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F-4 (FV)

WEAPON SYSTEM DEVELOPMENT and PROGRAM DEFINITION STUDY

Volume I
Technical Proposal

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INTRODUCTION AND SUMMARY

This report presents McDonnell Aircraft Corporation's unsolicited proposal for a three and one-half month, Navy-sponsored program definition of the Advanced F-4B fighter aircraft concept identified as the F-4(FV). Preliminary studies performed by McDonnell on this and previous configurations have been reviewed by the Bureau of Naval Weapons. Navy review of McDonnell's preliminary efforts directed the selection of the F-4(FV) configuration for fighter Weapon System Definition Study now proposed. The comprehensive study proposed in this report will result in the development of a program definition to assist the Navy in making a decision on procurement of an Advanced Fleet Air Defense Weapon System.

The F-4(FV) configuration is considered the optimum design resulting from a lengthy series of studies conducted by McDonnell's advanced design department. As now conceived, this design offers the Navy a weapon system capable of multiple launches of all-weather guided missiles against an incoming hostile raid plus a major improvement in carrier suitability, increased radius of action, and maneuverability as compared to the present F-4.

The scope of effort McDonnell will expend in definition of the F-4(FV) program is described in this report. The study will be a major effort involving 120 engineering personnel, and will be managed by the same staff responsible for conception and preliminary studies of this configuration. More than 50% of the total aircraft advanced design effort during the past three years has been devoted to a series of F-4 studies applicable and related to the proposed F-4(FV) study.

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STUDY PROGRAM APPROACH

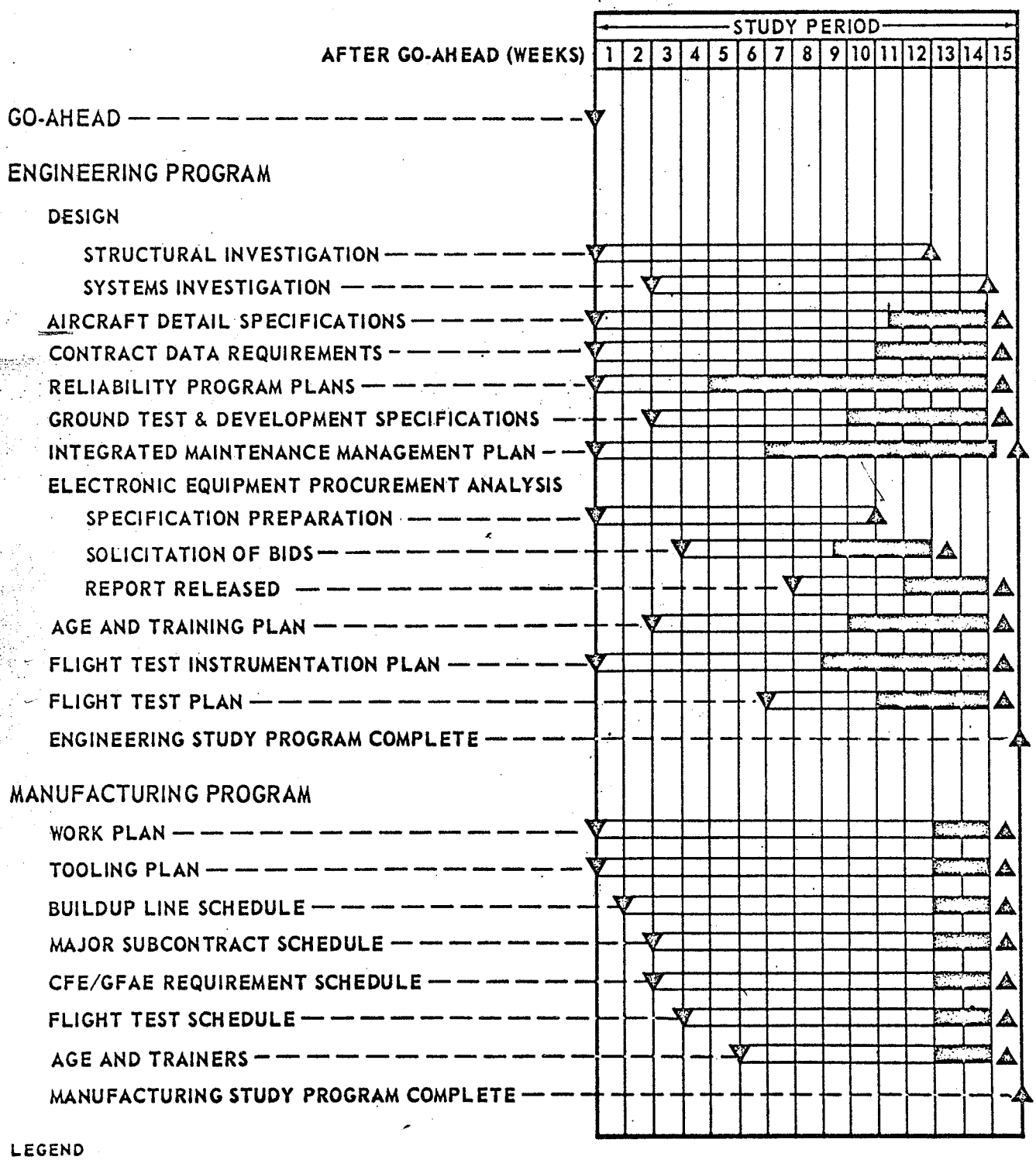
The basic objective of this study will be to define and investigate problem areas on the F-4(FV) aircraft to the extent and in such detail that an Aircraft Detail Specification and other supporting documents can be furnished to the Navy at the end of the study period.

The company funded preliminary studies already conducted and reported to the Navy have established the aircraft general configuration and predicted performance capabilities. Therefore, the approach to study tasks to be taken now by all contributing groups will be one of refinement of stated objectives and examination of technical areas. Heavy emphasis will be placed upon analysis of F-4(FV) effectiveness in an ECM environment. Westinghouse Electric Company and Raytheon Company will both participate directly in this program definition study of the Multi-Shot missile control system and the Advanced Sparrow missile system.

The study will be performed by the Aircraft Advanced Engineering organization. This guarantees a closely correlated and controllable study effort since the primary contributing personnel will all be grouped in the same office area. Program management and direction is both thorough and immediate with such a physical arrangement. Problems will be isolated and resolved on the spot, with the participation and contribution of all affected technical areas. Individual engineering groups will have immediate access to each other for discussion of interface technical problems. (McDonnell has conducted several similar study programs on this integrated project basis, including the Multipurpose Strategic Reconnaissance Aircraft Study for the Air Force, and the current 1975-1980 Fighter Attack Study for the Navy.)

For the production phase of the program, the design would be under the direction of the current F-4 Project Organization. To assure that past F-4 experience will be integrated into the design during the study phase, and that proper continuity will exist during production, key personnel now in the F-4 Project will be assigned to Advanced Engineering for the study.

F-4(FV) STUDY PROGRAM PLAN



WEAPON SYSTEM DESCRIPTION

The Model F-4(FV) aircraft configuration is based upon the Model F-4J, which is an advanced version of the current F-4B now in fleet service. Although more than a dozen advanced F-4 aircraft have been documented in company sponsored studies submitted to the Navy in the past three years, the F-4(FV) is considered the optimum configuration for sponsored study. Descriptions of the F-4(FV) and its base aircraft, the F-4J, have been provided to the Navy in the McDonnell reports listed in the Related Experience section.

While both aircraft are extensively defined in previously submitted reports, summaries of major features are included here for background reference. A performance summary, showing principal characteristics as they have changed from the F-4B through the F-4J to the F-4(FV), is presented below. The basic changes to the F-4J which make up the F-4(FV) are tabulated on page 4. The general arrangement of the F-4(FV) with dimensional comparison to the F-4J is also shown on page 4. The F-4(FV) internal arrangement showing new equipment, systems, and locations is presented on page 5.

Performance Summary Comparisons

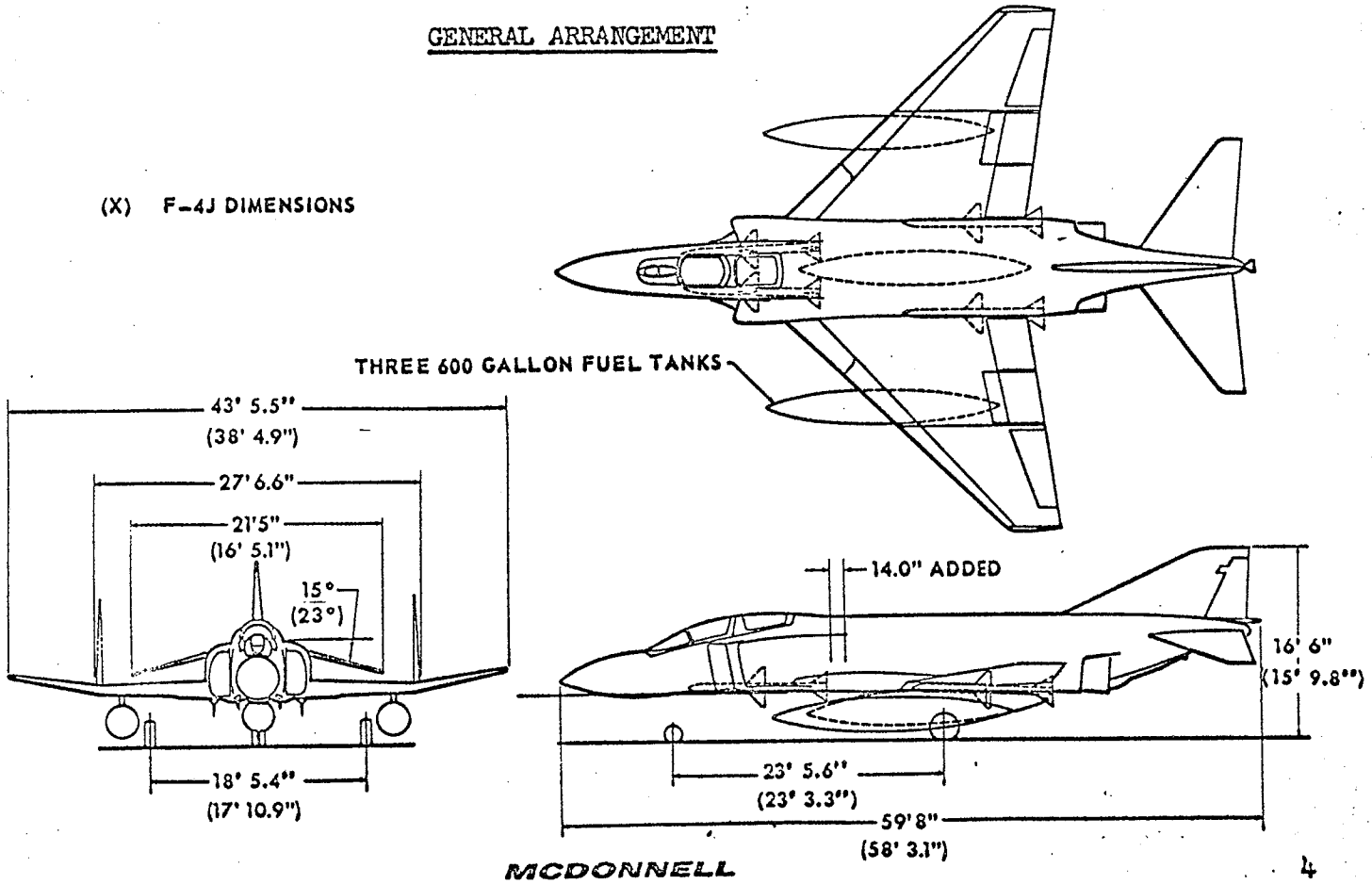
Item		F-4B	F-4J	F-4(FV)
Internal Fuel	gal.	1,986	2,008	2,200
Take-off Gross Weight	lb.	44,341	45,653	49,564
Take-off Distance Over 50 Ft.	ft.	2,580	2,760	2,580
Time to Climb to 40,000 Ft.	min.	2.28	2.40	2.04
Combat Gross Weight	lb.	38,931	40,191	43,580
Supersonic Ceiling	ft.	56,600	56,100	56,400
Maximum Level Flight Speed	M	2.25	2.25	2.15
Acceleration .9M to 2.0M at 36,089 Ft.	min.	3.47	3.65	3.52
Landing Gross Weight 4,000 Lb. Fuel & 4 Sparrow III6b Missiles	lb.	34,836	35,999	38,604
Approach Speed	kts.	142	137	129
Landing Ground Roll	ft.	2,480	2,450	2,260

F-4(FV) CHANGES

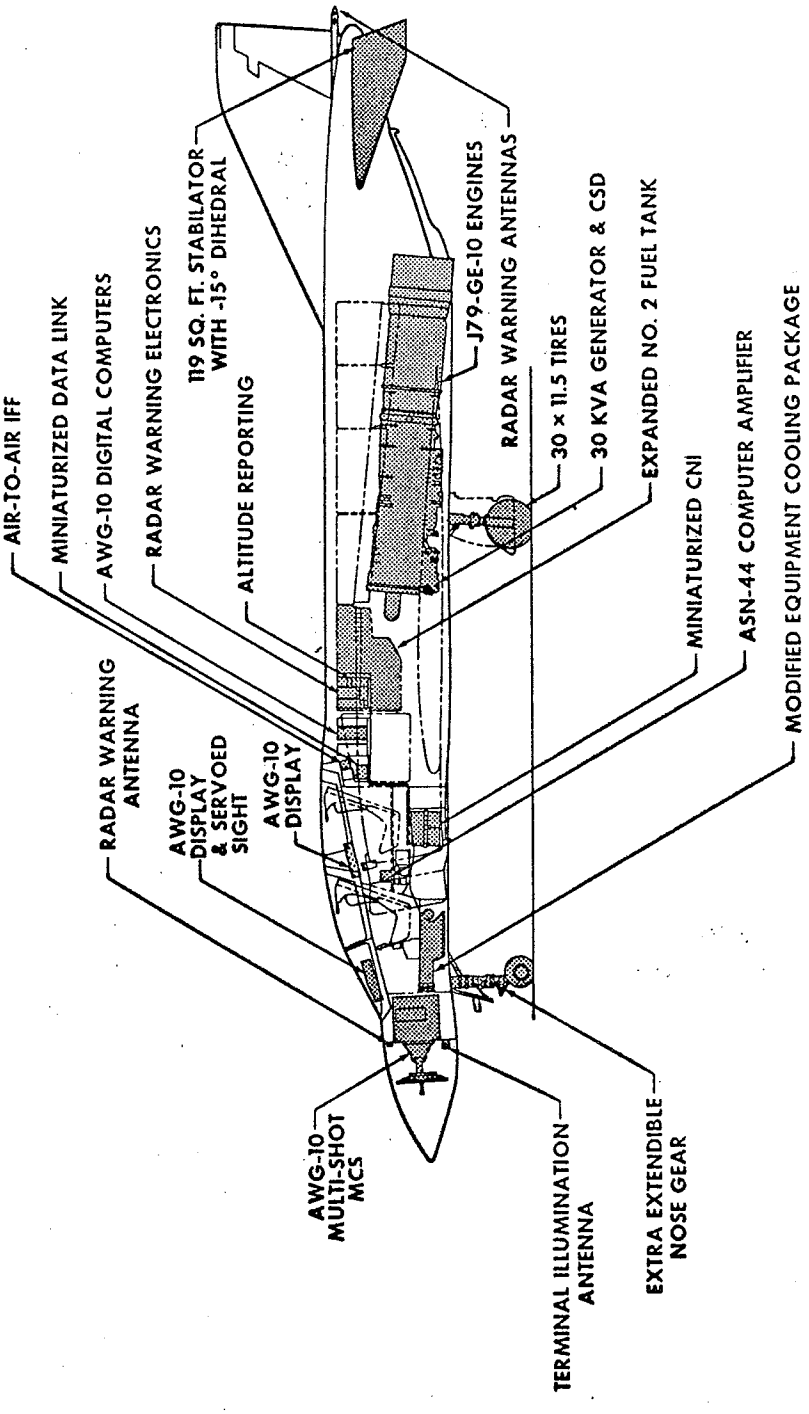
Delete (F-4J)	Add
J79-GE-8 Engines	J79-GE-10 Engines
530 Square Foot Wing and Drooped Aileron	640 Square Foot Wing (Flaperon and Outboard Ailerons) 14 Inch Center Fuselage Extension Extra Extendible Nose Gear
Slotted Stabilator (-23°)	Increased Area Stabilator (-15°)
Two 370 Gallon Wing Tanks Number 7 Fuel Cell	Two 600 Gallon Wing Tanks Increased Volume in Fuselage and Wing Fuel Cells
ASN-39 Navigation Computer GVR-10 Vertical Reference AWG-10 Analog Computer	ASN-44 Inertial Navigation System AWG-10 Digital Computer (Multi-Shot with Air-to-Ground Weapon Release Computations) Electronics Equip. Compartment Above No. 1 and 2 Fuel Cells Radar Warning and Homing Air-to-Air IFF Lead Angle Computing Set ALQ-100 Pods Cryptographic Computer and Altitude Reporting

GENERAL ARRANGEMENT

(X) F-4J DIMENSIONS



F-4 (FV) INTERNAL ARRANGEMENT



TECHNICAL DISCUSSION

1. Design

The primary purpose of the design effort during the proposed study will be to provide a more detailed definition of the F-4(FV) weapons system than was submitted previously to the Navy. The study will assure maximum knowledge of the technical requirements of the aircraft prior to development and production go-ahead. This aircraft description will be a major part of the final engineering report required by the study, and will also be used to provide the basis for preparation of the Aircraft Detail Specification. Definition of the aircraft involves design studies as described below.

1.1 Aircraft Contours - Changed contours will be examined in the following areas:

(a) Lower fuselage and nacelles forward of the wing front spar.

(b) Lower fuselage and engine compartments aft of the wing torque box.

(c) Lower radome, if necessary, for Terminal Illumination antenna.

(d) Engine duct contours as they change for the 14-inch extension of the fuselage over the wing torque box. This will also include possible changes to the outer nacelle contours.

(e) Wing contours, including the upper and lower bumps for the main landing gear.

(f) Stabilator contours.

1.2 Wing - Special attention will be given to primary and auxiliary control surfaces, their locations, actuation, and control systems. The leading and trailing edge flaps and flaperon mechanisms and boundary layer control ducting will be investigated, with special attention to the BLC duct cross-over at the wing-fold.

Studies of the expected installation of the new catapult hooks, mechanisms, and actuation devices for the 240,000 pound catapult tow will be made.

1.3 Fuselage and Power Plant Installation - Stowed positions of the fuselage mounted Sparrow III missiles will be determined in relation to the new fuselage contours forward and aft of the wing torque box. Location of missiles and launchers for clearance purposes with surrounding structure and equipment will be studied.

Investigation of changes to the front, main, and rear spar carry-through fuselage bulkheads and drop-out links will be made. The engine access doors, auxiliary breather door, and structural back-up members will be studied.

The J79-GE-10 power plant installation will be studied and engine accessories will be investigated.

1.4 External Stores Installations - Installation of all external store configurations will be studied, considering clearances for access doors, flaps, and ground lines. The pylons to be studied will include incorporation of the MAU-12/A Bomb Racks proposed as the basis for external store pylons on the F-4(FV) in M.A.C. Report B177.

1.5 External Fuel Tanks - A study will be made of new 600 gallon external fuel tanks which will incorporate the best features of M.A.C. value engineering proposals.

1.6 Electronic Installations - Detailed studies will be made of the installation of all electronic equipment and equipment bays. AWG-10 Multi-Shot radar envelope and mounting studies will determine the effect on radome and forward fuselage structural frames and back-up structure.

A study will be made to determine which of the four Terminal Illumination antennas being considered by Westinghouse and M.A.C. is the most desirable and feasible installation. The antenna choice must be made early in the study because of the possible effect of change to the radome and lower fuselage mold-lines.

1.7 Cockpits - Investigation of both cockpits will be made to assure that all controls and displays can be installed and are arranged in the most desirable manner. This study will include personnel ejection considerations as well as usability of cockpit equipment.

1.8 Systems - Investigations will be made for the new requirements and changes to the following systems: fuel, hydraulics, controls, refrigeration and pressurization, landing gear, boundary layer control bleed air ducting, electrical, and electronics. These studies will include the determination of control surface rates of motion, hydraulic and pneumatic fluid flows and requirements, and load and power requirement analyses of all systems.

1.9 Long Lead Time Structural Items - Requirements will be determined for new materials and large forged machine members that require a long lead time to meet production schedules.

1.10 Weight Saving Items - All weight saving items listed as effective on the F-4(FV) will be reviewed to determine item desirability and feasibility of incorporation.

2. Aerodynamics

The desire to improve certain performance characteristics of F-4 aircraft has resulted in the evolution of the F-4(FV) aircraft configuration. Studies to date have shown that a significant improvement in carrier suitability, time on station, range-radius, patrol altitude, and maneuvering capabilities will substantially increase the effectiveness of the F-4 weapon system.

In arriving at a configuration which provides improvement in these specific areas, numerous different wing configurations have been considered. A change in wing configuration together with differences in equipment requirements necessitates

changes in certain other configuration characteristics. The cumulative effects of these changes must be determined and evaluated to confirm the configuration selected to satisfy weapon system requirements.

2.1 Configuration - A series of trade-off studies were necessary to arrive at the configuration which was optimized for the given requirement. The effects of various wing configuration modifications on such significant performance items as cruise performance (Mach number and nautical miles per pound), acceleration capabilities, maximum Mach number capability, and low speed lift characteristics have been investigated and will be documented for the selected engine configuration. The effects of such factors as wing sweep, aspect ratio, thickness ratio, and area will be included.

2.2 Definition - Although the aerodynamic characteristics of the F-4(FV) will be similar to those of the F-4, several significant areas of difference between the two configurations do exist. In the low speed regime, significant differences in the high lift and lateral control systems require further definition and substantiation. The basis for drag differences throughout the Mach regime between the F-4(FV) and the F-4 configurations will be presented and substantiated.

The horizontal tail configuration and the high and low speed lateral control system and the speedbrake configuration will be considered during the study. The wing configuration will be further studied, and the effects of externally carried weapons will be investigated.

An assessment of projected technical improvements which may be applicable to the F-4(FV) configuration will be made. The possibility of improvement and the magnitude of the improvements considered feasible will be assessed.

2.3 Evaluation - The performance characteristics of the F-4(FV) configuration will be compared to the F-4J configuration to show the areas and magnitude of performance improvement offered by the F-4(FV). Catapulting and landing approach characteristics will be evaluated by use of an analog computer and appropriate simulation techniques to demonstrate the aircraft characteristics.

Dynamic stability characteristics of the F-4(FV) configuration will be spot checked to confirm compliance with specification requirements. High speed lateral control characteristics will be investigated in the critical flight regimes. An investigation of the low speed lateral control characteristics will be made involving a 5 degree of freedom analysis.

Analyses will be made to provide the information necessary for writing of the Aircraft Detail Specification. Performance to be used within the specification will be generated and analyzed. Stability and control characteristics and system requirements will be investigated and defined. Specification deviations will be stipulated and required deviations will be defined.

2.4 Development - The wind tunnel test program required to develop the configuration will be defined as to type and scope of tests and tentative scheduling. Aerodynamic areas to be investigated during a flight test program will be explored and defined. Requirements for the submittal of aerodynamic data will be investigated, and the amount and type of data to be submitted will be defined.

2.5 Special Considerations - A preliminary investigation will be conducted to determine the effects of installing advanced Spey and GE-1 type engines in the F-4(FV) airframe. The effects of the changes required by the installation of these engines will be assessed. Such items of aircraft performance as radius-range, acceleration, and maximum speed capabilities, as well as carrier suitability performance will be summarized. The compatibility of the engines with BLC bleed requirements will be determined.

3. Structures

Strength, weights, and loads studies as described below will be performed to provide complete structural definition of the F-4(FV) aircraft.

2.1 Strength - Strength studies to be performed will be directed toward presentation of current data, development of additional items, and expansion of details now summarized in M.A.C. Report B177. Some of the items to be presented are:

(a) Basic Structural Criteria.

(b) Structural Description.

(c) Derivation of sinking speeds and energy levels during arrested landings for both main gear and nose gear.

(d) Study of the nose gear loads, including catapult.

(e) Study of areas which have possibilities for unitized construction and other cost saving techniques.

(f) Basic wing configuration showing the location of spars, posts, ribs, control surfaces, actuators, wing-fold, high lift devices, BLC ducts.

(g) Changes necessary in fuselage to refair lower mold-line to lowered wing box, and to add 14 inches to center fuselage.

(h) Changes necessary in the fuselage to accommodate the extra extendible nose gear, new stabilator, and increased catapult and design weights.

(i) Horizontal tail configuration materials selections.

3.2 Structural Design Philosophy - Complete structural design criteria will be presented. The MIL-A-8860 specification series will be utilized as guidelines, together with experience gained from the F-4B aircraft. Special consideration will be given to establishing the structural adequacy of the existing F-4B/C forward and aft fuselage for F-4(FV) application. Free-flight engagement, catapulting, and flight loads will be examined for the forward fuselage. Forward and aft structural center of gravity limits and maneuvering and unsymmetrical horizontal tail loadings will be examined for the aft fuselage. Structural design objectives for carriage of external stores will also be established. Fatigue criteria will be presented, which will include the fatigue test program.

3.3 Test and Development - A ground test and development plan will be prepared in conjunction with the General Engineering Laboratories. A flight test instrumentation plan will be prepared in conjunction with the Flight Test Department.

3.4 Weights - Weight trade-off studies will be performed and the results analyzed to determine the significance of alternate concepts or methods. Weight reduction items will be investigated for incorporation into the aircraft.

Optimum fuel sequencing will be established. Calculations of center of gravity will be made and c.g. envelopes prepared for critical weapon loading conditions. A.M.P.R. weights will be derived for configuration cost evaluation.

4. Propulsion

The F-4(FV) aircraft uses the J79-GE-10 engine, which is described in detail in General Electric reports R63FPD274 dated July 1963 and R64FPD247, including Appendix A, dated September 1964. This engine provides performance improvements over the J79-8 by internal engine and nozzle improvements. The J79-10 engine has no significant change in airflow and consequently does not require an aircraft duct change. A description of this engine installation in the F-4(FV) is presented in M.A.C. Report B177. Propulsion system study requirements are defined below:

4.1 Fuel System - Fuel system changes will be analyzed and the fuel feed, transfer, and vent systems will be investigated. The work to be accomplished will include:

(a) Estimation of fuel system performance as affected by changes peculiar to the F-4(FV) fuel system.

(b) Comparison of fuel system performance with specification requirements.

(c) Evaluation of compatibility of the fuel feed system with the J79-10 fuel supply requirements.

(d) Provision of fuel system description and data for the Aircraft Detail Specification.

4.2 Inlet Duct - Analysis of the inlet ramp and bellmouth schedules will be made to identify any problems affecting proper operation, best performance, and adequate engine compartment airflow. These studies are required because of changes in engine compartment cooling requirements and nozzle pumping characteristics.

4.3 General Performance and Airframe Compatibility - Investigations of engine operating characteristics will be made on air start boundaries, afterburner light-off and blow-out limits, ground starting, revised fuel schedules, and oil system. Engine compressor bleed characteristics will be evaluated relative to boundary layer control requirements and the effect on engine performance. Engine exhaust plumes will be defined for all flight conditions, based on revised engine exhaust pressure and temperature conditions and new geometry.

Engine performance calculations will be made to support all aircraft performance calculations. Coordination with General Electric will provide necessary information

on engine geometry, performance, operating characteristics, accessories, delivery schedules, and costs.

4.4 Advanced Engine Investigations - In addition to the program definition of the basic configuration using the J79-GE-10 engine, preliminary engineering feasibility studies will be made of F-4 aircraft using an advanced version of the Rolls-Royce R.Sp.5R engine used in the F-4K and F-4M and a model of the General Electric GE-1/F12B engine. The preliminary characteristics of the advanced Spey and the GE-1/F12B are compared to the J79-GE-10 in the tabulations on page 12.

5. Structural Dynamics

Structural dynamics studies will be made to identify any problem areas concerning structural design of the wing and stabilator to prevent flutter and divergence of these primary surfaces within the required speed-altitude range. Analyses will also be required to assess the dynamic characteristics of the various wing-store combinations, with particular emphasis on the compartmented 600 gallon wing tank. Structural dynamics aspects of the various control surfaces, landing gear, guns, and engines will be considered. Structural dynamics tests and instrumentation requirements will also be defined.

5.1 Basic Wing - Preliminary analyses will be performed to investigate required stiffness levels (stiffness distributions assumed to be established by F-4B).

5.2 Stabilator - Preliminary analyses will be performed to investigate required stiffness levels, stiffness distributions, hinge line location, and actuator requirements.

5.3 External Wing Stores - Studies will be conducted for the 600 gallon tanks to investigate requirements for compartmentation, store location, and pylon stiffnesses. Analyses will be performed on the stores to be carried.

5.4 Increased Landing Weight - Studies will be performed to establish anticipated load levels.

6. Guidance and Control Mechanics

In arriving at a final configuration for the F-4(FV) aircraft, the effect of changes to the basic F-4 aircraft aerodynamics, control systems, and electronics will be studied relative to new flight control hardware, automatic stability augmentation, pilot handling qualities, and outer loop automatic control. Studies will be performed as necessary to define the specification requirements for the hardware and system designs to achieve the improvement in performance and control desired for the F-4(FV) aircraft.

6.1 Evaluation Studies - The following design areas will require study:

(a) A new stabilator power actuator may be required as a result of the larger horizontal tail with its associated changes in hinge moment capability and stiffness requirements. The required stiffness integrity, force output capability, and dynamic stability for the stabilator actuator will be investigated. Changes to the lateral

ENGINE COMPARISON

	J79-GE-10	GE1/F12B (C-D Nozzle)#	Advanced Spey R.Sp. 5R
Weight (pounds)	3,785	2,340	3,725*
Length (inches)	208	193.5	208*
Inlet Diameter (inches)	30.4	36.4	32.5
Maximum Diameter (inches)	39.1	46.5	43
S.L.S. Airflow (lb/sec)	169.7	226	205
Compression Ratio	13.5	20	20.1:1
By-Pass Ratio	0	1.5:1	0.8:1
SEA LEVEL STATIC:			
Maximum Power Net Thrust (lb)	17,900	18,490	21,150
Military Power Net Thrust (lb)	11,870	10,940	12,780
Maximum Power SFC (lb/hr/lb)	1.97	2.47	2.06
Military Power SFC (lb/hr/lb)	.84	.58	.64
36,089 FEET (INSTALLED)			
Mach 2.0, Maximum Power F_n (lb)	17,060	18,420	18,680
Mach 2.0, Maximum Power SFC (lb/hr/lb)	2.11	2.28	2.34
Mach .9, Cruise SFC (F_n = 2300 lb)	.96	.82	.836
50,000 FEET (INSTALLED)			
Mach 2.0, Modulated Afterburner, SFC (F_n = 7500 lb)	1.98	-	2.20

* Rolls-Royce indicates a modest increase in engine weight and nozzle length can be expected over the Spey R.Sp. 5R values shown. Definite values are not presently available.
# Convergent-Divergent Nozzle

control system will require new outboard aileron actuators and possibly new flaperon actuators. Stability studies will be performed for these new actuators.

(b) Longitudinal and lateral control system handling characteristics will be studied to assess the control harmonization throughout the low to high speed flight regimes.

(c) The present engine inlet control system as used with the J79-GE-10 engines will be reviewed to assure the desired inlet efficiency and performance.

(d) Longitudinal and lateral-directional dynamic stability of the F-4(FV) aircraft/stability augmentation system combination will be checked to assure compliance with specification requirements.

(e) Studies will be made of the Automatic Flight Control System (AFCS) at specified flight conditions to assure compliance with specification requirements for the F-4(FV)/AFCS combination for the outer loop modes of attitude hold, altitude hold, heading hold, automatic carrier landing (ACL), etc. The need for improving the reliability in the AFCS for the ACL mode will be studied.

(f) The Automatic Power Compensation System (APCS) will be reviewed and studied to determine compatibility with the F-4(FV)/J79-GE-10 aircraft/engine combination.

(g) Definitions of the Manual Terrain Following Mode and the Manual and Automatic Carrier Landing Modes will be made for the F-4(FV)/AWG-10 radar and F-4(FV)/ASW-21/SPN-10/AFCS aircraft system combinations, respectively.

6.2 Detail Specification - Results from the studies and analyses above will provide the necessary control system and flight control hardware information for incorporation into the Aircraft Detail Specification.

6.3 Development - Guidance and control system areas requiring investigation during laboratory and flight test programs will be explored and defined.

6.4 Special Considerations - If it is desired that automatic terrain following capabilities be made available with the F-4(FV) aircraft, additional studies will be required to formulate a new automatic flight control system. Such a system must be extremely reliable, fail-operative for any single failure, and provide high performance for task accomplishment.

7. Thermodynamics

Thermodynamics studies will be performed on the F-4(FV) particularly relating to those areas of change from the F-4B/J aircraft.

7.1 Boundary Layer Control - The larger wing will require changes in the BLC system. Studies made necessary by these changes will include:

(a) Preliminary sizing of BLC feed ducts and nozzles for the maximum flow rate.

(b) Evaluation of BLC system compatibility with maximum allowable engine bleed air flow rate.

(c) Determination of performance at takeoff and approach conditions with both full and half-flaps, and with one or both engines operating.

7.2 Equipment Environmental Control System (ECS) - Changes to equipment and engines will require investigations in the following areas:

(a) ECS package performance for this engine.

(b) Analysis of equipment cooling requirements compared with ECS package performance.

(c) Study of cooling airflow distribution system for the relocation of the electronic equipment from the nose to above Number 1 fuel cell.

7.3 Aft Fuselage and Stabilator Temperatures - The aft fuselage and stabilator temperatures will be affected by the change of engines, the extended nose gear, and -15° stabilator. The effects of these changes during ground static engine operation with afterburner and during high altitude maneuvering will be studied.

7.4 Engine Compartment Cooling - Engine compartment cooling will be analyzed to evaluate the cooling provisions for the J79/GE-10 engine.

8. Electronics

The F-4(FV) electronics systems are based upon the Model F-4J systems. Although all systems will be covered, emphasis will be placed upon systems modified or new to the F-4 Navy aircraft.

8.1 Multi-Shot AN/AWG-10 Missile Control System (MCS) - Studies now in progress will be continued by McDonnell, Westinghouse, and Raytheon working in a team effort to detail and document the F-4(FV) multi-shot system. The design studies to be completed are listed below.

(a) Terminal Illumination Antenna optimization.

(b) Radar indicator/displays and controls will be studied for optimum man-machine performance.

(c) Missile address and command coding.

(d) Multi-shot weapon system capability against maneuvering targets, using the threat aircraft characteristics as defined in M.A.C. Report B257.

(e) Definition of the digital computer characteristics and electrical interface with associated electronic systems.

(f) Aircraft/Missile Control System/Missile Interface.

(g) Advanced Sparrow definition - electrical and physical parameters, multi-target discrimination circuitry, block diagrams, and launch envelopes.

Results of these studies as well as studies completed previously will be incorporated into documents which define the characteristics of the major MCS components: radar, digital computer, displays, and advanced Sparrow missiles. These documents may take the form of company specifications or of preliminary Military Specifications. The multiple target ECM environment, as well as the counter-countermeasure techniques of the F-4(FV) multiple target weapon system, will be presented in the final engineering report.

McDonnell will place subcontracts with the Westinghouse Electric Company Aerospace Division, and with the Raytheon Company Missile Systems Division to perform certain of the preceding studies. This approach will most effectively utilize the specialties and available personnel of each company in a coordinated effort.

8.2 Navigation System - Navigation System studies will be concerned with definition of characteristics of the interface unit (an Output Signal Distribution Unit) between the INS and other electronic systems. The interface definition will determine the required information flow between systems. From this data, a preliminary Specification Control Drawing (SCD) will be prepared defining the required characteristics of the modified AN/ASN-44 units and Output Signal Distribution Unit.

8.3 Automatic Flight Control System - Since the F-4(FV) aircraft will be capable of automatic carrier landings, the principal AFCS effort will be to study the AN/ASA-32 Flight Control Group interface with its associated electronic systems.

8.4 Communication, Navigation, Identification Group - Since several units of the F-4(FV) CNI are common to the F-4J and F-4K aircraft, the SCD's existing for this equipment will be used with minor or no change.

Significantly more study is required to define the data link system for the multi-target weapon system. The multi-target environment requires changing the data link system to simultaneously handle the additional target data. Displays compatible to both the data link and the AWG-10 MCS will be determined. Also, a preliminary specification defining the data link system will be prepared.

Another CNI unit requiring study is the Air-to-Air IFF unit. The requirement for this unit has been generated by the AIMS SPO and will be furnished as GFAE on the F-4(FV) aircraft. However, the Air-to-Air IFF interface with the AN/APG-59 radar will involve several radar units. These interface requirements will be determined and the radar compatibility requirements will be incorporated in the MCS specification.

8.5 Radar Warning and Homing System - Analytical studies to define the F-4(FV) Radar Warning and Homing System antenna types and locations will be conducted. The warning and homing system display interfaces with other F-4(FV) cockpit displays will also be defined. A preliminary SCD will be prepared.

9. Reliability

The studies to be performed in the reliability area will be a continuation of the programs now being implemented on the existing F-4 series aircraft.

9.1 Design Coordination and Review - Plans for continuous liaison with all activities having interface with reliability will be prepared. In particular, attention will be given to design reliability improvement suggestions and the support of maintainability efforts in furnishing Maintenance Engineering Analysis Records (MEAR) information.

9.2 Specification Control Drawings - Paragraphs describing quantitative reliability and demonstration test requirements for each new electronic and other functional equipment will be prepared for inclusion in Specification Control Drawings (SCD's). To assure that proper emphasis is given to these considerations, plans for reviewing and approving all SCD's and major drawings by the Reliability Organization will be prepared. Data submittals required of each subcontractor will also be defined.

10. Integrated Maintenance Management

Studies will be made of activities and procedures required to provide an Integrated Maintenance Management and Maintainability Program Plan for the F-4(FV) aircraft. This study will be fully coordinated with all M.A.C. groups involved in providing optimum maintainability and product support. At the conclusion of the study, agreement will have been reached by all concerned as to the optimum method of approach.

10.1 Management Program

(a) Milestones - Major milestones which must be achieved to provide integrated management of all support resources from initial production throughout the service life of the F-4(FV) will be identified and recommended scheduling established. Check points will thus be established to assure orderly progression of each required action.

(b) Integrated Maintenance Management Team - The recommended composition and proposed schedule of meetings of the Integrated Maintenance Management Team will be defined. The team, composed of government and contractor personnel, will be jointly responsible for management of the complete logistic support program.

(c) Maintenance Concept - A maintenance concept will be defined to prescribe the scope of activity to be performed at each level of maintenance. This concept will be based on operational requirements and will provide the basis for all other planning. The concept will be compatible to the maximum practical extent with existing Navy organization, personnel, and facilities.

(d) Maintenance Engineering Analysis Records (MEARs) - Investigations will be made of the approach and procedures to be used in the preparation of MEARs. This will be based on the requirement for analysis of each maintenance task to provide a qualitative and quantitative measure of each required element of support. The MEAR task analysis will define the personnel, spares, facilities, support equipment, and time requirements of each specific maintenance task to permit realistic procurement and scheduling of each resource. The task analysis will also provide the basis for technical publication, training, training equipment, and maintainability demonstration and verification requirements.

Existing F-4 MEARs will be used to the maximum practical extent. Procedures will be defined for preparation of preliminary MEARs for all new systems and equipment and continual updating as the design progresses.

(e) Support Requirements Progress and Status Reports - Methods to be used for support resource progress and status reporting will be defined. These reports will provide management and using activities with a progressive accounting of procurement actions taken or required to satisfy support requirements.

10.2 Maintainability Program

(a) Design Review - Preliminary design concepts have already been reviewed for compatibility with operational requirements and current maintainability planning. During the study, this review will be continued and updated as design progresses. During the detail design/development period, analysis will be made to assure that subsystem and end item maintainability requirements are incorporated. Experience data from the F-4 program will be applied to the maximum extent for maintainability improvement and elimination of problem areas.

(b) Vendor Maintainability Programs - Procedures currently in use for F-4 vendor maintainability programs will be reviewed and refined for application to the F-4(FV). This will assure that each subsystem program will be compatible with, and can be readily integrated into, the over-all maintainability program which will be the responsibility of the prime contractor.

(d) Maintainability Demonstration and Verification - Definition will be made of the scope and procedures to be used for demonstration and verification of MEAR data.

11. Aerospace Ground Equipment (AGE)

The existing F-4J Specification Aircraft, with specific ECP's incorporated, is established as the base aircraft for the development of the F-4(FV) aircraft and associated aerospace ground equipment and training requirements. F-4(FV) subsystems that are common to the specification aircraft will be determined and supported by maximum utilization of common F-4 AGE. Maintenance, support, logistics, handling equipment, and training devices peculiar to the Model F-4(FV) will be investigated.

AGE requirements will be studied to determine consistency with aircraft operations, maintenance, support, mobility, and turnaround goals. The AGE study group will assist in establishing aircraft design features that will assure achievement of operational maintenance requirements.

Standard AGE required to support various mobility and turnaround requirements will be identified. Where utilization of standard Navy AGE is not feasible or practical, alternate standard equipment of other branches of the service will be considered for recommendation.

12. Operations Analyses

Analyses will be performed to evaluate the F-4(FV) effectiveness as an interceptor in an ECM environment. The ECM threat used for this analysis will be based on BuWeps recommendations.

13. Flight Test

Flight engineering studies will be directed toward analyses necessary for the preparation of a flight test plan and associated support documentation. Techniques to be employed in managing the flight test development program will be defined.

13.1 Contractor Ground and Flight Test Requirements - Ground tests will be limited to those which would be performed on a flight test aircraft. All aspects of flight testing will be considered, including aerodynamic, structural, dynamic, armament, equipment (both electronic and non-electronic), powerplant, and controls.

13.2 Instrumentation Requirements - The recording system or systems required for each test aircraft and a listing of the parameters for each program will be prepared.

13.3 Special Test Support Equipment - Peculiar AGE and instrumentation maintenance and check-out equipment will be identified. The number and type of all weapons and tanks necessary to perform the proposed testing will be determined. Engine requirements to support all test aircraft for the duration of the contractor program will be defined.

13.4 Remote Facility Requirements - The facilities which will be required at each remote site for contractor testing will be described, and new facilities not currently available will be identified.

13.5 Test Schedule and Aircraft Bailment Requirements - A flight test schedule showing the number and first flight of each test aircraft, test program assignments for each aircraft, and the duration of testing will be prepared. This schedule will be coordinated with Engineering and Manufacturing Divisions and all constraining factors will be considered.

STUDY DOCUMENTATION

The primary output of the F-4(FV) study period will be a set of technical reports defining and documenting the weapon system. Engineering reports, Specifications, program plans and schedules, and cost data will be provided as discussed below.

1. Summary Report

In addition to the specific documentation listed below, a comprehensive engineering summary report will be prepared to describe results of the F-4(FV) study. Each task group of the study organization will provide data in the form of narrative description, tabulations and charts, graphs, engineering drawings, diagrams, sketches and photographs.

Emphasis will be placed upon accurate, clear, and brief coverage of study activities. The primary objectives which governed the specific technical approach of each group will be stated as a reference upon which to base details and assess results. The particular engineering methods, techniques, and procedures (including supporting laboratory and computational studies) will be described. All report drafts and data will be checked and verified for accuracy and pertinence by the task group supervisor before release for inclusion in the coordinated summary report.

2. AN/AWG-10 Multi-Shot Missile Control System

The technical report to be published at conclusion of the study will contain a complete description of the electronic systems. Each system will be described in terms of operational modes, theory of operation, pertinent characteristics, and functional block diagrams. Photographs or outline drawings of units will be included as well as a simplified block diagram of the overall F-4(FV) electronic system integration.

3. Aircraft Detail Specification

An Aircraft Detail Specification will be prepared for the F-4(FV) in accordance with the format and content requirements of SD-24G, "General Specification for the Design and Construction of Airplanes for the U. S. Navy," dated 15 September 1953.

4. Ground Test and Development Plan

A review of the aerodynamic, propulsion, structural, and system changes from previously developed and produced F-4 aircraft will be made to determine the necessity for laboratory evaluation of such changes. A general ground test and development plan defining major test requirements will be prepared. Ground vibration testing, landing gear drop tests, static proof load tests, static ultimate load tests, fatigue tests, and wind tunnel tests will be included. Test schedules will be established, and anticipated cost will be determined.

5. Flight Test and Development Plans

(a) A flight test development program plan will be prepared, including a proposed amendment to MIL-D-8708A. This report will describe all ground and flight test requirements and will be the basis for negotiation of that part of the contract dealing with flight testing. The proposed amendment to MIL-D-8708A will outline all flight test demonstration requirements.

(b) A flight test instrumentation specification plan will also be prepared. This report will present the type and number of flights and the instrumentation necessary to evaluate the structural adequacy of the aircraft for field, carrier, and flight operations. Instrumentation will include pressure pickups, thermocouples, strain gages, and accelerometers to confirm analytical calculations of structural environments.

6. Reliability Program Plans

(a) Reliability Program Plan Report - A plan will be prepared covering the reliability program to be accomplished during the production phase. Such items as demonstration testing, failure reporting, corrective action, and supplier control will be included in this report.

(b) Mission Success Reliability Model Report - The report will present the probability of success for the primary and two alternate missions in terms of a goal, a best estimate, and a minimum expected value. It will be based on a model prepared by McDonnell for the F/RF-4C aircraft using WR-41, "Naval Weapons Requirements, Reliability Evaluation," dated 15 October 1962, as a guide.

7. Aerospace Ground Equipment and Training Devices Plan

A plan will be prepared that will establish policies, procedures, and scope of the AGE Engineering and Training Devices Program required to support the F-4(FV) aircraft.

8. Integrated Maintenance Management Plan

An Integrated Maintenance Management Plan will be provided which will define the actions and proposed procedures to be used for maintainability achievement and management of the complete logistic support program. The plan will define the methods for establishing the requirements for each maintenance resource to permit coordinated scheduling, procurement, and status monitoring as the program progresses.

9. Master Program Plan

The Master Program Planning Schedule (MPPS) will consist of major milestones, each of which will be selected because of its primary importance to the success of the F-4(FV) program. In addition to key events, the MPPS will show reprogramming alternatives so that planning for the application of resources may be adjusted to changing conditions. The MPPS will be the controlling document throughout the

program, and progress will be reported against this schedule. Back-up schedules containing events and activities leading to each MPPS milestone will also be prepared. These schedules will be supported by reasonable assumptions, will be consistent with conclusions derived from review of historical data, and will be accompanied by appropriate explanations and substantiations.

10. Contractual Data Requirements Report

A report will be prepared which lists the items of data to be furnished to the Navy, segregated by functional categories consistent with NAVMATINST 4000.15, "Management of Technical Data and Information." The list of selected data items will be coordinated and negotiated both within McDonnell and with the Navy to assure mutual concurrence and satisfaction of both Customer and Contractor needs during development, acquisition, and support phases. For each item of data, this report will indicate content and format requirements, delivery requirements (schedule, addressees, and number/type of copies), and whether the data item is to be furnished for Customer review and approval actions or for information.

11. Facilities Plan

The Facilities plan for the production program of the F-4(FV) aircraft will include results of investigations to determine the additional area requirements of the various manufacturing and related departments affected by the program. Availability of present facilities will be analyzed with regard to current and anticipated production schedules and a determination made on adequacy of these facilities.

Incorporation of the F-4(FV) requirements will be shown on a Master Space Allocation Plan, assuming current and proposed business. The Master Space Plan will show impact of F-4(FV) production on warehouse, fabrication, sub and major assembly areas, final assembly line, and ramp-hangar areas.

PROGRAM ORGANIZATION AND MANAGEMENT

The relationship of the Program Study Group to the overall corporate structure is shown in the chart on page 23. Merits of this organization are:

(a) Individuals performing all study design and supporting functions are assigned full time and are physically located together, resulting in maximum efficiency and coordination.

(b) Unimpeded lines to top management promote rapid decision making.

(c) A single point of contact is available for BuWeps coordination.

(d) Each supporting group reports through a "Program Line Organization" to the Program Study Engineering Manager for program direction, and through a "Functional Line Organization" to its own department head for technical direction. This promotes complete technical supervision and state-of-the-art awareness while still maintaining an authoritative responsibility so that decisions can be made promptly and effectively to achieve the best over-all systems.

Plantwide responsibilities that have been established for the F-4 program will apply to the F-4(FV) in terms of engineering, manufacturing, planning and scheduling, procurement, product support, quality assurance, and contracts. Management personnel will be selected for assignment to the project and the techniques and tools of project control successfully applied to the F-4 will be defined and assigned.

In addition to methods created specifically for the F-4(FV), general management procedures which the company has developed and utilized on other large scale projects will also be employed. An example of these companywide procedures (for all of which firm written requirements and instructions exist in company management manuals) is provided by Control Procedure CP 8.200: "Engineering Control of Design Changes for Department of Defense Programs." Thorough analysis of the necessity for and impact of design changes is accomplished through compliance with this procedure. All affected divisions provide management representatives for review and decisions on proposed changes.

1. Study Task Group

Engineering management and control of the F-4(FV) study program will be provided by the same basic organization which originally conceived the configuration of the aircraft and developed the design to its present level. All preliminary design and analysis work on the concept of an Advanced F-4B Fighter Aircraft which has developed into the specific model designated as the F-4(FV) was performed by personnel permanently assigned to the company's Aircraft Advanced Engineering Department. This same organization will carry on intact into the Navy study proposed herein.

Although the total engineering organization will be considerably expanded as required to effectively conduct the study within the contracted time period, the nucleus will be those men who have been associated with the F-4(FV) aircraft concept since its origination. The additional personnel required will be selected from Advanced

Organizational Chart (Page 23)
Not Included

Engineering groups now assigned to other company funded advance studies, and from the F-4 Aircraft Project Organization.

2. Personnel Qualifications

Edward M. Flesh (BSME) - Manager, Aircraft Advanced Engineering, will manage the proposed engineering study. He has been instrumental in the conception and development of the F-4(FV) to this point, and his past accomplishments are well known to Department of Defense program management personnel. He has been in charge of aircraft advanced design activities for the past three years, was McDonnell Engineering Manager of the Mercury space project for four years, and Project Engineer and Engineering Manager of the Air Force F-101 series aircraft from its origination through its firm establishment as a DOD weapon system. He has over 35 years experience in the aeronautical engineering industry, the first 16 with Curtiss-Wright and since 1946 with McDonnell.

Walter F. Smith (BSEE) - Senior Engineer, Reliability. Seventeen years engineering experience, including three in avionics design and five in aircraft reliability. For the past two and a half years, responsibilities in McDonnell Advanced Engineering have included multipurpose strategic reconnaissance aircraft and integrated avionic system studies, and various missile and spacecraft studies.

William W. Hamilton (MSME) - Senior Engineer, Dynamics. Sixteen years experience as Dynamics Analysis Engineer on helicopters and F-2H aircraft, and as Structural Dynamics Engineer on F-3B and F-4 aircraft and Typhon missile. Currently responsible for structural dynamics analysis on advanced aircraft design effort.

Charles J. Newman (BSME, MSAE) - Senior Engineer, Loads. Ten years experience in structural loads analysis, including seven and one-half years at General Dynamics, Fort Worth.

Gilbert C. Smith - Senior Design Engineer, Aerospace Ground Equipment. Fourteen years experience in aircraft and spacecraft design. Joined the Ground Support Engineering Department in 1957 and has contributed to the development of support programs for current F-101, F-4B, F-4C aircraft, and Mercury spacecraft. Has also participated in advanced study programs including VTOL and STOL aircraft, TFX, Surveyor, and Gemini spacecraft. Presently assigned to advanced aircraft design studies.

Donald B. Hamer (BSME) - Senior Group Engineer, Propulsion. Joined McDonnell in 1954 as a wind tunnel test engineer. Assigned to tne Aerodynamics Department in 1956 as an aerodynamics engineer on the F-101 aircraft. Propulsion experience began on the F-4 aircraft and includes extensive work on engine inlet and exhaust design and testing. Has contributed to the propulsion and design efforts on many M.A.C. advanced studies and proposals.

Otto R. Kosfeld (MSCE) - Group Engineer, Thermodynamics. Nine years experience in aircraft and spacecraft thermodynamics design and development. Background includes aerodynamic heating, heat transfer, and environmental control system design and analysis. Now responsible for advanced design and development of aircraft thermodynamics systems.

Maurice S. Smyth (BSEE) - Project Design Engineer. Twenty-three years in aircraft design. With McDonnell since 1945. Experience in flight controls, hydraulics and pneumatics, landing gear, power plant and fuel systems. Was Assistant Project Engineer on F-4B/C aircraft.

Frank Laacke (BSAE) - Project Aerodynamics Engineer. Eighteen years experience in aerodynamics research and analysis. Before joining McDonnell in 1952, he was with the Aircraft Laboratory at WADC. Was Project Aerodynamicist on F/RF-4C aircraft project and now directs advanced aircraft studies.

Robert L. Johnson (BSAE) - Section Manager, Strength. Seventeen years with McDonnell in aircraft and missile strength analysis. Was Project Strength Engineer on Talos missile program and on RF-4B/C aircraft. Now responsible for advanced aircraft strength design and development.

Fred M. Krachmalnick (BSME, MSRS) - Section Manager, Guidance and Control Mechanics. Nineteen years experience in stability and control, automatic flight control systems, automatic fire control, and automatic guidance and navigation systems. Background includes assignments on aircraft and missiles.

Herman W. Hamm (BSEE, MSRS) - Section Manager, Electronics Systems. Fourteen years background in electrical and electronic systems design and development. With McDonnell since 1957. Responsible for determination of electronics requirements for advanced aircraft systems and for projection of the state-of-the-art to meet these requirements in such areas as radar, infrared, CNI, ECM, and missile guidance.

Robert A. Baker (BSAO) - Supervisor, Maintenance Engineering. Twenty-three years experience in field service operations and maintenance engineering analysis. Has been with McDonnell for the past five years, where a major portion of his time has been spent in the analysis and prediction of maintainability characteristics for advanced aircraft systems.

Robert L. Short - Senior Engineer, Weights. Eight years experience with McDonnell in Weights Engineering. Primary concentration on estimation and analysis of advanced design aircraft concepts and systems, advanced F-4 weapon systems, and development of weight estimating methods and techniques.

3. Technical Cooperation

Program Study Managers from Westinghouse Electric Company (Baltimore) and Raytheon Company (Bedford) have been assigned for coordination and integration of the definition studies on AWG-10 Multi-Shot Missile Control System and the advanced Sparrow to be conducted under subcontract to M.A.C. In addition, the Large Jet Engine Division of the General Electric Company (Evandale) has agreed to provide required support in the propulsion area.

RELATED EXPERIENCE

McDonnell Aircraft Corporation's history has been one of thorough analysis associated with its successful design, manufacture, and assistance with operations of high performance aircraft and space vehicles. It was particularly necessary that the manufacturer be familiar with the operational problems of his system. To this end, M.A.C. has fostered the knowledge of operational problems by frequent visits of engineering personnel to operating commands, frequent contacts with operating personnel, and the performance of contracts of this type. More than 50% of the total aircraft advanced design effort during the past three years has been devoted to a series of studies applicable and related to the proposed study.

The Aircraft Advanced Engineering Department has continued design analysis studies of the F-4 series aircraft to develop improved performance characteristics, expansion of operational capabilities, and adaptability for additional military requirements. All of these studies have been conducted under the same managerial direction assigned to the proposed study; and it is this continuity of experience which McDonnell considers of greatest significance now. The studies listed below have been reported to the Navy and are examples of the comprehensive background the company has developed and the detailed design data available to facilitate a realistic and complete weapon system program definition.

M.A.C. Report	Title	Date
9809	Advanced F-4B (Model 98EC)	11 Jan 1963
A379	Modified F-4B Model Comparisons (F-4J, -K, -L)	16 Dec 1963
A884	Advanced F-4B (F-4J, -La, -Lb, -FOa, -FHa)	14 Aug 1964
B177	Advanced F-4B (F-4(FV))	21 Oct 1964
B257	F-4(FV) Multi-Shot Missile Control System	19 Nov 1964
B259	F/RF-4 Phantom II Configurations (F-4A, -B, -C, -D, -G, -J, -K, -E; RF-4B, -C)	7 Dec 1964
B341	Costs and AAW Effectiveness of Advanced F-4B with Multi-Shot AMCS (F-4J, -L, -FV, -FO, -FH)	11 Jan 1965

FACILITIES AND EQUIPMENT

McDonnell has consistently supported its design staff with complete research and test facilities. All facilities and equipment required for the study effort are currently available and will be scheduled as required. Laboratory facilities are located near the engineering study area, thus assuring close coordination with test programs. Major facilities that will be utilized in this study are briefly described below.

1. Computing Equipment

Portable signal conditioning and digitizing stations located strategically in major test areas condition, digitize, and transmit data in high level digital form to the Central Data Acquisition System (CDAS). The system presently consists of two digitizing stations, which may be located at any two of four test locations, and four hundred signal-conditioning channels. It will be expanded at a later date to five digitizing stations and one-thousand signal conditioning channels.

2. Polysonic Wind Tunnel

This is an intermittent, pressure-to-atmosphere blow-down type, producing test velocities from .5 to Mach 5.8 in the 4-foot square test section. Measured test data in usable format is automatically produced within 15 minutes of each test run. A Schlieren system is used to observe and record compressibility phenomena. A low-speed tunnel is available to generate velocities from 20 to 240 mph.

3. Flight Simulators

Facilities are available for development and performance testing of manual and automatic guidance and control systems, including terrain avoidance displays. Control system electronics and electro-hydraulic actuators may be evaluated by automatic mission sequencers or by a remote control system.