	FRDC	Existing		Yes	Fuel Nozzles Tests	As required
DM-49 Starting Bleed Valves	FRDC	Existing		Yes	Starting Bleed Valves Tests	As required
D-1 Bearing, Seal and Oil Pump	FRDC	Existing		Yes	Seal Rig Tests	As required
D-3 Bearing, Seal and Oil Pump	FRDC	Existing		Yes	Oil Pump Tests	As required

Table IV-11. Government-Owned Facilities (Existing)
(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
D-4 Bearing, Seal, and Oil Pump	FRDC	Existing		Yes	Seal Rig Tests	As required
D-23A Fuel/Oil Coolers and Oil Flow	FRDC	Existing		Yes	Deoiler and Tower Tests Shaft Bearings	As required
D-31 Gearbox High Temperature	FRDC	Existing		Yes	Main Gearbox Tests (Light Load)	As required
D-32 Ignition Systems Development	FRDC	Existing		Yes	Ignition System	As required
Ignition Lab NAS8-2690	FRDC	Existing		Yes	Ignition System	As required

Table IV-12. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV and/or V?	Justification	Availability
2 Beckman 2133 Analog Computers NAS8-5617(F)	FRDC	Existing		Yes	See Volume V, Report B for use	

Table IV-13. Government-Owned Facilities (Existing)
(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
Materials Development and Controls Laboratory Facilities						
IR-7 and DK2A Spectrophotometers	FRDC	Existing		Yes	See Volume III, Report F for use	As required
Fuel Coker Research	FRDC	Existing		Yes	" " "	As required
Chromatographs, Gas and Liquid	FRDC	Existing		Yes	" " "	As required
Sonntag Fatigue Machines	FRDC	Existing		Yes	" " "	As required
Combined Load Fatigue Machines	FRDC	Existing		Yes	" " "	As required
Tensile Machines	FRDC	Existing		Yes	" " "	As required
Vibration Testing	FRDC	Existing		Yes	" " "	As required
High-Temperature Stress Coat Units	FRDC	Existing		Yes	" " "	As required
Photoelastic Polariscopes	FRDC	Existing		Yes	" " "	As required
XRD-5 X-ray iff. Unit	FRDC	Existing		Yes	" " "	As required
Brew Vacuum Furnace	FRDC	Existing		Yes	" " "	As required

Table IV-14. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
Heat Treating Furnaces - Various	FRDC	Existing		Yes	See Volume III, Report F for use	As required
Plasma Gun	FRDC	Existing		Yes	" " "	As required
Metallizing Equipment	FRDC	Existing		Yes	" " "	As required
37 Creep Rupture Machines	FRDC	Existing		Yes	" " "	As required
Material Control Laboratory	FRDC	Existing		Yes	" " "	As required
X-Ray Machines	FRDC	Existing		Yes	" " "	As required
Standard Machine Shop Equipment	FRDC	Existing		Yes	" " "	As required
Photo and Direct-Read Spectrographs	FRDC	Existing		Yes	" " "	As required

Table IV-15. Government-Owned Facilities (Existing)
(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
Quartz Pressure Tubes NAS8-5623	FRDC	Existing		Yes	See Volume III, Report E for use	As required
Turbine Flow-meters and Flow Raters	FRDC	Existing		Yes	" " "	As required
Seraphin Volume Standards NAS8-5617(F)	FRDC	Existing		Yes	" " "	As required
Transonics Equiphase Cells NAS8-2690	FRDC	Existing		Yes	" " "	As required
L&N Optical Pyrometers	FRDC	Existing		Yes	" " "	As required
Trio Tech Centrifuge AF33(600)-34980	FRDC	Existing		Yes	" " "	As required
MB Vibration Exciters	FRDC	Existing		Yes	" " "	As required
Ideal Aerosmith Recording Barometer	FRDC	Existing		Yes	" " "	As required
Foxboro Temperature and Dewpoint Recorder	FRDC	Existing		Yes	" " "	As required

Table IV-16. Government-Owned Facilities (Existing)
(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Fate	Is Rent-Free Use Possible for Phases III, IV, and/or V?	Justification	Availability
Bendix-Friez Windspeed and Direction Recorder	FRDC	Existing		Yes	See Volume III, Report E for use	As required
Instruments Corp Universal Rain Gage	FRDC	Existing		Yes	" " "	As required
Cox and Stevens Force Calibrators (to 109,000 lb)	FRDC	Existing		Yes	" " "	As required
4 Frazier Balances NOa(S)59-6205F	FRDC	Existing		Yes	" " "	As required
6 Electronic Benches	FRDC	Existing		Yes	" " "	As required
AC and DC Amplifiers	FRDC	Existing		Yes	" " "	As required
Tape Recorders	FRDC	Existing		Yes	" " "	As required
Tenny Environmental Chamber	FRDC	Existing		Yes	" " "	As required
Mansfield Green Oil Dead Weight Tester NAS8-5617(F)	FRDC	Existing		Yes	" " "	As required

Table IV-17. Government-Owned Facilities (Existing)

(Contract NOw 6406-u, Unless Otherwise Indicated)

Description	Location	Date Required	Rental Rate	Is Rent-Free Use Possible for Phase III, IV, and/or V?	Justification	Availability
MB Calibrator	FRDC	Existing		Yes	See Volume III, Report E for use	As required
Radio Interference Room	FRDC	Existing		Yes	" " "	As required
Pneumatic Flow Bench	FRDC	Existing		Yes	" " "	As required
Missimers Humidity Chamber NAS8-5617(F)	FRDC	Existing		Yes	" " "	As required

Table IV-18. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Phase V - Facilities Production			
18 Horizontal Boring Machines	Existing		Production Engine Parts Fabrication
323 Vertical Turning and Boring Machines	Existing		Production Engine Parts Fabrication
89 Precision Boring Machines	Existing		Production Engine Parts Fabrication
121 Jig Boring Machines	Existing		Production Engine Parts Fabrication
28 Broaching Machines	Existing		Production Engine Parts Fabrication
530 Drilling Machines	Existing		Production Engine Parts Fabrication
231 Gear Cutting Machines	Existing		Production Engine Parts Fabrication
714 Grinding Machines	Existing		Production Engine Parts Fabrication
423 Horizontal Lathes	Existing		Production Engine Parts Fabrication
427 Milling Machines	Existing		Production Engine Parts Fabrication
36 ECM-EDM Machines	Existing		Production Engine Parts Fabrication
470 Miscellaneous Machines	Existing		Production Engine Parts Fabrication
231 Sheet Metal Forming Machines	Existing		Production Engine Parts Fabrication
440 Welding Machines	Existing		Production Engine Parts Fabrication

Table IV-19. Contractor Acquired Facilities (Existing)

	Description	Date Required	Estimated Cost	Use
	Phase III - IV Facilities Available At Prospective Subcontractors			
19	8 to 50-lb Conventional Furnaces	Existing		Turbine Blade and Vane Castings
5	50-lb PWA 664 Type Induction Furnaces	Existing		Turbine Blade and Vane Castings
2	100-lb Continuous Vacuum Furnaces	Existing		Turbine Blade and Vane Castings
1	175-lb Conventional Induction Melting Furnace	Existing		Turbine Blade and Vane Castings
1	100 KW Induction Furnace, 200-lb Capacity	Existing		Turbine Blade and Vane Castings

Table IV-20. Contractor Acquired Facilities (Existing)

	Description	Date Required	Estimated Cost	Use
	Phase III - IV Facilities Available at Prospective Subcontractors			
1	350 to 500 lb Induction Melting Furnace	Existing		Turbine Blade and Vane Castings
1	3000 lb NCR Induction Melting Furnace	Existing		Turbine Blade and Vane Castings
1	5000 lb NCR (currently being converted to 10,000 lb by 8-1-66)	Existing		Turbine Blade and Vane Castings
4	15 lb Indirect Arcs	Existing		Turbine Blade and Vane Castings
1	50 lb Indirect Arc	Existing		Turbine Blade and Vane Castings
25	Preheat Furnaces	Existing		Turbine Blade and Vane Castings
93	Wax Injection Machines	Existing		Turbine Blade and Vane Castings
18	Firing Furnaces for Molds	Existing		Turbine Blade and Vane Castings
2	One-Million Volt X-Ray Units	Existing		Turbine Blade and Vane Castings
3	300,000-Volt X-Ray Units	Existing		Turbine Blade and Vane Castings
1	260,000-Volt X-Ray Unit	Existing		Turbine Blade and Vane Castings
5	250,000-Volt X-Ray Units	Existing		Turbine Blade and Vane Castings
1	150,000 Volt X-Ray Unit	Existing		Turbine Blade and Vane Castings
1	150,000-Volt Norelco Image Intensifier	Existing		Turbine Blade and Vane Castings

Table IV-20. Contractor Acquired Facilities (Existing)(Continued)

	Description	Date Required	Estimated Cost	Use
	Phase III - IV Facilities Available at Prospective Subcontractors			
3	Zygio Facilities	Existing		Turbine Blade and Vane Castings
1	Magnaflux Facility	Existing		Turbine Blade and Vane Castings
3	Physical Testing and Chemical Laboratories	Existing		Turbine Blade and Vane Castings

Table IV-21. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Phase III - IV Facilities Available at Prospective Subcontractors			
30 Forge Presses	Existing		Compressor Blades and Vanes
271 Milling Machines; Vertical and Horizontal	Existing		" " "
7 Broaches; Horizontal and Vertical	Existing		" " "
35 Polish Jacks	Existing		" " "
64 Polish Machines	Existing		" " "
29 Shapers	Existing		" " "
18 Boring Mills	Existing		" " "
35 Airfoil Grinders	Existing		" " "
41 Die Sinkers	Existing		" " "
83 Lathes	Existing		" " "
57 Airfoil Mills	Existing		" " "
39 Duplicating Mills (Velvet Trace)	Existing		" " "
57 Drill Presses	Existing		" " "
3 X-Ray Units	Existing		" " "
2 Zyglo Facilities	Existing		" " "
2 Magnaflux Facilities	Existing		" " "
22 Kellers; up to 7 x 14 feet	Existing		Compressor Disks and Hubs, Shafts - Turbine, Spacer - Interstage Seals, Spacers, Machined Cases, Flanges and Dampeners

Table IV-22. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Phase III - IV Facilities Available at Prospective Subcontractors			
19 Boring Mills up to 100 inches	Existing		Compressor Disks and Hubs Shafts - Turbine, Spacer-Interstage Seals, Spacers, Machined Cases, Flanges and Dampeners
130 Lathes Engine and Turret up to 82 inch Swing	Existing		" " "
15 Thread Millers and Grinders, Internal and External	Existing		" " "
4 Blanchard No. 18 Vertical Surface Grinders	Existing		" " "
56 Vertical Turret Lathes to 180 inches	Existing		" " "
72 "T" Lathes with Tracing Attachments	Existing		" " "
59 Jig Borers, Jigmills, and Jig Grinders	Existing		" " "
60 Horizontal Mills up to No. 5 (large size)	Existing		" " "
73 Vertical Mills up to No. 5 (large size)	Existing		" " "
105 Surface and General Grinders up to 84-inch diameter	Existing		" " "
3 Madison Grinders up to 24 x 96 inches	Existing		" " "
10 Deep Hole Drills to 60 inches	Existing		" " "
15 Horizontal and Vertical Broaching Machines	Existing		" " "
14 Elox and Anocut Machines	Existing		" " "
120 Engine Lathes with Tracer Attachment	Existing		Afterburner Nozzle Flaps, Shafts and Housings, Precision Machined Parts

Table IV-23. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Pase III - IV Facilities Available at Prospective Subcontractors			
91 Turret Lathes (Horizontal)	Existing		Afterburner Nozzle Flaps, Shafts, and Housing, Precision Machined Parts
76 Turret Lathes (Vertical)	Existing		"
40 Profiling Machines	Existing		"
241 Milling Machines	Existing		"
27 Jig Mills	Existing		"
46 Hydrotel Millers	Existing		"
37 Shapers	Existing		"
16 Broaching Machines	Existing		"
59 Internal Grinders	Existing		"
71 External Grinders	Existing		"
33 Thread Grinders, Internal and External	Existing		"
33 Blanchard Type Grinders	Existing		"
94 Surface Grinders	Existing		"
71 Jig Borers	Existing		"
29 Boring Machines	Existing		"
17 Keller Machines	Existing		"
63 Radial Drills	Existing		"
312 Drill Presses	Existing		"

Table IV-24. Contractor Acquired Facilities (Existing)

Description	Date Required	Esimtated Cost	Use
Phase III - IV Facilities Available at Prospective Subcontractors			
101 Power Presses	Existing		Afterburner Nozzle Flaps, Shafts, and Housings, Precision Machined Parts
Heat Treating	Existing		" " "
9 Reischaur Gear Grinders	Existing		Gear and Spline Machining
21 Internal Gear Grinders	Existing		" " "
12 Involute Gear Grinders	Existing		" " "
28 External Gear and Spline Grinders	Existing		" " "
13 Tooth Gear Grinders	Existing		" " "
31 Helical Gear Grinders	Existing		" " "
66 Gear Shapers	Existing		" " "
37 Hobbers	Existing		" " "
4 Bevel Gear Generators	Existing		" " "
3 Coupling Gear Grinders, 19-inch Diameter	Exiting		" " "
5 Deep Hole Drillers	Existing		Bosses, Fittings, Small Hardware and Actuating Mechanisms
52 Screw Machines	Existing		" " "
128 Vertical Milling Machines	Existing		" " "
22 Horizontal Milling Machines	Existing		" " "
11 Three-Dimensional Milling Machines	Existing		" " "
20 Jig Bores	Existing		" " "
101 Engine Lathes to 49 inches	Existing		" " "

Table IV-25. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Phase III - IV Facilities Available at Prospective Subcontractors			
51 Turret Lathes	Existing		Bosses, Fittings, Small Hardware and Actuating Mechanisms
9 Thread Millers	Existing	"	"
4 "T" Lathes	Existing	"	"
10 "T" Raw Lathes	Existing	"	"
27 Hardinge Chuckers	Existing	"	"
44 Surface Grinders	Existing	"	"
20 ID and OD Grinders	Existing	"	"
12 Centerless Grinders	Existing	"	"
8 Thread Rollers	Existing	"	"
9 Thread Grinders	Existing	"	"
28 Power Presses to 150 Tons	Existing	"	"
8 Elox Machines	Existing	"	"
1 Anocut Machine	Existing	"	"
42 Power Tube Bending Machines to 3-1/2 inch OD	Existing	"	"
96 Hand Benders to 1 inch OD	Existing	Powerplant Plumbing	
12 Flaring and Bending Machines to 3-1/2 inch OD	Existing	"	"
10 Swaging Machines to 2-1/2 inch OD	Existing	"	"

Table IV-26. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Phase III - IV Facilities Available at Prospective Subcontractors			
16 Power Presses to 75-ton Capacity	Existing		Powerplant Plumbing
19 Induction Brazers	Existing	"	"
7 Resistance Brazers	Existing	"	"
14 Heliarc Welders	Existing	"	"
17 Engine Lathes to 36 inches	Existing	"	"
8 Turret Lathes	Existing	"	"
20 Vertical Milling Machines	Existing	"	"
6 Horizontal Milling Machines	Existing	"	"
2 Tube Tapering Machines to 3-1/2-inch OD	Existing	"	"

Table IV-27. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Phase III - IV Sea Level Engine Calibration and Endurance Test Facilities			
Sea Level Engine Test Stand, A-5	Existing		Engine Sea Level Calibration Testing
Sea Level Engine Test Stand, A-6	Existing		Engine Sea Level Calibration Testing
Sea Level Engine Test Stand, A-7	Existing		Engine Sea Level Calibration Testing
Phase III - IV Simulated Altitude and High Mach Number Component Test Facilities			
Compressor Test Stand, C-3	Existing		Full-Scale Compressor Testing at Simulated Altitude and Mach Number Conditions
X210 Stand, Willgoos Laboratory	Existing		Full-Scale Engine Testing at Simulated Altitude and Mach Number Conditions

Table IV-28. Contractor Acquired Facilities (Existing)

Description	Date Required	Estimated Cost	Use
Phase III - IV Computer Laboratory Facilities			
2 Benson-Lehner Electro-Plotters	Existing		Graph plotting
IBM System 360 Model 65 Computer	Existing	Leased	Analytical Computing
IBM System 360 Model 40 Computer	Existing	Leased	Analytical Computing
3 IBM 1130 Computers	Existing	Leased	Analytical Computing
IBM 1410 Digital Computer	Existing	Leased	Business Applications
IBM System 360 Model 30 Computer	Existing	Leased	Analytical Computing

Table IV-29. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
Phase III - IV Manufacturing Facilities (Development)			
1 Flat Rotab	1 Feb 68	$ 52,000	See Manufacturing Program Volume V, Report G, for use
1 ECM Cavity Sinker	1 Feb 68	132,000	" " "
2 Multispindle Hydrotels	1 Feb 68	229,000	" " "
1 ECM Surface Grinder	1 Feb 68	74,000	" " "
1 EDM Machine and Accessories	1 Aug 67	57,000	" " "
1 Rivet Machine	1 Feb 68	7,000	" " "
1 Twin Wheel Grinder	1 Feb 68	132,000	" " "
3 Surface Grinders	1 Feb 68	103,000	" " "
1 VTL 124-inch Diameter	1 May 68	344,000	" " "
1 Horizontal Boring Machine	1 Feb 68	218,000	" " "
1 Optical Tracing Mill	1 July 67	40,000	" " "
1 Craneway Extension	1 Feb 68	21,000	" " "
Shop Equipment	1 Feb 68	7,000	" " "
1 Duplex Mill	1 Aug 67	46,000	" " "
1 Hypowermatic Tracer Mill Control	1 Apr 67	3,500	" " "
1 Metal Gathering Machine	1 Feb 68	101,000	" " "
1 25-KVA Resistance Welder	1 Feb 68	4,500	" " "
1 25-KVA Resistance Heater	1 Nov 67	11,500	" " "
2 25-KVA Induction Heaters	1 Feb 68	4,000	" " "
1 15-KVA Induction Heaters	1 Feb 68	12,000	" " "

Table IV 30. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
1 10 inch Pedestal Grinder	1 Mar 67	$ 600	See Manufacturing Program Volume V, Report G for use
1 Rotary Swager	1 Feb 68	6,200	" " "
1 20 inch Sanding Machine	1 Feb 68	1,200	" " "
1 No. 4 Turret Lathe	1 July 67	23,000	" " "
1 Gun Drilling Machine	1 Feb 68	57,000	" " "
1 ECM Deep Hole Drill	1 Feb 68	35,000	" " "
1 Tilting Rotary Table	1 July 67	57,000	" " "
1 Keller Contour Mill	1 Feb 68	146,000	" " "
1 25-inch Tracer Lathe	1 July 67	46,000	" " "
1 Frauenthal Grinder	1 May 68	350,000	" " "
1 Blade Mill (New England)	1 Feb 68	90,000	" " "
1 Melt Pot	1 May 67	23,000	" " "
2 Surface Plates (10 x 10 feet)	1 Feb 68	11,500	" " "
Phase III - IV Manufacturing Facilities (Product Support)			
1 VTL, 108 inch	1 April 69	266,000	" " "
1 Horizontal Boring Machine	1 April 69	221,000	" " "
1 4EA Jig Bore (N/C)	1 April 69	221,000	" " "
1 3E Jig Bore with 24-inch Table	1 April 69	87,000	" " "
2 Universal Grinders	1 April 69	69,000	" " "
3 Bridgeport Mills	1 April 69	24,000	" " "

Table IV-31. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
Burring Equipment	1 Apr 69	$ 5,800	See Manufacturing Program Volume V, Report G, for use
4 Fusion Welders	1 Apr 69	5,800	" " "
2 Weld Positioners	1 Apr 69	17,000	" " "
2 60-inch Tilt Rotary Tables	1 Apr 69	69,000	" " "
1 EDMR Machine	1 Apr 69	58,000	" "
Stores Equipment	1 Apr 69	69,000	" " "
Phase III - IV Assembly Facilities (Development)			
1 Balance Machine (Reoperation)	1 May 67	6,000	" " "
1 Craneway Support	1 May 67	57,000	" " "
1 Hoist; 5-ton, Air	1 May 67	6,200	" " "
1 Balancer Conversion Kit, 75 HP Drive	1 May 67	31,000	" " "
1 Balancer Conversion Kit, 0-1500 rpm	1 May 67	1,700	" " "
1 Vapor Degreaser	1 May 67	9,000	" " "
1 Cleaning Tank	1 May 67	3,500	" " "
1 Parts Table	1 May 67	2,300	" " "
Phase III - IV Assembly Facilities (Delivery and Product Support)			
2 six-ton Levelators	1 Feb 67	69,000	" " "
2 Hoists 2-ton, Air	1 Feb 69	32,000	" " "
4 Hoists 5-ton, Air	1 Feb 69	32,000	" " "

Table IV-32. Contractor Acquired Facilities (New)

	Description	Date Required	Estimated Cost	Use
1	Vapor Degreaser, 10 x 10 x 10 feet	1 Feb 69	$ 9,000	See Manufacturing Program Volume V, Report G for use
1	Vapor Blast Machine, 10 x 10 x 10 feet	1 Feb 69	14,000	" " "
1	Cleaning Tank, 10'x 10'x 11'4"	1 Feb 69	3,700	" " "
1	Oil Flow Bench	1 Feb 69	11,700	" " "
10	Parts Tables, 8' x 10' x 2'6"	1 Feb 69	1,500	" " "
1	Balance Machine, Gisholt No. 5JP	1 Feb 69	55,000	" " "
1	Electric Craneway (2-Hoist)	1 Feb 69	15,000	" " "
	Phase III - IV Inspection Facilities			
5	Rotary Tables	1 July 68	71,200	See Quality Assurance Program; Volume IV, Report F, Section III for use
14	Surface Plates	1 July 68	22,648	" " "
3	Pla-Checks	1 July	13,680	" " "
1	Cathetometer	1 July 68	5,000	" " "
1	Etch Anodize Equipment	1 July 68	30,000	" " "
1	Sonoray	1 July 68	4,480	" " "
1	Vidi Gage	1 July 68	3,800	" " "
1	Etch Tank and Rectifier	1 July 68	8,300	" " "
	Fluid Penetrant Equipment	1 July 68	65,000	" " "
	Misc (Gages, Blocks, Benches, etc)	1 July 68	87,000	" " "

Table IV-33. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
Phase III - IV Sea Level Engine Calibration and Endurance Test Facilities (Development)			
Sea Level Engine Test Stand, A-5, Modifications	1 Oct 67	$ 34,100	Sea Level Calibration Testing
Sea Level Engine Test Stand, A-9	1 July 67	80,000	Reverser-Suppressor Testing
Sea Level Engine Test Stands Services	1 Sept 67	560,100	Fuel, Air, and Services for Sea Level Facilities
Phase III - IV Sea Level Engine Calibration and Endurance Test Facilities (Prototype and Overhaul)			
Sea Level Engine Test Stand, A-6, Modifications	1 June 69	34,700	Delivery Engine Calibration Testing
Sea Level Engine Test Stand, A-7, Modifications	1 Aug 69	34,700	Delivery Engine Calibration Testing
Phase III - IV Heated Inlet Engine Calibration and Endurance - Test Facilities (Development)			
Heated Inlet Engine Test Stand, C-8	1 June 68	718,300	Engine Heated Endurance Testing
Heated Inlet Engine Test Stand, C-9	1 Sept 68	257,000	Engine Heated Endurance Testing
Heated Inlet Engine Test Stand, C-10	1 Jan 69	521,000	Engine Heated Endurance Testing
Heated Inlet Stands Services	1 June 68	5,297,000	To provide Ram and Exhaust for Above Heated Inlet Stands
Phase III - IV Simulated Altitude and High Mach Number Engine Test Facilities (Development)			
Simulated Altitude and High Mach Number Test Stand, C-6	1 Oct 68	459,400	Test Full-Scale Engine at Altitude and Mach Number Conditions
Area C Facility Service Additions	1 Oct 68	9,092,500	Provide the Simulated Altitude and Mach Number Conditions to the Test Stands
X210 Stand, Willgoos Laboratory	1 July 68	245,900	" " "

Table IV-34. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
Phase III - IV Simulated Altitude and High Mach Number Component Test Facilities (Development)			
Compressor Test Stand, C-7	1 Jan 68	$2,493,200	Test Full-Scale Fan or High Pressure Compressors at Simulated Altitude and Mach Number Conditions
Phase III - IV Small Components Test Facilities (Development)			
Electronic Fuel Control Stands (2)	1 Dec 67	125,000	Calibration and Testing of Electronic Fuel Controls
Data Recording Carts (4)	1 Jan 68	96,000	Acquire and Record Transient and Frequency Response Data From Components
D-24 Gearbox Stand Modification	1 Jan 68	413,400	Engine Gearbox Testing
Phase III - IV Small Components Test Facilities (Prototype and Overhaul)			
Control Bench, Hydraulic Pump Bench, Nozzle and Spraybar Bench	1 May 69	550,000	Delivery Engine Component Calibration and Testing

Table IV-35. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
Phase III - IV Materials Development and Controls Laboratory Facilities			
Universal Low Cycle Fatigue Machine	January 67	$ 40,000	Testing of Disk Alloys
2 Creep Rupture Machines 30,000 lb Capacity	January 67	13,000	Alloy Development
1 Sinusoidal Vibration System (6000 lb Force) with Slip-Sync Strobe Light	January 67	43,350	Vibration Testing of Parts
1 Dual Trace Oscilloscope	January 67	1,500	Vibration Testing of Parts
1 Oscillograph (8 Channel Direct Printout)	January 67	5,500	Vibration Testing of Parts
3 Push-pull Constant Load Testing Machines	January 67	18,000	Testing of Disk Alloys

Table IV-36. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
6 [illegible]n Channel Switching and Ba[illegible]ancing Units	January 67	$ 2,400	Experimental Stress Analysis of Parts
2 Digital Strain Indicators	January 67	3,200	Experimental Stress Analysis of Parts
Other Miscellaneous Equipment		31,620	
Atomic Absorption Digital Concentration Readout	January 67	2,300	Development Testing of Oil
Differential Thermal Analyzer and Thermo Gravimetric Analyzer	January 67	13,500	Identification of unknown Material and Research on Specific Heat
Micro Ryder Gear Test Rig	January 67	4,500	Lubricant Testing
X-Ray Diffraction Unit - Film	January 67	8,000	Identification of Unknown Materials (Fuel and Oil System Development)
Tension-Compression Tester	January 67	1,500	Testing of Elastomers and Plastics
Other Miscellaneous Equipment		27,200	
Cathodic Vacuum Etcher	January 67	5,500	Etch Specimens for Electron Micro
Metallograph	January 67	2,736	General Metallurgical Development
Vacuum Melting Furnace	January 67	65,000	Alloy Development
Electron Microscope	January 67	14,149	Metallurgical Development
Other Metallurgical Equipment		12,446	
Wheel Forming Device	January 67	2,800	Quality Control of Material Both From Incoming Parts as Well as Incoming Raw Material

Table IV-37. Contractor Acquired Facilities (New)

Description	Date Required	Estimated Cost	Use
Metallograph	January 67	$ 2,110	Quality Control of Material Both From Incoming Parts As Well As Incoming Raw Material
Recording Polarigraph	Janu y 67	2,000	" " "
X-Ray Unit, Mg 300	January 67	18,000	" " "
Automatic Film Processor	January 67	15,500	" " "
Thread Grinder	January 67	34,000	" " "
Surface Grinder	January 67	8,500	" " "
Other Miscellaneous Equipment	January 67	6,650	
300 MV X-Ray Unit	January 67	18,000	
Other Miscellaneous Equipment	January 67	27,000	

Table IV-38. Additional Company Facilities Cost Summary

A.	DEVELOPMENT FACILITIES		
1.	Office, Manufacturing, Assembly, and Inspection Facilities		
	a. Shop and Office	$ 688,500	
	b. Manufacturing, Assembly, Inspection	2,661,200	
	Total	3,349,700	
2.	Engine and Component Test Facilities		
	a. Sea Level Engine Calibration and Endurance Test Facilities	$ 674,600	
	b. Heated Inlet Calibration and Endurance Test Facilities	6,793,900	
	c. Simulated Altitude and High Mach Number Engine Test Facilities	705,300	
	d. Simulated Altitude and High Mach Number Component Test Facilities	2,493,200	
	e. Simulated Altitude and High Mach Number Service Facilities	9,092,500	
	f. Small Component Test Facilities	641,000	
	Total	20,400,500	
3.	Supporting Facilities		
	a. Materials Development and Control Laboratories	$ 365,000	
	Total Development Facilities		$24,115,200
B.	DELIVERY FACILITIES		
1.	Office, Manufacturing, Assembly, and Inspection Facilities		
	a. Shop and Office	1,732,000	
	b. Manufacturing, Assembly, and Inspection	1,657,800	
	Total	3,389,800	
2.	Engine and Component Test Facilities		
	a. Sea Level Engine Test Facilities	69,400	
	b. Small Components Test Facilities	550,000	
	Total	619,400	
3.	Supporting Facilities		
	a. Materials Development and Control Laboratories	118,000	
	Total Delivery Facilities		4,127,200
	GRAND TOTAL - Development and Delivery Facilities		$28,242,400

REPORT C
CONFIGURATION MANAGEMENT PLAN

SECTION I
SCOPE AND OBJECTIVES

Configuration Management is the judicious use of all means to design and accomplish a specific arrangement and accountable disposition of parts for the JTF17 turbofan engine. The objectives are: an engine configuration consistent with the design requirements, product assurance requirements, and turbine engine experience; establishing development engine configurations; baseline control; establishment and control of the delivery engine configuration; component and part identification; and ensuring component assembly and engine assembly accountability. The Engineering Change, (figures 1 and 2), and the Engineering Change Control procedure are the heart of this system and the engine Parts List is the controlling document. For the experimental engines, the Experimental Release (figure 3) system serves this purpose. As the program progresses and engine development, airframe manufacturer coordination, or the FAA require changes to the engine design or engine model specification, or engine and assembly parts lists when established, the changes are implemented only by approved Engineering Changes. This configuration management is applied throughout the JTF17 engine program from initial design layouts and detail design, through development, production, follow-on development, and the service life of the engine. This provides end-item configuration control and accountability.

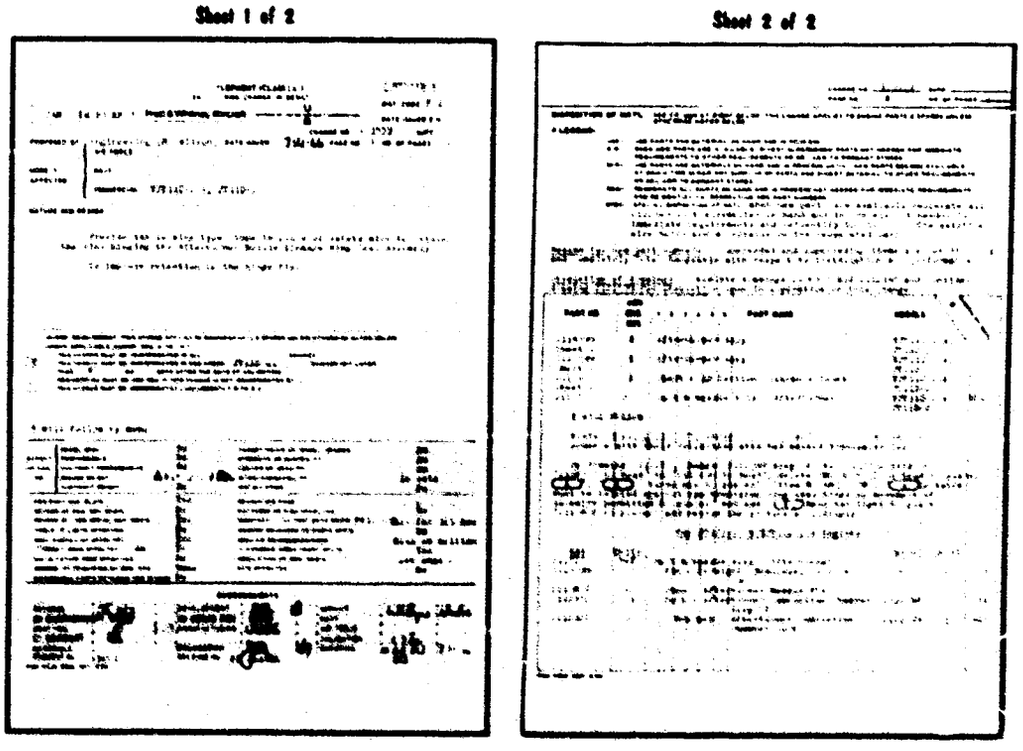


Figure 1. Engineering Change in Design (Development)

FD 17728
FD 17729
CV

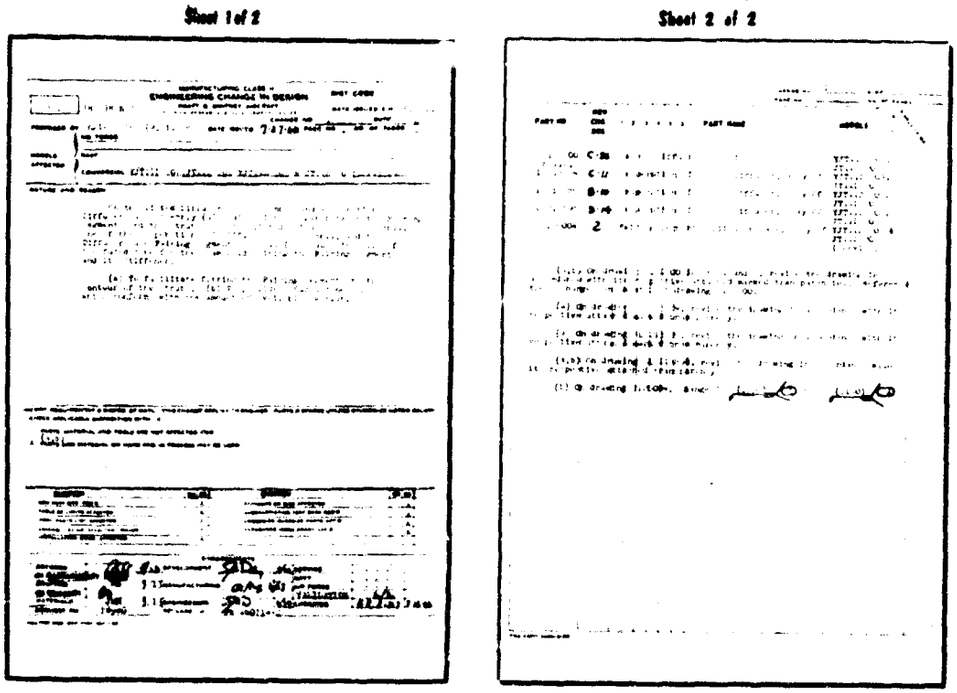


Figure 2. Engineering Change in Design (Manufacturing)

FD 17730
FD 17731
CV

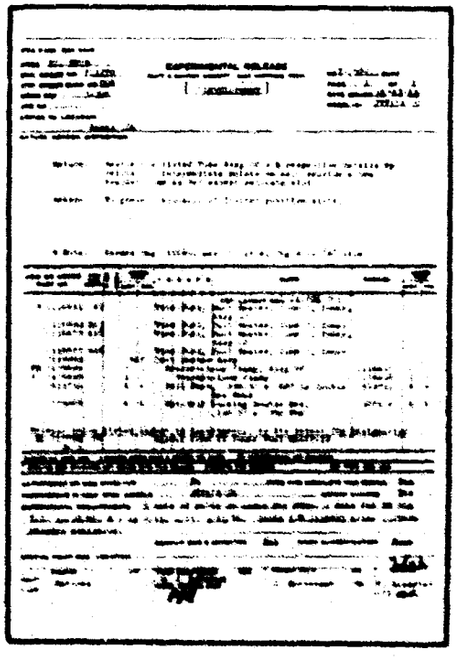


Figure 3. Experimental Release

FD 17732
CV

To assure complete compatibility between the engine and the airframe, the close working relationships and coordination developed with the airframe manufacturer and the FAA in Phase II-C will be continued. The baseline configuration for all coordination is the JTF17A-21 Engine Model/Performance Specification including the Installation Drawing. Primary tools for this coordination are the Engineering Change Request, Field Survey Layouts, engine mockup parts, and other correspondence described in Section IV and V of this plan.

The basic procedures and organization for accomplishing configuration management of commercial engine programs have existed for many years at Pratt & Whitney Aircraft and have proved to be effective. The Engineering Change and Experimental Release and control procedures are configuration management systems derived from P&WA Standard Procedures which were originally written in March 1941. The personnel in the various functions described have acquired experience in applying the appropriate P&WA Standard Procedures to ensure interface compatibility between the engine and airframe to maintain engine configuration control and accountability. The average experience level of the personnel directly involved in guiding the JTF17 Configuration Management Program is approximately 20 years. During this time approximately 140 P&WA turbine engine models released to production, representing about 80 different airframe/engine model combinations, were coordinated with airframe manufacturers and configuration control was maintained throughout each of these programs.

SECTION II
ORGANIZATION

The Program Manager for the JTF17 engine is responsible for directing all activities of the program throughout Pratt & Whitney Aircraft. A Deputy Program Manager and a program management staff organization with personnel responsible for each major functional area within the engine program support this effort. The managers on the staff are responsible for assuring that the program and Program Manager's requirements are met in their respective areas. For Configuration Management, this responsibility rests with the Chief, Configuration Management, reporting to the Manager, JTF17 Product Assurance. Coordination of the engine configuration and interfaces with the airframe manufacturer, the FAA, and the airlines is accomplished through Pratt & Whitney Aircraft's Product Support Groups. The organizational structure for the management of the JTF17 engine program is described in Volume V, Report I, and outlined for Product Assurance in figure 4. The managers who are also senior members of the Configuration Management Board have been indicated. A Configuration Management Board for the JTF17 Program has been established as a senior engine configuration review board. The board is composed of the various managers of the engine development and delivery sections and the major supporting groups. Specialists from all of the technical groups and the Product Assurance disciplines are available as Technical Consultants. While the size of the board meeting at any time may vary depending on the subjects under consideration, the board membership is:

Members

Program Manager, Chairman
Deputy Program Manager

Manager, JTF17 Development
Manager, JTF17 Product Assurance
Manager, JFT17 Delivery Engines
JTF17 Design Chief
Manager, JTF17 Product Support
JTF17 Performance Project Engineer
Chief, Configuration Management, Secretary

Technical Consultants

Chief, Engine Design
Chief, Materials Development Laboratory
Chief, Reliability
Chief, Maintainability
Test Operations
Safety Engineer
Quality Assurance

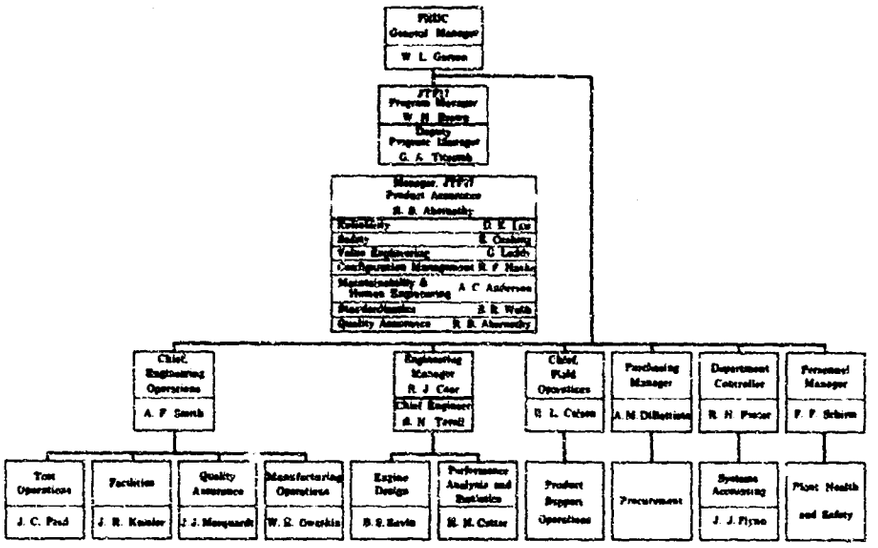


Figure 4. JTF17 Product Assurance FD 17704 CV

The board will act on matters which have been referred to it for decisions, approve configuration changes to the engine, and implement any FAA changes to the SST program insofar as they affect engine configuration. Generally, the board will meet and function as a part of the established weekly Project and Program Meetings. Special meetings will be held as required.

General responsibilities of the Configuration Management Board are:

1. Prepare Engine Model/Performance Specification including Installation Drawings and revise as required

2. Administration of policies and overall procedures to be employed by supporting groups for JTF17 engine baseline control

3. Schedule and participate in all engine informal and formal Pratt & Whitney Aircraft design reviews and the formal Engineering Design Review, Mockup Review, Certification Test Engine Review, Airframe Manufacturer Coordination Meetings, and First Article Inspection for both the Prototype and Production engines

4. Participate in Airline Review Board Meetings

5. Review and endorsement of all new Design Layouts, Experimental Releases, Engineering Releases, Requests for Engineering Change and of all Engineering Changes affecting engine configuration

6. Review and resolution of any problem associated with any proposed change to the program requirements or engine configuration baseline

7. Review of all engine model specification changes and transmittal letters and engine configuration change status reports prepared in response to the contractual requirements.

Specific responsibilities of the Chief, Configuration Management include, but are not limited to, the following:

1. Ensure Engine Model/Performance Specification is revised and issued.

2. Review and endorse all proposed changes to the engine system requirements, engine design requirements, and engine baseline configuration

3. Review and approve all Experimental Releases and Engineering Changes

4. Ensure maintenance of adequate liaison with the Federal Aviation Agency, the airframe manufacturer, subcontractors and vendors on matters relating to the JTF17 Engine Configuration

5. Administer all detail Configuration Management procedures and directives needed to implement Configuration Management decisions

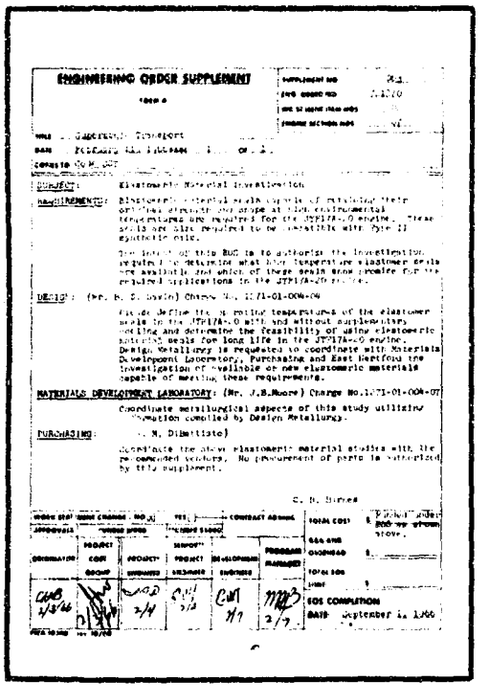
6. Direct and approve preparation of any revisions to Configuration Management procedures or directives.

Control of the engine configuration during the design and into the development phase is only the initial part of overall Configuration Management. Branches of the system extend into the engine Development Group, the Delivery Engine Group, the Experimental and Delivery Engine Manufacturing Departments, and the Experimental and Delivery Engine Assembly Departments. It is these branches that supply the necessary inputs, such as engine parts lists and assembly drawings, to the proper individuals or departments for the development and delivery engines, and the feedback that the required effort, such as an assembled engine confirmed part list or change incorporation, has been accomplished. The resulting records are maintained by Engineering Records and the Reliability Group for development engines and Service Engineering Records for delivered engines.

The accountability system for development and delivery engines is described in more detail in Section IV of this plan and the Reliability Plan, Volume IV.

SECTION III
BASELINE CONTROL - ENGINE DEVELOPMENT PHASE

The Pratt & Whitney Aircraft JTF17 Engine Model/Performance Specification, No. 2698A or 2710, including the Installation Drawing, the Engineering Order Supplements (figure 5), and the initial design layouts, form the basis for baseline control of the prototype and production engines.



ENGINEERING ORDER SUPPLEMENT

Figure 5. Engineering Order Supplement FD 17733 CV

The Engineering Assembly Parts List, Complete, together with the assembly drawings specified; and the Engine Model Specification, including the Installation Drawing, document the prototype or production engine configuration as it evolves during development. These documents provide a common frame of reference for all personnel engaged in the program, thereby permitting an orderly management of the engine configuration in the development phase prior to manufacturing the prototype or production engines.

Configuration control of all development (experimental) engines is based on the use of Experimental Releases, Form PWA F-1286 (figure 3), and the Engine Parts List, Form PWA F-1353 (figure 6). The Engine Parts List is a machine-stored numerical listing of the parts and assemblies comprising the latest configuration of an engine model. The list can be machine-printed quickly for ready reference by program management personnel or for use in establishing the next build configuration of a development engine.

UNITED AIRCRAFT CORP. — PRATT & WHITNEY AIRCRAFT DIV. FLORIDA OPERATIONS

ENGINE PARTS LIST — ENGINEERING DEPT

MODEL	DATE	SHEET NO
JT11D-20	08/12/66	79

PART OR ASSEMBLY NAME	ASSEMBLY NUMBER	ITEM NO.	QTY	PART OR BODY NUMBER	USED ON ASSY	QTY PER ASSY	TOTAL QTY	ASSEMBLY NO
NUT-PLAIN,BARREL,.190-32X.3[illegible]EX.540		1		2048099	2	1	2	M2078000
SHIELD SEG-HT,.375 TUBE,TEE	A	2	S	2048127	1	4	4	2048130
FLANGE-HEAT SHIELD TUBE,TEE	A	2	S	2048128	1	4	4	2048130
FLANGE-HEAT SHIELD TUBE,TEE	A	2	S	2048128	2	4	8	2048130
SHIELD SEGMENT-HT .375 TU TEE,45TO	A	6		2048130	2	1	2	2086836
SHIELD SEGMENT-HT .375 TU TEE,45TO	A	6		2048130	2	1	2	2121499
CASE-COMPR VANE,9 STAGE	B	5	S	2048178	1	1	1	2114639
SHROUD-CPR VANE OUTER 2 STAGE		10	S	2048353	1	1	1	2114642
SHROUD-COMPR VANE,OUTER,3 STAGE		9	S	2048354	1	1	1	2077813
SHROUD-COMPR VANE,OUTER,5 STAGE		11	S	2048355	1	1	1	2114643
SHROUD-COMP VANE OUTER 6 STAGE		10	S	2048356	1	1	1	2103336
SHROUD-COMPR VANE,OUTER,7STAGE		11	S	2048357	1	1	1	2114637
SHROUD-COMPR VANE,OUTER,8 STAGE		10	S	2048358	1	1	1	2114638
CASE-COMPR,5 STAGE	A	6	S	2048365	1	1	1	2114635
CASE-COMP 6 STAGE	B	8	S	2048366	1	1	1	2103336
CASE-COMPR,7 STAGE	B	9	S	2048367	1	1	1	2114637
SHIELD SEG-HT,.500 TUBE, 180 COMB	A	3		2048375	1	1	1	2085475
SHIELD SEG-HT,.500 TUBE, 180 COMB	A	3		2048375	4	1	4	2086405
SHIELD SEG-HT,.500 TUBE, 180 COMB	A	3		2048375	4	1	4	2086407

Figure 6. Engine Parts List FD 17734 CV

Changes to the Engine Parts List for the development engines or the release or revision of development engine drawings during the experimental development phase (Phase II-C) and development phase (Phase III) are controlled by Experimental Releases. These Releases require Configuration Management approval and are then approved by the Chief Draftsman and the JTF17 Development Manager's delegate. Configuration changes for development engines which affect the delivery engine Engineering Assembly Parts List are accomplished only through the formal Engineering Change system described in Section IV paragraph B of this plan.

A. DEVELOPMENT ENGINE CONFIGURATION

The design of the JTF17 engine is subject to continuing management control from creating the Engineering Order (Supplements)(figure 5) and initial design layouts to the qualification test, production, and service operation. Initial design is started with the EOS-established design requirements and goals including requirements and check lists for the Maintainability, Human Engineering, Reliability, Safety, Quality Assurance, and Value Engineering areas. The basic procedure for controlling the design is the design review system established in Phase II-C.

Having thus established the preliminary requirements, the design is reviewed continuously as it develops on the drawing board by the Design Project Engineer and the Design Engineers responsible for the specific disciplines. At completion, the design layout review procedure provides for a first review by the appropriate Design Engineers and, if satisfactory, approval by the Design Project Engineers. The Design Engineers listed below, or the Chief of the Design discipline, review the layout and it is signed and approved by the Development Project Engineer, if satisfactory.

Design Reliability Engineer or Chief of Reliability

Design Maintainability Engineer or Chief of Maintainability

Design Value Engineer

Safety Engineering

This constitutes the first level of Configuration Management approval. The Drafting Group then prepares or revises the part and assembly drawings, revises the Engine Parts List, and prepares the Experimental Release to issue the new or revised drawings, including the requirement for new parts for development testing. The test and parts requirements are established by the Development Project Engineer. After approval by the Chief Draftsman, the Release is approved by the JTF17 Development Manager's delegate and released to Experimental, thus completing the second level of Configuration Management approval. Where these drawings are to be included in the base-line configuration of the development engines, the release is also approved by the Chief, Configuration Management, and the drawings are released to Engineering Records for preparation of the revised Engine Parts List. If the Engineering Assembly Parts List has been established it will be changed by Engineering Records at the same time.

If the layout is not approved, a Review Sheet describing the reason the design is unacceptable is prepared and approved by the Chief of the particular discipline involved, or the Development Project Engineer. The Review Sheet and supporting information cause the layout to be returned to the designer for minor changes, or request specific development testing to clear the design, or refer the matter to the Configuration Management Board for a decision. The board meetings, more generally referred to as Project Meetings, are held once or twice a week and include representatives from all the program development, support and management areas as previously described in Section II. At this scheduled meeting, the design layout and supporting information are evaluated and a Board decision is made to direct approval, or request a trade factor study, or reject the change.

As the detail designs for the individual parts of a design layout are completed and integrated into the next higher assembly, the designs are reviewed by the Design and Development Project Engineers responsible for specific areas of the engine. When the overall engine design has reached the point that major component designs are available in layout form, an informal design review is held by the JTF17 Chief Design Engineer; Chief, Engine Design; the Development Manager; and the senior development Project Engineers. This review process continues through completion of the engine design. Periodic design reviews are held by the Company's senior Design and Development Engineers and Service Department personnel to take advantage of the experience gained from other engine programs. Two such reviews have been held in Phase II-C and another is scheduled for the fall of 1966 (figure 7).

MILESTONES

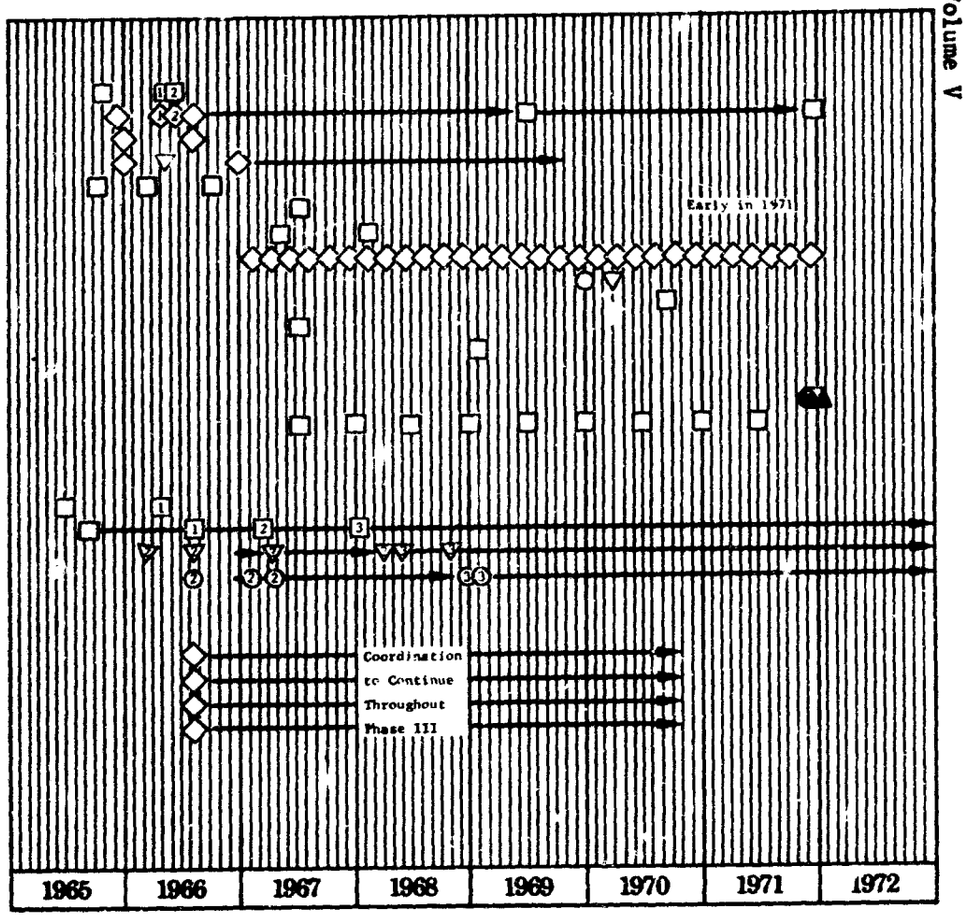
Model Specifications (JTF17A-20 ☐, A-21L ①, A-21B ②)
Revised Model Specifications* A-21L ◇①, A-21B ◇②
Airframe Engine Compatibility Plans*
Coordinated Inlet/Engine Test Plan*
JTF17 Engine - Engine Design Review (PSMA)
JTF17 Engine - Engineering Design Review
Engine Mockup Review
JTF17 Engine - Configuration Coordination Meetings
Airframe First Flight Review Meeting
Post 100-Hour Flight Test Engine Review
Establish Prototype Engine Engineering Assembly Parts List
Complete FTS Engine Design
JTF17 Engine Configuration
☐Production (Certification Test); ●Pretest Review; ▲Post-Test Review
Configuration Management Plan*

MOCKUP

Finish Preliminary JTF17A-20 Engine Design, ☐ (JTF17A-21 ①)
Fabricate Engineering Design Mockup: ①A-21, ②Class II, ③Class III
Deliver Installation Mockup - Lockheed Schedule*, ▽Class II, ▽Class III
Deliver Installation Mockup - Boeing Schedule*, ②Class II, ③Class III

CONFIGURATION ITEMS

Exterior Arrangements of Oil, Fuel, and Hydraulic System Components
Engine Mount System
Reverser-Suppressor Configuration
Components
- Power Takeoff
- Accessory Drives
- Fuel Supply and Return
- Flowmeter
- Secondary Air Ducting
- Overboard Drains



VC-12

Figure 7. Milestones Chart

FD 17735
CV

Initial engine design evaluation is obtained by laboratory testing, component rig testing, and finally, complete engine development testing as described in Volume III. Any of the testing required as a result of review and approval of new design layouts is handled in the same manner as initial engine design evaluation, depending on the significance of the test. In each case, a satisfactory test results in continuing with or incorporating the design into the baseline configuration and an assessment report (Maintenance Assessment, Reliability Assessment) to compare the test results to the design goals. A failure results in a failure analysis and report that recycles the particular design back to Design.

A simplified typical flow chart for these basic procedures of ensuring that the design requirements of all the product assurance disciplines are included in the design is depicted in figure 8. The complete procedures and specific differences are described in the Maintainability Program, Reliability Program, Value Engineering Program, and the Safety Plan in Volume IV.

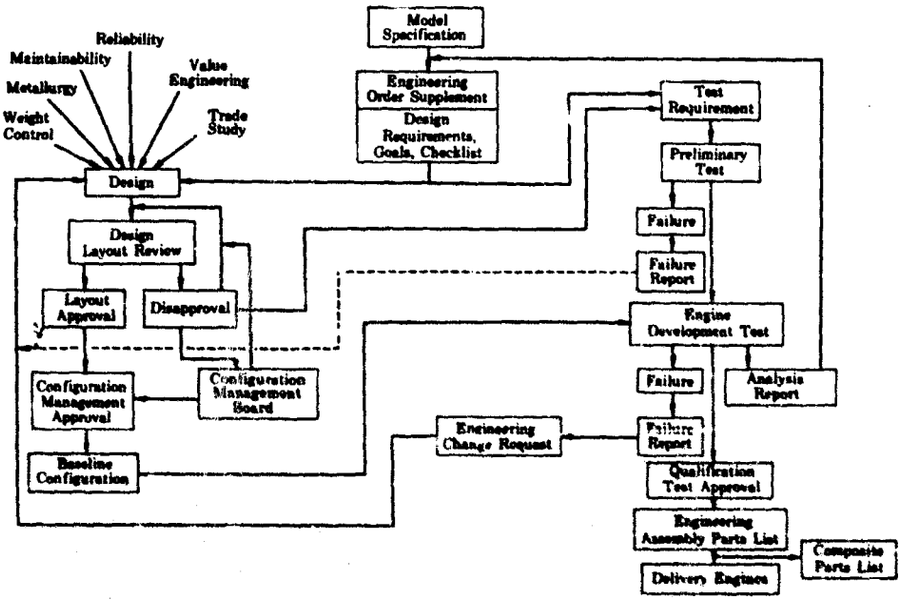
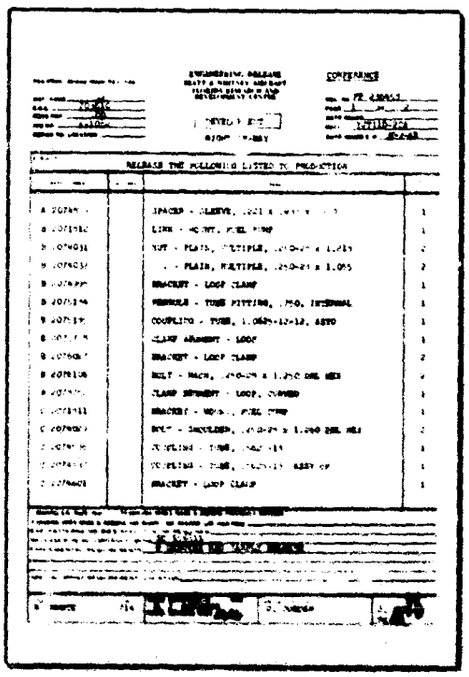


Figure 8. Product Assurance Flow Chart FD 17736 CV

During this engine development phase, changes to the engine design are submitted to the airframe manufacturer for coordination if they affect the airframe/engine installation, or physical or functional interchangeability of the engines. The design procedure described above for development engines is followed for the prototype and production engines except that, with the baseline of the development engine parts list as a point of departure, a preliminary Engineering Assembly Parts List and Installation Drawing are prepared. Parts and assemblies are released on Experimental Releases, and, if found satisfactory during development, are reviewed by design and drafting and an Engineering Release, Form PWA FR-192, (figure 9) is prepared with endorsements and approvals noted above for Experimental Releases. The Engineering Release is then sent to Engineering Records for

preparation of the preliminary Engineering Assembly Parts List, Form PWA F-1351B (figure 10), for the prototype or production engine. Shortages are prepared from this Parts List and design layouts are prepared, approved as noted above for development engines, and the necessary new drawings for parts and assemblies are approved and released on Engineering Releases and added to the preliminary Engineering Assembly Parts List. Changes in parts or assemblies released on Engineering Releases are accomplished only by the formal Engineering Change System described in Section IV paragraph B.

Sheet 1 of 2



Sheet 2 of 2

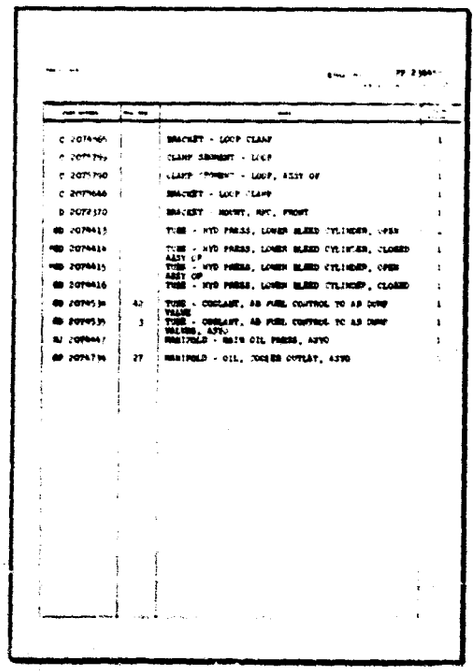
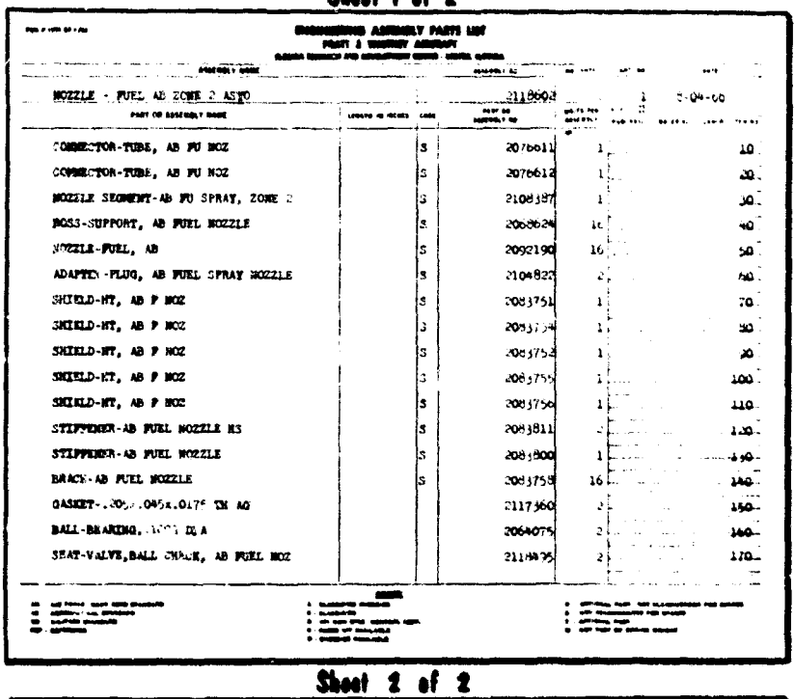


Figure 9. Engineering Release

FD 17737
FD 17610
CV

Sheet 1 of 2

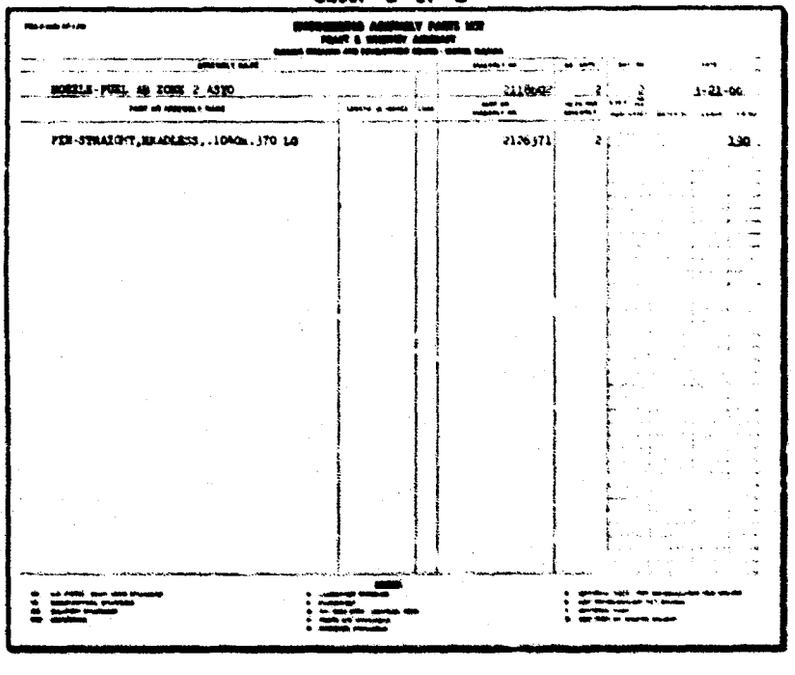


ENGINEERING ASSEMBLY PARTS LIST
PART 2 MILITARY AIRCRAFT

NOZZLE - FUEL AB ZONE 2 ASYO 2118602 1 5-04-66

PART OR ASSEMBLY NAME	LOCATING OR NOTES	CODE	PART OR ASSEMBLY NO	UNITS PER ASSEMBLY		
CONNECTOR-TUBE, AB FU NOZ		S	2076611	1		10
CONNECTOR-TUBE, AB FU NOZ		S	2076612	1		20
NOZZLE SEGMENT-AB FU SPRAY, ZONE 2		S	2108397	1		30
BOSS-SUPPORT, AB FUEL NOZZLE		S	2068624	16		40
NOZZLE-FUEL, AB		S	2092190	16		50
ADAPTER-PLUG, AB FUEL SPRAY NOZZLE		S	2104823	2		60
SHIELD-HT, AB F NOZ		S	2083751	1		70
SHIELD-HT, AB F NOZ		S	2083754	1		80
SHIELD-HT, AB F NOZ		S	2083752	1		90
SHIELD-HT, AB F NOZ		S	2083755	1		100
SHIELD-HT, AB F NOZ		S	2083756	1		110
STIFFENER-AB FUEL NOZZLE HS		S	2083811	2		120
STIFFENER-AB FUEL NOZZLE		S	2083800	1		130
BRACE-AB FUEL NOZZLE		S	2083758	16		140
GASKET-.305x.045x.017 TH AO			2117360	2		150
BALL-BEARING, .1875 ID A			2064075	2		160
SEAT-VALVE,BALL CHECK, AB FUEL NOZ			2114935	2		170

Sheet 2 of 2



ENGINEERING ASSEMBLY PARTS LIST
PART 2 MILITARY AIRCRAFT

NOZZLE-FUEL AB ZONE 2 ASYO 2118602 2 1-21-66

PART OR ASSEMBLY NAME	LOCATING OR NOTES	CODE	PART OR ASSEMBLY NO	UNITS PER ASSEMBLY		
PIN-STRAIGHT,HEADLESS,.1040x.370 LG			2126371	2		190

Figure 10. Engineering Assembly Parts List FD 17611
FD 17612
CV

B. DEVELOPMENT ENGINE ACCOUNTABILITY

The Engine Parts List (figure 6) is the basis for the initial manufacture and assembly of a development engine. At the time the schedule indicates the need to order parts for the engine, a run-off of the then current Engine Parts List is furnished by Engineering Records to the

Project Engineer responsible for that development engine. He reviews the Parts List with his Assistant Project Engineers on the basis of the development test requirements assigned to the engine to determine which of the alternate or optional designs, where they exist, will be incorporated in the engine. The modified Parts List is provided to the Project Materials Control Group for parts procurement and delivery to Experimental Engine Assembly. As the parts are delivered to the Assembly Floor, they are checked against the Parts List for correct part number and change letter. The Parts List will be manually revised during the time the parts are being pulled and the engine assembled to incorporate any new Engineering Changes consistent with the development test objectives. When the engine is delivered to Test, the modified Parts List is provided to Engineering Records and the Reliability Group.

It is the Reliability Group's responsibility to retain the Parts List and establish a parts history file, or Engine Historical Record Parts List (figure 11), for that engine by part number. The parts history record for selected parts by part number (and change letter) and serial numbers are maintained throughout the life of the part. This system is described in more detail in the Reliability Program, Volume IV, Report F, Section II.

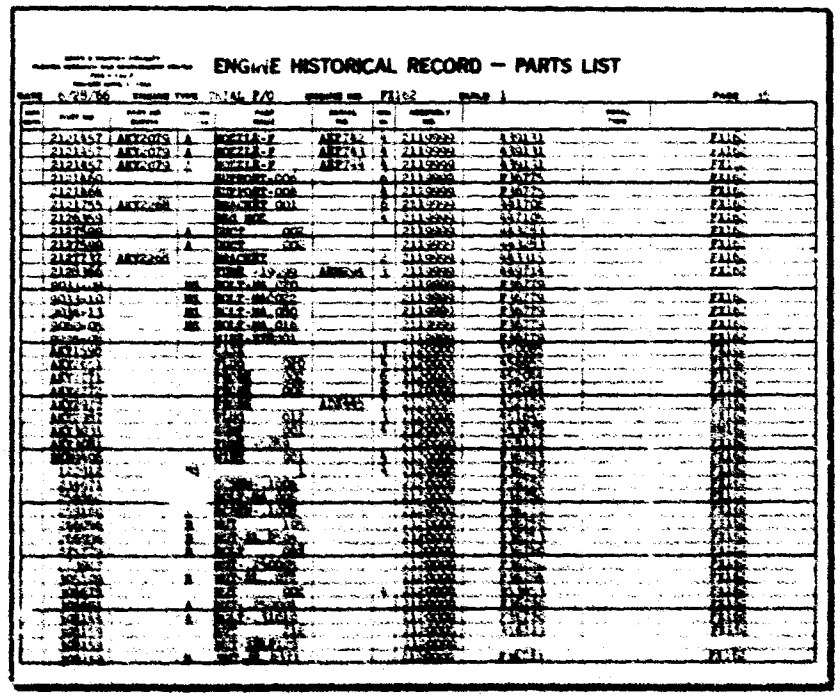


Figure 11. Engine Historical Record Parts List FD 17613 CV

Engine Parts Lists for the numerous rebuilds of a development engine are created by comparing the Part List for the last build of the engine to the current Engine Parts List obtained from Engineering Records. The table of differences or the "Add and Cancel" list is reviewed by the Project Engineer to determine what items in the "Add and Cancel" list are important, new, and must be incorporated for the new Development test objectives. This modified list is given to Project Materials Control for parts procurement in the manner described above. The final Engine Parts List is provided to Engineering Records and the Reliability Group when the engine is ready to go to Test.

SECTION IV
BASELINE CONTROL - ENGINE DELIVERY PHASE (PROTOTYPE AND PRODUCTION)

This Section of the plan has been entitled "Engine Delivery Phase" since the Configuration Management system for the Prototype and Production engines is the same; only calendar time and the type of engine qualification test (i.e. FTS or Certification) are different. Through continuing development, the configuration of the two engines may differ. Therefore, the following description of initial configuration, Configuration Management system, Engineering Changes, and Engineering Change control are applicable for both types of engines, and as an expedient in the Section, they will be referred to as "Delivery Engines."

A. INITIAL DELIVERY ENGINE CONFIGURATION

The initial configuration of the Prototype or Production engine is determined by the baseline control as described in Section III and established by a preliminary Engineering Assembly Parts List, Complete, Form PWA-F-1351B (figure 10) when issued. The Parts List Complete is a compilation of all the Engineering Assembly Parts Lists, assembly drawings, and part numbers required to assemble the JTF17 engine. The preliminary Parts List is prepared a considerable time (up to 2 years) ahead of the Parts List that will be used to assemble the Qualification Test Engine and finally establishes the configuration for the first Delivery Engines. During this period, it is revised as required as the engine development proceeds. The Qualification Test Engine shall conform to this Parts List, or as modified by subsequent Engineering Changes as described in paragraph B, following.

When the engine to be used for the Qualification Test is selected, the Engineering Records group provides the current Engineering Assembly Parts List, Complete, to the Chief, Configuration Management, for review and approval of the Configuration Management Board. It is then given to the Program Manager for his approval.

The final Parts List is established on the basis of the engine successfully completing the Flight Test Suitability (FTS) or the Certification Test. Satisfactory completion of the Qualification Test essentially freezes the design and initial configuration of the Delivery Engines to that of the engine successfully completing this test. The Parts List is then issued by an Engineering Release, Form PWA FRDC-192 (figure 9), to Delivery Engine Manufacturing as the baseline JTF17 engine configuration for delivery. The Engineering Release is approved by the Chief, Configuration Management, and the JTF17 Program Manager. All subsequent changes to the Delivery Engine configuration are by Parts List change and are accomplished only through a formal Engineering Change procedure under the control of the Chief, Configuration Management.

B. CONFIGURATION CHANGE CONTROL PROCEDURE

As described in Section I, the Engineering Change and Change Control procedures are instruments for configuration management. Pratt & Whitney Aircraft policy requires that Engine and Part Drawings and Assembly Parts Lists that are originated in the Engineering Department and have been

released for Delivery Engines on Engineering Releases, and all P&WA material, design, and process specifications be revised only by Engineering Change in Design (figures 1 and 2).

Pratt & Whitney Aircraft Engineering Changes are classified as Class IA, IB, or II as described below:

Class IA Changes

All design changes in the complete article, assemblies, sub-assemblies or parts thereof, or those changes recommended for retrofit when proposed, shall be designated Class IA Development Changes whenever any one of the following is affected:

1. Contract specification, contract price, contract weight, contract guarantees, contract delivery or contract test schedules

2. Performance, as stated in the contract, either in definite terms or goals, or as experienced in items in service use

3. Safety

4. Electrical interference to communications - electronic equipment or electromagnetic radiation hazards

5. Preset adjustments or preset schedules to the extent that (a) new identification must be assigned or (b) operating limits are affected

6. Systems, equipment, or facilities produced by another contractor to the extent that the other contractor must accomplish an engineering change to maintain compatibility at the interface

7. Contract reliability and/or contract maintainability

8. Interchangeability, or a change in category regarding substitutability or replaceability

9. Operational computer programs.

Class IB Changes

Design changes shall be designated Class IB Development Changes whenever any one of the following is affected and the change is not recommended for retrofit when proposed:

1. Contract reliability and/or contract maintainability

2. Interchangeability, or a change in category regarding substitutability or replaceability

3. Operational computer programs.

Class II Changes:

All other changes are classified as Class II Changes. Class II Changes are defined as "Manufacturing" Changes if they are made to facilitate manufacture, and do not change the part identification used for documentation. All other Class II changes are called "Development" changes.

Changes to the engine baseline configuration, as defined in paragraph A, to improve the installation, performance, durability, cost, manufacturing and/or development of the engine, can be requested by knowledgeable personnel by originating (1) an internal memorandum, (2) Engineering Order Supplement (EOS), Form PWA FRDC 298B (figure 5), or (3) an Engineering Change Request, Form PWA 396 (figure 12). A simplified detail flow chart for a typical Class IA Engineering Change is depicted in outline form in figure 13. If the change is requested by memorandum or EOS, the JTF17 Chief Draftsman will originate the Engineering Change Request and forward it to Engineering Records for processing. All requests pertaining to manufacturing problems are prepared on departmental request and then submitted to Engineering Records, as applicable, on the same Engineering Change Request Form (figure 12) by the Delivery Engine Engineering Group. (At this point, in anticipation of a revised design, the Chief, Configuration Management, with the Program Manager's approval may request the issuance of a "Red Flag Notice" (figure 14) to advise all departments that procurement of material or certain work be stopped or held to a required minimum to lessen financial loss due to a design change.) The Engineering Records Change Control Group assigns an Engineering Change serial number to the Engineering Change Request and returns it to the JTF17 Drafting Group for design analysis and, if required, takes it to the Program Manager for changes in the Engine Model Specification. Initial action on the part of the Design Engineers assigned to the request is to analyze the nature and reason on the Request for Change and any problem or failure reports attached. This analysis includes coordinating with the applicable Design and Project Engineering groups on feasibility, effect on airplane installation, weight, and parts assembly. If new parts are indicated, the drawings will be prepared and Engineering Release, Form PWA FRDC 192 (figure 9) initiated so that engine parts requiring development testing may be procured. If the request is a new requirement, results from a development problem, or results from a test failure in one of the specific areas of reliability, maintainability, or safety, Design Engineering will review the request with the Engineer responsible for the appropriate subject. Depending on the extent of the change, the Design Engineer will revise existing drawings or prepare a new design layout in accordance with the current design requirements and/or check lists. This design is periodically reviewed by the Design Project Engineer and the appropriate Design Engineer. At completion, if satisfactory, the layout is reviewed and signed by the listed Design Engineers to ensure complete Configuration Management approval:

Design Reliability Engineer

Design Safety Engineer

Design Maintainability Engineer

Design Value Engineer

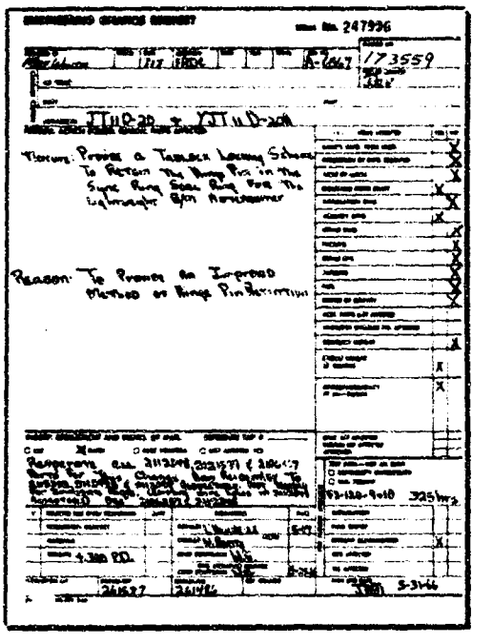


Figure 12. Engineering Change Request

FD 17614
CV

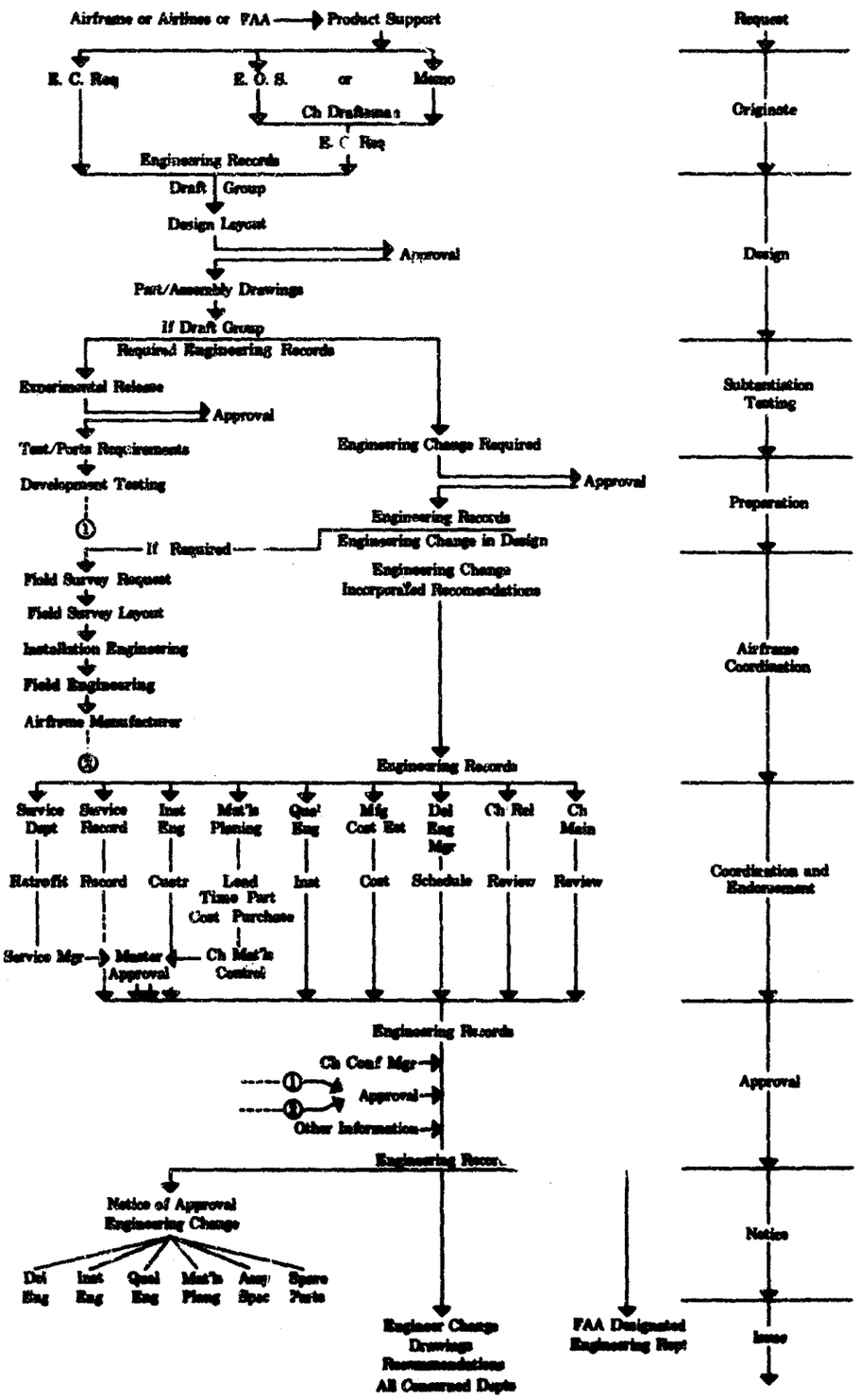
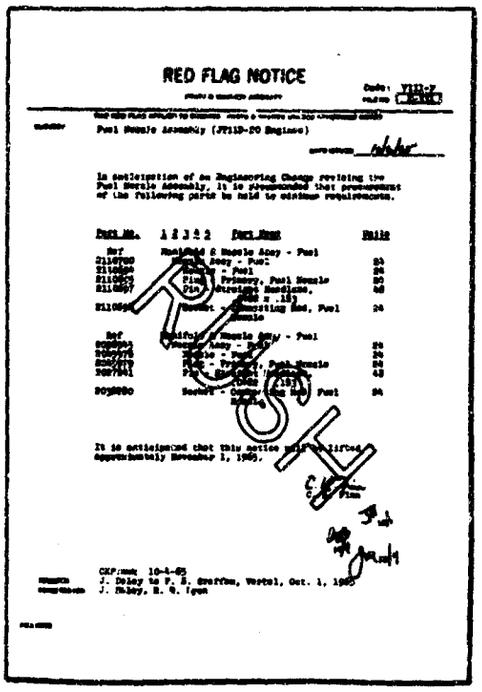


Figure 13. Class 1A Engineering Change Functional Flow Chart

FD 17615
CV



RED FLAG NOTICE

Figure 14. Red Flag Notice FD 17616

From this point, the procedure for a design change is similar to the procedure described in Section III for initial design of the engine.

The approved layout is returned to the JTF17 Drafting Group to prepare the necessary revised detail drawings, assembly parts lists, table of limits, and kits, and, if necessary, the Program Manager or his delegate obtains a Model Specification revision for the change. If the layout is not approved, a Review Sheet, approved by the Chief of the particular discipline involved, is prepared to request development testing to clear the design or refer it to the Configuration Management Board for a decision. Evaluation of the change by the Board results in a decision to either give overriding approval, request for a trade study, or reject the change. If approved and new parts are indicated, detail drawings will be prepared and an Experimental Release (figure 3) initiated so that engine parts requiring development testing and substantiation may be procured. The Engineering Change Request together with the above information is then presented to the JTF17 Program Manager or his delegate for approval.

At this time, action is initiated as required to coordinate the proposed Engineering Change with the airframe manufacturer; alert the manufacturing groups (by Red Flag Notice) of a pending change to prevent financial loss and schedule delays; and establish the degree of urgency. The approval results in the Experimental Release (figure 3) being issued and the Engineering Change in Design (figure 1) being initiated. In addition, a Development Engineering Change in Design Incorporation Sheet, Form PWA 1990 (figure 15), is prepared for all Class IA Development Changes if Delivery Engines have been shipped or parts interchangeability is involved. Both of these forms are now returned to the JTF17 Develop-

ment Engineer or his delegate for endorsing and indication of need for engine retrofit parts, field parts, or fit check parts and FAA Data Package, if required. The endorsed forms, together with the change incorporation recommendation, are returned to Engineering Records for coordination, distribution, review, and endorsement as indicated, of the preliminary Engineering Change by the following groups and individuals:

1. Service Department and Service Records
2. Installation Engineering
3. Materials Planning
4. Manufacturing Cost Estimating
5. Delivery Engine Engineering
6. Chief, Quality Assurance
7. Chief, Maintainability and Human Engineering
8. Chief, Reliability

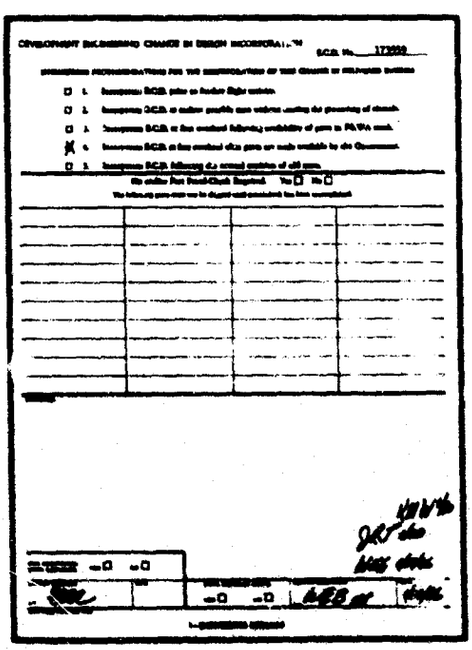


Figure 15. Development Engineering Change in Design Incorporation

FD 17617
CV

Product Support's Installation Engineering and Service Department groups review the change for effect on the airframe installation, the airframe manufacturer, the airlines, and delivered engines. Serial numbers of engines incorporating the change are requested to permit notification of the customers when the change is issued.

The copies simultaneously sent to the Materials Planning Department and the Manufacturing Cost Estimating Group permit investigation and coordination with the Purchasing and Delivery Engine (and Production) Departments to determine the new parts and tooling lead times, material availability, and manufacturing cost effects of the change on Delivery Engine Manufacturing. Estimates of the new change tool cost and parts cost per engine are determined by these groups and an Estimated Manufacturing Cost of Engineering Change, Form PWA 240, (figure 16), is prepared. The Engineering Change in Design Master (figure 1) and the cost of change (figure 16) are then reviewed by the Chief, Materials Control, or his JTF17 delegate for approval. If satisfactory, they are signed and returned to Engineering Records for incorporation of any revisions resulting from overall coordination of the preliminary change. The Change Master and the Development Engineering Change in Design Incorporation Sheet (figure 15) are then sent to the Service Department to determine if an FAA Data Package is required to authorize shipment of parts or parts kits to the customers under "urgent" situations, establish accounting control of these parts, and approve the Engineering Change.

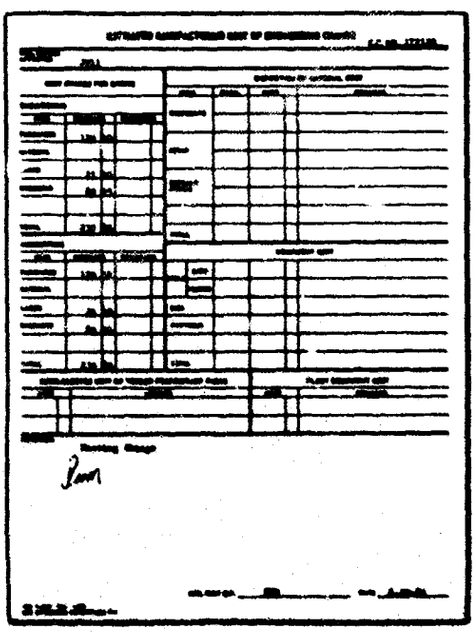


Figure 16. Estimated Manufacturing Cost of Engineering Change

FD 17618
CV

Engineering Records group prepares the complete Engineering Change package, including the master (figure 1), with approvals and endorsements mentioned above; development engine test substantiation data; Estimated Manufacturing Cost of Engineering Change (figure 16); new drawings, Engineering Change in Design Incorporation Sheet (figure 15); and other related reports. The package is reviewed by the Configuration Management Board and forwarded to the Chief, Configuration Management, who indicates final approval. If not satisfactory, the package is returned to the Chief of Configuration Management to obtain additional data. If the change is approved, all departments affected are immediately advised by Notice of Approved Engineering Change, Form PWA F-1344 (figure 17). This notification authorizes the use of preliminary drawings and copies of the preliminary Engineering Change. Departments notified of change approval are responsible for the transition, as soon as possible within the time specified in the incorporation recommendations, to the new change drawings, assemblies, and specifications to prevent financial loss or delay in incorporation. The notice is distributed by numbered copy as follows:

No. 1 Installation Engineering

No. 2 Quality Engineering

No. 3 Production Engineering

No. 4 Materials Planning, Materials Department

No. 5 Assembly Specifications

No. 6 Spare Parts Sales

No. 7 Engineering Records

PWA F-1344 Rev. 9/58

NOTICE OF APPROVED ENGINEERING CHANGE

Date 7/12/66

Engineering Change in Design 173559 is approved.

Departments affected are hereby authorized to do work required by this ECD, and use Preliminary blueprints forwarded with advance notice of Change.

P. S. Griffin
Engineering Branch

INSTALLATION ENGINEERING

Figure 17. Notice of Approved Engineering Change FD 17619 CV

The approved Engineering Change with incorporation recommendations, and new drawings, as required, are printed and distributed to all the groups and individuals previously discussed, to authorize parts procurement, change incorporation in new engines, incorporation in delivered engines as recommended, establish accountability in Service Engineering Records, and procurement and sale of spare parts. Incorporation of the Engineering Change in new engines is reported from the engine assembly floor via the Engineering Change Report, Form PWA F-1209 (figure 18), to the Engineering and Service Engineering Records Groups for incorporation in the individual engine historical record. This is described in more detail in paragraph F, following. The Configuration Management engine baseline controls are the Engineering Assembly Parts Lists and the Installation Drawing. Installation Engineering and the Engine Orders Group follow through by notifying the airframe or airline customers of the issued change and engine incorporation information, and selling price adjustment and contract amendments, respectively.

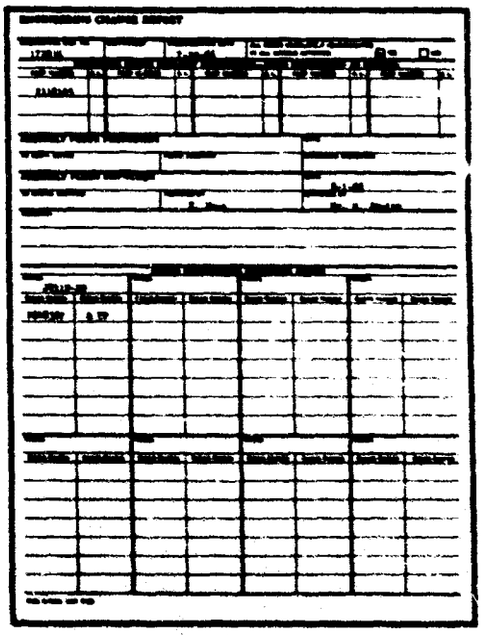


Figure 18. Engineering Change Report FD 17621 CV

C. PART AND ASSEMBLY NUMBER CONTROL PROCEDURES

Part numbers are initially assigned in numerical order as a new engine is being designed with the exception that six- or seven-digit numbers, ending in 00, 01, 02, 03, and 98-99, are reserved for engine or large component assemblies and Installation Drawings.

1. Part and Assembly Numbers

New part numbers are provided, as a part of the Engineering Change, for any detail, assembly, assembly-of, set, or kit where one of the following conditions applies:

1. Performance or durability is so affected that superseded parts must be discarded in service for reasons of safety or unsatisfactory functioning

2. Superseded and superseding items are not directly and completely interchangeable with respect to installation and performance

3. Standardization - Superseded parts are limited to use in specific articles or models of articles, but the superseding parts are not

4. Future segregation of parts in the field may be required.

New part numbers for assemblies are required if 1 or 2 above applies and the next higher assembly is sold as a spare part.

2. Part Number - Change Letters

In addition to part numbers, detail parts and assemblies are controlled by change letters for detail identification of minor changes not requiring a part number change.

a. Development Engineering Change

A Development Engineering Change always provides a new part number, as in paragraph C1, above, or advances the drawing change letter portion (e.g., "C") of the revision symbol (e.g., "C-3"), which is entered in a block under the part number on the drawing. With each such advance, the numerical portion of the revision symbol returns to "1" (e.g., "C-3" to "D-1").

b. Manufacturing Change

A Class II Manufacturing Change uses the same letter identification in the revision symbol (e.g. "C-3") which is located below the drawing number as introduced by the last development Engineering Change but advances the change symbol (numerical portion) in sequence (e.g., "C-3" to "C-4").

D. JTF17 ENGINE CHANGES REQUIRING FAA APPROVAL

1. Prior to Engine Certification

Engine Model Specification or engine design changes defined by the Contract as Category I, which change the type of engine cycle, or adversely affect contract specification, engine weight, contract specification, engine performance, or engine noise levels, will be submitted to

the FAA for approval. The request for approval will be by letter from the Program Manager and will include required substantiating data.

Significant engine configuration design and Engineering Changes requiring installation or interface coordination with the airframe manufacturer or airlines, will be processed in accordance with the preceding sections. When the coordination and approval has been obtained, the change will be reported in the Monthly Progress Report.

All other design changes are considered to be Category II.

2. Post-Certification Production Engines

Engineering changes for the production engines following engine Certification will be approved by the FAA-Designated Engineering Representative. The Engineering Changes will be submitted in accordance with the established procedures.

E. ENGINEERING CHANGE PROCESSING

The Engineering Change processing procedure described in paragraph B is known as General Processing. There are several methods of shortening the General Processing coordination, approval, and incorporation cycle of Engineering Changes depending upon the status of the manufacturing program in relation to delivery of the first engine and the urgency of the change. These are:

1. Conference Processing - Prior to Production Build of a new engine model, urgent Engineering Changes may be coordinated by means of conference, if approved in advance by the Program Manager or his delegate. All the aforementioned departments or groups are in attendance and, if the change is satisfactory, it is approved.

2. Expedited Processing - The Chief Draftsman processes and coordinates the change as required.

3. One Signature Processing - The Chief Draftsman processes, coordinates and approves certain minor changes classified as Manufacturing that do not affect costs or physical appearances.

All the above changes are approved and then distributed and handled in the manner described for general processing.

F. DELIVERY ENGINE ACCOUNTABILITY

The Engineering Assembly Parts List, Complete (figure 10) released to the Delivery Engine Engineering and Production Engineering Groups by Engineering Release (figure 9) is the basis for preparing a numerical card deck for building the first prototype or production engine. It is used to manufacture and requisition the parts for the first, or any later, engine. As the parts are delivered to the assembly floor they are inspected against the numerical deck print-out of the Parts List

("Spec Check") for correct part number and change letter before being placed in the segregated build-up racks for the specific engine.

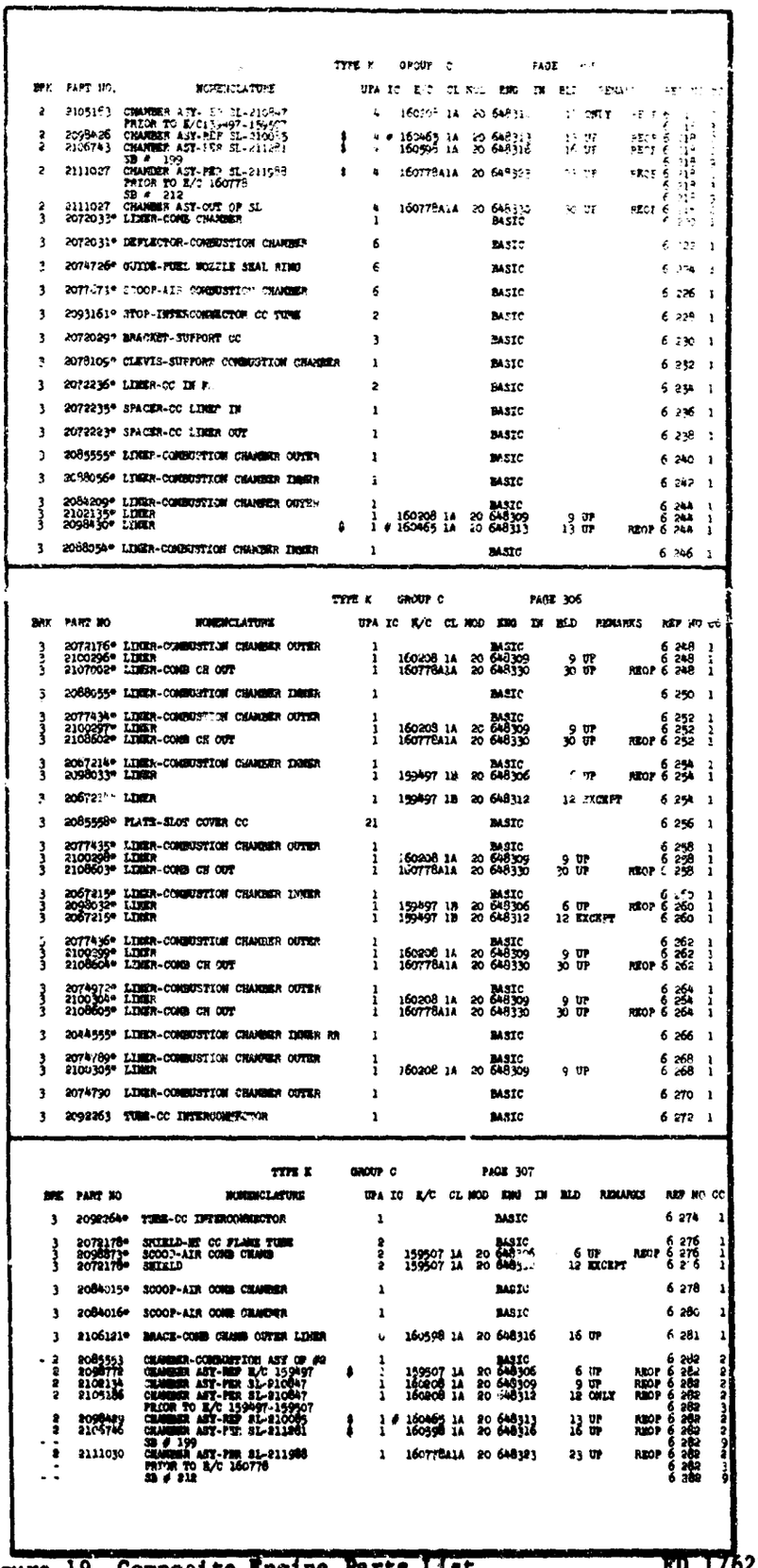
The engine is then assembled the first time in accordance with the Parts List for Initial Acceptance Test ("Green Run") in accordance with the Test Instruction Sheets for that engine model. Following this test the engine is returned to the assembly floor for disassembly, inspection of critical parts, correction of any deficiencies and incorporation of any new Engineering Changes.

The engine is then assembled for final build as above and sent to Delivery Engine Test for a Final Acceptance Test run. If accepted in accordance with the appropriate section of the Test Instruction Sheets the engine is prepared for shipment. At this time the engine model designation, serial number, installation arrangement number, maximum rated rpm, and the performance trim parameter value is stamped on the engine data plate. The Final Acceptance Test Log Sheet information is enclosed with the engine for shipment to the customer.

Any part introduced in a delivery engine after release of the Engineering Assembly Parts List, Complete is done by an Engineering Change. Any new part introduced by Engineering Change is recorded at the time of incorporation by the assembly floor and all interested departments are notified of incorporation of these Engineering Changes by the Daily Engineering Change Report, Form PWA F-1209 (figure 18), released by Quality Assurance Department.

This report alerts Service Engineering Records, and Engineering Records as to which part numbers were actually installed and the engine serial on "up" number of incorporation. The Engineering Assembly Parts List, Complete for delivered engines is then reflected in a Composite Engine Parts List (CEPL) as are all F-1209's after the first delivered engine. This CEPL, besides listing parts in the basic engine of a given model, and later engines, lists the incorporating Engineering Change, whether or not interchangeability is affected, possible reoperation of old parts, cancelled parts, and applicable service bulletins. This parts list is distributed to customers periodically.

The Composite Engine Parts List (figure 19) is maintained by Pratt & Whitney Aircraft Service Engineering Records for the life of any individual engine. A procedure for the reporting of engineering change incorporations by the airlines and other engine overhaul facilities has been coordinated with the airlines.



TYPE K GROUP C PAGE

BRK	PART NO.	NOMENCLATURE		UPA	IC	R/C	CL	MOD	ENG	IN	BLD	REMARKS	REF	NO	CC
2	2105163	CHAMBER ASY-REP SL-210847 PRIOR TO E/C 159497-159507		4		160208	1A	20	648311			ONLY			
2	2098826	CHAMBER ASY-REP SL-210847		4	#	160465	1A	20	648313		13	UP	RECP		
2	2106743	CHAMBER ASY-PER SL-211281 SB # 199		4		160595	1A	20	648316		16	UP	RECP		
2	2111027	CHAMBER ASY-PER SL-211988 PRIOR TO E/C 160778 SB # 212		4		160778	A1A	20	648323		23	UP	RECP		
2	2111027	CHAMBER ASY-OUT OF SL		4		160778	A1A	20	648330		30	UP	RECP		
3	2072032*	LINER-COMB CHAMBER		1					BASIC						
3	2072031*	DEFLECTOR-COMBUSTION CHAMBER		6					BASIC						
3	2074726*	GUIDE-FUEL NOZZLE SEAL RING		6					BASIC						
3	2077471*	SCOOP-AIR COMBUSTION CHAMBER		6					BASIC						
3	2093161*	STOP-INTERCONNECTOR CC TUBE		2					BASIC						
3	2072029*	BRACKET-SUPPORT CC		3					BASIC						
3	2078105*	CLEVIS-SUPPORT COMBUSTION CHAMBER		1					BASIC						
3	2072236*	LINER-CC IN F.		2					BASIC						
3	2072235*	SPACER-CC LINER IN		1					BASIC						
3	2072223*	SPACER-CC LINER OUT		1					BASIC						
3	2085555*	LINER-COMBUSTION CHAMBER OUTER		1					BASIC						
3	2080564*	LINER-COMBUSTION CHAMBER INNER		1					BASIC						
3	2084209*	LINER-COMBUSTION CHAMBER OUTER		1					BASIC						
3	2102135*	LINER		1		160208	1A	20	648309		9	UP			
3	2098430*	LINER		1	#	160465	1A	20	648313		13	UP	REOP		
3	2088054*	LINER-COMBUSTION CHAMBER INNER		1					BASIC						

Sheet 1 of 3

TYPE K GROUP C PAGE 306

BRK	PART NO	NOMENCLATURE	UPA	IC	R/C	CL	MOD	ENG	IN	BLD	REMARKS	REF	NO	CC
3	2072176*	LINER-COMBUSTION CHAMBER OUTER	1					BASIC						
3	2100296*	LINER	1		160208	1A	20	648309		9	UP			
3	2107002*	LINER-COMB CH OUT	1		160778	A1A	20	648330		30	UP	REOP		
3	2088055*	LINER-COMBUSTION CHAMBER INNER	1					BASIC						
3	2077434*	LINER-COMBUSTION CHAMBER OUTER	1					BASIC						
3	2100297*	LINER	1		160208	1A	20	648309		9	UP			
3	2108602*	LINER-COMB CH OUT	1		160778	A1A	20	648330		30	UP	REOP		
3	2067214*	LINER-COMBUSTION CHAMBER INNER	1					BASIC						
3	2098033*	LINER	1		159497	1B	20	648306		6	UP	REOP		
3	2067215*	LINER	1		159497	1B	20	648312		12	EXCEPT			
3	2085558*	PLATE-SLOT COVER CC	21					BASIC						
3	2077435*	LINER-COMBUSTION CHAMBER OUTER	1					BASIC						
3	2100298*	LINER	1		160208	1A	20	648309		9	UP			
3	2108603*	LINER-COMB CH OUT	1		160778	A1A	20	648330		30	UP	REOP		
3	2067215*	LINER-COMBUSTION CHAMBER INNER	1					BASIC						
3	2098032*	LINER	1		159497	1B	20	648306		6	UP	REOP		
3	2067215*	LINER	1		159497	1B	20	648312		12	EXCEPT			
3	2077436*	LINER-COMBUSTION CHAMBER OUTER	1					BASIC						
3	2100299*	LINER	1		160208	1A	20	648309		9	UP			
3	2108604*	LINER-COMB CH OUT	1		160778	A1A	20	648330		30	UP	REOP		
3	2074972*	LINER-COMBUSTION CHAMBER OUTER	1					BASIC						
3	2100304*	LINER	1		160208	1A	20	648309		9	UP			
3	2108605*	LINER-COMB CH OUT	1		160778	A1A	20	648330		30	UP	REOP		
3	2084555*	LINER-COMBUSTION CHAMBER INNER RR	1					BASIC						
3	2074789*	LINER-COMBUSTION CHAMBER OUTER	1					BASIC						
3	2109305*	LINER	1		160208	1A	20	648309		9	UP			
3	2074790	LINER-COMBUSTION CHAMBER OUTER	1					BASIC						
3	2092263	TUBE-CC INTERCONNECTOR	1					BASIC						

Sheet 2 of 3

TYPE K GROUP C PAGE 307

BRK	PART NO	NOMENCLATURE	UPA	IC	R/C	CL	MOD	ENG	IN	BLD	REMARKS	REF	NO	CC
3	2092264*	TUBE-CC INTERCONNECTOR	1					BASIC						
3	2078178*	SHIELD-HT CC FLAME TUBE	2					BASIC						
3	2098873*	SCOOP-AIR COMB CHAMB	2		159507	1A	20	648306		6	UP	REOP		
3	2078178*	SHIELD	2		159507	1A	20	648312		12	EXCEPT			
3	2084015*	SCOOP-AIR COMB CHAMBER	1					BASIC						
3	2084016*	SCOOP-AIR COMB CHAMBER	1					BASIC						
3	2106121*	BRACE-COMB CHAMB OUTER LINER	6		160598	1A	20	648316		16	UP			
2	2085553	CHAMBER-COMBUSTION ASY OF #2	1					BASIC						
2	2098778	CHAMBER ASY-REP E/C 159497	4		159507	1A	20	648306		6	UP	REOP		
2	2108134	CHAMBER ASY-PER SL-210847	1		160208	1A	20	648309		9	UP	REOP		
2	2106186	CHAMBER ASY-PER SL-210847 PRIOR TO E/C 159497-159507	1		160208	1A	20	648312		12	ONLY	REOP		
2	2098489	CHAMBER ASY-REP SL-210847	4	#	160465	1A	20	648313		13	UP	REOP		
2	2105746	CHAMBER ASY-PER SL-211281 SB # 199	4		160595	1A	20	648316		16	UP	REOP		
2	2111030	CHAMBER ASY-PER SL-211988 PRIOR TO E/C 160778 SB # 212	1		160778	A1A	20	648323		23	UP	REOP		

Sheet 3 of 3

Figure 19. Composite Engine Parts List

FD 17622
FD 17623
FD 17624

SECTION V
ENGINE CONFIGURATION AND AIRFRAME COMPATIBILITY

Throughout the initial phases of the Supersonic Transport program, Pratt & Whitney Aircraft worked closely with the airframe manufacturers toward the goal of optimum airframe/engine combinations. This was especially true in Phase II-C and culminated in the signing of the Airframe/Engine Interface Control, Technical and Basic Working Agreements. Although these agreements cover other subjects such as test programs and schedules, a primary objective is to establish a baseline for the Phase III program for engine/airframe compatibility and to agree upon procedures for maintaining complete compatibility as the engine and airframe design and configurations are refined.

The essential engine-related elements of the Interface Control or Technical Agreements are:

1. The JTF17 Engine Model/Performance Specification including the Engine Installation Drawing
2. The JTF17 Engine Mockups
3. The JTF17 Installation Handbook.

The Engine Model/Performance Specification is the basic document establishing the characteristics of the JTF17 engine and, in conjunction with the technical agreement, forms the basis for Interface Compatibility and Configuration Management Control.

The JTF17 Installation Handbook provides additional detail or descriptive engine information on the engine fuel, lubrication and electrical systems and airframe system design considerations related to engine performance calculations, accessories, instrumentation, and inlet and exhaust systems.

The Engine Installation Drawing and engine mockups depict the external physical configuration of the engine in detail and are necessary in the coordination process for required changes by either Pratt & Whitney Aircraft or the airframe manufacturer. In addition to the function of assisting in the accurate and rapid coordination of proposed Engineering Changes affecting interface control features, the engine mockups will serve to aid in the verification of the maintainability and servicing features of the engine. These mockups may also be used by the airframe manufacturer as a production checking fixture and for personnel familiarization.

The procedures for coordinating engine configuration changes with the airframe manufacturer are described in the following sections. The procedures are similar but differ in important details for prototype and production engines.

A. PHASE III PROTOTYPE ENGINE CONFIGURATION COMPATIBILITY PROCEDURES

1. A change request is required to be initiated by P&WA directly or at the request of the airframe manufacturer, an airline, or the FAA.

2. An Engineering Change Field Survey Request, Form PWA F-3085, (figure 20), is conducted by Product Support's Installation Engineering Group if the change is believed to affect the engine installation physical interchangeability of engine's maintainability or serviceability. The Field Survey is accomplished by submitting, through P&WA Field Engineers contacting the airframe manufacturers, layout drawings, photos, and/or descriptive information necessary to define the proposed change so the airframe manufacturer may determine its effect on the airplane. When necessary, engine mockup parts may be supplied to ensure installation compatibility.

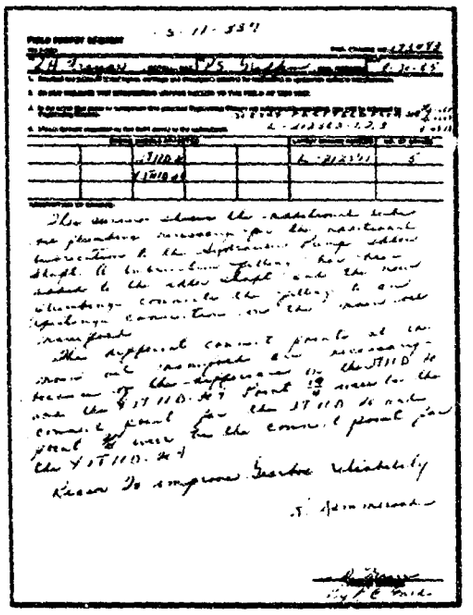


Figure 20. Field Survey Request FD 17625 CV

3. The Field Engineer advises Installation Engineering of all airframe manufacturer comments relative to the acceptability of the proposed changes from an installation compatibility standpoint. In accordance with established practices, the Field Engineer, when advised on the installation compatibility of the Field Survey by the Airplane Propulsion Manager, will provide him with the Engineering Change in Design number and then request written approval of the Engineering Change.

4. If a specific Engineering Change Proposal is unacceptable, negotiations will continue until an acceptable configuration is established. In some instances, this may require another Field Survey to establish the acceptability of a slightly modified change.

5. When written notification of acceptability has been received, P&WA will then approve and issue the Engineering Change if all internal reviews are satisfactory. The change will be incorporated in the engine, on the JTF17 Installation Drawing, and Model Specification, if required, in accordance with the incorporation schedule.

6. The JTF17 engine mockup will be revised to reflect the Engineering Change.

7. As soon as possible after final approval and issuance of the Engineering Change, P&WA will establish an estimated engine incorporation date for prototype engines and follow up with confirmed engine serial "up numbers". This information is signed by the Chief of Installation Engineering and transmitted to the airframe manufacturer.

B. PRODUCTION ENGINE CONFIGURATION COMPATIBILITY PROCEDURE

The following describes P&WA procedures in processing Engineering Changes for production engines that could have an adverse effect on: (a) the physical interchangeability of engines in the airplane installation, or (b) certified performance, and/or operational characteristics of the airplane, and/or FAA approved manuals applicable thereto.

1. Changes that fall into these categories require coordination with the airframe manufacturer, in addition to review and approval by the FAA. They are coordinated as follows:

   Steps 1 and 2 are the same as in paragraph A.

   Step 3. If the airframe manufacturer concurs that the physical interchangeability of the engine in the airplane is not affected, the field survey is approved by letter from the airframe manufacturer to Pratt & Whitney Aircraft and Steps 4 and 5 listed below are taken. If physical interchangeability is affected, coordination between Pratt & Whitney Aircraft and the airframe manufacturer will continue until a mutually acceptable solution is achieved.

   Step 4. Data and information applicable to the coordinated change will be submitted by P&WA to the FAA for their use in reviewing the change for approval.

   Step 5. Pratt & Whitney Aircraft will notify the airframe manufacturer when the change has been approved and issued by FAA. Changes that fall in the above category (1) of physical interchangeability should not require the airframe manufacturer to notify his cognizant FAA Region.

2. Changes that do or could adversely affect certified performance and/or operational characteristics of the airplane, or FAA approved manuals, are coordinated as follows:

   Step 1. Pratt & Whitney Aircraft submits an Engineering Change, Field Survey package consisting of data, drawings, or other information necessary to define the proposed change and requests the airframe manufacturer to determine the effect of the change on the certified performance, operational characteristics of the airplane, or FAA approved flight manuals. If the airframe manufacturer determines there is no adverse effect of the change on certified performance or FAA approved flight manuals, he will forward an approval letter of the field survey to Pratt & Whitney Aircraft and Steps 4 and 5 above, will be taken.

   Step 2. Upon finding that the proposed change does have an effect, the airframe manufacturer will advise Pratt & Whitney Aircraft of the nature and scope of the effect on certified performance, operational characteristics of the airplane, and/or released FAA approved flight manuals. If the airframe manufacturer finds it necessary to contact his local cognizant FAA Region, he must make it clear that P&WA has not at this point notified FAA of the proposed change. Coordination between Pratt & Whitney Aircraft and the airframe manufacturer will continue until a mutually acceptable solution is achieved.

   Step 3. If it is decided to proceed with the change, a letter of approval for the Engineering Change will be requested from the airframe manufacturer. Upon receipt of this approval letter, the proposed Engineering Change will be submitted by Pratt & Whitney Aircraft to FAA with data and information applicable to the coordinated change.

   Step 4. Receipt of approval of the proposed change from the FAA will constitute complete authorization for P&WA to deliver engines which incorporate the provisions of the Engineering Change. P&WA will notify the airplane manufacturer of the FAA approval.

3. As soon as possible after release of an Engineering Change, P&WA will establish an estimated incorporation date for all production engine models involved and will follow up with confirmed incorporation dates or engine "up numbers." This information will be transmitted by letter to the airplane manufacturers concerned.

In summary, the foregoing description of P&WA procedure for coordination of Engineering Changes with FAA and the airframe manufacturer conform to agreements reached at the 30 March 1966 meeting at FAA Headquarters in Washington, D.C., and are outlined here as confirmation of that agreement.

SECTION VI
SUBCONTRACTOR/VENDOR COMPONENT CONFIGURATION CONTROL

Pratt & Whitney Aircraft's established responsibilities for Configuration Management include the control of major components and all Engineering Changes requested or initiated by its subcontractors/vendors. Requirements are established by appropriate sections of the purchase specifications in each purchase order issued to a subcontractor. The purchase specifications explain in detail the specific responsibilities of the subcontractor in providing Pratt & Whitney Aircraft with a complete component parts list and sufficient and timely information on proposed configuration changes. Enforcement of specification and purchase order requirements is controlled by the appropriate Quality Assurance and Purchasing personnel, and will be monitored by the Product Assurance Manager.

One of the means for controlling the configuration and obtaining the best design and quality assurance is to procure parts from specific sources. This is achieved by the Source Approval Procedure.

Procurement of certain parts is limited by Source Approval controls to particular sources as follows:

1. The Design Department specifies the source of items when the P&WA drawing describes any item that may relate to vendor patent, manufacturing, or proprietary rights. The control information is indicated on the design layout and on the Source Approval Data List. Both documents are approved by Design and Development Project Engineering, as described previously in Sections III and IV. The dimensions, configuration, materials, vendor's name, address, and identifying number are shown on Source Control Drawings.

2. Development Engineering specifies the source of items when (1) manufacturing is considered so complex that ordinary means of conveying information are inadequate; or (2) it is desired to designate a vendor, including P&WA, who possesses particular skills or has acquired specialized knowledge or ability through cooperation with the P&WA Engineering Department during development of the item. The control information is indicated on the Source Approval Data List, and the P&WA Source Control Drawing.

The procedures for establishing parts lists, development testing and changes for configuration control of these components are similar to those established for prototype and production engines. They differ only in calendar time and type of qualification test.

A. DELIVERY ENGINE COMPONENT CONFIGURATION

The parts list for each major component of the engine's fuel, hydraulic, and ignition systems is established at the proper time by the development unit that successfully completes the prototype engine FTS test or the production engine Certification Test requirements. The parts list for the unit that is subjected to the FTS or the production engine Certification Test engine test is established by agreement between the subcontractor and the Development Engineering Department after development time and testing indicate that this list of parts defines a component capable of completing these tests.

The detailed parts list of the unit successfully completing the test is furnished by the subcontractor to Pratt & Whitney Aircraft for approval. P&WA then approves the subcontractor parts list, issues the subcontractor a P&WA part number, and prepares a component installation drawing known as a Source Control Drawing, including the vendor parts list number, as the definition of the unit. The P&WA part number is included in the JTF17 Engineering Assembly Parts List, Complete and the record system.

Any changes to the component required after this release can only be incorporated through an Engineering Change and the Engineering Change Control procedure.

Any changes affecting external configuration will be checked to the engine Installation Drawing and on the Engineering Design mockup, prior to coordinating any installation requirements, if needed, with the aircraft manufacturer as described in Section V. After the change is coordinated and the Engineering Change approved in the established manner, the installation definition of the component, as defined by the P&WA Source Control (Component Installation) Drawing, is revised.

B. CONFIGURATION CHANGE CONTROL PROCEDURE

Each subcontractor component is defined by a Pratt & Whitney Aircraft Source Control Drawing. This drawing contains the component external contour and installation dimensions as well as the subcontractor name and address, part number, and parts list identification.

The subcontractor component parts list is frozen upon satisfactory completion of the engine FTS or Certification tests, as applicable, or upon release of the component for production in the event that this release is prior to completion of the engine FTS or Certification test. All subsequent changes to the component require Pratt & Whitney Aircraft approval and are implemented by Engineering Change similar to engine configuration changes described in the following paragraphs.

1. Class I Engineering Changes

Briefly, changes affecting contract price, weight, delivery, radio interference, performance, or durability to a degree requiring rework of units delivered, and changes affecting interchangeability or installation and performance features of the engine or component, are deemed Class I Engineering Changes. For such changes, the subcontractor/vendor is required to submit a change proposal to Pratt & Whitney Aircraft's Development Engineering Department. This request must completely define all aspects of the desired change including nature, reason, substantiation, and add-and-cancel parts list in ranking order, old drawings and new preliminary drawings, salable parts, canceled parts disposition, and earliest possible effectivity. For acceptable proposals, which may include substantiation testing at Pratt & Whitney Aircraft before acceptance, a Pratt & Whitney Aircraft Engineering Change in Design (figure 1) is processed in accordance with established procedures. After the Engineering Change is approved by the Chief, Configuration Management, and the Program Manager or his delegate, it is issued and the vendor is authorized to incorporate the change in a manner defined by

Pratt & Whitney Aircraft by a supplement to the Purchase Order. Prior to shipment of components incorporating a new Engineering Change, the vendor must furnish the parts list identification of the change in the order of incorporation. Such identification is reflected on the Pratt & Whitney Aircraft Source Control Drawing.

2. Class II Changes

Engineering changes in vendor-supplied components that cannot be designated Class I are deemed Class II Development Changes. When the vendor desires to incorporate such changes, he is required to obtain the approval of the cognizant Pratt & Whitney Aircraft Project Engineer. An equivalent Pratt & Whitney Aircraft engineering change is processed only when the external contours or installation dimensions are affected by the change; and when, by the nature of the change classification, such changes in contour or dimensions are of a minor nature. The subcontractor parts list identification of Class II Development Changes must be by a means other than that defined on the Source Control Drawing.

3. Vendor-Supplied Minor Components

The preceding discussions are applicable to the majority of vendor components. Vendor-supplied minor components, such as drain valves or small actuators, are controlled in the same manner except that a vendor's parts list is not required. Such components are controlled by the vendor part number and change letter designation on the Pratt & Whitney Aircraft Source Control Drawing.

SECTION VII
JTF17 CONFIGURATION MANAGEMENT WORK PLAN

A. PREPARE AND ISSUE JTF17 ENGINE MODEL AND PERFORMANCE SPECIFICATION

A model specification for the production engine, including the performance decks and Installation Drawing defining the engine, will be prepared, issued and modified as required. The prototype engine will be defined in this specification by indicating appropriate differences only where applicable. Revision to the specification will be by specification change and transmittal letter and will be the responsibility of the Chief, Configuration Management. The Engineering Specification Group is responsible for maintaining and issuing a current specification.

B. ESTABLISH JTF17 ENGINE DESIGN (PROTOTYPE AND PRODUCTION)

The engine design will be established by program requirements, engineering design, analysis of design requirements and coordination of all airframe manufacturer design and interface requirements. The Chief, Engine Design is responsible for the design of the engine subject to continuing review of the various product assurance groups and the Chief, Configuration Management, and the approval of the Manager, JTF17 Development and the Program Manager.

C. PRATT & WHITNEY AIRCRAFT JTF17 ENGINE DESIGN REVIEW

Periodic reviews of the engine design will be conducted by the Pratt & Whitney Aircraft Design Review Board to assure that all related past and current turbine engine experience is considered in the design and development of the engine. Reviews will be scheduled by the Program Manager as major components on the engine design are completed. This is a continuation of the established Phase II-C reviews which have been held or are scheduled as indicated on the Milestone Chart (figure 7).

D. JTF17 ENGINE ENGINEERING DESIGN REVIEW (PROTOTYPE AND PRODUCTION)

A plan for an Engineering Design Review of the JTF17 engine by the FAA, airlines, and airframe manufacturer covering the program requirements, engine design requirements and the airframe manufacturer requirements will be established. Tentatively, the Engineering Design Review can be scheduled to coincide with the 100% release of drawings to manufacturing for the first development JTF17 engine, or approximately 6 months after go ahead. This review could possibly be combined with the Engine Mockup Review. The Engineering Design Review for the production engine will be scheduled early in 1971.

E. ESTABLISH JTF17 PROTOTYPE ENGINE CONFIGURATION

The prototype engine configuration will be established by continuing engineering design, the results of engine development testing and continuing coordination of all airframe manufacturer design and interface requirements. An Engineering Assembly Parts List, Complete will be prepared by Engineering Records prior to assembly of the engine to be used for qualification testing.

The Chief, Configuration Management will be responsible for review, approval and submission of an up-to-date list to the Development and Program Manager for approval of the configuration of the qualification test engine. This list will be issued following successful completion of the FTS.

F. JTF17 ENGINE MOCKUPS (PROTOTYPE AND PRODUCTION)

Engine Mockups will be manufactured and maintained for Pratt & Whitney Aircraft engineering design and the airframe manufacturer as mutually agreed upon. These are discussed briefly in Sections III and IV and identified on the figure 7 Milestone Chart. This program is described in detail in the Mockup Plan, Volume III, Report D.

G. JTF17 ENGINE MOCKUP REVIEW (PROTOTYPE AND PRODUCTION)

The formal engine Mockup Review can be tentatively scheduled for February 1968 for the prototype engine when the JTF17 Installation Design Engine mockup is scheduled to be available. An updated Phase II-C engine mockup will be available early in 1967. The production engine mockup which will incorporate all the development and flight test program required changes will be available for review early in 1971.

H. CONTROL OF JTF17 PROTOTYPE ENGINE CONFIGURATION

Control of the prototype engine configuration will be maintained by the Chief, Configuration Management, and accomplished only by Engineering Changes. The Configuration Management Review Board is responsible for review and approval of all configuration changes. The Engineering Records and Specifications group are responsible for issuance, revision, and distribution of the Engineering Changes including the revisions to the Engineering Assembly Parts Lists and the Engine Model Specification, respectively.

I. ESTABLISHMENT OF JTF17 PRODUCTION ENGINE CONFIGURATION

The production engine configuration will be established on the basis of the prototype engine development experience, the flight test program experience, by continuing engineering design and by continuing coordination of all airframe manufacturer design and development and interface requirements. An Engineering Assembly Parts List, Complete will be prepared by Engineering Records prior to assembly of the engine to be used for qualification testing. The Chief, Configuration Management, will be responsible for review, approval and submittal of an up-to-date list to the Manager, JTF17 Development, and Program Manager for approval of the configuration of the qualification test engine. This list will be issued following successful completion of the production engine Certification Test.

J. CONTROL OF JTF17 PRODUCTION ENGINE CONFIGURATION

Control of the production engine configuration will be maintained by the Chief, Configuration Management, and accomplished only by Engineering Changes. The Configuration Management Review Board is responsible for review and approval of all configuration changes. The Engineering Records

group is responsible for issuance, revision, and distribution of the Engineering Changes including the revisions to the Production Engine Engineering Assembly Parts Lists.

K. IMPLEMENTATION OF ENGINEERING CHANGE CONTROL PROCEDURES

Adherence to the established procedures throughout the Phase III, IV, and V programs will be the responsibility of the Chief, Configuration Management and the Program Manager.

L. AIRFRAME/ENGINE CONFIGURATION COORDINATION MEETING

Meetings will be held periodically to continue the close configuration and interface compatibility liaison established in Phase II-C and ensure that the requirements outlined in the Airframe/Engine Interface, Technical, and Basic Agreements are being met.

M. JTF17 ENGINE CERTIFICATION TEST - PRE-TEST AND POST-TEST REVIEWS

The engines selected for Certification Testing for production engine qualification test will be available for review following engine assembly.

At completion of the Certification Test, the engine will be available for inspection and the results of the test may be reviewed. Tentatively scheduled dates for these reviews are indicated on the Milestone Chart (figure 7).

N. JTF17 ENGINE POST-100-HOUR FLIGHT TEST REVIEW

Following completion of the 100-hour Flight Test Program, a meeting to review the engine test program results will be held at a time and place to be agreed upon.

O. AIRFRAME MANUFACTURER REVIEW MEETINGS

Pratt & Whitney Aircraft is planning to support the airframe manufacturer, to the extent he requests, or as required during all required review meetings. Insofar as we are currently apprised of these meetings, as follows, we have indicated the time period on the Milestone Chart (figure 7):

Airframe Mockup Review Meeting
Airframe First Flight Review Meeting
Post-100-Hour Flight Review Meeting

REPORT D
DATA MANAGEMENT PLAN

SECTION I
OBJECTIVE

The Data Management Plan describes the program that will be implemented to generate, collect, store and disseminate significant technical, financial, and managerial data to support the JTF17 engine program. These data will be used to facilitate program monitoring and decision making, promote economy, and coordinate with and inform the FAA, airframe contractor, and the airflines.

SECTION II
ORGANIZATION

As shown in figure 1, the authority of the Chief, Data Management to request, direct, and schedule the generation of data and to collect, store, and disseminate these data is derived from the Program Manager through the Manager, JTF17 Program Controls.

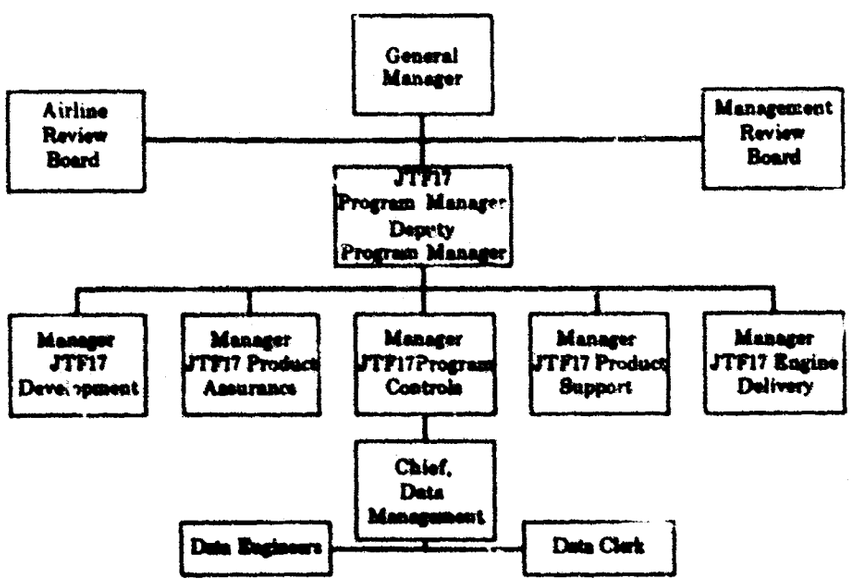


Figure 1. Data Management Organizations FD 17713 DV

A. FUNCTIONS AND RESPONSIBILITY

The Chief, Data Management's function is to identify document requirements, program the development of documents, and monitor the tasks required for delivery of documents to assure the timely flow of significant technical, financial, and managerial data throughout the design, development, delivery, and service phases of the Engine Development Program. The Chief, Data Management has the following responsibilities:

1. Establish data requirements and prepare a Data Requirements Document
2. Prepare and maintain a Data List to provide a current accounting of documents generated
3. Coordinate data requirements with other organizational elements within Pratt & Whitney Aircraft, the airframe contractor, the Government, and the airlines
4. Establish and maintain a JTF17 Program Room to interface with the Control Room maintained by the FAA
5. Maintain close coordination with the FAA, airframe contractor, and the airlines on matters pertaining to pertinent data acquisition and dissemination
6. Establish and/or maintain reference files of related data
7. Review the Technical Abstract Bulletin on a continuous basis
8. Update the Data Management Plan.

B. RELATIONSHIPS TO CHIEF, DATA MANAGEMENT

Coordination of JTF17 program data requirements within Pratt & Whitney Aircraft and with the FAA, airframe contractor, and the airlines will be monitored by the Chief, Data Management. Internal and external data will flow through the Data Center. The Data Center will record, establish requirements for, schedule, track, collect, prepare and disseminate program data, as required, to support program requirements.

1. Support Group Relationship

The Chief, Data Management is assisted by the Project Group and various support groups in all phases of the engine program. Formal communication of data tasks and schedules are provided to the project and departmentally organized support groups by the Chief, Data Management. In addition, he maintains a close working relationship with these groups to provide guidance and assure their continual awareness of data objectives and requirements as well as the data activities in interface areas. Through the Chief, Data Management, data are tracked and the feedback of significant data is provided to the Program Manager and other program management personnel.

2. Relationship to FAA, Airframe Contractor and Airlines

Data requirements for the FAA, airframe contractor, and airlines, and the dissemination of data to these sources will be coordinated through the Chief, Data Management.

SECTION III
DATA CENTER OPERATION

The functional operation of the Data Center is shown in figure 2. All requests for data from the FAA, airframe contractor, airlines, and Pratt & Whitney Aircraft will be directed to the Chief, Data Management. He will establish the data requirements, tasks and schedules through Engineering Order Supplements and Delivery Order Supplements and provide, as required, written detail instructions for data preparation to the appropriate Project Manager. All data items will be incorporated into the Pratt & Whitney Aircraft DATAMAT, which will permit the control and tracking of data preparation on a current basis using electronic data processing to produce weekly status reports.

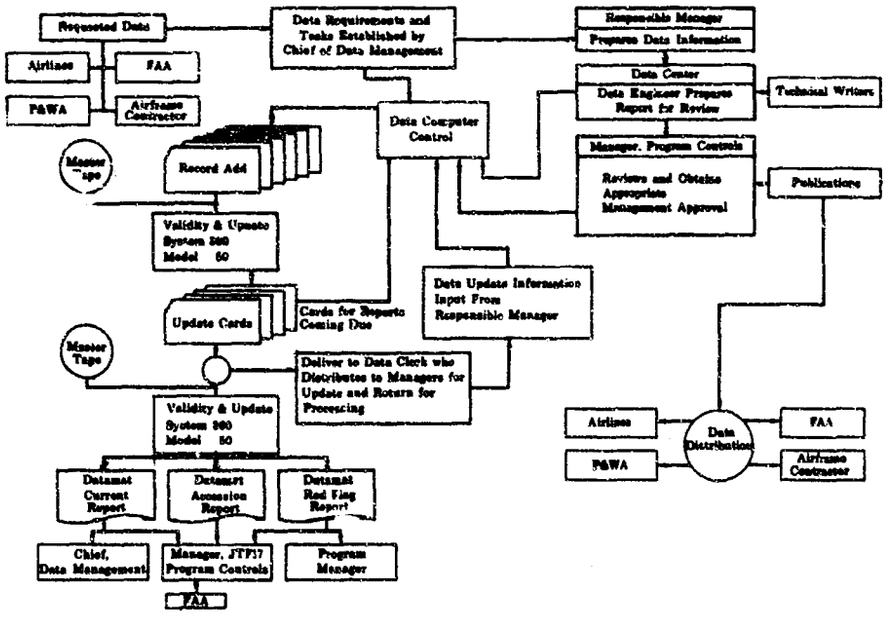


Figure 2. Data Center Functional Operation FD 17714 DV

A. DATAMAT

Pratt & Whitney Aircraft plans to develop and implement during Phase III a Data Management Analysis Technique (DATAMAT) system, which will be used to identify document requirements, program the development of documents, and monitor the tasks required for timely delivery of documents. DATAMAT subjects data preparation and transmittal for the Phase III JTF17 engine development program to computerized control and review. Three DATAMAT reports will be generated weekly:

1. The DATAMAT Current Report, essentially in the format shown in figure 3, which lists the status of all data required by the Data Requirements Documents and the Data List, is forwarded to the Chief, Data Management and Manager, Program Controls

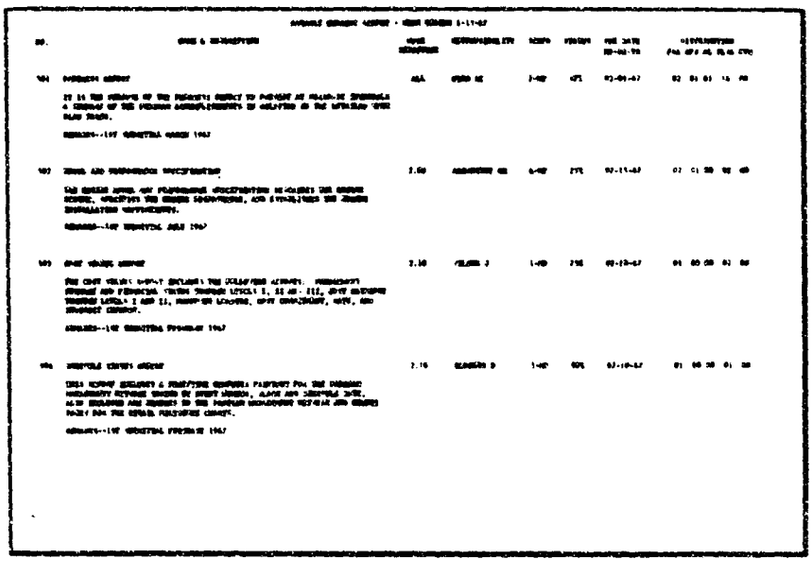


Figure 3. Datamat Current Report FD 17715

2. The DATAMAT Red Flag Report, which lists all data items that are late or behind schedule, is forwarded to the JTF17 Program Manager and Manager, JTF17 Program Controls for corrective action

3. The DATAMAT Accession Report, which lists all data items completed during the report period is forwarded to the Manager, JTF17 Program Controls, and the FAA.

The DATAMAT Reports will be updated weekly from inputs received from each project manager who has responsibility for the generation of specific data within his organization.

DATAMAT Update Input forms, in essentially the format shown in figure 4, will be generated by an IBM computer each week from the Data Requirements Control, maintained on the computer, for those reports and data that are due for transmittal within the immediate reporting period. For example, a report due on 10 February 1967 will be subject to an input check beginning the week of 10 January 1967. Status checks will be continued weekly from initiation until the report is submitted, at which time it will be placed on the Data Accession List for the period.

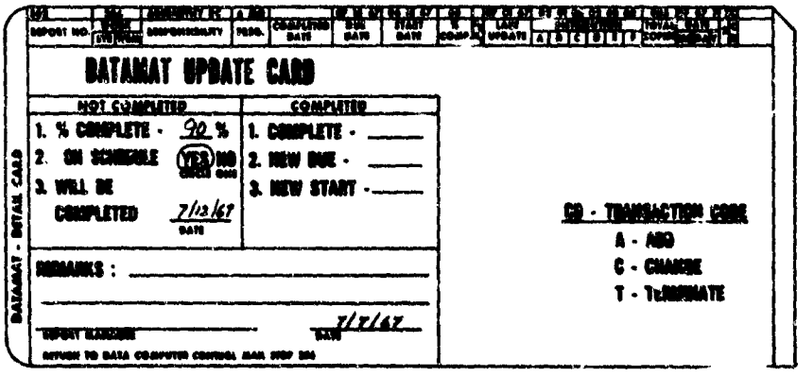


Figure 4. Datamat Update Input Form F 7

DATAMAT Update Input forms containing current data status information will be forwarded to the Data Clerk who will circulate them to the responsible JTF17 Manager. Updated input forms will then be forwarded directly to Data Computer Control by the Manager and the DATAMAT reports will be prepared.

B. DATA CENTRAL FILE

A Data Central File will be established and located adjacent to the Chief, Data Management. It will provide a file of record, on standard-size microfiche of all documents delivered to the FAA during Phase III. In addition, the file will contain a reference library, for the use of Pratt & Whitney Aircraft program management, of related data and of data supplied to the airframe manufacturer and the airlines together with other data information required for managerial control and presentation.

C. JTF17 PROGRAM ROOM

Program Management meetings will be held in the JTF17 Program Room. Certain charts will be displayed in this room for ready reference during the meetings. The Chief, Data Management and data files are planned to be adjacent to this meeting room to provide ease of reference.

The charts intended for display will be made available to the FAA to interface with the FAA Control Room. They include:

1. Chart - JTF17 Program Organization
2. Chart - Program Management Network
3. Chart - Master Milestone
4. Chart - Engine Sectional Breakdown
5. Chart - Work Breakdown Structure
6. Chart - Installation Drawing

These charts will also be made available to the airframe contractor. A brief description of the contents of each of the charts follows:

1. JTF17 Program Organization Chart - This will provide a comprehensive organization level with the titles and names of the personnel responsible for implementing and managing the program. The chart will be submitted monthly or as significant changes occur.

2. Program Management Network Chart - This chart will provide program network display of the integrated level II milestone activities related to the work breakdown structure. One copy will be submitted monthly or as significant changes occur.

3. Master Milestone Chart - This chart will provide management data, such as design, construction, test, etc., for all significant events that must be maintained throughout the Phase III program. One copy will be submitted monthly or as significant changes occur.

4. Engine Sectional Breakdown - This chart will provide an isometric sectional pictorial representation of the JTF17 engine. One copy will be submitted monthly or as significant changes occur.

5. Work Breakdown Structure Chart - This chart will provide a display which depicts the program subdivisions and their interrelationships. One copy will be submitted monthly or as significant changes occur.

6. Installation Drawing - This chart will provide a schematic representation of the engine/airframe installation interfaces. One copy will be submitted monthly or as significant changes occur.

In addition to the charts in the JTF17 Program Room, Pratt & Whitney Aircraft will provide the FAA with copies of other charts, as required, for managerial control and presentation.

D. TECHNICAL ABSTRACT BULLETIN

The Technical Abstract Bulletin will be reviewed on a continuous basis by the data management group. Appropriate data will be distributed directly to the responsible program personnel.

SECTION IV
LIBRARY

JTF17 program personnel are apprised of the receipt of technical and scientific literature through the direct distribution from the library of weekly listings of new material received (figure 5). The library issues three publications weekly: Library Bulletin, Science Contents, and Reports Received. Any document listed is ordered directly by the individual from the library on the request form shown in figure 5.

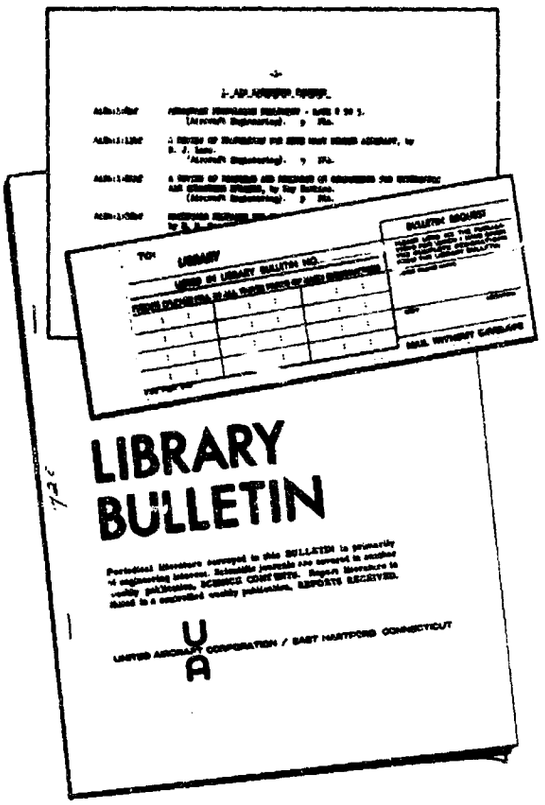


Figure 5. Library Bulletin and Request Form FD 17716
DV

SECTION V
DATA REQUIREMENTS DOCUMENT

The Data Requirements Document described in Appendix A provides a listing of the contractual documentation to be submitted to the FAA during Phase III.

A. REPORTING TO THE FAA

During Phase III, reports, data and plans will be submitted to the FAA in accordance with the schedule and quantity shown on the Data Requirements Document, Appendix A.

1. Management Reports

From the Data Requirements Document, the following data will comprise the management reports from Pratt & Whitney Aircraft to the FAA. Brief descriptions are contained in Appendix A.

Report	Phase III Submittal Initial	Frequency
Cost Status Report	February 1967	Monthly
Schedule Status Report	February 1967	Monthly
High Risk Area Report	February 1967	Two Months
Progress Report Including Data Accession List as an Appendix	March 1967	Two Months
Cost Baseline Report	September 1967	Annual
Annual Report	January 1967	Annual
Final Report	Phase III	Conclusion
Flash Failure Report	As Generated	
Master Program Plan	June 1967	Semi-Annual

2. Technical Reports

From the Data Requirements Document the following data will comprise the technical reports from P&WA to the FAA. Brief descriptions are contained in Appendix A.

Report	Phase III Submittal Initial	Frequency
Model and Performance Specification	July 1967	Semi-Annual
Engineering Change Proposal	As Required	
Data Central File	March 1967	Two Months
Integrated Test Program Update	August 1967	Monthly
Subcontractor Acceptance/ Qualification Test Report	As Generated	
Engine FTS Test Plan	Six Months Prior to Start of Test	
Final FTS Test Report	30 Days After Completion	
Final Report of Inlet/Engine Compatibility Testing	90 Days After Completion	
Final Report of Government Facility Testing	30 Days After Receipt of Data from Government Facility	
Final Report of 100-Hour Flight Test	30 Days After Completion	
Phases III and IV Detailed Test Plans	July 1967	Semi Annual
Engine Status and Usage Records	February 1967	Monthly
Failure and Analysis Report	As Generated	
Engine Installation Manual	July 1967	Semi-Annual
Engine Flight Test Report	As Generated	
Data Requirements Document	May 1967	Semi-Annual
Control Room Data	As Required	

3. Program Plans

From the Data Requirement Document the following data will comprise the program plans from P&WA to the FAA. Brief descriptions are contained in Appendix A.

Report	Phase III Submittal	
	Initial	Frequency
Configuration Management Plan including configuration inspection and review plan	July 1967	Semi-Annual
Detail Work Plan Update	February 1967	As Required
Cost Control System Update	February 1967	As Required
Schedule Control System Update	February 1967	As Required
Subcontract Plan Update	April 1967	As Required
Value Engineering Program Update	June 1967	Semi-Annual
Maintainability Program Update	August 1967	Semi-Annual
Airline Maintenance Plan	December 1969	---
Systems Safety and Human Engineering Plan Update	June 1967	Semi-Annual
Product Support Plan Update	July 1967	Semi-Annual
Reliability Program Update	July 1967	Semi-Annual
Quality Assurance Program Update	August 1967	Semi-Annual
Facilities Plan Update	July 1967	As Required
Follow-On Proposal	Prior to Phase III Completion	
Data Management Plan Update	May 1967	Semi-Annual
Manufacturing Program Update	July 1967	Semi-Annual

SECTION VI
DATA LIST

Pratt & Whitney Aircraft will prepare and maintain a Data List that will provide a current accounting of the documents generated during the Phase III program. In addition, a listing is provided in Appendix B of the data to be submitted to the airframe contractor in accordance with the requirements of the negotiated and signed SST Airframe/Engine Compatibility Agreements for Phase III.

SECTION VII
DATA ACCESSION LIST

Pratt & Whitney Aircraft will compile a Data Accession List that will provide a bi-monthly listing of the documentation completed during the reporting period under the terms of the development contract.

Item	Submittal	Frequency	Copies
1. Progress Report - It is the purpose of the progress report to present at periodic intervals a summary of the program accomplishments in relation to the Detailed Work Plan tasks.	March 1967	2 Months	20
2. Data Management Plan Update - The data management plan describes the program to generate, collect, store, and disseminate significant technical, financial and managerial data. The plan provides for the preparation of a Data Requirements Document and the preparation and maintenance of a Data List.	May 1967	6 Months	2
3. Data Accession List - The data accession list provides a periodic listing of the documentation completed during the reporting period under the terms of the development contract.	March 1967	2 Months	5
4. Data Requirements Document Update - The data requirements document provides a listing, the scope, and submission schedule of the documentation to be submitted to the FAA during Phase III.	May 1967	6 Months	5
5. Configuration Management Plan Update - The Configuration Management Plan describes the program that will be implemented to control the end-item configuration and provides engine and component part identification, engineering change control procedures, and component and engine assembly accountability for the JTF17 engine. Also described are the instruments for configuration coordination with the airframe manufacturer, the FAA, and the airlines and the configuration Inspection and Review Plan.	July 1967	6 Months	5

	Item	Submittal	Frequency	Copies
6.	Model and Performance Specification - The Engine Model and Performance Specification describes the engine design, specifies the engine performance, and establishes the engine installation requirements.	July 1967	6 Months	5
7.	Engineering Change Proposal - The Engineering Change Proposal is the instrument employed to present validated engineering changes prior to incorporation in the engine parts list.	As Required		20
8.	Cost Status Report - The Cost Status Report includes the following reports: Management Summary and Financial Status through levels I, II, and III, Cost Category through levels I and II, Manpower Loading, Cost Commitment, Rate, and Indirect Support.	February 1967	Monthly	2
9.	Schedule Status Report - This report includes a PERT/Time computer printout for the Program Management Network sorted by event number, slack and schedule data. Also included are changes to the Program Management Network and change pages for the detail milestone charts.	February 1967	Monthly	2
10.	Detail Work Plan Update - The Detail Work Plan describes the tasks, schedules and categorizes the items of work in relation to the work breakdown structure. Also included are the Program Management Network, Event Dictionary and activity descriptions.	February 1967	Update as Required	10
11.	Cost Baseline Report - This report will be prepared in accordance with the Cost Baseline Report Instructions, SST-65-16, Revision A, dated 30 June 1966, to update Phase IV and Phase V cost data.	September 1967	Annual	5

Item	Submittal	Frequency	Copies
12. Cost Control System Update - This report describes the cost planning and control system with respect to functions, capabilities, component structure, and work packages.	February 1967	Update as Required	2
13. Schedule Control System Update - This report describes the schedule planning and control system functions and capabilities. Also included is a Master Milestone Chart.	February 1967	Update as Required	2
14. Control Room Data - The control room data consist of various charts and related data. Among these are Organization Charts, Engine Sectional Breakdown, and copies of charts used for managerial control and presentation.	As Required		1
15. Subcontract Plan Update - The Subcontract Plan describes the subcontracting policy, a Make or Buy Plan, and list of suppliers or potential suppliers and their geographic locations.	April 1967	Update as Required	5
16. Value Engineering Program Update - The Value Engineering Program Report provides a function-to-cost evaluation system for the JTF17 engine program. Included are descriptions of the organization, functions, training program, and formal reporting system.	June 1967	6 Months	2
17. Annual Report - The Annual Report summarizes significant program progress, expenditure of resources and appraises progress in terms of the total JTF17 engine development program.	January 1968	Annual	20
18. Final Report - The final report will summarize the results of the JTF17 prototype engine development program and will assess the impact of the Phase III program on the total engine development program.	Phase III Conclusion		20

Item	Submittal	Frequency	Copies
19. **Data Central File** - The data central file will provide a file of record, on standard size microfiche, of all documents delivered to the FAA during Phase III.	March 1967	2 Months	1
20. **Maintainability Program Update** - The maintainability program plan describes the effort to ensure a maintainable engine throughout all phases of the JTF17 engine program from design inception through operational service. The program establishes maintainability objectives and requirements.	August 1967	6 Months	2
21. **Airline Maintenance Plan** - The Airline Maintenance Plan describes the installed and uninstalled engine inspection and maintenance tasks, procedures and schedules.	December 1969	--	5
22. **Systems Safety Plan Update** - The JTF17 engine Safety Plan describes the program to assure engine safety, and includes an Operational Safety Analysis of the engine installation. The safety plan establishes safety considerations during engine design and development in order to assure maximum safety during airframe/engine integration and operation of the Supersonic Transport.	June 1967	6 Months	5
23. **Product Support Plan Update** - The Product Support Plan brings together in one comprehensive plan the interdependent yet individual requirements of the basic product support elements for the Phase III ground and flight tests and how this experience will be utilized to prepare for the support of the engine in Phase IV and scheduled airline operation. These elements include: Phase II Maintenance and Overhaul, Field Personnel, Spares, Technical Publications, Training and Training Equipment, CSB, and Data. The effort expended to obtain airline recommendations during Phase II-C and how these efforts will be continued and expanded in Phase III and beyond is discussed.	July 1967	6 Months	2

Item	Submittal	Frequency	Copies
24. **Reliability Program Update** - The reliability program describes the management control and engineering functions to ensure compliance with the reliability goals of the JTF17 engine. Also included are the means for providing program visibility, information retrieval, and the method for statistical reliability assessment.	July 1967	6 Months	2
25. **Quality Assurance Program Update** - The Quality Assurance Program describes the organizational responsibilities, tasks and schedules to assure that all quality requirements are incorporated in the JTF17 engine from initial design through final test. Also included is the methodology to establish the requirements and guarantee compliance.	August 1967	6 Months	2
26. **Integrated Test Plan Update** - The Integrated Test Plan details the many and varied component and full-scale engine tests. The direction procedures and control necessary to achieve program performance requirements are shown. The automatic data collection system analysis procedures, and the integration of reliability, maintainability, and safety are discussed.	August 1967	Monthly	20
27. **Facilities Plan Update** - The Facilities Plan details the planned modifications or additions for JTF17 sea level and altitude test stands, component test stands, manufacturing capability and office space.	July 1967	As Required	2
28. **Master Program Plan Update** - The Master Program Plan describes the Pratt & Whitney Aircraft program management, design, manufacturing and tooling philosophy, the program management and subordinate management plans, management charts and reporting to the FAA.	June 1967	6 Months	20

Item	Submittal	Frequency	Copies
29. High Risk Area Report - The high risk area report presents a narrative discussion relative to the work breakdown structural of those areas or items where the contractor feels the development risk is the highest or the outcome is most uncertain and assesses the potential impact on the program.	February 1967	2 Months	10
30. Human Engineering Program Update - The Human Engineering Plan describes the program to integrate the principles of human physical and psychological characteristics into the JTF17 engine and ground equipment design. This effort is guided by MIL-STD-803A and emphasizes personnel convenience and safety, man-equipment accuracy and the combined man-equipment capability.	June 1967	6 Months	2
31. Follow-On Proposal - The Follow-On Proposal will include the data requested by the RFP.	Prior to Phase III Completion		30
32. Flash Failure Report - The Flash Failure Report is transmitted by TWX to notify the FAA of failures in test hardware having major impact on the program. It includes a brief description of the test hardware type of failure, preliminary analysis and proposed corrective action.	As Generated		1
33. Subcontractor Acceptance/Qualification Test Report - This report represents the results of system component and subsystem acceptance testing completed by the subcontractor.	As Generated		5
34. Engine FTS Test Plan - The Engine FTS Test Plan describes the methodology, specific tests, and facilities to be utilized for the engine FTS.	6 Months Prior to Start of Test		5

Item	Submittal	Frequency	Copies
35. **Final FTS Test Report** - The Final FTS Test Report describes the results of the test including engine performance and engine conditions.	30 days after completion		5
36. **Final Report of Inlet/Engine Compatibility Testing** - This final report will present a description of the inlet/engine compatibility testing completed at Pratt & Whitney Aircraft during Phase III together with performance results.	90 Days After Completion		5
37. **Final Report of Government Facility Testing** - This final report will present the results of engine tests conducted by Pratt & Whitney Aircraft at Government Facilities during Phase III. Included will be a description of the tests and performance analysis.	30 Days After Receipt of Data from Government Facility		5
38. **Final Report of 100-Hour Flight Test** - This final will present the results of JTF17 engine tests during the 100-Hour Aircraft Flight Test Program.	30 Days After Completion		20
39. **Phases III and IV Detailed Test Plan Update** - The test plan describes the engine and component test programs and the integration of these programs to achieve the required engine performance and maturity. The test plan integrates all elements of the program from design through manufacturing and engine certification.	July 1967	6 Months	5
40. **Engine Status and Usage Records** - These records for both the ground test and flight test engines include such items as engine serial number, number of running hours, and engine status, i.e., on test, teardown, buildup, etc.	February 1967	Monthly	5

Item	Submittal	Frequency	Copies
41. **Failure and Analysis Report** - This report presents all pertinent details surrounding the failure and the results of the investigati and analysis of the cause for failure.	As Generated		5
42. **Engine Installation Manual** - The Engine Installation Manual describes the requirements for mating of the engine to the airframe. Included are drawings, instructions, and procedures.	July 1967	6 Months	5
43. **Engine Flight Test Report** - The Engine Flight Test Report describes the results and engine performance during the series of test flight comprising the 100-Hou Aircraft Flight Program.	As Generated		5
44. **Manufacturing Program Update** - The Manufacturing Program describes the organization, tasks, and schedules for the manufacture of the JTF17 engine.	July 1967	6 Months	5

APPENDIX B
AIRFRAME CONTRACTOR DATA

1. THE BOEING COMPANY

	Report	Initial Submittal	Frequency	Copies
1.	Engine Model Specification	February 1967	6 Months	2
2.	Engine Installation Handbook	August 1967	3 Months*	5
3.	Engine Operating Instructions	July 1968	3 Months*	5
4.	Preliminary Service/Overhaul Manual	September 1968	3 Months*	2
5.	Spare Parts Catalogue	July 1969	3 Months*	2
6.	Service Bulletins	As Required		5
7.	Inspection and Repair/ Overhaul Schedules	As Required		2
8.	Engineering Change Proposal	As Required		2
9.	Maintainability Program Plan	March 1967	6 Months	2
10.	GSE Requirements List for Line Maintenance and Shop Maintenance	July 1967	As Required	2
11.	Reliability Program Plan	February 1967	6 Months	2
12.	Data to Support Reliability Program Plan	As Required Not to Exceed 6 Months		2
13.	Reliability Status Report	March 1967	Bi-Monthly	2
14.	Safety Plan	February 1967	6 Months	2
15.	Quality Assurance Plan	March 1967	6 Months	2
16.	Human Engineering Plan	March 1967	6 Months	2
17.	Marketing Support Data	As Required		2
18.	AIDS Interface Data		Bi-Monthly and/or Quarterly	2
19.	P&WA Conducted Engine/ Airframe Compatibility Test Data from the Integrated Development Tests	July 1967	Monthly	2
20.	Airframe/Engine Contractor Interface Events Progress	As Required		2
21.	Engine Calibration Test Program Procedures	Prior to Start of Test Program	As Required	2
22.	Special Problem Area Reports	As Required		2
23.	Engine Weight Data	As Required		2
24.	Analytical Model for Engine Inlet Dynamic Studies	As Required		1
25.	Safety Failure Mode and Effect Analysis	July 1967	6 Months	2

*Revised more frequently if required.

Report	Initial Submittal	Frequency	Copies
26. Data Reduction and Data Analysis Computer Decks	Following FTS	As Required	1
27. Noise Level Test Data		As Generated	2
28. Reverser Performance Demonstration Documentation		As Generated	2
29. Compressor Component Test Result Summaries		As Generated	2
30. Scale Exhaust Noise Suppression Test Results		As Generated	2
31. Engine Data for Development and Operation for a Flight Simulator	Phase III	As Required	2
32. Comments on Airframe Manuals Concerning Engine Procedures	As Generated	As Required	1
33. Program Status Report	March 1967	2 Months	2
34. Delivery Status Report	June 1967	As Required	2
35. Summary of FTS Test	30 Days After Completion		1
36. Nozzle Contour Data for Wing/Pod Integration Tests	February 1967	As Required	2

2. LOCKHEED CALIFORNIA COMPANY

Report	Initial Submittal	Frequency	Copies
1. Engine Model Specification	February 1967	6 Months	2
2. Engine Installation Handbook	August 1967	3 Months*	5
3. Engine Operating Instructions	July 1968	3 Months*	5
4. Preliminary Service/Overhaul Manual	September 1968	3 Months*	2
5. Spare Parts Catalogue	July 1969	3 Months*	2
6. Service Bulletins	As Required		5
7. Inspection and Repair/ Overhaul Schedules	As Required		2
8. Engineering Change Proposal	As Required		2
9. Maintainability Program Plan	March 1967	6 Months	2
10. GSE Requirements List for Line Maintenance and Shop Maintenance	July 1967	As Required	2
11. Reliability Program Plan	February 1967	6 Months	2
12. Data to Support Reliability Program Plan	As Required		2
13. Reliability Status Report	Not to exceed 6 months		
	March 1967	Bi-Monthly	2

*Revised more frequently if required.

	Report	Initial Submittal	Frequency	Copies
14.	Safety Plan	February 1967	6 Months	2
15.	Quality Assurance Plan	March 1967	6 Months	2
16.	Human Engineering Plan	March 1967	6 Months	2
17.	Marketing Support Data	As Required		2
18.	AIDS Interface Data		Bi-Monthly and/or Quarterly	2
19.	P&WA Conducted Engine/ Airframe Compatibility Test Data from the Integrated Development Tests	July 1967	Monthly	2
20.	Outline of Engine Development Test Program	February 1967	Monthly	2
21.	Airframe/Engine Contractor Interface Events Progress	As Required		2
22.	Engine Calibration Test Program Procedures	Prior to Start of Test Program	As Required	2
23.	Special Problem Area Reports	As Required		2
24.	Engine Weight Data	As Required		2
25.	Analytical Model for Engine Inlet Dynamic Studies	As Required		1
26.	Safety Failure Mode and Effect Analysis	July 1967	6 Months	2
27.	Comments on Airframe Manuals Concerning Engine Procedures	As Generated	As Required	1
28.	Program Status Report	March 1967	2 Months	2
29.	Delivery Status Report	June 1967	As Required	2
30.	Summary of FTS Test	30 Days After Completion		

3. DESCRIPTION OF AIRFRAME CONTRACTOR DATA

1. **Engine Model Specification**
   (Reference Data Requirements Document)

2. **Engine Installation Handbook**
   (Reference Data Requirements Document)

3. **Engine Operating Instructions**
   Operating Instructions will be presented in the form of a general engine operating instruction supplemented by specific JTF17 engine operating instructions. This will provide the necessary operating information, procedures, operating curves, and engine limits.

4. Preliminary Service/Overhaul Manual
   The Engine Maintenance Manual covers all maintenance practices including servicing, disassembly and assembly, inspection and repair, and extensive troubleshooting procedures and includes an engine description.

   The Engine Overhaul Manual provides engine description and instructions for complete overhaul of the engine including teardown, inspection, repair procedures, cleaning, plating, balancing, test, and reassembly.

5. Spare Parts Catalogue
   The Parts Catalogue lists and illustrates the assemblies and detail parts that comprise the JTF17 engine. It will encompass a numerical parts list and a complete assembly parts list with indexes. It will also list accessory component vendor equipment, units per assembly and non-procurable parts. Service bulletins that have been written and that affect the parts will be referenced in the Parts Catalogue.

6. Service Bulletins
   Each Engine and Vendor Component Service Bulletin will cover planning information, engine or component effectivity, reason for the bulletin, recommended compliance, manpower requirements, and tooling information relating to parts.

7. Inspection and Repair/Overhaul Schedules
   Time schedules for performing inspection and repair/overhaul on FTS engines will be periodically reviewed and as flight experience is accumulated will be updated accordingly.

8. Engineering Change Proposal
   (Reference Data Requirements Document)

9. Maintainability Program Plan
   (Reference Data Requirements Document)

10. GSE Requirements List for Line Maintenance and Shop Maintenance Spare Parts and Ground Support Equipment and Documentation List for engine test stand operation and maintenance will be delivered prior to receipt of the first engine at each test location. P&WA personnel will be responsible for maintaining accountability records and for issuing and reordering the required parts and equipment. They will also submit consumption data which will be collected and analyzed by Spare Parts and GSE personnel at FRDC for revisions to provisioning programing as necessary for continuing support during Phases III, IV, and V.

11. Reliability Program Plan
(Reference Data Requirements Document)

12. Data to Support Reliability Program Plan
Reliability support data shall include allocated reliability values and documented results of design reliability analysis. Sources and justification of reliability predictive data shall be included.

13. Reliability Status Report
The reliability status reports will provide a concise and accurate summary of Reliability Program Status, technical status, and significant problem areas.

14. Safety Plan
(Reference Data Requirements Document)

15. Quality Assurance Plan
(Reference Data Requirements Document)

16. Human Engineering Plan
(Reference Data Requirements Documents)

17. Marketing Support Data
To support this effort, P&WA will furnish engine related data essential for economic analysis of the aircraft which may include estimates of current engine development cost and engine sales price. Engine related data other than development cost and sales price may include but will not necessarily be limited to overhaul and line maintenance facilities and equipment requirements, maintenance, labor and material costs, and overhaul period progression.

18. AIDS Interface Data
AIDS Interface Data shall include "out of tolerance" failure criteria for each mode of failure identified in the failure mode and effect analysis; measurement accuracies; recommended sampling rate; sampling period; the recommended analytical logic to be used in fault detection, isolation, and prediction; recommendations for location of pickup points; and pertinent information relating to failure rate rapidity.

19. P&WA Conducted Engine/Airframe Compatibility Test Data from the Integrated Development Tests
(Reference Data Requirements Document)

20. Outline of Engine Development Test Program
(Reference Data Requirements Document)

21. Airframe/Engine Contractor Interface Events Progress
    P&WA will establish and schedule interface events with the airframe contractor and provide a status report of its progress towards meeting these airframe/engine contractor interface events. This report may be in the form of a PERT network of the applicable airframe/engine interface areas.

22. Engine Calibration Test Program Procedures
    A technical report describing in detail the calibration procedures, instrumentation systems and accuracies, and substantiating data relative to the analysis procedures employed will be provided the airframe contractor for his approval.

23. Special Problem Area Reports
    (Reference Data Requirements Document)

24. Engine Weight Data
    Engine weight breakdown, actual weight data, weight control procedure, and a weight and balance status shall be furnished to the Airframe Contractor.

25. Analytical Model for Engine Inlet Dynamic Studies
    A digital computer program describing dynamic characteristics of the engine and its associated control system.

26. Failure Mode and Effect Analysis
    Engine parts and components will undergo a safety and failure mode analysis to ensure that in case of failure an effective fail-safe mode exists.

27. Data Reduction and Data Analysis Computer Disks
    For the sea level static and altitude engine calibrations data reduction and data analysis computer decks shall be made available to the Airframe Contractor similar to what P&WA may develop for its own use.

28. Noise Level Test Data
    A document showing noise demonstration including a detail description of the acoustic measurement and analysis system employed shall be provided the Airframe Contractor.

29. Reverser Performance Demonstration Documentation
    Test data documenting the Static Reverser Performance Demonstration covering the range of reverse thrust settings from idle to maximum reverse will be provided to the Airframe Contractor.

30. Compressor Component Test Result Summaries
    Test result summaries of full-scale compressor rig tests simulating airframe inlet distortion patterns will be provided to the Airframe Manufacturer.

31. Scale Exhaust Noise Suppression Test Results
    A test summary of small-scale exhaust noise suppression tests to select promising designs for further analysis and full-scale testing will be provided the Airframe Manufacturer.

32. Engine Data for Development and Operation for a Flight Simulator
    Engine data for the development and operation of a flight simulator and/or engine simulator, as applicable for the SST program, will be provided the Airframe Contractor.

33. Comments on Airframe Manuals Concerning Engine Procedures
    P&WA will review and comment on drafts of all Airframe Contractor Manuals containing engine operating and maintenance data.

34. Program Status Report
    Progress reports in a format to be established after consultation with the Airframe Manufacturer and setting forth status of each item to be furnished will be provided by P&WA.

35. Delivery Status Report
    Engine delivery status will be provided in a prompt and timely manner to the Airframe Manufacturer for scheduling and planning purposes.

36. Summary of FTS Test Results
    (Reference Data Requirements Document)

37. Nozzle Contour Data for Wing/Pod Integration Tests
    P&WA will provide the Airframe Contractor with current models on contours for the engine nozzle and pass on information on any revision in the contours at the time they are incorporated.

REPORT E
SUBCONTRACTING PROGRAM
SECTION I
INTRODUCTION

It is our intention in this part of the proposal to highlight significant features of the purchasing system at the Florida Research and Development Center, to outline established methodology which will ensure the timely and economical procurement of hardware having the requisite quality and reliability for the Phase III program, and to present in a concise manner the information requested in the Request for Proposal.

The purchasing procedures of the Florida Research and Development Center have been made available to Defense Contract Audit Agency personnel, to the Naval Plant Branch Representative, and to other Government personnel at our plant. These procedures will be made available to the FAA evaluation team, should they desire to see them. Therefore, we have not presented detailed purchasing procedures in this report. The Purchasing Department at FRDC which will do the buying for the Phase III program, has handled the procurement of more than $400,000,000 worth of material and services in the past five years. The greatest part of this procurement was against cost type contracts. In this time period, there have been no disallowances because of improper purchasing procedures.

SECTION II
ORGANIZATION

Figure 1 shows the organization of the Purchasing Department at the Florida Research and Development Center. The Purchasing Department is organized on a functional basis. Three Assistant Purchasing Agents report to the Purchasing Manager. Two of these Assistant Purchasing Agents are responsible for the purchase of "product material," or finished parts which find their way into our engines, and the third is responsible for the purchase of all nonproduct material, and services. Reporting to each of the Assistant Purchasing Agents are two Chief Buyers. Each Chief Buyer heads up a team of Buyers and Buyer trainees. The buyers, because of the functional alignment of their duties, are experts in the various products they buy.

The Purchasing Manager reports directly to the General Manager of the Florida Research and Development Center. He also has direct lines of communication with, and at his request may receive the assistance of, the Purchasing Manager for Pratt & Whitney Aircraft's Connecticut Operations. Close coordination with the Connecticut Operations has made available to the Florida Research and Development Center a greater leverage for quality, economy, and timely delivery than either organization could command alone. The relationship of the Purchasing Department to, and as a part of, the SST Program is discussed in Report I of Volume V of this proposal.

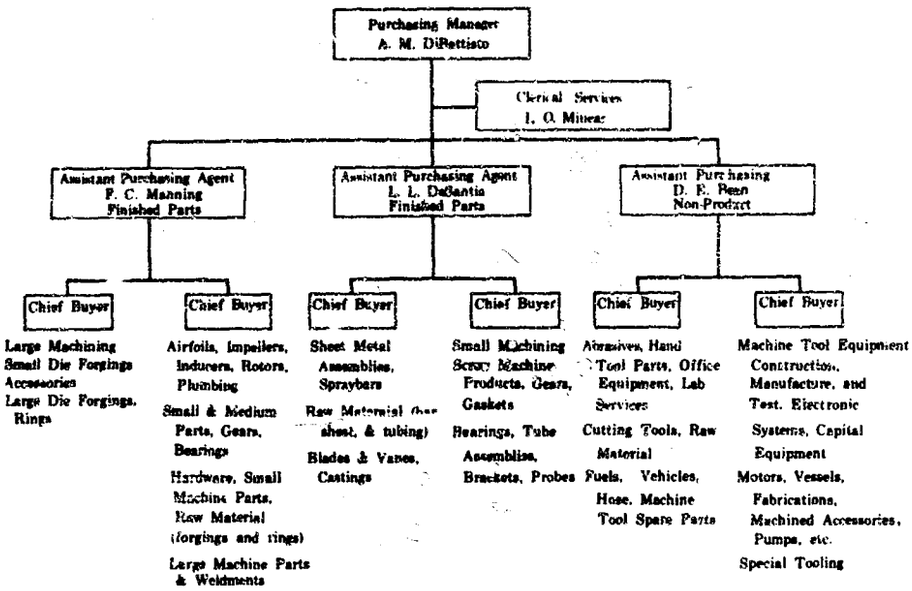


Figure 1. Purchasing Organization FD 17651 VE

SECTION III
PURCHASING PRODUCT MATERIAL

The requirement for experimental product material (material to be used in building "experimental" or "development" engines or hardware) is established by an Engineering Order Supplement issued by the Program Manager. This document, which is general in nature, is reduced to specific part numbers and quantities by Project Material Control (PMC). The function of PMC is discussed in detail in Volume V, Report G, Section V. Part numbers and quantities are either released to the shop or are transmitted to the Purchasing Department by Project Material Control in the form of a Request for Purchase Order (RPO), as dictated by the established make-or-buy plan.

The requirement for delivery prototype engines or hardware is established by Delivery Order Supplement issued by the Program Manager. The Delivery Order Supplement, like the Engineering Order Supplement, is very general and is reduced to specific part numbers and quantities by Delivery Material Control (DMC). The function of DMC is discussed in detail in the Manufacturing Plan. (See Volume V, Report G, Section V.) Part numbers and quantities are either released to the shop, or are transmitted to the Purchasing Department by Delivery Material Control in the form of a Request for Purchase Order, in accordance with the established make-or-buy plan. It is the responsibility of PMC or DMC, respectively, to include on, or with, the RPO, all AMS specifications, military and industrial specifications pertaining to materials, heat treat, brazing, and welding in addition to requirements for P&WA vendor quality control coverage.

A. PRODUCT ASSURANCE IN PURCHASED MATERIAL

The Purchasing Department has the responsibility for including in every order all of the product assurance requirements for the fabrication of the part covered by that order. They include quality assurance, reliability, maintainability, requirements for destructive or nondestructive testing, and the incorporation of applicable specifications. For all engine hardware, a Quality Assurance Document (QAD) is published and maintained for each part number by the Inspection Methods Group of Quality Assurance. The QAD includes all applicable P&WA specifications, Materials Control Laboratory bulletins, Quality Engineering inspection methods, and acceptance standards.

If the item to be purchased is an assembly, the QAD includes the detailed part numbers. The document also references the latest engineering change designations, specifications pertaining to surface finishes, nondestructive testing, and serial number marking requirements. The QAD is made a part of the purchase order and is furnished to the vendor, thus providing him complete and accurate information for all phases of manufacturing, inspection, assembly, and test of the part, as well as establishing the contractual requirements for those items.

This technique for control of product assurance requirements by means of the QAD has been used, and proved very successful, on the RL10 engine program.

B. ENSURING ON-SCHEDULE PROCUREMENT

As soon as a Request for Purchase Order is received in the Purchasing Department, it is fed into an automatic follow-up system which ensures that the appropriate Chief Buyer will review it at seven-day intervals until an order is placed. This system prevents the delay of critical procurement actions through oversight.

Each buyer, having selected a vendor for a particular procurement, is responsible for having up-to-date, accurate information concerning the manufacturing, technical, and management capabilities, as well as past performance on quality, delivery, and cost (when pertinent) of that vendor.

Each buyer is responsible for constant follow-up with vendors to whom he has awarded procurement actions, to ensure that deliveries are made on schedule. It is his responsibility to notify the Program Manager of any delay as far in advance of the time such delay occurs as is possible.

Each buyer is required to maintain such liaison with his vendors as is required to ensure that he is aware of problems as they occur, and buyers, Chief Buyers, and, in the case of large vendors, the Purchasing Manager visit vendors' facilities with appropriate representatives from P&WA engineering, quality control, etc., to assist vendors in solving problems which affect the vendors' ability to meet their commitments.

C. SELECTION OF TYPE OF CONTRACT

Whenever possible, procurements are made by competitively placed, firm fixed-price purchase orders. Next in order of choice would be a firm fixed-price order on a negotiated basis, in which case cost or price analysis would be used to determine the reasonableness of price. We do not anticipate an inability to buy any engine hardware on a fixed price basis.

D. VENDOR SELECTION

Once an item has been designated as a "buy" item, except for items designated "Engineering Source Approved" (see Volume IV, Report E, Section I), vendor selection, as a matter of policy, is the job of the Purchasing Department. The tools available to the Purchasing Department, as outlined below, ensure that vendors are selected objectively, fairly, and with an eye to value. In addition, if a buyer believes that an "Engineering Source Approved" part could be acquired from other than the approved source, at less cost, it is his responsibility to investigate thoroughly and furnish the appropriate information, for decision, to the Engineering Department.

The Purchasing Department maintains a list of vendors who are qualified, by reason of personnel, facilities, management, financial status, delivery record, quality record, and other experience, to perform work for P&WA. Additions to this list of qualified vendors are made constantly, based on investigation of credit rating and financial stability and on-site inspection and evaluation of facilities, quality assurance, technical competence, and other factors.

Vendor lists include qualified vendors which are small businesses, and vendors from surplus labor areas. It has been, and continues to be, our policy to place procurements with such firms if they are competitive in price and can meet quality standards and delivery schedules. An indication of the importance we place on small business participation is the fact that our Purchasing Manager is also the Small Business Liaison Officer for the Florida Research and Development Center.

E. VALUE ANALYSIS IN PURCHASING

Every buyer is trained to act as a value analyst. The Purchasing Department is required to report monthly to the General Manager, bona fide cost reductions effected through the Purchasing Department's efforts. These reports must be auditable, must comply with specific rules for cost reduction reporting established by Corporate headquarters, are reviewed and approved by a committee from top level management, and are reported semiannually through Corporate headquarters to interested Government agencies. On the present contract between P&WA and the Government, Contract FA-SS-66-8, the Purchasing Department has effected reportable cost reductions of more than $600,000 in the twelve months ended July 31, 1966. The Purchasing Department includes appropriate Value Engineering Incentive clauses in all contracts under Contract FA-SS-66-8 which exceed $100,000 in face value.

F. SPECIAL PATENT PROVISIONS AND DATA RIGHTS PROVISIONS

The FAA special Patent Clause as contained in the Prime Contract is physically attached to and incorporated in every purchase order which has research and development as one of its purposes. In order to avoid inadvertent omission of this important requirement, every Request for Purchase Order has printed on it the words "Patent Rights Clause Required" and a "yes" and "no" block one of which must be checked. Appropriate "data rights" clauses are included in our standard purchase order provisions.

SECTION IV
MAKE-OR-BUY DECISIONS

The make-or-buy decision on major components (see list appended to this section) is made by a panel on which are management representatives of the Purchasing Department, Manufacturing, Program Management, Project Material Control, and Delivery Material Control. The make-or-buy decision on other components is made by Project Material Control and Delivery Material Control with assistance as required from the various organizational components listed above.

Certain parts and components, by their nature, may be categorized as "must buy" or "must make" parts.

Those parts which are "Engineering Source Approved" to an outside source must be purchased. Such parts might be "Engineering Source Approved" because manufacturing techniques are so complex that the subcontractor's "know-how" must be utilized to ensure success in fabrication, or facilities required for manufacture are only available at the designated source, or design of the required part is proprietary to the designated source. Some parts which fall into the "must buy" category are:

Forged compressor blades
Ball and roller bearings
Certain instrumentation
Certain valve assemblies

Similarly, certain parts fall readily into a "must make" category. In addition to parts Engineering Source Approved to P&WA, parts might fall in this category because manufacturing development is required, or manufacturing techniques, skills, and/or facilities are peculiar to P&WA, or dimensional tolerances and quality control are of critical importance. Some representative "must make" parts are:

Vane and shroud assemblies
Major welded assemblies
Annular burners
Compressor and turbine disks
Compressor and turbine shafts
Gearbox housing
Turbine blades and vanes

It is, thus, on the balance of parts that a "make-buy" decision must be made. The prime consideration in the "make-buy" decision is value. Optimum value results when the decision provides parts of the requisite quality, on time, and at the lowest cost. When there is no decision which will provide "optimum value," the compromise must be made in reverse order; i.e., cost must be compromised before schedule or quality can be affected. Obviously, no matter how cheap, a part which does not have the requisite quality is a waste of money. Similarly, a delay in the whole program caused by the lack of a part can be far more costly than the part itself, even if we must pay a premium for on-time delivery.

Table 1 indicates the make-buy decision on major components and parts for the Phase III JTF17 engine development program and provides, for each "buy" part or component, a list of possible vendors. Selection of actual vendors is scheduled early in the Phase III program, and the Make-Buy Plan will be revised as provided in the Phase III contract.

Table 1. Make-Buy Plan
Phase III
JTF17 Engine Development Program

Item	Make-Buy Decision* Development	Prototype	Potential Supplier**
Forged Airfoils	Buy	Buy	TRW, Ex-Cell-O
Cast Airfoils	Buy	Buy	Misco, Martin Metals, TRW
Fuel Controls	Buy	Buy	Bendix, South Bend; Hamilton Standard
Main Fuel Pump	Buy	Buy	Bendix, Utica; Chandler Evans, Inc.; Hamilton Standard; TRW; Vickers
Hydraulic Pump	Buy	Buy	Bendix, Utica; Chandler Evans, Inc.; Hamilton Standard; TRW; Vickers
Ignition System	Buy	Buy	Bendix, Scintilla; General Laboratory Associates
Bearings	Buy	Buy	Fafnir Bearing Co.; Heim; Marlin Rockwell; Bower Roller Bearing; SKF Industries
Valve Assemblies	Buy	Buy	ABA Tool & Die; Bachan, Detroit; Dexter Tool Co.; Delavan Mfg. Co.; Florida Tool and Gage; Mal Tool; Hamilton Standard; Ivashuk Manufacturing; Norwood Precision; Parker Hannifin; TRW; Vickers, Inc.; Valcor Engineering
Standard Parts	Buy	Buy	Accurate Threaded Products; Camcar Screw; Elastic Stop Nut; Standard Pressed Steel; Valco Machine Company; Rosan, Inc.; Products Design & Mfg.; Voi-Shan Manufacturing

Table 1. Make-Buy Plan
Phase III
JTF17 Engine Development Program
(Continued)

Item	Make-Buy Decision* Development	Prototype	Potential Supplier**
Bar, Sheet, Tubing	Buy	Buy	Stellite Division; Universal Cyclops; Atlantic Steel; Alvac Metals; Titanium Metals; Eastern Stainless; Jenks Metals; Huntington Alloy; DuPont; J. M. Tull; Superior Tube
Castings	Buy	Buy	TRW Metals; Arwood; Misco; Martin Metals; Stellite Div.
Forgings	Buy	Buy	McWilliams Forge, Transue Williams, J. H. Williams, Moore Drop, Steel Improvement & Forge Co., Storms Drop Forge, Ladish, Wyman-Gordon, Cameron Iron Works, Taylor Forge & Pipe Works, American Welding, Baldwin-Lima-Hamilton
Major Fabrications	Make and Buy	Make and Buy	B. H. Aircraft, Bliss-Portland, Hoosier Metal Fabricators, Precision Sheet Metal, Saffran Engineering, Smith-Morris, Solar, TRW
Liners	Make and Buy	Make and Buy	B. H. Aircraft; Bliss-Portland; Precision Sheet Metal; Hoosier Metal Fabricators; Smith-Morris Corporation; Solar
Machined Airfoils	Make and Buy	Buy	Amco Manufacturing, Inc.; Mal Tool and Engineering Co.; TRW, Inc.
Compressor Discs and Hubs	Make and Buy	Make and Buy	Atlantic Machine Tool Works, Inc.; Ex-Cell-O Corporation; Mal Tool and Engineering Co.; Machinery Builders, Inc.; TRW, Inc.
Minor Fabrications	Make and Buy	Make and Buy	B. H. Aircraft Co., Inc.; Bachan Manufacturing Co., Inc.; Ivashuk Manufacturing; Thermo Industries; Hoosier Metal Fabricators; Midway Company; Saffran Engineering; Smith-Morris

Table 1. Make-Buy Plan
Phase III
JTF17 Engine Development Program
(Continued)

Item	Make-Buy Decision* Development	Prototype	Potential Supplier**
Burners	Make and Buy	Make and Buy	Solar, TRW, Hoosier Metal Fabricators, Bliss-Portland
Interstage Seals, Spacers, Dampeners	Make and Buy	Make and Buy	Amec Manufacturing; ABA Tool & Die; Atlantic Machine; Bachan Manufacturing; Caval Tool & Machine; Machinery Builders, Inc.; TRW
Turbine Vanes and Blades (Machining and Fabrication)	Make and Buy	Make and Buy	LaPointe, TRW, Mal Tool, Ex-Cell-O Corporation
Turbine Shafts	Buy	Buy	Machinery Builders, Inc.; Mal Tool; Atlantic Machine; Ex-Cell-O; TRW; 20th Century
Housings, Seals, Shafts, Bosses, Fittings, Spray Bars, Flaps, Actuators Small Hardware	Make and Buy	Buy	Bachan Manufacturing; Bliss Portland; Florida Tool & Gage; Hoosier Metal Fabricators; Machinery Builders; Smith-Morris; Solar; TRW; United Tool & Die; Atlantic Machine; Caval Tool & Machine; Dexter Tool; Norwood Precision; Ex-Cell-O; Gaylord Engineering; Ivashuk Manufacturing; Keco, Inc.; Mal Tool; Parker Hannifin
Stator Assemblies	Make and Buy	Buy	TRW, Solar, Hoosier Metal, Machinery Builders
Turbine Disks and Hubs	Make and Buy	Make and Buy	Atlantic Machine, TRW, Mal Tool, Ex-Cell-O
Brackets & Small Sheet Metal	Make and Buy	Make and Buy	ABA Tool & Die, Bachan Manufacturing, Federal Stampings, Esarbe Manufacturing, Gaylord Engineering, Hoosier Metal Fabricators, Ivashuk Manufacturing, Smith-Morris, Thermo Industries, Florida Tool & Gage

Table 1. Make-Buy Plan
Phase III
JTF17 Engine Development Program
(Continued)

Item	Make-Buy Decision* Development	Prototype	Potential Supplier**
Plumbing	Make and Buy	Make and Buy	Aeroquip Corp., Alcap Manufacturing, Kreisler Industrial, Thermo Industries, Precision Sheet Metal, Stainless Steel Products, Tube Processing, Tube Bends
Gears	Make and Buy	Buy	Aero Gear, Arrow Gear, Equitable Engineering, Mal Tool, Norwood Precision Products, Don Prior, Inc., Vinco

* For percentage split between make-buy decisions which are both make and buy, see Manufacturing Plan, Report G, Volume V.

**See attached list for addresses of sources

Actual and Potential Subcontract Sources for Product

ABA Tool & Die Co., Inc. of Florida
St. Petersburg, Florida 33708

The Accurate Threaded Products Co.
Newington, Connecticut 06111

Aero Gear Machine and Tool Corp.
Little Ferry, New Jersey 07643

Aeroquip Corp., Marman Division
Los Angeles, California 90064

Alcap Manufacturing Co., Inc.
Middletown, Connecticut 06457

Amco Manufacturing, Inc.
Warehouse Point, Connecticut 06088

The American Welding & Mfg. Co.
Warren, Ohio 44484

Arrow Gear Company
Downers Grove, Illinois 60515

Bliss Portland
South Portland, Maine 04106

Bower Roller Bearing Division
Detroit, Michigan 43214

Camcar Screw and Mfg. Company
Rockford, Illinois 61101

Cameron Iron Works, Inc.
Houston 1, Texas 77001

The Caval Tool & Machine Co., Inc.
Newington 11, Connecticut 06111

Champion Spark Plug Company
Toledo, Ohio 43601

Chandler Evans, Inc.
West Hartford, Connecticut 06101

Delavan Manufacturing Company
West Des Moines, Iowa 50265

Actual and Potential Subcontract Sources for Product (Continued)

Atlantic Machine Tool Works, Inc.
Newington, Connecticut 06111

B. H. Aircraft Co., Inc.
Farmingdale, L. I., N. Y. 11738

Bachan Manufacturing Co., Inc.
Pompano Beach, Florida 33060

Bachan Mfg. Company, Inc.
Madison Heights, Michigan 48071

Baldwin-Lima-Hamilton Corporation
New York, New York 10017

The Bendix Corporation
Bendix Filter Division
Madison Heights, Michigan

The Bendix Corporation
Bendix Products Aerospace Division
South Bend 2, Indiana

The Bendix Corporation
Scintilla Division
Sidney, New York 13838

The Bendix Corporation
Utica Division
Utica, New York 13503

Ex-Cell-O Corporation
Black Mountain, North Carolina 28711

Fafnir Bearing Company
New Britain, Connecticut

Federal Stampings
St. Petersburg, Florida 33710

Ferrotherm Company
Cleveland, Ohio 44125

Florida Tool & Gage, Inc.
Fort Lauderdale, Florida 33314

Gaylord Engineering & Machine, Inc.
Lake Worth, Florida

Delaware Alloy Forge Company
Philadelphia, Pennsylvania 19134

Dexter Tool Company
Warren, Michigan 48091

Dexter Tool Company
West Palm Beach, Florida 33407

Dynamic Filters Division
Detroit 38, Michigan 48238

Eastern Tool and Die, Inc.
Newington, Connecticut 06111

Elastic Stop Nut Corp. of America
Union, New Jersey

Englehard Industries, Inc.
Instruments and Systems Division
East Newark, New Jersey 07104

Equitable Engineering Company
Royal Oak, Michigan 48073

Esarbe Manufacturing Co., Inc.
Fort Lauderdale, Florida

Ex-Cell-O Corporation
5835 Martin Avenue
Detroit, Michigan 48232

Kreisler Industrial Corporation
East Paterson, New Jersey

Ladish Company
Cudahy, Wisconsin 53110

Machinery Builders, Inc.
New York 51, New York

Mal Tool and Engineering Company
West Palm Beach, Florida 33406

Marlin-Rockwell Company
Jamestown, New York 14701

Martin Metals Company
Wheeling, Illinois 60090

Actual and Potential Subcontract Sources for Product (Continued)

General Laboratory Associates, Inc.
Norwich, New York

General Manufacturing, Inc.
Fort Lauderdale, Florida 33312

Hamilton Standard
Division United Aircraft Corp.
Windsor Locks, Connecticut

Harco Laboratories, Inc.
Branford, Connecticut 06406

Heintz
Philadelphia 20, Pennsylvania

Holley Carburetor Company
Warren, Michigan

Honeywell, Inc.
Minneapolis, Minnesota

Hoosier Metal Fabricators, Inc.
Gas City, Indiana 46933

Industrial Precision Products, Inc.
Fort Lauderdale, Florida 33312

Ivashuk Manufacturing Corp.
Pompano Beach, Florida 33060

Jervis Corporation
Grandville, Michigan 49418

Keco, Inc.
Pompano Beach, Florida

King Fifth Wheel Company
Wilkes-Barre, Pennsylvania 18703

Revere Corporation of America, Inc.
Wallingford, Connecticut

Rosan, Inc.
Newport Beach, California

Saffran Engineering Company
St. Claire Shores, Michigan

Schwartz Boring Company, Inc.
Detroit, Michigan

McInnes Steel Company
Corry, Pennsylvania 16407

McWilliams Forge Company, Inc.
Rockaway, New Jersey 07866

Midway Company
Lodi, New Jersey 07644

Misco, Div. of Howmet Corporation
Muskegon, Michigan 49440

Monroe Forgings, Inc.
Rochester, New York 14603

Multi-Techniques Company
Lake Worth, Florida 33460

National Water Lift Company
Kalamazoo, Michigan

Norwood Precision Products, Inc.
Melvindale, Michigan 48122

Parker Hannifin Corporation
Cleveland 12, Ohio 44112

Precision Sheet Metal, Inc.
Los Angeles, California 90045

Don Prior, Inc.
Oak Park, Michigan 48237

Products Design & Mfg. Corporation
Newington, Connecticut 06111

Tube Bends, Inc.
New Britain, Connecticut

Tube Processing Corporation
Indianapolis, Indiana 46203

20th Century Machine Company
Utica, Michigan 48087

U. S. Bearing Division of Networks
Electronic Corporation
Chatsworth, California

Actual and Potential Subcontract Sources for Product (Continued)

SKF Industries, Inc.
Philadelphia 32, Pennsylvania

Smith Bearing Division of
Accurate Bushing Company
Garwood, New Jersey

Smith Morris Corporation
Ferndale 20, Michigan

Solar
San Diego, California 92112

Stainless Steel Products, Inc.
Burbank, California

Standard Pressed Steel Company
Jenkintown, Pennsylvania

Star Tool and Die Works, Inc.
Detroit, Michigan 48216

Sterling Engineering Corporation
Winsted, Connecticut

Taylor-Forge and Pipe Works
Chicago 90, Illinois 60690

Thermo Industries, Inc.
Boca Raton, Florida

TRW Metals Division
TRW, Inc.
Minerva, Ohio 44657

TRW Jet & Ordnance Division
TRW, Inc.
Cleveland, Ohio 44117

TRW Equipment Group
TRW, Inc.
Cleveland, Ohio 44117

E. I. DuPont DeNemours & Co., Inc.
Metal Prod. Marketing
Wilmington, Delaware

Eastern Stainless Steels Corporation
Baltimore, Maryland

The United Tool & Die Company
West Hartford 10, Connecticut

The Heim Universal Corporation
Fairfield, Connecticut 06430

The Valco Machine Company
Bloomfield, Connecticut

Valcor Engineering Corporation
Kenilworth, New Jersey

Vickers, Inc.
Administration & Engineering Center
Troy, Michigan 48084

Vinco Corporation
Detroit, Michigan 48228

Voi-Shan Manufacturing Company
Culver City, California

Westport Development & Mfg. Co., Inc.
Milford, Connecticut

Whittaker Corporation
Chatsworth, California 91311

Wyman Gordon Company
Worcester 1, Massachusetts

Arwood Corporation
New York, New York 10022

Atlantic Steel Service Center
Orlando, Florida 32806

Baldwin-Lima-Hamilton Corporation
New York, New York 10017

Universal Cyclops Specialty Steel Div.
Bridgeville, Pennsylvania 15017

J. H. Williams and Company
Buffalo 7, New York

Actual and Potential Subcontract Sources for Product (Continued)

Huntington Alloy Products Division
Huntington, West Virginia

Jenks Metals Co., Inc. of Miami
Miami, Florida 33148

McWilliams Forge Company, Inc.
Rockaway, New Jersey 07866

Moore Drop Forging Company
Springfield 7, Massachusetts

Steel Improvement and Forge Company
Cleveland 3, Ohio

Storms Drop Forging Company
Springfield, Massachusetts 01101

Superior Tube Company
Norristown, Pennsylvania

Titanium Metals Corp. of America
West Caldwell, New Jersey

Transue & Williams Steel Forging Corp.
Alliance, Ohio 44601

J. M. Tull Metals Company, Inc.
Miami, Florida

Union Carbide Corporation
Stellite Division
Kokomo, Indiana 46901

REPORT F
COST AND SCHEDULE CONTROL PROGRAM

SECTION I
INTRODUCTION

This section will describe the Cost and Schedule Controls Systems that are now effectively operating at Pratt & Whitney Aircraft's Florida Research and Development Center and will illustrate how the SST Phase III Program requirements will be met by utilization of these control systems. The guidance provided in Exhibit 3G of the Request for Proposal has been used in the plan's preparation. Paragraph A contains the "Cost Control System," and Section B the "Schedule Control System." These control systems will be resubmitted in February 1967 as required by the Request for Proposal Data List, Exhibit 3H, and will be updated periodically during the program as changes affecting them occur.

SECTION II
COST PLANNING AND CONTROL SYSTEM

A. ORGANIZATION AND RESPONSIBILITIES

The JTF17 Program Manager will be responsible for planning and controlling all program costs. He has monitored the proposal preparation and will be a principal member of the company negotiating team prior to contract award when estimated program costs are firmly established. Representing the General Manager, he will have full authority in directing the program effort over functional lines. He will be responsible for keeping the Federal Aviation Agency and the General Manager abreast of actual versus planned progress for the JTF17 engine program with explanations and justifications for any variances. As shown on the organization chart "Program Controls," Volume V, Report I, of this proposal, the Program Controls Group and the Project Cost Control Centers are coordinated by the Manager, Program Controls, who reports to the JTF17 Program Manager. They will perform the planning and control effort necessary to assure that a well-managed program results.

Upon receipt of a contract, in this case for the Phase III SST Program, the Manager, Program Controls, the Project Cost Control Center, and the Program Manager establish the budgets for the functional groups based on the estimates that these groups have made for the work planned under the program. These operating departments are responsible for performing their assigned tasks, as specified, on schedule and within budget. Each operating department has a functional Cost Control Center which is responsible for keeping the cognizant Project Manager's Cost Control Center informed of the status of all actual and forecast expenditures and commitments as related to their budgeted tasks. The Department Controller's organization is responsible for collecting the costs according to the planned Work Breakdown Structure, promptly feeding back the results to the Program Manager and his Cost Control Center to the Cost Control Centers in the functional departments. The Department Controller also issues the contractually required financial reports to the Customer after review and approval by the Program Manager.

The mechanics of operation of the Cost Planning and Control System, the means of controlling direct and indirect costs, and the integration of the Phase III SST Program into the Pratt & Whitney Aircraft's Florida Research and Development Center Cost Control System are explained in this plan. The estimating procedures and practices utilized in the preparation of proposals and forecasts are also discussed. The complete planning and control cycle is graphically outlined in figure 1.

B. PROGRAM OBJECTIVES

The over-all Phase III program objectives are as follows:

Development of the JTF17A-21 engine through FTS

Deliver ground and flight FTS engines

Support the aircraft 100 hour flight test program.

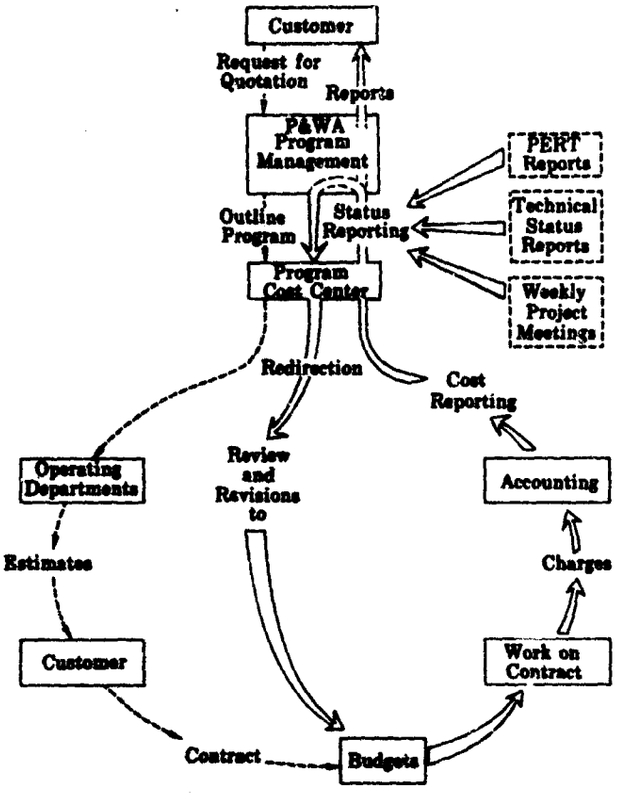


Figure 1. Closed Loop Cost Control FD 17628
FV

The achievement of these objectives will be measured against the following Phase III milestones:

Phase III Go-Ahead	1 January 1967
Deliver First Test Engine for AEDC PWT Test	September 1968
Deliver First Ground Test Engine	September 1968
Complete FTS Test	30 June 1969
Deliver First FTS Engine	July 1969
Deliver Last FTS Engine	February 1970
Complete Support for 100 Hour Flight Test Program	15 September 1970

With these milestones established, the Program Manager's organization has prepared a detailed Work Breakdown Structure in three levels to cover the schedule effort required to meet the program objectives. (The Master Program Plan, included as Volume V, Report A of this proposal, describes the planned effort to accomplish the work set forth in the Work Statement).

A more detailed discussion of this initial definition and its relationship to the total program control cycle follows.

C. DEVELOPING COST ESTIMATES

1. Establishment of Program Requirements

The Program Manager is responsible for outlining the scope of the contract and for defining the work to be performed in attaining the program goals (as defined in paragraph B above), as follows:

1. Establishing engine performance, size, and weight objectives based on known Customer requirements and the results of preliminary systems analyses

2. Evaluating the relative complexity of the proposed program with past programs and anticipating major problems involved in meeting the program objectives

3. Setting forth the general time phased schedule to completion covering major events within the contract

4. Dividing the various tasks into major measurable work areas that become the Work Statement items of the contract.

2. Program Planning

The Program Manager and his assigned personnel then develop a work plan which starts with the work statement items and further subdivides them into detailed work items which include the following:

1. An outline of the development tasks to be performed for components and complete engine.

2. A list of the types of parts and components that will be subject to design effort.

3. A schedule of development testing of the components and complete engine. The schedule includes types of tests to be performed, number of tests, and anticipated running hours of test, as well as test stand locations, modifications, and construction requirements.

4. A list of the types and quantities of hardware requirements to support development testing of the engine and engine components.

5. A list of deliverable end-items with time schedules compatible with contract requirements.

6. Product support requirements.

3. Cost Estimating and Pricing

The detailed work plan is forwarded to the functional areas where the departmental cost groups, in conjunction with the department supervisors, determine the amount of man-hour effort and material required to support the program and assure accomplishment of program objectives. These departmental groups include Design, Construction, Assembly, Quality, and Test.

Extensive use is made of historical cost data from previous related programs or technology. In addition, a considerable core of historical cost ratios and relationships has been developed in all functional areas in a continuing effort to improve on our estimating ability.

The Construction Manufacturing Cost Center obtains estimated material and shop labor costs for all hardware to support the development program. A mechanized historical price file for all experimental hardware is maintained. Wherever possible, the estimated cost of engine or component parts is based on actual known cost of similar parts. Where historical cost data is not available, engineering judgment is applied in the form of a complexity factor to represent the difference between a known part and the proposed part. Where no similar parts have been made in the past, hardware costs are obtained from estimates by manufacturing planning groups, or estimates from potential vendors obtained through the Purchasing Department.

The Department Controller has the responsibility for verifying material values used on all tasks and for extending all estimated labor hours by applying anticipated hourly rates. Therefore, the Accounting Department Pricing Group works closely with the departmental cost centers in developing their estimates and assessing the estimates for reasonability, completeness, and agreement with program requirements and accounting records. The Pricing group compiles the final cost estimate in the formats required by the customer and applies the appropriate overhead and general and administrative expenses to arrive at a total estimated cost.

4. Cost Reviews and Approvals

The completed cost estimates are reviewed and approved by the functional department heads and then reviewed and approved in turn by the Project Cost Centers, the Program Manager, and the General Manager. Estimates are returned to the Cost Centers for revision during these reviews if the reviewers consider them inaccurate or inconsistent with program objectives.

This is the cost estimating system which produced the SST Phase III cost proposal and its related support data, as presented in Volume VI, Section III.

D. INITIATION OF THE PROGRAM

Upon receipt of the negotiated contract for Phase III, the Department Counsel, Contracts, will release copies to the General Manager, Program Manager, and operating department heads. The Engineering Manager's office will immediately prepare an Engineering Order for approval by the General

Manager which is the internal document authorizing the start of engineering work on the program. In a rapid succession of events, with most of the preparations having been made in advance, budgets and corresponding cost control numbers will be assigned to tasks of the Work Breakdown Structure by the Project Cost Control Group. Separate Engineering Order Supplements (EOS's) will be prepared by the respective Project Engineers, describing the effort required by each functional department to achieve the detailed task. The Manager of Product Support and the Manager of Engine Delivery, along with their staffs, will prepare Delivery Order Supplements (DOS's) which define the deliverable end-items called for in the contract statement of work. These will also define responsibilities and schedules to be maintained. Upon approval of initial supplements by the Program Manager, the SST engine Phase III program will commence.

E. COST SEGREGATION AND BUDGET DETERMINATION

1. Work Package Authorizations

Engineering work to be performed by the functional departments at the Florida Research and Development Center or at Connecticut Operations is authorized by the Project Engineer assigned to the program. The vehicle through which these tasks are defined is called the Engineering Order Supplement (EOS). The EOS not only defines the task but also assigns the responsibility for specific functions and establishes a budget. The EOS in general constitutes the official communication link between program development management and the operating groups. The EOS is an integral part of our cost control system and must be issued before any costs may be incurred on any project. The Project Engineers utilize the EOS to establish separate work packages which identify nonrecurring costs from recurring costs (such as special test equipment and subcontractor costs for component development programs).

In a similar manner, a Delivery Order Supplement (DOS), issued by the Manager of Product Support or the Manager of Engine Delivery, provides the direction to functional groups to initiate activities toward procurement and/or manufacture of the required deliverable items.

2. Budgets (Direct)

The Project Cost Control Group assists the Project Engineers (or Managers) in providing estimated costs for each EOS (or DOS) as it is written. These costs become the direct labor and/or material budgets for the specific functional areas involved. Each EOS (or DOS) also contains the coded cost control charge number to be used for cost accumulation. It is through this method that actual costs are compared with targeted costs in the feedback, control, and reporting system to be discussed in paragraph 7.

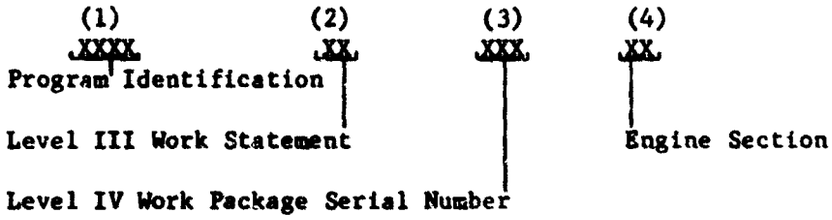
The Project Cost Control Center prepares the direct labor and material dollar budgets for each departmental cost control center. The departmental cost control centers then distribute the work to be performed. In manufacturing and testing work is initiated through an internal Work Order system. Each Work Order identifies the job, such

as manufacturing a part or running a component test, as well as the source EOS (or DOS), work statement, and contract. These Work Orders in effect become lower tier cost measurement and internal control devices, in addition to serving as a source of future estimating data substantiation.

3. Cost Control Account Number System

The direct-cost control account numbers, specified in each EOS (or DOS) as issued, contain a coding system which lends itself to identification, reporting, and control of four levels of work packages.

The cost control number contains eleven digits with field grouping as follows:



1. Program Identification - The first three digits represent a specific project or contract. The fourth digit is the location of the cost function code which broadly relates the cost to the Pratt & Whitney Aircraft organization structure. The codes currently used are:

   1 - Design

   2 - Construction

   3 - Test

   4 - Quality Assurance

   5 - Tooling

   6 - Assembly

   8 - Engineering

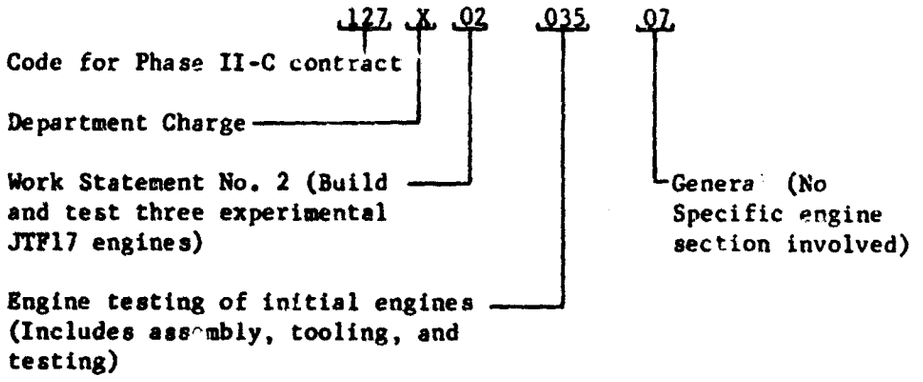
   9 - Raw Material

2. Level III Work Statement - This follows the contractual definition of work to be performed.

3. Work Package Serial Numbers - The Engineering Order Supplements (or Delivery Order Supplements) are issued with definitions and assignments aimed at this level of detail.

4. Engine Section - This section permits identification of major engine sections or other subdivisions of major program tasks.

The following is an example of the utilization of this cost control numbering system as currently in practice on the SST Phase II-C Development Program:



F. COST COLLECTION SYSTEM

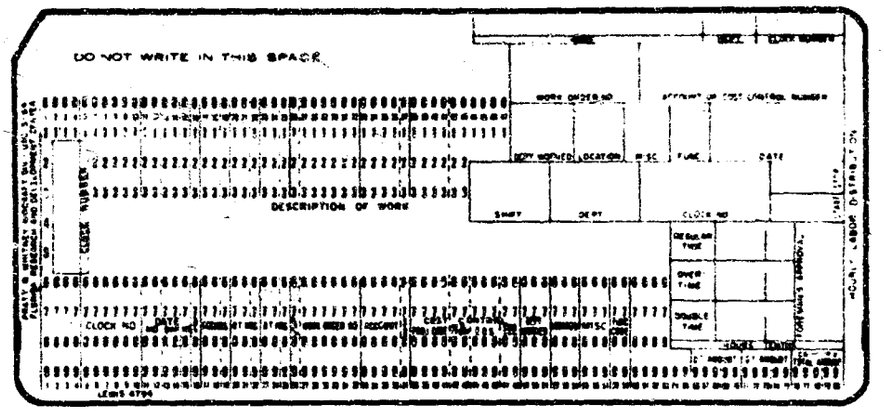
1. Direct Labor

Direct labor expended in support of a program is recorded by the individual on labor cards that identify the job or work order. All labor hour recording is under the constant surveillance of timekeepers throughout the areas, and these hours are reconciled to attendance cards on a daily basis. All recorded labor is ultimately reconciled to payroll records prior to formal charging of this labor to accounting cost records.

Direct labor costs are collected by Cost Control cards (see figure 2) which are processed in EDP equipment. These cards are audited by the timekeepers and the Defense Contract Audit Agency to assure correctness and applicability to the work packages as defined in the EOS's (or DOS's).

In the departments which have lower tier work order systems at the Florida Research and Development Center, direct workers are instructed to use a six-digit work order number which is issued by the departmental cost control center involved. These work orders permit a more detailed internal reporting and control of specific EOS's (or DOS's). Approvals of individual time card charges are made by departmental supervision. Timekeeping further monitors work orders and cost control numbers. All work order numbers are cross referenced to the correct cost control number through means of a master computer record. Thus, in the example above, (paragraph 5. c) for the cost Control Number 127X-02-035-07, all test department work order numbers which are issued relating to EOS 35 will automatically be cross referenced as labor cards are processed, and accounting charges will accumulate under Cost Control Number 1273-02-035-07. Likewise, in assembly, work done on EOS 35 will be charged to Code 06 (Assembly) and will be reflected on reports summarized under Cost Control Number 1276-02-035-07.

HOURLY LABOR COST CONTROL CARD



SALARY LABOR COST CONTROL CARD

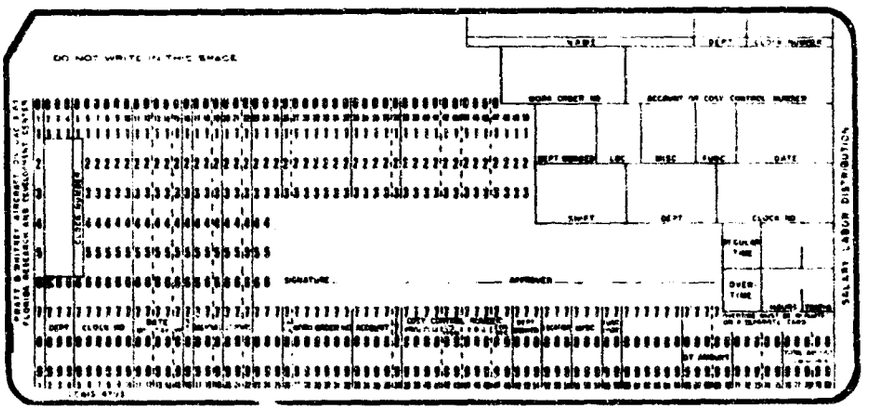


Figure 2. Labor Cost Control Cards

FV

2. Direct Material

Project material charges stem from a Purchase Order/Accounts Payable System which controls the flow of all purchase orders and vouchers. Purchase orders and vouchers are identifiable to levels within the program via the cost control number. The vouchers are generated from receiving reports or material transfer requisitions and are controlled by means of a reconciliation with the Accounts Payable System prior to becoming formal charges to cost records.

Computer rental for project applications and business reports are accumulated and distributed to contracts by means of a computer-generated utilization record.

3. Indirect Costs - Budgets and Controls

Indirect salaries and expenses representing the overhead costs of the company are the responsibility of line management. Purchasing personnel, maintenance groups, timekeepers, and shop supervisors are examples of the

types of labor classified as indirect salaries and wages. Support material supply costs (such as shop supplies, perishable tools, power, and heat) are in the indirect material category. Any change to the classification of direct and indirect expenses must have the concurrence of both the Company Controller and the Resident Defense Contract Audit Agency.

A closed loop system of controlling indirect costs starts with budgets being issued by the General Manager to each operating department head for each indirect account number over which he has control, both labor and material. For example, such indirect material accounts as Shop Supplies, Perishable Tools, Heat, Light, and Power are controllable by the Chief of Engineering Operations; however, such indirect accounts as Depreciation and Property Taxes are not controllable by an operating department head.

The budgets are established by the General Manager after considering the total business forecast and the mix of types of business, the history of spending by each operating department for each applicable account, and knowledge of changes of departmental requirements. The change of departmental requirements could be caused by a make-buy ratio change in direct contract work, for example, which could result in more or less machine shop personnel and which could, in turn, result in a requirement for more or less perishable tools.

The indirect costs for labor are collected by means of the regular attendance cards for indirect personnel and the job account charge cards for direct labor personnel when they charge to an indirect account. The Electronic Data Processing System accumulates and reports the charges by account number and departmental grouping, as shown in figure 3.

Indirect supplies and materials are channeled into the reporting system from two subsystems, namely, a Crib Inventory System and the Purchase Order System. Departmental withdrawals from indirect inventory are automatically priced and charged to the receiving department by account. Departmental purchase orders for supplies not channeled through an inventory system are identified by the Purchase Order System, and the costs are accumulated by department and account.

EDP reports are furnished to each operating department head and are compared to the previously established budgets to determine variances. The General Manager is provided data in curve form, figure 4, to show actual performance versus budget.

Corrective action is taken by the operating department head when an adjustment within his budget is the potential solution. The General Manager directs action when variances from budget cannot be accomplished within the operating department.

FLORIDA RESEARCH AND DEVELOPMENT CENTER

MANAGEMENT BUDGETARY ANALYSIS REPORT - INDIRECT SALARIES AND WAGES

	FRDC TOTAL	ENG OPNS	ENG DEV	GEN ADM	ACCTG TREAS	PERS	PURCH
TOTAL INDIRECT LABOR							
CUR BUDGET							
CUR ACTUAL							
PCT VAR							
CUM BUDGET							
CUM ACTUAL							
PCT VAR							
BASIC INDIRECT LABOR							
CUR ACTUAL							
CUM ACTUAL							
DIVERTED DIRECT LABOR							
CUR ACTUAL							
CUM ACTUAL							
HOLIDAYS + VACATIONS							
CUR ACTUAL							
CUM ACTUAL							
SICK + AWP							
CUR ACTUAL							
CUM ACTUAL							
BLUEPRINTING							
CUR BUDGET							
CUR ACTUAL							
PCT VAR							
CUM BUDGET							
CUM ACTUAL							
PCT VAR							
PURCHASING							
CUR BUDGET							
CUR ACTUAL							
PCT VAR							
CUM BUDGET							
CUM ACTUAL							
PCT VAR							

SAMPLE

Figure 3. Management Budgetary Analysis Report - Indirect Salaries and Wages

Pratt & Whitney Aircraft
PWA FP 66-100
Volume V

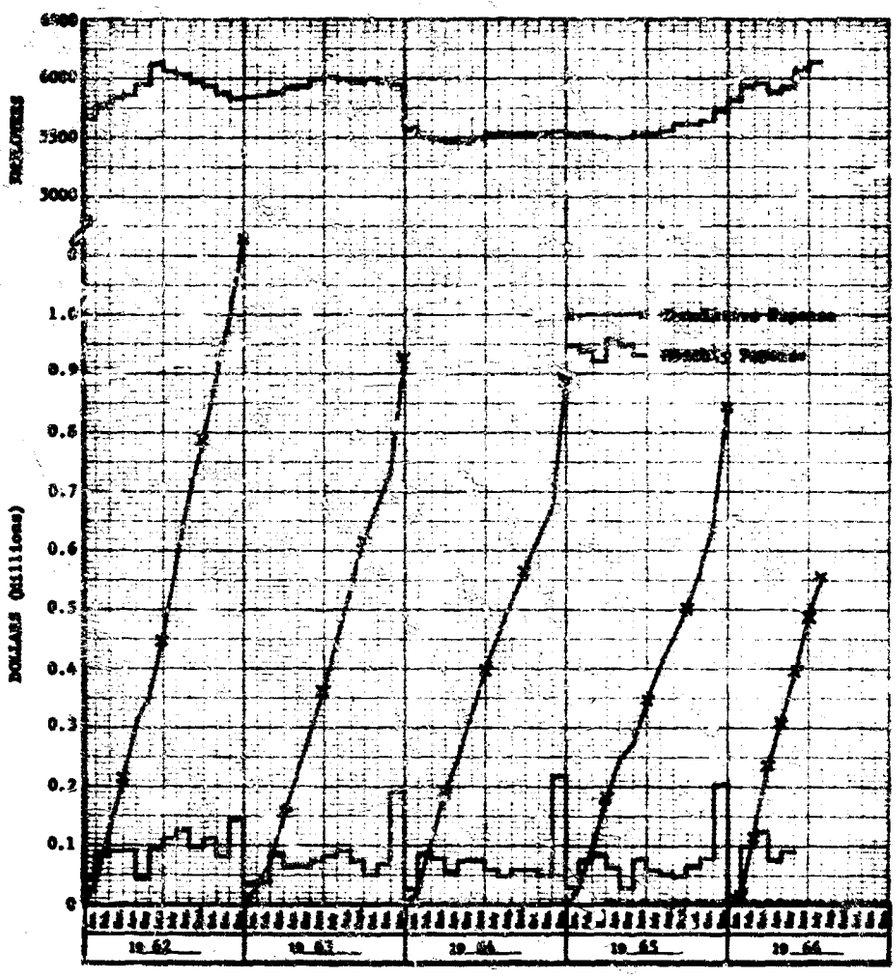


Figure 4. Shop Supplies and Expenses - Account 7471

FD 17629
FV

G. COST REPORTING AND CONTROL

1. Internal Reporting and Corrective Action

The cost control numbering system makes possible the rapid reporting of cost data to all responsible levels of project and operating management. The collection of cost information is completely mechanized. This permits grouping and summarization of cost data, as required, for cost effective control.

In total, the Accounting Department distributes more than twenty different type cost reports each month to project and operating management. Frequency of this information flow ranges from daily to monthly. Some examples of the cost data covered are as follows:

1. New commitments by contract
2. Weekly receipts of material by contract
3. Labor dollars expended by EOS (or DOS), Work Statement, and contract

4. Overtime hours and costs by department, function, and contract

5. Material transfers from indirect inventories

6. Computer charges by EOS (or DOS), Work Statement, and contract

7. Labor expended during the week and cumulative to date on work order level tasks.

PROJECT ENGINEERING COST REPORT

			REG HRS	AVG RAT	LAB COST	ENG O/H	MATERIAL	OVHC	PREM	G/A	TOTAL	COMMITMENT
127 11 .15 1	M											
	C		19	96	76	82	24		10	18	200	
127 11 .15 2	M		829	1,458	2,368	3,596	7,70[illegible]		194	747	8,631	3,866
	C		23,095	79,530	91,692	142,[illegible]26	436,821		8,831	68,346	699,185	
127 11 .15 3	M											
	C						11			1	12	
127 11 .15 4	M		4	14	14	15				3	32	
	C		281	1,199	1,[illegible]95	1,482	48		48	292	2,977	
127 11 .15 5	M											
	C		230	755	831	914	715		38	260	2,720	
127 11 .15 6	M		1,186	3,603	4,305	4,779	351		351	925	10,356	
	C		15,836	45,956	51,867	57,[illegible]75	3,537		3,294	11,942	124,781	
127 11 .15 7	M											
	C		1,[illegible]96	4,[illegible]15	5,[illegible]31	4,[illegible]46	303		399	1,266	13,514	
127 11 .15	M		1,763	5,[illegible]5[illegible]	6,[illegible]67	7,[illegible]96	1,[illegible]91		545	1,679	18,819	3,866
***	C		38,551	127,677	151,[illegible]97	1[illegible],[illegible]19	441,539		12,[illegible]2	82,114	843,369	

Figure 5. Project Engineering, Cost Report

FV

An example of a semimonthly cost report prepared for Project Engineering is shown in figure 5. This report shows the monthly and cumulative experience of labor hours, labor dollars, overtime premium, material charges, computer rental, and open commitments. The report also includes engineering overhead and general and administrative expenses so as to reflect total cost at each of three levels. (The accumulated cost to date is summarized by function code with EOS (or DOS), further summarized at the Work Statement level, and finally at the total contract level.) This report is closely monitored by the Project Cost Control Centers which are physically located adjacent to the Program Managers to facilitate frequency of communication. Any deviations from the previously established EOS (or DOS) cost target plan are analyzed in conjunction with the originating Project Engineer (or Manager) to determine the reason or reasons involved. Corrective action required may involve redirection of effort or realignment of budgeted work package dollars. Such action requires approval of the Program Manager. In either event, the comparison of actual experience to budget is a continuous process. It also provides assurance of detailed cost monitoring and control at Levels I through III on the contract.

Since this cost system is structured to permit the control and reporting of costs by types of effort (such as Design, Construction, Assembly, and Test), it is utilized by the departmental control organization, as well as the project control centers. The departmental (functional) budgets, which are established and coordinated by the Cost Control Centers upon issuance of the EOS's (or DOS's), are monitored by means of the types of report shown in figure 6. Distribution of this report is made to Cost Accounting and to all Project and Department Cost Control Centers. (The particular sample shown contains a portion of the effort expended on the SST Phase II-C Program for the week ended 31 July 1966, under the project code 1271.) This report is grouped to illustrate function code hours for the weekly period within major departments and is also summarized by contract within function. Both line and project management use this report to spot trends which vary from the established budgets. Here again,

an analysis of the charged effort is made by the involved Cost Control Center, and an attempt is made to determine whether the deviation constitutes an abnormal trend which must be corrected or whether a re-evaluation of the budgeted effort is in order.

21197-5 WEEKLY EOS REPORT NO. 5 LABOR M.E. 07 31 66 PAGE 5

COST CONTROL	DEPT	REG-HRS	OT-HRS	DT-HRS	TOT-HRS
1271	541	*	20.8 *	*	20.8 *
1271	543	76.2 *	*	*	76.2 *
1271	544	40.0 *	*	*	40.0 *
1271	593	55.5 *	*	*	55.5 *
1271	711	1,654.6 *	272.3 *	*	1,926.6 *
1271	712	1,281.8 *	380.8 *	*	1,662.6 *
1271	713	655.7 *	122.0 *	*	977.7 *
1271	714	148.0 *	*	*	148.0 *
1271	715	77.3 *	*	*	77.3 *
1271	719	249.2 *	141.8 *	*	391.0 *
1271	720	63.0 *	*	*	63.0 *
1271	721	64.0 *	29.0 *	*	93.0 *
1271	722	7.8 *	8.0 *	*	15.8 *
1271	723	2.0 *	*	*	2.0 *
1271	724	12.0 *	*	*	12.0 *
1271	726	26.4 *	*	*	26.4 *
1271	727	60.0 *	*	*	60.0 *
1271	728	20.0 *	4.0 *	*	24.0 *
1271	730	124.0 *	*	*	124.0 *
1271	731	43.0 *	20.0 *	*	63.0 *
1271	733	240.0 *	23.0 *	*	263.0 *
1271	734	51.0 *	16.0 *	*	67.0 *
1271	735	244.5 *	64.0 *	*	308.5 *
1271	736	113.5 *	60.0 *	*	170.5 *
SALARY TOTALS		5,519.7	1,161.7		6,680.9
1271	01025	3.0 *	*	*	3.0 *
1271	01034	56.9 *	*	*	56.9 *
1271	01956	*	2.0 *	*	2.0 *
1271	01963	488.3 *	77.2 *	*	564.1 *
1271	01964	9.0 *	*	*	9.0 *
HOURLY TOTALS		551.3	79.2		631.0
		6,071.1 **	1,240.9 **	**	7,311.9 **
1201	712	1.0 *	*	*	1.0 *
SALARY TOTALS		1.0			1.0
		1.0 **	**	**	1.0 **
1291	720	1.0 *	*	*	1.0 *
SALARY TOTALS		1.0			1.0
		1.0 **	**	**	1.0 **
1301	594	28.0 *	*	*	28.0 *
1301	711	191.0 *	7.0 *	*	198.0 *
1301	712	4.0 *	*	*	4.0 *
1301	715	42.1 *	*	*	42.1 *
1301	717	40.0 *	*	*	40.0 *
1301	720	1.0 *	*	*	1.0 *
1301	723	78.5 *	*	*	78.5 *
1301	724	32.0 *	*	*	32.0 *

Figure 6. Weekly EOS Report

FV

Integration of Cost and Schedule Reporting

The Program Manager uses many tools available to him in measuring the progress of the individual program work packages against the current cost status of those packages.

1. He receives daily status reports from his Program Managers.
2. At weekly meetings with Program Managers, and the Project Cost Control representatives, he receives reports on technical progress and the latest cost information.
3. The Project Cost Control Center provides budget versus actual cost status semimonthly for each of the EOS's (or DOS's) issued on the program, and an analysis of variances.
4. Reports on schedule status via the latest PERT/Time reports are reviewed.

5. The Program Managers are required to report progress against the Master Program Plan, Volume V, Report A.

Corrective action will be initiated by the Program Manager if required (usually at the meetings in paragraph G.2.2. above), or else consideration may be given to a budget revision of the efforts involved. Any serious cost or schedule problem is discussed by the Program Manager at the weekly Management Committee meetings in order to resolve the problem.

3. Customer Reporting

As a further byproduct of the Cost Planning and Control System, the summarized monthly reporting to the Federal Aviation Agency currently practiced under Phase II-C is planned for Phase III.

This cost report information consists of seven items as listed below and discussed in the following paragraphs.

Report	Frequency	Calendar Day Submitted
*1. Combined Financial Plan and Management Summary Report	Monthly	15
*2. Cost Category Status Report	Monthly	15
*3. Manpower Loading Report	Monthly	15
*4. Commitment Report	Monthly	15
*5. Overtime Report	Monthly	15
6. Rate Report	Monthly	15
7. Indirect Support Report	Monthly	15

*Current Phase II-C Reports

a. Combined Financial Plan and Management Summary Report

This will show the estimated rate at which costs and commitments will be incurred during Phase III. This report contains a series of charts with time phased cost and commitment estimates from Level I through Level III. The Level I chart will show the funding status and total cost plus commitment status. The Level I chart will be shown both on a total Phase III basis and on a calendar year basis for funding control. Significant items in the Work Breakdown Structure will be shown for Level II and for Level III. The monthly submission of these charts will indicate an estimate of the costs incurred to date at each level. Actual labor and material charges for the month and Defense Contract Audit Agency approved provisional overhead and general and administrative rates are the basis for the actual cost-to-date totals.

b. Cost Category Status Report

This will provide a cost breakdown by functional categories for Level I and three Level II reports on a monthly basis in table form. Functional categories covered will be Engineering, Construction, Test, Quality, Tooling, and Assembly. Tables will afford comparison of costs versus planning for the total program, Level I, and by Work Breakdown Structure, Level II.

The current Cost Category Report submitted on Phase II-C (which shows planned versus actual costs broken down by labor, material, and other elements of cost) will be supplemented by additional Cost Category Reports in Phase III in the "Format A" form requested (figure 7). The constant integration of cost and schedule status (as discussed in paragraph G.2. above) will continue to serve as the basis for the "Latest Revised Estimate" column. Projections and expenditures will be broken down into labor, overhead, material, and general and administrative expense categories.

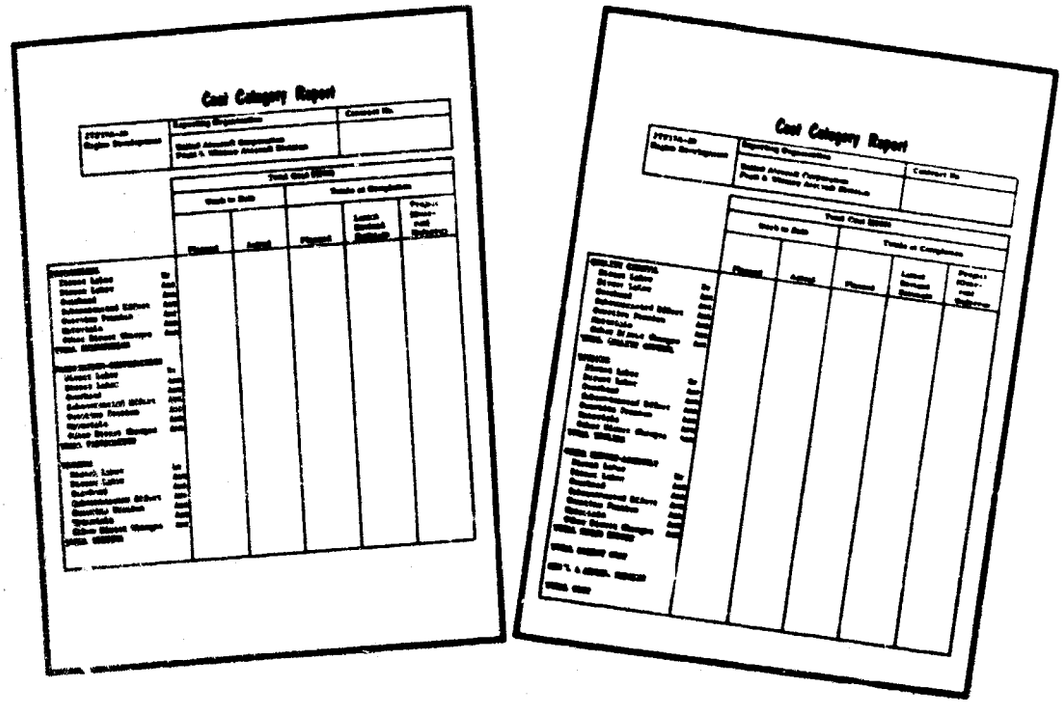


Figure 7. Cost Category Report

FD 12647A
FD 12647B
FV

c. Manpower Loading Report

The Manpower Loading Report will provide, on a Level I basis, a functional category breakdown of direct manpower assigned to the program in terms of equivalent people. Determination of equivalent people will be made by dividing total regular time hours worked during a month by the number of regular time single-shift working hours in the month reported. Manpower information on activity to date as well as projected effort will be shown.

d. Commitment Report

The Commitment Report will show the planned rate of commitments in graph form for Phase III, Level I, of the development program. Total actual cumulative commitments will be shown on the graph at each monthly submittal. This report will continue to be on a calendar year basis since the important status of current open commitments is displayed in the Total Program charts previously discussed.

e. Overtime Report

The Overtime Report will present direct labor overtime hours on Level I basis by functional category and total overtime premium dollar expenses incurred each month.

f. Rate Report

The Rate Report (figure 8) will be a table of actual average rates for labor associated with the functional categories. Overhead billing rates are approved by the Defense Contract Audit Agency for a calendar year period. Current approved rates will be shown.

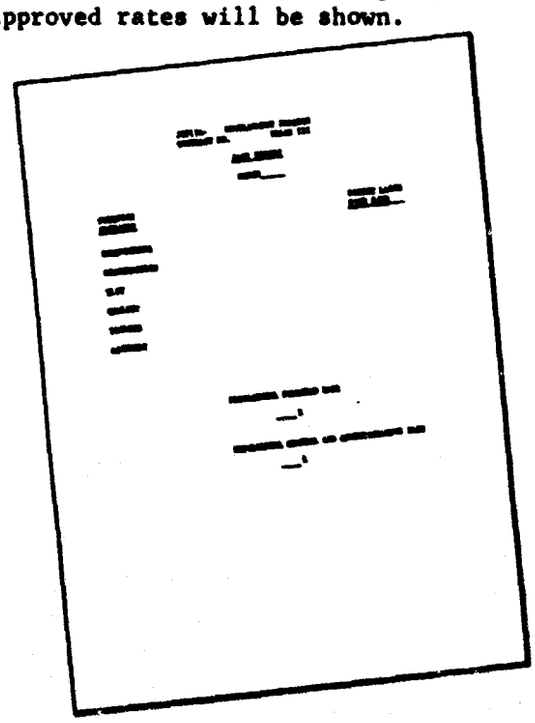


Figure 8. Rate Report FD 17631 FV

g. Indirect Support Report

The Indirect Support Report (figure 9) will show the number of equivalent indirect personnel who are charged to the total SST Program. Indirect labor is distributed to the SST Program in the same ratio as SST direct labor to total plant direct labor.

The records from the accounting system provide the necessary current cost reporting information for these reports. The projections and estimates of future spending and manpower requirements, which will be furnished in these reports, are prepared under the direction of the Program Manager utilizing the communication links and status reporting outlined previously, and the Schedule Planning and Control Systems Reporting to be outlined in Section II.

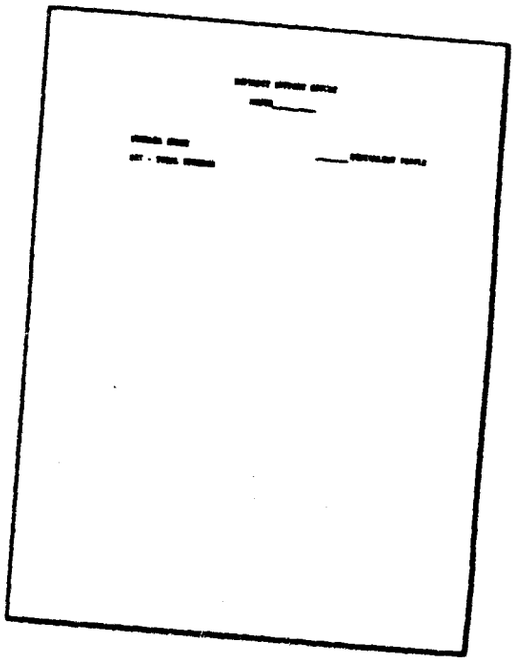


Figure 9. Indirect Support Report FD 17632 FV

H. SUMMARY

The cost control systems described herein have been used at the Florida Research and Development Center for several years and have proved effective. This is evidenced by the fact that all major contracts have been completed on schedule and within target costs since the system has been in effect.

The Project and Departmental Cost Centers have been successful in relating actual costs to program scheduled progress and to highlight to the Program Managers the need for corrective action and/or program redirection. The established estimating procedures have helped to alert personnel in each operating department to program requirements. We will bring this experience to bear on the integration of our SST efforts to date with future development plans.

SECTION III
SCHEDULE PLANNING AND CONTROL SYSTEM

A. METHOD OF OPERATING AND ORGANIZATION RESPONSIBILITIES PERT/TIME

This will be used as the management system for schedule planning, reporting, and for controlling work accomplishment during Phase III.

The PERT Group reports to the Systems Accountant who will provide the Manager, Program Controls, with the flow of PERT status data for inclusion in the program evaluation weekly meetings.

B. SYSTEM IMPLEMENTATION

The Program Work Breakdown Structure for Phase III, which serves as an over-all PERT Network guide, is shown in the Work Statement. These Work Statement items, against which contract costs will be collected, have subsequent Level III subdivisions for each manageable end-item work package. The work packages, to further identify and control the program effort, are also individually defined on the PERT Network.

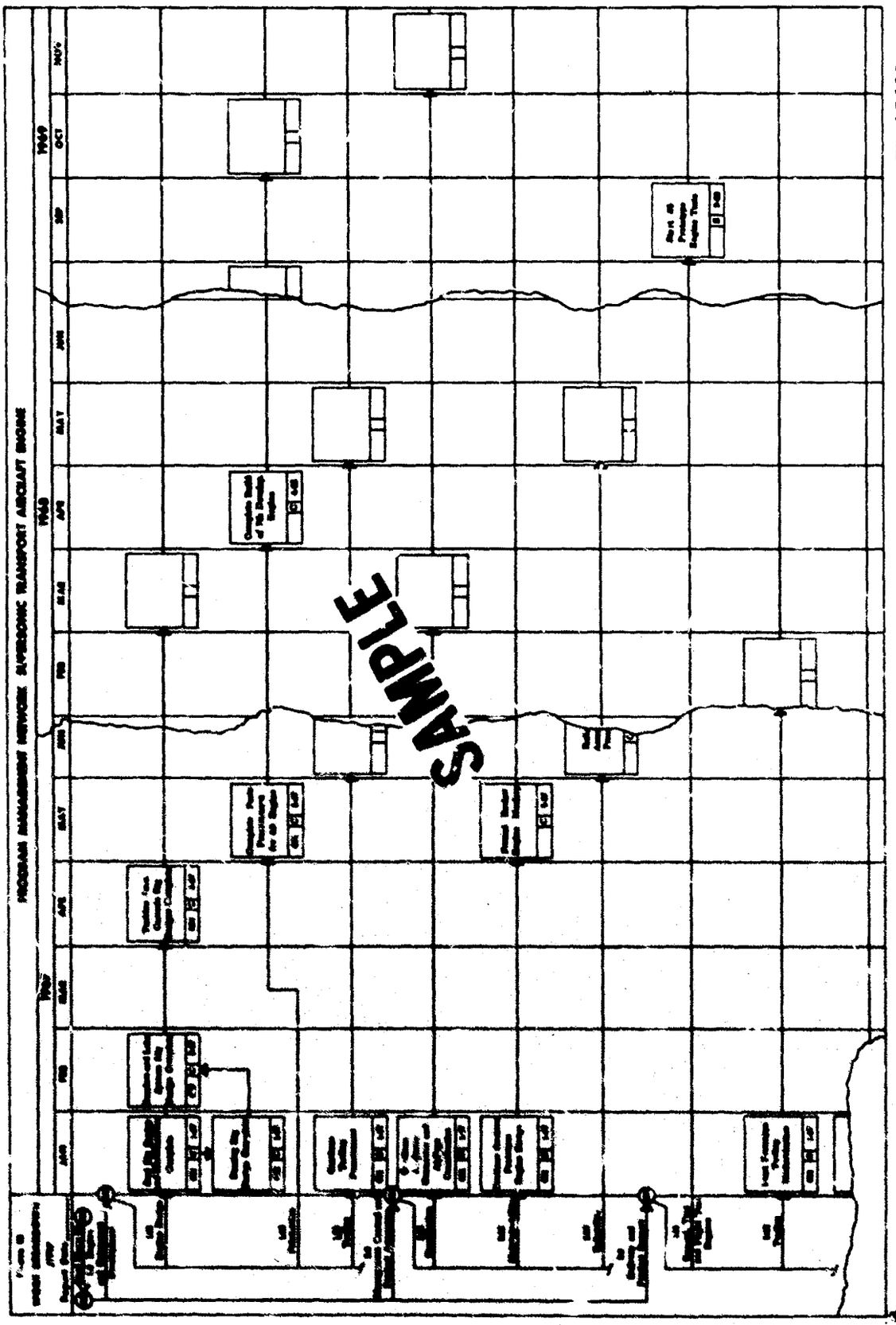
The Program Management Network (figure 10) represents the sequential steps needed to reach the objectives for the JTF17 Phase III Engine Development Program and is displayed on a time-banded basis.

These reports will sequence the events and activities by (1) Predecessor and Successor Event, (2) Paths of Criticality, (3) Expected Date and Predecessor Event, and include all events and activities of the Network.

C. SYSTEM FUNCTIONS AND CAPABILITIES

The overall network plan is developed directly from the Work Breakdown Structure. Each major development area is assigned to a Project Engineer who has the responsibility for detailed definition within the area of work, or work package. Each Project Engineer determines a preliminary schedule with the milestone items displayed on a time phased bar chart form. These milestone charts are the basis for the PERT Networks and enable Program Management to integrate milestones into a concise plan combining all items of the Work Breakdown Structure. Delivery item milestones will be prepared by the Manager of Product Support and the Manager of Engine Delivery for their respective responsibilities. These will also be integrated by Program Management into the total plan.

Schedule performance status reporting by structural level is achieved through network tiering and computer printouts. Levels I and II of the Work Breakdown Structure are displayed on the Program Management Network. Detail Networks or Subnets are prepared for all work packages at Level III of the Work Breakdown Structure. These networks include all the milestones that appear on the Program Management Network.



FD 17630
FV

Figure 10. Program Management Network

Revisions to the Program Plan and resultant redirections of program effort are incorporated throughout all networks and schedules and through revisions of the logic networks and result in revised PERT reports for management action. Revisions to the Program Plan require management evaluation of the revised slack conditions and a rescheduling of work through adjustments in manpower and resources.

Major subcontractor efforts are identified by separate events, and activities are interfaced on the networks where deliveries are critical, or are limiting, to future development activity.

Planned, actual, and forecast schedule status is reported in regular biweekly and monthly PERT reports (figures 11 and 12). Summarizations are made for the various levels of responsibility. Project Engineers and managers for deliverable items receive reports for their work packages only and Program Management receives over-all program reports.

A basic section of the PERT report is the Path-of-Criticality, which identifies items of program slippage and their effect through interfaces on future program objectives and milestones. Relative criticality of the various events and activities are measured through the amount of projected slippage and effects on future milestone items. This analysis enables management to be informed of critical areas, their relative effect on program objectives and defines areas which require attention and management action.

The Project Engineer's staff individually reviews his area of responsibility with the PERT Administrator. Each staff member receives status information daily from key people from all departments which affect his area of responsibility. During formal update periods, this information is summarized and transmitted to the PERT Administrator for use in revising and updating of the Networks. Basic problems are isolated by the Manager, Program Controls, and a plan of action is formulated by the Program Manager to correct the deficiency. (Each department involved is alerted to the need for corrective action, and an action schedule is formulated which is then approved by the Program Manager.) Revised Networks are made, and progress is closely evaluated during future update periods.

D. PERT ORGANIZATION

The PERT Organization at the Florida Research and Development Center consists of full-time personnel who are responsible for the establishment of PERT requirements. They have responsibility for developing the PERT System for proposals and then for updating the system through the contract period of performance. The PERT group also provides services and assistance through the development of supplementary control programs for project personnel.

The PERT group, in addition, constantly researches new or revised PERT systems and techniques to ensure incorporation of the latest compatible PERT operations and techniques with the Florida Research and Development Center organization.

NASA PERT TIME I
PRATT+WHITNEY AIRCRAFT
FLORIDA RESEARCH + DEVELOPMENT CENTER PAGE 1

RUN 1 DATE OF THIS REPORT IS 6/30/66
BY PREDECESSOR AND SUCCESSOR EVENT NUMBER
NETWORK 00 JTF17A-20 SST AIRCRAFT ENGINE DEV. -FAA- DETAIL NETWORK 1965-66

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	TIME REM.	WORK ITEM
0- 1	1-100	ENGINE DESIGN				* 7/ 1/65			1.01
0- 1	2-100	ENGINE TEST PROGRAM				* 7/ 1/65			1.04
0- 1	3-100	COMPRESSOR DEVELOPMENT				* 7/ 1/65			1.11
0- 1	4-100	COMBUSTOR DEVELOPMENT				* 7/ 1/65			1.12
0- 1	5-100	TURBINE DEVELOPMENT				* 7/ 1/65			1.13
0- 1	6-100	DUCT HEATER DEVELOPMENT				* 7/ 1/65			1.14
0- 1	7-100	REVERSER-SUPPRESSOR DEVELOPMENT				* 7/ 1/65			1.15
0- 1	8-100	CONTROLS DEVELOPMENT				* 7/ 1/65			1.16
0- 1	9-100	BEARINGS AND SEALS DEVELOPMENT				* 7/ 1/65			1.17
0- 1	9-250	FUELS				* 7/ 1/65			1.11
0- 1	9-300	LUBRICANTS				* 7/ 1/65			1.22
0- 1	10-100	ENGINE NOISE				* 7/ 1/65			1.00
0- 1	10-150	INLET SYSTEM COMPATIBILITY				* 7/ 1/65			1.04
0- 1	11-100	MOCKUP				* 7/ 1/65			1.06
1-100	1-105	FAN LAYOUT DRAWINGS	9.1	8/27/65	9/30/65		4.9	-43.0	1.01
1-100	1-120	HIGH COMPRESSOR LAYOUT DRAWINGS	7.1	8/20/65	9/20/65		0.0	-44.0	1.01
1-100	2-135	MAIN BURNER LAYOUT DRAWINGS	11.0	9/20/65	9/20/65		0.0	-40.4	1.01
1-100	1-150	TURBINE LAYOUT DRAWINGS	8.7	8/31/65	8/30/65		-0.1	-43.3	1.01
1-100	1-165	DUCT HEATER LAYOUT DRAWINGS	9.1	8/27/65	8/27/65		0.1	-43.0	1.01
1-100	1-180	REVERSER-SUPPRESSOR LAYOUT DRAWINGS	15.6	10/13/65	10/17/65		-0.1	-34.4	1.01
1-100	1-191	PRELIMINARY FAILURE MODE+EFFECTS ANALYSIS	13.0	9/30/65	9/30/65		0.0	-39.0	1.01
1-100	1-195	ACCESSORIES DRIVE LAYOUT DRAWINGS	24.1	12/31/65	12/31/65		0.1	-25.0	1.01
1-100	1-205	MOCK-UPS PRELIMINARY DRAWINGS	13.0	9/30/65	9/30/65		0.0	-39.0	1.01
1-100	1-220	CONTROLS	0.0	7/ 1/65	7/ 1/65		0.0	-43.0	1.01
1-105	1-110	FAN DETAIL DRAWINGS	-0.0	8/27/65	9/30/65		4.9	-43.0	1.01
1-110	1-115	FAN DESIGN COMPLETE FIRST ENGINE	-0.0	8/27/65	10/15/65		7.1	-43.0	1.01
1-110	3-135	FAN DESIGN COMPLETE FIRST ENGINE	0.0	8/27/65	9/30/65		4.9	-.0	1.01
1-115	1-250	DESIGN SUPPORT FOR SST CONFIGURATION	69.1	11/15/66	12/31/66		7.1	[illegible]	1.01
1-120	1-125	HIGH COMPRESSOR DETAIL DRAWINGS	10.3	10/31/65	10/31/65		0.0	-34.4	1.01
1-125	1-130	HIGH COMPRESSOR ENGINE DESIGN COMPLETE	0.0	10/31/65	10/31/65		0.1	-34.4	1.01
1-125	3-155	HIGH COMPRESSOR ENGINE DESIGN COMPLETE	0.0	10/31/65	10/31/65		0.0	-34.4	1.01
1-130	1-250	DESIGN SUPPORT FOR SST CONFIGURATION	60.8	12/30/66	12/31/66		0.1	24.2	1.01
1-135	1-140	MAIN BURNER DETAIL DRAWINGS	6.9	11/ 7/65	11/ 7/65		0.0	-33.5	1.01
1-140	1-165	MAIN BURNER DESIGN COMPLETE	0.0	11/ 7/65	11/ 7/65		0.0	-33.5	1.01
1-140	4-205	MAIN BURNER DESIGN COMPLETE	0.0	11/ 7/65	11/ 7/65		0.0	-33.5	1.01
1-145	1-250	DESIGN SUPPORT FOR SST CONFIGURATION	59.8	12/31/66	12/31/66		0.0	24.2	1.01
1-150	1-155	TURBINE DETAIL DRAWINGS	10.9	11/15/65	11/16/65		-0.1	-32.4	1.01
1-155	1-160	TURBINE DESIGN COMPLETE	0.0	11/15/65	11/15/65		0.0	-32.4	1.01
1-155	5-210	TURBINE DESIGN COMPLETE	0.0	11/15/65	11/16/65		-0.1	-32.4	1.01
1-160	1-250	DESIGN SUPPORT FOR SST CONFIGURATION	58.7	12/31/66	12/31/66		0.0	24.2	1.01
1-165	1-170	DUCT HEATER DETAIL DRAWINGS	9.1	10/20/65	10/30/65		0.1	-36.4	1.01
1-170	1-175	DUCT HEATER DESIGN COMPLETE	0.0	10/29/65	10/30/65		0.1	-36.4	1.01
1-170	6-165	DUCT HEATER DESIGN COMPLETE	0.0	10/29/65	10/30/65		0.1	-36.4	1.01
1-175	1-250	DESIGN SUPPORT FOR SST CONFIGURATION	61.0	12/30/66	12/31/66		0.1	24.2	1.01
1-180	1-184	REVERSER-SUPPRESSOR LAYOUT REVISION	15.0	1/31/66	1/30/66		-0.1	-21.4	1.01
1-184	1-185	REVERSER-SUPPRESSOR MFG. DRAWINGS	6.1	3/ 1/66	2/28/66		-0.1	-17.3	1.01
1-185	1-190	REVERSER-SUPPRESSOR MFG.DWGS.COMP.	0.0	3/ 1/66	3/ 1/66		0.0	-17.3	1.01
1-185	7-165	REVERSER-SUPPRESSOR MFG.DWGS.COMP.	0.0	3/ 1/66	2/28/66		-0.1	-17.3	1.01

Figure 11. NASA PERT Time Printout (Run 1)

NASA PERT TIME I
PRATT+WHITNEY AIRCRAFT
FLORIDA RESEARCH + DEVELOPMENT CENTER PAGE 1

RUN 13 DATE OF THIS REPORT IS 6/30/66
BY PREDECESSOR AND SUCCESSOR EVENT NUMBER
NETWORK 00 JTF17A-20 SST AIRCRAFT ENGINE DEV. -FAA- DETAIL NETWORK 1965-66

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	TIME REM.	WORK ITEM
0- 1	9-250	FUELS				* 7/ 1/65			1.13
9-250	9-255	FUEL COKER T[illegible]TS	8.7	8/31/65	8/31/65		0.0	-43.3	1.13
9-250	9-260	MATERIAL EROSION AND CORROSION TEST	10.9	9/15/65	9/15/65		0.0	-41.1	1.19
9-250	9-265	SUBNICITY TESTS	10.9	9/15/65	9/15/65		0.0	-41.1	1.19
9-250	9-270	J58 ENGINE TESTS	69.9	8/31/66	8/31/66		0.0	0.0	1.19
9-250	9-275	COORD W/ AIRFRAME CONTR AIRLINES FUEL COMP	70.3	12/31/66	12/31/66	12/31/66	0.0	24.2	1.19
9-255	9-275	EVAL OF THERMAL STAB OF FUEL+ADDITIVES	69.6	12/31/66	12/31/66	12/31/66	0.0	24.2	1.19
9-260	9-275	COMPATIBILITY FUEL TESTS	67.4	12/31/66	12/31/66	12/31/66	0.0	24.2	1.19
9-265	9-275	PICHO MYCER GEAR MIG TESTS	67.4	12/31/66	12/31/66	12/31/66	0.0	24.2	1.19
9-270	9-275	SIMULATED OPERATION TESTING	17.4	12/31/66	12/31/66	12/31/66	0.0	24.2	1.19

RUN 14 DATE OF THIS REPORT IS 6/30/66
BY PREDECESSOR AND SUCCESSOR EVENT NUMBER
NETWORK 00 JTF17A-20 SST AIRCRAFT ENGINE DEV. -FAA- DETAIL NETWORK 1965-66

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	TIME REM.	WORK ITEM
0- 1	10-150	INLET SYSTEM COMPATIBILITY				* 7/ 1/65			1.04
10-150	10-155	INLET COMPATIBILITY STUDIES+PLAN FORMULATE	24.1	12/31/65	12/31/65		0.0	-25.0	1.04
10-155	10-160	CONTINUE INLET STUDIES	52.1	12/30/66	12/30/66		0.0	24.2	1.04
10-155	10-165	COORD-ENG/INLET COMPAT TEST PROGRAM PLAN	52.1	12/30/66	12/30/66	12/30/66	0.0	24.2	1.04
10-160	10-165	DUMMY	0.0	12/30/66	12/30/66	12/30/66	0.0	24.2	1.04

RUN 15 DATE OF THIS REPORT IS 6/30/66
BY PREDECESSOR AND SUCCESSOR EVENT NUMBER
NETWORK 00 JTF17A-20 SST AIRCRAFT ENGINE DEV. -FAA- DETAIL NETWORK 1965-66

EVENT PRE.	SUC.	ACTIVITY DESCRIPTION	ACTIV. TIME	DATE EXPECTED	DATE ALLOWED	DATE SCHD/ACT.	SLACK	TIME REM.	WORK ITEM
0- 1	1-100	ENGINE DESIGN				* 7/ 1/65			1.01
0- 1	11-100	MOCKUP				* 7/ 1/65			1.06
1-100	1-205	MOCK-UPS PRELIMINARY DRAWINGS	13.0	9/30/65	10/ 1/65		0.1	-39.0	1.01
1-205	11-120	RELEASE OF PRELIMINARY DRAWINGS	0.0	9/30/65	10/ 1/65		0.1	-39.0	1.01
11-100	11-105	PRELIMINARY DESIGN	[illegible].3	7/31/65	7/31/65		0.0	-47.7	1.06
11-105	11-110	PROCURE PARTS	10.8	10/19/65	10/19/65		0.1	-34.9	1.06
11-105	11-115	CONT DESIGN	4.4	9/30/65	8/31/65		0.0	-43.3	1.06
11-110	11-130	CONT PROCURE PARTS	50.0	9/30/66	9/30/66		0.0	13.2	1.06
11-110	11-160	ENGINEERING USE+MOCKUPS REVISION	69.1	12/31/66	12/31/66	12/31/66	0.0	24.2	1.06
11-115	11-110	PAD F/S ENGR EXPERIMENTAL MOCKUP	4.5	10/19/65	10/19/65		0.0	-34.9	1.06
11-115	11-120	CONT DESIGN	4.1	9/30/65	10/ 1/65		0.1	-39.0	1.06
11-115	11-135	P/P FOR GAS GENERATOR	4.3	9/30/65	10/ 1/65		0.1	-39.0	1.06
11-120	11-130	CONTINUE DESIGN	52.1	9/30/66	9/30/66		0.1	13.1	1.06
11-130	11-160	CONTINUE DESIGN	13.1	12/31/66	12/31/66	12/31/66	0.0	24.2	1.06
11-135	11-136	ASSEMBLE GAS GENERATOR	7.1	10/19/65	10/19/65		0.1	-34.9	1.06
11-136	11-160	MODIFICATIONS AS REQUIRED	69.1	12/30/66	12/31/66	12/31/66	0.1	24.2	1.06

Figure 12. NASA PERT Time Printout (Run 2)

The PERT group receives requirements from the Manager, Program Controls, while also maintaining direct contact with project groups and other service groups to assure information flow to the PERT system. The PERT group works with and uses the services provided by Accounting, the Computing Laboratory, and other service groups.

The PERT staff has a background in Engineering, Accounting, Systems and Procedures, and Administration. With the added experience of PERT implementation on several major Government contracts, Pratt & Whitney Aircraft is well prepared to implement the PERT system for Schedule Planning and Control during Phase III of the Development Program for the JTF17 engine.

E. PERT EXPERIENCE

Pratt & Whitney Aircraft, Florida Research and Development Center, has over six-years' experience in the application of PERT to various study, development, and production contracts. PERT requirements have been completed, or are actively being compiled with, under the following study, development, and production contracts conducted by the Pratt & Whitney Aircraft, Florida Research and Development Center, Engineering Organization.

Contract	Agency/Prime Contractor	Contract No.
RL10 Rocket Engine Development	NASA	NAS8-2690 NAS8-5607 NAS8-5623 NAS8-15494
High Pressure Rocket Engine Feasibility Program	Air Force	AF04(611)-7435
SST Engine Development	FAA	FA-SS-66-8

This experience has provided Pratt & Whitney Aircraft personnel with the necessary background to permit the effective use of PERT on programs that range from short duration study programs to major engine development programs.

F. ADDITIONAL SCHEDULE PLANS AND CONTROLS

1. Master Milestone Chart

The major events and program efforts are displayed on a chart, which will enable the Program Manager to obtain a rapid appraisal of the complete program. (See Master Program Plans, Volume V, Report A.)

2. Line of Balance Charts and Reports (Delivery Engines)

Considerable success in monitoring previous deliverable engines at FRDC was obtained through the use of the Line of Balance technique. Monthly status reports with analyses of delinquent items are planned for the twenty prototype engines in Phase III. A typical Line of Balance chart is shown in figure 13.

3. Supplemental Reports

Daily and weekly written reports will detail the status of all major component, rig and development engine test programs and support activities. These are formalized at the discretion of the individual Project Engineers and/or Program Managers, and serve to supplement formal schedule planning and control as outlined in paragraphs 1-6 (above).

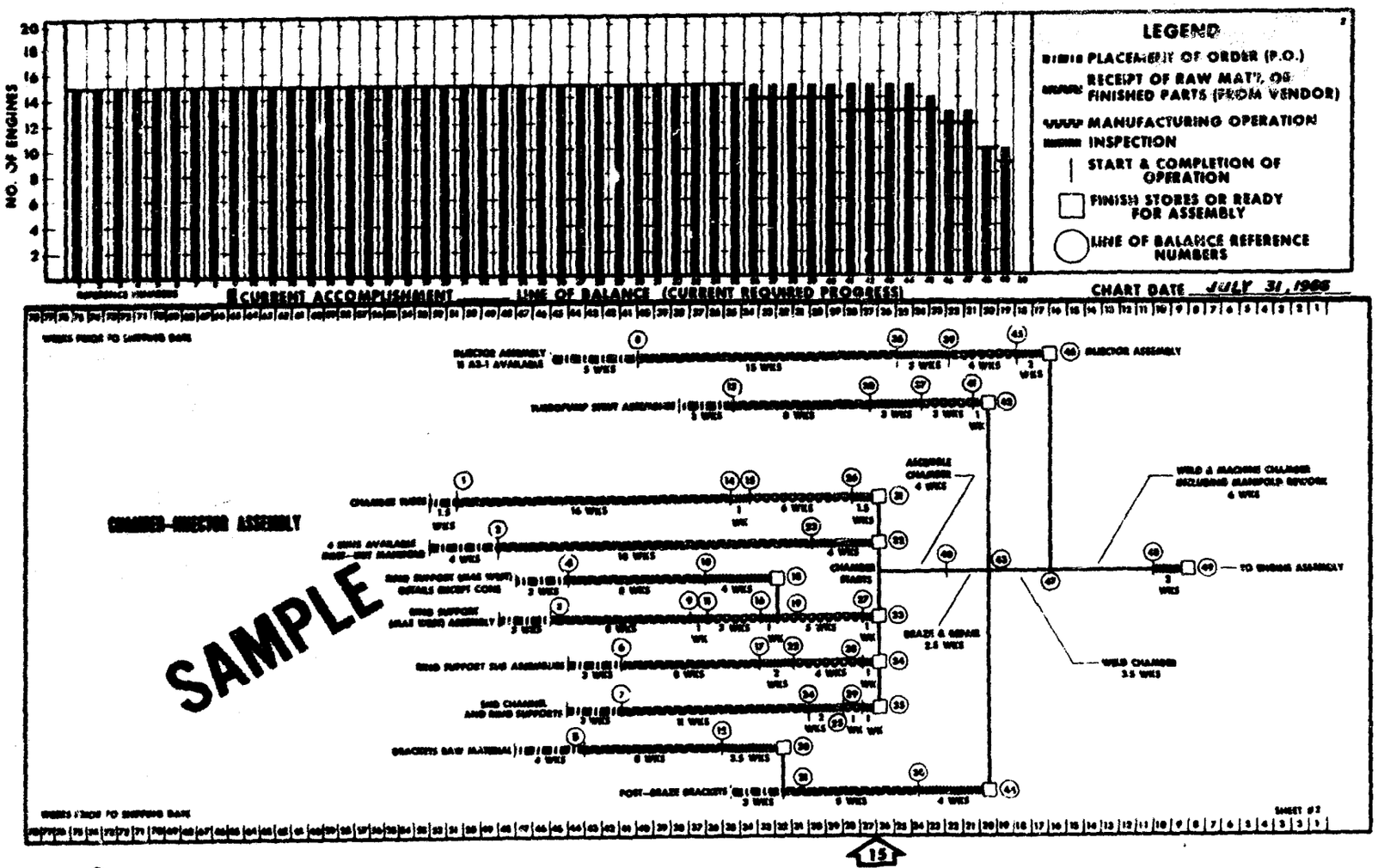


Figure 13. Typical Line of Balance Chart

REPORT G
MANUFACTURING PROGRAM

SECTION I
OBJECTIVES

The objectives of the Manufacturing Program are to:

1. Provide the new development engines, rigs, and their supporting spare parts and alternate design parts; and to convert the three demonstrator engines to the latest design as required by the development test plan

2. To build and ship engine mockups as required

3. To manufacture, test, and ship the ground-test engines on schedule

4. To manufacture, test, and ship the pre-FTS and prototype engines as planned

5. To rebuild the pre-FTS engines as prototypes, and overhaul prototypes as required, on the shortest turn-around cycle, to minimize the number of these engines required

6. To manufacture, most economically, the production engines and spares on schedule.

SECTION II
MAJOR MILESTONES

The major milestones of the Manufacturing Program, as shown in figure 1, are:

1. Completion dates of 12 new development engines and the modernization of the three demonstrator engines
2. Completion dates of new major rigs
3. Shipping dates of engine mockups
4. Shipping dates of ground-test engines
5. Shipping dates of Prototype (pre-FTS and post-FTS) engines
6. Scheduled first delivery of Production Engines and delivery rate escalation.

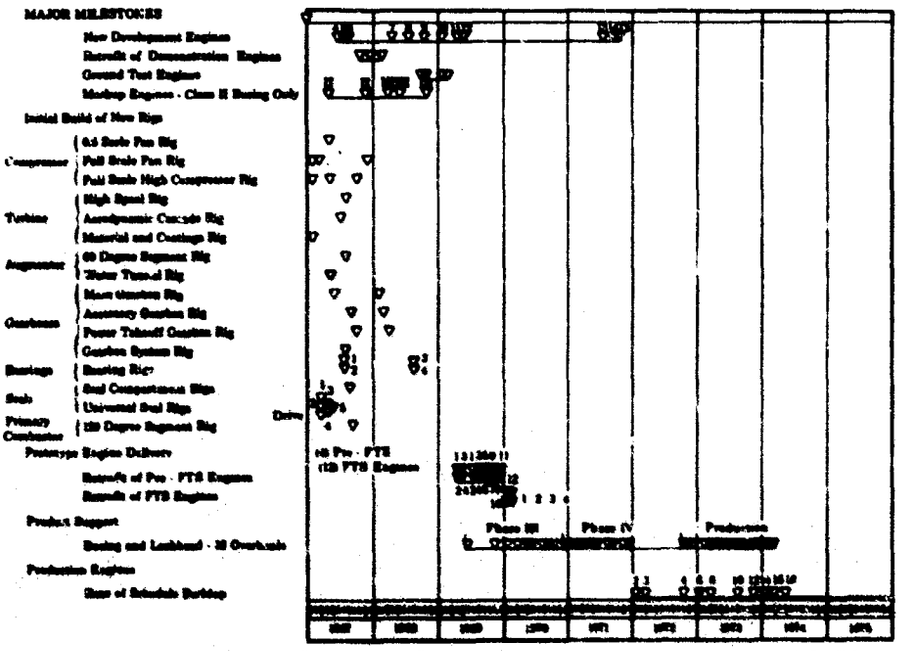


Figure 1. Engine Development Program Major Milestones — FD 17571 VG

Within these major milestones are second level objectives that are key events in arriving at the major milestones listed above. These are the times of initiation and completion of the first Development Engine for Phase III, first Prototype Engine, and first Production Engine, as follows:

1. Release of Bill of Materials
2. Planning and processing
3. Procurement of raw material
4. Preparation of operation sheets

5. Design of tools
6. Fabrication of tools
7. Inspection and tryout of tools
8. Manufacture of details
9. Manufacture of subassemblies
10. Manufacture of final assemblies
11. Assembly of engine
12. Test of engine (Prototype and Production).

For the first Development Engine of Phase III (Development Engine No. 4), see figure 2. The first Prototype Engine is shown in figure 3. The first Production Engine is shown in figure 4.

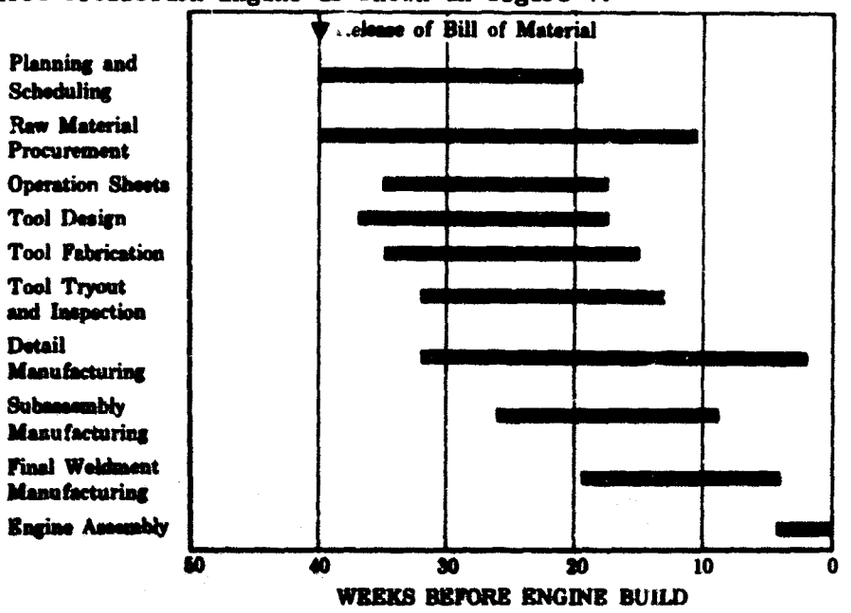


Figure 2. Lead Time Chart - Manufacturing Cycle for Fourth Development Engine FD 17572 VG

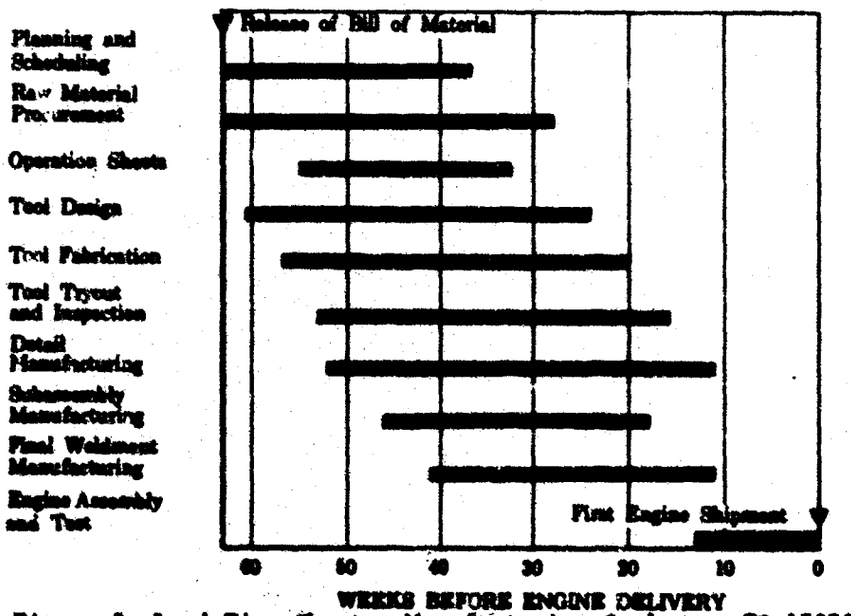


Figure 3. Lead Time Chart - Manufacturing Cycle for First JT9D Prototype Engine FD 17573 VG

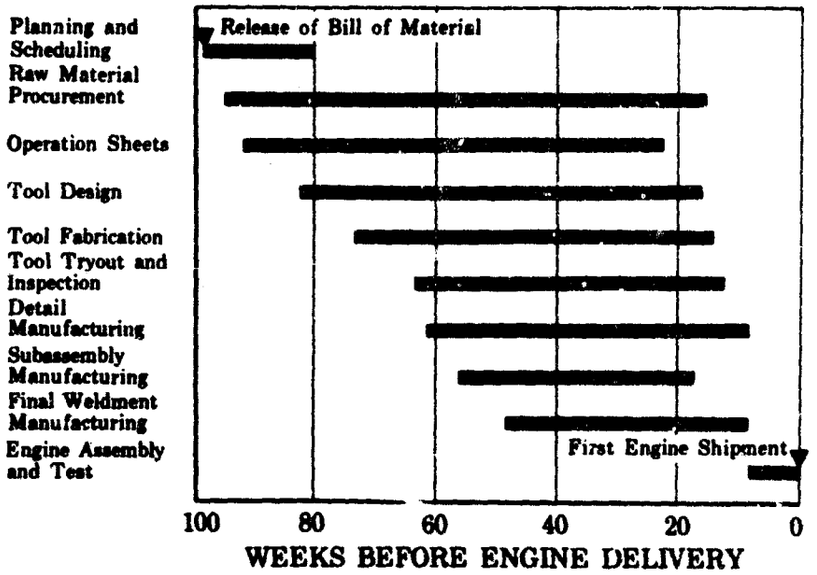


Figure 4. Lead Time Chart - Manufacturing Cycle First JTF17 Production Engine FD 17574 VG

The individual engine part with the longest lead time, establishing the manufacturing cycles for the Development and Prototype Engines, is the Intermediate Case. (See figures 5 and 6 for detail manufacturing events.) The Intermediate Case, along with the Diffuser Case, establishes the manufacturing cycle for Production Engines. (See figures 7 and 8.)

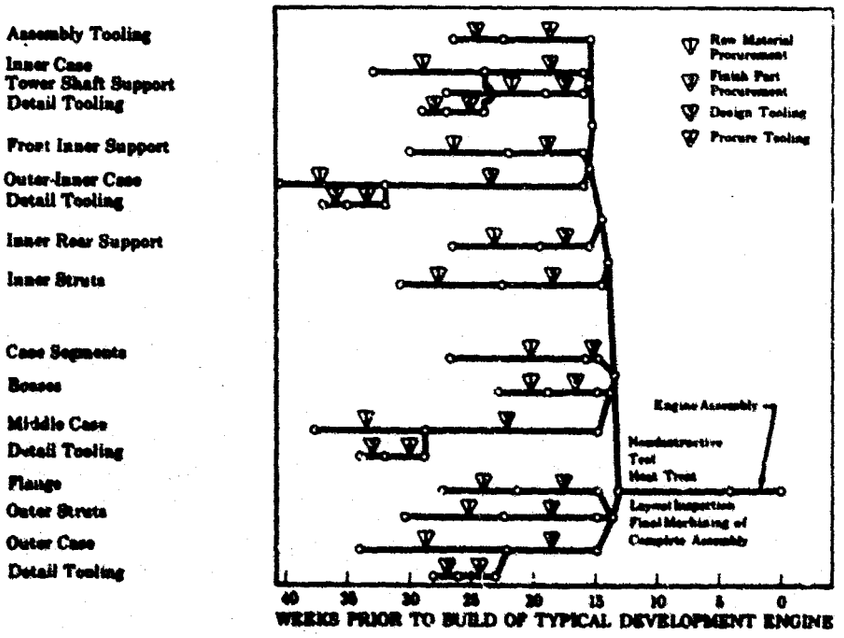


Figure 5. JTF17 Intermediate Case Assembly Schedule (Typical Development Engine) FD 17575 VG

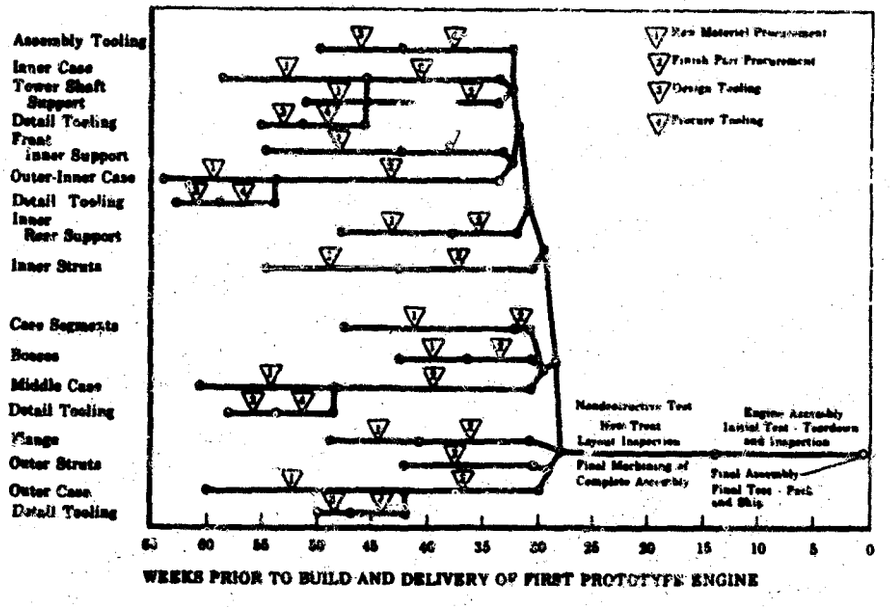


Figure 6. JTF17 Intermediate Case Assembly Schedule (First Prototype Engine) FD 17576 VG

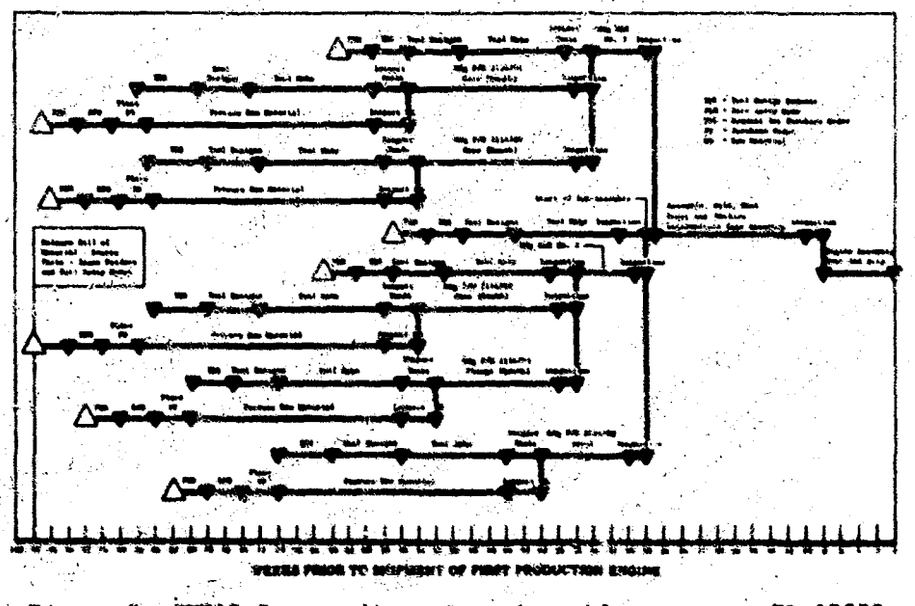


Figure 7. JTF17 Intermediate Case Assembly Schedule (First Production Engine) FD 17577 VG

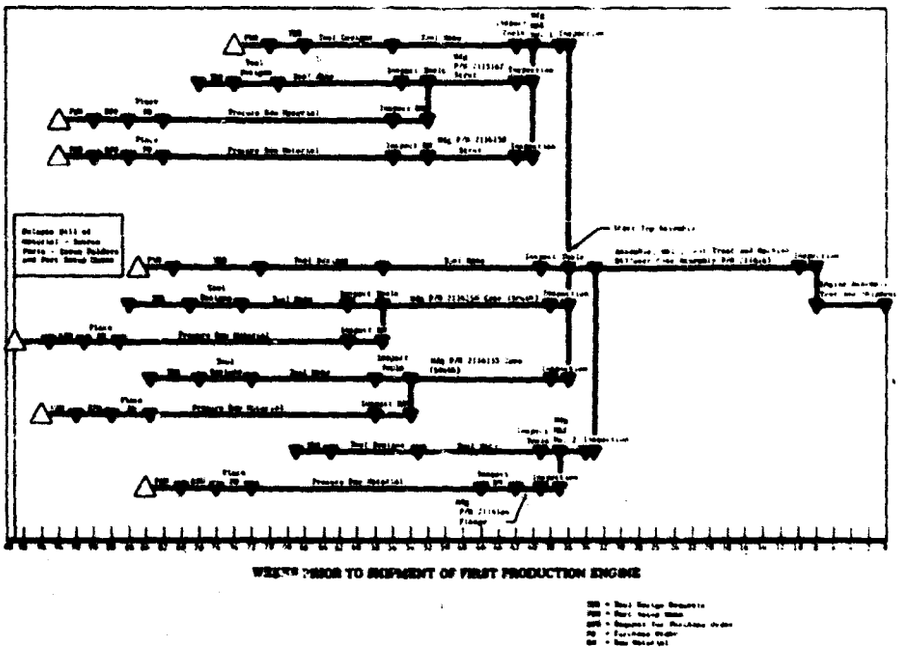


Figure 8. JTF17 Diffuser Case Assembly Schedule (First Production Engine) FD 17578 VG

The unitized fuel and area control is the pacing-subcontractor-designed-and-manufactured component for the Prototype and Production Engines. (Refer to Section IX.)

SECTION III
MAJOR RESPONSIBILITIES

A. FLORIDA RESEARCH AND DEVELOPMENT CENTER

The Florida Research and Development Center (FRDC) has been designated by P&WA management to be (1) responsible for the development of the JTF17 engine; (2) to produce the mockups, the ground test and prototype engines; and (3) to perform the overhaul (product support) of the prototype and early production engines through aircraft certification. This program will fill the void caused by the decline in other engine development programs. A manufacturing team, fully qualified as the result of the successful development program on the J58 supersonic jet engine and RL10 rocket engine, is available to undertake the SST program. FRDC manufacturing and its subcontractors have experience with all of the materials involved in the JTF17 engine through actual hardware produced, either in Phase II-C or in other supersonic jet engine programs. Manufacture, overhaul, and support of flight engines will not be a new experience for FRDC since it has extensive experience in the J58 engines and RL10 rocket engine programs. All departments have proven procedures for, and personnel experienced in, producing flight quality hardware, and in all phases of production control.

B. CONNECTICUT OPERATIONS

Connecticut Operations will be responsible for the manufacture, test, and delivery of the Phase V Production Engines. Many of the subcontractors utilized by FRDC during Phase III prototype and spares manufacture will be used for production hardware. During Phase V, many hardware items needed in the sustaining engineering program at FRDC will be obtained from production sources. (Refer to Volume V, Report B, Facilities Program.) Other engine programs now in production in Connecticut will be declining prior to and during Phase V. Additional floor space at the Connecticut Operations will not be required, and the program can be handled with the manpower available at that time.

After aircraft certification, overhaul of the Production Engines not handled in airlines' shops will be transferred to the Southington, Connecticut plant.

SECTION IV
MANUFACTURING ORGANIZATIONS AND GENERAL FACILITIES

A. FRDC DEVELOPMENT

The FRDC Manufacturing Department (figure 9) consists of three major functions; Construction, Traffic, and Project Materials Control. Each function is directed by a general supervisor, reporting to the Chief of Manufacturing. A Cost Control Group also reports to the Chief of Manufacturing as a staff function. Activities of the Test Department, relative to prototype and production, are also described in this Section. The Quality Assurance Program is covered in Volume IV, Report F, Section III.

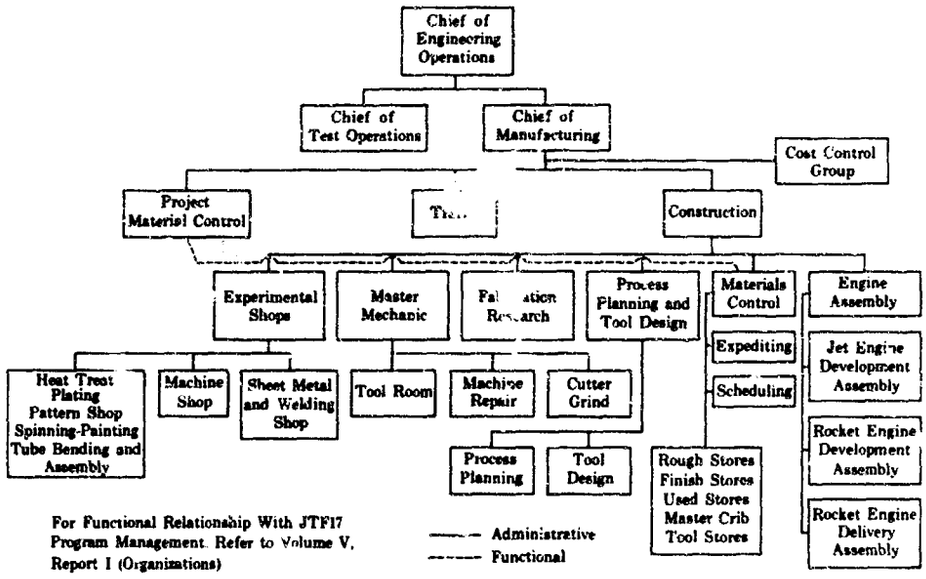


Figure 9. JTF17 Development Manufacturing Organization

FD 17579
VG

1. Experimental Construction

Construction consists of six major groups: Experimental Shops, Master Mechanic, Materials Department, Process Planning and Tool Design, Experimental Assembly, and Fabrication Research.

a. Experimental Shops

The Experimental Shops produce engine and rig hardware and are composed of the Machine Shop, Sheet Metal Shop, Welding Shop, Heat Treat Department, Pattern Shop, Tube Bending and Assembly Department, and Plating. The Shop covers 171,000 square feet of floor space and includes approximately 640 major machine tools and related pieces of equipment. A detailed description of these facilities is given in Appendix A to this Report. Lists of equipment appear in Volume V, Report B (Facilities Program) and table 1, following.

Table 1. Description of Facilities

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Major Fabricated Assemblies	Make 40% Buy 60%	Make 20% Buy 80%	EDMR Machine - Special	1	0	1
			108 in. VTL	1	0	1
			124 in. VTL	1	0	1
			76 in. VTL	2	2	
			66 in. VTL	1	1	
			Furnace (96 x 85 in.)	1	1	
			4 ft Radial Drill	1	1	
			120 in. Horizontal Boring Mill	3-1/2	2	2
			42 x 96 in. Jig Bore	2	1	1
			Welding Positioner - Large	2	2	
			TIG Auto Welder	2	2	
			Fusion Welders	6	2	4
			12 ft Power Shear	1/3	1	
			4 ft Rolls	1/4	1	
			Resistance Welder - Large	1	1	
			Resistance Welder - Small	1	1	
			Horizontal Rotary Layout Table - 100 in.	1	0	1
			Expander	1/4	1	
			Spin Lathe - 100 in.	1/4	1	
			14 ft Press Brake	1/2	1	
			48 in. Drop Hammer	1/2	1	
			Radial Draw Former	1/2	1	
			Large Contour Mill	2	1	1

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Major Fabricated Assemblies (continued)	Make 40% Buy 60%	Make 20% Buy 80%	Vertical Grinder - 100 in.	1/2	0	1
			Contour Mill	2	2	
			Clean and Rinse Tanks	5	5	
			Salt Bath Tank	1	1	
			Salt Bath Rinse Tank	1	1	
			Burring Equipment			
			Craneway Extension			
			Shop Equipment			
			Surface Plates (10 x 10 ft)	2	0	2
Liners	Make 90% Buy 10%	Make 20% Buy 80%	12 ft Power Shear	1/3	1	
			14 ft Press Brake	1/4	1	
			Weld Positioner	1/8	1	
			TIG Auto Welder	1/8	1	
			Box Furnace (135 x 96 x 85 in.)	1/16	1	
			10 x 8 ft Vacuum Tank	1/4	1	
			Resistance Welder	1/2	1	
			Radial Draw Form	1/4	1	
			Melt Pot (Kirksite)	1	0	1

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Compressor Blades and Vanes	Make 10% Buy 90%	Buy 100%	Blade Mill (1-Spindle)	1	0	1
			Multispindle Contour Mill	3	1	2
			Cam and Template Machine	1/2	1	
			New England Master Mill	1	1	
			Horizontal Mills	6	6	
			Vertical Mills	2	2	
			Duplex Mills	3	2	1
			Rise and Fall Mills	1	1	
			Blade Mills (6-Spindle)	2	2	
			Single-Spindle Contour Mills	2	2	
			Surface Grinders	2	1	1
			Tracer Mill Control	1	0	1
			Optical Tracer Mill	1	0	1
Compressor Disk and Hubs	Make 10% Buy 90%	Make 10% Buy 90%	Broach	1/4	1	
Minor Welded Assemblies	Make 20% Buy 80%	Make 20% Buy 80%	16 in. Band Saw	1/2	1	
			Resistance Welder	1/2	1	
			TIG Auto Welder	1	1	
			Spin Lathe	1/2	1	
			Sheet Metal Roll	1/4	1	
			Hydraulic Press	1/2	1	
			Jig Bore	1	1	
			Grinder (ID)	1/2	1	
			Engine Lathe	2	2	
			Vertical Mill	4	1	3
			EDMR Machine	1/2	1	

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan.)

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Burners	Make 95% Buy 5%	Make 30% Buy 70%	Bliss Horn Press (60-Ton)	3/4	1	
			Punch Press (62-Ton)	1/2	1	
			Spin Lathe (48 in.)	1/3	1	
			110 in. Dia Vacuum Tank	1/4	1	
			Resistance Welder	1/4	1	
			Weld Positioner	1/2	1	
			TIG Auto Welder	1/2	1	
			96 x 85 in. GF Box Furnace	1/3	1	
			76 in. VTL	1/4	1	
			72 x 120 in. Horizontal Boring Mill	1/3	1	
			Special EDMR Machine	1/2	0	1
			Tilt Rotary Tables (60 in.)	2	0	2
Interstage Seals, Spacers, and Dampeners	Make 20% Buy 80%	Make 20% Buy 80%	Turret Lathe	2	2	
			Engine Lathe	4	4	
			Grinders - OD & ID	6	6	
			Spin Lathe (48 in.)	1/2	1	
			GF Furnace	1/3	1	
			Hand Welder	1/8	1	
			Auto Welder	1/8	1	
			Rivet Machine	1/2	0	1
			Jig Bore No. 3	1-1/2	1	1
			Mills - Plain	6	6	
			Universal Grinders	2	0	2

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Turbine Blades and Vanes	Make 80% Buy 20%	Make 40% Buy 60%	ECM Cavity Sinker	1	0	1
			GF Box Furnace (92 x 5 x 48 in.)	1/4	1	
			Mills - Plain	6	6	
			EDM Machine	2	2	
			Fruenthal Grinder	1	1	
			Drill Press	1	1	
			Twin-Wheel Grinder	1	0	1
			ECM Grinder	1	0	1
			Surface Grinders	4	2	2
			ECM Deep-Hole Drill	1	0	1
Turbine Shafts	Buy 100%	Buy 100%				
Housings	Make 20%					
Bearings	Buy 80%	Buy 100%				
Seals						
Shafts						
Bosses						
Fittings						
Spray Bars						
Flaps						
Actuators						
Actuating Mech						
Small Hardware						

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Stator Assemblies	Make 10% Buy 90%	Buy 100%	76 in. VTL			
			Special Vane Pierce Machines	1	1	
			54 in. VTL			
			Horizontal Boring Mill (72 x 120 in.)	1/2	1*	
			Horizontal Boring Mill (42 x 60 in.)	1/2	1	
			Radial Drill	1/2	1	
			Rivet Machine	1/2	1*	
			GF Box Furnace (77 x 78 x 100 in.)	1/3	1	
			36 in. Spin Lathe	1/2	1	
			Weld Positioner	3	1	2
			Auto Welder	1/2	1	
			Fusion Welder (Hand)	2	2	
Turbine Disks and Hubs	Make 90% Buy 10%	Make 30% Buy 70%	Tilting Rotary Table	1/2	0	1
			T-Lathe	1	1	
			Broach	1/4	1	
			Mills - Plain	4	4	
			Jig Bore	1	1	
			Grinder - OD and ID	1	1	
			Engine Lathe	1	1	
			Horizontal Gear Shaper	1/4	1	
			Gun Drilling Machine	1/2	0	1

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

* Capacity available from prior listing of additional equipment.

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Brackets and Other Small Sheet Metal Work	Make 80% Buy 20%	Make 20% Buy 80%	Press Brake	1/8	1	
			Hydroform	1/16	1	
			Punch Press	1/16	1	
			Shears	1/16	1	
			Hand Welding Machine	1/4	1	
			48 x 52 in. Furnace	1/3	1	
			Mill - Plain	1	1	
			Jig Bore	1/16	1	
Plumbing	Make 90% Buy 10%	Make 70% Buy 30%	Metal-Gathering Machine	1	0	1
			25-KVA Resistance Welder	1	0	1
			25-KVA Resistance Welder	1	0	1
			25-KVA Induction Heaters	2	0	2
			15-KVA Induction Heater	1	0	1
			10 in. Pedestal Grinder	1	0	1
			Rotary Swager	1	0	1
			20 in. Sanding Machine	1	0	1
			No. 4 Turret Lathe	1	0	1

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Required for SST Program	Additional Equipment Required for SST Program
Gears	Make 20%		Tracer Lathe (25 in.)	1	0	1
	Buy 80%	Buy 100%	Engine Lathe	1	1	
			Gear Shaper	1	1	
			Gear Hobber	1	1	
			Gear Grinder	1	1	
			Pinion Rougher	1	1	
			Gear Generator	1	1	
			Hypoid Tester	1	1	
			Cutter Truing Device	1	1	
			Involute Checker	1	1	
			Cone Checker	1	1	
			Red Liner	1	1	
			Lead Checker	1	1	
Controls Igniters Valves Fuel Nozzles Gearbox Oil Tanks	Buy 100%	Buy 100%				

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

Table 1. Description of Facilities (Continued)

Item	Make or Buy (Development)	Make or Buy (Prototype)	Equipment To Be Used (for Development and Prototype Program)	Capacity Required for SST Program	Capacity Available for SST Program	Additional Equipment Required for SST Program
Assembly Floor Requirements			Balance Machine (Reoperation)	1	0	1
			Craneway Support	1	0	1
			5-Ton Air Hoist	5	4	1
			Balancer Conversion Kit 75-hp Drive	1	0	1
			Balancer Conversion Kit 0-1500 rpm	1	0	1
			Vapor Degreaser	1	0	1
			Cleaning Tanks	2	0	2
			Parts Tables	20	0	20
			Two 6-ton Levelators	2	0	2
			Six Air Hoists - two 2-ton	2	0	2
			four 5-ton	4	0	4
			Vapor Degreaser (10 x 10 x 10 ft)	1	0	1
			Vapor Blast Machine (10 x 10 x 10 ft)	1	0	1
			Cleaning Tank (10 x 10 x 11ft 4 in.)	2	0	2
			Oil Flow Bench	1	0	1
			10 Parts Tables (8 x 10 x 2 ft 6 in.)	10	0	10
			1 Balance Machine (Gisholt No. SJP)	1	0	1
			Electric Craneway (2-Hoist)	1	0	1

Notes: 1. Existing manufacturing inspection equipment is adequate to assure Quality Control of parts during the manufacturing process.
2. Existing manufacturing equipment is Government-owned and has been furnished under Government contract unless otherwise noted.
3. Equipment utilization and additional equipment needed apply at the height of the program in 1968 and 1969. For listings of potential subcontractors, refer to Volume V, Report E (Subcontracting Plan).

b. Master Mechanic

(1) Tool Room

The Tool Room, sized to the Manufacturing Shops, builds and reoperates special tooling. The Tool Room covers 15,000 square feet of floor space and is equipped with horizontal and vertical lathes with capacity to 100 inches in diameter, die sinkers, millers, jig boring machines, bore mills, shapers, and other standard tool room equipment, numbering approximately 100 machines.

(2) Cutter Grind Department

The Cutter Grind Department services new, used, and special cutting tools

(3) Machine Repair Department

The Machine Repair Department accomplishes major overhauls on FRDC shop machine tools and provides oil and coolant service. Preventative maintenance of major machine tools is programed.

c. Materials Department

(1) Scheduling and Expediting

The Expediting Group follows up both tool orders and engine parts fabricated in the FRDC Shops. The Scheduling Group is responsible for proper machine-loading of the FRDC Manufacturing Shops and participates in the "Make-Buy" decision. (Refer to Report E, Subcontracting Program.)

(2) Stores

The Product Stores Group stores, issues, and accounts for raw materials, finished parts, and used parts. The Non-Product Group is responsible for storage and inventory control of shop supplies and perishable tools

d. Process Planning and Tool Design

(1) Process Planning

The Process Planning Group participates in initial design coordination and is responsible for preparation of operation sheets, tool determination, and shop coordination through first piece manufacture. (Refer to Section VII.) They also participate in Value Engineering studies. (Refer to Volume IV, Report F, Section IV.)

(2) Tool Design

The Tool Design Group is responsible for manufacturing and assembly tool design and tool standardization.

e. Experimental Assembly

Experimental Assembly provides those services required by Engineering for the assembly, disassembly, and maintenance of all engines and test rigs originating at or assigned to FRDC.

These services include manufacturing-in-process requirements, such as balancing, pressure test, spin zyglo, and proof spinning. The facility covers an area of approximately 61,000 square feet, completely enclosed to provide all necessary security. It is equipped with 1250 feet of monorail designed to lift up to 20,000 pounds, has 10 levelators, of which 4 will accommodate engines up to 96 inches in diameter. A small machine shop provides for special assembly tool repair. A blueprint file is available for use by Engineering and Assembly Floor personnel. The area also provides other necessary equipment to process engines and rigs through the assembly and disassembly cycle, such as cleaning equipment, parts tables, pressure test tanks, oil flow and hydrostatic test benches, and deep freeze equipment. (For further information, refer to Appendix A of this Report.)

f. Fabrication Research

Fabrication Research performs manufacturing research on advanced concepts and processing of new materials. Its function is to advance the state-of-the-art in manufacturing techniques.

2. Traffic

Traffic performs the functions of verification, routing and expediting of material shipments and receipts and transportation of material within and outside the plant. It is also responsible for travel arrangements of plant personnel.

3. Project Materials Control

Project Materials Control is responsible for ordering and scheduling all engine and rig raw material and finished parts and issuing status reports. They also participate in the "Make-Buy" decision, coordinate Producibility and Value Engineering studies for the Manufacturing department, and maintain technical liaison with subcontractors and the FRDC Shops. The department is Project organized. (Refer to Section V.)

4. Cost Control Group

The Cost Control Group is responsible for issuing direct and indirect material and labor budgets, cost reduction reports, and compilations of general manufacturing statistics. They also prepare cost estimates and coordinate proposals covering manufacturing responsibilities.

5. Experimental Test Operations

A description of the experimental test operations is included in Volume III, Report E, (Test and Certification Plan Report).

B. FRDC MANUFACTURING ORGANIZATION FOR PHASE III PROTOTYPE DELIVERY

A Prototype Assembly Department will be organized in late 1968 to meet the scheduled delivery of the first two pre-FTS engines in April, 1969. The nucleus of this group will be drawn from Development Assembly.

For the function of Production Control, a new group, Delivery Materials Control, will be organized in early 1968 to direct the ordering and scheduling of prototype hardware. Pratt & Whitney Aircraft experience has shown that production control and assembly of delivery hardware cannot be handled effectively by integrated development and delivery groups. Prototype engine parts assembly requires more formalized quality documentation and process controls than is desirable for an intensive development program.

Figure 10 shows the proposed organization for Phase III Prototype Delivery. Test Organization is the same as described in Volume III, Report E. For Quality Assurance, refer to Volume IV, Report F, Section III.

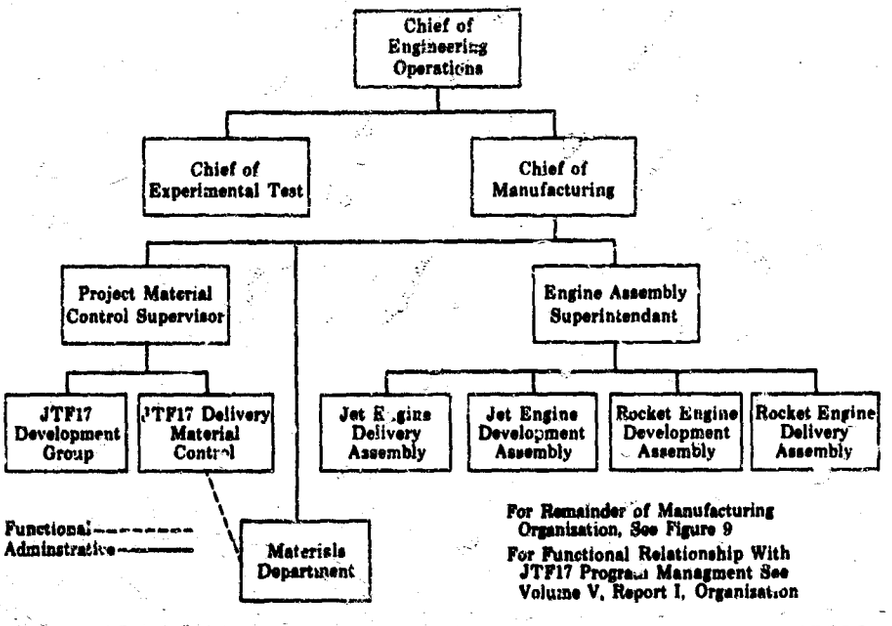


Figure 10. JTF17 Prototype Manufacturing Organization FD 17580 VG

C. FRDC MANUFACTURING ORGANIZATION FOR PHASES III AND IV PRODUCT SUPPORT

The Delivery Materials Control Group, organized for the Prototype Delivery Program in Phase III, will also be responsible for the ordering and scheduling of overhaul and field support hardware in Phases III and IV.

The Prototype Assembly Department will be responsible for the predicted 38 overhauls of ground test, pre-FTS, FTS, and Production engines from June, 1969, through aircraft certification in March, 1974.

Although the organizational structure will remain the same as in the Prototype Delivery phase, there are additional functional relationships for Product Support. This will occur because the Product Support Effort is directed by the Field Operations Group. These relationships are shown in Volume V, Report I (Organization).

Test Organization is the same as described in Volume III, Report E. For Quality Assurance, refer to Volume IV, Report F, Section III.

D. CONNECTICUT OPERATIONS MANUFACTURING ORGANIZATION, PHASE V

1. Summary

a. Responsibilities

A JTF17 Production Manager will be appointed in late 1969 to direct the production of engines for Phase V. The basic Manufacturing Department will not be changed. The JTF17 Production Manager will have overall responsibility for ensuring not only that the scheduled requirements for engines and spares are met, but also that production costs are held to a minimum. The Production Manager type organization offers the advantage of utilizing an established and functioning production control system and organization, while at the same time having the advantage of the special control and time-saving lines-of-communication inherent in a project-oriented system. Experience has been gained with this approach to production management through several previous programs. The RL10 rocket engine program and the J58, JT8D, and TF30 turbine engine programs were controlled by project-oriented production manager organizations.

A close relationship between the Engineering and Manufacturing Departments will be provided by the planned organization. A JTF17 Project Engineering Group located in East Hartford, Connecticut, will represent the FRDC Engineering Department on problems of specification definition, inspection requirements and design change incorporation. A liaison Engineering and Manufacturing Group located at FRDC will be responsible for coordinating requests for changes in design and for providing information required by manufacturing. These groups will provide the channels of communication necessary for the successful completion of the program.

A staff group comprised of supervisory personnel from each of the 10 Manufacturing Departments will assist the Production Manager. They will be responsible for reporting potential JTF17 problems occurring in their departments and for carrying out decisions reached by the Production Manager.

Other minor changes to ensure better communications will be made. A special Dispatching Group (Materials Control Department), reporting to the JTF17 Materials Manager, will be established for the control of JTF17 Production and Assembly. JTF17 control groups will be assigned to each Branch Plant to control the manufacture of JTF17 engine parts and assemblies.

b. Facilities

Pratt & Whitney Aircraft Production facilities have evolved over 16 years of gas turbine engine production and are well suited for the develop-

ment and production of the JTF17 engine program. This is indicated by past production performance, existing facilities, planned engine programs, and future facilities plans. Four manufacturing facilities of Pratt & Whitney Aircraft, all company-owned and all in Connecticut, will be involved in the production of JTF17 engines. (Refer to Report B, Facilities Program).

In January 1964, an extensive management study to analyze manufacturing facilities and determine a most efficient layout for the production of present and future generations of gas turbine engines, resulted in the approval for initiating a modernization program. Pratt & Whitney Aircraft is mid-way in the completion of facilities arrangements for production manufacturing areas and the relocation and combining of related service groups. Additional facilities modernization included the construction of a $??,000,000 building complex including a new Materials Center, Assembly Floor, and a three-story office building. The recent completion of a new Materials Center and assembly floor provides Pratt & Whitney Aircraft with a centralized facility for material-handling activities and additional capabilities for engine assembly. The Shop rearrangement program will be completed by early 1968.

(1) Machine Tool Modernization Program

A completely P&WA-financed machine modernization and replacement program is conducted at Pratt & Whitney Aircraft on a continuing basis. New types of machines are evaluated for use to ensure increased capacity and reduced manufacturing costs consistent with quality and performance requirements. A modernization budget of $12,000,000 for capital improvements has been approved for 1966. This represents 7% of the estimated value of the total machine and equipment inventory at Pratt & Whitney Aircraft. Modernization budgets of $12,000,000 per year are planned for the years 1967 through 1969.

2. Description of Departments

The Connecticut Manufacturing Organization consists of 10 major departments (figure 11). Each department has a department head reporting directly to the Factory Manager. He is responsible for the operating efficiency of his organization. Following is a brief description of each major department in the manufacturing organization.

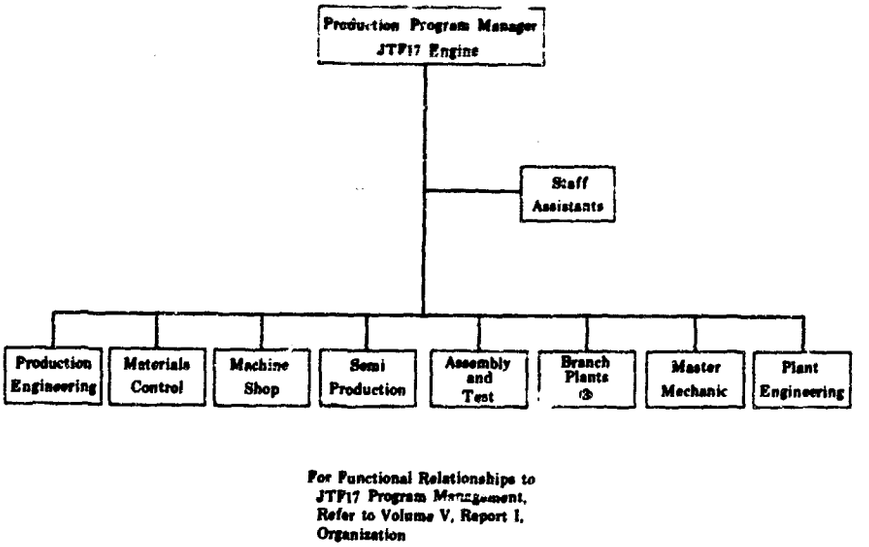


Figure 11. Production JTF17 Engine Manufacturing Organization FD 17581 VG

a. Production Engineering (Figure 12)

Production Engineering is divided into three major areas: Planning, Control, and Procurement; Process Engineering; and, Tool Design and Development. Each area is directed by a general supervisor, reporting to the Chief of Production Engineering. Major sections within each area are headed by supervisors, supported by group leaders and operating personnel.

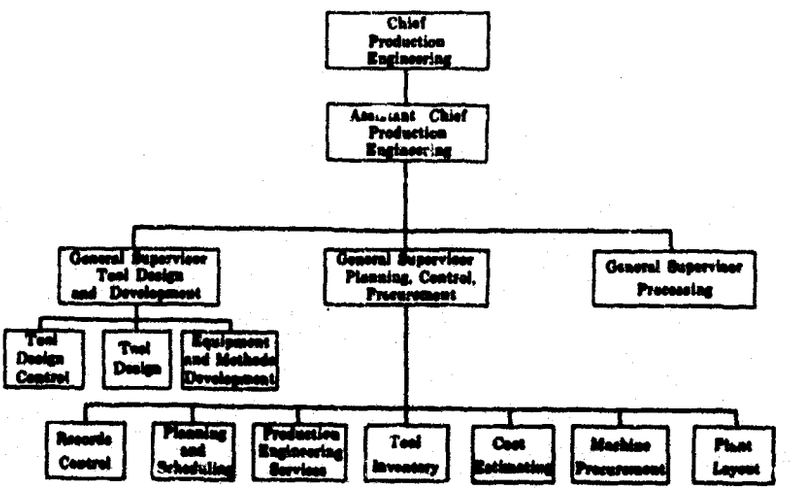


Figure 12. Production Engineering Organization FD 17582 VG

(1) Planning, Control, and Procurement

Planning, Control, and Procurement is divided into the following seven groups:

(a) Records Control

The Records Control Group is responsible for (1) maintaining work status records, (2) recording manufacturing assembly specifications, and (3) maintaining cost information records and Engineering Changes.

(b) Planning and Scheduling

The Planning and Scheduling Group determines schedules for Process Engineering, for tool design completion, and delivery of tools. Planners establish the source of part manufacture based on the "Make-Buy" Policy. They also determine and distribute ordering and scheduling requirements.

(c) Production Engineering Services

The Production Engineering Service Group types all manufacturing operation sheets, maintains a central file and control of the original operation sheets and tool designs, and duplicates and distributes operation sheets and tool designs as required.

(d) Tool Inventory Control

The Tool Inventory Control Group is responsible for ordering, inventory control, and distribution of Production Engineering Tools and supplies, using advanced techniques of data collection, processing, and statistical analysis.

(e) Cost Estimating

The Cost Estimating Group is responsible for processing manufacturing cost estimates of proposed engineering changes and new parts for Engine Development, Value Engineering, and the Materials Control Department.

(f) Machine Procurement and Utilization

The Machine Procurement and Utilization Group is responsible for (1) reviewing machine tool requests, (2) preparing machine tool specifications, (3) maintaining machine load files, (4) analyzing machine load reports to determine machine requirements, and (5) maintaining machine tool inventory records.

(g) Plant Layout

The Plant Layout Group is responsible for planning and layout of facilities rearrangements.

(2) Process Engineering

Process Engineering is organized into groups that are classified by type of subassembly or part processed and correspond to the seven machine

shop areas in the East Hartford Plant, three shop areas in the North Haven Plant, and one shop each in the Southington and Middletown Plant. Process Engineering is responsible for preparing operation sheets, issuing tool-design-and-make requests, and providing technical assistance to the shop.

(3) Tool Design and Development

Tool Design and Development is divided into the following three sections:

(a) Tool Design Control

Tool Design Control directs the flow of work through Tool Design and is responsible for assignment of jobs to applicable tool design groups or subcontractors, job followup, and status reporting.

(b) Tool Design

Tool Design department is organized into five specialized groups to support Process Engineering in East Hartford, North Haven, Southington, and Middletown. In addition to designing tools, Tool Design is responsible for analysis and time estimates of tool design requests and quality requirements of in-house and subcontracted designs.

(c) Equipment and Methods Development

Equipment and Methods Development is divided into three sections; Equipment Development and Standardization, Manufacturing Methods Development, and Welding Development. The Equipment Development and Standardization Group is responsible for design and development of special equipment and the tool standardization program. The Manufacturing Methods Development Group is responsible for development of new manufacturing processes and methods. The Welding Development Group is responsible for developing and certifying new welding and brazing techniques. (Refer to Section VIII.)

b. Materials Department

The Materials Department, directed by the Chief, Materials Department, is responsible for materials ordering and planning and dispatching functions in the Manufacturing Department. The present Materials Department, as shown in figure 13, is organized into seven groups: Parts Control; Materials Requirements; Dispatching; Materials Planning; PERT Group; In-Plant Traffic, Shipping, and Receiving; and Materials Stores. (Refer to Section V.)

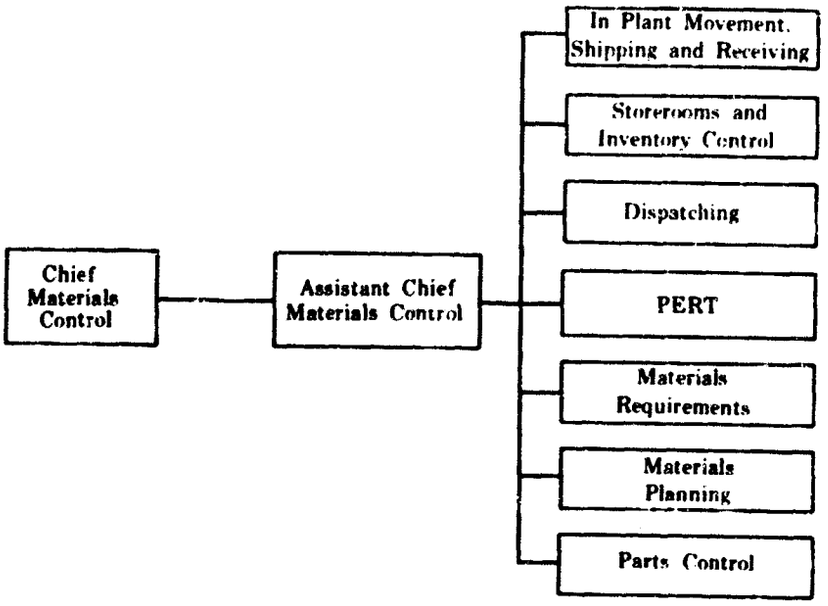


Figure 13. Materials Department Organization FD 17583 VG

c. Machine Shop

The Pratt & Whitney Aircraft East Hartford Machine Shop is organized into seven manufacturing areas, directed by divisional superintendents reporting to the Machine Shop Superintendent (figure 14). Work flow is part-oriented, with each area responsible for the complete manufacturing process of parts sourced to it, except for such processes as paint and preservation, heat treatment, shot peen, plating, and tumbling, which are the responsibility of specialized departments serving several areas. The seven areas are further subdivided into Manufacturing Departments. These are managed by General Foremen and Foremen who are responsible to the Division Superintendents for manufacturing quality parts and for meeting production schedules.

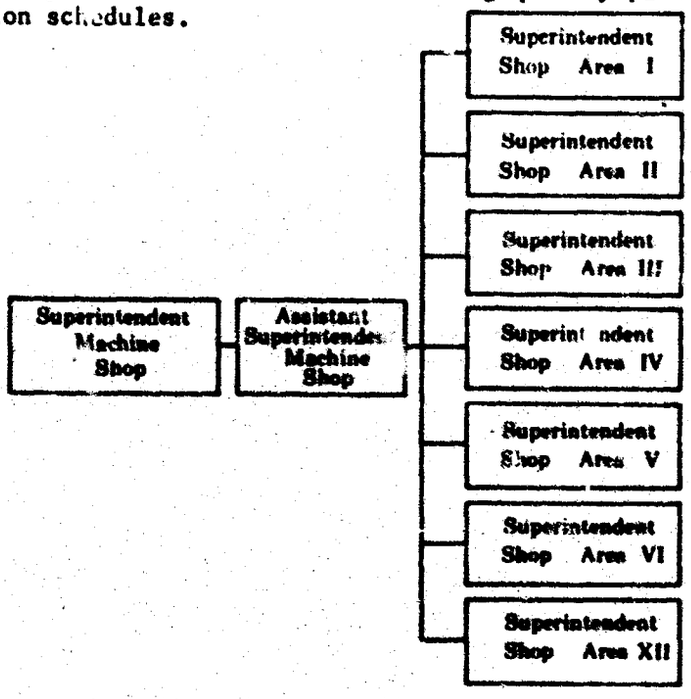


Figure 14. Machine Shop Organization FD 17584 VG

d. Assembly and Test

The Assembly and Test Department, directed by the Superintendent reporting to the Factory Manager, is separated into four sections (figure

(1) Assembly and Test Process Engineering

Assembly and Test Process Engineering is responsible for preparation and distribution of assembly and test operation sheets; issuing design-and-make requests for assembly, test, and service tooling; and providing technical assistance to the Assembly Floor and Test Area.

(2) Assembly Engineering

Assembly Engineering is responsible for establishing assembly floor procedures, coordinating assembly engineering problems with engine development, and notifying the Materials Department of engineering change incorporation.

(3) Assembly Floor

The assembly floor is organized into departments for green and final subassembly, balancing, teardown, and green and final engine assembly operations.

(4) Test Area

The Test Area is organized into departments for accessory test, engine pretest preparation, engine test, and engine packing operations.

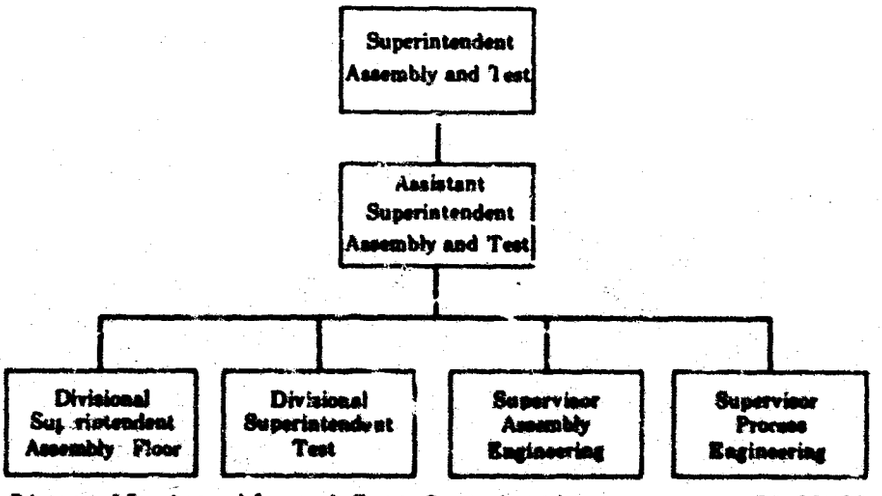


Figure 15. Assembly and Test Organization FD 17585 VG

e. Semi-Production

Semi-Production is separated into two departments: semi-production machining and semi-production sheet metal (figure 16).

(1) Semi-Production Machining

Semi-Production Machining is established to perform machining operations on initial production engine parts, using a minimum of tooling. It is directed by a superintendent reporting to the factory manager and is organized into three sections; (1) Process Engineering, (2) Production Control, and (3) Machine Shop.

(a) Process Engineering

This group is responsible for designing, applying, and ordering tools; preparing operation sheets for Semi-Production Parts; and providing assistance to the machine shop.

(b) Production Control

This group is responsible for ordering and inventory control of tools and gages. They are also responsible for machine shop scheduling and work-in-process control.

(c) Semi-Production Machining Machine Shop

This shop manufactures machined details and performs machining operations on welded assemblies.

(2) Semi-Production Sheet Metal Shop

The Semi-Production Sheet Metal Shop performs sheet metal forming and welding operations on initial production engine parts. The Semi-Production Sheet Metal Shop is organized into three sections; Process Engineering, Production Control, and a Sheet Metal and Welding Shop, all of which operate substantially the same as the corresponding sections in Semi-Production Machining.

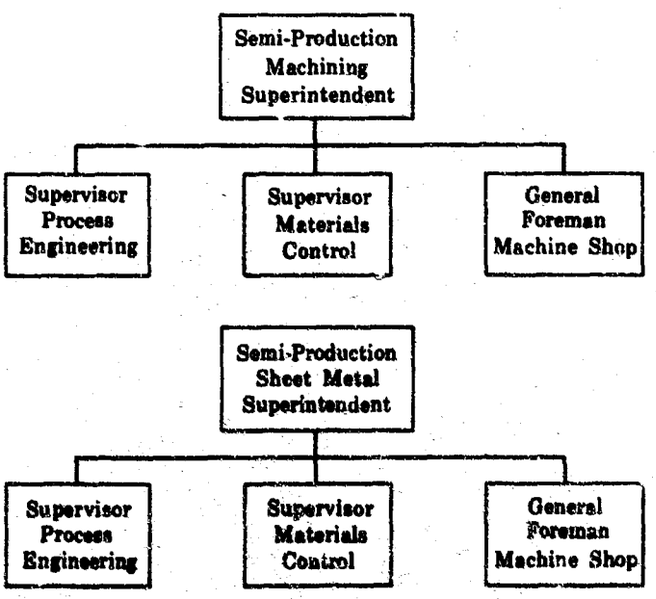


Figure 16. Semi-Production Organization FD 17586 VG

f. Branch Plants

Branch Plants at Southington, North Haven, and Middletown are feeder plants that support the East Hartford machine shop and assembly floor. Each branch plant, typically organized as shown in figure 17, consists of a machine shop, a materials control department, a master mechanic, a plant engineer, and a Process Engineering Group. Each functions in the same manner as corresponding departments in the East Hartford Plant.

The North Haven machine shop is divided into three manufacturing areas, while the Southington and Middletown Shops have one area each.

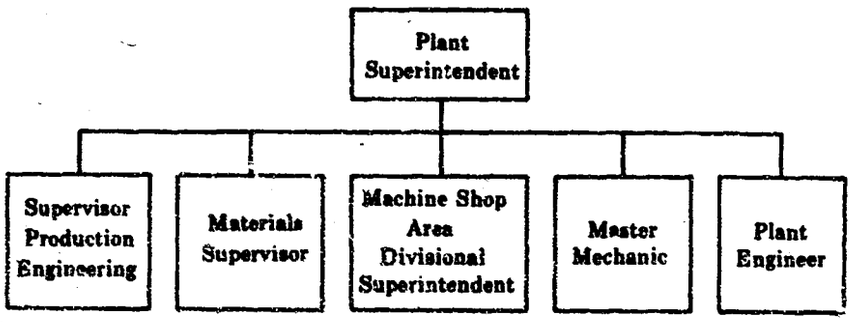


Figure 17. Typical Branch Plant Organization FD 17587 VG

g. Master Mechanic

The master mechanic, reporting to the Factory Manager, is responsible for a department organized into eight sections that perform the following support and service activities (figure 18):

(1) Machines and Tool Service Supplies

The Machine and Tool Service Supplies Department is responsible for servicing machine tools and equipment with coolants, compounds, cleaning fluids, and lubricants and for periodic inspection thereof.

(2) Machine Preventive Maintenance and Repair

The Machine Repair Group is responsible for preventive maintenance and repair and overhaul of all machine tools.

(3) Tool Room

The Tool Room manufactures, modifies, and maintains special tools, jigs and fixtures for the Machine Shop and Semi-Production.

(4) Die Room

The Die Room manufactures, modifies, and repairs the majority of dies required by the Machine Shop and Semi-Production. They also manufacture master contour models and patterns together with checking fixtures for use by manufacturing subcontractors.

(5) Gage Room

The Gage Room manufactures, modifies, and repairs gages for the Machine Shop, Quality Assurance Department and Assembly Floor.

(6) Tool and Gage Inspection

Tool and Gage Inspection is responsible for: (1) dimensional inspection of new or altered tools and gages, (2) inspection of the first piece produced from new or altered tools and dies, (3) periodic inspection and calibration of Machine Shop and Assembly and Test Gages, (4) operation of a constant temperature metrology laboratory for precision measurement of standard gages that are traceable to the National Bureau of Standards, and (5) periodic inspection and layout of machine shop work in process.

(7) Cutter Grind

The Cutter Grind Department is responsible for maintenance and repair of reserviceable tools.

(8) Planning and Data Collection Office

The Planning and Data Collection Office is responsible for collecting data to maintain data processing programs for work control and scheduling of the Master Mechanics Department.

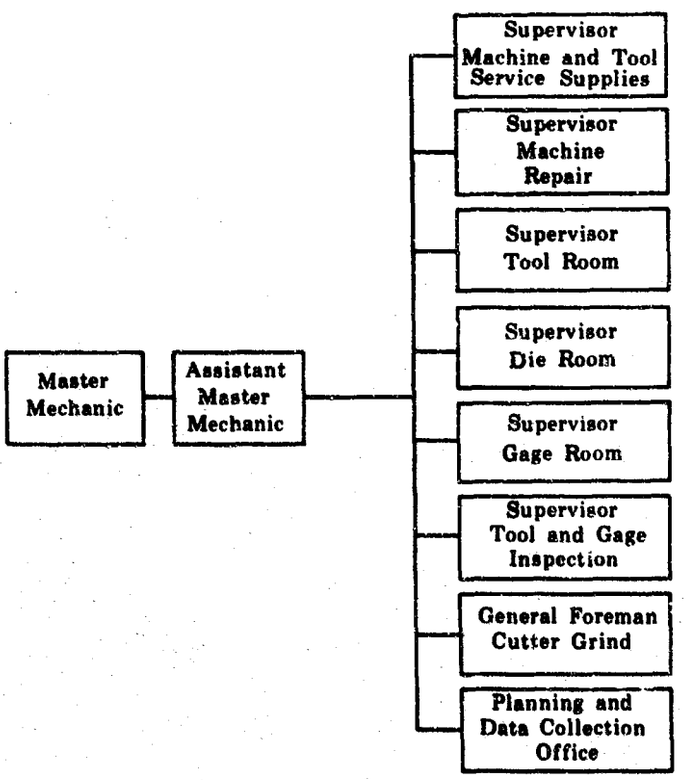


Figure 18. Master Mechanics Organization FD 17588 VG

h. Plant Engineering

The Plant Engineer, reporting to the Factory Manager, is responsible for maintenance, repair and construction of plant and facilities. The Plant Engineering Department is divided into six sections, as shown in figure 19. They are responsible for plant rearrangement and modification projects including installation of machines and equipment, test cell modifications, and corresponding electrical, fuel and utility systems modifications.

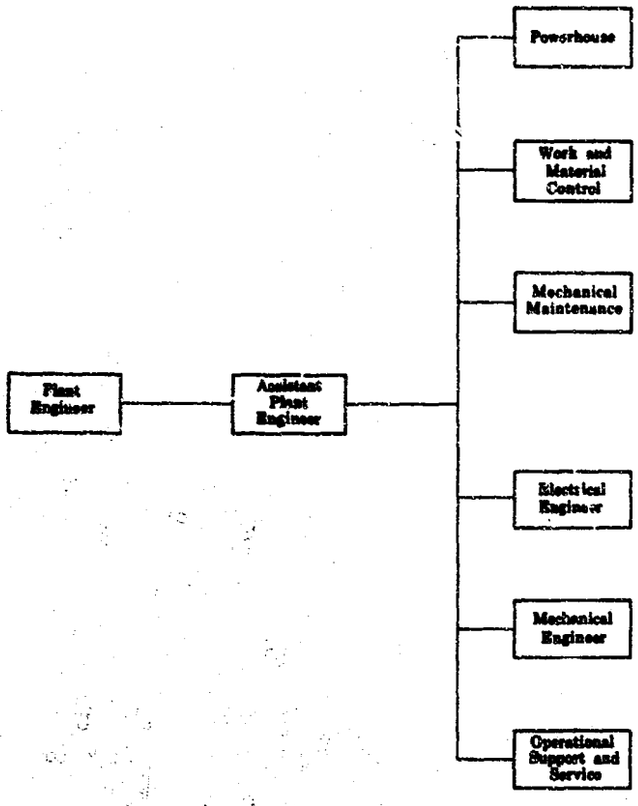


Figure 19. Plant Engineering Organization FD 17589 VG

SECTION V
PRODUCTION CONTROL, MATERIALS CONTROL AND PROCUREMENT

The development of an aircraft engine is characterized by frequent design changes and limited quantities of parts subject to changing schedule requirements. Pratt & Whitney Aircraft Management, recognizing that proper communications and coordination are vital in meeting these characteristics, has developed a unique production control system. The following paragraphs describe the FRDC and Connecticut production control; materials control and procurement functions; and systems, procedures, and methods of control from Phase III through Phase V.

A. PRODUCTION CONTROL AT FRDC (PHASES III, IV, AND V)

Project Material Control (for development hardware) and Delivery Material Control (for prototype and product support hardware) are responsible for establishing parts quantities and schedules and coordinating manufacturing and procurement activities to assure the availability of quality parts -- most economically and on schedule -- in accordance with Engineering Order Supplements and Delivery Order Supplements issued by the JTF17 Program Manager.

They issue directives to the Purchasing and Materials Departments to meet these goals. Responsibilities and functions of Project Material Control and Delivery Material Control are identical, as discussed below. Differences will be indicated where procedures or methods of control differ between development and delivery systems. (See figure 20 for work flow and figure 21 for data flow.)

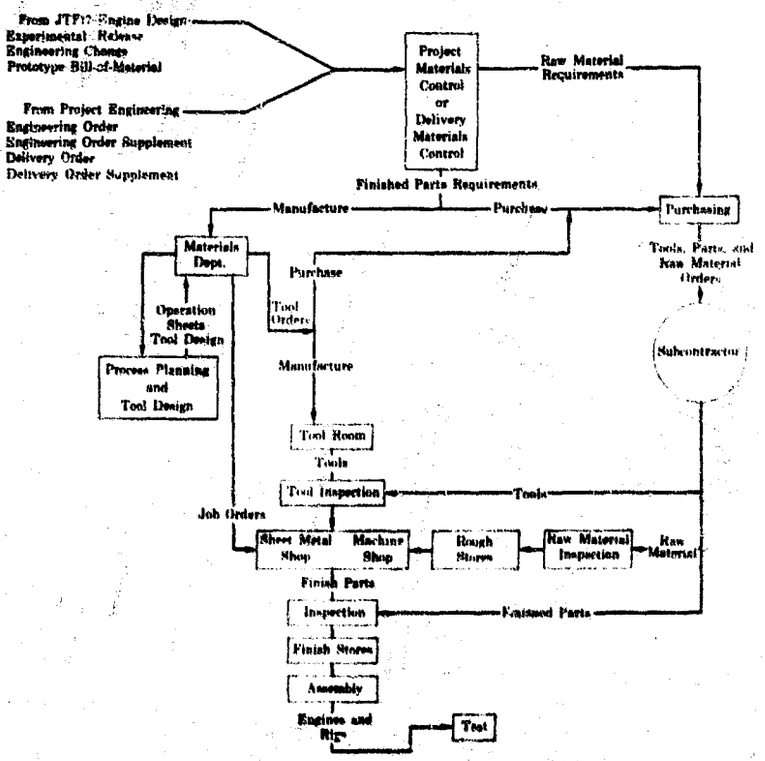


Figure 20. FRDC Manufacturing Flow Chart for Development, Prototype and Overhaul Hardware FD 17590 VG

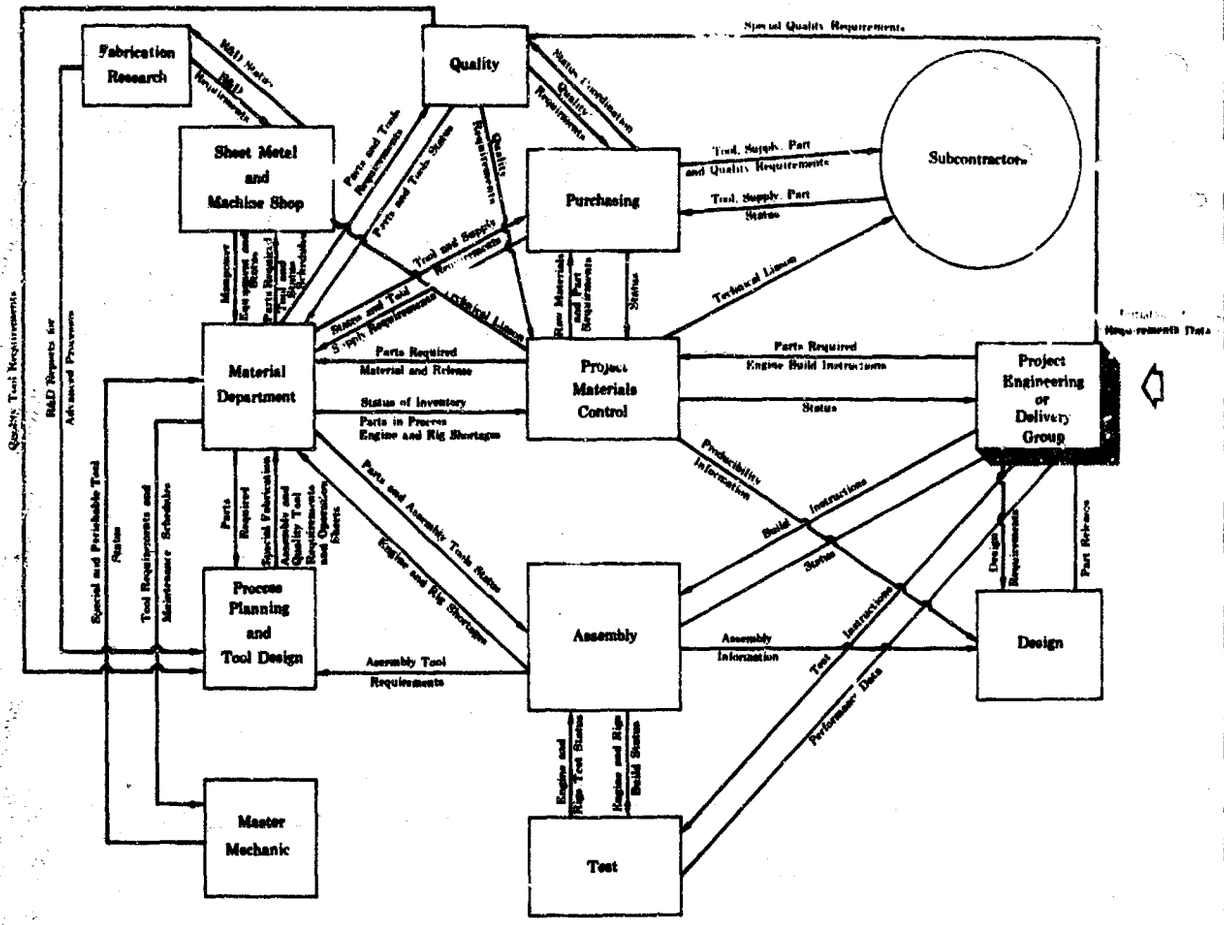


Figure 21. Data Flow for Manufacturing Department - FRDC FD 17591 VG

1. Functions

Project Material Control and Delivery Material Control are project-organized and perform the functions of:

1. Ordering and scheduling of all development, prototype, and product-support assemblies, sub-assemblies, details, and raw materials
2. Directing "Make-Buy" decisions
3. Issuing of status reports on the progress of all parts towards meeting the schedules and milestones
4. Incorporating Engineering Changes
5. Documenting the engine configuration (i.e., maintaining individual engine bills of materials)
6. Serving as manufacturing value engineers
7. Coordinating producibility studies and recommending actions
8. Conducting technical liaison with subcontractors and FRDC shops.

2. Operations

a. Ordering and Scheduling

(1) Development

JTF17 Project Engineering authorizes all development product procurement by issuance of an Engineering Order Supplement that defines the task to be accomplished and specifies the hardware requirements. These parts, if a new design, are released from Design to Project Material Control on an Experimental Release. The Experimental Release will restate the required quantity of parts and the requested delivery date for proper integration into the development test program. The Project Material Control Engineer, from previous experience, and after discussing the task with purchasing and/or shop representatives, may confirm the Project Engineer's requested delivery schedule or may arrive at a revised schedule with the Project Engineer.

In reaching the decision for a required schedule, the Project Material Control Engineer considers raw material and tooling availability, part complexity, previous experience with similar parts, and shop loading. Project Material Control personnel determine the raw material necessary for each part and write requirement cards for all details, subassemblies, and assemblies to be manufactured.

(2) Prototype and Product Support

Hardware requirements are issued as Bills of Material from Design for the prototype engines and on Delivery Order Supplements from Spare Parts Sales for overhaul engines. Delivery Material Control personnel schedule the hardware deliveries to provide adequate lead time prior to prototype engine builds or before delivery dates specified on the Delivery Order Supplement.

b. Manufacture or Purchase Decision

The requirement cards for detail parts and minor assemblies are submitted daily to a panel made up of representatives from Purchasing, Project Material Control, Process Engineering, Tool Design and Quality Assurance chairmanned by the Supervisor of the Materials Department. This panel has in its possession all of the information relative to raw material availability, equipment, quality requirements, work in process, current and future availability of manpower, priorities, tooling and previous source(s) and cost history on the same or similar parts. On the basis of all of this information and considering the required date for the part or parts, a "manufacture or purchase" recommendation is established by the chairman and submitted to the Project Material Control Engineer for approval. Once this decision has been made, Project Material Control releases the requirement card to the Materials Department for manufacture or, for parts designated "purchase," issues Requests for Purchase Order (RPO). Prints and specifications are sent by Purchasing to the appropriate subcontractors for quote and comment. Before the order is placed on the basis of these competitive quotes the subcontractor's promised delivery schedule must be satisfactory to the JTF17 Project Material Control Supervisor. If unsatisfactory, further negotiations are carried on or the decision to "purchase"

the part may be reversed and the item made in-house. Quality requirements are a part of the Shop Work Order or Purchase Order.

For procedures employed in manufacture or purchase decisions on major parts and assemblies, see Volume V, Report E. Subcontracting Program. For procurement of fuel controls, hydraulic, and ignition system components, see Volume III, Report B, Engine Design Report.

c. Status Reporting

(1) Development

Progress on subcontracted parts and all work in process is closely monitored by Purchasing and the Materials Department regarding the dates requested for each part. If a date slippage becomes apparent, a change of delivery date notice is sent to Project Material Control. The Project Material Control Engineer issues weekly status reports and holds regularly scheduled meetings to review delivery dates on all major parts or programs and takes steps to bring these late parts back into schedule or to inform Project Engineering of schedule slippages so that test plans may be revised. For configurations involving relatively few parts, this personalized service of status reporting proves more responsive. In cases where a complete development engine is to be built initially, a computer program of reporting status has proved to be more useful. Either approach, or a combinati , can be used on any program as requested by the JTF17 Project Material Control Engineer.

(2) Prototype and Product Support

The Requirements Section of Delivery Material Control is responsible for issuing an individual Bill of Material for each prototype engine which is updated as Engineering Changes are issued. Spare Parts Sales issues revisions by Delivery Order Supplements to specify Engineering Change Requirements. The Requirements Section of Delivery Material Control will maintain an updated master file of all Delivery Order Supplement Requirements. Computer print-outs of parts status will be run bi-monthly collating the Bill of Material or the master file. Progress of the JTF17 prototype engine parts will be continuously monitored by the Delivery Materials Control Supervisor and his organization using PERT and weekly status raports generated by the Delivery Materials Control Requirements Section. These reports will be distributed to supervisory personnel in the Engineering, Purchasing and Manufacturing Departments and will identify overdue conditions as they occur so that effective corrective action can be taken to restore the program to schedule.

d. Engineering Changes

(1) Development

The Project Material Control organization effects incorporation of Engineering Changes rapidly, a necessary requirement in the engine development program. Changes are released from Design on an Experimental Release with incorporation instructions. Most of the changes have been previously discussed between the Project Engineer and Project Material Control Engineer,

the status of the work in process determined and "hold" instructions issued if necessary. Revised drawings are issued to Purchasing on an RPO Supplement Order and to the Materials Department on a Change in Shop Work Order. When engine testing shows that a configuration should be completely changed, this close liaison between Project Engineering and Project Material Control enables all parts in process to be stopped immediately. Hardware obsolescence is thus held to a minimum.

(2) Prototype

Engineering Changes will be introduced by the JTF17 Project Engineering Group and will be expedited through regularly scheduled meetings with the JTF17 Delivery Material Control Supervisor and representatives of the Materials Department, Process Planning and Purchasing. These change conferences will review part prints of the new or altered parts, consider the impact on raw material schedule requirements, and, if necessary, determine the manufacturing sources. The Delivery Material Control Supervisor will be responsible for designating the incorporation date for each Engineering Change and the Requirements Group Supervisor of DMC will be responsible for incorporation of all Engineering Changes into the Master Bill of Material.

e. Engine Configuration Control

(1) Development

Project Material Control is also responsible, from the broad direction of Project Engineering, for issuing the engine or engine sections parts lists to the assembly floor in order that a specific engine or rig may be built to the configuration desired by Engineering.

(2) Prototype and Product Support

The Bill of Material kept by the Requirements Section of Delivery Material Control serves as the assembly floor build parts list for prototype engines.

The Service Department specifies to the Requirements Section of Delivery Material Control the Engineering Changes and Service Bulletins to be incorporated in each engine being returned for overhaul and will supply a parts list of the engine configuration. Preliminary engine parts shortages can be issued for each engine prior to receipt at FRDC, thus reducing the overhaul cycle. Complete shortage information will be obtained after teardown and disposition of the parts made by the Service Department and Quality Review personnel.

f. Value Engineering

The Project Material Control or Delivery Material Control Engineer with the assistance of qualified personnel is responsible for Value Engineering on development and prototype parts respectively. Being aware of schedule requirements for development parts he is able to reach decisions regarding omission of machining operations or substitutions of more easily obtained or less costly material (Material Substitution Request) when less

critical engine testing is involved. For prototype or development parts he specifies the degree of tooling or stops costly premium effort when a closely-held schedule is no longer necessary. He is also responsible for examining the merit of cost saving suggestions by subcontractors and submitting a Request for Change in Design if necessary.

5. Producibility

The Project Material Control Engineer through his close contacts with Design, Manufacturing and subcontractors is responsible for acceptance of the engine design regarding producibility. He is also responsible for recognizing and resolving fabrication or dimensional problems that are not part of the "learning curve".

6. Technical Liaison

The Project Material Control Engineer is responsible for resolution of fabrication and material problems at subcontractors' plants and in FRDC shops, or proposing alternate solutions in order that delivery schedules may be met.

B. MATERIALS CONTROL AT FRDC

The Material Department has two basic functional operations; (1) Scheduling and Expediting and (2) Product and Non-Product Stores.

1. Scheduling and Expediting

Upon receipt of an order for the manufacture of engine parts from Project Material Control, the Scheduling and Expediting section of the Material Department generates a detailed manufacturing chedule for material, tools, details, parts, subassemblies, and assemblies in accordance with the basic engine assembly requirement. For major parts, these details are presented in PERT type networks. Shop Work Order are prepared for each requirement and assigned to expediters within the section who:

1. Release orders to Manufacturing in accordance with schedules
2. Coordinate all tooling requirements for each order through the Process Planning and Tool Design Groups (Refer to Section X.)
3. Release tooling orders for in-house manufacture or procurement
4. Requisition all raw material, details, and subassemblies required for each order
5. Expedite orders throughout the course of manufacture, inspection, and assembly
6. Evaluate the status of all orders in process and assign priorities to maintain schedules or recommend alternate or varied sequences or production processes

7. Report status of all orders in process and advise Project Material Control of schedule problems arising from deviations, scrap, engineering change, machine breakdown, or other factors affecting schedule

8. Deliver parts or tools to the proper storeroom upon completion.

This section also maintains constant surveillance of all work in process, controls all work on a job-order basis, and maintains perpetual work in-process inventory control through a computer program designed to define the status, location, and quantity of all work from origination to incorporation in material inventories. Work in-process is physically verified on a daily basis.

2. Stores

Stores is charged with the responsibility for activities involving the receipt, checking, marking, packaging, storing, issuing, and recording of raw material, finished parts, subassemblies, and assemblies required for engines. Parts received in Stores in a finished or semifinished condition or either (1) manufactured in FRDC Experimental Shops, (2) procured from a subcontractor, or (3) procured from other divisions of UAC.

Upon receipt, Stores produces a stock record card for all raw material or finished parts and publishes an inventory for use by Project Material Control, Materials Department, Engineering, and Assembly. Stores packages, identifies, and stores all materials in accordance with specifications to permit ready identification and eliminate the possibility of physical or chemical damage.

All materials stored by the storerooms must be released by properly authorized paperwork containing sufficient information to determine the ultimate destination. Physical inventories are performed monthly within all storerooms, insuring (1) inventory accuracy, (2) compliance with storage requirements, and (3) proper segregation (accountability).

C. PRODUCTION CONTROL, CONNECTICUT OPERATIONS (SEE FIGURE 22 FOR WORK FLOW)

The production control organization for the JTF17 program will be as shown in figure 23. The JTF17 production manager will have overall responsibility for meeting scheduled requirements for engines and spare parts.

1. Ordering and Scheduling

The ordering function is performed by the Requirements and Parts Control Groups of the Materials Department. The following operations are performed in the ordering of requirements:

1. Engine orders, spare parts orders, Service Stores Requisitions, and other sources of production requirements are received by the Materials Department.

2. Orders for engines are converted into gross requirements for all levels of assembly, subassembly, and detail parts by the Parts Control Group.

3. Orders for spare parts are exploded into gross requirements for all levels of assembly, subassembly, and detail parts by the Requirements Group.

4. The Requirements Group compares gross requirements for engine and spare parts to quantities on order and determines net ordering requirements for raw material, purchased parts, and shop-made parts

5. Where part requirements exceed the amount of orders placed for raw material or purchased parts, the Requirements Group issues a Request for Purchase Order (RPO) for the net requirement. Requirements are scheduled by the appropriate lead time.

6. Where part requirements exceed the amount of orders placed for shop-made parts, the Requirements Group issues a shop release for the net requirement. Requirements are scheduled by the appropriate lead time.

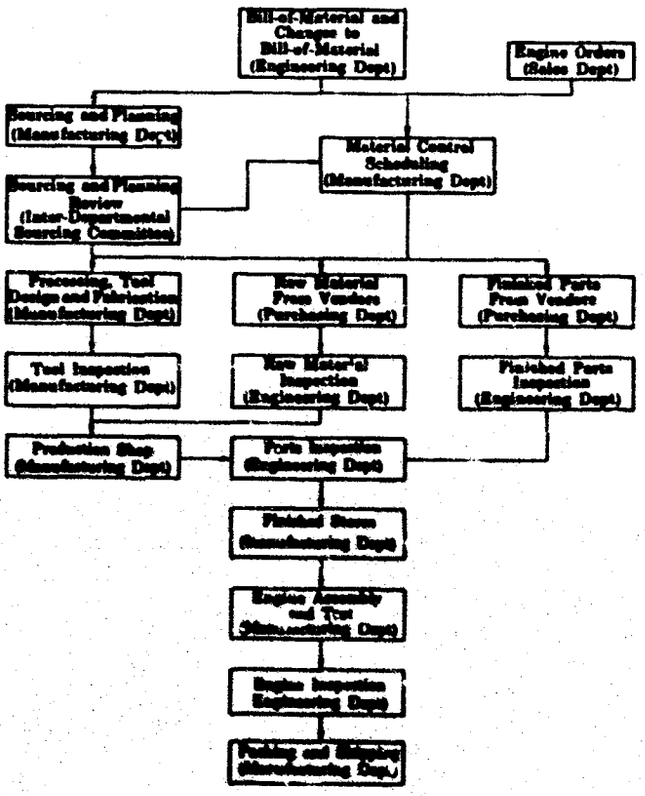


Figure 22. Manufacturing Flow Chart FD 17592 VG

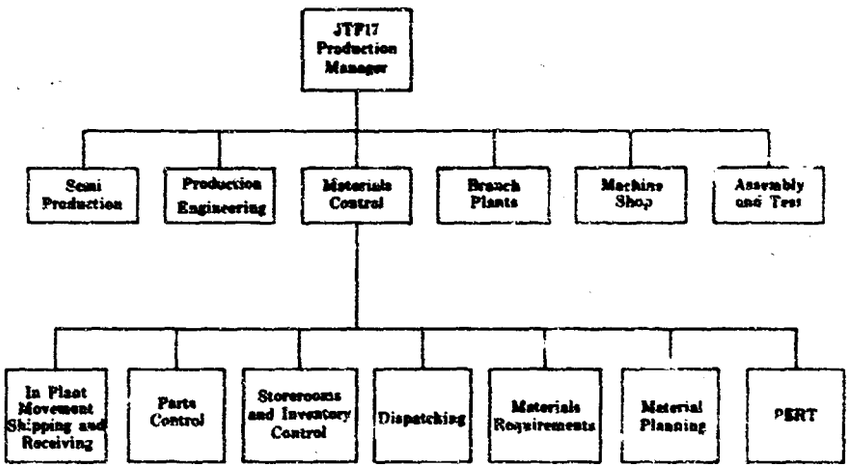


Figure 23. Connecticut Production Control Organization

FD 17593
VG

2. Application of Electronic Data Processing Techniques

Materials Accounting issues a weekly-updated schedule that has significantly reduced the lead time required to generate net requirement schedules. The weekly updating of requirements is important because more than 1800 schedule changes per week presently affect production requirements. Engineering Design Changes, source changes, raw material changes, lead time changes, and changes in scheduled quantities all affect the requirements schedule. The use of RAMAC files for the storage of schedule information can allow the incorporation of last-minute changes into the schedule.

3. Release of Orders

Shop Orders that are issued by the Requirements Group are forwarded to the Parts Control Group of the Materials Department. The Parts Control Group, guided by the Raw Material Release Schedule, releases raw material to the production departments for the beginning of engine part manufacturing. The proper timing of shop releases has an important bearing on the size of inventories, the availability of parts, and the overall economy of the shop operations. A data processing program analyzes scheduled requirements, set-up costs, and inventory carrying costs and then calculates the economic production lot sizes for the majority of detail parts to be produced.

4. Progress Reporting

The following sources of information are available to alert Production Control management to areas where actual progress is behind planned production:

a. Shortage Lists

(1) The Net Shop Parts Delivery Schedule

This schedule shows net monthly requirements for Pratt & Whitney Aircraft manufactured parts. The schedule is updated weekly to ensure timely information. Parts that have not been delivered on schedule are listed.

( ) The Net Purchase Parts Delivery Schedule

This listing provides the schedule of monthly purchased parts delivery requirements and also lists parts that have not been delivered on schedule.

(3) The Raw Material Delivery Schedule

This schedule designates the additional quantities of raw material required to satisfy production needs.

(4) The Raw Material Release Schedule

This schedule designates the quantities of raw material to be released from inventory for use in production.

(5) The 5-Day Shortage Report

Lists of net part requirements for assembly of engines in the following 5-day period are issued daily. These lists contain information on the status of the required parts.

(6) The 30-Day Shortage Report

Lists of net part requirements for the assembly of engines in the following 4-week period are issued semi-weekly.

b. PERT System Control

The PERT group is responsible for establishing PERT networks used to control the initial production of the JTF17 engines. The production networks include a high level of detail covering the provision of tooling, the development of operation sheets, the procurement of raw material, and the manufacture of engine parts and assemblies. Weekly reports are issued to indicate the potential trouble areas identified by PERT analysis. Line of balance analysis is used to follow new programs beyond the delivery of the first engine and through the initial months of production.

c. Special Parts Control

The Production Manager's staff will maintain special surveillance of critical production parts and assemblies following the end of PERT and Line of Balance reporting. On these items, close followup and control of promised delivery dates provide the basis for spotting trouble areas before the difficulties result in overdue parts.

D. MATERIAL CONTROL, CONNECTICUT OPERATIONS (SEE FIGURE 24 FOR WORK FLOW)

1. Dispatching

The Dispatching Group is responsible for controlling the flow of material through the production areas from raw material stores to finish part stores. Dispatching maintains control of work in process to ensure that material not only is started into production at the proper time, but also is processed through the required series of operations at a rate which will ensure the delivery of finished parts at the scheduled time and in a manner that will provide for efficient utilization of production resources.

2. Engineering Change Control

The Material Planning Group of the Materials Department is responsible for the integration of Engineering Change Designs into the flow of material through the Manufacturing Department. The Materials Planning Group reviews all Engineering Changes, determines their impact on material inventories, and schedules the time of change incorporation. This group ensures that requirements for superseded parts are cancelled, new parts reordered, and that raw material requirements are adjusted in accordance with the instructions on the Engineering Change.

3. Work in Process Information

Work in process control systems in each of the detail manufacturing areas maintain current information on the location of material in production. These systems utilize electronic data collection equipment to record the completion of each operation on each lot of work in process. Data processing techniques are used extensively throughout the production control information system in order to permit the whole system to react to changing requirements. Figure 24 shows the flow of requirements information through the scheduling system into the work-in-process control system, thus generating reports for the use of Dispatching such as:

1. Foreman's Priority Report, issued daily
2. Performance Reports, issued weekly
3. Machine Load Forecast, issued weekly
4. Raw Material Shortage, issued weekly
5. Work in Process Inventory Status, issued daily.

4. In-Plant Traffic, Shipping, and Receiving

Movement of materials throughout the plant is directed by a Movement Control Center. The Materials Department also controls the receipt of material into the plants and the shipment of parts and material to other locations. Complete records of material movements are maintained as part of the company-wide material control system.

5. Materials Stores

The Materials Stores Group is responsible for the storage of raw material and finished parts. Another function of this group is the packaging and preservation of spare parts. The Inventory Group takes periodic inventories of raw material, work-in-process, and finished parts to reconcile inventory records with material on hand.

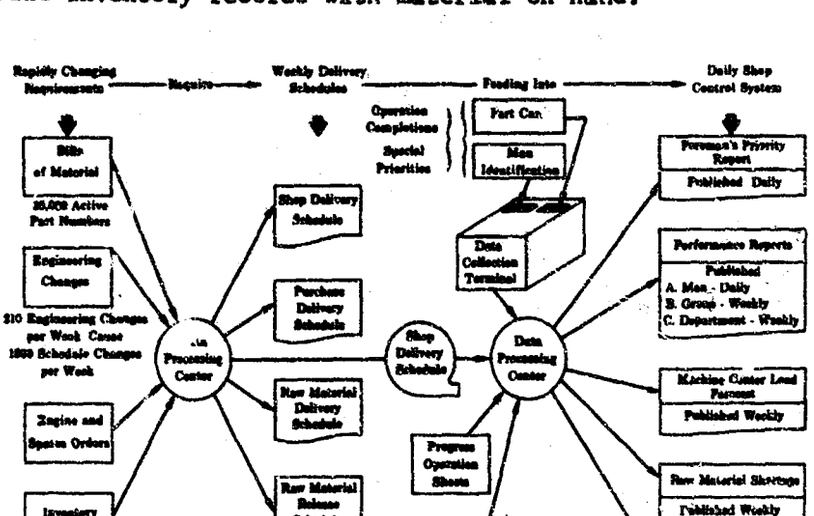


Figure 24. Manufacturing Department Material Control System FD 17594 VG

E. PROCUREMENT, FRDC AND CONNECTICUT OPERATIONS

The Pratt & Whitney Aircraft Purchasing Department is responsible for on-schedule delivery of quality subcontractor hardware at a reasonable cost. A detailed description of procurement procedures is included in Report E.

SECTION VI
PLANS FOR MEETING MANUFACTURING MILESTONES

A. DEVELOPMENT

1. Design Information and Parts Manufacture

To implement construction of the first development engine in Phase III preliminary engine layouts have been reviewed. From this review and experience in manufacturing the similar demonstrator (Phase II-C) engines, long lead time material weight and ingot size requirements have been determined. Make-buy decisions for major parts have been made where demonstrator engine tooling exists and may be used as-is or converted in whole or in part. (See table 1.) Quantities of major parts required for new development engines and test support have been estimated through 1969 and shop loading figures have been completed by considering all programed manhours for major parts for all development engines and rigs with allowances, supported by experience, for manhours for minor parts, alternate designs, engineering changes, and parts reoperations following engine test. Schedules have been established for both "make" and "buy" major parts for final raw material requirements releases, layouts, and design releases for the fourth development engine. (See figure 2.)

Tooling studies by Process Planning and Tool Design will start from preliminary parts layouts by 1 October 1966, as will subcontractor coordination. Producibility studies have begun and will continue through design release. Upon release of major parts, the Materials Department will prepare PERT networks and Process Planning will complete operation sheets to be followed by Tool Design. PERT charts show required dates for raw materials, tools, details, subassemblies and final assembly, and machining. The engine assembly has been sequenced, with required time of parts availability. (See figure 25.) This will be updated as required.

2. Manpower, Training, and Hiring (See Volume V, Report J, Resources)

Manpower requirements have been forecast in all departments for this program and others. Where additional employees will be required, it has been determined that such growth is entirely feasible. Though forecasted expansion in the number of skilled hourly personnel is not great, very recent hiring experience strengthens P&WA's position relative to training new employees in P&WA schools. Approximately 75 to 80% of the skilled hourly employees added for expansion and to offset attrition will be trained at FRDC. Existing training facilities will be increased in 1967 to attain the required output.

The manufacturing shops, starting with 725 skilled mechanics and machinists at the end of 1966, will employ 825 by the end of 1967 and 900 by the close of 1968 and through 1969, when FRDC's SST manufacturing program will peak. The plan to hire 20 to 25% of this increase is supported by the recent hiring experience from September 1965 to April 1966 for shop expansion.

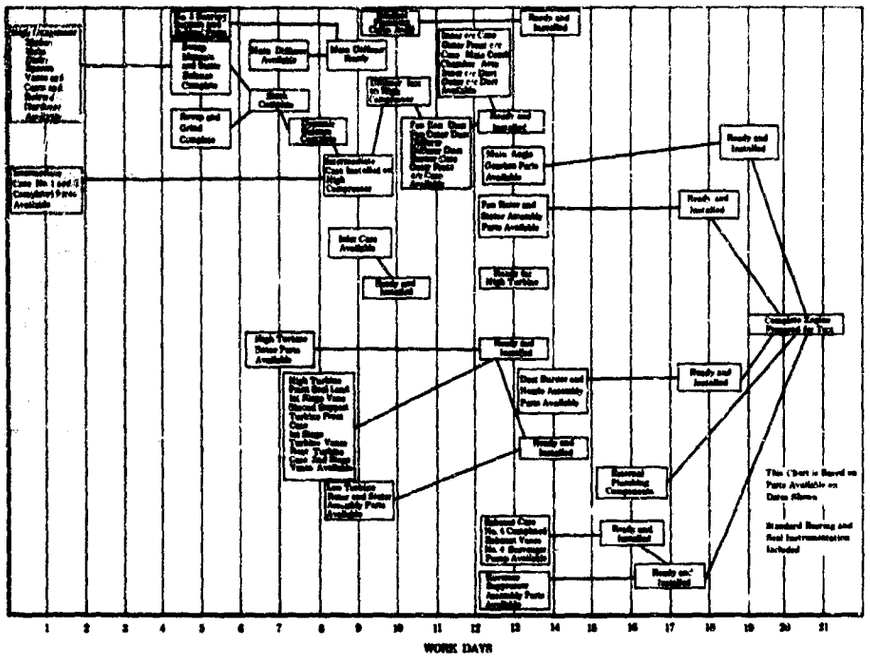


Figure 25. JTF17 Assembly Lead Times-Initial Build of Typical Development Engine FD 17597 VG

The Assembly Department will expand from the 1966 level of approximately 240 mechanics to 250 in 1967, 290 in 1968, and 350 in 1969. These employees will satisfy the requirements of all development programs and delivery of four ground test engines and mockups.

The Quality Assurance Department will require 10% growth, an addition of 25 employees, by January 1968. This represents the peak development effort.

The number of development test mechanics and operators will increase by approximately 200 employees.

3. Facilities (See Volume V, Report B, Facilities Plan)

Existing facilities have been examined completely for additional capacities or capabilities required by the addition of the engine design and test plan requirements of the SST program to other development programs. Studies have progressed sufficiently to allow determination of extent, location, and basic construction of building additions. Architectural and Engineering work is expected to start by late 1966 and be completed by early 1967. Actual construction will have been completed by early 1968.

All additional (or modifications of existing) test stands have been specified, and detailed schedules for design, equipment procurement, build, and checkout have been established as shown in Volume V, Report B.

Requirements for additional machine tools to increase capacity have been established. Where specifications are required, these have been completed. Coordination with machine tool manufacturers of specifications, accessories, prices, and deliveries has been accomplished. The first year of the Phase III Development Test Plan specifies a buildup to six engines; this will not overtax existing facilities with the planned make-buy ratios. Additional capacity will be required in 1968 when the Test Plan calls for 12 active engines. Quoted machine tool deliveries will be compatible with program buildup.

4. Organization

Basic changes in organization as a result of SST development are not necessary within Manufacturing, Test, and Quality Assurance.

B. PRE-FTS AND PROTOTYPE DELIVERY

1. Design Information and Parts Manufacture

The manufacturing lead time for the four pre-FTS engines in April and May of 1969, and for the prototypes in the last half of 1969, has been calculated to be approximately 15 months after the release of the bill of materials. Schedules have been established for raw material procurement, manufacturing studies including operation sheets and tool designs, major parts procurement from subcontractors, tool procurement, parts manufacutre, inspection, engine assembly, and test. (See figure 3.) For the engine build and test cycle, see figure 26.

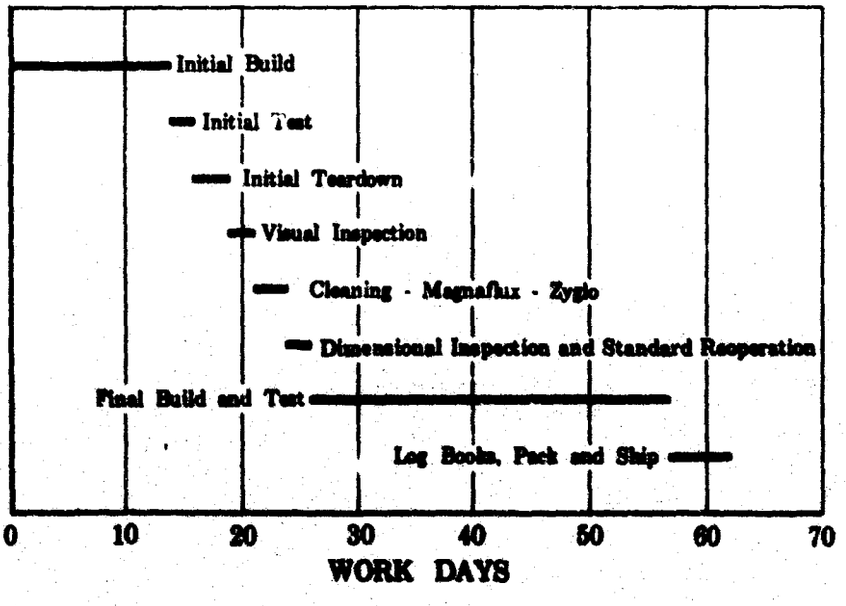


Figure 26. Prototype JTF17 Build Cycle FD 17595
VG

2. Manpower (See Volume V, Report J (Resources).)

Plans have been completed for the manpower expansion necessary to implement delivery of the pre-FTS and prototype engines. These plans cover skills, numbers of employees, and methods of recruiting employees. A new department for the SST program, Delivery Materials Control, will required 25 employees, with a nucleus being drawn from Project Materials Control (Development) and the others hired and trained. Assembly will require 100 additional employees, to be produced by P&WA's training organization, by 1969. Quality Assurance will acquire 130 new employees by January, 1969, and Test will add one crew of twelve test mechanics.

3. Facilities (See Volume V, Report B.)

A new department for the SST program, Jet Engine Delivery Assembly, will be operational by 1 January 1969, with the actual space being available by mid-1968 at the latest. All equipment for this facility has been specified, and procurement and installation lead times should present no problems. Two sea level test stands will become available, one in 1968 and one in 1969, for FRDC delivery items and product support.

4. Organization

Planned additions to the existing organization are the Delivery Materials Control Department and Jet Engine Delivery Assembly. The structures of these two departments are planned to be the same as those of departments in existence for Rocket Engine Delivery. All existing delivery procedures are available for use by the new departments. Delivery Materials Control will be organized in December, 1967 and fully manned by April, 1968. Jet Engine Delivery Assembly will begin organization in September, 1968 and be fully operational by January, 1969. Quality Assurance and Test are presently organized to accomplish the delivery tasks.

C. PRODUCT SUPPORT AT FRDC

1. Planned Turnaround Cycle (See figure 27.)

2. Manpower

From the estimated number of engine overhauls (including pre-FTS conversions to prototypes) and experience in other jet engine programs, the manpower requirements have been determined for Assembly and Quality Assurance. These requirements are included in the figures given for the delivery task since Delivery and Product Support activities overlap. The employees added in the Test and Delivery Materials Control Department for the pre-FTS and prototype engine deliveries will also be responsible for Product Support activities.

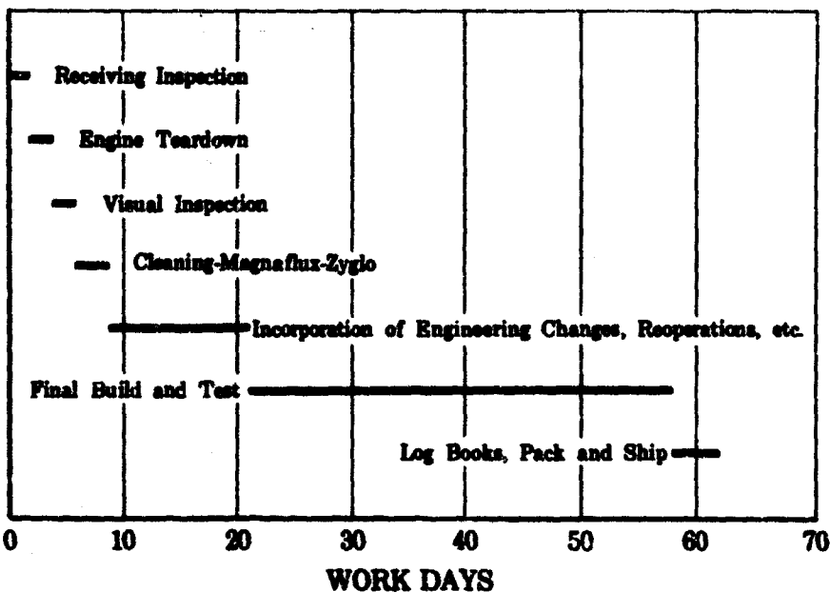


Figure 27. Typical Overhaul Cycle for JTF17 Prototype or Production Engines at FRDC — FD 17596 VG

3. Facilities (See Volume V, Report B.)

The assembly and test facilities planned for delivery of pre-FTS and prototype engines satisfy the requirements of the Product Support task. To increase capacity for incorporation of changes and for part repairs, it is planned to add 18 machine tools to the Construction Shops. Since first need will be in September 1969, there will be more than adequate time for procurement and installation. All machine tool vendors are now being contacted for costs, procurement times, and special specifications and accessories.

4. Organization

No organizational changes are planned beyond those already made for the pre-FTS and prototype engine delivery assignment.

D. PRODUCTION - PHASE V

1. Design Information and Manufacturing Planning

The production bill of materials will be released approximately two years prior to the first engine delivery. Planning, including final producibility studies and resulting changes, is shown in figure 4.

During the first stages of manufacturing for a production engine program, the production departments frequently require assistance from other departments because of the problems inherent in the initial production of parts and because of changes in design causing short lead times. The semi-production departments in East Hartford (Department 96, Machining, and Department 97, Sheet Metal) are organized for small lot

production of parts using a minimum of tooling. These departments will temporarily assume the responsibility for performing operations on problem parts. The second source of assistance will be FRDC Manufacturing and the subcontractors who have been making parts for the prototype engines. The overlap in the timing of the prototype, overhaul, and production engine programs will enable FRDC to assist in the early stages of the production engine program. As required, the tooling and experience developed for the prototype engine production will be utilized to assist the production departments.

Preliminary planning for JTF17 engine production extends several years ahead of the formal release of the production bill of material to the Manufacturing Department. Preliminary planning of manufacturing processes has been completed on a detailed level to develop time estimates and to guide the selection of sources. Master planning summaries of operations have been developed for a majority of potential shop-sourced parts. An analysis of manufacturing lead times for the major case assemblies has been conducted by the PERT Group.

2. Manpower (See Volume V, Report J (Resources).)

The manpower required by forecasted engine delivery schedules will be available. Engine assembly mechanics from the Connecticut operations will be trained by the FRDC during the delivery of prototype engines.

3. Organization

Basic changes are not required. A Production Program Manager will be appointed approximately two years prior to the first engine delivery.

4. Facilities (See Volume V, Report B.)

Additional facilities beyond test stand modification are not required.

SECTION VII
PRODUCIBILITY

A. GENERAL

A producible design requires a cooperative effort by Manufacturing, Engineering, Design, and Quality Assurance to assure a constant surveillance of design; application of optimum manufacturing methods, process development, and refinement; and advantageous selection of materials.

The effort to create an engine design capable of being produced and adaptable to manufacture by available techniques, equipment, and tolerances begins early in the design stage. As first layouts progress, manufacturing representatives initiate design review; throughout the subsequent stages of development and prototype and initial production, continuous contact is maintained, and mechanical design and required manufacturing processes are jointly surveyed, by manufacturing and quality personnel.

The activities of the involved groups and areas of responsibilities are briefly discussed in the following paragraphs.

B. PRODUCIBILITY PRIOR TO DESIGN RELEASE

Basic Design philosophy permits the maximum tolerance possible in a part consistent with the functional requirement. However, to achieve maximum producibility, Design must have access to information about the weldability, machineability, formability, and forgeability of materials, as well as information on the utilization and flexibility of available equipment. Hardware is theoretically designed for maximum producibility at the eventual production source. Data regarding producibility of materials are always available to the designer, but the designer depends on the following agencies to supplement this information:

1. Project Materials Control

The JTF17 Project Materials Control Supervisor chairmans the development producibility team. Besides being responsible for the development and prototype Value Engineering input for the Manufacturing Department, the Materials Control Supervisor is also responsible for offering recommendations that will yield the best manufacturing possibility. Assisted by Purchasing, through direct subcontractor contact, and Process Planning Supervisors, the supervisor provides Design with knowledge of specialized vendor manufacturing techniques, material availability predictions mechanical design recommendations, and engine assembly techniques.

2. Quality Engineering

Producibility evaluation is part of the quality program, beginning with the development phase and continuing through all following phases. Quality Engineering reviews all layouts and determines if necessary nondestructive tests and dimensional inspections can be performed. Upon finding a problem resulting from the manner in which Engineering has specified dimensioning or processing, Quality Engineering requests a revision so that inspection may positively assure part compliance with the requirements.

3. Process Planning Engineering at the Florida Research and Development Center

A group of Senior Process Engineers, experienced in jet engine manufacturing techniques, has the responsibility for studying preliminary designs and offering mechanical design recommendations to permit production by available techniques. The recommendations of this group are based on manufacturing knowledge and experience averaging more than 25 years per man. These Senior Process Engineers report to Process Planning Supervisors who serve on the Producibility Committee coordinated by the Project Material Control Supervisor

4. Purchasing

Purchasing provides liaison to potential subcontractors for the items designated "buy" and solicits fabrication recommendations from these subcontractors, which are screened and weighed by Project Materials Control (PMC). PMC Engineers and Planning Engineers take field trips as required to survey vendor facilities, review methods, and weigh suggestions.

5. Production Engineering at Connecticut

The FRDC Value Engineering Group (see Volume IV, Report F, Section IV) forwards all drawings of proposed production engine components to Production Engineering in Connecticut to review for Value Engineering and producibility. Recommendations and comments are based on production quantity and manufacturing and fabrication techniques projected through the production period. Value Engineering forwards the recommendations to Design after review by the Design Analytical Group.

6. Project Engineering, Development Manager

Conflicts between the Producibility team and Design are resolved by the JTF17 Development Manager, who is responsible for final design. The Producibility team may suggest a temporary alternate course based on the difference between development and prototype requirements and production needs.

C. PRODUCIBILITY ACHIEVED AFTER DRAWING RELEASE

1. Quality Engineering

Quality Engineering prepares Quality Assurance Data Sheets and Inspection Methods Sheets after release of detailed drawings. If a problem is found while the sheets are being written, Quality Engineers initiate a drawing change request.

2. Project Materials Control

Fabrication problems may occur after release of orders to subcontractors and for in-house manufacture. PMC Engineers must separate problems which are part of the "learning curve" from those which affect producibility. Purchasing and Process Planning continually feed back information required to reach these decisions. When required, a request for change in design is processed to allow maximum part producibility.

3. Inspection

Experimental Inspection and Delivery Inspection refer inspection problems and nonconformances that are discovered during performance of an Inspection operation to Quality Engineering and Quality Review, respectively. Quality Engineering initiates a change request to the drawing or specification as needed. Quality Review investigates each deviation to determine the corrective action necessary to prevent recurrence and initiates a drawing or specification change request if necessary because of marginal producibility.

4. Production Engineering and Purchasing at Connecticut

Production Engineering prepares the operation sheets for parts manufactured inhouse. Purchasing solicits manufacturing suggestions for procured items. Design changes to facilitate manufacture are coordinated through the Engineering Liaison Representative, and if feasible, a drawing change is processed.

5. General Policy

Information on deviate shop-made material is reported to shop supervision, and information on such purchased material is forwarded to the subcontractor through Purchasing. Thus, process and equipment capabilities can be evaluated and correlated against recurring deviations.

D. PRODUCIBILITY - MATERIALS, PROCESSES, AND ADVANCED TECHNOLOGY

Substantiating information for these factors is contained in Volume III, Report F (Manufacturing Techniques and Materials).

E. PRODUCIBILITY - EQUIPMENT

1. FRDC and Subcontractors

A general description of the versatile manufacturing equipment in the FRDC shops is contained in Section IV. A complete list of manufacturing tools at the FRDC and at some of P&WA's commonly used subcontractors is contained in Volume V, Report B. Table 1 lists additional job shop equipment proposed to give the required development hardware producibility.

2. Connecticut Facility

Pratt & Whitney Aircraft has been active in the development of new concepts of machining tooling for those processes unique to the fabrication of gas turbine engine parts. Examples are center-drive lathes for simultaneously turning contours on both sides of turbine and compressor disks, vane stabbing machines to pierce through shrouds, special induction equipment for brazing fuel manifolds, three-wheel grinders for forming turbine blade tips, vacuum bag injection to bond fiberglass onto wear surfaces of shrouds and ducts, and a multi-spindle tape-controlled drilling machine to drill the complex hole pattern required in oil-cooled headers and baffles. Some of the more standard modern machines in regular use at Pratt & Whitney Aircraft are electron beam welders, five-axis numerical control machines, and electrochemical and electrical discharge milling machines.

Numerically controlled machine tools have been used in production at Pratt & Whitney Aircraft for eight years. In that time, the number of point-to-point and continuous path machines has increased to 148, with another 52 on order. Numerical control machines eliminate the need for elaborate jigs and fixtures, machine with excellent repeatability and consistent accuracy, lower tool costs, increase productivity, reduce scrap, shorten lead times, and improve quality.

A selection of modern manufacturing techniques with the application to the production of JTF17 engine parts is included in Appendix A, with photographs of the machines and processes.

SECTION VIII
MANUFACTURING RESEARCH AND DEVELOPMENT OF NEW TECHNIQUES

Flexibility is required by the designer and the metallurgist in choosing materials and structural designs. Advancing the state of the metal-forming and metal-joining arts provides economic production and also increases the designer's freedom, since the designer may choose unusual and intricate shapes utilizing varied processes and materials to fashion economical and durable parts with the lightest possible weight.

To develop advanced manufacturing techniques, to find and improve methods for processing new materials, and to achieve maximum refinement of these techniques and processes, Pratt & Whitney Aircraft manufacturing organizations have distinct departments with the functions of (1) basic research, (2) application to development programs, and (3) refinement in production for maximum quality and minimum cost.

At FRDC, the Fabrication Research Department under the direction of the Chief of Construction performs the first of these functions, and at the Connecticut operation, a department within Experimental Construction performs the similar function. These two groups are in close contact to complement each other and avoid duplication of effort. Fabrication Research is staffed with engineers and technicians having a wide variety of knowledge and skills related to materials and processing methods, such as metallurgy, welding, brazing, machining, forming, coating, and heat-treating. The results of the research projects are incorporated in standard report form.

The second step in the development of a new manufacturing technique is the application of the technique to development hardware by the Experimental Construction Process Planning Department and the Experimental Shops which use the Fabrication Research reports for guidance. This function is accomplished within Pratt & Whitney Aircraft, both at the FRDC and at the Connecticut operations. Throughout the development manufacturing cycle, the activity is monitored by Fabrication Research, Process Planning, and Manufacturing to refine critical and unique methods and to provide updated data to Production Engineering at the Connecticut operations. On the basis of these data and after other independent work, Production fulfills the third function, economical application under full control to production engine hardware.

Production Engineering at the Connecticut operations has established several development groups responsible for creating and refining new production techniques, design of new and specialized machines, and adaptation of special experimental processes to production demands. Fabrication Research at the FRDC and the Experimental Department of the Connecticut operations maintain constant contact and idea exchange to assure a maximum effort to achieve quality at minimum cost.

The Welding Development group is primarily concerned with the testing, development, and evaluation of new methods, techniques, and equipment for welding, brazing, and surface coating of urbine engine parts. Every significant metal joining process is available, from metalic arc welding to electronically controlled fusion and resistance welding equipment. In

addition to providing the necessary assistance to the manufacturing department, this group assists the design engineering department in the selection and design of fabrication methods for parts on current and future engine programs.

The Methods Development group is responsible for the investigation and development of new machining processes and equipment for application to production work. Methods Development is cognizant of such new methods of machining as electrochemical and electrodischarge machining, flowturning, tube drawing, and similar nonconventional processes. New methods of machining are developed on a project basis and, after a pilot lot run has been successfully completed, are turned over to production for process application. Besides supporting processing, the Methods Development group is also concerned with developing superior tools for cutting the new, tougher materials required in the manufacture of many critical turbine engine parts.

The Equipment Development and Standardization group is responsible for the design and development of special machines and related equipment for production application. This group designs and modifies major chip-forming machining equipment required for drilling, milling, turning, and grinding, as well as non-chip producing machines and equipment related to electrochemical and electrical discharge machining (ECM and EDM), electron beam welding, induction brazing, riveting, flame cutting, chemical milling, and heat-treating. Besides providing production with the design and modification of new equipment for new manufacturing techniques, this group is also responsible for the development of tapes for numerically controlled machines and for the standards on tools, materials, and equipment used at Pratt & Whitney Aircraft.

The Chemical and Metallurgical Development group investigates new processes involving the use of chemical or thermal treatment. Adapted processes are finalized by the issuance of Process Procedures.

Pratt & Whitney Aircraft is an industry leader in the invention, development, and application to production of new manufacturing techniques. In addition to expenditures on conventional machining equipment, Pratt & Whitney Aircraft has spent over $25,000,000 in acquiring 200 numerical control machines and 31 pieces of related production equipment. Pratt & Whitney Aircraft has also established an EDM center consisting of 31 electrochemical and electrodischarge machines devoted to production work.

For further description of the development of manufacturing techniques and controls, refer to Volume III, Report F, Section I (Material Processing and Fabrication Techniques).

SECTION IX
SUBCONTRACTOR REQUIREMENTS IN SUPPORT OF THE PROTOTYPE AND PRODUCTION PROGRAM COMPONENT PROCUREMENT

A. VENDOR SELECTION OF SUBCONTRACTOR-DEVELOPED COMPONENTS

Refer to Volume III, Report B (Engine Design) and Volume IV, Report E (Test).

B. SCHEDULING OF SUBCONTRACTOR-DEVELOPED COMPONENTS

Fuel, hydraulic, and ignition systems components are scheduled on the basis of the total lead time required at the subcontractor plus bench test calibration time at Pratt & Whitney Aircraft. Production and prototype scheduling groups supply the component procurement requirements that will meet the engine quantities to the Pratt & Whitney Aircraft Purchasing Department. Purchasing - subcontractor negotiations establish the lead times on procurement of castings, machining, and assembly and test times to establish the total lead time. Purchasing releases purchase orders and delivery dates based upon these lead time requirements. Delivery requirements from vendors are modified by purchase order supplements if needed to meet changes in engine schedules.

After release of the prototype or production parts list, the following lead times are estimated for the longest lead time control component, the unitized fuel and area control:

Fabrication of complete set of parts	12 months
Completion of assembly	1 month
Completion of vendor production acceptance testing	3 weeks
Completion of Pratt & Whitney Aircraft production acceptance bench testing	1 week

C. CONFIGURATION CONTROL OF SUBCONTRACTOR DESIGNED COMPONENTS

Refer to Volume V, Report C (Configuration Management Plan).

D. OTHER ENGINE HARDWARE SUBCONTRACTED

Hardware for prototype engines and production engines will be procured from subcontractors of proved ability who are completely familiar with Pratt & Whitney Aircraft standards, specifications, and controls. Procurement of such items as finished compressor blades and vanes, turbine airfoil castings, compressor and turbine disks, hub and shaft forgings, and proprietary items (such as bearings and seals) will usually remain with the same subcontractors from the development through the production phase. Many other items, when reduced cost or capacity to meet the production schedule dictates a change or an addition, will be procured initially from the development and prototype source. Purchasing gives careful consideration to overlap of deliveries before changing sources. In cases where major parts are double sourced for a make-buy split, initial in-house units will be scheduled as backup to subcontractor deliveries until the subcontractor's performance is assured.

E. SUBCONTRACTOR REQUIREMENTS

Subcontractor contributions to all engine parts, expressed as a percentage of the total value of one engine, is estimated to be as follows:

	Estimated Percent of Value		
	Development, %	Prototype, %	Production, %
Raw materials	27	27	43
Major cases	15	20	8
Proprietary (subcontractor designed)	8	8	7
Balance of hardware	32	35	20
Total subcontracted	82	90	78

SECTION X
TOOLING

A. TOOLING PHILOSOPHY

The selection of manufacturing processes and the design of tooling for the JTF17 engine will be based on providing, whenever possible, the maximum value in trade-off of labor costs and tooling costs for each phase of engine construction. The degree of tooling provided and designation of source will give proper weight to potential utilization in each task; Development, Prototype, Product Support and Production.

B. DEVELOPMENT CONSTRUCTION TOOLING

Tooling for the development phase will be held to a minimum because of the large number of engine design changes that are anticipated with limited quantities of identical parts required for development engines. "Soft Tooling" of an expendable nature is commonly selected to minimize tool cost and lead time. For example, hardwood was used in constructing the assembly fixture for the Phase II-C reverser-suppressor transition duct (figure 28). Because of part configuration and close tolerance requirements, certain engine parts will require tooling of a more durable nature (figure 29).

Based on experience, engine areas that have a high probability of change are identified and tooling for such areas is designed to be as versatile as possible to minimize the cost of obsolescence. Standard tooling and standard methods of gaging are used where possible to reduce the quantity of special tooling required, and to make use of "Catalogue" or shelf-type low-cost items. Historically, this policy of minimal tooling and gaging for the construction of development engines has proved to be most economical and has resulted in an ability to incorporate Engineering Changes in the minimum time. Tooling required for forming and fabricating titanium, while designed and built to an absolute minimum, requires a different approach than the tooling for more coventional materials. To form titanium intricately, tools and/or blanks are usually required to be heated to controlled high temperatures. This is accomplished by different methods to accommodate the various engine part configurations, depending on severity of deformation. The "creep-forming" method, whereby the blank is placed in the die and both are subjected to controlled high temperatures in the furnace, allowing the blank to conform to the die shape, lends itself well in the development phase as the tooling is economical and requires less lead time to design and build than electrically or flame heated dies. A second process, in which the tooling is relatively inexpensive, is the resistance heating of the blank to the required temperature and immediate striking in a cold die (figure 30).

The fabrication of development tooling is predominately subcontracted with the most critical or urgently required tooling being made by Pratt & Whitney Aircraft. New tooling is always thoroughly inspected and tool tryout carefully monitored by the Process Planning and Tool Design Department and shop personnel to ensure that quality requirements are met and that the tool functions as intended.

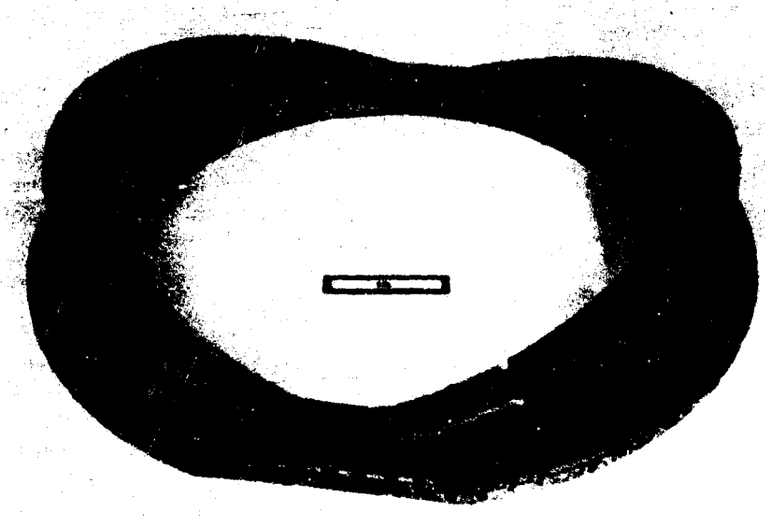


Figure 28. Fixture for Fit-up and Riveting of Phase II-C Reverser-Suppressor Transition Duct — FC 12759 VG

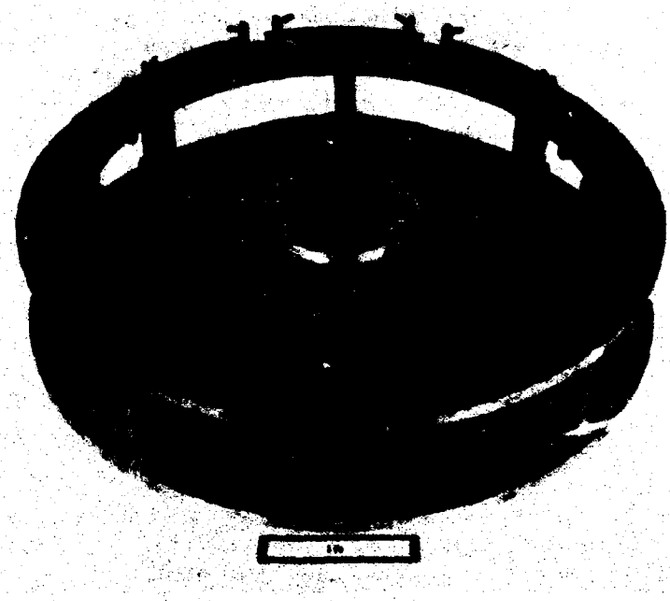


Figure 29. Phase II-C Intermediate Case Welding and Machine Fixture — FC 12758 VG



Figure 30. Hot Forming Titanium FC 12692
VG

To determine the type, quantity, and cost of tooling required for the in-house manufacturing activity, preliminary drawings will be provided to each process planning group as required. Operation sheets will be prepared denoting operation sequence, description of work to be performed, type of manufacturing equipment to be employed, special tooling required, and a graphic illustration of the operation when necessary for clear direction. A sample operation sheet is shown in figure 31. Assembly tooling requirements such as special wrenches, pushers and pullers, balance tooling, spin pit arbors, handling stands, and hoists, originate from the Assembly Planning Section Of Process Planning from a study of the engine layouts. The "Make or Buy" decision, subcontracting manufacture and inspection are handled in the same manner as other shop tooling.

Subcontractor tooling for the development phase will also be as universal as possible. Tooling requirements can be held to a minimum by manufacturing parts in the subcontractors experimental shops, utilizing toolroom techniques and universal machines. The FRDC Purchasing Department is always in a position to evaluate new tooling requirements for the development phase through updated knowledge of subcontractors equipment and machinery. This assures that changes are accomplished economically.

C. PROTOTYPE CONSTRUCTION TOOLING

Planning, as performed during the development phase, will continue during the prototype program. All major assemblies and subassemblies will be analyzed during the layout stage. The experience gained during development will be invaluable not only to planning and manufacturing, but also as input to Design relative to producibility, which will stabilize the engine design and expedite final planning and tool design.

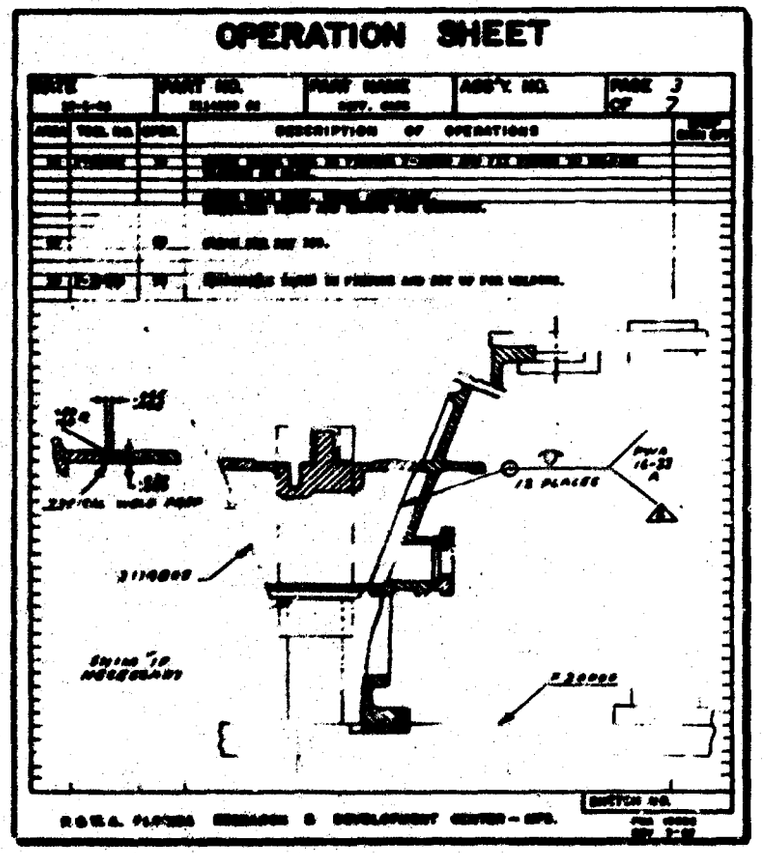


Figure 31. Operation Sheet (Sheet 1 of 2) FD 17599 VG

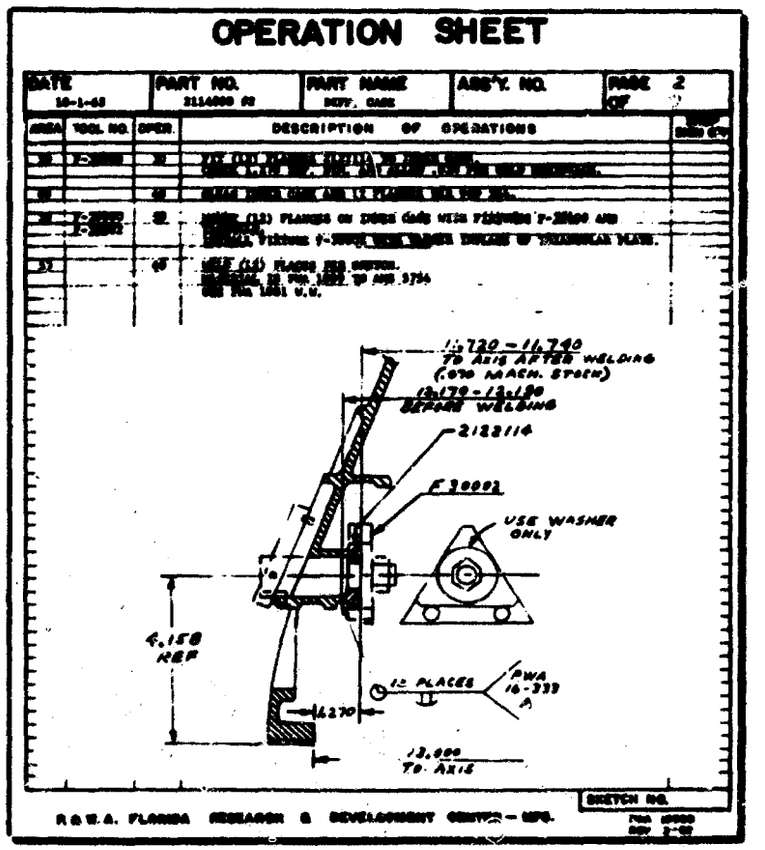


Figure 31. Operation Sheet (Sheet 2 of 2) FD 17598 VG

Process Engineering, which is responsible for specifying the special tools required by the manufacturing areas, is organized into groups that parallel the manufacturing areas of operation. This permits specialized effort and maximum application of experience. Special tools will be planned, designed, and ordered in the quantity to provide capacity to meet manufacturing schedules. Tool design and tool build will be scheduled to ensure that tooling will be available as required.

The majority of updated subcontractor and in-house development tooling (70 to 80%) is planned to be reused in the prototype phase. This is possible because of the gradual updating and modernization of development tooling as design changes are incorporated during the development phase, and the resulting similarity of the development and prototype engines at the beginning of the prototype phase.

Most of the subcontractors utilized during the development phase will continue manufacture during the prototype and overhaul phase. In some cases additional or "hard" tooling must be added to supplement existing tooling for manufacture of JTF17 prototype and overhaul quantity of parts. Since the overhaul phase overlaps early production, subcontractors will have the ability to assist the Connecticut Manufacturing Department in their initial requirements.

D. PRODUCTION, PHASE V, TOOLING

Parts and assemblies for production engines are assigned to the Semi-production Departments, the production areas and subcontractors. The selection of internal source for Pratt & Whitney Aircraft parts will be based on the anticipated volume of production, the stability of parts or subassembly design and the availability of skills and equipment. Parts sourced to the Semi-production Departments are produced with a minimum of specialized tooling while parts sourced to the Production areas are generally manufactured with tooling which is applicable to production engine programs. It is normal to rely on the Semi-production Departments for the initial production of parts having a high probability of change in design. As the design of the engine stabilizes and the risk of obsolescence of tooling diminishes, an increasing proportion of the engine is shifted to production areas.

The semi-production manufacturing areas, Department 96 (Machining) and Department 97 (Sheet Metal), maintain separate organizations for the planning, design, fabrication and maintenance of tooling. This arrangement not only provides for the specialization of these groups in the type of tooling applied to semi-production processes, but also insures timely delivery, flexibility and control of tooling requirements. Control of semi-production tooling for the JTF17 engine will be exercised by the JTF17 Production Manager's organization.

Process Engineers in the Production Engineering Department will be responsible for planning the special tooling required by the production areas. The organization of process engineers into groups which coincide with the production shop areas allows for specialization by type of process and tooling. Special tools will be planned and ordered to provide capacity for

designated rates of production. The scheduling of tool design and fabrication is controlled by Production Engineering to ensure that tools will be available when they are required.

Durable tooling or "hard tooling," (consisting of jigs, fixtures, floturn mandrels, welding chambers, gages, etc.) required by subcontractors for production engines will be designed for use on standard machinery whenever possible. Designing tools for use on standard rather than special-purpose machines gives flexibility as to choice of subcontractor and, also, is important for the incorporation of urgent design changes. Prior to authorizing subcontractors to proceed with the manufacture of any production tooling, a close check will be made to determine if any usable development or prototype tooling is available from experimental or prototype programs. Many times an obsolete tool may be altered and redesigned to fulfill a production requirement, resulting in substantial cost savings. The design of the JTF17 engine is not predicated on requirements for novel or undeveloped manufacturing processes or tooling methods. Tooling from the prototype phase that can be used directly in the production engine program consists of forging dies, casting patterns, sheet metal forming tools and brazing fixtures. It is estimated that 20% of the subcontractors' tools will be used in the production program. All updated development and prototype in-house tooling is available and may be used for assisting Connecticut Operations in the production phase. Manufacturing planning for production continues over nearly a 2-year period.

A well staffed tool design organization, capable of designing all types of required tooling, is maintained at Pratt & Whitney Aircraft. This organization will be available to design urgent, unusual, or difficult tooling. To maintain stable tool design employment within the company, tool design work is subcontracted during periods of peak activity. This subcontracted design work has historically accounted for approximately 42% of the tool design work load at FRDC and 60% at the Connecticut facility. The Tool Design organization regulates the assignment of work, maintains design status records, and provides follow-up to ensure that scheduled dates are met.

Pratt & Whitney Aircraft's policy for tool build is to maintain the capability of manufacturing any non-proprietary tool in-house; however, a great percentage of tool fabrication is subcontracted for reasons similar to those discussed under the Tool Design section. Tooling made within Pratt & Whitney Aircraft generally falls into the following categories:

1. Alternations to existing tools required for engineering and process changes

2. Complex tooling that subcontractors do not have the capability of building

3. Urgently needed tooling, with very short lead time. This category generally arises from machine or tool breakdown and the requirements of test support and field support tooling

4. Tools for test and field support will always receive the highest priority in tool design and tool build and are very seldom subcontracted.

The Tool Control group determines whether tooling is to be built in-house or subcontracted and is responsible for maintaining tool status records and providing tool followup.

Tool expenditure commitments will be monitored by a computerized control system to ensure tooling budgets are not exceeded.

Alterations to tooling resulting from design or process changes will be performed by the Master Mechanics group. New tooling required by changes will be handled in a manner similar to the procurement of initial tooling.

E. TOOL DATA SECTION

The forecast of special tooling for development and prototype phases is shown in tables 2 through 8. These data show planning estimates of the quantity of in-house tools by types (jigs, dies, fixtures, gages, and miscellaneous) required for the first generation development engine, those convertible to prototype, additional tools for prototype for both capability and capacity, and the special inspection gages for first development and prototypes. Data are also tabulated for planning estimates of engine assembly tool requirements and typical major engine parts.

Table 2. Total Number of Manufacturing Tools for JTF17 Engines

	Jigs	Dies	Fixtures	Gages	Others	Total Development Tools	Total Prototype Tools
Number of Development Tools	63	197	378	112	466	1216	
Number of Development Tools Converted to Prototype	52	153	299	79	383		966
Number of Prototype Tools (Excluding Tools Converted from Development)	16	83	127	40	204		470
Duplicate Prototype Tools for Two Engines Per Month	5	0	49	10	77		141
Number of Inspection Tools						255	370
Total Tooling Required for Development and Prototype						1471	1947

Table 3. Total Number of Final Assembly Tools for J F17 Engines

	Special Wrenches	Pullers/ Pushers	Fixtures	Balance Tools	Others	Total Development Tools	Total Prototype Tools
Number of Development Tools	84	155	125	288	300	952	
Number of Development Tools to be Used on Prototype	0	0	0	150	0		150
Prototype Tools, Including Duplicates for Two Engines Per Month	70	127	75	85	250		607
Total Tooling Required for Development and Prototype Engines						952	757

Table 4. Example of Manufacturing Tools for JTF17 Engines - 1st-Stage Turbine Blade

	Jigs	Dies	Fixtures	Gages	Others	Total Development Tools	Total Prototype Tools
Number of Development Tools	1	0	17	12	16	46	
Number of Development Tools Converted to Prototype	1	0	12	8	12		33
Number of Prototype Tools (Excluding Tools Converted from Development)	0	0	8	6	8		22
Duplicate Prototype Tools for Two Engines Per Month	0	0	2	2	2		6
Number of Inspection Tools				6			6
Total Tooling Required for Development and Prototype						46	67

Table 5. Example of Manufacturing Tools for JTF17 Engines - 1st-Stage Turbine Vane

	Jigs	Dies	Fixtures	Gages	Others	Total Development Tools	Total Prototype Tools
Number of Development Tools	1	4	22	22	23	72	
Number of Development Tools Converted to Prototype	1	3	14	14	15		47
Number of Prototype Tools (Excluding Tools Converted from Development)	0	2	10	10	12		34
Duplicate Prototype Tools for Two Engines Per Month	0	0	3	3	4		10
Number of Inspection Tools				2			2
Total Tooling Required for Development and Prototype						72	93

Table 6. Example of Manufacturing Tools for JTF17 Engines - Intermediate Case Assembly

	Jigs	Dies	Fixtures	Gages	Others	Total Development Tools	Total Prototype Tools
Number of Development Tools	18	5	26	3	62	114	
Number of Development Tools Converted to Prototype	15	3	24	2	50		94
Number of Prototype Tools (Excluding Tools Converted from Development)	4	2	5	1	34		46
Duplicate Prototype Tools for Two Engines Per Month	1	0	4	0	12		17
Number of Inspection Tools				0			
Total Tooling Required for Development and Prototype						114	157

Table 7. Example of Manufacturing Tools for JTF17 Engines - Reverser-Suppressor Main Structure

	Jigs	Dies	Fixtures	Gages	Others	Total Development Tools	Total Prototype Tools
Number of Development Tools	2	36	17	0	15	70	
Number of Development Tools Converted to Prototype	2	32	13	0	12		59
Number of Prototype Tools (Excluding Tools Converted from Development)	1	11	4	0	4		20
Duplicate Prototype Tools for Two Engines Per Month	0	0	4	0	2		6
Number of Inspection Tools				0			
Total Tooling Required for Development and Prototype						70	85

Table 8. Example of Manufacturing Tools for JTF17 Engines - Primary Combustor Assembly

	Jigs	Dies	Fixtures	Gages	Others	Total Development Tools	Total Prototype Tools
Number of Development Tools	2	76	55	0	21	154	
Number of Development Tools Converted to Prototype	2	57	45	0	18		122
Number of Prototype Tools (Excluding Tools Converted from Development)	0	38	17	0	15		70
Duplicate Prototype Tools for Two Engines Per Month	0	0	6	0	3		9
Number of Inspection Tools				0			
Total Tooling Required for Development and Prototype						154	201

F. INSPECTION GAGES

1. Gage Types

The Pratt & Whitney Aircraft system divides gages into two categories: (1) specially designed gages, and (2) catalogue-type gages. Special gages include any for which a tool design must be prepared to provide instruction for fabrication. Examples of gages in this category for turbine engines are pressure test fixtures, disk etching fixtures, and spline gages. Catalogue-type gages include such gages as plug gages, dial indicator gages, and thread gages.

2. Special Inspection Gages

The Inspection Methods subsection of Quality Engineering is responsible for special inspection gages used in the development, prototype, and production phases of a program. During the development and prototype phases, procurement of special gages is restricted to those for parts of a design that cannot be inspected by use of layout-type equipment and catalogue-type gages. During the production phase of the program, single-purpose, specially designed gages may replace the use of layout techniques when this can be accomplished to provide more economical inspection. The Tool Design section of the Process Planning Department creates gage designs in a manner similar to tool design for part fabrication.

3. Catalogue-Type Gages

The Gage Standards section of Quality Engineering is responsible for procurement of all catalogue-type gages needed. Gage Standards determines the need for such gages by review of the Inspection Methods Sheet for the part, and orders are initiated for any gage specified that is not available in the gage crib.

4. Gage Control

The Gage Standards subsection of Quality Engineering is responsible for inspection of all new specially designed gages and all new catalogue-type gages. After acceptance, Gage Standards sets up a record for that gage in the periodic inspection system, which provides for call-in and reinspection at predetermined intervals, based on expected and actual use of the gage and its nature, so that continuous accuracy is assured. When duplication of gages is necessary, each gage is assigned a serial number for identification purposes, and a separate record is maintained. All gages are tagged with the date of the next inspection. All masters used in gage inspection are calibrated periodically with standards traceable to the National Bureau of Standards.

5. Special Inspection Control of Manufacturing Tools

Gage Standards maintains control over manufacturing tooling that creates part dimensions that can not be inspected without part destruction by including such tooling in the periodic inspection record system and notifying Tool Inspection when an inspection is due. Upon completion of inspection

and verification that the tool is correct, Inspection approves and releases the tool for continued use. The Tools are tagged with the date of the next inspection.

6. Prototype Gages Converted to Production

Gages used for the prototype program at the FRDC will be needed for the overlapping overhaul and continuing development program. New inspection tooling must be ordered by Connecticut Quality Assurance for the Production Program. Any parts manufactured at the FRDC in support of Phase V will make full use of prototype gages.

SECTION XI
MATERIAL FLOW

A. SHOP AREAS-FLORIDA RESEARCH AND DEVELOPMENT CENTER

As illustrated in Section IV, the machine shop and sheet metal shop are functionally oriented. This type of layout gives maximum flexibility for manufacture of the small quantities of parts inherent in a development program and is most adaptable to schedule interruptions caused by Engineering Changes. Supervision in each functional area can provide the complete range of technical assistance required in machining a wide range of hardware.

B. ENGINE ASSEMBLY-FLORIDA RESEARCH AND DEVELOPMENT CENTER

The assembly floor is arranged to build major subsections of the engine in separate areas. Figure 25 defines engine assembly progress. Engine hardware is delivered to the major engine section areas on the assembly floor in detail form. The JTF17 engine is designed so that major sections can be assembled separately and concurrently. High compressor rotor details are statically balanced, assembled as a rotor assembly and then dynamically balanced. All major compressor and turbine rotating details of the engine undergo proof spinning tests prior to delivery to the assembly floor. Necessary assembly fits and clearance measurements are taken and special instrumentation installed during engine subsection builds on the floor.

Bearing compartments and their supporting cases are assembled, the oil jets are flowed on an oil flow bench under simulated operating conditions and the accessory drive gear drives are tracked to assure correct mesh. The turbine assembly and fan stages are assembled as separate major subsections of the engine as are the duct heater and variable nozzle assemblies. These sections are ultimately joined to make up the overall engine assembly at the final line section of the assembly floor where the engine controls and related plumbing are installed.

C. SHOP AREAS-CONNECTICUT OPERATIONS

The manufacturing layout at the Connecticut Operations is part and process oriented rather than engine or program oriented. The production layout design, being part and process oriented, has resulted in the concentration of specialized skills within individual areas such that the skills will be readily available to any program. This organization permits a new engine program to be implemented within existing facilities without necessitating complete relocation of areas. Part and process orientation enables flexibility in production scheduling and permits a new advanced engine to be developed and fabricated without extensive shop reorganization.

1. Work Flow

Figure 32 displays the overall work flow for the JTF17 engine. The new materials center will serve as a centralized facility to handle the receipt, inspection, storage and disposal of purchased parts and raw material to various areas of the shop and finished parts to the assembly floor.

Raw materials, forgings, castings, and sheet and bar stock, will be forwarded to the detail machining and forming areas located in each of the four Pratt & Whitney Aircraft plants from the rough stores section of the materials center. Completed details are returned to the finished stores section of the materials center. Details required for subassembly fabrication are drawn from finished stores and stored in detail cribs located in the respective assembly areas. This arrangement provides immediate availability of details for subassembly departments to ensure meeting schedule dates and maintaining proper production contro' Finished sub-assemblies are returned to finished stores from where all parts are routed to the production assembly floor for engine assembly.

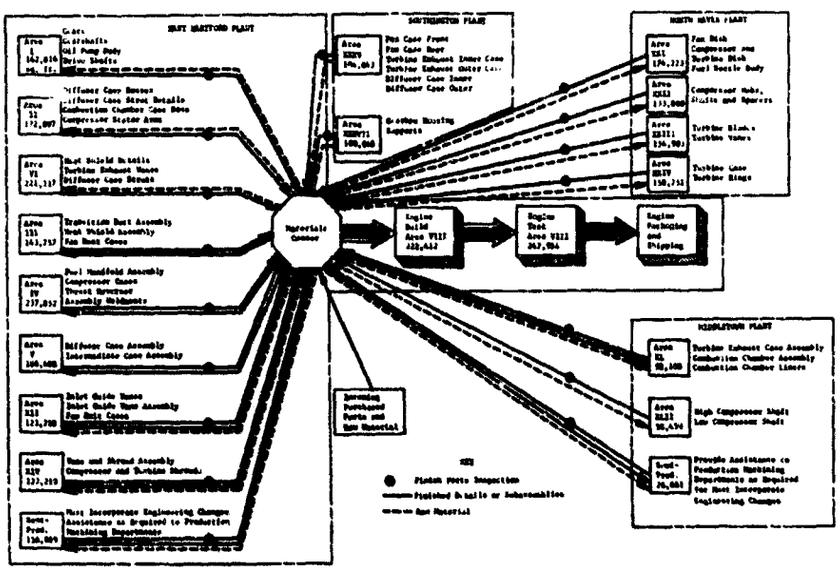


Figure 32. JTF17 Production Engine Work Flow FD 17600 VG

2. Detail Manufacturing

The major JTF17 rotating parts, turbine cases and turbine vanes will be machinad in North Haven. Southington will machine the inner and outer diffuser cases, fan cases and gearbox housing. Middletown will produce the long and short shafts.

JTF17 engine gears and gearshafts will be machined in Area I, which has experience in the manufacturing of these type parts since the piston engine era. Area II will produce small diameter parts, such as machined bosses and strut details, from forgings, castings and bar stock. The EDM and ECM center within Area II will be responsible for producing the stand-up configuration on compressor and diffuser shrouds and contour slotting on various cases and rings. Completed details will be inspected within their respective areas and upon acceptance, transferred to the finished stores section of the materials building.

3. Subassembly Manufacturing

Subassembly areas in East Hartford will receive purchased and shop details from finished stores. Each assembly area is self contained and capable of fabricating its own parts with the exception of surface treat operations required outside the department. The Middletown plant manufactures and fabricates complete burner can assemblies. Raw material (sheet stock) is directed to Middletown from finished stores in East Hartford. Facilities at Middletown include dies and presses for forming burner can details and seam welding equipment for the final assembly operations. Completed assemblies are inspected and routed to finished stores awaiting the start of engine build operations.

D. ENGINE ASSEMBLY-CONNECTICUT OPERATIONS

Finished parts and assemblies for each engine included on the engine part list will be drawn from finished stores and will be delivered to the Assembly Department. Strict control will be maintained to ensure that parts to be incorporated into engines have the correct level of engineering design change.

Parts for the assembly floor are scheduled to be available 2 months prior to engine shipment. A 2 day float of engine parts in production assembly lines in addition to a 2 day availability in assembly cribs is maintained daily by a special dispatching activity provided to satisfy these requirements. Subassemblies are built in separate areas as previously described and will be stored in a centralized area between the two assembly line departments, enabling parts to be efficiently routed for incorporation into respective assembly line stations.

Engines at the Connecticut Operations are assembled vertically to best utilize floorspace, reduce tooling costs and facilitate stacking. Engines will be positioned horizontally for external attachments of plumbing and engine accessories to complete the assembly phase.

E. ENGINE TEST-CONNECTICUT OPERATIONS

Completed JTF17 engines will be transported to the test preparation area for the installation of instrumentation to monitor vibration, temperature, pressure, engine rpm and for the provision of the necessary electrical, fuel and pneumatic connections. This installation reduces the amount of time and inconvenience that would otherwise be incurred within the test cell, thereby increasing the utilization of each cell.

An initial and final testing two-build program is maintained at Pratt & Whitney Aircraft. After completing "Initial Test", the engine will be returned to the assembly floor disassembly area for disassembly, inspection and corrective work, if necessary, then reassembled along their parent lines for final testing. During the teardown period, parts will be sent out to various production machining areas or semi-production departments to satisfy inspection requirements or to complete necessary repair work. Having completed final test, accepted JTF17 engines will be moved to the packaging area where they will be prepared for shipment.

APPENDIX A
MANUFACTURING FACILITIES AND TECHNIQUES

1. FRDC DEVELOPMENT MANUFACTURING FACILITIES

a. Machining Facilities (figure A-1)

The machine shop has a wide range of capability in the normal machining operations of vertical and horizontal turning, milling, grinding, and drilling. The turning capabilities are up to 82 inches in diameter and 120 inches in length. Surface grinding capability extends to 100 inches in diameter and the largest horizontal broach has a stroke of 180 inches. Some of the machine tools have numerical control equipment installed to provide repetitive accuracy on experimental lots of parts with a minimum of special tools being required.



Figure A-1. Overall Machine Shop FC 8620 VG

(1) Jig Boring Machines (figure A-2)

There are nine jig boring machines in the machine shop. They have capabilities to 84 inches in diameter and up to 72 inches under the spindle. All are operated in a uniformly controlled area of temperature and humidity and therefore provide the ultimate in machining accuracy.

(2) Vertical Turret Lathes and Horizontal Boring Machines (figure A-3)

A total of 17 boring mills and turret lathes are located in the machine shop. The vertical turret lathes have a diameter capacity to 82 inches and the horizontal boring machines have a vertical travel to 84 inches. The boring mills have a length capacity of 128 inches and a width maximum of 168 inches. These machines also are operated in the temperature and humidity controlled area of the Manufacturing Shops.



Figure A-2. Jig Boring Machines FC 8595
VG



Figure A-3. Vertical Turret Lathes and Horizontal Boring Machines FC 8594
VG

(3) Horizontal Lathe Area (figure A-4)

The horizontal lathe section is equipped with a total of 34 machines. Eight of the machines have either electronic or hydraulic tracing attachments and the turning capacities are up to 60 inches in diameter.



Figure A-4. Horizontal Lathe Area FC 8599
VG

(4) Electrical Discharge Machining (figure A-5)

Seven units provide capacities for the average size parts requiring electrical discharge machining operations and a specially designed large unit provides coverage for parts of all sizes and shapes up to 56 inches in diameter. The large machine has dimensional control capabilities comparable to a standard jig borer.



Figure A-5. Electrical Discharge Machining Area FC 12768
VG

(5) Broaching (figure A-6)

The machine shops have a broaching department that includes five machines. Three vertical broaches of 50-ton capacity with 100 inches of stroke are complemented by two horizontal broaches with capacity up to 180 inches of stroke with 50 tons capacity and capable of broaching parts up to 60 inches in diameter.



Figure A-6. Broaching Area FC 8597
VG

(6) Grinding Machines and Gear Cutting Area (figure A-7)

These two areas of manufacturing operations have a total of 67 machines. Grinding capabilities include conventional surface OD and ID grinding. In addition, airfoil grinders, electrolytic grinders, thread grinders and tool and cutter grinders round out the capability to fulfill any grinding requirement. The gear cutting and checking equipment can produce any type of gear to a maximum of 36 inches in diameter.

(7) Contour and Conventional Milling Area (figure A-8)

This section has a wide variety of contour machining units. Duplicating mills range from single spindle to six-spindle units and master cam and templet equipment is included. Also included in this area is a wide range of vertical and horizontal plain milling machines.

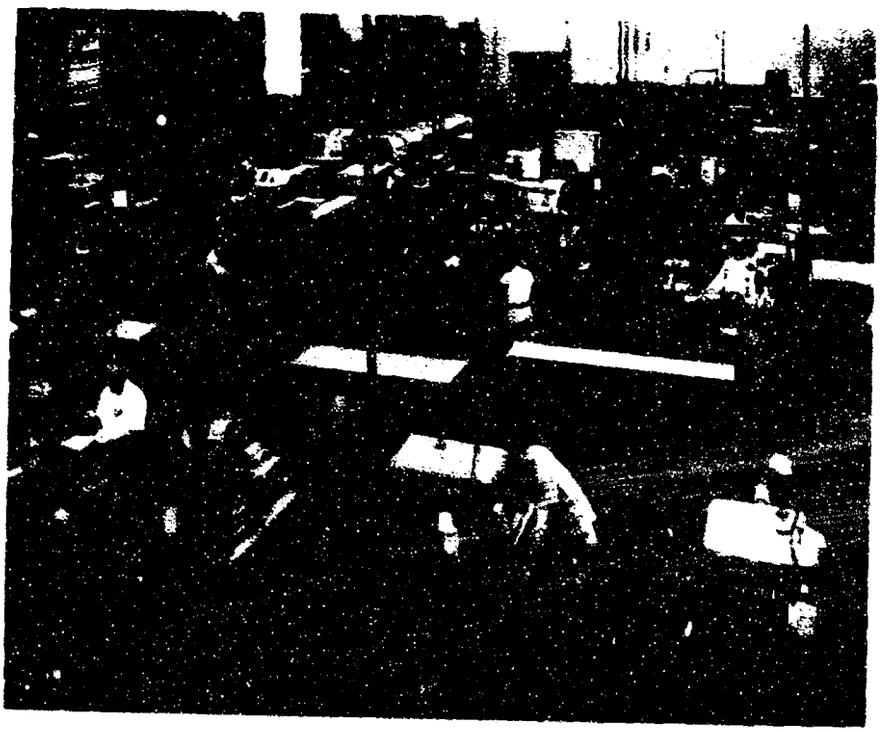


Figure A-7. Gear Cutting Machines

FC 8614
VG



Figure A-3. Contour Mill Area

FC 8596
VG

b. Sheet Metal Facilities (figure A-9)

The sheet metal shop is fully equipped with conventional sheers, machanical presses, brakes, saws, riveting machines, tube benders and spin lathes. In addition, its forming capabilities include Cincinnati Hydroforms, radial draw formers, drop hammer, and a large triple action hydraulic press. The shop activities have adequate support in the fully equipped pattern and wood working shop, a foundry for the casting of Kirksite dies and lead punches and a large capacity heat-treat and plating section.

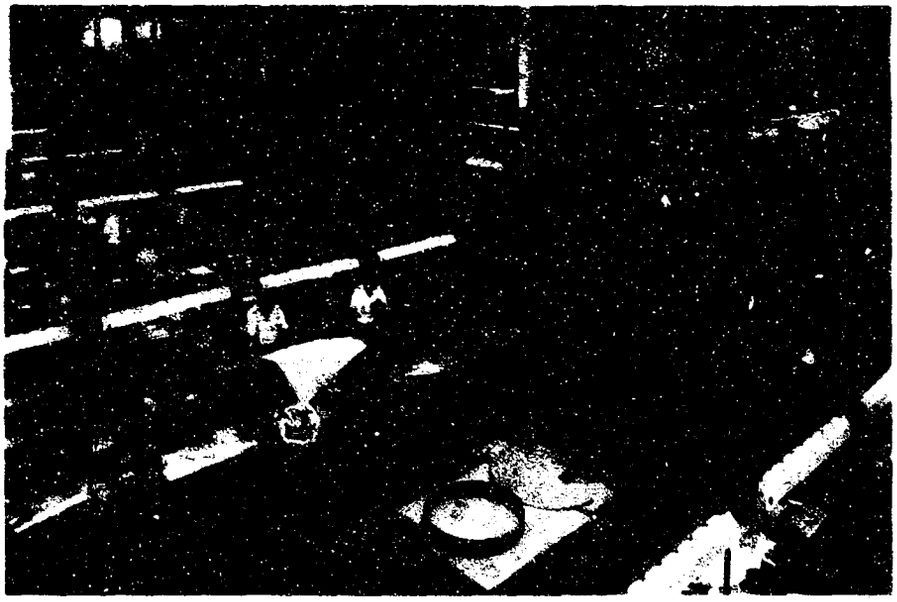


Figure A-9. Overall Sheet Metal Area FC 8602 VG

(1) Metal Spinning (figure A-10)

Six lathes are assigned to the spin operation. Capacities are available up to 100 inches in diameter.



Figure A-10. Spinning Section FC 8609 VG

(2) Tube Bending

Figure A-11 shows a portion of the tube bending area which is equipped with the latest hydraulic tube bending machines. This equipment has been specially tooled to provide the flexibility of producing plumbing in one piece orders or in multiple requirements. The bending area is supported by a tube assembly section with all the necessary fixturing to produce finished tube assemblies in quantities, using induction brazing, resistance brazing and furnace brazing as materials and configurations dictate.



Figure A-11. Tube Bending Area

FC 8610
VG

(3) Metal Gathering Machine (figure A-12)

Florida Research and Development Center has developed the upsetting of standard tubing to provide tube assemblies with integral ferrules. This special machine has a capacity of producing forged ends on 1 1/4-inch diameter tubing. An additional machine of increased capacity and refinement will provide the ability to upset forged ends on 2 1/2-inch OD tubing.

(4) Explosive Forming Operations (figure A-13)

The high energy rate forming area covers 13,000 square feet and includes four vacuum tanks (one of which accommodates 109-inch diameter limit rings). Facilities and techniques have been developed for the explosive welding of nickel and cobalt base alloys. Forming of metal has been accomplished with all of the alloys now used in high Mach number engines.

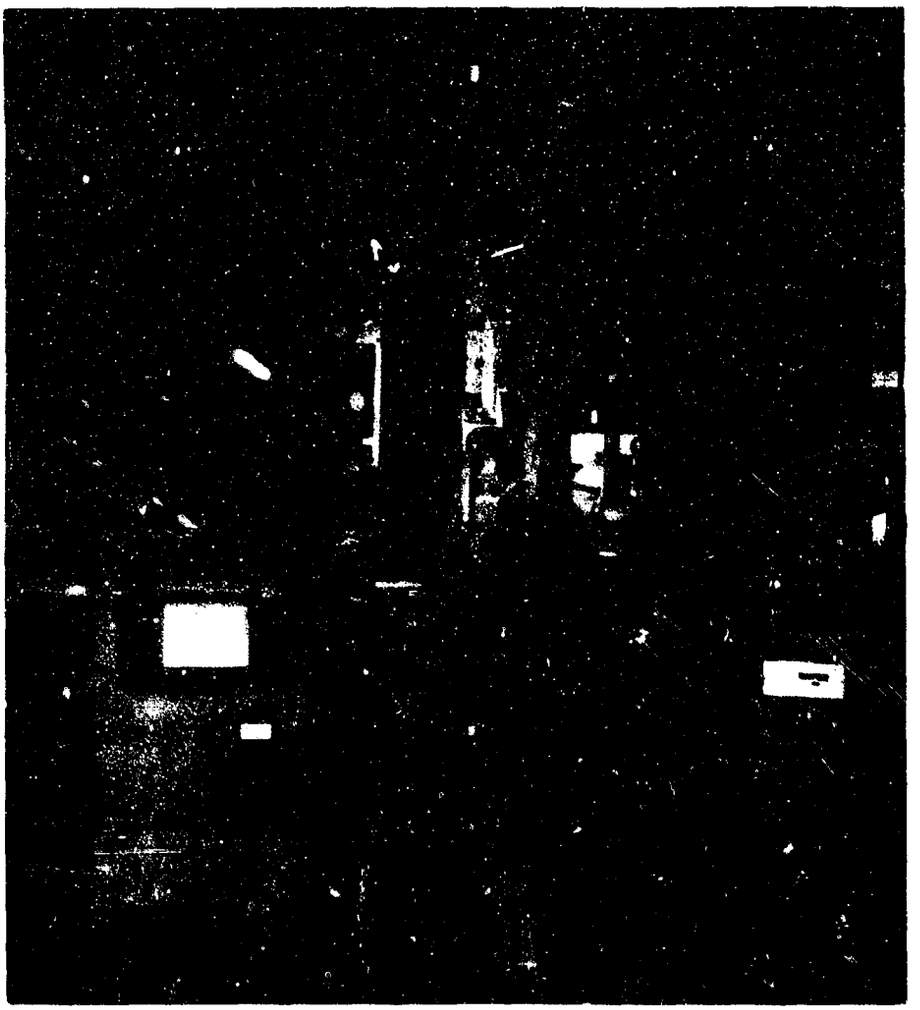


Figure A-12. Metal Gathering Machine FC 8372



Figure A-13. Explosive Forming Operations FC 8226

The form press and expander section consists of 19 machines, from a 6-ton capacity press to the 1,650 ton triple action Hydraulic Press illustrated in figure A-14. This press is used not only in deep draw forming operations, but as an actuator for radial expansion activity when high tonnage capacity is required. The main ram acting in triple action has a forming capacity of 1,000 tons and the hold down platen has a capacity of 650 tons. A 500-ton cushion actuates the die pins to complete the triple action of the press.

A Cincinnati Hydroform forming press has a blank capacity up to 26 inches in diameter and can form parts up to 12 inches in depth. Forming pressures are up to 15,000 pounds per square inch and the equipment produces quality parts from the minimum of tooling expenditure.

A Cyril Bath Radial Draw Former of 25 tons capacity can form parts 100 inches in diameter and 30 inches in width. It is equipped with a yield sensing device to maintain constant tension during the forming cycle in the yield range of the material.

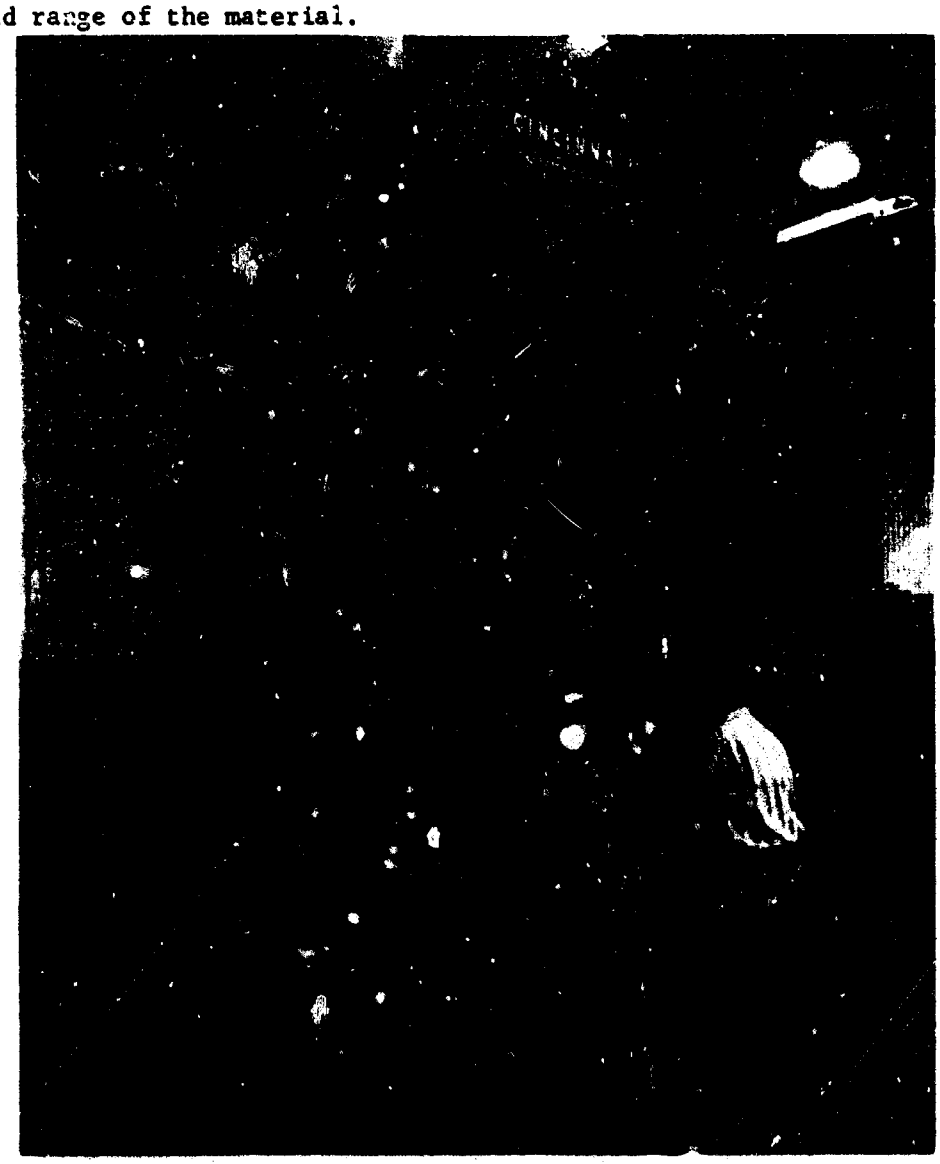


Figure A-14. Press Section

FC 8616
VG

c. Welding Facilities

The welding shop is equipped to accomplish manual and semiautomatic fusion weld and resistance weld in ranges up to 80-inch diameter and 84-inch lengths. Four semiautomatic inert arc welding machines are supplemented by 12 manual inert arc machines and 10 resistance welding machines.

Induction heating equipment up to 100 kw capacity is provided for brazing, using an argon or helium atmosphere to make gold nickel, silver, copper and other alloy joints. Oxyacetylene brazing with flux coating can be accomplished at 12 stations within the area.

An electron beam welder with a thickness range of 0.003 to 0.125 inch and 10 welding positioner units complete the major equipment list.

Argon gas is used as the atmosphere in all inert welding operations. Titanium alloy assemblies are welded in a high purity argon filled chamber to ensure maximum weld quality and material properties.

(1) Resistance Welding (figure A-15)

Seven spot welders and three seam welders comprise the total capacity of the resistance weld section. The range is from 5 KVA spot welder to a 400 KVA seam welder. Material thickness may vary from foil to plate 0.375 inch thick.



Figure A-15. Resistance Welding Section PC 8592 VG

d. Heat-Treat Area (figure A-16 and figure A-17)

The Heat-Treat facilities consist of 22 furnaces, the largest having an internal work area of 135 inches deep, 96 inches wide and 85 inches high and a maximum temperature of 2600°F.

Complete facilities are available to perform normalizing, annealing, hardening, tempering, mar-quenching, stress relieving, gas and pack carburizing, brazing, solution and precipitation treatment of ferrous and nonferrous age hardening alloys. Liquid nitriding of high-speed cutting tools, hydrogen cleaning and sub-zero treatment operations are also performed.

Vacuum, nitrogen, argon, endothermic and hydrogen are used as protective atmospheres.

The Lindberg Vacuum Furnace has a work area of 72 inches in diameter by 72 inches in height. The temperature range has a maximum of 2250°F. The furnace is of the cold wall design and the vacuum pressures that can be achieved are 5 x 10^{-6} microns. This unit has been installed in an airconditioned area to provide the maximum efficiency of the furnace and of all the related pumps and equipment.

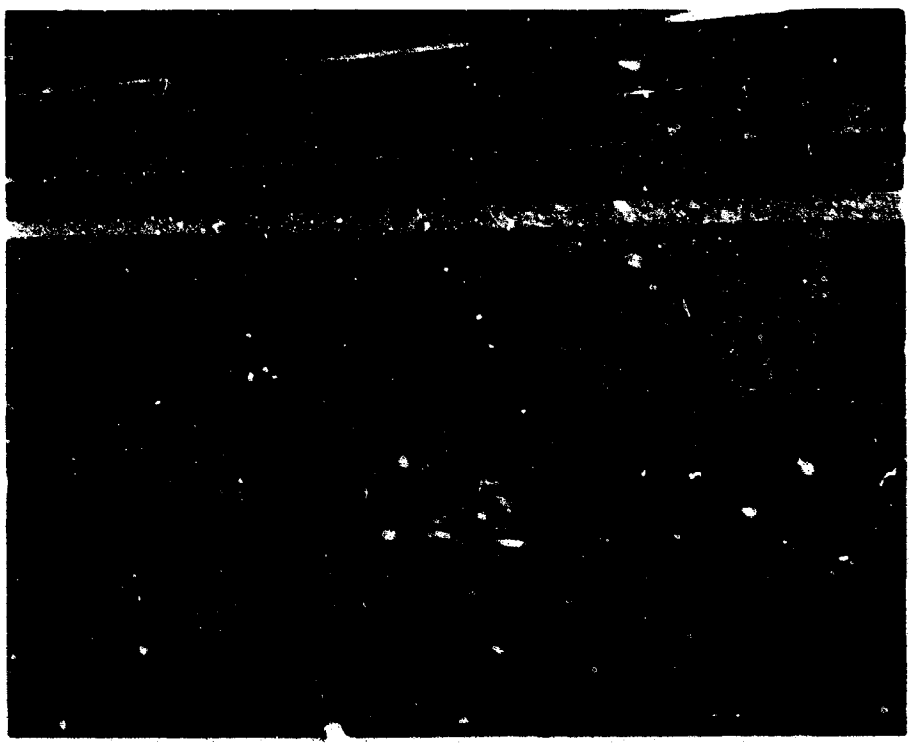


Figure A-16. Heat Treat Furnaces and Controls FC 8606
VG



Figure A-17. Lindberg Vacuum Furnace FC 8612
VG

e. Plating (figure A-18)

Complete facilities to perform all standard plating processes are available in the plating area. In addition, the plating shop can do chemical etching, metal stripping, anodizing, electro-polishing and impregnation of aluminum and magnesium. Plating and cleaning line tanks have capacities up to 84 inches in diameter.

f. The Pattern Shop

The pattern shop has all of the woodworking facilities to produce full-scale mockups of gas turbine engines in wood and reinforced fiberglass. This area also produces patterns for drop hammer and hydroform dies and makes wood tube bending checking fixtures to aid in the manufacture of development engine plumbing, as well as "soft" tooling for development parts.

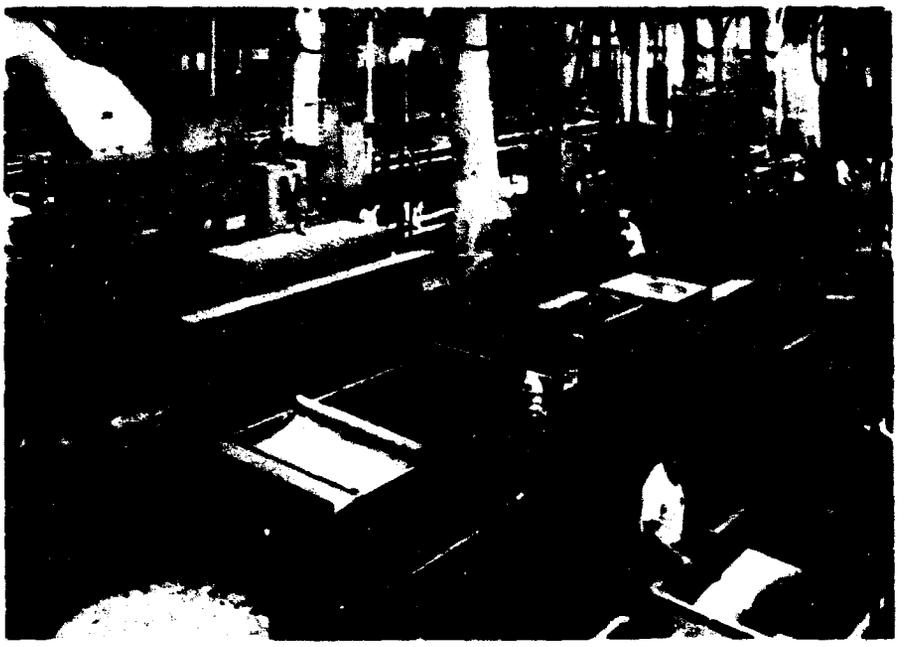


Figure A-18. Plating Shop FC 3607
VG

g. Development Assembly

The development assembly area at FRDC is shown in figure A-19. The assembly facility balancing section (figure A-20) is equipped with eight balancing machines and a spin pit. There are two balancing machines capable of handling parts or assemblies up to 88 inches in diameter, 120 inches in length, and up to 2000 pounds in weight. Also available are two vertical machines for balancing blade and disk assemblies, two small machines for gear and detail part balancing and two high speed machines capable of 12,000 rpm maximum. The spin pit diametrical capacity is 54 inches; it is equipped with air drive turbines rated at 25,000, 60,000 and 100,000 rpm and can be evacuated to 500 microns. Two spin pit heating furnaces are also available with 1400°F capability.



Figure A-19. Experimental Assembly Area FC 4069
VG

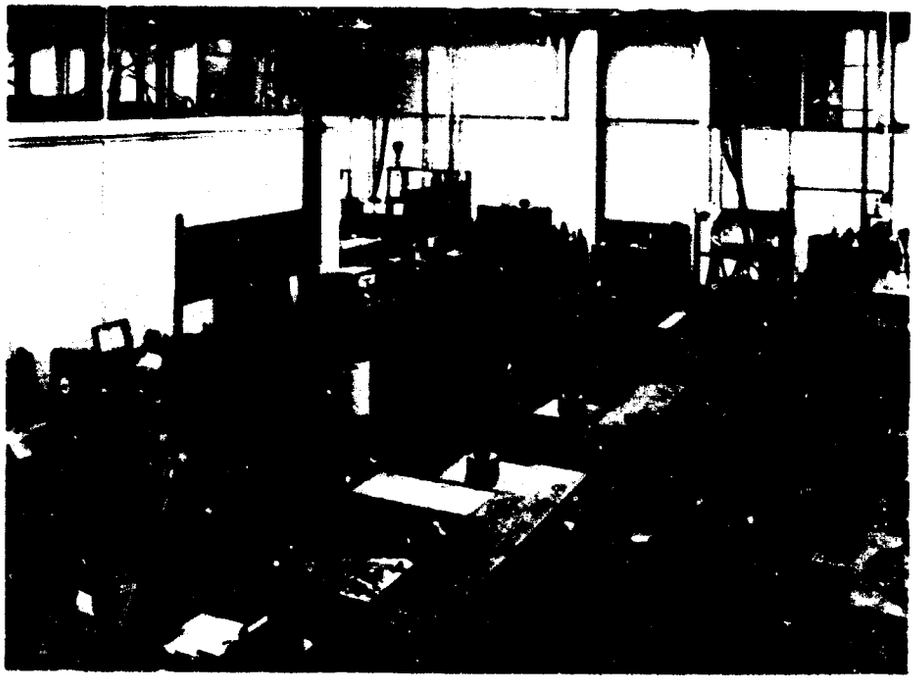


Figure A-20. Experimental Assembly Area FC 8619
VG

2. SELECTED PRODUCTION MANUFACTURING TECHNIQUES

a. Plasma Spraying (figure A-21)

Plasma spraying is used to increase the useful life of many turbine engine parts that are exposed to extreme heat and wear.

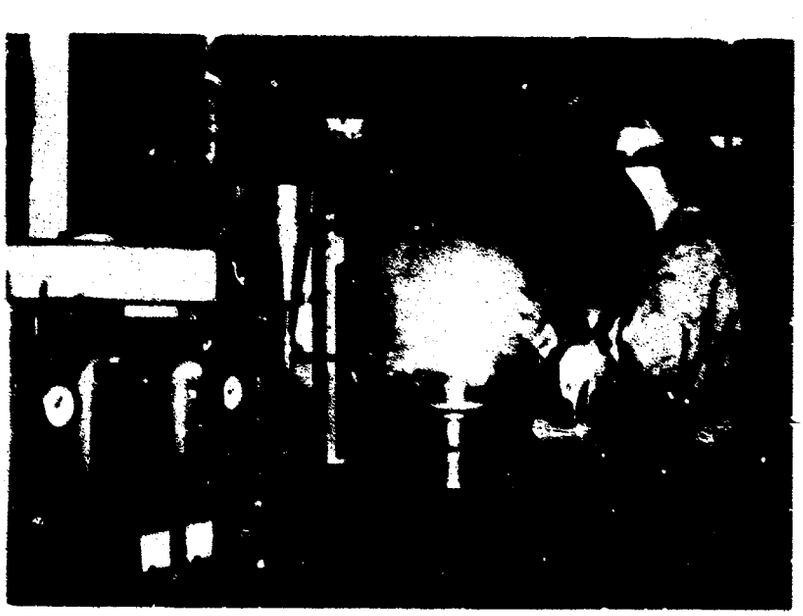


Figure A-21. Flame Spray Equipment - Plasmadyne S-212 Spray System H 38560
VG

b. Center Drive Lathe (figure A-22)

The center drive lathe was developed by Pratt & Whitney Aircraft to permit simultaneous contour turning of both sides of a jet engine turbine or compressor disk. As the disks are held and driven on their periphery, the tools on both sides of the part oppose each other, preventing flexing of the metal and producing precision parts. This method will be used to machine the disks for the JTF17 engine.

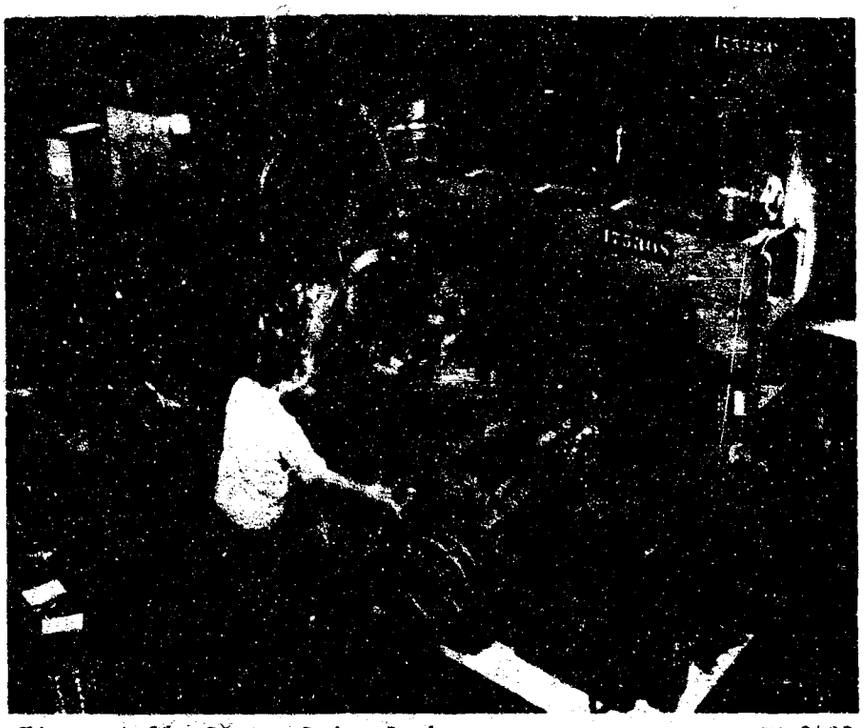


Figure A-22. Center Drive Lathe CN 2438 VG

c. Three Wheel Grinder (figure A-23)

This machine was conceived at Pratt & Whitney Aircraft and developed with Pratt & Whitney Aircraft's engineers assistance. It will simultaneously grind nine closely-toleranced surfaces on 19 vanes with one set-up. The entire cycle is automatic, utilizing a multiple fixture which presents the work to three independent grinding heads, producing quality parts at reduced costs. This machine will be used to grind the vane feet for the JTF17 engine.

d. Vane Stabbing Machine (figure A-24)

This machine was designed and developed specifically for P&WA to pierce vanes through a solid wall of metal shroud. The vanes are magazine loaded into a shuttle which positions and drives them through the shroud by hydraulic pressure. This process ensures a consistently tight fit of the vanes in the shroud and will be used on vanes and shrouds for the JTF17 engine.

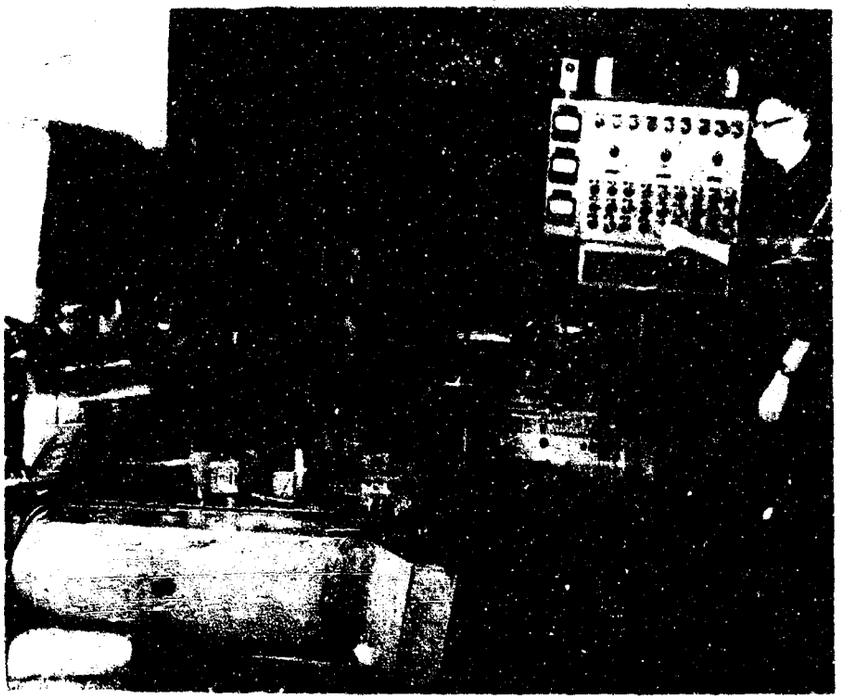


Figure A-23. Three Wheel Grinder

Z-21731
VG



Figure A-24. Vane Stabbing Machine

K-4235
VG

e. Large Flowturning Machine (figure A-25)

Flowturning, a specialized manufacturing technique, was originally developed by Pratt & Whitney Aircraft to produce stronger, lighter weight cases by eliminating longitudinal welding. This machine is capable of handling work up to 80 inches in diameter. This technique will be used where applicable on the JTF17 engine program.

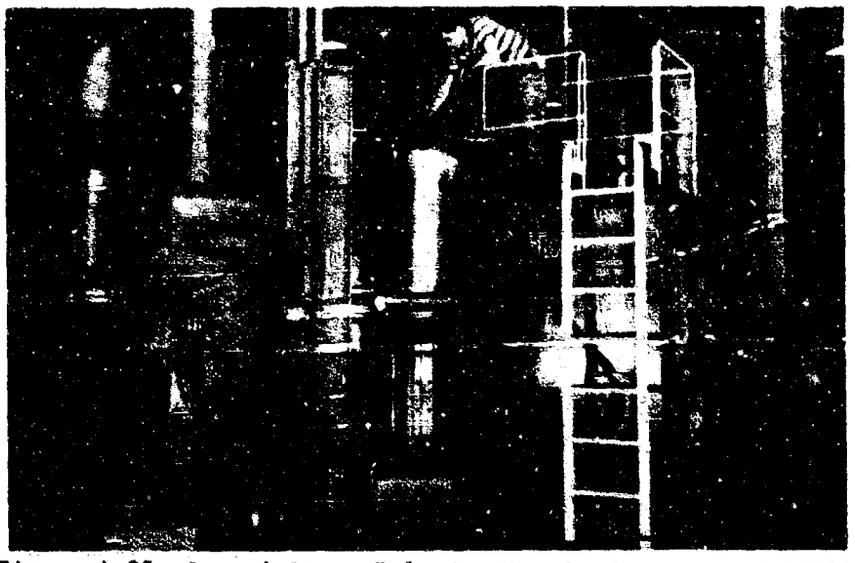


Figure A-25. Second Stage Polaris Missile Case H-12813
80 in. Lodge and Shipley Flowturn VG
MDG Project #2332. 16 May 1966

f. Electrical-Discharge Machines (figure A-26)

Electrical-discharge machining (EDM) is also well adapted for the generation of difficult configurations in the new turbine engine materials. The process is well suited for the machining of contour slots and deep recesses. The machining of air foil slots on JTF17 inner and outer diffuser cases will be accomplished by this process.

g. The 6 KW Electron Beam Welder (figure A-27)

The ability of electron beam welding to overcome distortion and handle intricate welds in both large and small parts makes this process ideally suited for the fabrication of critical turbine engine parts. Electron beam welding will be used for producing deflector assemblies used in the combustion chamber assemblies on the JTF17 engine.



Figure A-26. Electrical Discharge Machines CN 537D
VG



Figure A-27. Hamilton-Zeiss Electron Beam Welder H-40847
VG

h. Three-Axis Continuous Path Numerical Control Milling Machine (figure A-28)

This numberical control machine with a rotary table will be used for performing numerous operations on the JTF17 diffuser case.

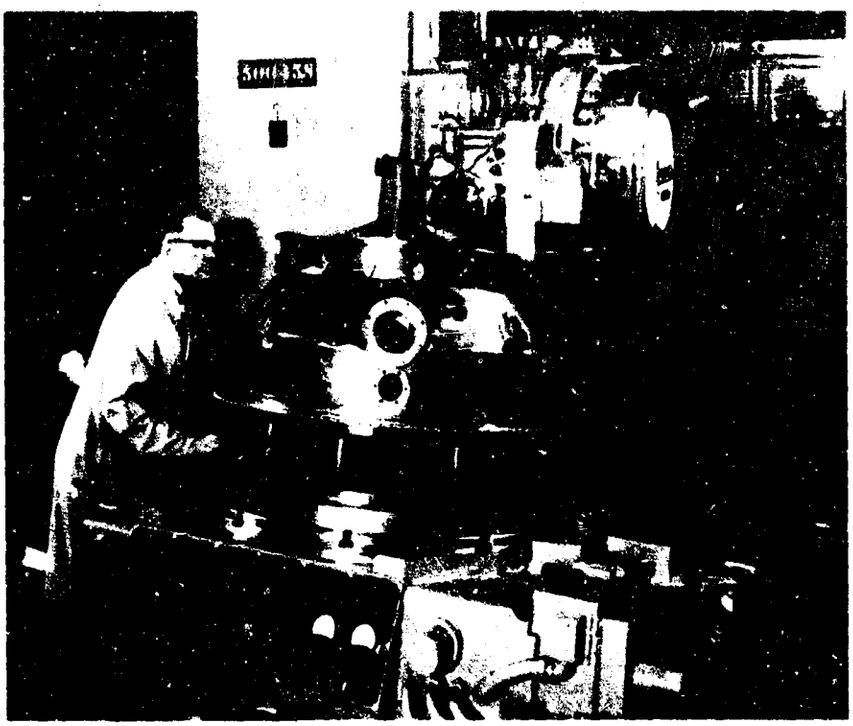


Figure A-28. 3-Axis Continuous Path Numerical Control Milling Machine H-24429 VG

i. Electrochemical Machines (figure A-29)

Pratt & Whitney Aircraft has devoted extensive effort to the development of electrochemical machining (ECM) techniques to the production of aircraft engine parts. The new generation of engines employs complex configurations and materials more difficult to machine to withstand higher operating temperatures and to minimize weight. The ECM process is well suited for the production of these parts. Designs that were impractical to manufacture prior to the development of this process can be produced efficiently. Therefore, ECM has provided increased flexibility for the design of turbine engines and for the selection of materials to be used.

The applications of this process to JTF17 production will include the machining of airfoil-shaped bosses on the diffuser, intermediate and compressor case shrouds and the machining of diffuser case bosses.

j. Five Axis Continuous Path Numerical Control Milling Machine (figure A-30)

Five of these machines are installed and two more on order at Pratt & Whitney Aircraft. An automatic tool holder containing 31 cutters permits the performance of several operations with one setup and reduces the amount of time otherwise spent in tool changes. In addition to control over the X, Y, and Z axes, control of rotary and tilt motors is provided.

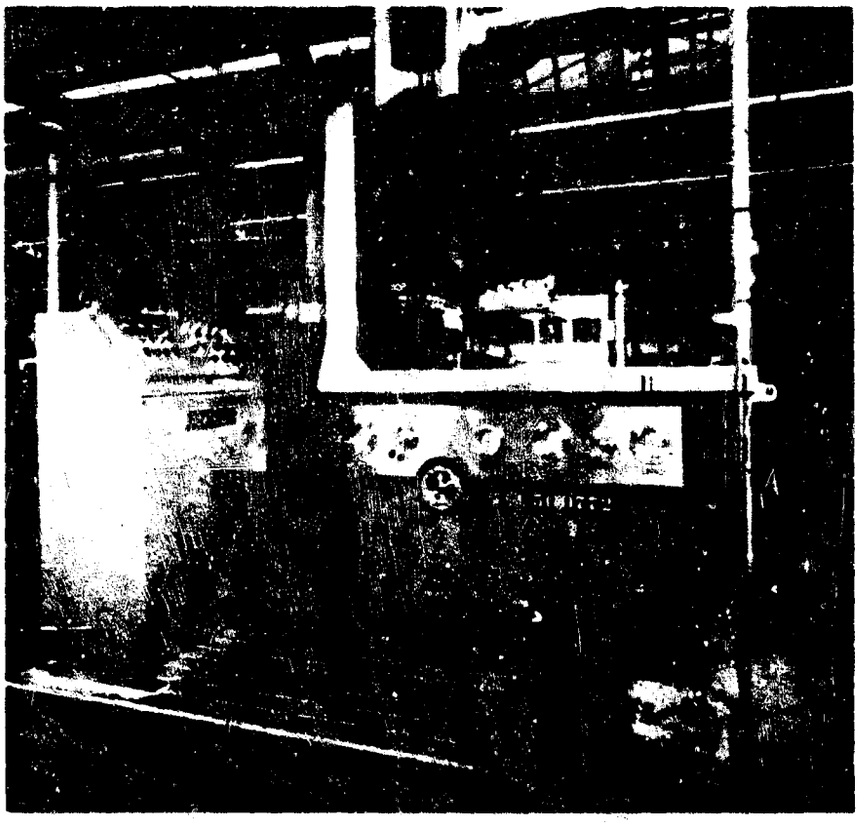


Figure A-29. Electrochemical Machines H-25795



Figure A-30. 5-Axis Continuous Path Numerical Control Milling Machine CN-5364 VG

k. Three-Axis Continuous Path Numerical Control Milling Machine (figure A-31)

This numerical control machine will be used for the milling, boring, and drilling of JTF17 gear housings.

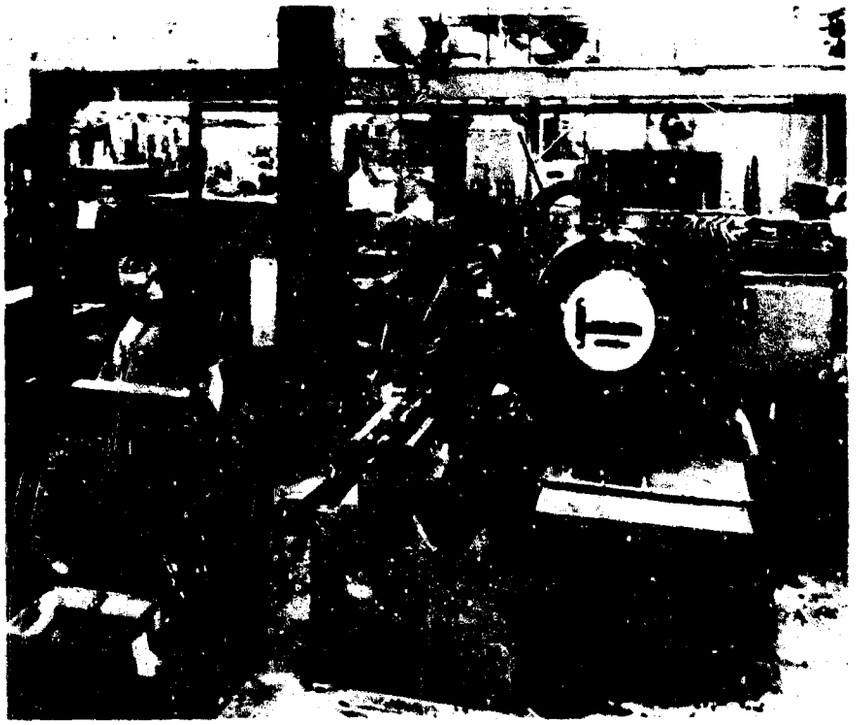


Figure A-31. 3-Axis Continuous Path Numerical Control Milling Machine H-50840 VG

REPORT H
DETAIL WORK PLAN

The Detail Work Plan, Report H, is provided under separate cover.

REPORT I
ORGANIZATION

SECTION I
INTRODUCTION

In 1956 United Aircraft Corporation made the decision to establish a new research and development center for the Pratt & Whitney Aircraft Division. A site remote from urban and densely populated areas yet readily accessible to residential areas attractive to employees was required, and in November 1956 the Florida Research and Development Center was established on a 6,750-acre tract in Palm Beach County, Florida. This site in the Everglades provided the necessary isolation to avoid the need for building soundproof structures at prohibitive cost, and was in an area four' to be favored by prospective employees over possible New England locations.

In establishing the Florida Research and Development Center as one of the most advanced and complete facilities for propulsion system research and development, Pratt & Whitney Aircraft recognized the need for providing this operation with manufacturing and test facilities and a management structure having the capability and authority to accomplish major development programs for which the Florida Research and Development Center would have complete responsibility. In July 1965, the responsibility for the SST propulsion program was transferred to Florida to take advantage of the specialized engineering background and high-Mach-number test facilities there that had been instrumental in the development of the supersonic J58 engine. The program management for continuing work under Phase III of the Supersonic Transport Program will be the same as that used on other major projects at the Florida Research and Development Center. Mr. William H. Brown, currently J58 program manager, and Mr. Gordon A. Titcomb, currently the Phase IIC SST program manager, as JTF17 Program Manager and Deputy Program Manager respectively, will be responsible for all aspects of the SST propulsion program, reporting directly to the General Manager of the Florida Research and Development Center, Mr. W. L. Gorton.

The organizational locations of the Pratt & Whitney Aircraft Division and the Florida Research and Development Center within the United Aircraft Corporation are shown in figure 1. The members of the Corporation's Scientific Advisory Committee are listed below, and the Directors, Officers, and senior management personnel are listed on the pages directly following. The organization of the Florida Research and Development Center and the program management to be utilized for the JTF17 SST Engine Program are then described in this report, with descriptions of the responsibilities and qualifications of the key personnel who will be assigned to this program. Their educational background may be found in the Appendix A to this report.

UAC SCIENTIFIC ADVISORY COMMITTEE

Dr. Sanborn C. Brown
Dr. Pol E. Duwez
Dr. Irvin Glassman
Dr. George B. Kistiakowsky
John G. Lee
Dr. Bernard Lewis
Dr. Thornton Page
Wright A. Parkins
Dr. Robert V. Pound
Dr. Isidor Rabi
Dr. Frederick Seitz
Dr. Igor I. Sikorsky
Dr. C. Richard Soderberg
Dr. H. Guyford Stever
Dr. Theodore Theodorsen
Dr. George E. Valley
Eugene Vidal
Dr. Walter Wrigley

United Aircraft Corporation - Functional Organizational Chart

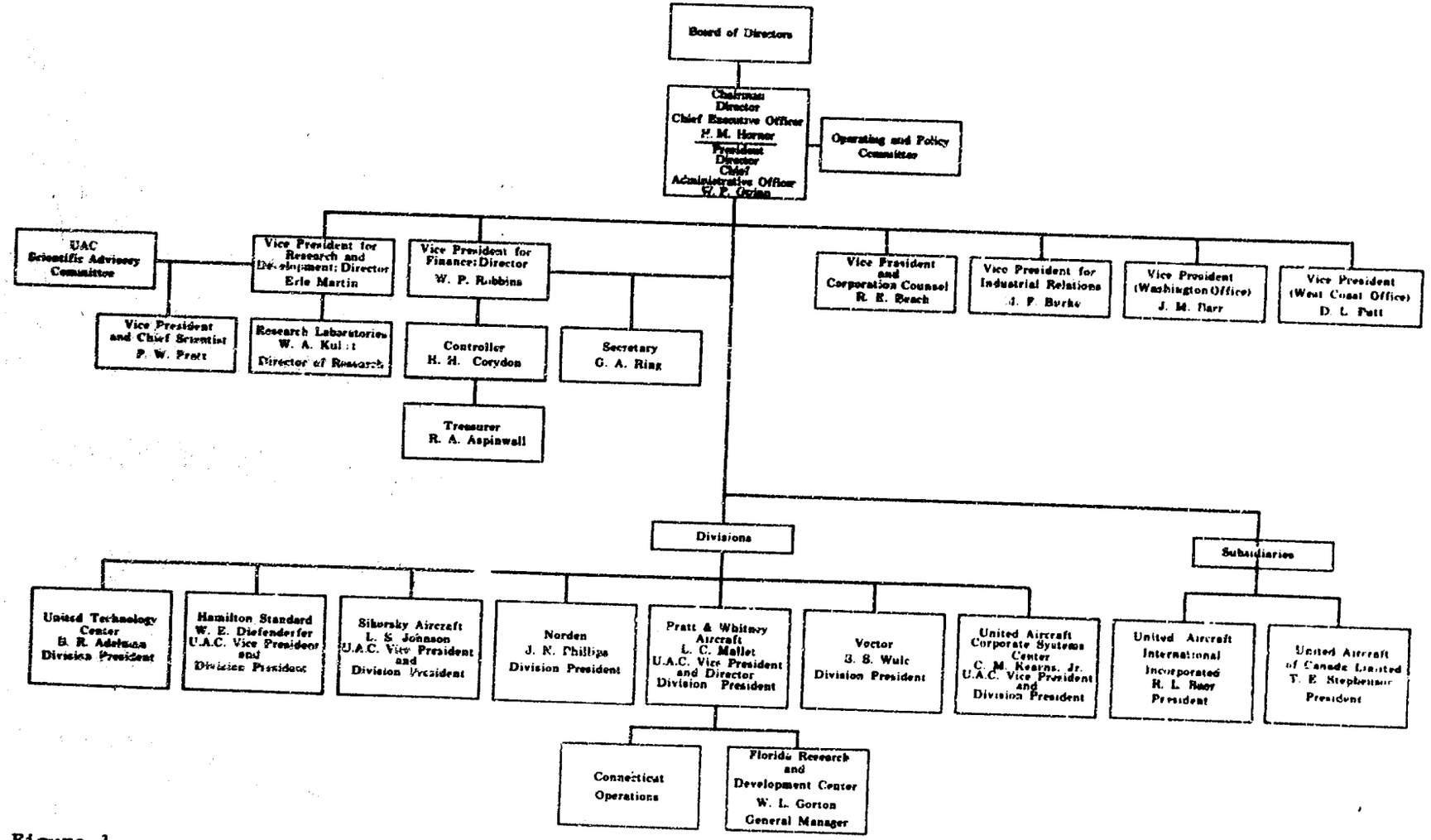


Figure 1.

UNITED AIRCRAFT CORPORATION

BOARD OF DIRECTORS

Dana T. Bartholomew,
Vice President and Chief Financial Officer, Aluminum Limited, Montreal, Canada

Henry S. Beers,
Glastonbury, Conn.

Harold J. Berry,
President, Harriman Ripley & Co., Incorporated, New York, N.Y.

J. Doyle DeWitt,
Chairman of the Board, The Travelers Insurance Companies, Hartford, Conn.

Ostrom Enders,
Chairman, Hartford National Bank and Trust Company, Hartford, Conn.

William P. Gwinn, President

Leonard S. Hobbs,
West Hartford, Conn.

H. M. Horner, Chairman

Leonard C. Mallet, Vice President, Division President, Pratt & Whitney Aircraft Division

Erle Martin, Vice President for Research and Development

Ellis C. Maxcy,
President, The Southern New England Telephone Company, New Haven, Conn.

George S. Moore,
President, First National City Bank, New York, N.Y.

William R. Robbins, Vice President for Finance

Dr. Guyford Stever,
President, Carnegie Institute of Technology

EXECUTIVE COMMITTEE

H. M. Horner, Chairman
J. Doyle DeWitt
Ostrom Enders
William P. Gwinn
Leonard S. Hobbs

OPERATING AND POLICY COMMITTEE

H. M. Horner, Chairman
Barnet R. Adelman
Joseph M. Barr
W. E. Diefenderfer
William P. Gwinn
Lee S. Johnson
Charles M. Kearns, Jr.
Leonard C. Mallet
Erle Martin
John N. Phillips
Perry W. Pratt
Donald L. Putt
William R. Robbins

CORPORATE OFFICERS

H. M. Horner, Chairman
William P. Gwinn, President
Erle Martin, Vice President for Research and Development
William R. Robbins, Vice President for Finance
Leonard C. Mallet, Vice President
Lee S. Johnson, Vice President
W. E. Diefenderfer, Vice President
Charles M. Kearns, Jr., Vice President
Perry W. Pratt, Vice President and Chief Scientist
Robert E. Beach, Vice President and Corporation Counsel
Martin F. Burke, Vice President for Industrial Relations
Joseph M. Barr, Vice President
Donald L. Putt, Vice President
Harvey H. Corydon, Controller
Carroll L. Gault, Treasurer
Grant A. Ring, Secretary

TRANSFER AGENT

First National City Bank, New York, N.Y.

REGISTRAR

Bankers Trust Company, New York, N.Y.

OPERATING MANAGEMENT

Leonard C. Mallet, Vice President
Division President, Pratt & Whitney Aircraft Division,
East Hartford, Conn.

Lee S. Johnson Vice President
Division President
Sikorsky Aircraft Division
Stratford, Conn.

William E. Diefenderfer, Vice President
Division President
Hamilton Standard Division
Windsor Locks, Conn.

Charles M. Kearns, Jr., Vice President
Division President
United Aircraft Corporate Systems Center
Farmington, Conn.

John N. Phillips,
Division President
Norden Division
Norwalk, Conn.

Barnet R. Adelman,
Division President
United Technology Center
Sunnyvale California

Wesley A. Kuhrt,
Director of Research
Research Laboratories
East Hartford Conn.

Robert L. Baer,
President
United Aircraft International, Incorporated
East Hartford, Conn.

Thor E. Stephenson,
President
United Aircraft of Canada Limited
Jacques Cartier, P.Q., Canada

SENIOR ENGINEERING STAFF

Erle Martin
Perry W. Pratt
David Altman
Richard T. Baseler
Richard J. Coar
Walter Doll, Jr.
[illegible]ard L. Gorton, Jr.
[illegible]ald J. Jordan
Wesley A. Kuhrt
Herbert R. Lawrence
Ralph B. Lightfoot

Davis G. Phinney
Frank S. Preston
Will M. Quinn, Jr.
Einar M. Ramberg
Thomas B. Rhines
Donald G. Richards
Bernard A. Schmickrath
Robert H. Shatz
Elvie L. Smith
Carlos C. Wood

SECTION II
ORGANIZATION - FLORIDA RESEARCH AND DEVELOPMENT CENTER

The Florida Research and Development Center is a separate profit center of the Pratt & Whitney Aircraft Division, and has both the authority and the responsibility for managing the programs conducted in Florida, within the bounds of over-all corporate and division policy. The Center may propose new programs, and enter into contracts. Approval by the Division President is obtained when commitments are made by the Center that involve corporate funds or use of other company facilities.

The Florida Research and Development Center has recognized that special problems are created by the physical separation from P&WA Connecticut Operations and its line departments. For this reason the project engineering system traditional at Pratt & Whitney Aircraft has been expanded in the course of the RL10 and J58 programs to place all aspects of these programs under the full-time direction of a single individual or Program Manager. This program manager directs the activities for his program (including development, delivery, and product support) whether the work is performed in Connecticut, Florida, or in the field. In addition, special interplant communications systems and scheduled interplant visits have been brought into play to provide effective coordination between Florida and Connecticut. This included regular company plane service (discontinued since commercial jet service was established to Palm Beach County), computer tie lines, overnight mail delivery, telephone tie lines, and conference lines, and teletype facilities.

In practice, the program manager's authority over the operating department activities transcends the functional organization's lines. A program manager is selected based on his qualifications to organize, direct, and control the technical and business management of his programs. The fundamental criterion governing the placement of the program in the organization is to provide active management participation at a level commensurate with the needs of the program. For example, the RL10 and J58 managers reported to the General Manager of the Florida Research and Development Center during the critical phases of these programs; currently these program managers report to the Chief Engineer. Other smaller programs that involve primarily research and development currently report to the Director of Applied Research or to the Assistant Chief Engineer - Advanced Technology. Fundamentally, the program manager is successful in directing his work through the overlay of program management on the line departments because all elements of the organization are indoctrinated in this method of operation by experience and as a matter of policy, and because the program manager authorizes and controls the incurrence of costs. The success of this program management system at the Florida Research and Development Center is borne out by the results achieved in two major programs encompassing development and production phases. The JT11 turbojet and the RL10 liquid oxygen/hydrogen rocket engines were developed at the Florida Research and Development Center and later produced at Pratt & Whitney Aircraft's Connecticut Operations. Program management for both these programs has remained with the Florida Research and Development Center throughout the development, production, and product support phases. The JT11 turbojet engines now in production are the only turbojet engines known to be flying daily at sustained speeds

in excess of 2,000 miles per hour. Liquid hydrogen was little more than a laboratory curiosity when the company began the development of the RL10 hydrogen-fueled rocket engine in 1956; from this challenging beginning, the RL10 space engine has achieved a record of complete success in all of its missions, the latest being the Surveyor soft lunar landing.

The program management concept which will be used for Phase III is the same one that has been used at the Florida Research and Development Center since 1961 for the J58, the RL10, and other research and development programs. The personnel who will manage the various aspects of the JTF17 program and those who will conduct the work not only have broad experience in powerplant development and production, but also have the benefit of having all worked together as a team on other programs. In many cases, these associations have existed for ten or twenty years.

For Phase III of the SST Program, the JTF17 Program Manager will report directly to the General Manager of the Florida Research and Development Center. The general relation of the JTF17 program to the Florida Research and Development Center staff functions, to the six operating departments, and to other programs is shown on figure 2. Each functional, or operating department is, of course, specialty oriented and as such is charged with the responsibility of acquiring and maintaining the necessary high level of competence in the specialized fields required for the fulfillment of business obligations. This basic functional organization provides the type and level of effort which may be required by each program within the constraints of time, costs, and performance as established by the Program Manager. The experience and background of the Florida Research and Development Center management group shown in figure 2 is described below:

WILLARD L. GORTON - GENERAL MANAGER

As General Manager, Mr. Gorton has direct responsibility for management of the Florida Research and Development Center. Mr. Gorton has 30 years experience with Pratt & Whitney Aircraft in various engineering and engineering management positions and has been General Manager of the Florida Research and Development Center since July 1961. He was Project Engineer in charge of R-2800 engine development when it was introduced into commercial airline service in the DC-6, Convair 240, and Martin 202. Mr. Gorton directed development of the J42 and J48 jet engines starting in 1947. Subsequently, in an engineering management capacity, he was involved in the introduction of the JT3 and JT4 turbojet and the JT3D turbofan engines into commercial airline use. The development of the Mach 3 J58 engine was also conducted under his overall management.

EDWIN L. DAVIS - ASSISTANT TO THE GENERAL MANAGER

As Assistant to the General Manager, Mr. Davis functions as business manager and has the responsibility for the Contract Administration activity. He has 13 years experience with Pratt & Whitney Aircraft as legal counsel and contract negotiator and has been in his present position since 1961. Mr. Davis was formerly a practicing attorney and is a member of the Bar of the United States District Court for the District of Columbia and of the United States Court of Appeals for the District of Columbia Circuit.

Pratt & Whitney Aircraft

Florida Research and Development Center Functional Organization

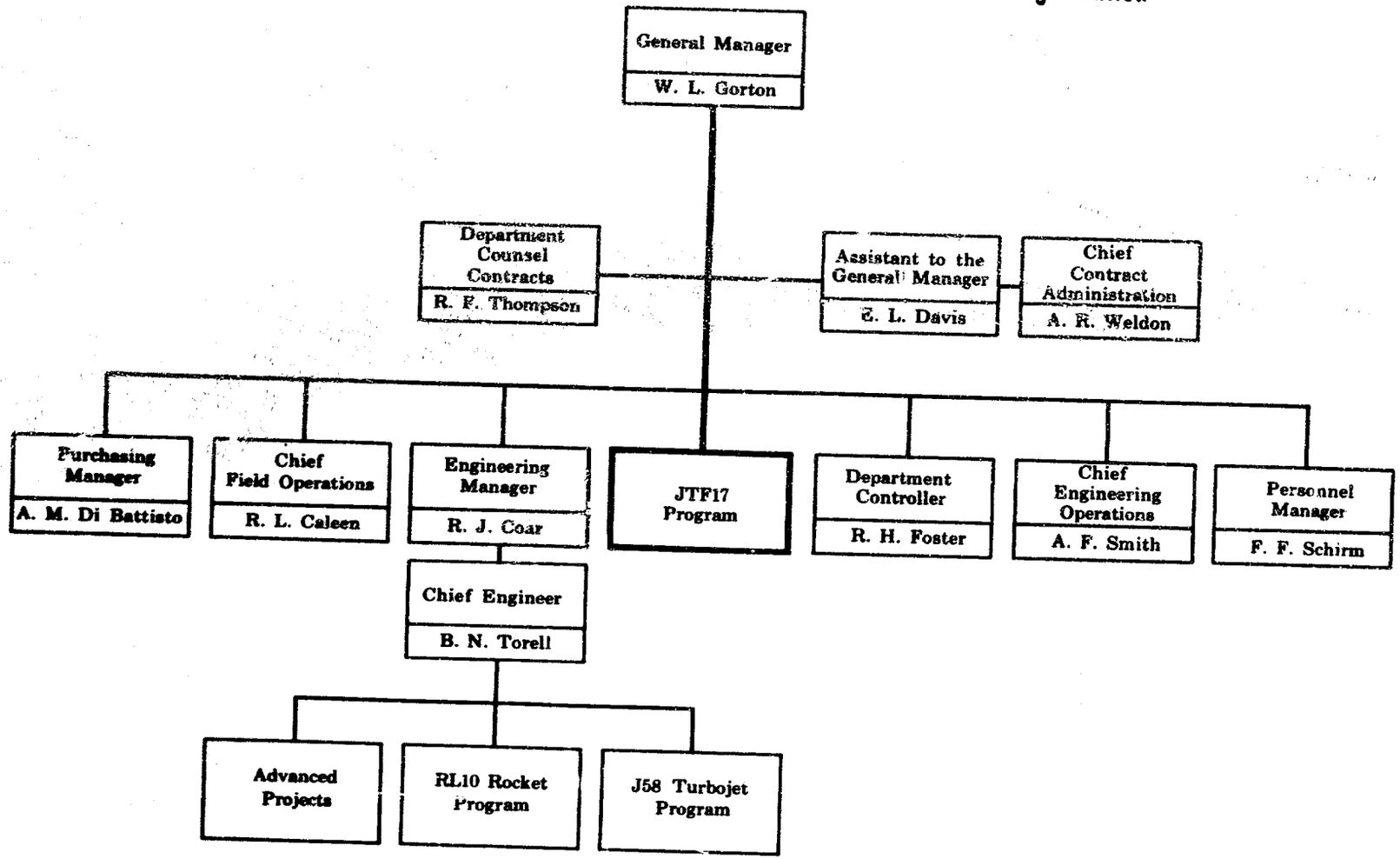


Figure 2.

ALBERT R. WELDON - CHIEF, CONTRACT ADMINISTRATION

As Chief, Contract Administration, Mr. Weldon is responsible for the negotiation and administration of contracts and for coordination and submission of proposals. He has 9 years experience with Pratt & Whitney Aircraft, 6 years of which have been as Chief, Contract Administration. Mr. Weldon is a graduate of the United States Naval Academy and retired as Captain, United States Navy, after 22 years service including assignments such as Director of Contracts Division and Deputy Comptroller and Comptroller, Bureau of Aeronautics.

RONALD F. THOMPSON - DEPARTMENT COUNSEL, CONTRACTS

As Department Counsel, Contracts, Florida Research and Development Center, Mr. Thompson provides legal advice in the negotiation and administration of contracts. He was formerly a practicing attorney in New York City and is a member of the Bar of the State of New York and of the United States District Court for the Southern District of New York. Mr. Thompson is a member of the American Bar Association.

ALBERT M. DI BATTISTO - PURCHASING MANAGER

Mr. Di Battisto, as Purchasing Manager, is responsible for all procurement at the Florida Research and Development Center. Mr. Di Battisto has 14 years experience in all phases of purchasing with Pratt & Whitney Aircraft and has been responsible for purchases totaling $60 million annually.

REYNOLD L. CALEEN - CHIEF, FIELD OPERATIONS

In his current position, Mr. Caleen provides product support for the RL10 rocket engine and the J58 supersonic turbojet engine program managers and will have similar responsibilities for the JTF17 engine in Phase III. Following five years experience in flight test engineering with United Airlines, Mr. Caleen has held various product support positions with Pratt & Whitney Aircraft for the past 27 years. This has included five years as Chief, Western Field Engineering and six years in his current assignment at the Florida Research and Development Center.

RICHARD J. COAR - ENGINEERING MANAGER

Mr. Coar, as Engineering Manager, is responsible for the management of engineering design and development functions at the Florida Research and Development Center. Mr. Coar has 24 years experience in propulsion development at Pratt & Whitney Aircraft and has guided the engineering programs at the Florida Research and Development Center since it was established in 1956. As project engineer he was deeply involved in the development of the JT4 engine prior to its introduction into airline service.

BRUCE M. TORELL - CHIEF ENGINEER

As Chief Engineer, Mr. Torell assists the Engineering Manager in directing the design and development of air breathing and rocket engines at the Florida Research and Development Center. Mr. Torell has 24 years experience in propulsion system development, of which 20 years have been with Pratt & Whitney Aircraft. He held a project engineering position in the development of the JT4 engine, and for the past five years at the Florida Research and Development Center has been involved in the development of the RL10 rocket engine, the J58 supersonic turbojet, and the JTF17 Phase IIC engine.

ROBERT H. FOSTER - DEPARTMENT CONTROLLER

Mr. Foster, as Department Controller, is responsible for all accounting and treasury operations at the Florida Research and Development Center. He has had this responsibility since 1961 and has a total of 24 years' experience in accounting and treasury with Pratt & Whitney Aircraft.

ALDEN F. SMITH - CHIEF, ENGINEERING OPERATIONS

As Chief, Engineering Operations, Mr. Smith is responsible for manufacturing, assembly, test, materials engineering, computing laboratory, facilities, and quality assurance. These line departments provide the Florida Research and Development Center program managers with the manufacturing and laboratory support required to fulfill program requirements. Under Mr. Smith's direction since 1961, these departments have provided services for both RL10 and J58 development and delivery programs, in addition to other engineering projects. Mr. Smith has had 25 years' experience with Pratt & Whitney Aircraft including overall design engineering responsibility for the JT3 and JT3D engines. He is the inventor of the bifurcated short fan duct configuration used on the JT3D and TF33 turbofans.

FRANK F. SCHIRM - PERSONNEL MANAGER

Mr. Schirm was appointed Personnel Manager at the Florida Research and Development Center in 1957 and is responsible for all Employment, Personnel Training, Personnel Health and Safety, Plant Protection, Wage and Salary Administration, and Employee Labor Relations activities. He has 23 years' experience with Pratt & Whitney Aircraft in the field of personnel and industrial relations.

SECTION III
JTF17 PROGRAM MANAGEMENT

One of the major strengths of the Pratt & Whitney Aircraft program management approach is the ability to handle several major programs concurrently through utilization of a strong functional organization that serves the needs of the several programs. The system of staffing and providing facilities to support the functional requirements of multiple programs permits the most advantageous application of the company's resources to all programs. Trained, experienced personnel and specialized facilities are available and can be phased in and out of each program as requirements dictate. This minimizes uneconomical duplication of facilities and avoids the instability associated with recruiting new personnel for each new program, and avoids the discharge of those whose functions are phasing out. As a result, a staff experienced in specialized fields and capable of fulfilling the functional requirements of each program has been developed and retained. This management approach is designed to derive the maximum benefit from the strengths of a functional organization. Design, development, and production of propulsion systems is the division's chief business, and new programs that fall within the field of experience developed by the functional organizations benefit from the interchange of expert knowledge which has been accumulated. Accordingly, Pratt & Whitney Aircraft believes that the use of its existing program management structure is uniquely suited to the requirement of the SST Engine Program, and will result in the most judicious use of funds, facilities, and personnel.

For Phase III of the SST Program, Mr. W. H. Brown, currently the J58 Program Manager, has been selected to be JTF17 Program Manager, and Mr. G. A. Titcomb, currently the Phase II-C JTF17 Program Manager, has been selected to be JTF17 Deputy Program Manager. The day-to-day direction of the JTF17 program will be provided by the Program Manager and his deputy, assisted by five managers assigned to the following areas of responsibility:

- Development
- Program Controls
- Product Assurance
- Product Support
- Engine Delivery

A JTF17 Management Committee having as members the General Manager, the heads of the Florida Research and Development Center line departments, and the Assistant Sales Manager will meet periodically to establish policy and provide management guidance for the program. The JTF17 program management will also be responsive to the airlines' requirements as expressed by an Airline Review Board. This overall JTF17 program management organization is summarized on figure 3. The specific responsibilities of the five Managers assigned to the program and their relation to the functional departments are shown in subsequent sections of this report. These responsibilities are related to the Phase III work breakdown structure in Appendix C to this report.

JTF17 Program Management

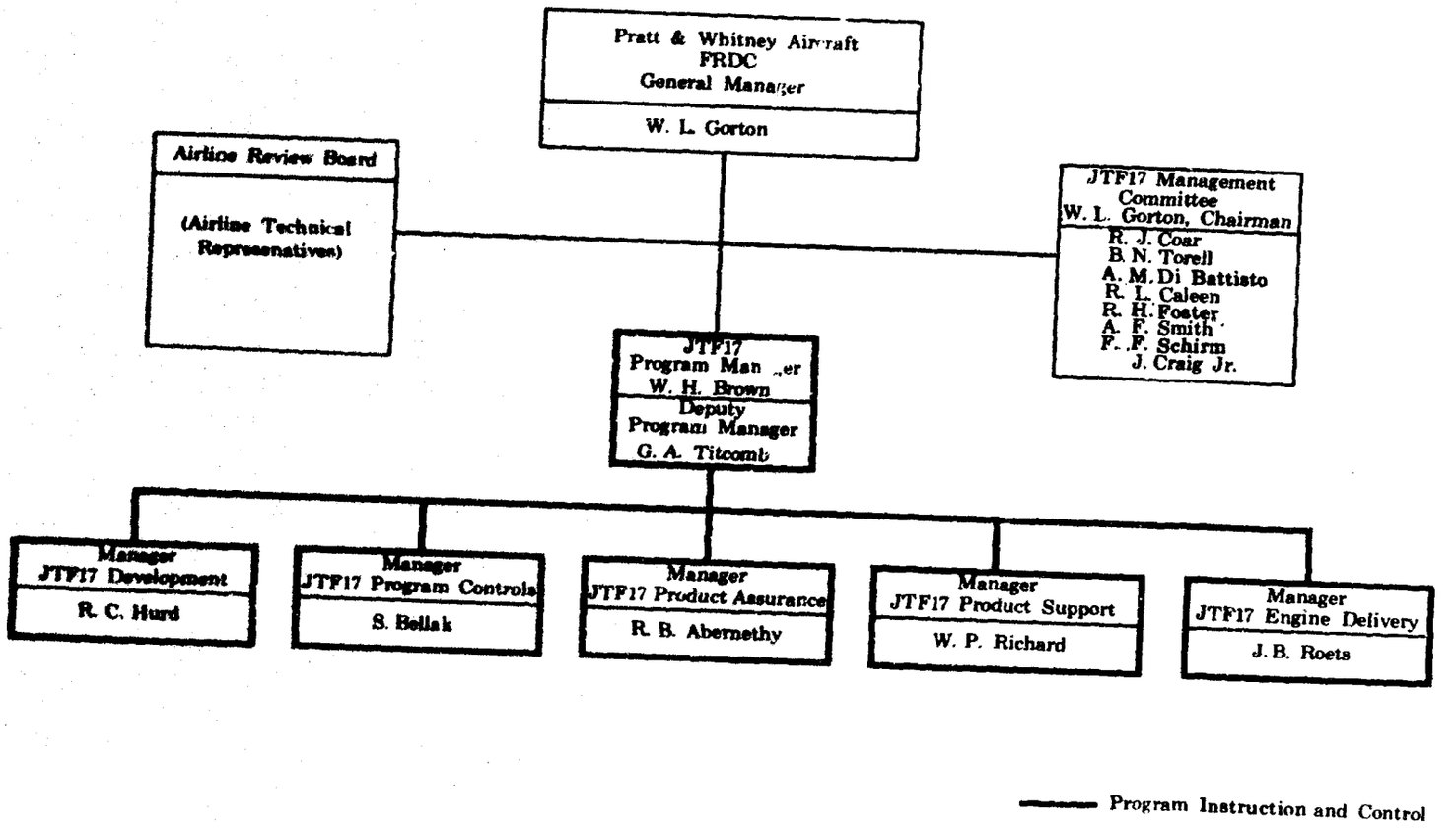


Figure 3.

Meetings of the Management Committee will normally be held weekly, and special meetings will be called by the General Manager or Program Manager as program developments require. By the operation of the Management Committee, Florida Research and Development Center management will participate actively in the conduct of the JTF17 program and will be kept fully aware of program problems and requirements for management action. This management technique is identical to that used at the Florida Research and Development Center on the J58 supersonic turbojet, the RL10 hydrogen rocket engine, and Phase II-C of the SST Program. These meetings will be directed by the Florida Research and Development Center General Manager, or in his absence the Engineering Manager, who will receive oral reports from the JTF17 Program Manager. His report will cover the areas of design, development, manufacturing, and product support and will also include progress in meeting the cost, schedules, and performance requirements. The Program Manager will call upon the managers responsible for JTF17 Development, Program Controls, Product Assurance, Product Support, and Engine Delivery to assist in making this report. They will review major program problems, provide a planned course of action along with any alternatives, and report on their final successful solution. The Chairman will assign responsibilities, resolve conflicts in plans or use of facilities, and establish schedules to support the Program Manager's recommendations for meeting program requirements or solving problems. On occasion, the Chairman may direct program changes or problem solutions if they are required in his judgment to meet over-all program objectives. The Deputy Program Manager will serve as secretary and, as directed by the Chairman, will maintain a list of problems including the assigned responsibilities and schedules for corrective action.

Pratt & Whitney Aircraft recognizes that the airlines desire to work directly and closely with the airframe and engine contractors during the SST design and development programs. To achieve the maximum effectiveness, the airlines have organized industry committees and endeavored to reach a common position on policy and planning regarding technical questions. One committee known as the Airline Supersonic Transport Committee with Mr. W.C. Mentzer as Chairman has already contributed substantially to the SST Program in Phase II-C. So that the airlines' contributions may continue to be effective, Pratt & Whitney Aircraft will plan specific program reviews for the airlines and will invite them to serve as an Airline Review Board for the JTF17 Engine Program. The schedule for these reviews will be coordinated with the airlines. These reviews to be conducted by JTF17 Program Management will cover policy and planning aspects of major technical questions, as well as reports on program progress.

Personnel shown on Figure 3 who have not been identified in earlier sections of this report have the qualifications and responsibilities described below:

WILLIAM H. BROWN - JTF17 PROGRAM MANAGER
GORDON A. TITCOMB - JTF17 DEPUTY PROGRAM MANAGER

As Program Managers, Mr. Brown and Mr. Titcomb will be responsible for managing all phases of the SST Engine Program and for providing

effective coordination and communication with the Federal Aviation Agency, the selected airframe contractor, and the using airlines. These managers will be delegated the necessary authority to meet cost, schedule, and performance requirements of the Phase III program.

Mr. Brown has been selected as Program Manager to take full advantage of the experience he gained in managing the J58 engine program. In that program, he has pioneered in solving the development problems associated with qualifying a turbine engine to operate continuously at high turbine temperatures in an environment more hostile than foreseen for the SST. He has also demonstrated the ability in the YF-12A and SR-71 airplane programs to resolve interface compatibility problems between the engine and its installation and has provided effective field support in the post-certification phase. Mr. Brown has 27 years experience with Pratt & Whitney Aircraft in engine development and engineering management including 9 years at the Florida Research and Development Center. He held the position of project engineer successively on the J42 and J48 engine programs in the late 1940's and was directly responsible for the development of the first Pratt & Whitney Aircraft afterburner as well as the afterburners used on military J57 engines. He subsequently was Project Engineer on the JT3 when it was first flown in the prototype Boeing 707 (367-80), and later on the JT4 engine, and was directly responsible for the development program necessary to obtain the commercial Type Certificates for these two engines.

Mr. Titcomb's experience in program management includes his current position as program manager of the JTF17 Phase IIC activity, and his prior assignment as RL10 Program Manager where he was responsible for development, delivery, and field support of the world's first hydrogen-fueled rocket engine. He has 18 years experience at Pratt & Whitney Aircraft including development responsibility as project engineer in the J52, JT4, and JT3D engine programs.

Both Mr. Brown and Mr. Titcomb have had overall program management responsibility for previous programs where the development was conducted in Florida, and which involved product support from the Connecticut functional departments and the production delivery of engines manufactured in Connecticut.

JOHN CRAIG, JR. - ASSISTANT SALES MANAGER

As Assistant Sales Manager, Mr. Craig has had direct responsibility under the Vice President, Marketing, for all of the marketing activities on the SST engine project. Mr. Craig has 32 years experience with Pratt & Whitney Aircraft, 27 of which have been in various field engineering and marketing capacities. In these capacities, he has been closely associated with the transport aircraft manufacturers and with the airline operators, both domestic and foreign, on many commercial transport projects. Mr. Craig will continue to serve the SST program as a member of the JTF17 Management Committee representing the Marketing Department.

RICHARD C. HURD - MANAGER, JTF17 DEVELOPMENT

As Development Manager, Mr. Hurd will be responsible for directing the design and development of the JTF17 engine. He has been selected

for this position based on his experience as project engineer during the JTF17 Phase II-C program and as the project engineer responsible for the 150 hour qualification testing of the only U.S. Mach 3+ production turbojet (J58). Mr. Hurd has 20 years of research and development experience at United Aircraft Corporation, including assignments as project engineer on the JT4 engine.

SEYMOUR BELLAK - MANAGER, JTF17 PROGRAM CONTROLS

Mr. Bellak will be responsible in this position for fiscal management, data management, and program planning aspects of the JTF17 program. Mr. Bellak has had similar responsibilities in the JTF17 Phase II-C program and earlier in the RL10 rocket engine program. He has 18 years' experience in propulsion development at Pratt & Whitney Aircraft, including nine years at the Florida Research and Development Center.

ROBERT B. ABERNETHY - MANAGER, JTF17 PRODUCT ASSURANCE

Dr. Abernethy's program responsibilities will include Configuration Management, Reliability, Safety, Maintainability and Human Engineering, Standardization, Value Engineering, and Quality Assurance. He is currently responsible for JTF17 performance analysis and was earlier in charge of all reliability and statistics at the Florida Research and Development Center. He has 11 years' experience at Pratt & Whitney Aircraft and is the inventor of the bleed-bypass cycle used currently in the J58. Dr. Abernethy is a Fulbright Scholar and a Fellow of the Royal Statistical Society.

WARREN P. RICHARD - MANAGER, JTF17 PRODUCT SUPPORT

Mr. Richard will be responsible for directing all product support activities for the JTF17 program including spare parts provisioning, field service, and field engineering. He will also coordinate field problems with the reliability, safety, and maintainability engineers and will maintain an effective liaison for the program manager with the Federal Aviation Agency, the airframe contractor, and the airlines. He brings to this position his past experience as RL10 product support manager, and his knowledge of the JTF17 program gained during his current assignment as assistant to the JTF17 program manager. Mr. Richard has 24 years' experience in product support positions at Pratt & Whitney Aircraft. From 1945 to 1953, as Supervisor of field service for the eastern United States, he was responsible for Pratt & Whitney Aircraft's support of engine overhaul activities at Pan American, Eastern, National, and Capital airlines.

JAMES B. ROETS - MANAGER, JTF17 DELIVERY

Mr. Roets will manage the delivery of prototype engines during Phase III and will direct the overhaul of these engines. Mr. Roets held similar responsibilities under the RL10 program manager, where he directed the on-time delivery of over 100 rocket engines. His 24 years' experience at Pratt & Whitney Aircraft includes assignments in development engineering, quality assurance, materials control, and production liaison engineering.

A. DEVELOPMENT MANAGEMENT

The development of the JTF17 engine will be directed by project engineers under Mr. Hurd using the project engineering system initiated at Pratt & Whitney Aircraft in 1939. These project engineers direct the design-construct-test-analyze-redesign cycle that is the key to successful propulsion development.

Figure 4 shows the program management provided by these project engineers as it is overlaid on the operating departments. Generally, the design analysis and drawings are provided by the Design Department; hardware is scheduled by Manufacturing Operations either within the engineering shops or through Purchasing from vendors; parts are assembled in Experimental Assembly, and subjected to test in the Test Operations or Materials laboratories. Analysis of results is performed in Test Operations and Design using, as required, the services of the Computing Laboratory. All of these functions are performed in accordance with project engineers' instructions. Any development activity must be authorized by an engineering order supplement approved by the Development Manager and the Program Manager.

To provide positive assurance that there will be a cross flow of information from other related projects to the JTF17 design, a Design Review Board of senior program personnel has been established. This Board will continue to review the JTF17 design and development status on a scheduled basis to ensure that the JTF17 program will derive full benefit from the knowledge gained in state-of-the-art research programs, the continuing J58 program, and particularly from the experience gained from our other engines in commercial service. The members of this Board, headed by Mr. Brown and Mr. Titcomb, will be as follows:

Florida Research and Development Center Members

J. F. McDermott - (J58)
H. N. Cotter - (Performance)
R. A. Schmidtke - (Applied Research)
W. P. Richard - (JTF17 Product Support)

Connecticut Operations Members		Title
F. H. Morrison	- (JT4)	Project Engineer
G. E. Woodger	- (JT3D and JT9)	Project Engineer
F. T. Sprogell	- (JT8D)	Asst. Chief Engineer, Production Engines

JTF17 Development Management

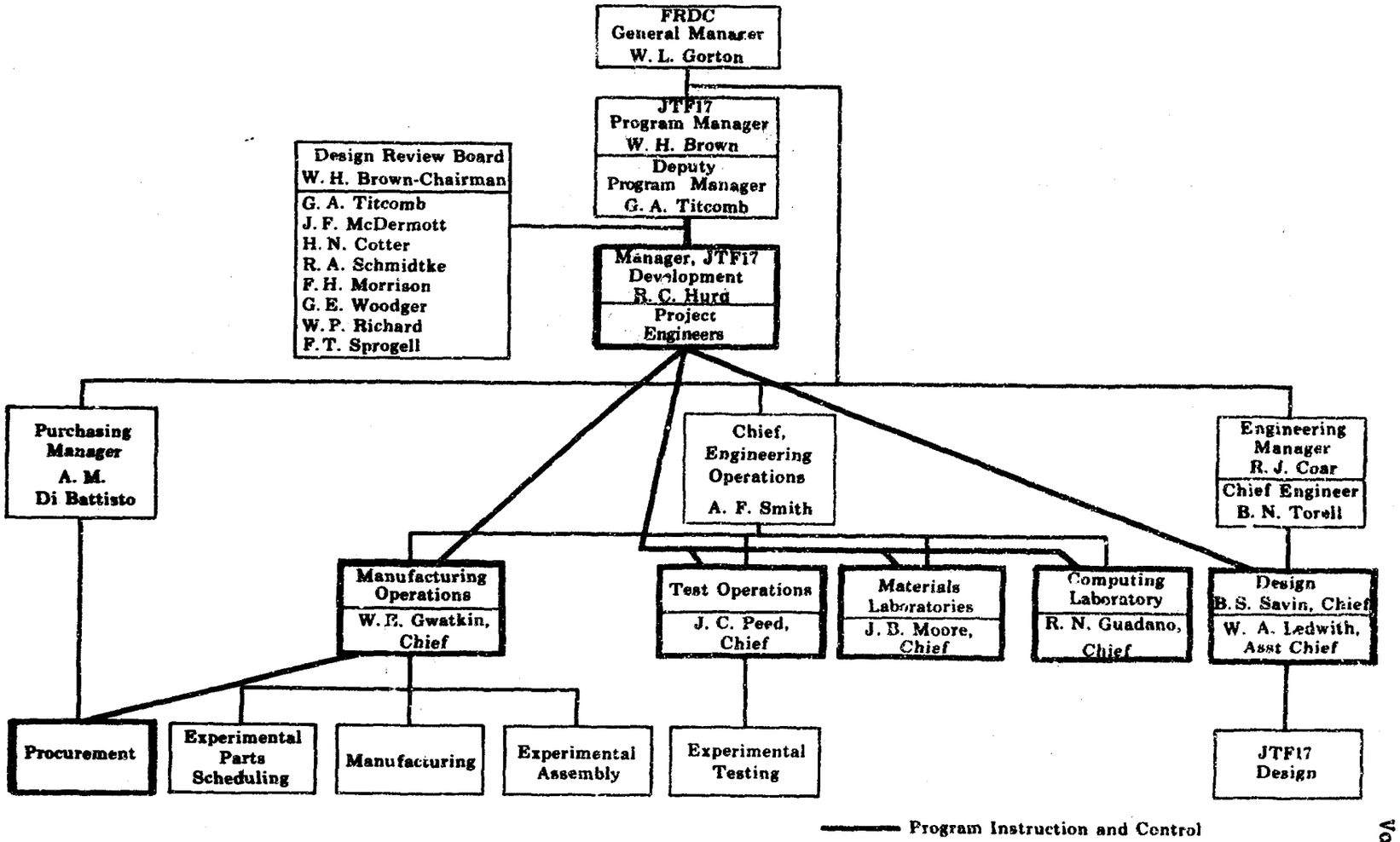


Figure 4.

Key personnel in the operating departments that will support the JTF17 development are listed below:

WESLEY E. GWATKIN - CHIEF, MANUFACTURING OPERATIONS

Mr. Gwatkin is responsible for providing the manufacturing capabilities required by program management, including facilities, tooling, and manpower. The assembly and material control phases of manufacturing are also under his supervision. He has 28 years' experience in engineering, material control, and manufacturing including 5 years in his present position at the Florida Research and Development Center.

JAMES C. PEED - CHIEF, TEST OPERATIONS

Mr. Peed, is responsible for supervising the activities of all turbojet and rocket engine test departments including instrumentation and data acquisition activities. He has had this responsibility since 1961. Mr. Peed has 21 years' experience in aircraft propulsion development engineering and testing activities at Pratt & Whitney Aircraft in a variety of technical and supervisory positions including 5 years in charge of the company's flight test activities at Edwards Air Force Base, California.

JOSEPH B. MOORE - CHIEF, MATERIALS LABORATORIES

Mr. Moore is responsible for all materials development activity and provides metallurgical, chemical, and physical testing services for program management. Mr. Moore has been responsible for much of the high temperature metallurgy used in the J58 turbine, particularly the successful application of IN100 to turbine airfoils, and the development of consistent properties in Astroloy forgings. He has 12 years' experience in materials engineering.

ROBERT N. GUADANO - CHIEF, COMPUTING LABORATORY

Mr. Guadano is responsible for supervision of specialists engaged in scientific and engineering problem mathematical analysis, digital applications programming, analog simulation, and scientific data processing operations. He provides program management with the required electronic data processing and computing capability. Mr. Guadano has 14 years' experience in the application of high speed computers to scientific and engineering problems at the United Aircraft Corporation Research Laboratories and as Chief, Computing Laboratory at the Florida Research and Development Center since 1957.

BENNETT S. SAVIN, JR. - CHIEF, ENGINE DESIGN

As Chief, Engine Design, Mr. Savin is responsible for all design activities including board design, analytical design, drafting, and design services. Mr. Savin has 28 years' design experience of which 24 years have been with Pratt & Whitney Aircraft. During the period 1950-1956, he was assistant chief of the design group which designed the JT3/J57 engine, and he holds the patent for the twin-spool engine concept employed in the JT3, JT4, JT3D, JT8D, and other Pratt & Whitney engines. He has been in charge of the Florida Research and Development Center Design Department since 1957. He (and Mr. Ledwith, below) carried primary responsibilities for the J58 engine design.

WALTER A. LEDWITH - ASSISTANT CHIEF, ENGINE DESIGN

Mr. Ledwith has assisted Mr. Savin in the technical direction of the Florida Design Department since 1961. He has 27 years experience in design engineering of which 25 years have been with Pratt & Whitney Aircraft and includes involvement in most of turbine engines designed in Hartford up to the time he came to Florida Research and Development Center in 1961. Mr. Ledwith was one of the design engineers responsible for the original JT3 design and holds 47 patents in the field of propulsion.

The qualifications of some of the design specialists who will be assigned to the JTF17 program are listed in Appendix B to this report.

1. Project Engineering

The senior project engineers assigned to assist Mr. Hurd in the development of the JTF17 engine are shown on figure 5. Where the sharing of facilities or specialist services is required, as in control development or performance analysis, the assigned project engineers reside with a specialist group. In this way, the JTF17 control development will benefit from the experience encountered in the J58 program, with over-all guidance for the work on both control systems continuing under Mr. Esmeier. Similarly, the JTF17 performance section will receive guidance from Mr. Cotter and will have available the analytic methods developed in the RL10 and J58 programs. Experimental programs advancing the state-of-the-art and which may have application to the JTF17 will be conducted under the general supervision of Dr. R. A. Schmidtke's Applied Research group because new concepts in combustion, heat transfer, or compressor techniques receive more attention and make better initial progress when they are divorced from the day-to-day pressures of a development program that has a schedule to meet.

The qualifications of the senior project engineers selected for the key positions shown on figure 5 are given below:

ARTHUR F. HIEGEL - PROJECT ENGINEER

As Project Engineer, Mr. Hiegel will continue to be responsible for hot section engine development as he has been during Phase II-C. Mr. Hiegel has 18 years' experience with Pratt & Whitney Aircraft in design and development engineering. He has been largely responsible for the development of the J58 high temperature convectively cooled turbine. His previous experience included work on the R2800 and JT3/J57 and JT4/J75 engines.

FREDERICK L. PARKER - PROJECT ENGINEER

Mr. Parker will be responsible for general engine development and for fan and compressor component development. He has 27 years' experience in engine development and was one of the project engineers on the JT3/J75 engine. Mr. Parker has specialized in hydrogen turbopump development and is currently project engineer in charge of advanced RL10 rocket engine activity.

JOSEPH M. SILK - PROJECT ENGINEER

As colonel, United States Air Force, Mr. Silk has been Chief of the Aeronautical Propulsion Laboratory, Directory of the Rocket Propulsion Laboratory, and Deputy Chief of Staff for Research and Engineering, in the Air Force Systems Command. Prior to these assignments, he was chief engineer in the B52 weapon systems project office. Mr. Silk's experience in airframe/engine integration will be valuable in his position in charge of engine development programs aimed at improving inlet compatibility and solving interface problems between the engine and airframe. He will also be responsible for development of external engine components including the exhaust system.

JTF17 Project Engineering Organization

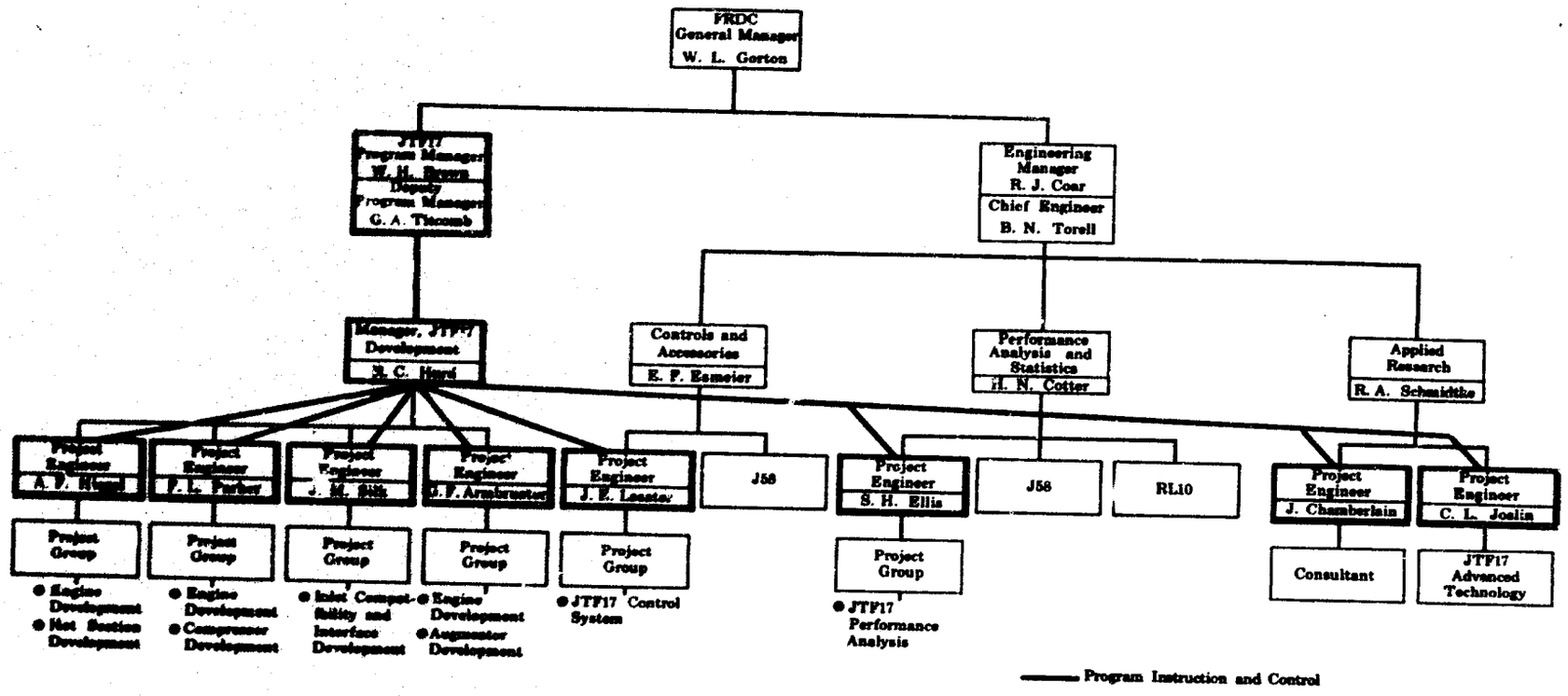


Figure 5.

GEORGE F. ARMBRUSTER - PROJECT ENGINEER

Mr. Armbruster will be assigned to the JTF17 program to conduct general engine and augmentor development. He is currently a project engineer on the supersonic cruise J58 engine, and has 26 years' experience at Pratt & Whitney Aircraft, including work on the commercial version of the R4360 engine. He was the project engineer in charge of the first Federal Aviation Agency certification test on the JT4 commercial jet engine.

EDWARD F. ESMEIER - CHIEF, CONTROLS & ACCESSORIES

Mr. Esmeier will continue in charge of the project groups responsible for control and accessory development on the J58 and JTF17 engines. He is familiar with the competence of all the major vendors in this field of activity and has specialized in this work for most of his 26 years at Pratt & Whitney Aircraft. Mr. Esmeier has been directly responsible for the development of the operational engine controls used on the JT3/J57 and J58 engine. The J58 control system operates without external cooling under environmental conditions considerably more severe than will be encountered on the SST engine.

JOHN E. LASATER - PROJECT ENGINEER

Mr. Lasater will be assigned to the JTF17 program to take charge of the control and fuel system component development for the engine. He has 18 years' experience in engine and control development at Pratt & Whitney Aircraft. In his current assignment as a J58 control project engineer, Mr. Lasater has been responsible for the development of the engine governing system that provides airflow control to meet supersonic inlet requirements of the YF-12 and SR-71 aircraft.

HARRY N. COTTER - CHIEF, PERFORMANCE AND STATISTICS

Mr. Cotter will continue to have technical supervision of the analytical groups responsible for performance analysis of ground and flight test results from JTF17, J58, and RL10 engines. He has 18 years' experience at Pratt & Whitney Aircraft and was in charge of JT4/J75 performance analysis prior to his transfer to the Florida Research and Development Center in 1958. At the Florida Research and Development Center he has supervised supersonic exhaust system model testing and analysis, in addition to cycle analysis and flight test data reduction programs.

STANLEY H. ELLIS - PROJECT ENGINEER

Mr. Ellis will be in charge of all JTF17 performance analysis. He has been selected for this position because of his outstanding work in the analysis of J58 flight and ground test data, for which he is currently responsible. Mr. Ellis has been a flight test section leader for Armstrong-Whitworth Aircraft and a chief engineer for United States Industries, Incorporated, prior to joining Pratt & Whitney Aircraft in 1958.

RICHARD A. SCHMIDTKE - DIRECTOR OF APPLIED RESEARCH

As Director of Applied Research, Dr. Schmidtke manages contract and company programs aimed at improving the state-of-the-art in air-breathing and rocket propulsion. Under his direction the Applied Research group has evolved several highly efficient cooling techniques, the ram induction burner, the double-wall vaporizing combustor, and has made progress in advanced variable geometry compressor concepts. He received his doctorate in mechanical engineering from the University of Illinois in 1953 and has held his present position since 1960. Work on advanced concepts for the JTF17 will be performed under Dr. Schmidtke's supervision by JOHN CHAMBERLAIN and CHARLES L. JOSLIN. Mr. Chamberlain was responsible for the novel chamber cooling technique used in the Pratt & Whitney Aircraft high pressure rocket engine and is co-inventor of the ram-induction burner that has made turbofans practical for SST application. Mr. Joslin conducted the initial experimental work on the ram-induction burners and on advanced heat transfer concepts that made possible the application of full convective cooling to the JTF17 turbine.

The qualifications of other development specialists who will be assigned to the JTF17 Phase III program are listed in Appendix B to this report, following the design personnel resumes. Experienced assistant project engineers and experimental engineers will be assigned to this project engineering team to conduct the development program.

B. PROGRAM CONTROLS

The JTF17 program control organization under Mr. Bellak is shown on figure 6.

JOE J. WILCOX, a cost control engineer, will be in charge of establishing budgets, evaluating costs, revising estimates, and advising the program manager on the financial status of the program. Mr. Wilcox has had 20 years' experience in the United States Navy, including 14 years of procurement and contracting officer responsibilities. He is well qualified for this new assignment by his past four years' experience as cost control engineer for the J58 program manager.

NICHOLAS W. BARRE will continue to be responsible for data management on the JTF17 program, including the generation, collection, preparation, and dissemination of JTF17 data to the government, the airframe contractor, and the airlines. Mr. Barre has three years' experience with the company in development engineering work.

JAMES T. DAUGHTRIDGE will be assigned to the program control organization to coordinate the requirements for and to maintain the Master Program Plan and the Detailed Work Plan, described in Volume V. He is currently an assistant project engineer in the JTF17 development group and has 8 years' experience in propulsion development.

JTF17 Program Controls

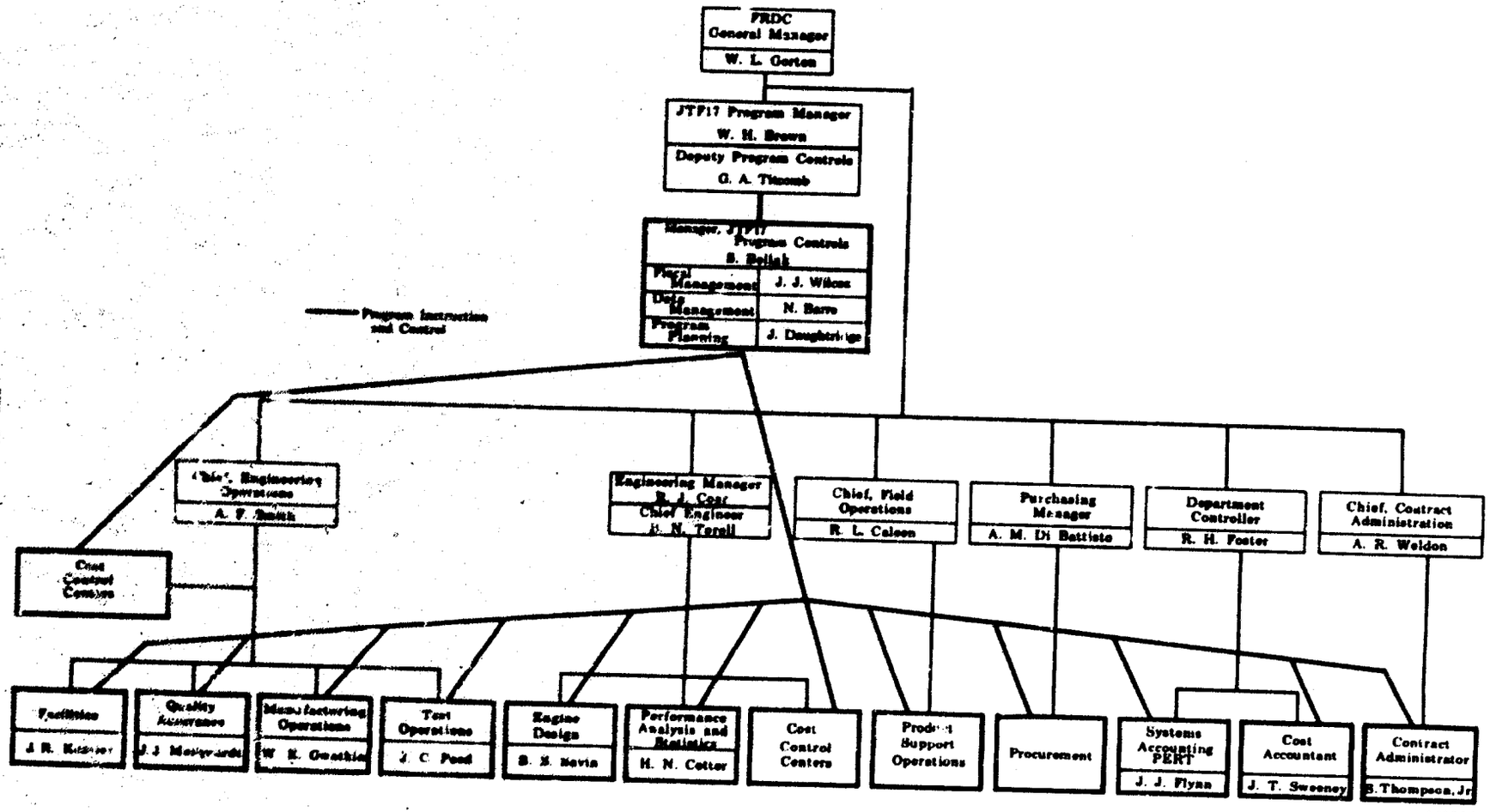


Figure 6.

661508
FD 17703

C. PRODUCT ASSURANCE

The product assurance organization under Dr. Abernethy and its relation to the operating departments are shown on figure 7.

DONALD E. LAW, as Chief, JTF17 Reliability, will be responsible for all reliability analysis, assessment and reporting, and for providing technical direction to the Design and Development Reliability Groups to assure that the JTF17 meets its reliability goals. Mr. Law has 8 years' experience in engineering analysis and has been responsible for reliability analysis for the RL10 rocket engine program.

EDWARD CUSHING, as JTF17 Safety Engineer, will coordinate the work to provide maximum engine safety consistent with other engineering parameters throughout the design, development, production, and service phases of the engine program and assure that safety aspects have been coordinated with the airframe manufacturer. Mr. Cushing has 23 years in propulsion development, of which 11 years have been with Pratt & Whitney Aircraft. He was responsible for the high pressure hydraulic system for the J58.

GERARD LEDDY, as JTF17 Value Engineer, will coordinate and control the implementation of the Value Engineering Program to provide function-to-cost evaluation of all aspects of the JTF17 engine program, as described in Volume IV. Mr. Leddy has 16 years' experience in propulsion system design and development, including nine years at the Florida Research and Development Center as a supervisor in Project Material Control where he was responsible for supplying hardware to meet engine development requirements.

ROBERT T. HASKO, as Chief, Configuration Management, will coordinate the JTF17 configuration management program to provide engine and component part identification, engineering change control procedures, and component and engine assembly accountability, as described in Volume V, Report C. Mr. Hasko is currently a senior design analyst at the Florida Research and Development Center, responsible for adapting electronic data processing to the configuration management records system. He has 20 years' experience in engineering design work.

ALLAN ANDERSON, as Chief, JTF17 Maintainability and Human Engineering, will coordinate the effort necessary to ensure that the objectives of reducing engine maintenance cost, reducing engine-chargeable downtime, and minimizing human error are considered throughout all phases of the JTF17 engine program from design inception through operational service. Mr. Anderson has 22 years' experience in product support capacities for Pratt & Whitney Aircraft. He was Assistant Area Supervisor covering the central United States providing service coverage for this region, prior to his current assignment supporting the J58 engine. In addition to this experience with the supersonic J58, Mr. Anderson has an intimate knowledge of airline maintenance and engine overhaul problems gained from his earlier assignments at various airlines including Eastern, National, American, Northwest, Braniff, Pan American, BOAC, Swissair, Sabena, and Air India.

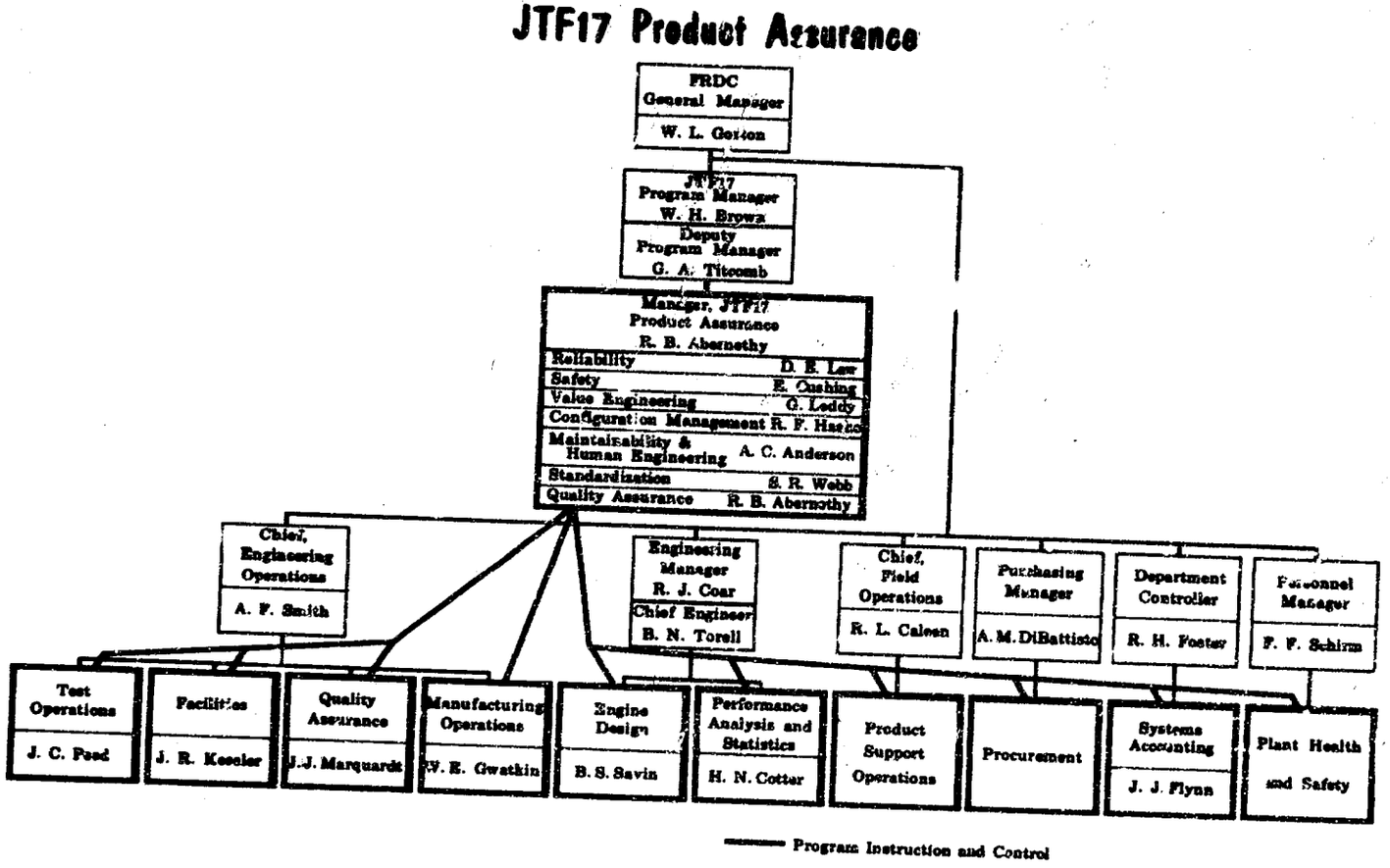

JTF17 Product Assurance
FRDC
General Manager
W. L. Gorton
JTF17
Program Manager
W. H. Brown
Deputy
Program Manager
G. A. Titcomb
Manager, JTF17
Product Assurance
R. B. Abernethy
Reliability D. E. Law
Safety E. Cushing
Value Engineering G. Leddy
Configuration Management R. F. Hazzo
Maintainability & Human Engineering A. C. Anderson
Standardization S. R. Webb
Quality Assurance R. B. Abernethy
Chief, Engineering Operations
A. F. Smith
Engineering Manager
R. J. Coar
Chief Engineer
B. N. Torell
Chief, Field Operations
R. L. Calean
Purchasing Manager
A. M. DiBattisto
Department Controller
R. H. Foster
Personnel Manager
F. F. Schirm
Test Operations
J. C. Pead
Facilities
J. R. Keesler
Quality Assurance
J. J. Marquardt
Manufacturing Operations
W. E. Gwatkin
Engine Design
B. S. Savin
Performance Analysis and Statistics
H. N. Cotter
Product Support Operations
Procurement
Systems Accounting
J. J. Flynn
Plant Health and Safety
Program Instruction and Control

Figure 7.

J. F. WEBB, as Standardization Engineer, will provide the direction necessary to ensure that the standardized parts, processes, and procedures are considered for application to the JTF17 engine consistent with the objectives of ensuring reliability, safety and quality, improving maintainability, and reducing costs. Mr. Webb has five years' experience in turbine engine design, including three years specializing in standardization.

JOHN J. MARQUARDT, as Chief, Quality Assurance, will direct all phases of the quality control program, as described in Volume V. He will keep the JTF17 Product Assurance Manager apprised of quality assurance status and provide special reports or corrective action as requested by the program management. Mr. Marquardt, a graduate engineer, has 24 years of quality assurance experience at Pratt & Whitney Aircraft. He has been responsible for adapting air-gage systems to airfoil inspection and for developing optical alignment systems to inspect engine interface locations. At the Florida Research and Development Center, Mr. Marquardt has established quality assurance procedures that meet the standards of MIL-Q-9858A and NPC-200-2 for both development and production aspects of the RL10 and the J58 engines.

D. PRODUCT SUPPORT

A general description of Pratt & Whitney Aircraft's product support activities is given in the company competence section, Report K of this Volume V.

The JTF17 product support organization is shown on figure 8. During the development phase, in addition to the normal product support functions under Mr. Richard, project engineers and experimental engineers will also be stationed at AEDC, at the airframe contractor's plant, and at the flight test site to provide engineering assistance for these test programs. The product support groups shown on figure 8 function as follows.

FLIGHT OPERATIONS ENGINEERS work with the commercial airlines' flight operations groups in the refinement of Pratt & Whitney Aircraft Specific Operating Instructions to meet the needs of each airline's route structure. They assist the airlines in establishing operating procedures to extend useful engine life and ride in the cockpit as necessary to assist in the analysis and solution of operational problems encountered in flight on the airlines routes. Flight Operations Engineers will be assigned to the JTF17 product support organization to assist in the development of the JTF17 Specific Operating Instructions to guide the application of the AIDS system to engine condition monitoring and to bring practical airline engine operations experience into the early development phase.

WILLIAM E. BURKE will be responsible for the Service Support activities for the JTF17 program. This includes the Field Service Representatives assigned to the ground and flight test activities and to the engine heavy maintenance and overhaul sites, the technical support for these representatives, the design and development of ground support equipment, preparation of JTF17 Service Bulletins and Maintenance and Overhaul Manuals, and Customer training. Following a career in Naval Aviation as a carrier operations and test pilot, Mr. Burke has spent the last twelve years in the Pratt & Whitney Aircraft Service Department in technical activities associated with maintenance and overhaul commercial engine planning. Since 1958 he has been responsible for all service functions associated with the J58 program.

WALTER L. THIER will direct the JTF17 Spare Parts activity which includes the planning for and provisioning of spare parts and GSE to support the ground and flight test activities, the control of these parts and GSE throughout the logistic cycle, the preparation of spares and GSE documentation such as Parts Catalogs, Prices Parts Lists, and recommended spares levels for airline operation, and the Spare Parts Representatives stationed at the field sites. Mr. Thier's twenty-four years at Pratt & Whitney Aircraft includes a broad background of worldwide logistic experience. Since 1954 he has been directly associated with field logistic activities at various military engine overhaul depots and at major operating bases throughout Europe and the Far East. Mr. Thier has directed all spares activities associated with the J58 and the RL10 programs.

JTF17 Product Support

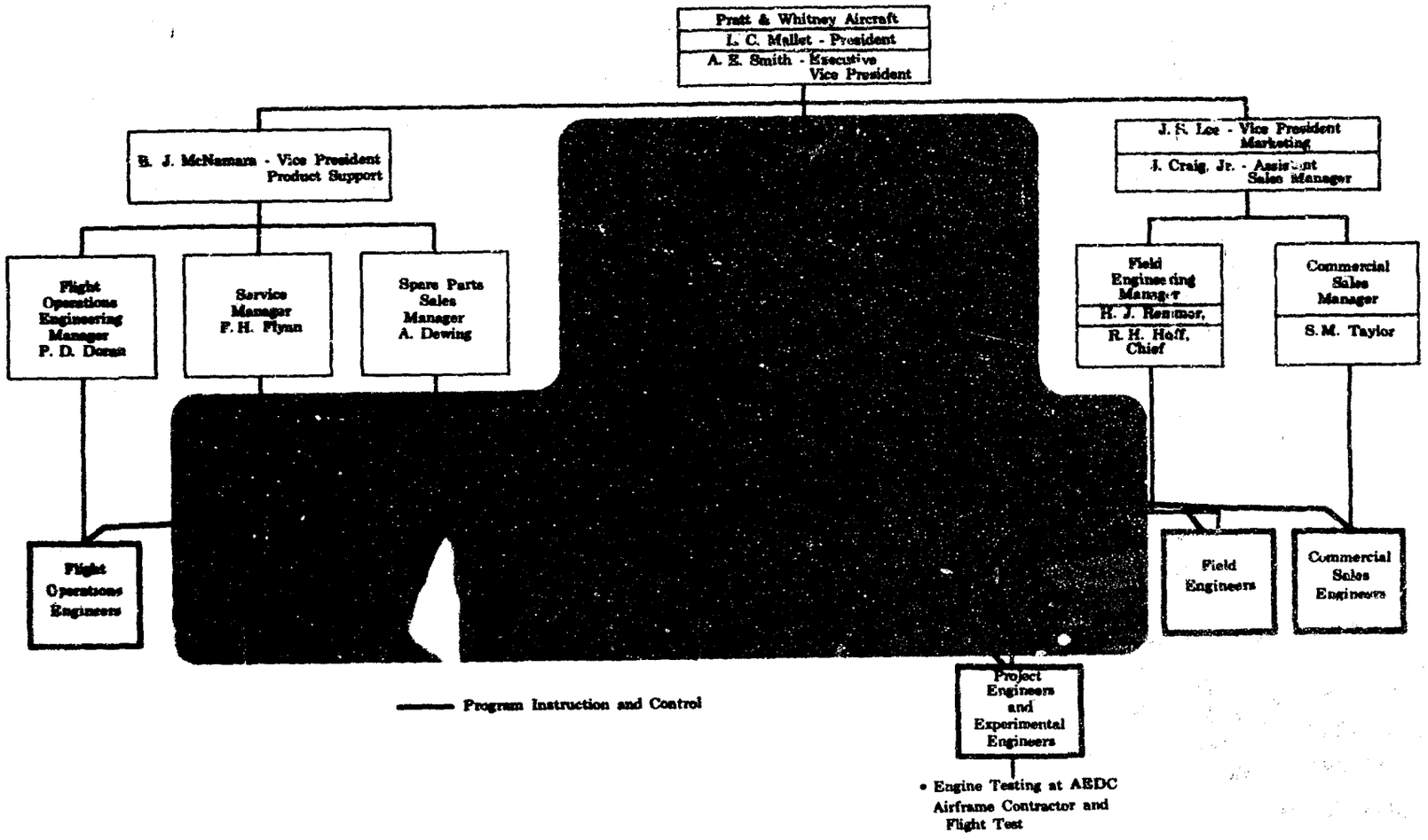


Figure 8.

ROBERT H. FRAZIER will continue to be responsible for all Installation Engineering activity in the JTF17 program. This includes control of the Pratt & Whitney Aircraft Field Survey Layout System by which all Pratt & Whitney Aircraft engineering changes in the airframe/engine interface areas are coordinated with the airframe manufacturer. Installation Engineering provides the technical liaison between the project engineering organization responsible for JTF17 development and the Pratt & Whitney Aircraft Field Engineers at the airframe manufacturer's production and test sites. He is responsible also for the support of JTF17 mock-ups at the airframe manufacturer's design and engine buildup sites and the publication of the JTF17 Installation Handbook and Specific Operating Instructions. Mr. Frazier has been associated with Installation and Field Engineering activities at Pratt & Whitney Aircraft for the past fifteen years including participation in the Boeing 707 flight test program as a field engineer. He has been responsible for all J58 installation engineering effort since 1959.

FIELD ENGINEERS are currently active at both airframe manufacturers in providing JTF17 technical assistance to each relative to their SST design study effort. This activity will increase with the initiation of Phase III, and additional Field Engineers will be assigned to the JTF17 Product Support organization. Field Engineers are responsible for assisting the airframe manufacturer in the design integration of the JTF17 engine into the SST airframe. Their primary function is to coordinate all performance and installation engineering information with the airframe manufacturer. This includes the engineering change activity in the airframe/engine interface areas associated with the Pratt & Whitney Aircraft Field Survey Layout System and JTF17 mock-ups.

COMMERCIAL SALES ENGINEERS are actively participating in the present competitive phase of the SST program by keeping the airlines abreast of Phase II-C JTF17 developments. This activity will intensify as Phase III proceeds. The Commercial Sales Engineers provide the medium through which all technical and marketing data is exchanged with the potential SST customers.

E. ENGINE DELIVERY

The JTF17 Engine Delivery organization (Prototype and Overhaul) at the Florida Research and Development Center is shown on figure 9. During Phase III, four ground test and sixteen prototype engines are scheduled for delivery. In addition, during Phases III and IV, engine overhauls will be performed in support of the aircraft flight test program. This work will be performed at the Florida Research and Development Center, where in addition to a separate management group, physically separate areas will be set aside for inspection, storage, and assembly of the parts, materials, and components used in delivery and overhaul engines. By this segregation, any accidental commingling of flight parts and experimental parts is avoided, and the formalized documented procedures necessary for quality assurance, assembly, and test of flight engines can be readily implemented.

The Manager, JTF17 Engine Delivery (Mr. J. B. Roets) and the delivery project engineers assigned to his group will direct the efforts of the functional departments in accomplishing the delivery of engines to meet the required schedules. In accordance with instructions from the Delivery Manager, Manufacturing Operations will issue orders to the Purchasing Department for those raw materials, finished parts, and tooling to be procured for the program, and will also perform the day-to-day scheduling and expediting, and the manufacture of tooling and parts in the shops at the Florida Research and Development Center. The Engine Delivery Manager's project group will issue instructions to the segregated Delivery Assembly Floor for the assembly of new prototype engines and for the reassembly of overhaul engines. As directed by this project group, acceptance testing of these engines will be performed on a designated test stand by the delivery engine test section, and assistance in the evaluation of test results will be provided by the JTF17 performance group.

The Phase V Production Management Organization, together with the Program Management lines of authority over the production program and the relationship of the J58 and the TF30 production engine programs, is shown on figure 10. The JTF17 production engines will be manufactured in Connecticut, with program management and development remaining in Florida. This arrangement is the same as that used in the RL10 and J58 programs while these engines were manufactured in Connecticut. The JTF17 Production Manager in Connecticut will be designated at the beginning of Phase V.

As indicated by figure 10, configuration control of the manufacture of production engines is the responsibility of the JTF17 Program Manager, and no change, no matter how small, can be made in the design of the production engine without the approval of the JTF17 Program Manager or his Florida based Engine Delivery manager. This includes changes made simply to facilitate manufacturing and is the same system of design configuration control employed for those commercial and military engines design and developed by the East Hartford Engineering Department.

JTF17 Engine Delivery

Prototype and Overhaul (Phases III and IV)

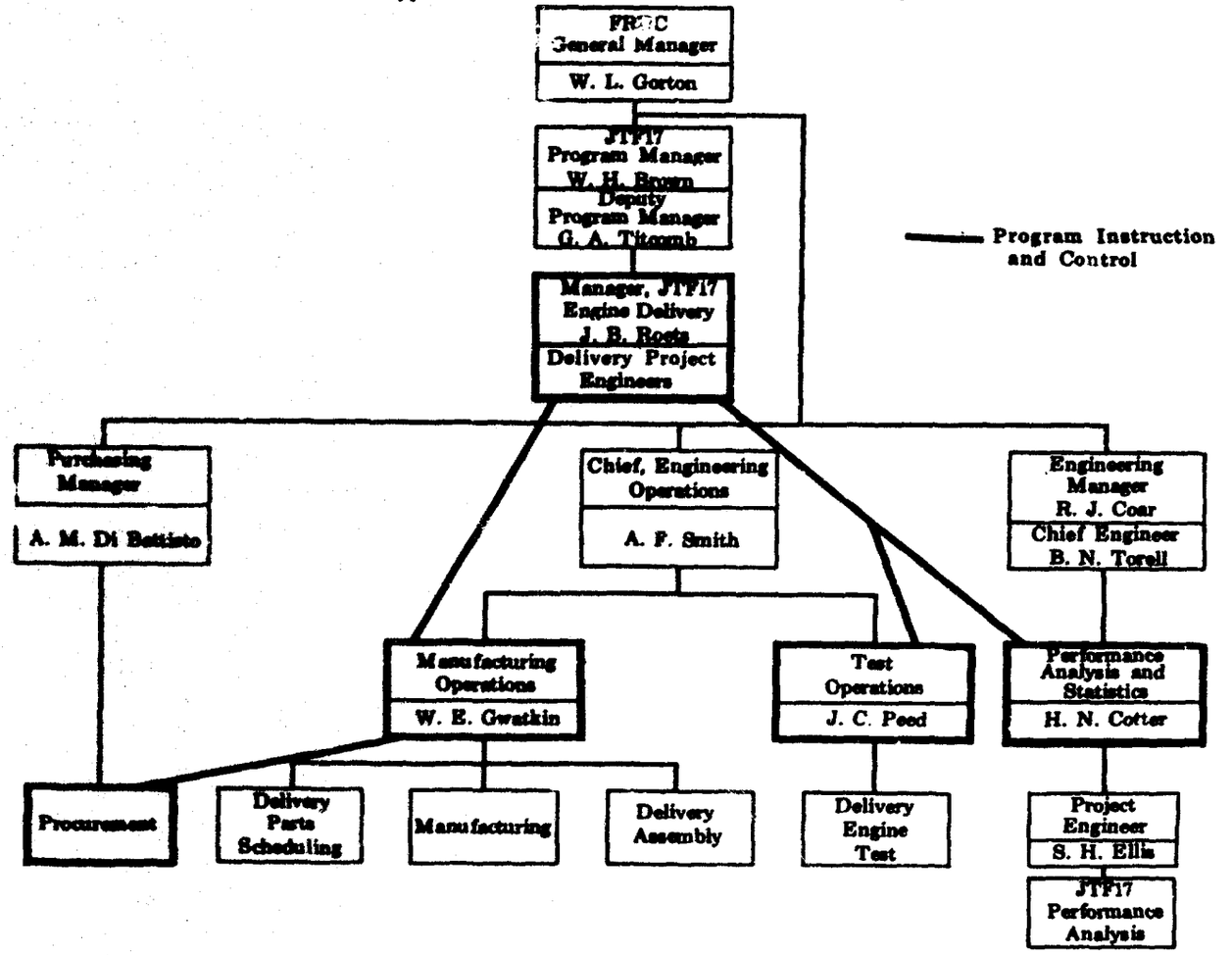


Figure 9.

JTF17 - Phase V Production Engine Delivery

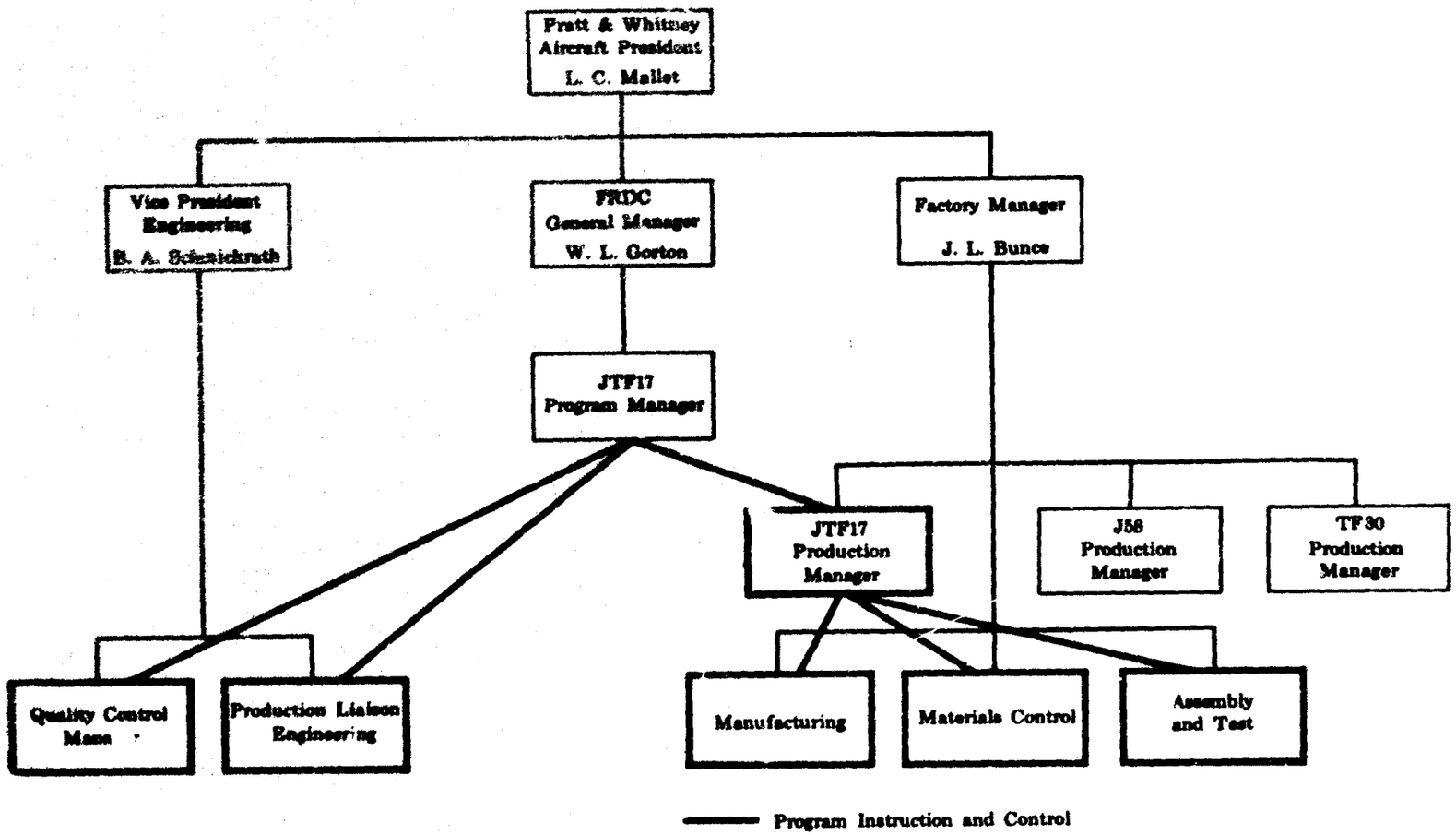


Figure 10.

SECTION IV
COMMUNICATIONS

Formal communications are received through the Florida Research and Development Center Mail Control Section which logs, disseminates, and follows-up on action requirements of each incoming piece of correspondence. Recipients of action correspondence are required to prepare responses as requested, obtain the necessary approvals, and appropriately distribute the replies. External informal communications, usually by telephone or meeting, are recorded by internal memorandum and, when appropriate, confirmed by letter. Internal communication is mostly written and follows the Program Management lines of authority with informal coordination occurring at all levels. Data management for the Phase III program is described in Volume V, Report D.

A. COMMUNICATIONS WITH THE FEDERAL AVIATION AGENCY, AIRFRAME CONTRACTORS, AND AIRLINES

The working level channels of direct communication already established between the Program Management organization and their Federal Aviation Agency counterparts will be continued and expanded to meet the needs of the program. The Program Manager will maintain direct communication with the Federal Aviation Agency Engine Project Manager. The JTF17 managers, who have full authority and responsibility to accomplish their particular portions of the program, will maintain direct communications with their Federal Aviation Agency counterparts. Those individuals covering specific areas of effort such as Reliability, Safety, Maintainability, and Quality Assurance will be direct points of contact for matters relating to these subjects. Contractual matters will be coordinated by the Contract Administrator. These direct channels of communication are maintained at appropriate organizational levels to eliminate delays inherent in systems which permit contact only at the top levels.

Communications with the airframe contractor will be coordinated by the JTF17 Product Support Manager who will maintain close contact with the airframe contractor personnel directly as well as through Pratt & Whitney Aircraft Field Engineers who will be in residence at the airframe contractor's facility. Telephone discussions and frequent visits between the aircraft contractor's engineering staff and the JTF17 project engineers will continue to supplement normal communication through our established Field Engineering organization.

Normal communication and coordination with the airlines through our Commercial Sales Engineering, Flight Operations Engineering, and Field Service organizations will be augmented by the Airline Review Board previously described. In addition, when the airlines start SST operation, periodic visits to the airlines' engineering, maintenance, and overhaul activities will be made by JTF17 project engineers personally to acquire information concerning any problems being encountered so that appropriate corrective design and development work can be initiated on the basis of first-hand knowledge.

The Pratt & Whitney Aircraft office in Washington will continue to be available to assist with communications.

B. INTERNAL COMMUNICATIONS

The Program Manager utilizes both formal and informal channels of communication in directing the course of the program. The formal channels are used for program directives and periodic technical, budgetary, and manpower reports. Upon receipt of a contract, for example, formal work orders describing the effort to be accomplished are directed to the appropriate functional departments. These key documents establish the basis for over-all program performance, scheduling, and cost control.

Informal communications play the most vital part in the management of the program. Weekly Management Committee meetings are conducted for schedule, cost, and performance reviews. Daily informal morning reports are submitted by the individual sub-managers (Development, Delivery, Program Control, etc.) to the Program Manager and General Manager presenting the status of activities in their areas of effort. Informal channels provide immediate intelligence on all phases of the program to the Program Manager so that he is at all times advised as to the latest developments and no time is lost in making vital decisions to effect prompt resolution of program problems.

SECTION V
SUPPORTING FUNCTIONS

Engineering Operations provides services of the machine shop, assembly and test, master mechanic, prototype engine production engineering, materials control, plant engineering, facilities planning, quality assurance, materials laboratory, and computing laboratory. These extensive services and facilities will be used for the manufacture of parts, assembly, and testing of the JTF17 development and prototype engines. These functional organizations will be employed to satisfy the requirements established by the JTF17 Program Managers as described earlier in this report.

Quality Assurance reports directly to the Chief, Engineering Operations who in turn reports to the General Manager. The organization under the Chief, Quality Assurance has jurisdiction over quality control of all parts and materials to determine their compliance with the design and quality standards. They review drawings to establish quality requirements and assure that assemblies, components, and tests meet the specified requirements. A complete description of this function has been presented in the Product Assurance Program, Volume IV.

Manufacturing Operations will provide the necessary services including make-or-buy determination, process planning, tool design, machine shop, sheet metal shop, assembly, heat treat, plating, and master mechanic (tooling), as described in the Manufacturing Plan, Volume V. As directed by the Program Management, manufacturing operations will produce the mockups, parts, assemblies of components and engines required for development, prototype delivery, and overhaul portions of the program.

Test Operations will provide the test facilities, equipment, instrumentation, and trained personnel required to perform the program testing as directed by the JTF17 project engineers. Services provided by the Test Operations organization include the accumulation of specified data and preliminary analysis, and data reduction preparatory to analysis at the Computing Laboratory.

Facilities Section will provide the necessary facilities planning and construction to meet the program requirements specified by the program management.

Materials Laboratory will provide the services necessary to establish that materials received meet applicable specifications, assist with engineering materials investigations, including failure analysis, and assure vendor materials conform to specification.

Computing Laboratory will provide computing services to meet the engineering and business requirements of the program. Development engineering is provided with digital and analog data reduction, and analysis utilizing the most recent equipment available. Business statistics, analyses, and reports suited to computer programming are prepared.

Field Operations Department directs the activities of field service representatives, provides service training, spare parts support, and flight operations engineering services in support of all Florida Research & Development products. This department will provide engine logistics support, including all service operations, personnel training, spare parts support, aerospace ground equipment, contractor technical services, and technical publications in response to direction from the JTF17 Product Support Manager.

Accounting-Treasury Department is responsible for all financial records and reporting and for documenting the costs and selling prices of the Division's products. The Department utilizes established procedures of cost data collection and reporting under a work order and program authorization system. Detailed accounting procedures have been made available to the DCAA auditors and, of course, will be made available to the evaluators as required. The Program Manager is supplied with financial reports in the detail required to control program commitments and expenditures. (See Report F, Volume V.)

Purchasing Department is responsible for the procurement from outside sources of all finished parts, nonproduct materials, raw materials, and services required in the operation of Pratt & Whitney Aircraft. The policy for subcontracting recognizes these three most important objectives: 1) to assure quality, 2) to assure on-schedule delivery, and 3) to obtain reasonable prices. The descriptions of how these objectives will be met and Pratt & Whitney Aircraft's procurement policies are included in Volume V.

Personnel Department - Employment, Plant Protection, Shop Training, Personnel Investigation, and Plant Health and Safety are under the direction of the Personnel Manager. He is responsible for recruiting and training new personnel. He provides the services required to support the requirements of the Safety Plan shown in Volume IV. Appropriate security clearances are arranged by his department.

Contract Administration under the Chief, Contract Administration, coordinates proposal preparation and assists in negotiating contracts and contract revisions. The Contract Administrator advises the Program Manager on contractual requirements and contractual interpretation. He also provides administrative services to all Pratt & Whitney Aircraft functional departments regarding contract requirements.

APPENDIX A
PERSONNEL SUMMARY

Experience on the Pratt & Whitney Aircraft Team and the Educational Background of some of the specialists to be assigned to the SST Phase III program are listed below.

Years with P&WA	Name	Institution	Degree
11	Abernethy, R. B.	Rensselaer	1952-BSME
		Rensselaer	1958-M. Sc. Ind. Mgt.
		Univ. of London	1965-Ph. D. Statistics
26	Armbruster, G. F.	Rensselaer	1939-BSAeE
3	Barre, N.	Missouri	1959-BSME
		Missouri	1962-MSME
18	Bellak, S.	Delaware	1948-BSME
9	Borgmeyer, C. H.	Miami	1957-BSME
		Trinity & Rensselaer	Graduate Studies
27	Brown, W. H.	Mississippi State	1939-BSME
6	Brown, L. L.	Duke	1949-BSME
20	Chamberlain, J.	M.I.T.	1944-BSAeE
13	Churchill, L. O.	Bucknell	1950-BSME
6	Clark, J. C.	North Carolina State	1960-BSME
18	Cotter, H. N.	Cornell	1946-BSME
		Cornell	1946-1948 Graduate Studies
11	Cushing, E.	Rhode Island State	1943-BSME
8	Daughtridge, J.	North Carolina State	1958-BSME (Aero)
24	Demers, J. R.	Connecticut	1952-ME
37	Doran, P. D.	Yale	1927-BS
9	Dower, J. H.	Worcester Polytechnical Instit.	1940-BSME
16	Dutton, J. A.	Nebraska	1950-BSME
8	Ellis, S. H.	Coventry Technical College	1943-Higher National Certificate in Aeronautical Engineering
		Cincinnati, Brevard, California	1953, 1960-Graduate Studies
26	Esmeier, E. F.	Purdue	1940-BSME
10	Elsaesser, F. J.	South Dakota State	1943-BSME
		Columbia	1949-MSME
18	Flynn, J. J.	Oregon	1941-BS
		Harvard	1947-MBA
15	Frazier, R. H.	Rensselaer	1952-BAE
		Univ. of Conn. & Trinity	Graduate Studies
6	Funkhouser, R.	Illinois	1950-BSAE
5	Gordon, R. E.	Univ. of Idaho	1948-BSME
9	Guadano, R. N.	Univ. of Bridgeport	1950-BS in math
		Columbia	1952-MS in applied math
26	Gwatkin, W. E.	U.S. Naval Academy	1936
		M.I.T.	1938-BSME
18	Hiegel, A. F.	Notre Dame	1943-BSAeE
23	Hoff, R. H.	Rochester	1942-BSME
16	Hurd, R. C.	Purdue	1946-BSME
		Connecticut	1954-MSME

Years with P&WA	Name	Institution	Degree
14	Hurley, R. B.	Delaware	1950-BSME
3	Joslin, C. L.	U.S. Naval Academy	1943-BSEE
		U.S. Naval Post Graduate School	1951-BSAE
		M.I.T.	1952-MSAE
15	Kalb, A. G.	Purdue	1951-BSME
23	Kessler, J. K.	Oregon State	1935-BSME
9	Kobush, H. J.	New Mexico	1950-BSME
		SMU and MIT	1955-56 Graduate Studies
18	Lasater, J. E.	Virginia	1945-BS NROTC engineering
		Duke	1948-BSME
5	Law, D. E. Jr.	Hobart	1956-BS Math/physics
		Columbia	1958-MSIE
9	Leddy, G.	Stevens	1950-BSME
		NYU	1953-Graduate Aero Eng. studies
25	Ledwith, W. A.	Northwestern	1939-BSME
		Connecticut	1942-Graduate Studies
24	Marquardt, J. J.	Clarkson	1942-BME
25	McDermott, J. F.	Columbia	1940-BSME
			1941-ME
5	Moore, J. B.	Alabama	1948-BSAE
			1955-MSME
20	Morrison, F. H.	Worcester Polytechnic Institute	1943-BSME
27	Parker, F. L.	Brown	1939-BSME
16	Peed, J. C.	Minnesota	1940-BSME
25	Remmer, H. J.	Columbia	1940-BA
		Columbia	1941-BSME
24	Richard, W. P.	Minnesota	1942-BME
24	Roets, J. B.	Rutgers	1942-BSME
18	Rubel, H. J.	CCNY	1948-BSME
		Connecticut	1953-MSME
17	Ryberg, R. J.	Minnesota	1949-BSME
		Conn. & Rens.	Graduate Studies
24	Savin, B. S.	Michigan	1938-BSME
6	Schmidtke, R. A.	Stanford	1945-ASTP Certificate
		Michigan	1948-BSME
			1949-MSME
		Ill. Inst. of Tech.	1953-Ph.D.ME
	Silk, J. N.	Military Ac.	1941-BS
		Rensselaer	1947-MS in Jet Propulsion
27	Sprogell, F. T.	Michigan	1939-BSME
15	Stetson, H. D.	Virginia	1948-BA Physics
		Rensselaer	1959-MSAE
24	Taylor, S. M.	Brown	1942-BSME
		Harvard	1955-MBA
6	Thompson, S. Jr.	Cornell	1946-BSAEME
		Columbia	1954-MSBA

18	Titcomb, G. A.	Princeton	1948-BSME
6	Volpi, U.	CCNY	1950-BME
5	Webb, S. R.	Kentucky	1961-BSME
		Florida	1961-64 Graduate Engineering studies
4	Wilcox, J. J.	Naval Academy	1944-BS
		Harvard	1947-MBA
26	Woodger, G. E.	Pratt Institute	1939-BME
		Rensselaer	1966-Certificate in Mgmt. Training

APPENDIX B
DESIGN AND DEVELOPMENT PERSONNEL

A. DESIGN SPECIALISTS

In the Design Department under Messrs. Savin and Ledwith, design specialists with applicable experience will be assigned to support the JTF17 program. The qualifications of some of these design engineers are summarized in the following paragraphs:

CHARLES NUTE as Chief Design Engineer will continue to be responsible for all JTF17 design activity, reporting to Mr. Ledwith. Prior to his current assignment, Mr. Nute was in charge of all J58 design activity.

HOWARD KOBUSCH, Senior Design Project Engineer, was responsible for external design and installation coordination of the J58 advanced high Mach number jet engine. This work included directing the designs of controls, accessory drives starting system, and afterburner. Mr. Kobusch has been responsible for the mechanical design aspect of installation coordination for the JTF17 engine. He has 9 years' experience in gas turbine design.

ARNO G. KALB is a Senior Design Project Engineer with 14 years' experience in gas turbine design. His past experience includes mechanical design of the JT3 compressor, design of a variable vane compressor for an experimental engine, and mechanical design responsibility for major J58 components. These have included the compressor, burner, and main bearing section.

HAROLD D. STETSON, a Senior Design Project Engineer, is responsible for the aerodynamic, thermodynamic, heat transfer, and fluid flow analysis, and the aero-thermodynamic design of air breathing engines. His experience has included the aerodynamic design and development of commercial and military engines over the past 15 years. These engines include the JT3, JT4, JT3D, JT8D, and JT12 commercial powerplants as well as the TF34, J57, J75, J52, J60, and J58 military engines.

RAY FUNKHOUSER, a Design Project Engineer, will continue to be responsible for the design of the turbine, primary combustor and duct heater on the JTF17. His past experience includes responsibility for the mechanical design concepts of the high temperature burner and the high temperature turbine now in the J58. He has 8 years' experience in gas turbine design.

LLOYD L. BROWN, a Design Project Engineer with 17 years' experience in gas turbine design, will be responsible for the design of the reverser-suppressor and accessory drives for the JTF17 engine. His past experience at the General Electric Company includes design supervision of the J93 external engine configuration. In this capacity, he was responsible for the design and airframe coordination of all engine external accessory drives of the J93 engine as installed in the B70. Mr. Brown supervised the mechanical design of the external accessory drives for the J58, both for engine accessories and airframe drives.

JOSEPH R. DEMERS is a Design Project Engineer who has been associated 24 years with aircraft engine design. He has 17 years' experience in gas turbine design. He has been responsible for the design of J58 fuel systems, variable fuel nozzles, and external engine configurations.

HERBERT J. RUBEL is a Design Project Engineer with 18 years' experience in gas turbine design, and specializes in stress and vibration analysis. His past experience includes the supervising of these same activities on the J58. He was responsible for the design of the extended root cooled turbine blades and the extended root damping designs now used on the J58.

ROBERT HURLEY, as a Design Project Engineer will have over-all direction of the aerodynamic and thermodynamic design of the combustion sections at the turbine of the JTF17. During his 13 years' experience at Pratt & Whitney Aircraft he has been associated with the analytical design of the JT3, JT4, JT8, J58, and JT12 engines in a similar position. He was associated with the original development of the cooled turbine blade and directed the thermodynamic design work of the turbine on the J58.

CLARENCE H. BORGMEYER, Design Project Engineer with 9 years' experience in gas turbine design, will be responsible for directing the JTF17 engine and control system design analysis, and the formulation and development of computer simulations of these systems. During the past eight years he has directed the work in this area on all major jet engine and rocket programs conducted at the Florida Research and Development Center. At present he is supervisor of the Engine Controls and System Analysis Section and the Computer Applications Group.

UGO VOLPI, a Senior Designer, will continue to be responsible for the SST combustion systems. He established the preliminary design analysis of both the primary and duct burner systems for the SST engine and is co-inventor of the ram-induction duct burner, Patent Application Serial No. 459,565. Mr. Volpi's past experience includes responsibility for analytical design of the J58 main combustor and afterburner. He has 16 years' experience in gas turbine design.

JOHN C. CLARK, Senior Designer, will supervise the analytical design of bearings, seals, and bellows. He has six years' experience in the design of these components for the J58 engine. He has been responsible for the analytical design in investigation of high speed, high load bearing parameters.

B. DEVELOPMENT SPECIALISTS

In the project engineering groups under Mr. Hurd, development specialists with applicable experience will be assigned. The qualifications of some of these project engineers are given below:

JOSEPH A. DALEY, JR., has 23 years' experience in the development of fuels, lubricants, combustors, gearboxes, bearings and seals for gas turbine engines. He has been responsible for the performance and reliability development of the J58 engine main combustor section, afterburner section, gearboxes, bearings and seals, and hydraulic system components.

RODGER J. RYBERG has 17 years' experience with Pratt & Whitney Aircraft in engineering development of J57, T34, JT3D, commercial engines and the supersonic transport J58 engine. In particular, Mr. Ryberg did development work on the JT3D thrust reverser and on exhaust sound suppression before being assigned to the J58 program. Mr. Ryberg has been responsible for resolving installation problems during Phase II-C of the JTF17 program.

JAMES A. DUTTON has 16 years' experience with Pratt & Whitney Aircraft on development of gas turbine engines. He has been performing development work on combustors and fuels for the Phase II-C JTF17 program. Mr. Dutton has worked on the J42, J48, J57, and J58 engine programs, as well as development in the area of advanced combustion concepts.

LESLIE O. CHURCHILL has been selected to develop the JTF17 fan and compressor because of his 13 years' experience with Pratt & Whitney Aircraft in gas turbine compressor development. He was responsible for much of the development of the J58 compressor, which has an unusually high specific flow and operating range. Mr. Churchill has since been assigned to the Phase II-C JTF17 fan and compressor development.

JOHN H DOWER has 24 years' design and development experience on controls, servomechanisms, and gas turbines. He has been responsible for much of the development of the main engine fuel controls, exhaust nozzle control, and main fuel pump on the supersonic J58 engine.

FREDERICK L. ELSAESSER has 23 years' experience in control systems and control details development including control work on the J65 and JTN11 (nuclear turbojet) engines. He has been in charge of developing several of the J58 control system components for the last 6 years.

RICHARD E. GORDON has 17 years' experience in gas turbine control development of which 5 years have been at the Florida Research and Development Center in J58 control development. He has been responsible for the Phase II-C JTF17 fuel pump and ignition system. Mr. Gordon has previously worked for a control vendor developing a control for the production J57 engine and also was responsible for control dvelopment on the J34, J36, and J40 engines.

APPENDIX C
WORK BREAKDOWN STRUCTURE VS FUNCTIONAL RESPONSIBILITY

	Program Manager and Deputy Program Manager	Development Manager and Project Engineers	Fiscal Control Group	Data Management Group	Program Planning Group	Chief - Reliability	Chief - Maintainability and Human Engineering	Safety Engineer	Value Engineer	Chief - Configuration Management	Standardization Engineer	Chief Quality Assurance	Product Support Manager	Delivery Manager	Design	Performance analysis and Statistics	Materials Laboratory	Test Operations	Manufacturing Operations	Purchasing	Flight Operations Engineers	Support Services	Spares	Installation Engineers	Field Engineers	Department Controller
Engine & Component Development																										
Engine Design	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Fabrication and Assembly	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Tooling	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Engine Instrumentation	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Test Equipment	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Engine Test (Ground)	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Engine Performance	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Inlet System Compatibility	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Noise	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Growth Potential	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Fan and Compressor	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Primary Combustor	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Turbine	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Augmentor	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Exhaust System	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Controls and Accessories	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Bearings, Seals, Gears, Lubricants	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Fuel	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Manufacturing and Materials	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Weight Control	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Management Controls and Product Assurance																										
Coordination	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Maintainability and Human Engineering	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Reliability	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Quality Assurance	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Value Engineering	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Configuration Management	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Safety	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Test Planning and Integration	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Data Management	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Program Management	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Facilities Plan	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Cost Analysis	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Proposals	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Delivery and Product Support																										
Ground, Test, and Flight Engines	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Tooling	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Performance	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Set-up	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Spares	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Overhaul	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Flight Test Evaluation	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Data and Handbooks	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Training	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
Ground Support Equipment	N	N	S	S	S	S	S	S	S	S	S	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P

Code:
1. Prime responsibility
2. Shared responsibility
3. Active Participation
4. Advisory function
5. Monitoring function
- Not applicable

REPORT J
RESOURCES

SECTION I
INTRODUCTION

This report will review how the SST program will be integrated within Pratt & Whitney Aircraft's projected research and development efforts and production programs. The development, prototype, and initial overhaul work will be accomplished at the Florida Research and Development Center, while the engines to be delivered in Phase V will be manufactured at the East Hartford plant. The discussion will deal with the Division's two primary areas of activity, Development and Production. The Florida Research and Development Center contains a completely integrated operation for the management, design, manufacturing, procurement, assembly, quality control, test, and related activities necessary to perform the development and sustaining engineering effort required. These Florida facilities represent an investment of over $90,000,000, more than half of which is company owned. A hard core of skilled personnel from this broad field of experience, in depth, will be made available from existing programs for the JTF17 Engine Development Program. It will be shown that, in terms of manpower, company resources and commitments, plant capacity, and facilities, the SST program lies well within Pratt & Whitney Aircraft's capability for the period through 1978.

The most recent business projections, used as a basis for the preparation of this report, forecast the anticipated engineering and development activity for the Florida Research and Development Center through the Phase III time period (1970). (See figure 1.) Production business projections are represented by a unit delivery schedule (figure 2).

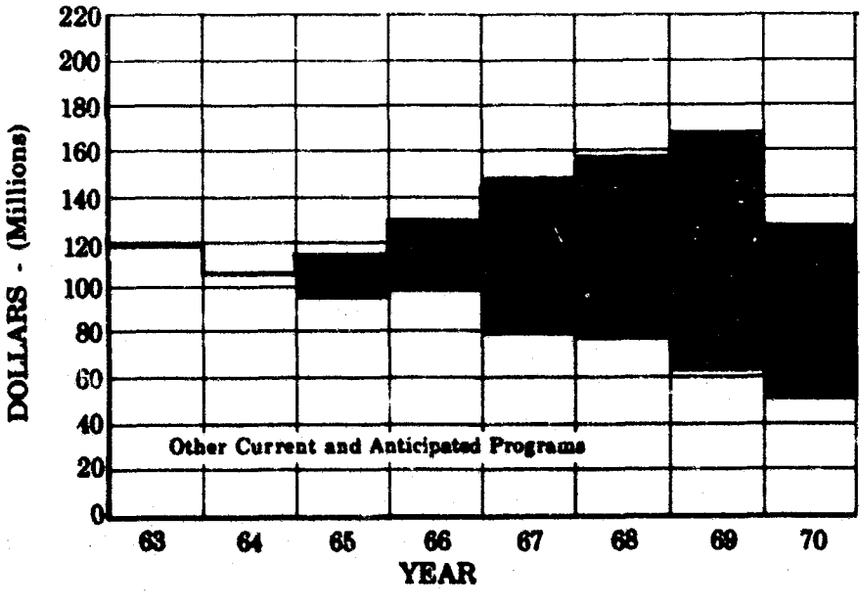


Figure 1. FRDC Forecast of Total Expenses

FD 16517
VJ

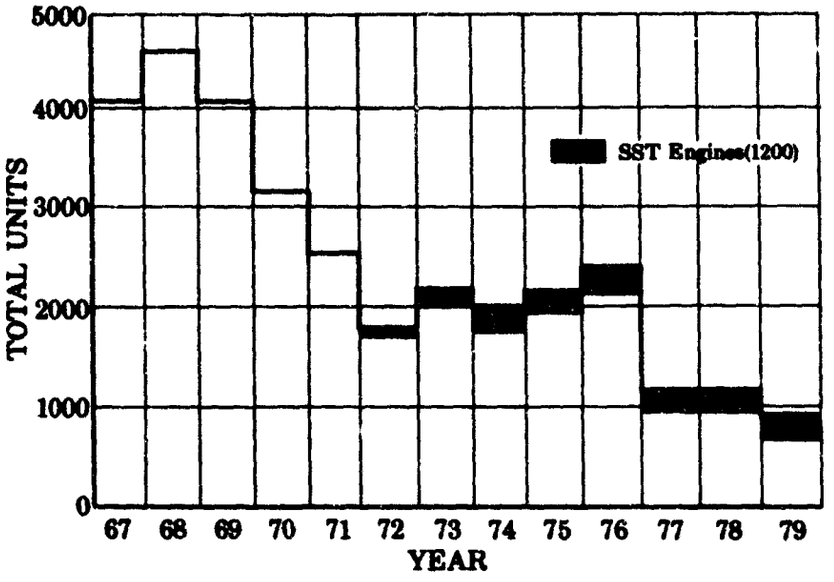


Figure 2. East Hartford Production Schedule FD 16518
VJ

SECTION II
DEVELOPMENT (FLORIDA RESEARCH AND DEVELOPMENT CENTER)

A. MANPOWER REQUIREMENTS (TOTAL)

The Florida Research and Development Center overall manpower requirements during the Phase III period are forecast to peak in the year 1969 with a slight increase over the 1966 level, as shown in figure 3. The additional manpower of approximately 1600 people estimated to be needed in this period is significantly less than that added in the period from mid-1959 to mid-1962, when the total FRDC employment was increased from 2300 to 6100.

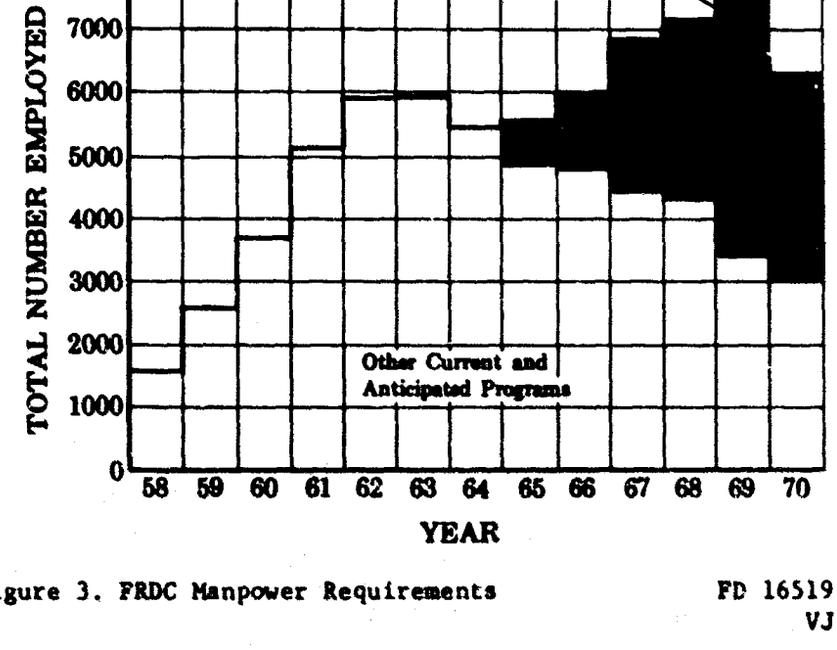


Figure 3. FRDC Manpower Requirements FD 16519
VJ

B. TECHNICAL MANPOWER

The increase in technical personnel required to continue the SST engine development program will be obtained by transfers from current programs, which will be decreasing, as well as by adding approximately 220 new technical employees by 1968. The graph (figure 4) illustrates the growth rate of technical manpower at the Florida Research and Development Center and shows the projected growth to 1600 in 1969. The rate of growth required in technical population to meet this figure is less than that experienced in the past [illegible] years (as can be seen in figure 4). Technical attrition has averaged about 1% per month in this 5-year period, as shown in figure 5. Our recruiting effort for technical personnel extends nationwide. Current acceptances of recent college graduates number 155, and acceptances of experienced engineers are presently running at a rate of 120 per year, which more than meets forecast requirements.

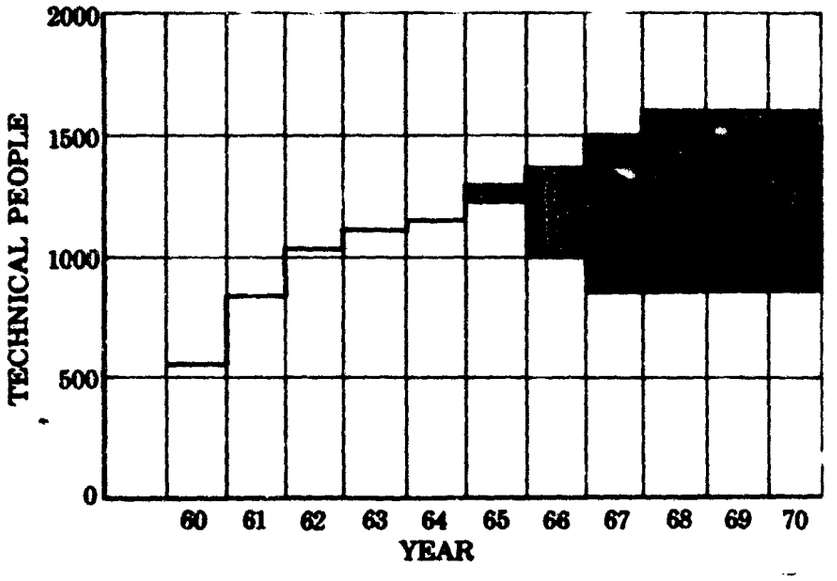


Figure 4. FRDC Technical Manpower FD 16520
VJ

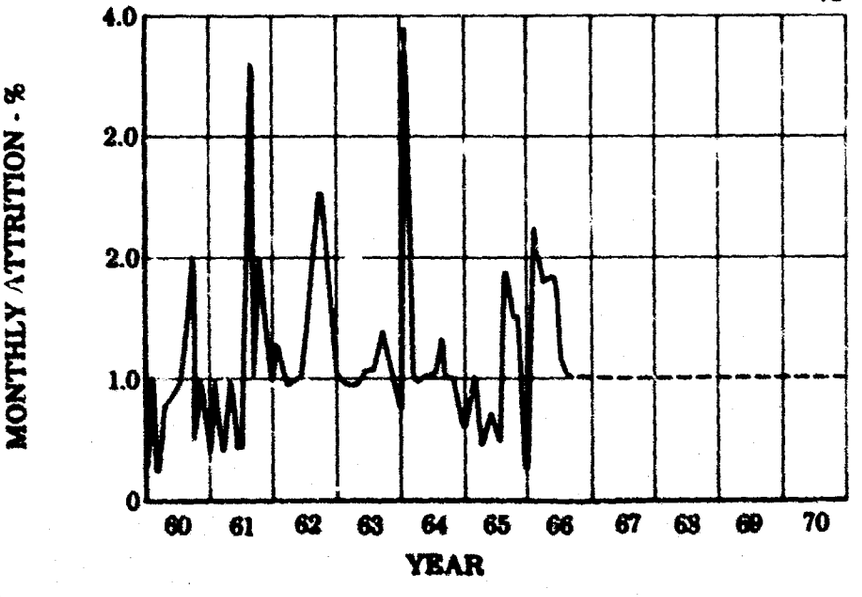


Figure 5. FRDC Technical Attrition Rate FD 16521
VJ

C. HOURLY AND NONTECHNICAL SALARY MANPOWER

The continuing growth of the Florida industrial community promises to attract more and more skilled and semiskilled workers to this area. Figures 6 and 7 indicate the historical population of hourly and nontechnical salary personnel, as well as the projected requirements. Increases required for skilled hourly workers in the experimental shop areas will be attained by our normal recruiting activity and training programs. (Refer to paragraph D.) A net increase of approximately 700 hourly rated employees over the attrition rate projected in figure 8 is forecast to meet peak requirements in 1969.

Nontechnical salary requirements are forecast to reach peak requirements of 2900 in 1969, which is well within the Florida Research and Development Center's recruiting capability.

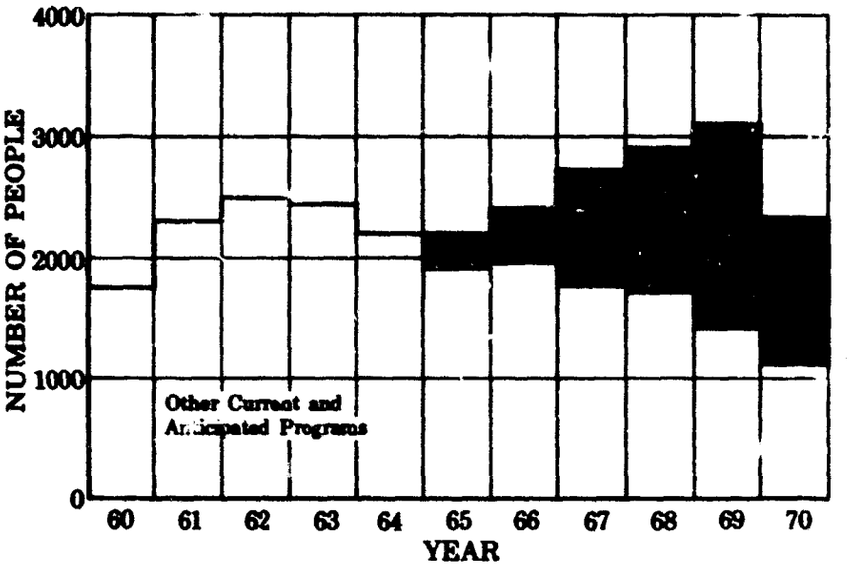


Figure 6. Hourly Personnel Population FD 17556
VJ

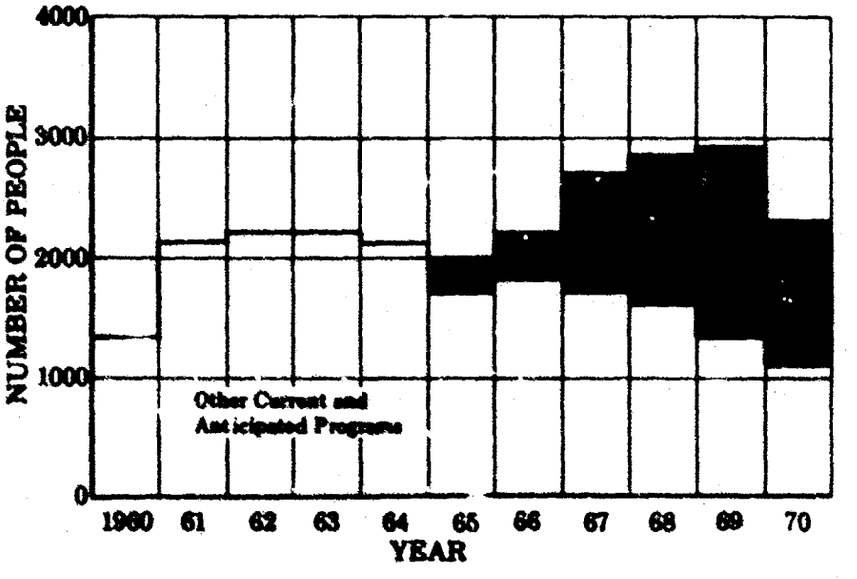


Figure 7. Nontechnical Salary Population FD 17557
VJ

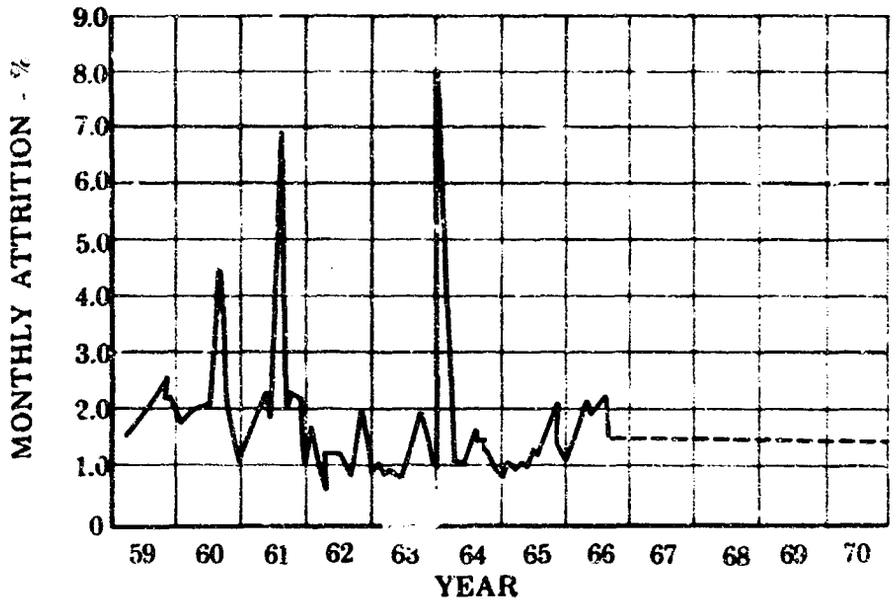


Figure 8. FRDC Hourly and Salary Attrition Rate FD 16523
VJ

D. EMPLOYEE SKILLS TRAINING

Training programs have been used at the Florida Research and Development Center since its opening in 1956 to train qualified employees and newly hired employees to the skill levels demanded for producing, inspecting, assembling, and testing needed hardware and engines. Presently, nearly 160 persons are enrolled in major training programs involving a wide range of specialized skills. These training programs are presently geared to deliver about 16 trained employees per month and will be increased to about 22 per month to handle the expansion for the SST program. The following program categories are typical of those conducted as required:

Experimental Machining

Experimental Sheet Metal

Engine Assemblers

Test Mechanics

Tool Room Machining

Tube Bending

Tube Assemblers

Inspection

Requirements for acceptance and entrance into the programs vary slightly, but commonly require a high school education with good academic records, plus six months or more of trades training or closely related experience. Careful screening and selective hiring minimize attrition losses and reduce unit training costs. Screening is conducted both by personnel interviewers and by a followup consultation with training personnel. These programs generally provide 9 months or more of intensive training, in-

cluding at least 3 months of on-job training. It is significant to note that selective screening of applicants results in a high retention rate of company-trained personnel. For example, 76% of the trainees remain with the Florida Research and Development Center after the first year, 66% after the second year, and 60% after the third year.

In addition to the programs listed above, Pratt & Whitney Aircraft's Florida Research and Development Center regularly conducts other courses and programs to improve and update employee skills. For example, there are a number of programs for supervisory and administrative personnel, cooperative engineering students, and new engineers and technicians. Shop and test workers are also indoctrinated in such specialized fields as fluid lines and connections, cryogenics, leak detection, radiography, and slide rule operation, as well as in all phases of general skilled work in manufacturing, inspection, and test.

Figure 9 illustrates the history of hourly training activity in Florida.

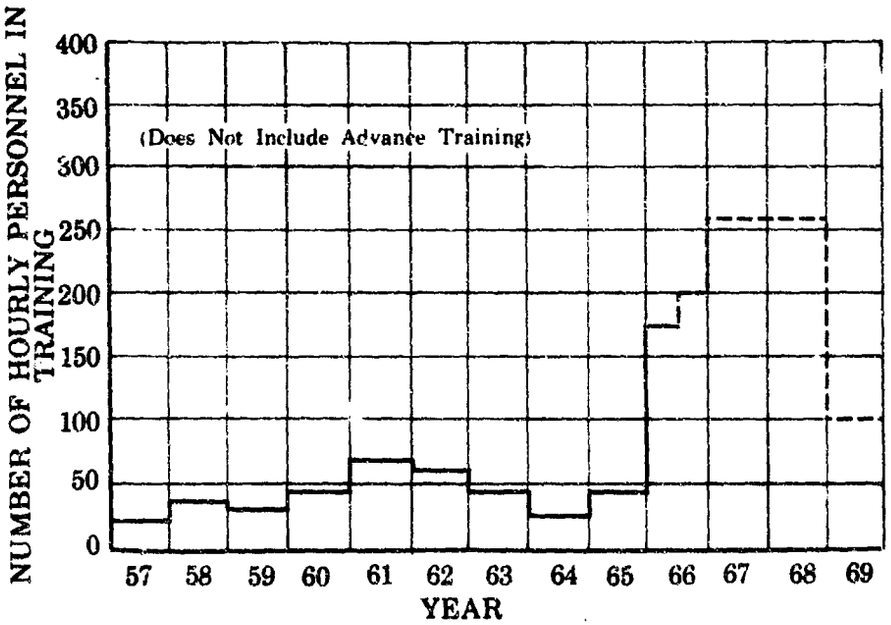


Figure 9. Average Florida Hourly Training Population — FD 16524 VJ

E. PLANT CAPACITY AND FACILITIES

The Florida Research and Development Center currently has 1,150,000 square feet of floor space allocated to experimental manufacturing, experimental assembly, test, and supporting activities. Of this total, 550,000 square feet are devoted to manufacturing activities, 200,000 square feet to office space, and 400,000 square feet to various laboratories.

1. Manufacturing

For the development, prototype, and initial overhaul portions of the SST program, we will add an additional 96,000 square feet to the shop and assembly areas.

The Experimental Machine Shop has a wide capability in the normal machining operations of vertical and horizontal turning, milling, grinding, and drilling. The turning capabilities are up to 96 inches in diameter and 120 inches in length. Grinding capability extends to 100 inches in diameter, and the largest broach has a stroke of 180 inches. Approximately 32 new machine tools will provide sufficient increased capacity in the machine shop area.

The Experimental Sheet Metal Fabrication and Welding Shops are fully equipped with shearing, forming, welding, heat treating, plating and brazing equipment. Seven machine tools will be required to increase the capacity of this area for the SST program. In addition, this area contains a pattern shop that produces full-scale mockups in wood and reinforced fiberglass; drop hammer and forming dies; tube manufacturing, and checking fixtures. The explosive forming facility occupies 13,000 square feet with vacuum pits accommodating up to 109 inches in diameter.

The areas devoted to support of manufacturing include a completely equipped tool room, cutter grinding, machine repair, and equipment and electrical maintenance.

The air-conditioned assembly area contains all of the necessary supporting equipment such as cleaning tanks, flow benches, ovens, balancing machines, craneway, and hoists.

Supporting the actual shop and assembly operations is a Tool Design and Process Planning organization experienced in the use of the materials, machines, and manufacturing methods needed to produce all types of modern jet engine parts.

The Quality Assurance area is equipped to handle the largest of SST parts on Rotabs with up to 84 inches in diameter faceplates and fluorescent penetrant tanks 96 inches square and up to 84 inches deep. The present area of 27,500 square feet will be expanded to 45,400 square feet in order to handle the SST parts and assemblies.

In the interest of avoiding duplication, additional Florida Research and Development Center manufacturing capabilities, which would merit discussion at this point, are more fully detailed in Report B (Facilities Program).

2. Test Laboratories

Current jet engine testing facilities comprise 9 full-scale engine test stands and 43 basic component test stands. Four additional full-scale engine test stands, and component test stands as required, will be added in order to conduct the testing of the JTF17 engine and components at simulated cruise Mach number conditions.

Detailed descriptions, as well as the comprehensive pl r addi-tions to the testing capability, are covered in Report B ies Program).

3. Other Laboratories

The Material Control Laboratories assure that all incoming product material conforms to requirements established by Engineering. Materials testing is accomplished in an area containing 30 items of machine shop equipment, as well as 20 items of major testing equipment and 17 items of chemical and spectrographic analysis equipment. X-ray equipment and associated processors and viewers account for an additional 15 major items devoted to assurance of product material quality.

The Material Development Laboratory specializes in aerospace materials, with the capability of performing a wide variety of development tasks in the fields of metallurgy, applied mechanics, and chemistry. The personnel in this laboratory (over 200) are experienced in all phases of materials development associated with high-performance jet engines. Included are chemists, metallurgists, mechanical engineers, and chemical engineers from the PhD level to the experienced technician. These people are functionally divided into categories that deal with alloy development, coating development, process development, metallography, polymers, propellants, fuels, oils, stress analysis, analytical instrumentation, spectrographic analysis, X-ray, fatigue, vibrations, creep rupture, and tensile groups. Equipment currently in use includes electron microscopes (2), chromatograph, X-ray diffraction, infrared spectrophotometer, X-ray, and vacuum heat-treat furnaces.

Assistance in the materials evaluation area is provided by an additional 228 chemists, engineers, metallurgists, and technicians in the East Hartford Materials Development Laboratory. Basic theoretical and practical research is conducted at the Advanced Materials Research and Development Laboratory by a select group of scientists (80% of the senior professional personnel have doctorate degrees). This laboratory is devoted to the research and development of high temperature alloys and coatings, ultra-high-strength materials, materials for energy conversion devices, and special materials to meet the demanding requirements of advanced turbine powerplants such as the JTF17.

The Andrew Willgoos Turbine Laboratory in East Hartford will be used to complement Florida facilities in providing high-altitude testing of the JTF17 with refrigerated air.

The Instrumentation Laboratory comprises several sections, each responsible for the development and application of various phases of instrumentation technology. A total of 12,000 square feet of space is devoted to this laboratory, which is equipped and staffed to design, manufacture, test, and calibrate all types of precision instruments used for measurements required in propulsion system testing. An additional 3500 square feet are used for data acquisition systems maintenance and strain gage development and application. Technical guidance for all instrumentation activity is provided by an instrument engineering group containing over 150 engineers, engineering assistants, and computists. The 24 Project Engineers contained in this group average over 12 years of instrument engineering experience at Pratt & Whitney Aircraft, mostly devoted to high Mach number turbojet engine development.

The Florida Research and Development Center's Computing Laboratory facilities include two IBM System 360's (Model 50) for engineering and scientific calculations. These are to be replaced by a larger Model 65 in late 1966. In addition, an IBM 1410 computer is used for producing business reports, and another on-line IBM 1410 with remote feedback is used to process turbojet test data. It is planned to increase the latter capability in mid-1967 with an IBM System 360, Model 40. Smaller computers (IBM 1620's) are located in Engineering for smaller scale calculations. These are to be replaced in 1967 by three IBM 1130's to improve capability and economy. High order, complex differential equations are solved with a Beckman-Berkeley "EASE" 2133 Repetitive Analog Computer. Automatic plotting from magnetic tape is accomplished with two Benson-Lehner plotters, which also have curve line drawing capability.

All of these facilities, and additional areas forming our complete research and development capability, are more fully described in Report B (Facilities Program). In summary, the existing resources at the Florida Research and Development Center, with some additional space and equipment are fully capable of meeting the SST Phase III requirements for development and prototype engines.

In the area of total resources, note should be made here that, in addition to the resources outlined above, Pratt & Whitney Aircraft has in the past supplemented the Florida capability by drawing on an East Hartford Engineering Department that has over 16,000 people in an area devoted to research and development, utilizing fixed assets valued at over $200,000,000.

SECTION III
PRODUCTION (EAST HARTFORD)

Pratt & Whitney Aircraft's production manpower requirements are currently increasing and are projected to peak at about 39,000 people in 1969. Thereafter, the problem will be to continue to utilize available manpower and facilities more fully. The continuous program of modernization and replacement of obsolescent production facilities is detailed in Report G (Manufacturing Program). Current and projected capacity is more than adequate to accommodate the planned production of the JTF17.

A. MANPOWER

1. Requirements

Pratt & Whitney Aircraft's forecast peak production requirement of 39,000 people in 1969 represents an increase of 7000 people over current production manpower. As can be seen from our history to date (figure 10), we have experienced an increase of 7000 people in the past 2 years. This means attaining a corresponding increase in the next 3 years in the categories of nontechnical and nonprofessional salary and hourly rated personnel. Thereafter, the impact of the JTF17 engine program would consist of essentially maintaining levels equal to, or slightly below, the 1969 value.

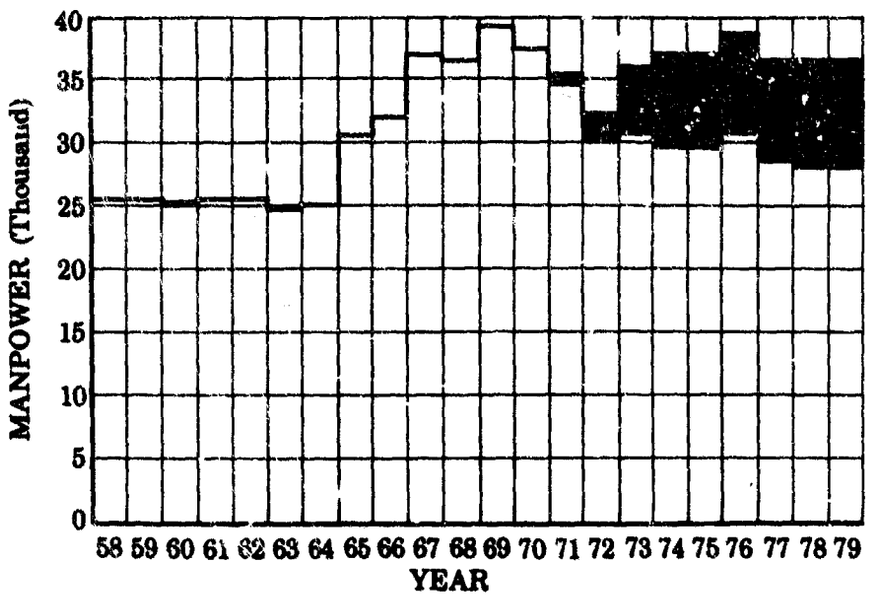


Figure 10. East Hartford Total Manpower FD 16525
VJ

2. Sources and Availability

Information concerning the labor market from which our East Hartford production facilities will draw the required nontechnical, nonprofessional salary and hourly employees during the next 10 years is based upon data published by the Connecticut Labor Department and the United States Department of Labor. Present employment records indicate that 70% of Pratt & Whitney Aircraft's East Hartford employees reside in the Greater Hartford Area (a complex of 24 towns that cover an area slightly greater than Hartford County) and 24% reside in the rest of Connecticut. (The remaining 6% reside out-of-state.) The main source of manpower for the future should be the two areas within Connecticut. The Connecticut Labor Department has made projections of population and work force for both areas, as shown in figures 11 and 12. The population from 1957 to 1965 grew an average of 2.3% per year for the State of Connecticut and an average of 2.1% per year for the Greater Hartford Area. Future growth for Connecticut is forecasted to be 1.8% per year through 1975. The Greater Hartford Area population growth is forecasted to average 1.7% per year for the same time period

For the State of Connecticut, the work force participation rate (that percentage of the population that works) will continue to decline from 41% in 1964 to 37% by 1975. The Greater Hartford Area participation rate is forecasted to remain constant through 1975. These curves, then, indicate an 8% rise in the labor force from 1964 to 1975 for Connecticut and a 20% rise for the Greater Hartford Area. This means a 90,000 increase for Connecticut, which includes 50,000 in the Greater Hartford Area.

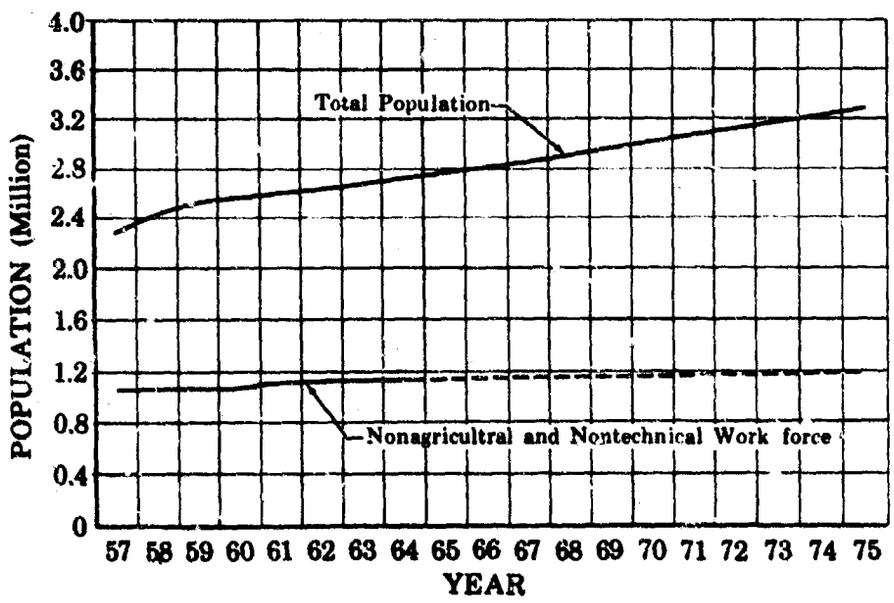


Figure 11. Total Connecticut Population and Total Nonagricultural and Non-technical Work Force

FD 16526
VJ

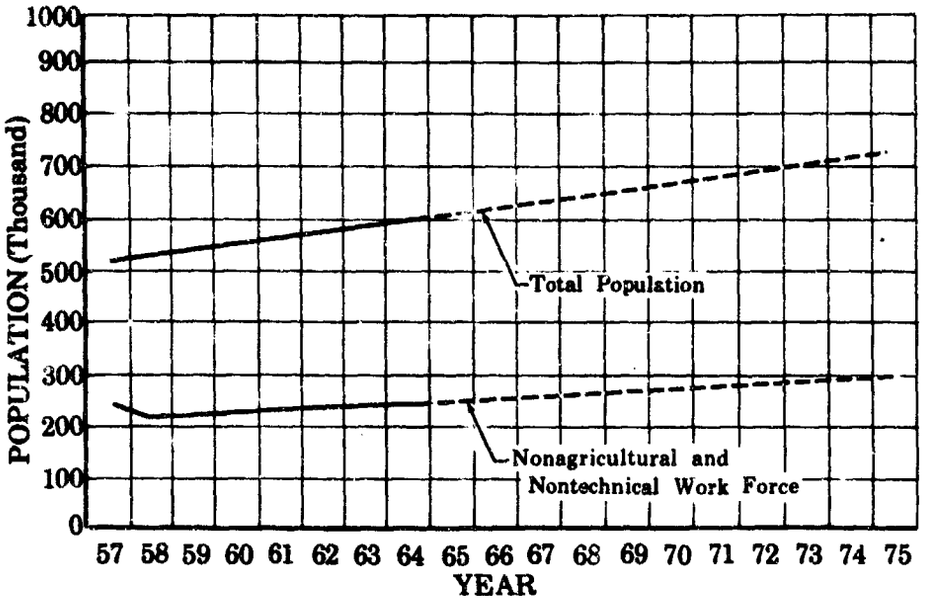


Figure 12. Greater East Hartford Population and Nonagricultural and Non-technical Work Force FD 16531 VJ

An important additional factor affecting the availability of manpower in the Connecticut Area is the annual number of new entrants into the labor market. Figure 13 represents data provided by the Connecticut Labor Department and the Connecticut Education Department.

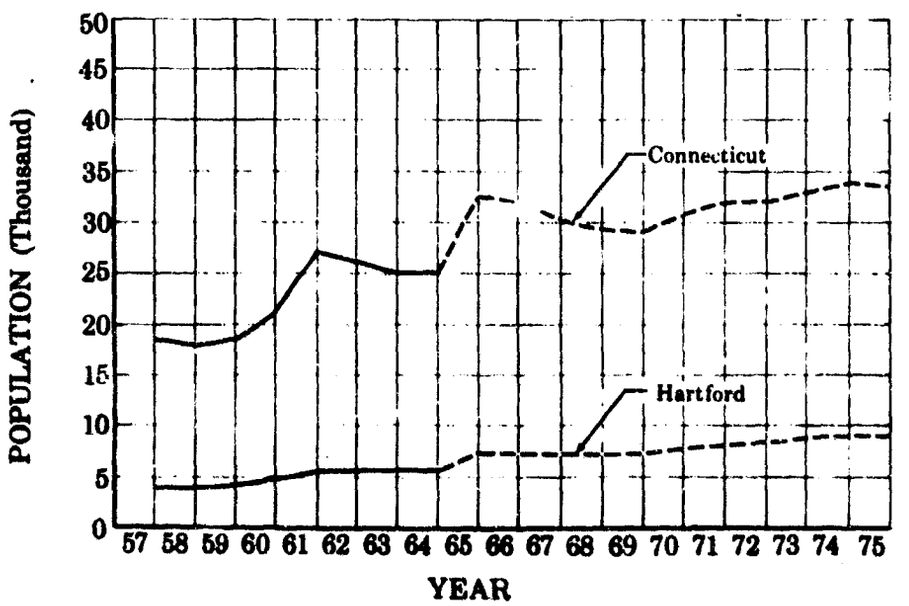


Figure 13. Forecast of New Labor Market Entrants (Excludes Four Year College Graduates) FD 16634 VJ

3. Manpower Training

Approximately 30% of Pratt & Whitney Aircraft's new hires come with 1 year or more of related prior experience. The remaining 70% have relatively little or no related training. Approximately 15% are hired directly out of high school. Extensive training programs have been established to train qualified employees to the skill levels needed for both nontechnical engineering and production jobs. More than 100 specialized training courses have been conducted by Pratt & Whitney Aircraft's training organization. Presently, there are 31 courses in progress with an enrollment of over 1615; approximately 376 are enrolled in the four apprentice training programs. The follow ng nine categories of courses are conducted as required:

Series No.	Name
100	Administrative Programs
200	Working Leader Programs
300	Apprentice Programs
400	Engineering Programs
500	Technical Programs
600	Machining Programs
700	Sheet Metal Programs
800	Welding Programs
900	Inspection Programs

The following specific apprentice training courses are currently being conducted:

Course No.	Course Name	Hours in Course
301	Jet Engine Metalsmith Apprentice	6000
302	Machinist Apprentice	6000
303	Tool and Diemaker Apprentice	2000
304	Electronics Technician Apprentice	6000

The Tool and Diemaker Course is available to selected graduates of the Machinist Apprentice Course.

Advanced training courses cover such skill areas as:

Course No.	Course Name	Weeks in Course
556	Aircraft Powerplant Mechanic	75
619	Production Machining	22
623	Semi-Production Basic Machining	24
625	Experimental Machining	28

627	Master Pipe Maker	32
628	Tool, Die or Gage Making	116
629	Machine Maintenance	96
637	Master Mechanic Basic Machining	24
704	Experimental Sheet Metal	37
706	Pipe Making	29

Requirements for entrance into these courses run as high as 4 years of high school with a good academic record, plus 2 years of diversified aircraft mechanic's training and experience — or equivalent Pratt & Whitney Aircraft experience — and evidence of supervisory potential. These are requirements for course No. 556. In contrast, requirements for course No. 619 are two years of high school, including 1 year of algebra or geometry plus 1 year of machine shop experience. Generally, the trainee must be a high school graduate with 6 months of Pratt & Whitney Aircraft experience. The 6 months previous experience is required for two important reasons. First, attrition at the end of a course is reduced considerably if the employee has a chance to first become familiar with the area in which he will work upon graduation; second, this allows the Training Department to obtain full classes, which reduces training costs per man. In addition to the courses listed above, Pratt & Whitney Aircraft utilizes other course programs to improve and update employee skills. For example, there are 11 courses for supervisory training, 4 courses for working leaders, and 36 courses in various types of machining and machine operation.

There are also 6 courses in sheet metal training and 19 courses in welding, as well as courses of a specialized and advanced nature. A few examples of these are:

Course No.	Course Name	Hours in Course
611S	Man-Au-Trol Familiarization	80
614S	Man-Au-Trol Advanced	120
617S	Specialized Training (Lathes-Grinders)	120
630T	Plastics Tooling	80
634M,S	Vertical Turret Lathe Operators	240
815S	Specialized Brazing Course	40
816S	Welding Processes and Controls - Fusion Welding	80

4. Attrition

Attrition history of hourly and nontechnical salary personnel is illustrated in figure 14. Nontechnical salary attrition has remained constant at 1.2% for the past five years and is forecast to remain at that level. Attrition of hourly employees has been forecast at 1.1% per month. The overall weighted average attrition of about 1.1% per month is well below the national average of about 1.4% (U.S. Department of Labor).

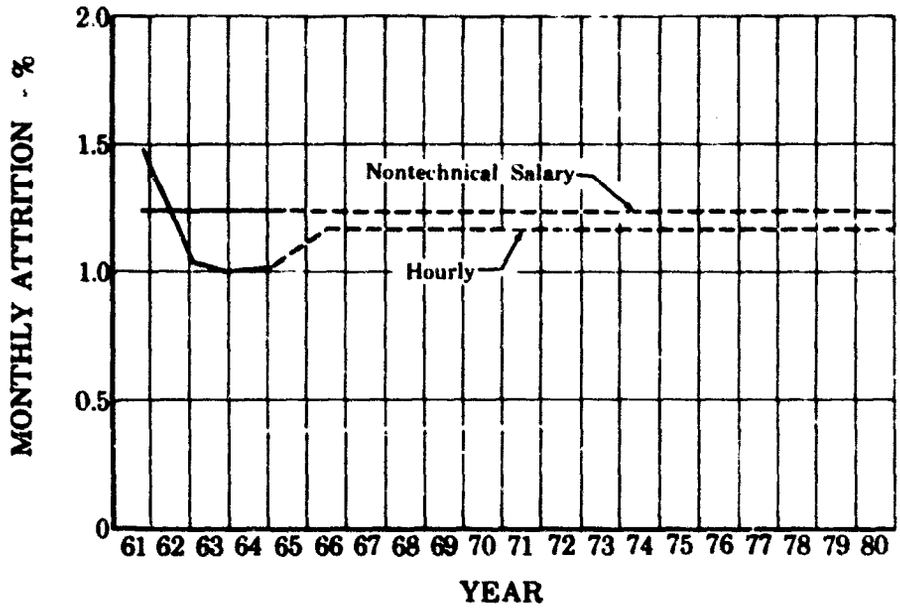


Figure 14. Attrition Rates FD 16625
VJ

B. PRODUCTION CAPACITY

Capacity requirements for production manufacturing are discussed in Report G (Manufacturing Plan). Manufacturing capacity is more than adequate, as is readily seen from the production schedule during the period of SST performance (figure 2), which is considerably below the preceding years' requirements.

C. FACILITIES REQUIREMENTS

The SST program requirements are well within the capability of the bulk of East Hartford production facilities. No major office space additions are required for SST, as the time phasing for this program is below the earlier peak occupancy years.

Additional details and descriptions of Pratt & Whitney Aircraft faciliti available for the SST program may be found in Report B (Facilities Program).

REPORT K
COMPANY COMPETENCE

SECTION I
SUMMARY

Pratt & Whitney Aircraft's ability to develop and to support in commercial operation the powerplant for the U.S. Supersonic Transport is demonstrated by the company's development of advanced designs that make possible daily supersonic cruise operation with the J58 engine, and by the record of the company in supplying aircraft powerplants for airline service for more than 39 years. Pratt & Whitney Aircraft's competence to provide a safe and economical SST powerplant program is indicated by the following.

A. COMMERCIAL EXPERIENCE

The company's total experience includes over 239,000,000 hours of powerplant operation in commercial service, 39,000,000 of which is turbine engine experience. The fact that 6000 Pratt & Whitney Aircraft turbine engines have been delivered for commercial service and the reliability record of these engines attests to Pratt & Whitney Aircraft's reduction to practice of those elements that make a safe, economic airline transport powerplant. The world-wide commercial product support organization covering over 200 airlines in 82 countries provides Pratt & Whitney Aircraft with the vital commercial customer-manufacturer link necessary for the development of a powerplant responsive to the customer's needs.

B. SUPERSONIC CRUISE EXPERIENCE

This experience includes over 1,000,000 miles of J58 engine operation at or above the continuous supersonic cruise speeds and altitudes required for the SST in the USAF YF-12 and SR-71 airplanes. This flight experience, combined with the 9 years and 22,805 hours of ground and altitude test stand development work at Pratt & Whitney Aircraft's Florida Research and Development Center provide powerplant know-how in the environment in which the SST must successfully and economically live for the balance of its life.

C. MILITARY GAS TURBINE EXPERIENCE

Military gas turbine experience in development, production, and flight accumulated over the past 20 years in supplying over 35,000 turbine engines for leading USAF and Navy military aircraft. Supersonic dash flight experience on the Pratt & Whitney Aircraft J57 powered F-100 fighter commenced 13 years ago. Since that time, supersonic dash flights with various J57 and J75 powered airplanes have become commonplace, and the flight spectrum for dash operation is now being extended by the TF30 engine in the F-111 and Mirage 3F aircraft. On these military programs, representing 10,000,000 flight hours, 205,000 engine flight hours have been accumulated at speeds of Mach 1 and above.

D. AIRCRAFT POWERPLANT RESOURCES

Facilities available to Pratt & Whitney Aircraft for Development, production, and support of aircraft powerplants represent a facility investment of $400,000,000, primarily company owned. Total employment of Pratt & Whitney Aircraft on 31 December 1965 was 47,960. Pratt & Whitney Aircraft's current engineering programs currently represent an annual expenditure of approximately $280,000,000, employ over 4,000 technical personnel, utilize $128,000,000 in engineering development facilities, and require 3,680,000 square feet of engineering floor space.

In producing the J58 operational supersonic cruise engine, Pratt & Whitney Aircraft has employed high Mach No. (Mach 3 plus) development and testing facilities at the Florida Research and Development Center and at East Hartford, Connecticut - which represents an investment in excess of $100,000,000. These facilities, plus a seasoned team of J58 design, development, test and product support personnel numbering in excess of 2800 people are available for direct application to the SST powerplant program. Further details on these facility and manpower resources will be found in Volume V, Report J (Resources).

E. RECORD IN MEETING COMMITMENTS

On the JT3C, JT3D, JT4 and JT8D commercial engines, Pratt & Whitney Aircraft has demonstrated its ability to deliver commercial engines which were on schedule, at or below specification weight, and which meet or bettered specification thrust and specification fuel consumption. Examples of Pratt & Whitney Aircraft's performance in meeting or bettering engine weight and TSFC commitments on its commercial engines is provided in figure 1. On Government R & D programs covering the J57, J75, J52, TF33, TF30 engines, the RL10 rocket engine, and on advanced airbreathing engine study and component programs, Pratt & Whitney Aircraft has demonstrated its ability to advance the state-of-the-art and to fulfill contract commitments.

F. FINANCIAL CAPABILITY

Assurance of financial capability of United Aircraft Corporation (parent corporation of the Pratt & Whitney Aircraft Division) to meet the requirements of the 4-year Phase III SST powerplant program is provided by a review of its record of gross sales and before income tax earnings for the past four years (1962, 1963, 1964, and 1965).

Four Year Total Gross Sales	$5,107,200,000
Four Year Total Earnings Before Income Tax	219,230,000

United Aircraft has financed without contractual support, research and development programs that have cost in excess of $225,000,000 over the past 8-year period.

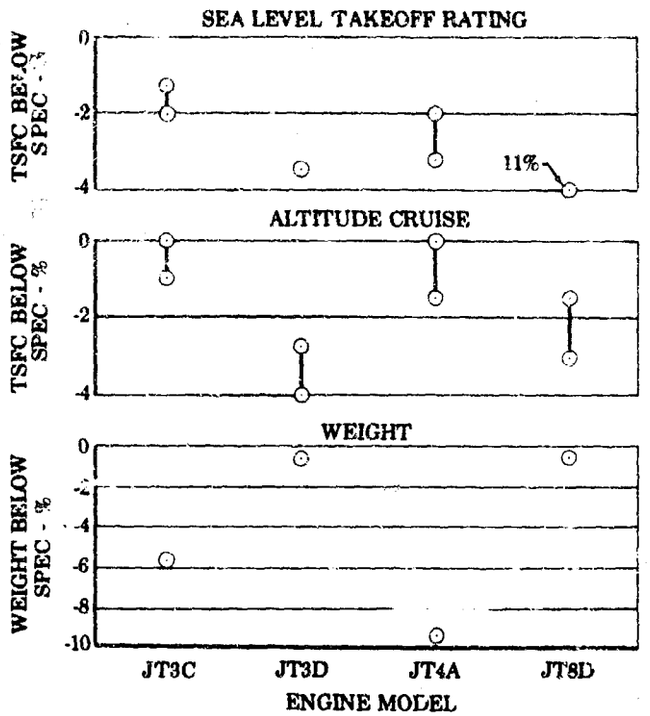


Figure 1. Comparison of Actual Production Engine Weight and Performance To When Ordered Specification Values - P&WA Commercial Turbine Engine

FD 17832

SECTION II
SUPPORTING DOCUMENTATION

A. COMMERCIAL EXPERIENCE

1. General

In the 39-year period that Pratt & Whitney Aircraft has served as a supplier of 66% of all the world's air transport powerplants, it has delivered over 21,000 reciprocating and turbine engines (figures 2 and 3) to a total of 239 airline operators. Since 1958, 6000 commercial turbine engines have been delivered and 39,000,000 flight hours have been accumulated on Pratt & Whitney Aircraft commercial turbine powerplants. Photographs of some of the commercial aircraft powered by Pratt & Whitney Aircraft turbine engines are shown in figure 4.

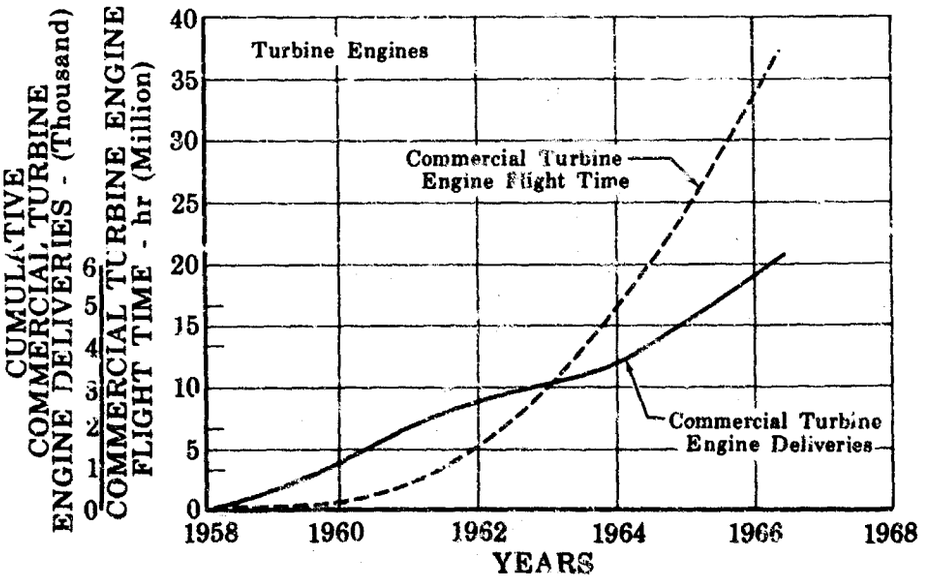


Figure 2. P&WA Commercial Turbine Engine Deliveries and Flight Time

FD 17539
K

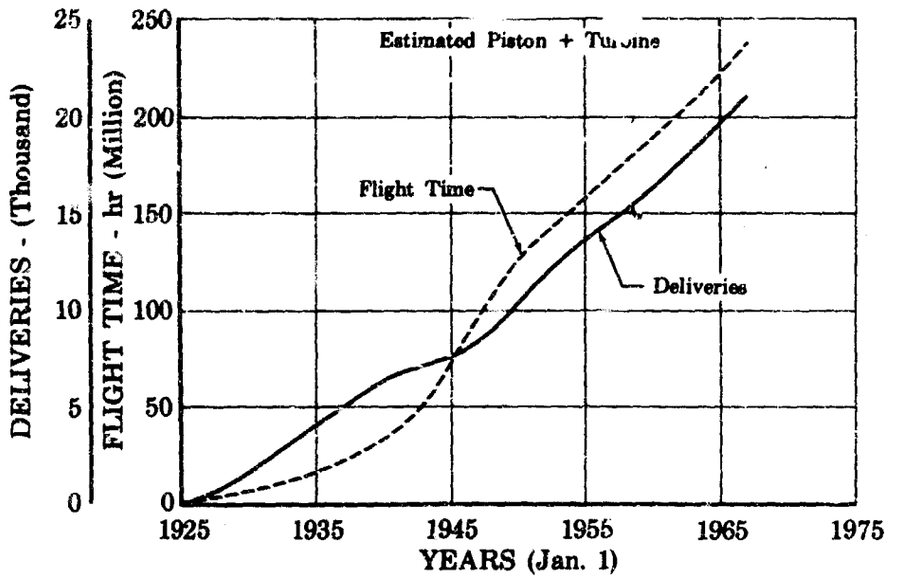


Figure 3. Estimated Total P&WA Commercial Engine Deliveries and Flight Time — FD 17540 K

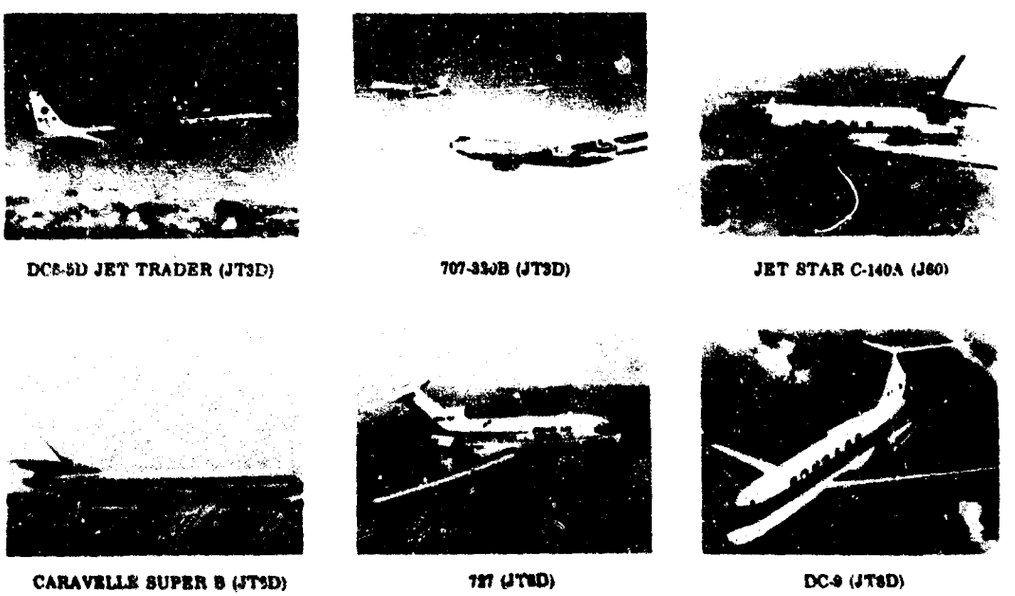


Figure 4. P&WA Powered Commercial Aircraft — FD 16909 K

2. Description - Commercial Engine and Applications

The JT3 commercial turbojet was first delivered in 1958 and draws heavily on its J57 military counterpart. It is an axial flow, two spool, high pressure ratio turbojet with can-annular combustion chambers and a nine-stage low and seven-stage high compressor driven by a single-stage high and two-stage low turbine developing up to 13,500 pounds of thrust when augmented with water injection. This engine was used in the first United States commercial jet aircraft. Various JT3 commercial applications and operating hours are listed below.

Aircraft Models	Operating Hours	Number of Engines
Boeing 707-120	3,166,660	409
Boeing 720	3,501,875	341
Douglas DC8-10	1,450,265	147
Total	8,118,800	897

The JT4 engine, the commercial equivalent of the military J75 engine is an axial flow, twin-spool turbojet with eight can-annular combustion chambers; it develops up to 17,500 pounds of thrust and was first delivered in 1959. An eight-stage low compressor and a seven-stage high compressor are driven by two and one turbine stages respectively. Various JT4 commercial applications and operating hours are listed below.

Aircraft Models	Operating Hours	Number of Engines
Boeing 707-220,-320	5,701,277	431
Douglas DC8-20, -30	7,102,219	574
Total	12,803,496	1005

The JT3D, first delivered in 1960, is a turbofan engine developed from the JT3 engine. It is the commercial equivalent of the military TF33 engine and delivers up to 19,000 pounds of thrust in the latest version to be available in 1967. Fifty percent increase in takeoff thrust, 15% decrease in cruise TSFC, and significant reductions in engine takeoff noise were provided by this engine which have led to its wide acceptance for commercial usage, with many jet aircraft being retrofitted to accept this turbofan. Various JT3D commercial applications and operating hours are listed below.

Aircraft Models	Operating Hours	Number of Engines
Boeing 707-120B, -320B and -320C	6,661,357	1036
Boeing 720B	4,345,075	420
Douglas DC8	3,979,826	767
Total	14,986,258	2223

The JT8D is an axial flow, twin-spool, turbofan engine with nine can-annular combustion chambers, a four-stage reaction turbine, and a thirteen-stage compressor. This engine develops up to 14,500 pounds of thrust for takeoff in the latest version to be available in 1967. This engine was developed by Pratt & Whitney Aircraft as a commercial venture. It was first delivered in 1963. The first two stages of the six-stage low compressor are the fan stages; the bypass air from these stages is ducted around the basic engine and mixed with turbine exhaust in a common nozzle. Various JT8D commercial applications and operating hours are listed below.

Aircraft Models	Operating Hours	Number of Engines
Boeing 727	2,558,648	1154
Boeing 737	Not in service until late 1966	
Douglas DC9	47,634	170
Sud Caravelle 10B, 10R	58,732	51
Total	2,665,014	1375

The JT12 engine is an axial-flow, single spool turbojet with eight combustion chambers, a two-stage reaction turbine, and a nine-stage compressor. This engine, which develops up to 3,300 pounds of thrust in the latest version to be available this year, was also developed by Pratt & Whitney Aircraft as a commercial venture and was first delivered in 1960. JT12 commercial applications and operating hours are listed below.

Aircraft Models	Operating Hours	Number of Engines
Lockheed Jetstar	214,003	356
North American Sabreliner	66,427	160
Total	280,430	516

The JT9D is a turbofan engine which is being developed under company funding for use in the Boeing 747 aircraft. It is planned for production in 1969. This is a high bypass ratio (5:1) twin-spool engine with a single-stage fan and a three-stage low compressor driven by a four-stage turbine, and an eleven-stage high compressor driven by a two-stage turbine. The engine will provide 41,000 pounds takeoff thrust with a TSFC of 0.337 at sea level static conditions.

3. Commercial Turbine Engine Record

a. Maintenance Material and Labor Cost

Evidence of the favorably low labor and material costs being experienced during airline operation of Pratt & Whitney Aircraft turbine engines is provided by examination of figure 5. This figure shows that for aircraft powered by turbojet engines (11,200 to 17,500 lb T.O. thrust category), the average powerplant maintenance labor and material costs on a dollars per 1000 T.O. lb thrust basis for the CV880 powered by General Electric engines

are over twice similar costs for B707, 720, and DC8 aircraft powered by Pratt & Whitney Aircraft engines. Average powerplant maintenance costs on the SE210 Caravelle powered by Rolls Royce engines are almost twice the costs for B707, 720, and DC8 aircraft powered by Pratt & Whitney Aircraft turbine engines.

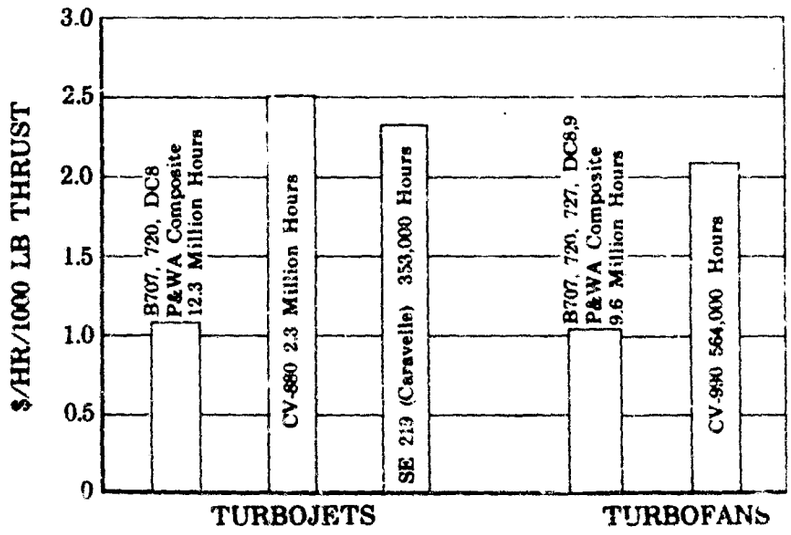


Figure 5. Total Engine Labor and Material Maintenance Cost - CAB Form 41 Data for 1961 Through 1965 FD 16464 K

For aircraft powered by turbofan engines (14,000 to 18,000 lb T.O. thrust category), the average powerplant maintenance labor and material costs on a dollars per 1000 lb of T.O. thrust basis for the CV990 powered by General Electric engines are almost twice similar costs on B707, 720, 727, DC8 and DC9 aircraft powered by Pratt & Whitney Aircraft engines.

Figure 5 is derived from the following tabulation:

Installation	Engine Time (Hours)	CAB Form 41 Total Power-Plant Maint. Labor and Material Cost $(000)	Engine Thrust S. L. Static T. O. (lb)	Thrust-Hour Operating Factor (Thrust × Hours) (000,000)	Powerplant Maint. Cost ($/HR/1000 lb Fn)
B707 DC8 (JT3C-6)	3,073,615	62,310	13,500	41,494	—
B720 (JT3C-7)	2,021,776	37,210	12,000	24,261	—
B720(JT3C-12)	388,748	7,958	13,000	5,054	—
B707 DC8 (JT4A)	6,849,456	115,649	17,500	119,865	—
All P&WA Turbojets	—	223,127	—	190,674	1.17

Installation	Engine Time (Hours)	CAB Form 41 Total Power-Plant Maint. Labor and Material Cost $(000)	Engine Thrust S. L. Static T. O. (lb)	Thrust-Hour Operating Factor (Thrust x Hours) (000,000)	Powerplant Maint. Cost ($/Hr/1000 lb Fn)
General Electric Turbojet In CV880	2,286,204	64,271	11,200	25,605.5	2.51
Rolls Royce Turbojet In SE210 (Caravelle)	352,896	10,412	12,725	4,490.6	2.32
B707) B720) JT3D DC9)	8,297,528	152,738	18,000	149,356	—
B727 DC9 JT8D	1,275,006	22,338	14,000	17,850	—
All P&WA Turbofans	—	175,076	—	167,206	1.05
General Electric Turbofan in CV990	631,896	21.270	16,100	10,173.5	2.09

The above tabulation is based on CAB Form 41 submittals* of all United States airline operators for the 5-year period, 1961 through 1965. It presents total powerplant QEC (Quick Engine Change) material and labor costs reported on all aircraft powered by Pratt & Whitney Aircraft turbine engines, as well as similar costs reported on aircraft powered by several competitive engines. Although these submittals include labor and material costs for other powerplant QEC items not provided by the engine manufacturer, as well as for engines, the engine represents by far the major portion of total reported QEC costs.

b. Time Between Overhaul

The JT3D provides an example of the durability of P&WA turbine engines. This engine has an allowable TBO (time between overhaul) of 8000 hours, which is the highest FAA authorized commercial engine TBO period in use today. Based on a 9-hour-per-day utilization, engine overhaul is required only once every 2-1/2 years with an 8000-hour engine TBO.

---

*The pertinent account numbers are as follows:

1. Labor - Aircraft Engines — Account 5225.2
2. Aircraft Engine Repair - Outside — Account 5243.2
3. Materials - Aircraft Engines — Account 5246.2

As shown in figure 6, P&WA engines have consistently shown an impressive rate of increase in TBO with time in airline service. In addition, each succeeding engine model (JT3C, JT4, JT3D, and JT8D) has exhibited a more rapid rate of TBO increase with time than its predecessor.

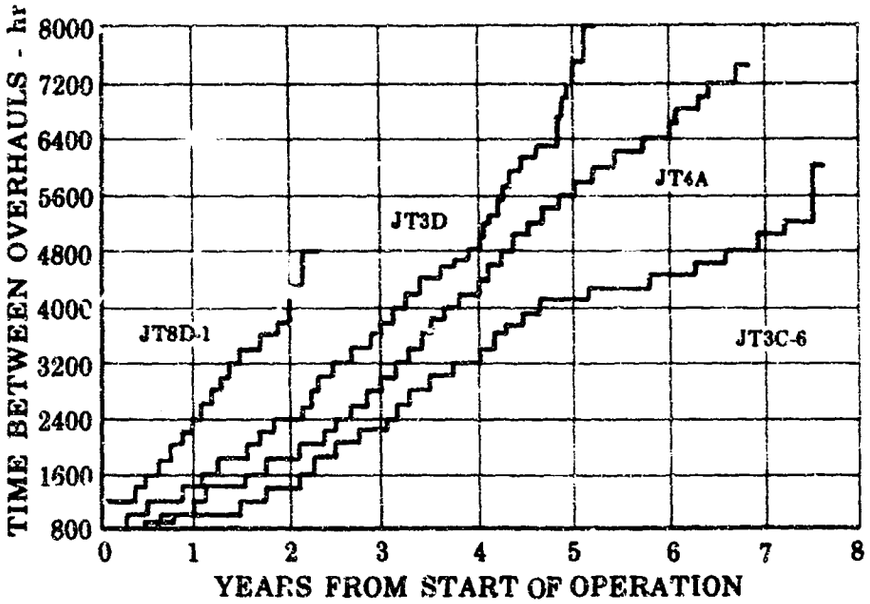


Figure 6. Time Between Overhaul Growth FD 17081 K

c. Engine Premature Removal Rate

In addition to reliability considerations, the cost of removing and repairing or overhauling a powerplant previous to scheduled periods is a significant element of profit or loss to an airline operator. From this standpoint, the engine premature removal record is an important economic criterion to the air transport operator. Yearly engine premature removal rates on P&WA turbine engines in commercial service since 1960 are shown in figure 7 and average 3460 hours per premature engine removal. The

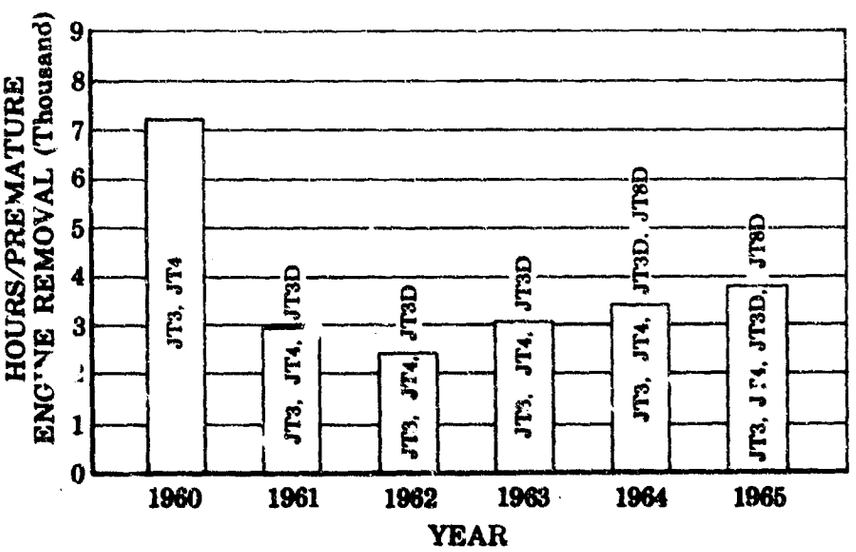


Figure 7. Engine Premature Removal Record - P&WA Service Department Statistics FL 16472 K

JT3D has a current rate of 5250 hours between premature removals, which means on a four-engine transport operating 10 hours per day that only three engines per year would be removed prior to schedule.

d. Engine In-Flight Shutdown Rate

A measure of powerplant dependability is provided by an examination of in-flight engine shutdown record. From a safety and reliability viewpoint, this is the most important FAA and airline criterion. In airline service since 1960, P&WA's engines have demonstrated an average in-flight shutdown rate for all turbine engines of 14,400 hours between shutdown. Figure 8 shows the average yearly in-flight shutdown rates being experienced on all P&WA engines in airline service for the past 6 years.

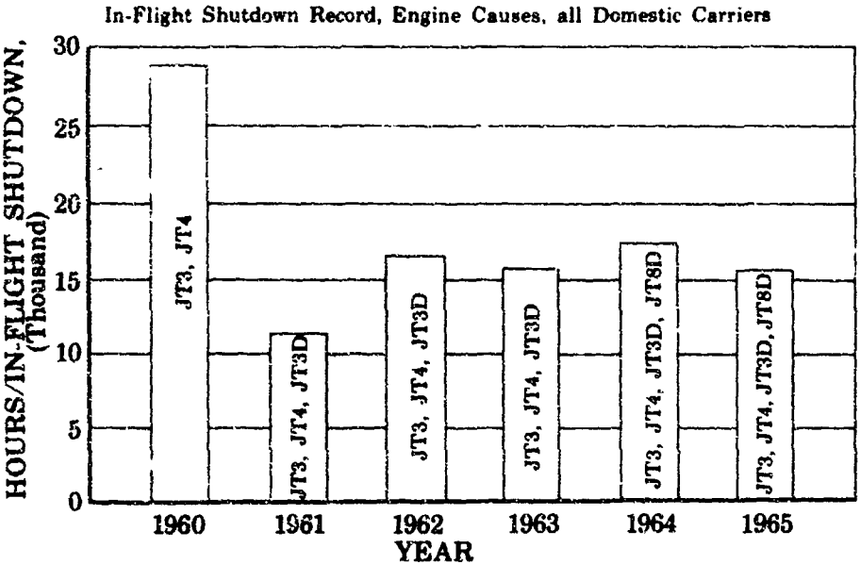


Figure 8. Durability of P&WA Engines FD 16473 K

The JT4 P&WA engine has a current in-flight shutdown rate of 28,700 hours per shutdown. This means that on the average, a four-engine airplane operated 10 hours per day could expect only one in-flight shutdown every 2 years chargeable to the powerplant.

Using published information shown in FAA document (FIS-FS-820-4) the experience of aircraft using P&WA turbine engines and similar data on aircraft using competitive turbine powerplants is illustrated in figure 9. Since airframe equipment items other than those supplied by the engine manufacturer contribute to the FAA "in-flight shutdown" rate, this criterion not only provides a measure of the engine manufacturer's ability to supply a safe, reliable powerplant, but also indicates his ability to work with the prime aircraft manufacturer in the design and delivery of a powerplant installation which provides safe and reliable service to the airline operator. From figure 9 it can be seen that aircraft using P&WA powerplants have experienced significantly better time between in-flight powerplant shutdowns than aircraft using competitive turbine powerplants.

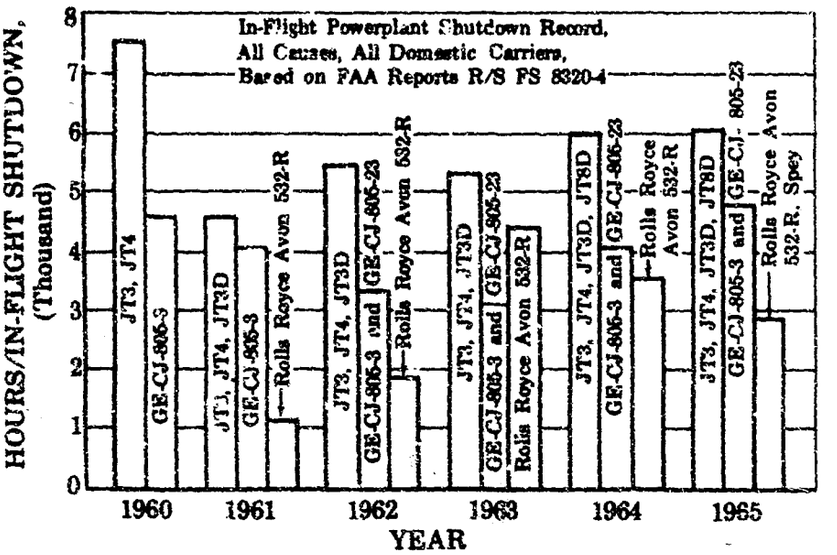


Figure 9. Dependability FD 16474 K

4. Private Risk-Taking for Commercial Engine Development

The willingness of United Aircraft (parent corporation of P&WA Division) to provide private credit and private risk-taking capital for commercial engine ventures has been demonstrated on the JT3, JT3D, JT4, JT8, and JT12 programs. The $75,000,000 Company R & D funding which has been provided to a purely commercial engine, the JT8D, is a pertinent example of our commitment to the commercial transport market as a valuable segment of our principal business and an important part of our future. The sale of over 3400 of this type engine in the Boeing 727, 737, DC9, and Caravelle attests to P&WA's understanding of the air transport industry's requirement for a high performance, economical commercial powerplant.

United Aircraft has recently embarked on a company-funded development program for the JT9D turbofan for the subsonic "jumbo jet" which will not carry passengers until 1969. This provides an example of our continued willingness to risk company funds on engines designed to meet commercial transport requirements.

5. Development for Growth in Commercial Engines

The fact that successful transport engines must grow and offer improvements to be responsive to airline operators' changing requirements is another commercial lesson which the record shows has been put to use by Pratt & Whitney Aircraft on its JT3C, JT3D and JT8D commercial engines.

Examples of the application of this lesson are provided by the JT3C-7 and JT3C-12 which were developed and offered to the commercial transport industry by Pratt & Whitney Aircraft as growth versions of the original JT3C-6. The C-7 provided 7% growth and the C-12 a 16% growth in engine dry T.O. thrust from the C-6. The weight of the C-7 engine was decreased 18.5% and the weight of the C-12 was decreased 16.5% below the original

JT3C-6 weight. A similar growth and weight reduction program was offered by Pratt & Whitney Aircraft on the commercial JT4. Between the original JT4A-3 and the JT4-11, takeoff thrust was increased 17% and engine weight was decreased 2.5%.

6. Product Support

The original group, which was initially formed to "service" Pratt & Whitney Aircraft engines has over the past 39 years grown to more than 1400 people, including some of the initial group that are still with the company. The current organization consists of world-wide field support in areas of installation, operation, performance, maintenance, overhaul, spares support, tools and facilities. These specialists are backed by other in-house specialists, many of whom have served in the field themselves. This direct customer contact surrounds the manufacturer/operator with support for every phase of his operation (see figure 10) and permits the closest liaison possible.

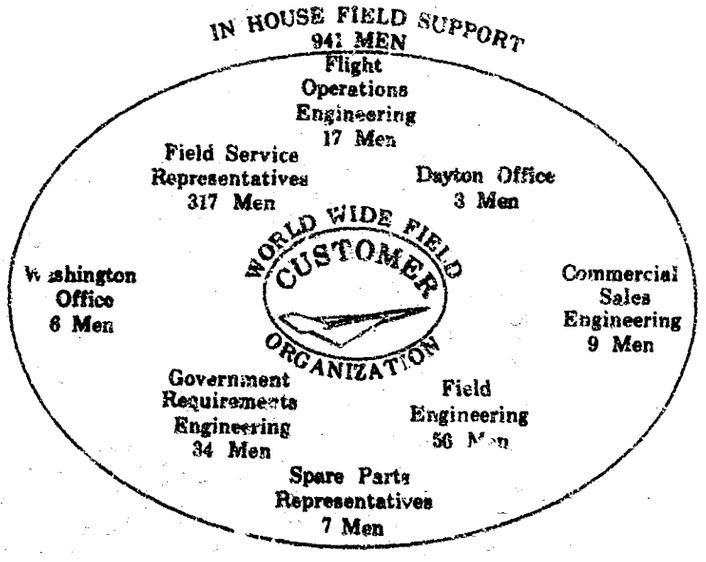
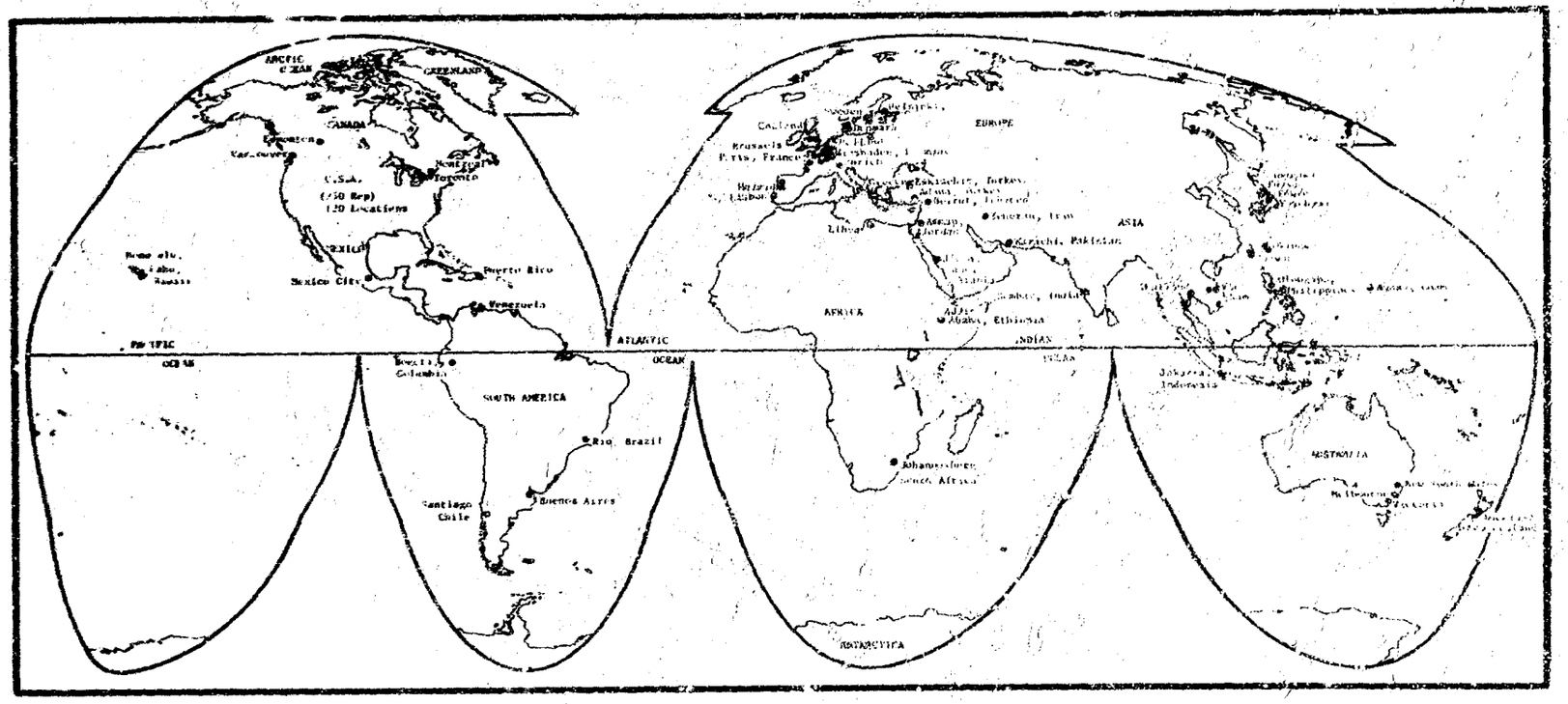


Figure 10. Pratt & Whitney Aircraft Product Support FD 16499 K

The world-wide dispersement of the 317 P&WA Field Service Representatives in 22 countries is shown in figure 11. The location of the Field Service Representatives in this country is also shown in figure 12.



VK-15

Figure 11. Location of Field Service Representatives (International)

FD 16303
K

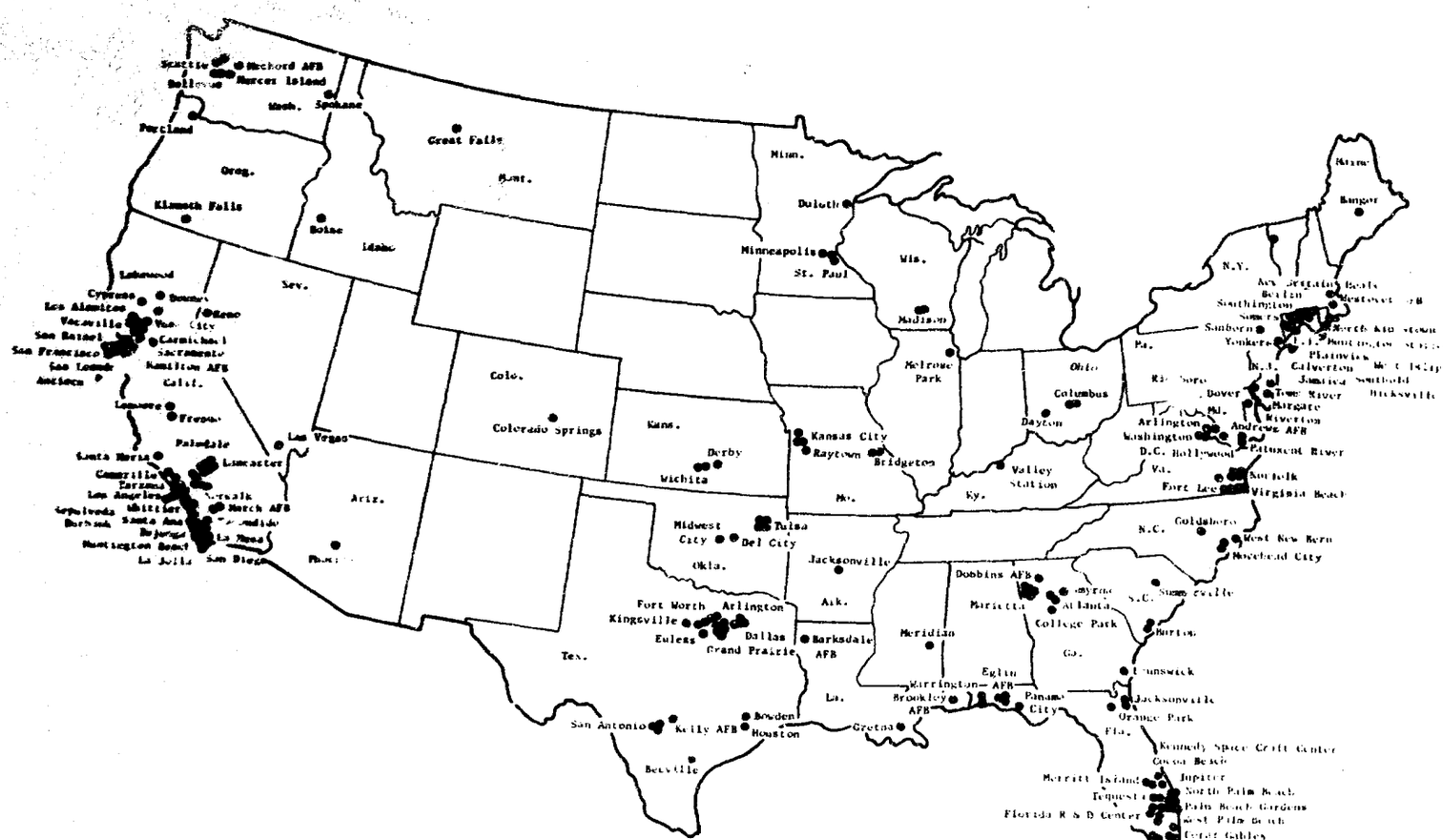


Figure 12. Location of Field Service Representatives (National)

FD 16512
K

Pratt & Whitney Aircraft's record in commercial airline service depends on the concept that the experience and capability of the entire company must be available to the customer whenever assistance is required, and that the company must have firsthand knowledge of the customer's problems requiring corrective action by Pratt & Whitney Aircraft. Recognition of this concept by the company's management has assured the evolution of a capable and large field organization. This organization has developed not only a sensitiveness and responsiveness to field problems, but also a fast working communication system. At first instance, field problems are channeled directly to the Program Manager and his Project Engineer responsible for the solution in order that fixes can be initiated and incorporated in test engines for evaluation without delay. In addition, the Pratt & Whitney Aircraft system assures top management awareness of these problems. It is not a request but a requirement that the Vice President, Product Support, the Vice President, Engineering, the Vice President, Sales, and the Divisional President, the Service Manager, the Spare Parts Sales Manager, and the Manager, Overhaul and Repair, be provided reports on customer problems.

A detailed and documented discussion of the P&WA field organization is presented in Volume IV, Report F, Section VI (Product Support). However, it should be noted here that this organization will not be disbanded nor be diminished in size before the SST enters airline service. It is conservatively estimated that between now and the mid-1970's the airlines of the world will have flown more than three times the currently existing hours. The P&WA world-wide field organization is being expanded to provide product support not only to those carriers who are adding to their inventory, but equally important, to provide support for those airlines which have not previously operated turbine equipment. By the end of 1966, Pratt & Whitney Aircraft will be providing support to 22 world-wide commercial operators who have not previously had jets; in 1967 support will be provided to 18 new jet operators; and in 1968, 15 new operators. It is significant to note that P&WA will have in place and functioning, before the SST becomes operational, an organization that will be accumulating more commercial airline experience than there exists in the world today.

B. SUPERSONIC CRUISE EXPERIENCE

Over 2-1/2 years ago the President announced the existence of the J58 powered YF-12/SR-71 aircraft and described them as the world's fastest operational aircraft. (See figure 13.) The total of engine flight experience gained by the Pratt & Whitney Aircraft Florida Research and Development Center in the SR-71/YF-12 programs to date represents over 1,000,000 miles of engine operation at Mach 2.7 (SST cruise speed) and above. The J58 engine used in these installations (figure 14) is an afterburning turbojet engine of the 30,000-pound thrust class. The current production engine is qualified for continuous operation above Mach 3.0, for continuous turbine inlet temperature above 2000°F, and for continuous operation of the variable augmentation afterburner. The J58 is the highest thrust engine now in production.



Lockheed YF-12A



Lockheed SR-71

Figure 13. Pratt & Whitney Aircraft J58 Powered Aircraft — FD 16564 K



Figure 14. Pratt & Whitney Aircraft J58 Engine — FE 42662 K

Aircraft operation at sustained supersonic cruise speed introduces the following three important powerplant design and development considerations that are of relatively little significance in subsonic or supersonic dash aircraft:

1. Engine operation and mechanical durability in a hostile powerplant temperature environment (See figure 15.)
2. Operation of the powerplant with a complex pressure pattern at the engine inlet face resulting from operation behind a high performance variable geometry supersonic inlet. (See figure 16 for pressure patterns with which the J58 engine has been tested successfully.)
3. Efficient operation of the engine variable exhaust nozzle and ejector system over a wide range of airspeeds and altitudes.

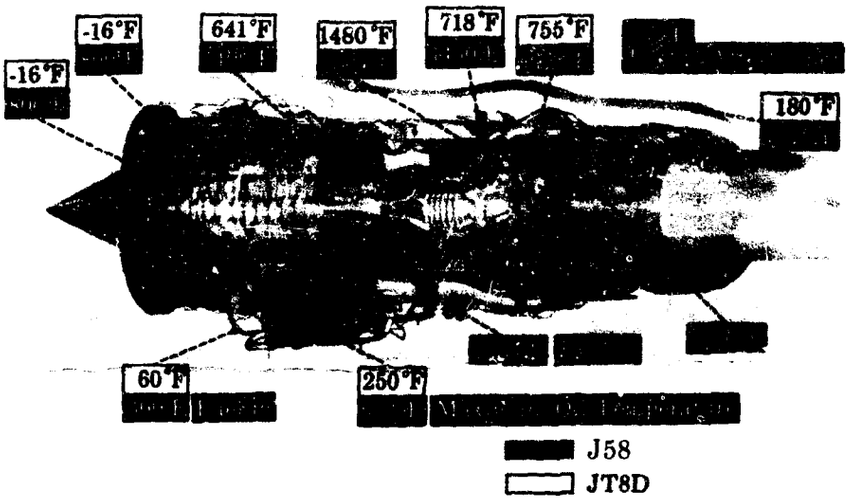


Figure 15. Engine Temperature Environment Comparison FD 2565E K

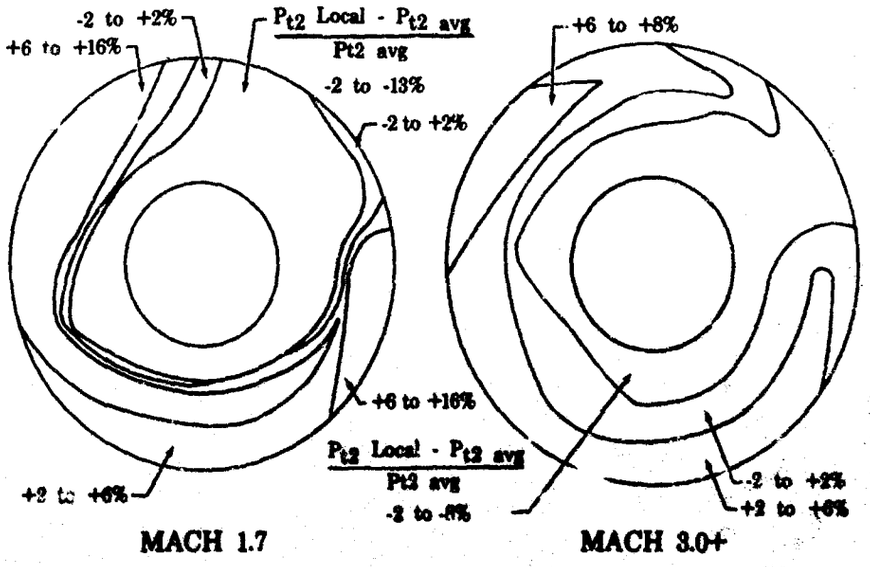
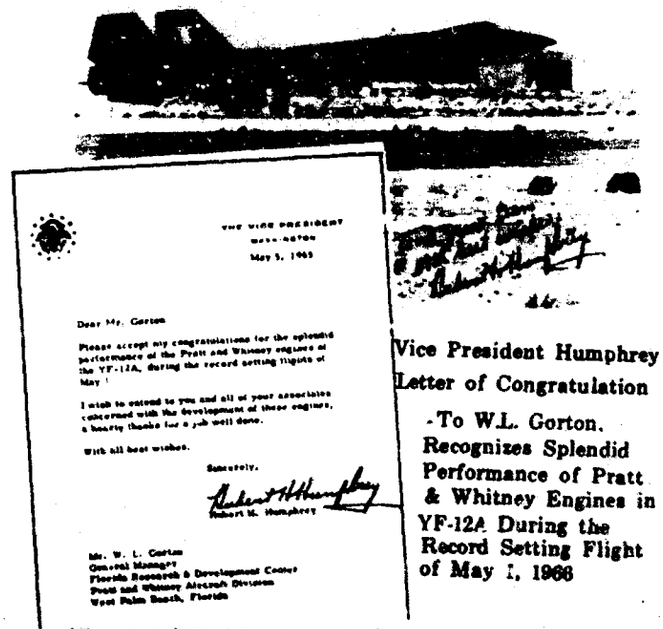


Figure 16. Typical Inlet Distortion Levels Experienced by J58 During Simulated Supersonic Operation FD 17541 K

In the 9 years since start of development of the J58 and the subsequent flight of this engine in operational airplanes, the Pratt & Whitney Aircraft Florida Research and Development Center has faced and found solutions to these unique problems of supersonic cruise powerplants. Evidence of this is provided in the performance of the J58/YF-12 aircraft, which holds the world record for speed (2,062 mph - Mach 3 plus) and altitude (80,000 feet).

CONFIDENTIAL

Figure 17 shows Vice-President Humphrey's letter to W. L. Gorton, plus a signed picture. The Colonel Stephens Plaque, which was awarded to W. H. Brown, is shown in figure 18. The United Aircraft Corporation Engineering Award to FRDC is shown in figure 19.



Vice President Humphrey
Letter of Congratulation
-To W.L. Gorton,
Recognizes Splendid
Performance of Pratt
& Whitney Engines in
YF-12A During the
Record Setting Flight
of May 1, 1966

Figure 17. J58/YF-12A Award FD 16911 K

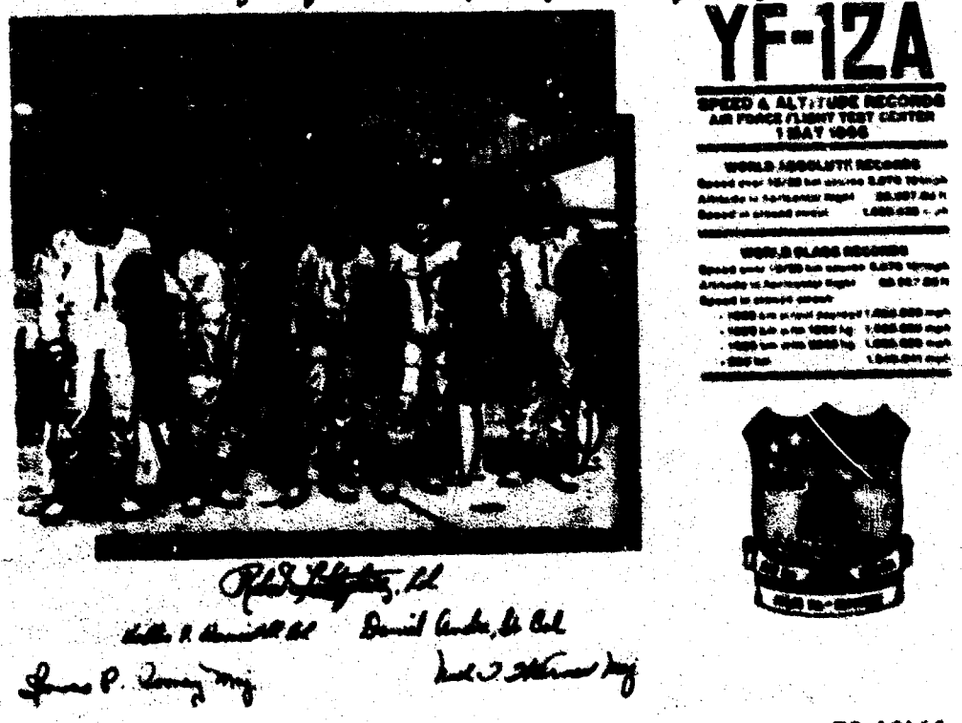


Figure 18. Colonel Stephens Award VK-20 FC 13163 K

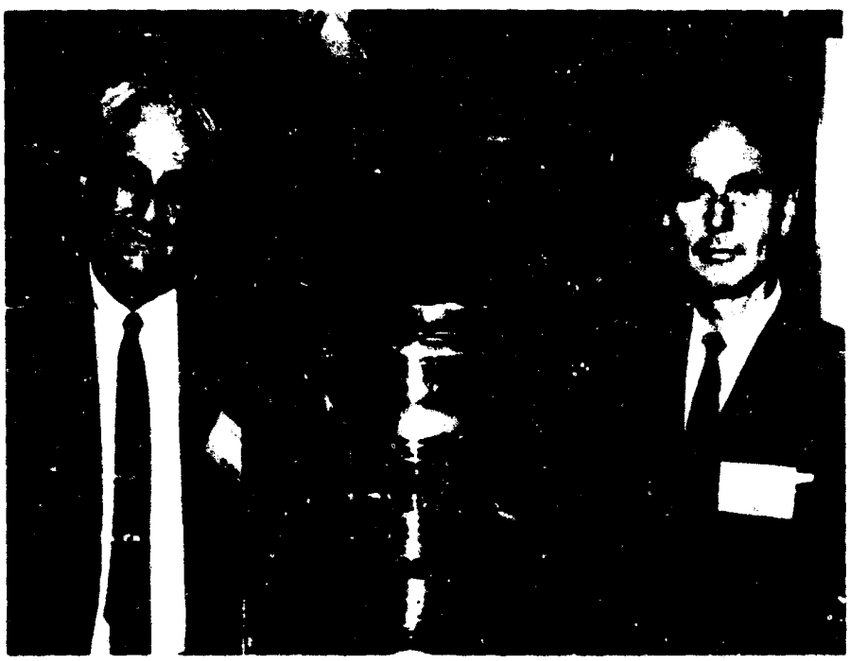


Figure 19. United Aircraft Corporation Award for J58

FC 13357
K

The YF-12/SR-71 programs are the only United States programs that will provide significant operational experience in the Mach 2.7 and above supersonic cruise regime between now and the time the first United States supersonic transport takes to the air. Because of this, the continuing lessons of experience yet to be learned on these programs will provide invaluable inputs to the powerplant development program on the SST.

Pratt & Whitney Aircraft's Florida Research and Development Center flight experience in the YF-12/SR-71 programs represents more engine flight hours at and above SST cruise speed (Mach 2.7) than all other engine manufacturers in the free world combined. A summary of Pratt & Whitney Aircraft's Florida Research and Development Center full-scale J58 development and qualification testing conducted in P&WA facilities in West Palm Beach, Florida, and East Hartford, Connecticut, is given in table 1. This includes successful completion of a preliminary flight rating test and full 150-hour model qualification tests. In the course of this extensive effort on the J58, Pratt & Whitney Aircraft has developed the engine to a high level of stall tolerance and engine durability under a wide range of airplane yaw and pitch angles, under conditions of disgorged inlet shock, and under a highly unfavorable steady-state engine inlet distortion pattern. (See figure 16.) Materials (and their fabrication into operational engine parts) that will withstand the sustained high temperatures of supersonic cruise and their cycling to ambient conditions have been developed on the J58.

Table 1. J58 Development Test Experience

Total Test Time	22,805 Hours
Test Time at M = 2.5	6,011 Hours
Test Time at M = 3.0	5,427 Hours
Test Time at or above 1900°F TIT	10,974 Hours
Test Time at or above 2000°F TIT	4,759 Hours
Test Time at 50,000 feet or above	6,955 Hours

Satisfactory engine operation demonstrated on test stand at Mach 2.9, 108,000 ft altitude conditions.

Serviceable leakproof liquid and air plumbing connections, as well as engine accessories that can live in the supersonic cruise environment are accomplishments of the J58 program. Lubricating oils and fuels for operation in Mach 3 cruise powerplants were developed and have been proven in operational service on the J58. The development of these fuels and lubricants has made possible the use of self-cooled lubrication systems on the J58 engine.

The J58-powered YF-12/SR-71 aircraft was the first to adapt the blow-in-door ejector nozzle to provide efficient operation over the full range of flight speed from takeoff to better than Mach 3. The aerodynamic design and model testing of the nozzle were provided by Pratt & Whitney Aircraft, who also conducted full-scale engine tests of the Lockheed-built ejector. Blow-in-door placement was carefully worked out as a cooperative engineering effort between the two companies, so that the subsonic performance potential of this nozzle concept could be realized.

In addition to its wide operating range, the installation of this nozzle in the YF-12/SR-71 has provided substantial engine noise attenuation. This same nozzle concept is proposed for the Pratt & Whitney Aircraft JTF17 SST engine.

C. MILITARY GAS TURBINE EXPERIENCE

1. General

Pratt & Whitney Aircraft has been a leader in the field of aircraft propulsion since the introduction of its 400-horsepower Wasp engine in 1926. Since that time, a total of 500,000 Pratt & Whitney Aircraft-designed engines have been delivered. Since World War II more than 35,000 Pratt & Whitney Aircraft gas turbine engines have been delivered. Quantities and dollar values of turbine engine shipments are shown in figure 20, and pictorial representations of some of the more recent Pratt & Whitney Aircraft turbine engines are given in figure 21. Commercial installations for these engines in Boeing, Douglas, Lockheed, North American, and Sud Aviation aircraft have been outlined previously, but many United States military aircraft are also powered by Pratt & Whitney Aircraft engines. Figure 22 shows some of the military applications of P&WA turbine engines.

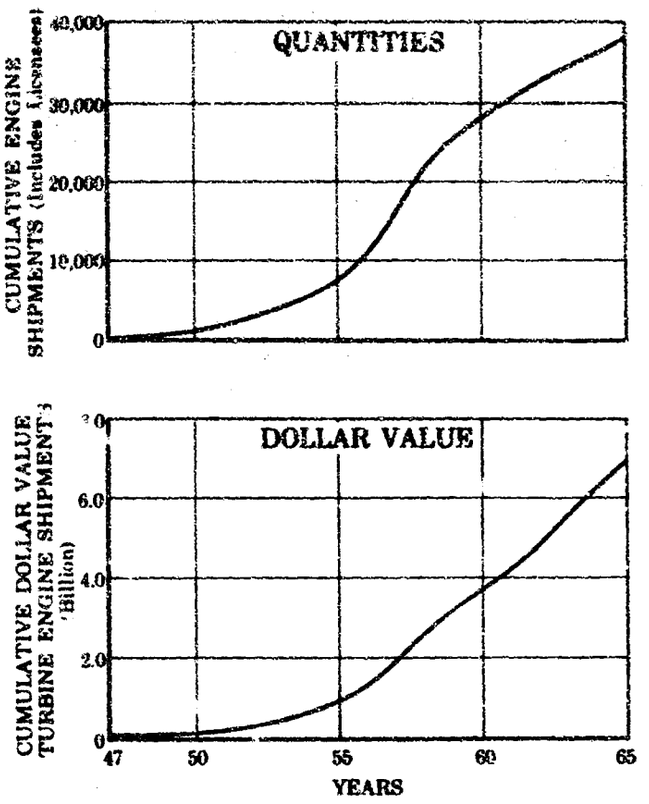


Figure 20. Turbine Engine Shipments FD 16475

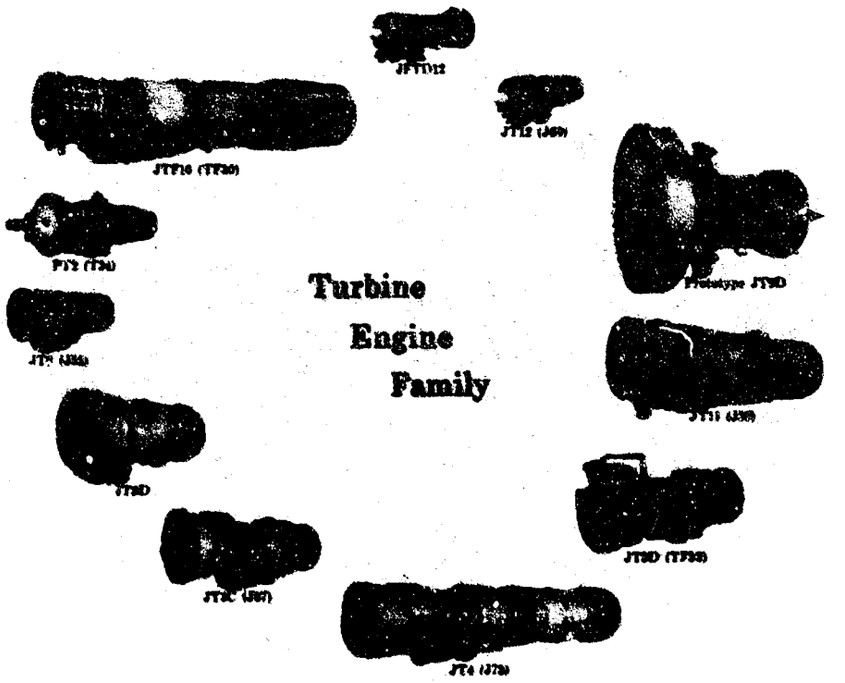


Figure 21. Turbine Engine Family FD 16563 K

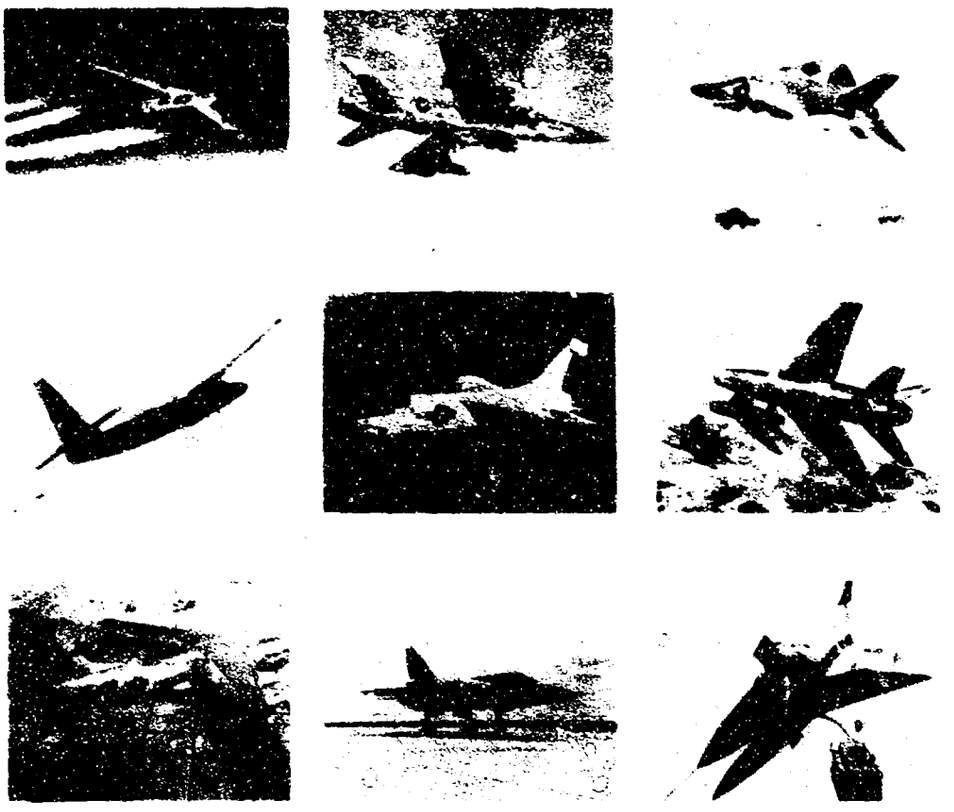


Figure 22. P&WA Powered Military Aircraft FD 16908 K

2. Description of Military Engines and Applications

A brief description of the engines and some of the military applications are presented in the following paragraphs.

a. J42 Turbojet (JT6)

The J42 engine is a turbojet with a single-stage, centrifugal compressor and single-stage, axial-flow turbine; takeoff rating is 5,000 pounds of thrust at sea level. A total of 1,139 J42 engines were delivered, with first engine deliveries in 1948. This engine is used in the Grumman F9F aircraft and has accumulated approximately 2,000,000 operating hours in this installation.

b. J48 Turbojet (JT7)

The J48 engine is a turbojet engine with a single-stage centrifugal compressor used in Grumman F9 fighters and Lockheed F-94 aircraft. This engine develops up to 7250 pounds of thrust without augmentation, or 8000 pounds with afterburner augmentation. A total of 4108 J48 engines were delivered, with first engine deliveries in 1949. This engine is used in the Grumman F9F and Lockheed F-94 aircraft and has accumulated approximately 2,835,000 hours in these installations.

c. J57 Turbojet (JT3)

The J57 is the military version of the JT3 engine; it is an axial-flow, twin-spool, turbojet engine with eight combustion chambers, a 3-stage reaction turbine, and a 16-stage compressor. The latest version of this engine develops 13,750 pounds of thrust with water injection, or 18,000 pounds with afterburning augmentation. A total of 14,071 military J57 engines have been delivered with first engine deliveries in 1951. Various J57 military applications and operating hours are listed below.

Aircraft Models	Operating Hours
B-52	19,445,854
KC-135	7,165,666
C-135	476,095
A-3	994,863
F-64	347,600
F-8	1,219,814
F-100	3,465,650
F-101	2,421,295
F-102	1,556,401
RF-57D	Not available
VC-137A	Not available
WU-2	Not available
SM-62	Not available
Total Military	37,093,238

d. TF33 Turbofan (JT3D)

The TF33 engine is an axial-flow turbofan developed from the J57 engine, and is the military equivalent of the JT3D. The first two stages of its compressor are fan stages, and a portion of the air from these stages is directed by ducts to discharge nozzles to produce part of the total thrust. The remainder of the air goes through the 14 additional stages of the compressor, eight burners, and four turbine stages to exit through the exhaust nozzle and produce the remainder of the thrust. The most powerful version of this engine develops 21,000 pounds of thrust. Aircraft powered by these engines have demonstrated range increases of more than 20% when compared to earlier J57 turbojet-powered models. A total of 1993 TF33 engines have been delivered, with first engine deliveries in 1959. Various TF33 military application and operating hours accumulated in these installations are listed below.

Aircraft Models	Operating Hours
B-52H	2,267,865
C-135B	777,567
KC-135B	99,178
VC-137C	Not available
C-141	379,258
Total	3,523,868

e. J75 Turbojet (JT4)

The J75 is the military version of the JT4 engine; it is an axial-flow, twin-spool turbojet engine with eight combustion chambers, a 3-stage reaction turbine, and a 15-stage compressor. The latest version of this engine develops 17,500 pounds of thrust, or 26,000 pounds with afterburner and water injection augmentation. A total of 1473 J75 engines have been delivered, with first engine deliveries in 1956. Various J75 military applications and operating hours accumulated in these installations are listed below.

Aircraft Models	Operating Hours
F-105	669,229
F-106	418,474
U-2A	Not available
Total	1,087,703

f. J52 (JT8) Turbojet

The J52 engine is an axial-flow twin-spool engine with nine combustion chambers, a 3-stage reaction turbine, and a 12-stage compressor. This engine develops up to 9300 pounds of thrust. A variable-area, convergent-divergent plug nozzle was first used successfully for the version of this engine used in the GAM-77 missile installation. A total of 1965 J52 engines have been delivered, with first engine deliveries in 1958. Various J52 military applications and operating hours accumulated in these installations are listed below.

Aircraft Models	Operating Hours
A-6A	428,225
A-4E	Included in hours shown for A-6A
GAM-77 Missile	588,249
Total	1,016,474

g. J60 Turbojet (JT12) - JTFD12 (Free Turbine Versions)

The J60 engine is the military version of the commercial JT12 engine. It is an axial-flow, single-spool, turbojet engine with eight combustion chambers, a 2-stage reaction turbine, and a 9-stage compressor. This is a small, high performance engine that develops up to 3300 pounds of thrust in the latest version to be available this year. The JTFD12 is a free-turbine engine developed for helicopter use. It employs the JT12 as a gas generator, adding a 2-stage free turbine that extracts 4050 shp. This engine is used in the Sikorsky CH-54 Skycrane. A total of 852 military J60 and JTFD12 engines have been delivered, with first engine deliveries in 1959. Various military applications and operating hours accumulated in these installations are listed below.

Aircraft Models	Operating Hours
C-140	146,228
T-39	972,324
T-2B	51,408
S-64 Skycrane	8,000
VC-10	Not available
XV-4A	Not available
DFS-82	Not available
Total	1,177,960

h. JT8D Turbofan

The JT8D is an axial-flow, twin-spool, turbofan engine previously described, which in its commercial version, develops up to 14,500 pounds of thrust for takeoff in the latest version to be available in 1967. An afterburning version of this engine is being developed by the Royal Swedish Air Force under a licensing agreement for use in the SAAB J37 Viggen fighter.

i. T34 Turboprop (PT2)

The T34 is an axial-flow turboprop engine with eight combustion chambers a 3-stage turbine, and a 13-stage compressor. The compressor drives the propeller shaft through double planetary reduction gearing delivering 6950 shp. Additional thrust is obtained by discharge of high velocity turbine gases through a fixed area nozzle, which raises engine output to 7500 equivalent shp. A total of 484 T34 engines have been delivered, with first engine deliveries in 1951. Besides experimental versions of the Boeing C-97 and Lockheed C-60, which used T34 engines, this engine is the powerplant for the Douglas C-133. In this installation, the T34 has accumulated 1,524,763 hours.

j. TF30 Turbofan (JTF10)

The TF30 is a high Mach No. afterburning turbofan engine used in this country's latest supersonic joint service fighter, the F-111. It also powers the Navy's A-7 fighter, and has most recently demonstrated supersonic flight in the French supersonic fighter, the Mirage IIIF. The TF30 is an axial-flow, twin-spool, turbofan engine with full-length ducted fan exhaust. This engine is in the 20,000-pound thrust class with afterburning. A total of 130 TF30 engines have been delivered, with first engine deliveries in 1961. Various TF30 military applications and operational hours accumulated in these installations are listed below.

Aircraft Models	Operating Hours
F-111, A, B	2412
A-7A	784
French Mirage III	15
Total	3211

3. Supersonic Dash Flight Experience

As depicted in figure 23, Pratt & Whitney Aircraft engines have provided power for supersonic dash airplanes for the past 13 years, commencing with the J57 installed in North American F-100 aircraft. Following the use of the J57 in F-100, F-101, and F8U applications, Pratt & Whitney Aircraft engines have been used in F-105, F-106, and the joint service F-111 aircraft. During the 13 years that these aircraft have been operated, 25,000,000 total hours have been accumulated by the P&WA engines in these installations, and an estimated 200,000 of these hours were flown at supersonic speeds. (See figure 23.) With the early experience in supersonic flight achieved by J57-powered aircraft, problems have been encountered and solved to provide for improved models of J57 and successive improvements in J75, J58, and TF30 engines. The improved engines resulting from increased knowledge of the supersonic regime, and component developments, have contributed to significant improvements in aircraft operations over the years.

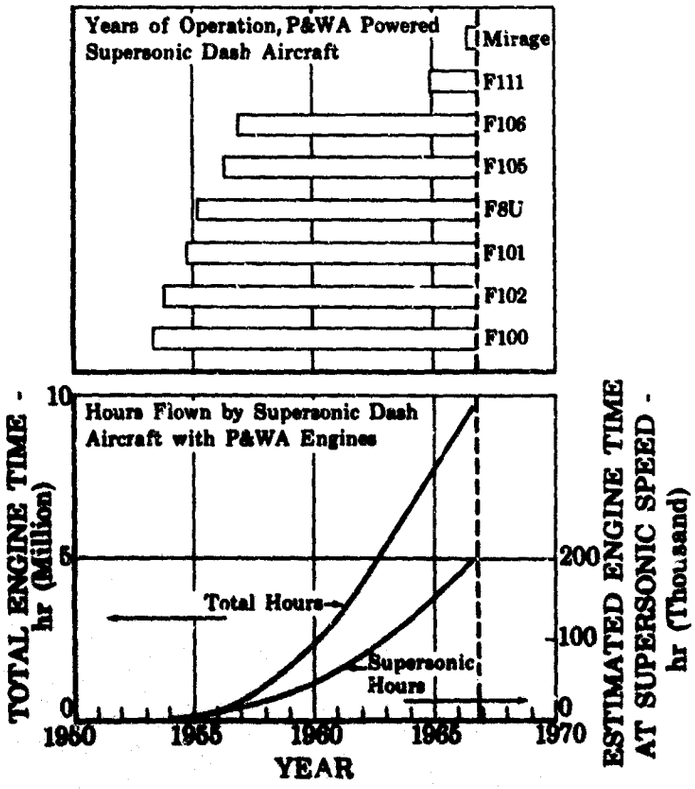


Figure 23. Operation of Pratt & Whitney Aircraft Powered Supersonic Dash Aircraft FD 16530 K

D. AIRCRAFT POWERPLANT RESOURCES

Figures 24, 25, 26, and 27 show the growth of Pratt & Whitney Aircraft since 1950 in total facilities, personnel, and floorspace available for development, production, and support of aircraft powerplants.

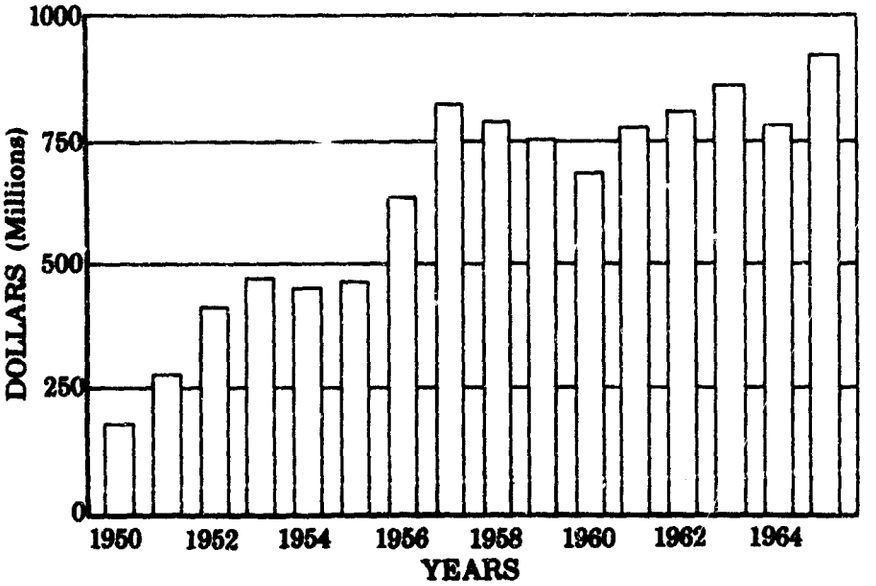


Figure 24. Pratt & Whitney Aircraft Total Expenditures — FD 16481 K

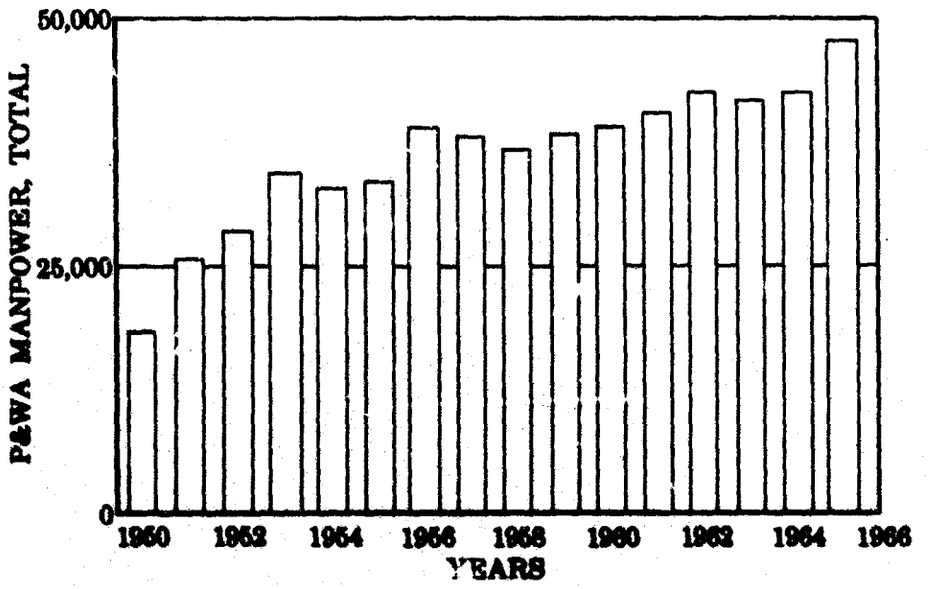


Figure 25. Pratt & Whitney Aircraft Total Employment (Year-End) — FD 16480 K

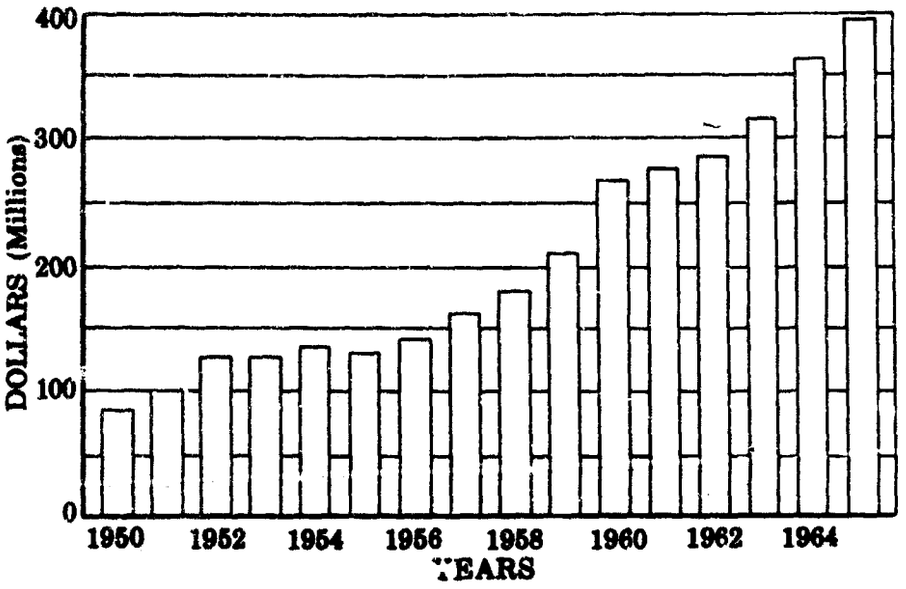


Figure 26. Pratt & Whitney Aircraft Facilities Investment — FD 16482 K

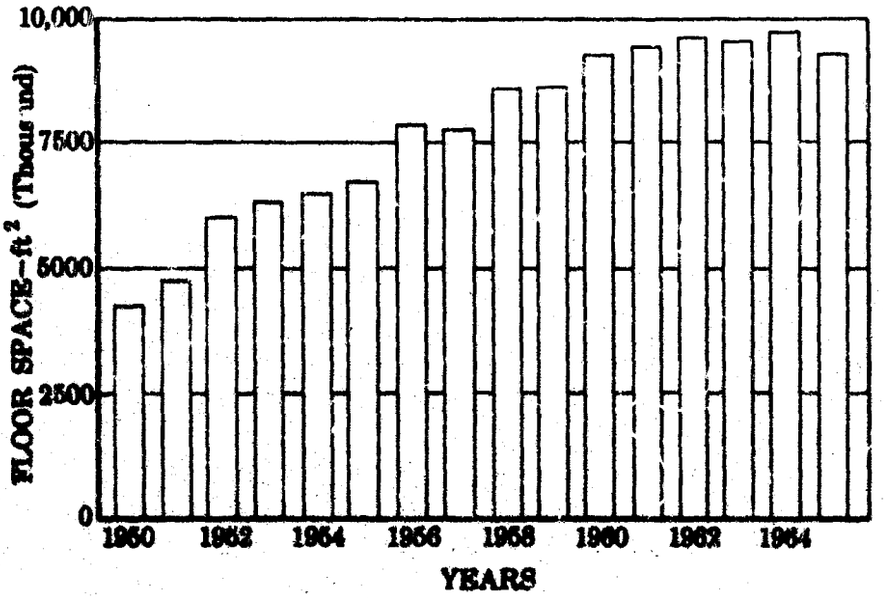


Figure 27. Pratt & Whitney Aircraft Total Floor Space — FD 16483 K

Consistent with Pratt & Whitney Aircraft emphasis on engineering, our Engineering Department has shown consistent growth and has acquired the engineering talent and research, development, and manufacturing facilities required to maintain a position of leadership within the aircraft industry. Figures 28, 29, 30, and 31 show this growth since 1950 in Pratt & Whitney Aircraft Engineering Department expenditures, technical manpower, facilities, investment and floorspace.

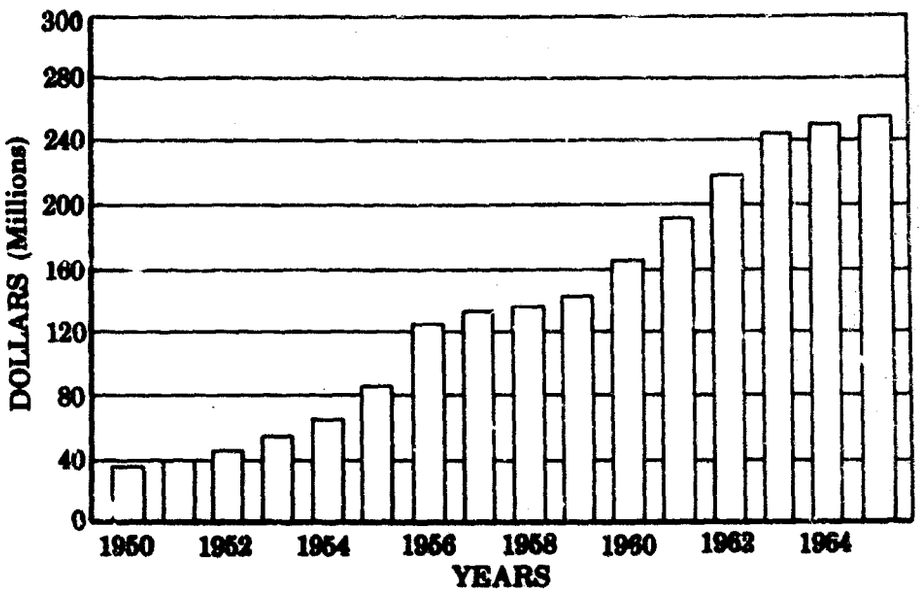


Figure 28. Engineering Expenditures FD 16476 K

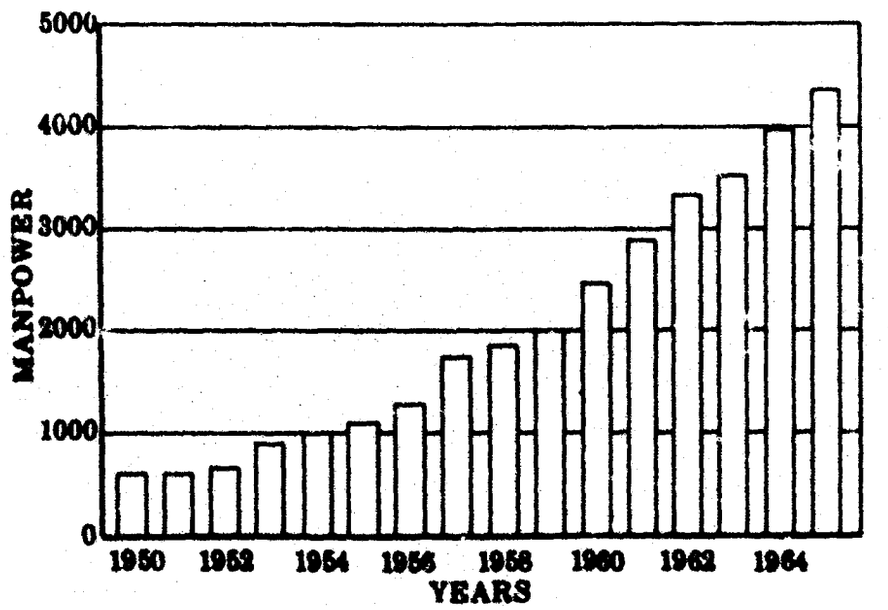


Figure 29. Technical Manpower FD 16477 K

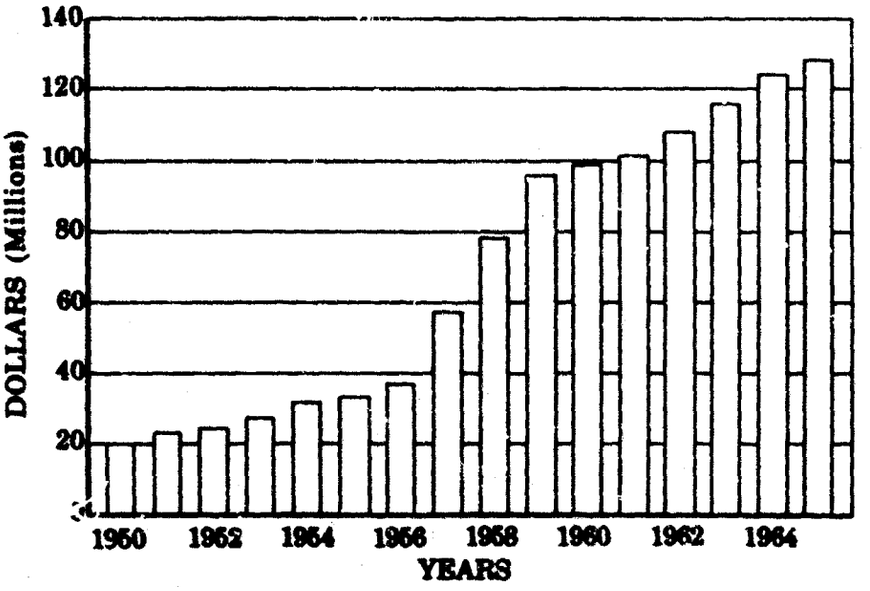


Figure 30. Engineering Facilities Investment FD 16478 K

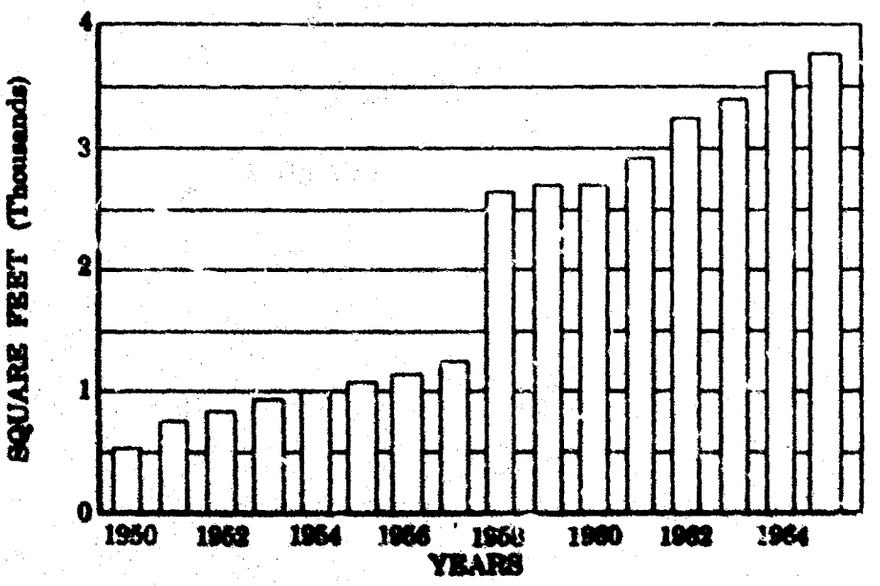


Figure 31. Engineering Floor Space FD 16479 K

To develop the Mach 3 plus J58 engine, the Pratt & Whitney Aircraft Florida Research and Development Center has used high Mach number altitude and sea level engine development facilities with a replacement cost exceeding $100,000,000; this represents the largest on-site high Mach number engine manufacture facilities available in the world today. Heated inlet stands to subject test engines to the 800°F inlet temperatures of supersonic cruise flight are in daily use on the J58 at Florida Research and Development Center. Altitude test facilities to check the performance of full-scale engines at 80,000 feet and Mach 3 are available and have been in use on the J58 at both Florida Research and Development Center, and at Pratt & Whitney Aircraft's Willgoos Laboratory in East Hartford, Connecticut.

Pratt & Whitney Aircraft has assigned the development of the JTF17 engine to the Florida Research and Development Center to take full advantage of the facilities and management team that exist there with this unique high Mach number background.

E. RECORD IN MEETING COMMITMENT

1. Commercial

Table 2 presents the record of Pratt & Whitney Aircraft in meeting performance, weight, and schedule commitments on commercial turbine engines. Note that in all cases engines were delivered on or ahead of schedule*, their weight at delivery was on or below original specification weight**, their takeoff thrust at delivery was either on or above the original specification thrust, and TSFC at takeoff and cruise at time of engine delivery was either on or below original specification value.

2. Government R & D

A complete listing of all Government R & D programs undertaken by Pratt & Whitney Aircraft since 1947 is available for inspection at the Florida Research and Development Center. The following are summaries of selected programs that demonstrate company competence in carrying out turbine engine R & D programs, as well as other advanced state-of-the-art technology programs.

---

*A strike involving more than 50% of all Pratt & Whitney Aircraft production personnel during the summer of 1960 was responsible for the 1-month slip in delivery date of the first JT4A engine.

**Customer-requested changes after original order date were responsible for the 61-pound change in specification weight on the JT8D at time of delivery.

Table 2. Pratt & Whitney Aircraft Record In Meeting Commitments, Commercial Engine

Engine Model	Order Date	Delivery Schedule When Ordered	Delivery Schedule When Delivered	Engine Weight When Ordered Spec	Engine Weight When Delivered Actual	Takeoff Thrust When Ordered Spec	Takeoff Thrust When Delivered Actual	TSFC Sea Level Takeoff Rating (% Below Original Specification When Delivered)	TSFC Altitude Cruise (% Below Original Specification When Delivered)
JT3C	Oct 1955	Apr 1958	Apr 1958	4350	4030	12,500	13,000	1.3 - 2	0 - 1
JT3A	Oct 1955	Jun 1959	Apr 1959	5570	4971	14,000	15,800	2 - 3.1	0 - 1.5
JT3D	Mar 1959	Aug 1960	Sep 1960*	4025	3982	17,000	17,000	3.5	2.6 - 3.9
JT8D	Oct 1960	Feb 1963	Feb 1963	2980	3041**	14,000	14,000	11	1.6 - 3.0

*1 month delay due to labor strike idling more than 50% of production personnel

**61-pound addition to engine weight due to customer requested changes after original order

a. Production Engine R & D Programs

(1) J57 Engine

The following contracts provided for development and production improvement of the J57 engine covering the time period from 29 August 1947 to 14 March 1963: W33-038-ac-18662, AF33(038)-9505, AF33(600)-5839, AF18(600)-126, NOas52-1080-f, AF33(600)-22940, NOas53-594-f, NOas-53-834-f (T57 Design), AF33(600)-23146, NOas57-235-f, NOas57-264-f (T57 Development). These 11 contracts with the Air Force and Navy BuAer were all fixed-price, prime contracts. The J57 work under these contracts has a dollar value of $156,607,138 and was all completed on or ahead of schedule, or was terminated on or ahead of schedule.

(2) TF33 Engine

The following contracts provided for development of the TF33 engine over the time period of 29 October 1958 to 29 January 1963: NOas59-8014-f, NOw60-0699-f, and NOw62-0884-f. These three contracts with the Navy BuAer were all fixed-price, prime contracts. The TF33 work under these contracts had a dollar value of $42,625,000 and was all completed on schedule.

(3) J75 Engine

The J75 engine was developed under the following contracts over a time period from 29 November 1952 to 31 January 1959: AF33(600)-22950, NOas57-265-f, and NOas59-8003-f. These three contracts with the Air Force and Navy BuAer were all fixed-price, prime contracts. The J75 work under these contracts had a dollar value of $81,000,000 and was completed on schedule.

(4) J52 Engine

The following contracts covered development of this engine over the time period of 18 May 1953 to 1 February 1963: NOas53-685-f, NOas56-429-f, NOas58-531-f, NOas59-0314-f, NOw60-0698-f, NOw62-0741-f. These six contracts with Navy BuAer and BuWeps were all fixed-price, prime contracts. The J52 work under these contracts had a dollar value of $67,511,000 and was completed on schedule.

(5) J58 Engine

The J58 development was initiated under Navy contracts - NOas57-257-f and NOas59-0318-f. Since 1957, all development work on this engine was conducted at the Florida Research and Development Center. The purpose of this program was to design, develop, manufacture, and test an advanced-type jet engine for operation at flight speeds up to Mach 3.0 and at altitudes up to 80,000 feet. The current production engine is qualified for continuous operation above Mach 3.0, for continuous turbine inlet temperature above 2000°F, and for continuous operation of the variable augmentation afterburner. The J58 is the highest thrust engine now in production. Some significant commendations and awards for work on this

engine are shown in figures 17, 18, and 19. See figure 17 showing Vice-President Humphrey's letter to W. L. Gorton plus signed picture, Col. Stephens Plaque to W. H. Brown (figure 18), and UAC Engineering Award to FRDC for J58 (figure 19).

(6) TF30 Engine

The following contracts have covered development work on this engine over the time period of 20 June 1960 until the present: NOw60-0322-f, NOw60-0821-f, NOw60-0140-f, NOw63-0141-f, NOw64-0140-f, NOw53-140-f, NOw65-0546-f, NOw66-01550-f, NOw66-0638. These 10 contracts with the Navy BuWeps have all been fixed-price, prime contracts with a dollar value of $102,411,642. All but one of the completed contracts were completed on schedule, and work on the active contracts is currently on schedule.

(7) RL10 Engine

The following contracts have provided for study, design, development, test, support, product improvement and deliveries of the RL10 rocket engine; and for high energy liquid rocket, advanced technology programs in which the RL10 has been used: AF04(647)-648, AF18(600)-1774, NAS8-2590, NAS8-2691, NAS8-5605, NAS8-5607, NAS8-5623, NAS8-15494, NASw-754, NASw-4196, NAS8-13001, NAS3-7950, NAS3-6296. These 12 contracts with the Air Force and NASA have been cost-type, prime contracts and represent a combined dollar value in excess of $206,500,000. These contracts cover the time period of March 1958 until the present. The RL10 is a 15,000-pound thrust liquid hydrogen/liquid oxygen engine for propulsion of upper stage vehicles, and was the first rocket engine produced for use of this high-performance propellant combination. Work with the RL10 involved many advanced technologies and required pioneering work with cryogenic (hydrogen, oxygen, fluorine, liquified petroleum gases) propellants. However, the RL10 engine has achieved a degree of reliability and performance unmatched by any other hydrogen-oxygen production rocket engine. The Pratt & Whitney Aircraft achievements working with the RL10 have been recognized in engineering and aerospace circles, resulting in a number of awards for individuals and for the company's Florida Research and Development Center where this work has been accomplished. Some significant commendations for this work are shown in figures 32 through 37.



**Dr Von Braun Plaque
To W.L. Gorton,**

**Recognizes The FRDC RL10
Development Team and Success
of the RL10 Engine Program**

Figure 32. Von Braun RL10 Award

FD 16919
K

To G.D. Lewis; Shared with Hans J.P. Ohain, Chief Scientist, Aerospace Research Lab, Wright Patterson AFB and A.W. Blackman, United Aircraft Corp, for His Work in the Area of Combustion Instability



Figure 33. The Goddard Award

FD 16918
K



Vice President Congratulates Richard Coar

Jackson Aerospace Award

-Accepted by R.J.Coar for Demonstrating the Technical Feasibility of Liquid Hydrogen as the Next High Energy Fuel for Extending the Horizon of Space Exploration

Figure 34. Jackson Aerospace Award

FD 16915
K

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546

IN REPLY REFER TO: SV

JUN 24 1965

Mr. H. H. Ansubaugh
Program Manager
Florida Research & Development Center
Pratt & Whitney Division
United Aircraft Corporation
West Palm Beach, Florida

Dear Dick:

The flawless performance of the RL-10 engines on the recent Atlas Centaur 10 flight, in support of the first Surveyor mission, made a significant contribution to the over-all success of the mission. Attached is the letter my office received from Dr. H. E. Newell indicating his pleasure with the Centaur performance. Please pass these commendations on to your entire organization along with the appreciation of my office for their contribution to one of the major milestones in the space program.

Sincerely yours,

V. L. Johnson
Director of Launch Vehicle
and Propulsion Programs

Enclosure

Figure 35. NASA Commendation Letter FD 16920 K



UAC Chairman H. M. Horner Presents Mead Gold Medal to John Chamberlain.

UAC Engineering Award (Mead Medal)

To J. Chamberlain for His Invention of New Techniques for Transpiration Cooling of High Pressure Rocket Engine Combustion Chambers.

Figure 36. UAC Engineering Award FD 16914 K

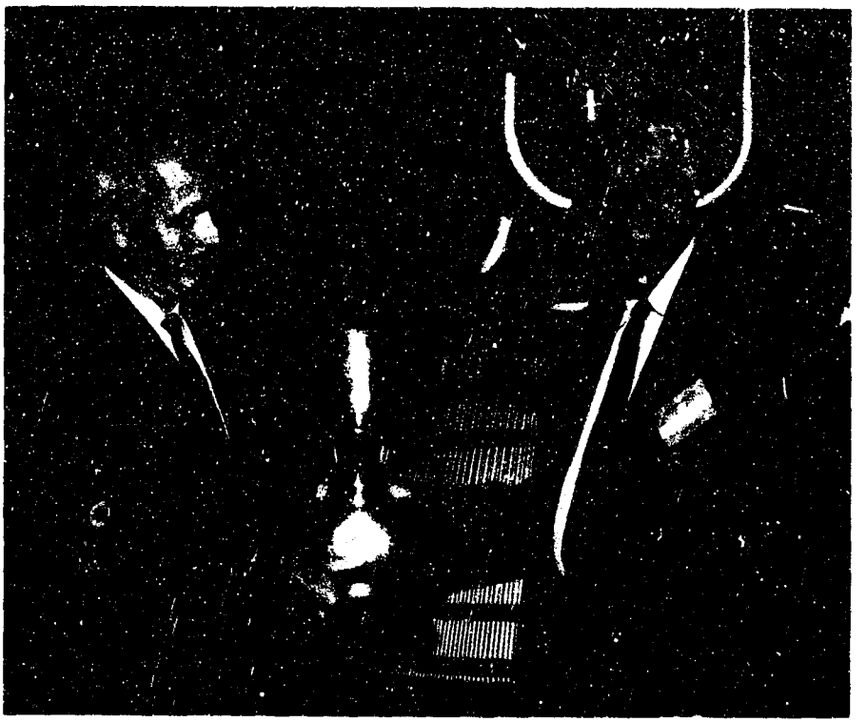


Figure 37. UAC Award for RL10 FC 13356 K

b. Advanced Airbreathing Engine R & D Programs

(1) Lightweight Gas Generator

Work on this program was conducted under the following contracts and covered the time period of 18 May 1959 to 31 August 1962: AF33(600)-39086 and AF33(600)-41506. These contracts were fixed-price, prime contracts with the Air Force. The lightweight gas generator work under these contracts had a dollar value of $11,442,500. Program requirements included building and testing of demonstrator engine, testing of various components in test rigs, and powerplant design studies. Powerplant studies were completed successfully, leading to design, testing, and fabrication of a lightweight gas generator with augmented thrust-to-weight ratio of 10:1 or higher. The engine is designed for an operational altitude of more than 80,000 feet and Mach capability in excess of 4.

(2) SST Powerplant

The following contracts have been provided for work on this program over the time period of 15 June 1961 until the present: AF33(600)-43496, AF33(657)-9059, AF33(567)-9283, AF33(657)-11189, FA-SS-64-2, FA-SS-65-18, FAA-SS-66-8. These contracts with the Air Force and the FAA have been prime contracts and have included fixed-price, CPFF, cost reimbursement, and cost sharing types. The dollar value of these contracts has been $67,429,938; they have all been completed on schedule except FAA-SS-66-8, which is currently on schedule. This program has been directed toward engine study, identification of required development,

selection of engine cycle and design, component development, and engine fabrication and test. Speed ranges from Mach 2.0 to 3.5 have been studied, and the influence of engine parameters on operating costs, performance, and noise levels has been considered. Areas requiring research and development have been identified and this R & D has been undertaken in areas including compressors, primary combustors, duct heaters, turbines, exhaust systems, bearings and seals, engine controls, fuels, lubricants, noise research, cycle optimization, and engine design. The program has also placed major emphasis on considerations such as weight reduction, reliability, long life, maintainability, safety, value engineering, and configuration management at an early stage in the engine program. Successful completion of each phase of this program has led to competition in the succeeding phases.

(3) AMSA Engine

The following contracts have provided for work on the AMSA powerplant over the time period of 11 January 1965 to the present: P.O.L5E1-DM-10016 and AF33(657)-14903. The first of these was a subcontract from North American Aviation with a value of $100,000, and the other is a fixed-price, prime contract with the Air Force with a value of $19,998,000. Also, work directly contributing to the AMSA program has been conducted under Advanced Turbine Engine Gas Generator (ATEGG) demonstrator engine program. The contract for ATEGG was AF33(657)-14479 which was a fixed-price, prime contract with the Air Force, had a value of $750,000 and covered the time period of 26 April 1965 to 15 June 1966. The work on this program has been conducted at East Hartford.

A demonstrator engine incorporating the same general technology level that will be incorporated in the AMSA engine was built under the ATEGG program. This engine was transferred to the AMSA program when the ATEGG program phased out; an additional engine is to be built under the AMSA contract and both engines will demonstrate the general technology requirements for the AMSA engine.

Comparative engine cycle studies have been conducted to determine the best cycle for this application. Major components such as compressors, turbines, burners and augmentors are being tested and theoretical studies and experimental tests are being conducted to determine means to suppress engine infrared radiation.

(4) Short Takeoff Landing (STOL) Fighter Aircraft Propulsion System

Work on this program was conducted under the following contract over the time period of 21 October 1960 to 8 December 1961: AF33(600)-41609. This was a fixed-price, prime contract with the Air Force, had a dollar value of $1,750,000, and was completed at East Hartford.

(5) C5A Engine

The following contracts provided for work on the CX-HLS and C5A engine programs over the time period of 15 June 1964 to 15 July 1965: AF 33(615)-1921 and AF 33(657)-14195. These were fixed-price, prime contracts with the Air Force. The C5A engine work under these contracts had a value of $5,703,194 and was completed on schedule.

(6) Aerospaceplane Propulsion

This study was conducted over a time period of 16 April 1962 to 30 November 1962 under Contract AF 33(657)-8671. This was a fixed-price, prime contract with the Air Force and was completed on schedule. This study was conducted at East Hartford and the dollar value was $200,000.

c. Advanced Airbreathing Engine Components

R & D work on components for airbreathing engines is essential to provide for continual upgrading of engine technology. Consistent, well-coordinated programs are carried on at Pratt & Whitney Aircraft in component technology areas such as compressors, turbines, combustors, controls, bearings, seals, etc. Some of the work in these areas is funded by Government agencies, and some is conducted on company funds.

NASA-Lewis has funded development work which is of particular interest to the SST engine program. Contract NAS3-7907 is a CPFF contract that provides for full-scale testing of duct burners of the same general design as those used in the P&WA SST engine. Work on this contract was initiated on 29 June 1965 at the Florida Research and Development Center, and has provided valuable test data on this burner design. Work under this contract is still active, and the contract value is $1,054,385. Two additional contracts with NASA-Lewis, NAS3-7603 and NAS3-7604, are CPFF contracts that provide for study and component testing of advanced compressor designs in support of SST engine technology. Work on these contracts started on 27 May 1965 at the Florida Research and Development Center and has provided aerodynamic data important to advanced compressor design. Work under these contracts is still active and the combined dollar value is $1,150,469.

Table 3 lists some additional contracts that are representative of contracts in the area of component work for advanced airbreathing engines. Pratt & Whitney Aircraft was the prime contractor on each of these contracts.

Table 3. Representative Airbreathing Engine Component Contracts

Contract No.	Description	Amount and Type	Customer	Contract Status	Effective Date/Estimated Completion
NAS3-7918	High-Temperature, Aircooled Turbine Blade Test Rig	$900,000 Fixed-price	NASA	On schedule	5-6-66/7-6-67
N123(60530)-53039A	Infrared Suppression Devices	$83,480 Fixed-price	Navy	On schedule	5-26-65/12-30-66
AF 33(615)-3128	Turbo Propulsion Exhaust Nozzle	$1,915,000 CPFF	USAF	On schedule	7-1-65/8-1-68
NAS3-7909	Thermal Stress Cracking in Turbine Blades	$195,523	NASA	On schedule	6-29-65/7-29-66
NAS3-7614	Advanced Compressor Concepts	$568,768 CPFF	NASA	On schedule	6-29-65/4-29-67
NAS3-7609	Development of Main Shaft Seals	$267,652 CPFF	NASA	On schedule	6-29-65/6-29-67
NAS3-7605	Development of Compressor End Seals, Stator Interstage Seals, Stator Pivot Seals	$388,643 CPFF	NASA	On schedule	6-29-65/10-10-67
DA44-177-AMC-181(T) Mod 2	Small Gas Turbine Component Development	$1,118,470 CPIF	Army	On schedule	5-7-64/9-7-66
AF 33(657)-10420	Solid Film Lubricated Bearings	$98,000 Fixed-price	Air Force	Completed on schedule	5-3-63/8-30-64
AF 33(657)-8445 Mod 2	High Temperature Turbine Design	$2,757,500 Fixed-price	Air Force	Completed	3-15-62/6-15-64

d. Advanced Material R & D

R & D work is continually pursued at Pratt & Whitney Aircraft, with support from the United Aircraft Research Laboratories, on materials that relate to propulsion system requirements. The extreme temperature, vibration, and stress environments that exist in aircraft engines mean that developing new materials is a particularly important part of the continuous efforts to improve engine performance.

Early this year an announcement was made of an important development in materials technology resulting from work at the UAC Research Laboratories. This work has resulted in discovery of a method to produce precision-cast gas turbine components in the form of alloy crystals. This method can be used with certain alloys to eliminate all grain boundaries in the material with the result that the material has excellent thermal shock resistance, high stress-rupture life, and excellent high temperature creep characteristics. Turbine parts made with this process promise to permit the use of higher temperatures in future engines, contributing to improved performance in these engines.

Some representative contracts for materials work are listed in table 4. Each of these is a prime contract with Pratt & Whitney Aircraft.

Table 4. Representative Materials Contracts

Contract No.	Description	Amount and Type	Customer	Contract Status	Effective Date/Estimated Completion
AF 33(615)-5129	Evaluation of Welded and Brazed Stainless Steel and Super-Alloys	$73,035 CPFF	Air Force	On schedule	6-1-66/7-1-67
AF 33(615)-2117	Coatings for Columbium Alloy Turbine Vanes and Blades	$319,392	Air Force	On schedule	4-1-65/7-1-66
AF 33(615)-1636	Coatings for Super-Alloy Turbine Blades	$120,275 CPFF	Air Force	Work completed on schedule	7-1-64/2-1-66
NASr-1[illegible] Amend. 9	Emissivity of Materials and Coatings	$600,597 CPFF	NASA	Completed on schedule	9-18-59/12-31-63

F. FINANCIAL CAPABILITY

1. Business History

United Aircraft Corporation has, from its beginning, placed great emphasis on research, engineering, and development, in which more than a fourth of its employees are engaged. The Corporation continues to make substantial expenditures for research and development, including capital expenditures to maintain a favorable competitive position in the industry. During the last eight years United Aircraft has financed, without contractual support, research and development costs in excess of $225,000,000.00

United Aircraft's business for the last eight years is indicated in table 5.

Table 5. United Aircraft Corporation
Business for 8 Years

Period	Sales		Unfilled Orders and Government Letters of Intent at the End of the Period		
	Total	Government, %	Approximate Total	Government, %	Gross Plant Account
1965	1,429,738,247	66	1,725,000,000	58	483,211,334
1964	1,235,918,321	71	1,200,000,000	65	445,089,250
1963	1,281,070,409	79	950,000,000	70	402,960,241
1962	1,160,458,684	80	1,025,000,000	72	366,312,215
1961	1,094,756,591	77	1,100,000,000	71	338,717,487
1960	987,879,119	72	1,150,000,000	79	319,261,526
1959	1,080,980,782	78	1,000,000,000	71	288,166,299
1958	1,200,427,387	88	1,400,000,000	75	271,364,985

2. Financial Status

Based on the SST financial plan as presented in the Phase III Request for Proposal, and the following United Aircraft financial statements for the past three years, United Aircraft Corporation can be expected to meet the financial requirements for Phase III Supersonic Transport development.

The following balance sheets and statements of income and earnings employed in the business have been examined by Price Waterhouse & Co., independent public accountants. In their opinion, "the accompanying balance sheet and statements of earnings and of earnings retained in the business present fairly the financial position of United Aircraft Corporation and consolidated domestic subsidiaries at 31 December 1965, and the results of their operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis was made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. Receivables from the United States Government were not confirmed, but we have satisfied ourselves as to these balances by means of other auditing procedures."

UNITED AIRCRAFT CORPORATION

CONSOLIDATED STATEMENTS OF EARNINGS AND OF EARNINGS RETAINED IN THE BUSINESS

Years Ended December 31, 1965, 1964 and 1963

	1965	1964	1963
Income:			
Sales	$1,429,738,247	$1,225,918,321	$1,281,070,409
Royalties from licensees	1,914,331	1,905,159	1,565,948
Dividends from affiliates	131,975	1,381,616	327,972
Other income	4,666,858	3,351,066	3,505,463
	$1,436,451,411	$1,242,556,162	$1,286,469,792
Costs and Expenses:			
Cost of goods and services sold	$1,048,084,410	$ 938,780,017	$1,011,962,128
Depreciation and amortization	34,715,268	33,592,610	30,786,142
Engineering, development, selling and administrative expenses	256,151,207	208,440,737	195,044,881
Interest expense	7,207,851	7,456,918	6,081,625
Other deductions	463,143	857,215	1,829,319
Federal taxes on income	40,837,563	24,344,595	19,315,319
	$1,387,469,382	$1,213,472,122	$1,265,019,414
Net Earnings for the Year	$ 48,982,029	$ 29,084,040	$ 21,450,378
Earnings Retained in the Business at beginning of the year	150,263,199	135,551,682	128,335,683
	$ 199,245,228	$ 164,635,722	$ 149,786,061
Dividends on Capital Stock:			
Preference Stock—(retired in 1965) $2.00, $4.00 and $4.00 per share, respectively	$ 617,871	$ 1,362,826	$ 1,370,762
Common Stock—$1.40, $1.33⅓ and $1.33⅓ per share, respectively (adjusted to reflect 50% common stock distribution in 1965)	14,491,675	13,009,697	12,863,617
	$ 15,109,546	$ 14,372,523	$ 14,234,379
Earnings Retained in the Business at end of the year	$ 184,135,682	$ 150,263,199	$ 135,551,682
Earnings Before Federal Income Tax	$ 89,319,592	$ 53,428,635	$ 40,765,697

UNITED AIRCRAFT CORPORATION

CONSOLIDATED BALANCE SHEET

Years Ended December 31, 1965, 1964 and 1963

ASSETS

	1965	1964	1963
Current Assets:			
Cash	$ 32,651,142	$ 28,372,155	$ 26,092,184
Accounts receivable:			
United States Government	91,496,128	76,393,352	93,246,161
Commercial customers (less $50,000 allowance for doubtful accounts)	140,405,326	91,690,988	73,920,111
Other	2,430,497	1,065,176	1,277,468
Inventories, at cost	396,186,943	350,749,783	307,927,408
Less—Payments, secured by lien, from United States Government on uncompleted contracts	125,536,982	117,406,891	103,701,322
Total Current Assets	$537,633,054	$430,865,560	$398,762,313
Notes and Accounts Receivable due after one year	$ 8,550,430	$ 7,056,301	$ 9,148,065
Investments in and advances to affiliated companies, at cost	$ 7,975,432	$ 7,080,910	$ 13,563,402
Fixed Assets, at cost:			
Land	$ 10,644,007	$ 10,654,670	$ 10,127,815
Buildings and improvements	217,044,509	214,635,961	208,182,222
Machinery, tools and equipment	229,325,700	214,623,855	173,477,168
Under construction	26,007,118	5,174,764	11,173,036
	$483,221,334	$445,089,250	$402,960,241
Less—accumulated depreciation and amortization	300,104,892	279,875,778	254,214,195
	$183,116,442	$165,213,472	$148,746,046
Deferred Charges	$ 3,612,383	$ 3,629,566	$ 4,158,887
	$740,887,741	$613,855,812	$574,318,713

UNITED AIRCRAFT CORPORATION

CONSOLIDATED BALANCE SHEET

Years Ended December 31, 1965, 1964 and 1963

LIABILITIES

	1965	1964	1963
Current Liabilities:			
Notes payable to banks	$ 60,000,000	$ 20,000,000	$ 20,000,000
Long term debt—currently due	3,000,000	3,000,000	—
Accounts payable	73,954,805	55,421,434	46,005,363
Accrued liabilities	58,281,965	50,127,946	47,368,912
Dividend payable on Preference Stock	—	336,944	342,669
Federal taxes on income	28,544,360	22,804,537	19,475,955
Advances on sales contracts	47,161,834	28,109,582	21,958,502
Total Current Liabilities	$270,942,964	$179,800,113	$155,151,431
Deferred Investment Tax Credit	$ 5,179,221	$ 4,194,719	$ 3,568,562
Long Term Debt:			
5% Sinking Fund Notes due June 15, 1981	$ 69,000,000	$ 72,000,000	$ 75,000,000
4½% Subordinated Debentures, due August 15, 1988 (convertible)	28,935,600	42,858,100	42,883,900
	$ 97,935,600	$114,858,100	$117,883,900
Stockholders' Equity:			
Capital Stock:			
Preference Stock of $100 par value:			
Authorized—500,000 shares			
4% Series of 1955 (convertible), outstanding—25,752 shares in 1964	$ —	$ 2,575,200	$ 3,142,000
4% Series of 1956 (convertible), outstanding—311,192 shares in 1964	—	31,119,200	31,124,900
Common Stock of $5 par value:			
Authorized—15,000,000 shares			
Outstanding—11,169,372 and 6,552,467 and 6,433,355 shares respectively	182,694,274	131,044,951	127,896,238
Earnings retained in the business at end of the year	184,135,682	150,263,199	135,551,682
	$366,829,956	$315,302,550	$297,714,820
	$740,887,741	$613,855,812	$574,318,713