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North American Aviation, Inc.

XB-70 PROGRAM

ENGINEERING EFFORT

TO BE ACCOMPLISHED

ON CONTRACT 42058

(31 JULY 1962 THROUGH 30 JUNE 1964)

INTERNATIONAL AIRPORT LOS ANGELES 9, CALIFORNIA

LOS ANGELES DIVISION

9-8-62

XB-70 ENGINEERING

ANALYSIS OF ENGINEERING EFFORT TO BE PERFORMED ON CONTRACT AF33(600)-42058 FROM 31 JULY 1962 TO 30 JUNE 1964.

INDEX

	Pages
STATISTICAL ESTIMATE	1 - 7
ENGINEERING COSTS BY ELEMENT	8, 9
DIRECT LABOR COSTS BY MANAGER	10 - 15
TECHNICAL ENGINEERING	16 - 30
MECHANICAL & PROPULSION ENGINEERING	31 - 39
ELECTRICAL & ELECTRONIC ENGINEERING	40 - 50
CHIEF PROJECT ENGINEER'S OFFICE	51 - 56
STRUCTURAL ENGINEERING	57 - 64
FLIGHT TEST	65 - 70
COMPONENTS ENGINEERING	71 - 77

STATISTICAL ESTIMATE OF ENGINEERING MANHOURS
FOR THE B-70 PROTOTYPE PROGRAM

1. Statistical Estimate Vs. Actual through Completion of A/V #1

1.1 Using the formula shown on figure #1 and actual recorded manhours of other NAA experimental and production aircraft, the XB-70 engineering effort was plotted on an engineering manhours scale to arrive at the total manhours required through A/V #1 completion. As a result, a statistical estimate was presented to and concurred in, by the Air Force during the September 1961 negotiations for AF33(600)42058. This estimate indicated an anticipated manhours expenditure of ---------- 13.800 M

1.2 As A/V #1 nears completion (28 September 1962) the total applicable XB-70 manhours recorded through 31 July 1962 (13.024) plus an estimate of the relatively few remaining manhours (.599) is ---------- 13.623 M

1.3 However, the statistical estimate (13.8 M) and the current (13.623 M) above, both include effort which was expended during a program which contained numerous redirections and contract revisions. To present a more accurate accounting by relating the engineering program to AF 33(600)42058, it is necessary to deduct that effort which was applicable to the XB-70 program but was expended against contracts other than Contract AF33(600) 42058. During the subject negotiation, the Air Force

concurred in the applicability of XB-70 effort to the contracts as set forth below.

Contract	Period	Total	% Applicable	Hours (Less Flight Test)
AF33(600)36599 Phase I	1-1-58 to 2-28-59	(2.394M)	63.5	1.520 M
AF33(600)38669 Phase II (Part 1)	3-1-59 to 7-31-59	(1.307M)	63.5	.830 M
AF33(600)38669 Phase II (Part 2)	8-1-59 to 11-30-59	(1.44M)	52.0	.750 M
	12-1-59 to 6-30-61	(5.77M)	100.0	5.770 M
	Total XB-70 recorded to contracts other than AF33(600)-42058			8.870 M

1.4 Adjusting the statistical estimate and current estimate in paragraphs 1.1 and 1.2 above (through 28 September 1962):

Statistical	13.800 M	Less	8.870 -------	4.930 M
Current	13.623 M	Less	8.870 -------	4.753 M

This, therefore, shows a very close correleation over a period of three years and 9 months of the statistical estimate (per the formula) and the current hours (recorded through 31 July 1962 and estimated 1 August 1962 through 28 September 1962).

2. Estimate to completion of A/V #3 (excluding Flight Test)

2.1 The graphical formula shown on chart #2 is based on the same contractor's experience as that used in chart #1, and shows the statistical method of estimating the engineering manhours for a period from completion of A/V #1 through completion of A/V #3 excluding flight test effort.

Using the total months required for the completion of each of the three air vehicles as a basis, an acceleration/correlation curve can be plotted, the slope of which determines unit cost reduction in manhours/vehicle (U.C.R.).

2.2 The U.C.R. (62% slope) for the 61-4-1 Schedule for three XB-70 Air Vehicles indicated a requirement for a total of-------- 19,230,000 manhours through completion of A/V #3. Subtracting the manhours through completion of A/V #1 (including applicable XB-70 manhours charged to earlier B-70 contracts), a statistical estimate for completion of the program (less flight test contract) equals 19,230,000 (62% U.C.R.)-13.623 (Paragraph 1.2)---------- 5.967 M manhours.

2.3 However, the contractor performance statistics for U.C.R. calculations is based on contracts requiring the <u>development</u> of aircraft for operational use, whereas the XB-70 contract requires the determination of the <u>feasibility</u> of the aircraft to become a combat weapon. In addition, past contracts have usually required complete production type drawings and specifications, handbooks, etc., as opposed to experimental type drawings, minimum data, etc., required under the XB-70 Contract. Recognizing the above variations in contract requirements in addition to funding limitations, and accepting the risks

which might be incurred, the engineering allocation to complete the subject program was established at a 58% U.C.R. (in lieu of a 62% slope) thus reducing the total XB-70 engineering manhours to ---------- 17.316 M

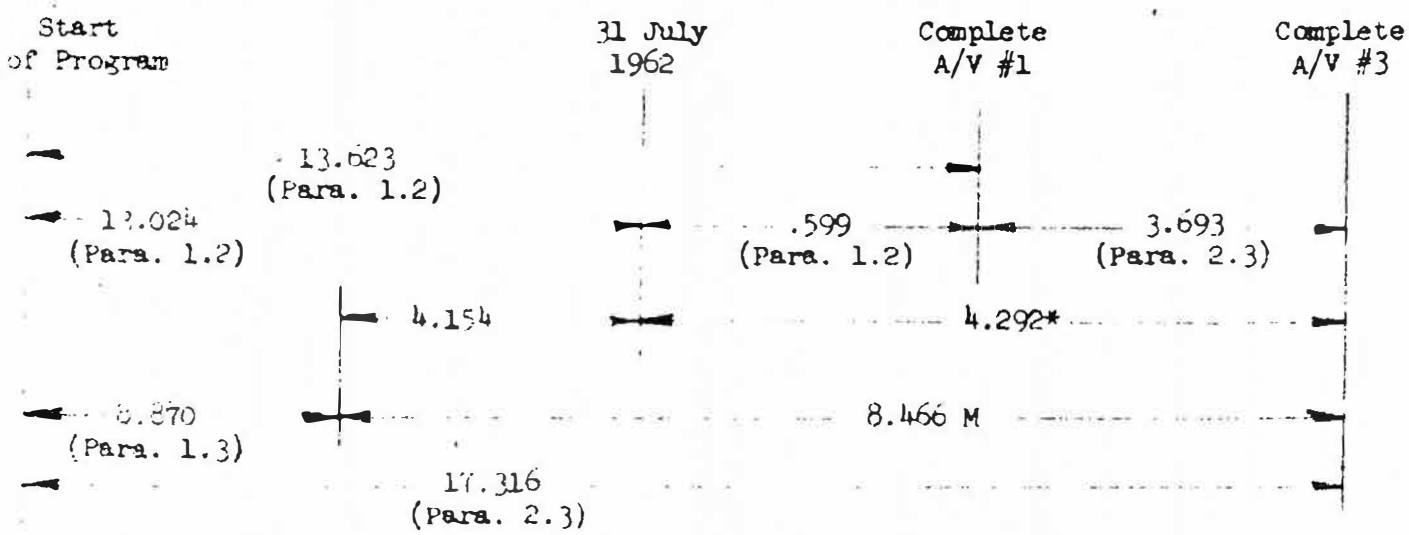
By subtracting the "current" hours (Paragraph 1.2) from the allocated hours above, the hours available from completion of A/V #1 through completion of A/V #3 equals 17.316M (58% U.C.R.)-13.623 (Paragraph 2)---------- 3.693 M manhours.

2.4 A relationship to Contract AF33(600)42058 for the period of 31 July 1962 through A/V #3 completion can be established by subtracting the hours charged to earlier contracts and those expended on AF33(600)42058 through 31 July 1962 from the total hours per the 58% U.C.R. allocation thus:

	17.316 M	manhours
	- 8.870 M	(Charged to earlier contracts)
(Sub Total)	8.446 M	
	- 4.154 M*	(Recorded through 31 July 1962)
(Total)	4.292 M	Hours required from 1 August 1962 through 31 June 1964 (less flight test)

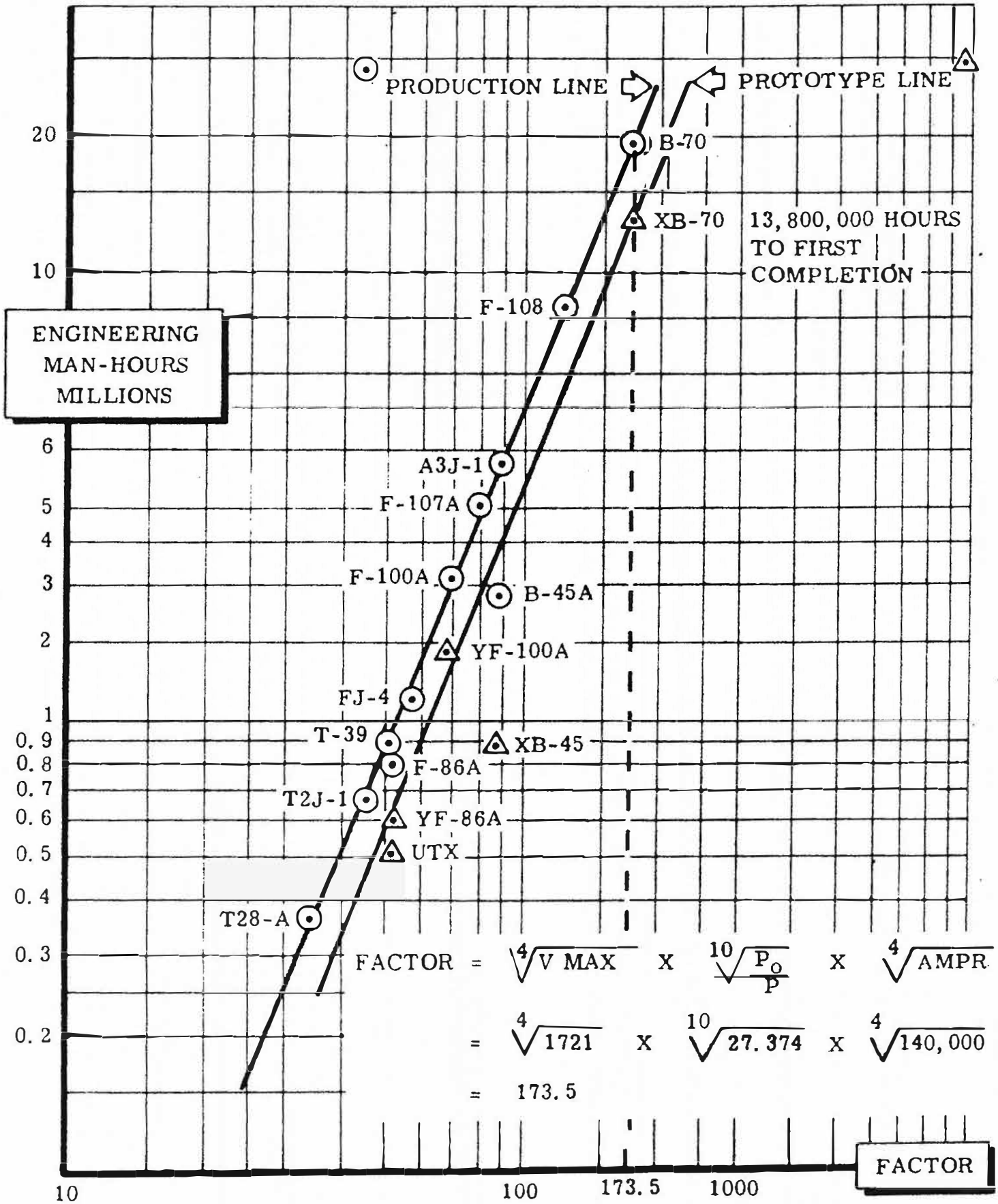
(*Does not include .565M hrs. recorded against AF33(600)42058 but applicable to YB-70 only)

2.5 Graphically, the above computations may be presented as follows:



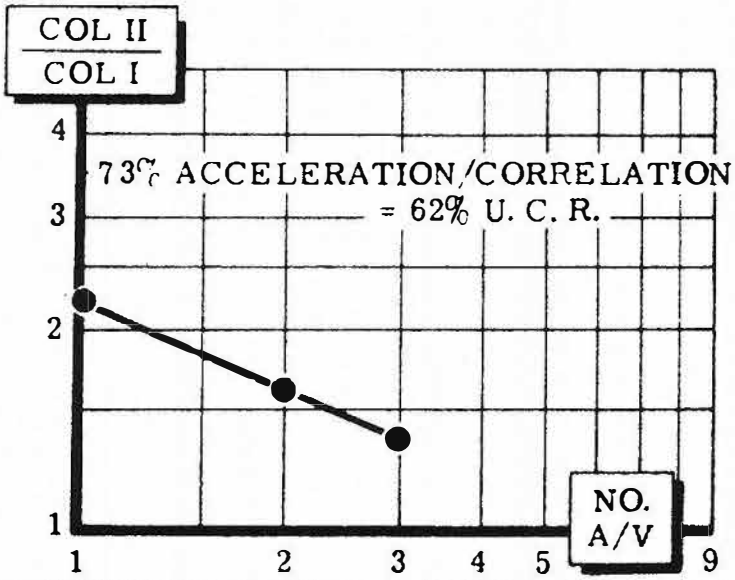
* As indicated above, the engineering manhours required from 1 August 1962 until completion of A/V #3 is 4,292,000. This number of labor hours plus the related burden equals $44,766,000.

XB-70 A/V ENGINEERING MANHOUR PREDICTION FACTOR



ACCELERATION/CORRELATION

(INFLUENCE OF NO. AND SCHEDULE OF A/V'S PRODUCED)

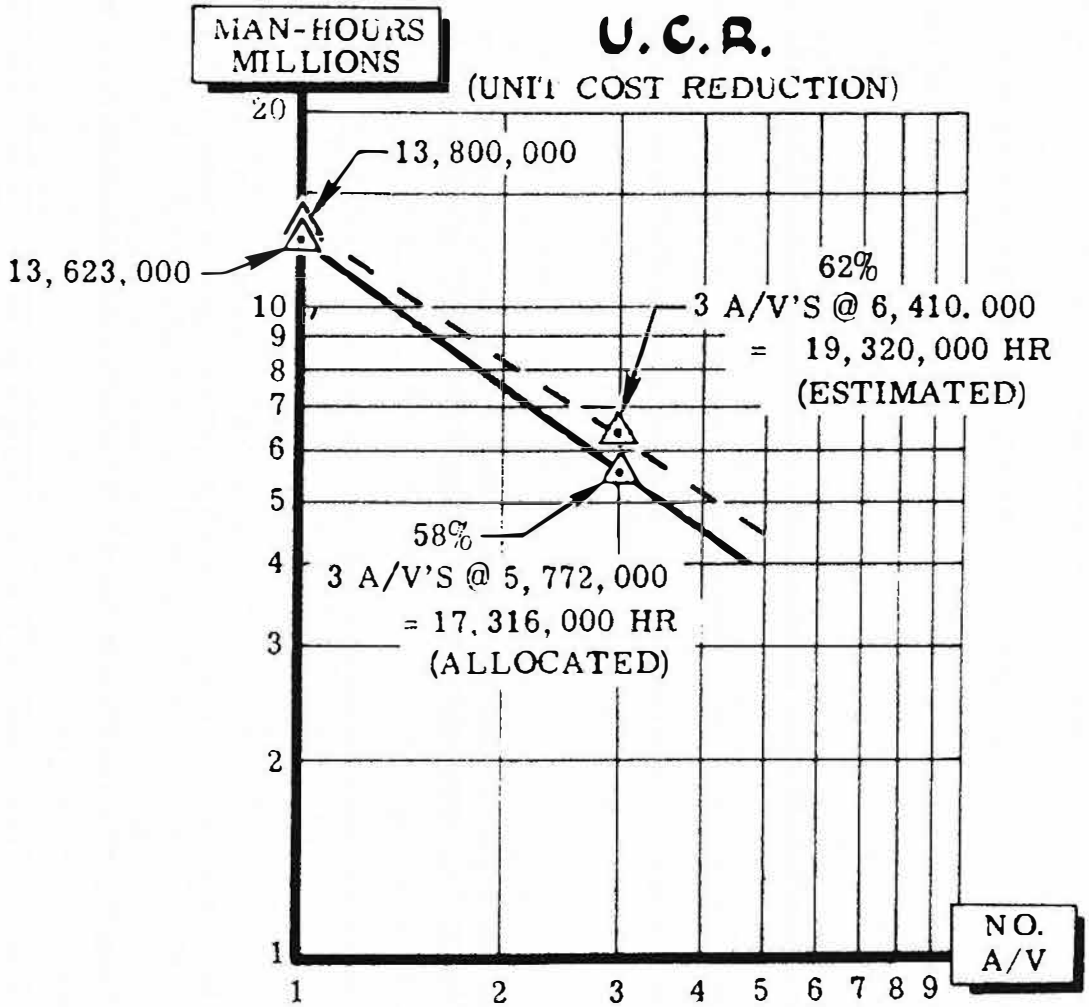


NO. OF ACFT	MONTHS FROM BASIC RELEASE TO COMPLETION	COL II / COL I
1	22	22
2	32	16
3	41	13.7

FORMULA TO CONVERT FROM ACCELERATION/CORRELATION TO UCR.

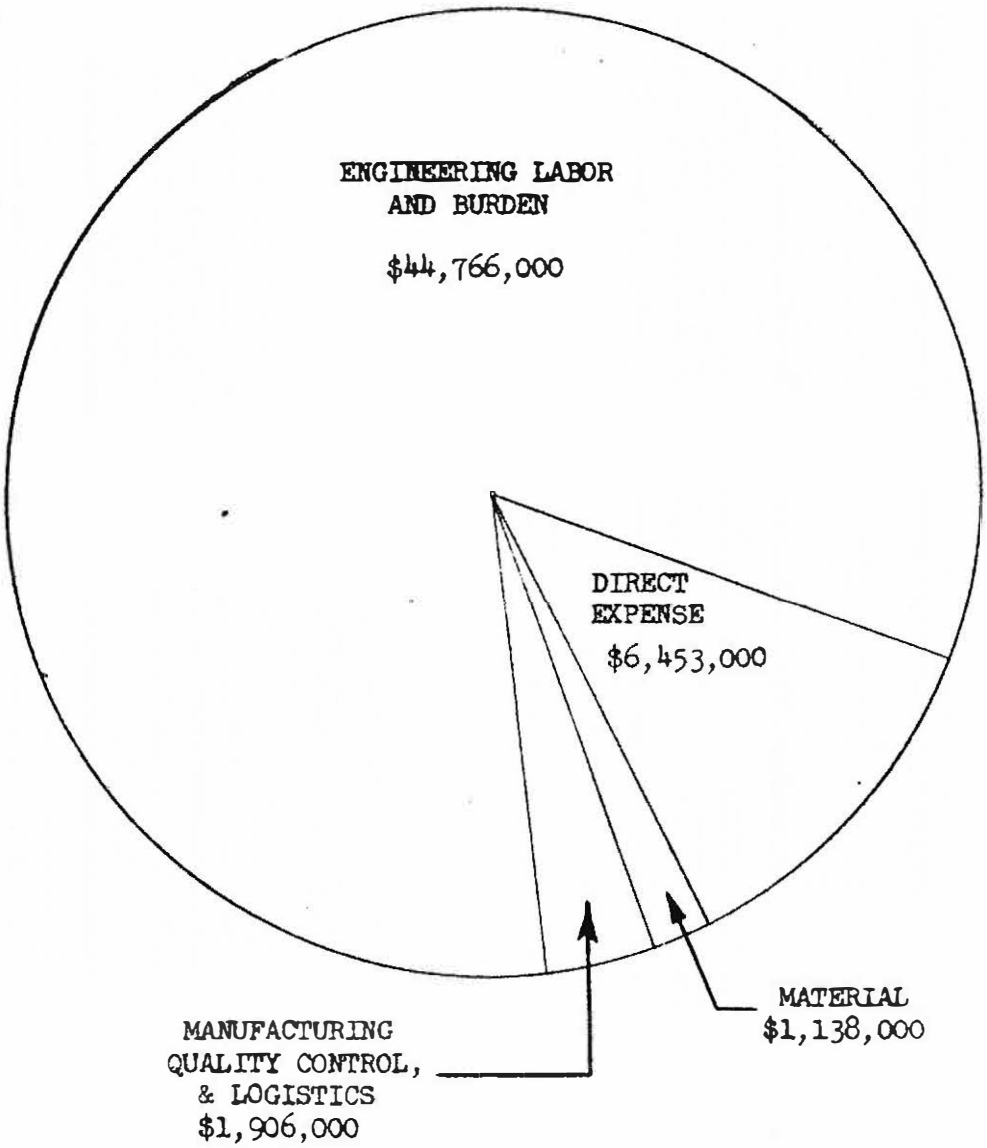
$$A(\%) = .533B(\%) + C$$

WHERE:
A = UNIT COST REDUCTION
B = ACCELERATION/CORRELATION
C = 23.12



XB-70 ENGINEERING
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY, 1962, THROUGH 30 JUNE, 1964)

ENGINEERING COSTS BY ELEMENT



TOTAL $54,263,000

ELEMENTS OF COST

ENGINEERING LABOR includes salaries and wages incurred by all Engineering personnel working directly on the program. This will include not only the designers and draftsmen physically designing the air vehicle, but also aerodynamicists, the thermodynamicists, stress analysts, laboratory technicians, mathematicians, specification writers, wind tunnel model builders and tunnel technicians and varied other specialties. This direct labor is applied to the contract, after which burden is applied on a pro-rata basis, based on burden charges throughout the entire Los Angeles Division Engineering function. These burden charges include burden labor such as higher supervision and clerical personnel, supplies, space charges, facilities, utilities, and general and administrative expense.

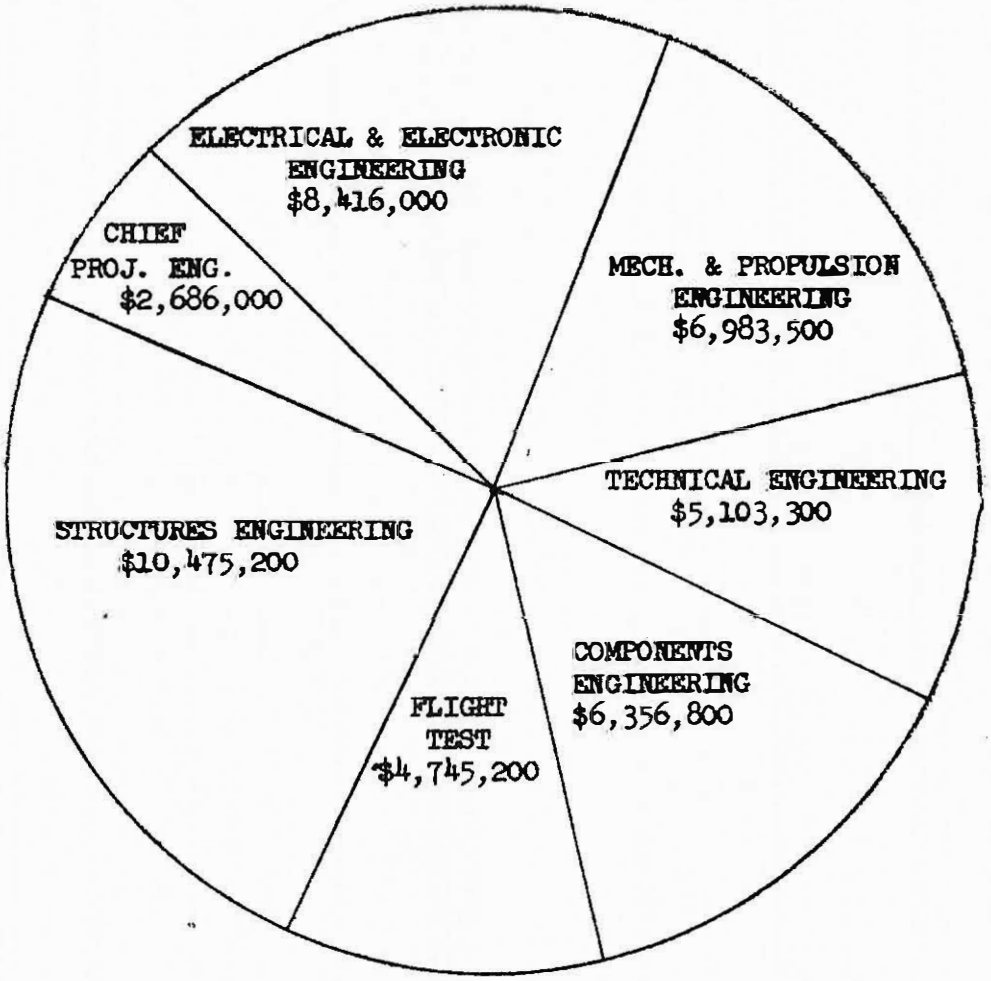
ENGINEERING DIRECT EXPENSE covers the cost of operating wind tunnels, wind tunnel rentals; travel costs to and from subcontractors, Air Force facilities, and NAA facilities; and automatic computation machine rental (such as the IBM 7090).

ENGINEERING MATERIAL includes all hardware purchased for test purposes. Also covered are design, development, testing, and test reports for purchased equipment for the air vehicle. Excepted from above are all major subcontract items such as the Bomb/Nav System or Auxiliary Gyro Platform. These items are charged in their entirety to Material Division.

MANUFACTURING, QUALITY CONTROL AND LOGISTICS SUPPORT OF ENGINEERING covers material and labor to fabricate test specimens and jigs and tools for testing. Any labor required from manufacturing during the actual testing is also charged into this element.

DIRECT LABOR
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY 1962, THROUGH 30 JUNE 1964)

DIRECT LABOR COSTS BY MANAGER



TOTAL - $44,766,000

B-70 ENGINEERING DEPARTMENT

DEFINITION OF RESPONSIBILITIES

The following paragraphs outline the functional breakdown of the B-70 Engineering Departments and, in brief, the activities which will be carried out during the period from July 31, 1962, to the end of Contract AF33(600)-42058 on June 30, 1964. These will be discussed in more detail in succeeding pages.

DEPT. 181 - TECHNICAL ENGINEERING

The Technical Department is responsible for all aerodynamic, thermodynamic, and flight control system analysis work. Considerable effort will be applied toward monitoring and updating data and performance charts. Wing tunnel testing will be carried out, particularly the .10 scale aero model and completion of testing on the .577 inlet model. The many changes required for the Ship 3 modification will be analyzed and design criteria will be established. The flight simulator will be in operation as an aid in flight test of the air vehicles.

DEPT. 182 - MECHANICAL & PROPULSION ENGINEERING

This department will continue to resolve problems connected with fabrication and operation of the aircraft in the areas of fluid power, landing gear, flight controls, the inlet system, power plant installation, fuel system, and the environmental system. Changes will be made as a result of flight test data. The Ship No. 3 modifications, particularly in the environmental control system, but also in other areas, will be designed and released. A continuing coordination with subcontractors will be accomplished, particularly with the engine manufacturer, to assure correct fit and functioning. Airworthiness testing of many hydraulic and environmental hardware items will be completed.

DEPT. 183 - ELECTRICAL & ELECTRONIC ENGINEERING

This department will continue to resolve problems and to optimize design of the electrical system, electrical power and control, electrical and electronic installation, weapon delivery and navigation systems, communication and indicating systems, and in integration of electronic systems. The changes associated with Ship No. 3 will be designed and released to manufacturing, including installation of much additional electronic equipment, and greatly increased power output. "SOCKO" lab for Ship No. 3 will be built and operated. Automatic wire bundle print-out for manufacturing of ships 2 and 3 will be done. Coordination with the many subcontractors supplying hardware for the air vehicles will be a major item.

DEPT. 184 - CHIEF PROJECT ENGINEER'S OFFICE

This department is charged with the overall engineering program administration. It is responsible to the Chief Engineer in assuring that the overall program is oriented within the requirements established by the USAF and NAA management. This department is further charged with final release authority on all engineering documentation associated with the B-70, including drawings, specifications, purchase orders. It is charged with a direct responsibility of maintaining close coordination with the customer and of assuring the integration effort of the respective engineering departments and the allied activities in the B-70 Division manufacturing and materiel areas.

Equipment and process specifications will be maintained and revised as necessary and new specifications will be released for Ship No. 3.

Personnel from all departments will be permanently stationed at either Palmdale manufacturing or EAFB (the flight test operational site). These personnel are onsite for engineering support of manufacturing and flight test operations. These administratively report to a project engineer assigned to Dept. 184.

DEPT. 185 - STRUCTURES ENGINEERING

The Structural Department will formulate basic load information, basic design criteria, structural analyses, and weight control of each element of the B-70. This department also includes design producibility functions to ensure proper usage of materials, establish design standards and investigates and evaluates new procedures for B-70 application. The structural dynamics group is concerned with flutter, vibration and acoustical analyses and testing, to establish the proper flutter design criteria.

Design criteria will be established for design of Ship 3, and the design will be stress-checked to insure proper load paths. A continuing effort will be made to simplify design for ease of fabrication.

Material review dispositions will continue to occupy a large share of time as an aid to manufacturing.

DEPT. 186 - FLIGHT TEST

The Engineering Flight Test Department will prepare flight test schedules for air vehicles 2 and 3 and will conduct the ground test operations on all three airplanes. Procedures will be established for the flight test program. A data reduction procedure is being formulated.

The instrumentation package for Ship No. 1 is being tested and will be shipped to Palmdale for installation in the air vehicle.

Instrumentation will be developed and designed for Ships Nos. 2 and 3.

Pilots will be trained on the flight simulator.

Taxi tests and ground run-up tests will be conducted prior to first flight of each vehicle.

DEPT. 187 - COMPONENTS ENGINEERING

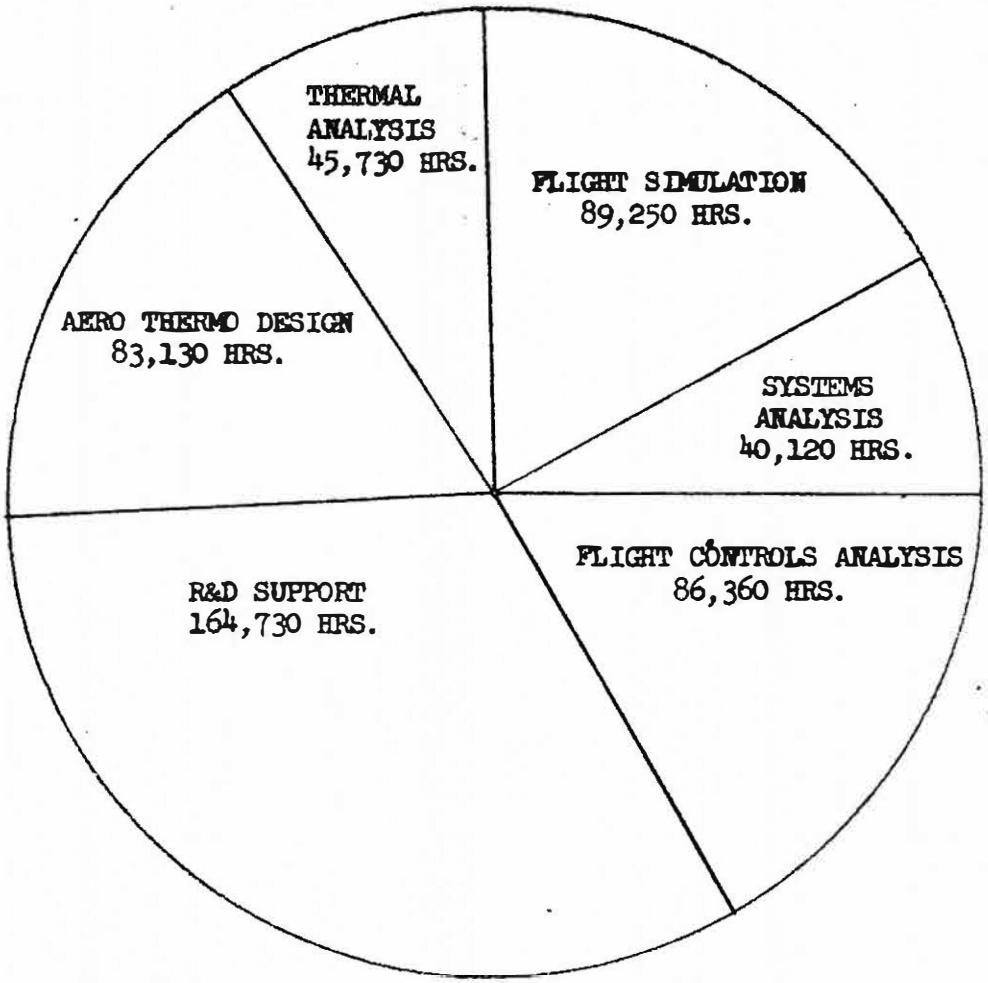
The Components Department is responsible for the detail design of the structural elements of the B-70, such as the wing, empennage and fuselage. This department serves as the focal point of control and line routing, internal configuration control, drawing checking, and the overall human factors and crew station design.

Material review dispositions will occupy a large portion of effort as an aid to manufacturing. Considerable redesign will be required to facilitate fabrication.

The Ship No. 3 modification will be designed and released to manufacturing. This will include design of two additional crew stations and structural provisions for installation of new equipment.

DEPT. 181 - L. M. ROSE, MANAGER
TECHNICAL ENGINEERING
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY 1962 THROUGH 30 JUNE 1964)

BREAKDOWN BY FUNCTION



TOTAL HOURS - 509,320

TOTAL DOLLARS - $5,103,300

TECHNICAL ENGINEERING

EXTERNAL AERODYNAMICS

Effort during this period is divided into three categories; Performance, Flight Qualities, and Test.

Under the general aspect of Performance, considerable effort is anticipated in monitoring and updating the fundamental parameter undermining performance, i.e., drag. Work in this area will include continued estimation and correlation of available data in the specific areas of skin friction, shock drag, lifting drag, and the miscellaneous aspects of components as more information becomes available from either analysis or test. Additionally, XB-70 mission capability must be continually monitored as revised system data becomes available in order to maintain a performance status. Further, continued effort must be conducted in such specific performance regimes as takeoff and landing, climb and descent, acceleration and maneuvering, and ceiling, and in the general "trade data" area of weight, drag, and SFC. To maintain an adequate flow of such information to interested parties, reporting activity is also required. These include detailed SAC charts, performance reports, TFD's, and analysis letters.

In the realm of flight qualities, continued examination of the air vehicle flight envelope is required to insure both safe and satisfactory air vehicle characteristics. The impact of such items as weight, center of gravity, Mach number, and altitude must be continually monitored in maintaining up to date definitions of both the static and dynamic response capability. In order to perform these functions, both simple and complex analytical programs will be employed involving digital and analog techniques. The equations of motion will continue to be utilized about all three axes with and without the influence of the structure. Because of the impact of the latter item, particularly in the high speed regions of the flight envelope, programs involving up to 15° of freedom will be employed. These procedures will also be used to determine the influence of design changes in attempting to improve flying capability.

because of configuration modifications, control system changes, additional Wind Tunnel results or non-linear effects. Correlation and analysis constantly mold data into simplified linearized forms consistent with present knowledge. Continued analysis reveals potential problem areas requiring re-evaluation of aerodynamic characteristics. Similarly, the flixible corrections to the aerodynamic data are subject to excitations which require re-evaluation or reiteration. The primary influences are moditication in the rigid aerodynamic load distribution, structural redefinition of any component, effects of temperature, inertia redefinition due to fuel slosh evaluation, attitude variations or weight changes.

The development of analysis technique involves methods and program revisions as required to solve design problems. Additional technique development potential includes optimization of structure, configuration or missions by improved aerodynamic definition for deformed surfaces.

THERMODYNAMICS

Throughout the flight test period of the XB-70, engineering manpower will be expended to develop and improve the B-70 air induction and complete propulsion system. This effort will fall into two categories. (1) Development and improvement in the areas that prior to flight test are suspected of being deficient or that offer large performance improvement potential. (2) New areas found during the flight test program that warrant or require a development program separate from the flight test effort.

Areas that fall under category (1) are as follows:

(1) AICS - Many compromises exist in the design of the XB-70 automatic air induction control system to obtain a simple and cheaper control utilizing "off-the-shelf" hardware. Engineering effort will be expended to determine system requirements for a production type air vehicle and methods of achieving these requirements. A considerable effort will be made to obtain basic improvements in the control system by utilizing aerodynamic stabilizing or control technique. Also, an effort will be made to

improve control accuracy and characteristics by obtaining improved control pressure signals. This will include supersonic wind tunnel tests with an inlet control model.

(2) Inlet-Engine Control Compatibility - An IBM program has just been completed which permits analysis and evaluation of the dynamic characteristics of the complete propulsion system. Detail and complete representation of the engine, engine control, inlet and inlet control plus provision for introducing effects of A/V transient maneuvers are included in the dynamic simulation program. Analysis and studies will be made to determine means of improving inlet and engine control and control system compatibility. These studies will probably result in changes to both the J93 engine controls and B-70 inlet control systems.

(3) Inlet - A/V Stability Problems - Reducing to a minimum the effects of air induction system transients upon air vehicle stability is an area that will require continuous engineering effort. Basic approaches to this problem include rearrangement and relocation of the air induction system components. These revisions must be experimentally evaluated both from the standpoint of A/V stability and air induction system characteristics. This program will require wind tunnel test of both inlet control and A/V stability models. Other approaches to this problem that will be investigated will be changes or additions to the AICS that eliminate or prevent these undesirable conditions from occurring.

(4) Improvement in Installed J93 Performance - A potential for significant improvment in the installed performance of the J93 exists in careful and detailed analysis of flight test data. By knowing the exact full scale performance characteristics of the XB-70 air induction system and YJ93 engine, accurate evaluation of changes to both these systems can be made. As an example, more exact matching of engine airflow demands to inlet availability offers potential for significant improvements in thrust. Changes that will match inlet bleed flow to exact secondary nozzle requirements is another possibility.

THERMAL ANALYSIS

AERODYNAMIC HEATING

The aerodynamic heat flux forward of Sta. 930-1/2 will be determined for ship #3 because of the internal differences between #1 and #3 in this area. The nose, forward of Sta. 369-1/2, will contain equipment which requires thermal protection. The cabin area, Sta. 369-1/2 - 605, will have higher heat flux in the aft portion due to electronic equipment and two additional crew stations. Installation of most electronic equipment in a separate cooled bay, Sta. 605 - 857-1/2 has increased the heat flux in this area. The ice storage tank has increased heat flux from Sta. 857-1/2 to 930-1/2. The increased heat flux and the revised interval configuration will influence most of the temperature predictions and environmental control provisions in the forward portion of the air vehicle.

CREW COMPARTMENT

Total heat loads will be determined and design criteria for compartment environmental control will be established for ship #3. Air distribution and collection requirements for a four (4) man crew will be determined. The underfloor area will be used as a collection plenum for the return air. This allows a simplified air collection system and reduced transpiration wall coverage. Design criteria for these items will be established. Most of the above work has been initiated although it is still in the early stages.

Phase II laboratory tests will be conducted on the Environmental Simulator to evaluate crew environment utilizing actual ECS components for XB-70 #3. Both normal and emergency conditions will be simulated to assure an acceptable environment for the crew. The simulator will also be on stand-by during the XB-70 #3 Flight Test program to assist in evaluating crew environment problems.

EQUIPMENT ENVIRONMENT

The equipment and installation on air vehicle #2 is basically the same as air vehicle #1 with the exception of some GFAE units. These are being procured as CFE for air vehicles #2 and #3 and involve thermal coordination with subcontractors as well as air vehicle installation changes.

The electronic equipment installations on air vehicle #3 will be considerably changed because of the addition of the Bombing and Navigation subsystem and the additional electrical power required. The electrical heat load is approximately 50 KW, compared with 23 KW for Ship #1. In addition, liquid cooled black boxes are now included and some units, radar antennas and inertial platform, are installed in the nose. Design criteria will be prepared to assure adequate cooling, heating and pressurization of these items. Coordination effort with subcontractors will be continued to insure a compatible thermal environment.

ENVIRONMENTAL CONTROL

The approximately doubled refrigeration requirements for ship #3 has necessitated considerable change in ECS configuration and requires the use of ice as a heat sink. The basic schematic and heat exchanger specs have been prepared. Procurement specs for remaining components and development and airworthiness test programs will be prepared. The environmental control system for ship #3 will be procured on a component basis instead of a system management basis. System management and integration will be part of the "in-house" effort.

ENGINEERING DESIGN SUPPORT

Analytical support will be provided for both design groups and manufacturing in order to maintain and develop ships #1 and #2. Specific areas depend on the daily development in manufacturing, testing and results from the subsequent flight test program.

FLIGHT CONTROL ANALYSIS

AIR INDUCTION CONTROL SYSTEMS

Definition of detailed requirements for the manual, semi-automatic, and automatic is in the process. Breadboard mechanizations of system concepts will be set up and evaluated on the simulator. Simultaneous control of the inlet geometry by the co-pilot and of the air vehicle by the pilot will be simulated during normal maneuvers and inlet unstart conditions. Modified air vehicle ground and flight test programs will be necessary. The final aspects of the program will include the investigation and implementation of necessary control improvements as defined during flight testing.

PRIMARY AND SECONDARY FLIGHT CONTROL SYSTEM

Due to the size of the air vehicle and the importance of maintaining a high performance primary flight control system for operation by the pilot and augmentation, detail requirements for and evaluation of parameters such as friction freeplan, rigidity, dynamic response and stability have been maintained. Improved techniques for defining and evaluating these parameters are under constant development. In addition, the continued updating of the aerodynamics characteristics through flight testing requires considerable analysis of accelerated and speed stability forces, bobweight and damper characteristics and system response characteristics.

FLIGHT AUGMENTATION CONTROL SYSTEM

As definition of the air vehicle characteristics are achieved, an updating of the analysis must be conducted to insure good dynamic characteristics and stability margins, and modifications to the procurement specifications must be made. Along with the defining of system modifications requirements and evaluation, the detailed system component evaluation and malfunction effect must be conducted. Consideration of the effects of aeroelasticity or body bending will be included as they become accurately defined.

FLIGHT CONTROL SIMULATOR

The simulator effort will continue, evaluating new design, flying qualities studies and training. Sufficient operating time will be accumulated on the revised system components to insure adequate performance in flight. During flight test, the flight environment will be duplicated on the simulator to investigate in detail flight characteristics encountered by the pilot in flight and to practice techniques prior to flight. This will provide the pilot with familiarity of the flight regime which he is entering.

FLIGHT SIMULATION

The XB-70 flight control simulator cockpit will be completed with the addition of operational fuel and engine instruments and the air induction control system control panel. Display evaluation programs will be supported by installation of various experimental instruments. Development of specialized test equipment and test setups will continue and existing instrumentation will be maintained and up-dated as necessary. The Link developed landing display will be integrated with the simulator and optimized.

In the area of vehicle test equipment the portable computer facility will be completed and checked out. Personnel will be provided to support the preliminary tests conducted on ship numbers 1, 2 and 3.

An evaluation of the air induction control system panel using a cockpit simulator will be supported by development of experimental display hardware.

As required, computing equipment will be prepared, developed and improved for continuing pre-flight and post flight studies. Communication between computers and the flight control simulator will be considerable improved for faster response in supporting investigation of potential design problem areas.

Analog simulation of air vehicle motion and dynamic response will continue. The programs being run on the existing aeroelastic simulation of the B-70 will continue.

In addition, a complete three-dimensional simulation of the XB-70 throughout its entire flight regime is being prepared for integration with the flight simulator. The analog mechanization will include the 6 engines, the air induction control system with buzz, shock limit with start and unstart capabilities and the landing gear. Emphasis will be placed on landing studies prior to first flight. The simulation will also be employed for pilot familiarization and training as well as pilot evaluation and engineering studies. Similar studies will be carried on for all three ships.

Cancellation of the Hamilton Standard air induction control system and subsequent development of a replacement for this system with revised components have made it necessary to simulate portions of the automatic control loop which will be used in the later flight test phase. Analog studies will be made in conjunction with the development of this system. These will also be incorporated in the pilot training simulator.

Studies are continuing to completely define landing gear and air vehicle response on the following landing impact, and to determine the effectiveness of the braking system and its effect on taxi dynamics. The analog studies thus far have been with pure symmetrical landing but future studies may investigate the effects of the landing where lateral-directional motions are involved.

Among the various systems such as the hydraulic supply, fuel, and electrical generation systems, simulation efforts will continue as required as aids in correcting problems and improving performance in these areas.

In general, simulation activity will be geared to rapidly respond to potential problem areas.

SYSTEMS ANALYSIS

The majority of the non-flight test work to be performed by Systems Analysis during the remainder of the XB-70 program can be grouped into four basic categories:

(1) System performance verification analysis, (2) Subcontractor proposed specification deviation review, (3) Modifications to basic system requirement (BDM-9P), and (4) Cost reduction studies.

Continued analysis of the overall system is required to eliminate as many design problems as possible before actual flight test. This function has taken a high status of importance during the XB-70 program since the amount of flight test time and dollars is limited, and it is necessary that the system be in the "best shape possible" prior to testing.

Analytical review of subcontractor proposed specification deviations ensures that these changes will be compatible with XB-70 flight test goals, that these modifications are necessary from a performance and/or dollar savings point of view, and that the subcontractor justifications for the feasibility of such changes are correct.

The "basic system requirement effort" includes coordination of subsystem requirement modifications between the various design groups, checking the compatibility of those modifications with other subsystems in the aircraft and, documentation and distribution of BDM-9P.

In conjunction with the above mentioned funding and time limitation, Systems Analysis will continue to review the various XB-70 subsystems to insure that the system is not over-designed to meet flight test goals. Specific areas to be examined will include:

Bomb-Nav - Elimination of the Doppler calibration effort; study of possible techniques for using the lower quality G6 gyros in place of the expensive G8 gyros in the AN/ASQ-28 inertial system; and use of the high resolution data processor in the XB-70 without modification of the C121 processor configuration.

Mission & Traffic Control - Safety of flight analysis of the communication and navigation aid equipment; intelligibility analysis; TACAN effectiveness analysis; ILS failsafety analysis; updating of GCE parameters; and analysis of antenna requirements and effects upon M & TC performance.

Radar - Analysis of performance of C-121 radar equipment operated in XB-70 environments (velocity, altitude, etc.); application of C-121 flight test data to XB-70 A/V #3 radar requirements; radar range, resolution, contract, and operator recognition analysis.

RESEARCH AND DEVELOPMENT SUPPORT

In the aerodynamic testing area, support will be provided by the model shop personnel in parts construction and instrumentation. This effort involves both detail problem area investigation of the present XB-70 airframe as well as the aforementioned design changes. Servicing of these models while engaged in the actual testing phase will also be performed. Further, to properly support the planning, conducting and analysis of the various programs, test aid from specialists in Wind Tunnel engineering will be provided. These efforts will include model installations and check outs, force balance and pressure instrumentation calibrations, data reduction programs, and detailed Wind Tunnel test reports.

Phase II tests of the Thermal Simulator Program will be conducted in the environmental chamber. Maximum altitude and skin temperatures, corresponding with cruise conditions, will be used. Thermal characteristics and response will be determined, for both normal and emergency operation, with ECS hardware installed. This is the only test setup where the components will be integrated to perform as a system.

Laboratory tests will also be performed to determine design data and to demonstrate airworthiness. Included will be some thermal data tests on equipment, duct calibrations and tests to determine physical heat transfer properties.

The Numerical Analysis Group will continue to prepare such digital programs as are necessary for analog setup and checkout, design analysis and test data processing. Relative to Air Vehicle No. 3, store trojectory and general shape effects will be examined. Support of the pilot training effort through the use of both fixed and moving base simulation will be prepared on a continually updated foundation.

Programming and coding of analytical techniques needed to evaluate subcontractor proposed deviations, investigate subsystem performance and determine the effects of various cost reduction modifications will also be provided. Subsystems requiring

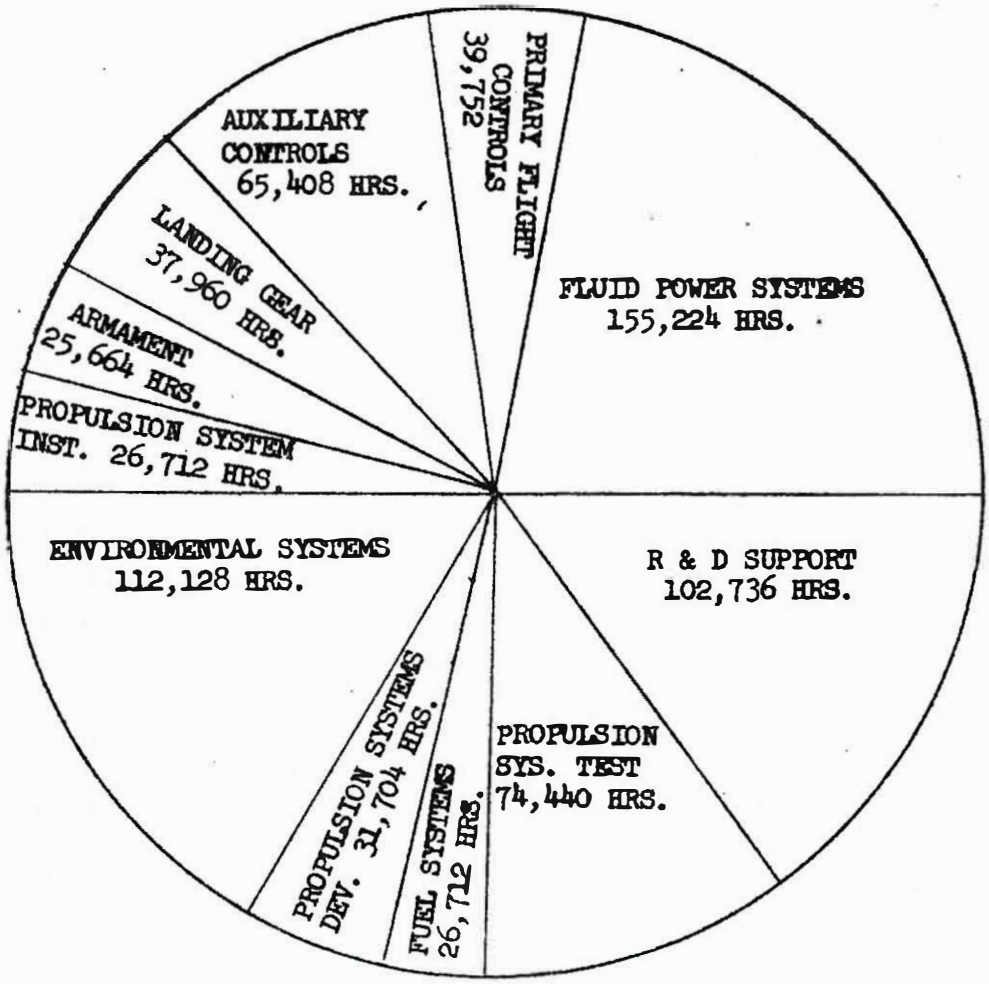
this support include (1) both the ACPS and AN/ASQ-28 inertial platforms, (2) Doppler radar system, (3) Stellar monitor system (4) Search and High Resolution radar systems, and (5) the integrated AN/ASQ-28 system.

The Life Sciences Group will provide a continuing effort in motion studies, verification time line analyses, and procedural techniques.

Flight control system support will encompass two general areas. The first will consist of high temperature tests of the hydraulic system on the flight control simulator including the inboard elevon actuators, the vertical actuators, and the FACS servos in all three axes. These tests are designed to define the stability characteristics of the primary flight control system at elevated temperatures. The second area will be airworthiness testing of the electronic package fabricated within the Flight Control Analysis Group.

DEPT. 182 - A. F. WEISSENBERGER, MANAGER
MECHANICAL & PROPULSION
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY 1962, THROUGH 30 JUNE 1964)

BREAKDOWN BY FUNCTION



TOTAL HOURS - 693,288

TOTAL DOLLARS - $6,983,500

MECHANICAL & PROPULSION ENGINEERING

Effort in Mechanical Systems will be concentrated in bringing the airworthiness test program to a successful conclusion, supplying manufacturing support for the remaining aircraft, designing and testing equipment for #3 air vehicle weapon system platform and possible design changes resulting from data obtained in flight test.

In-house coordination with other departments such as Flight Test and Manufacturing as well as other engineering groups is an ever continuing item. Air Force correspondence, contact and surveillance reporting will continue through the program.

FLUID POWER SYSTEMS

The remaining effort required to completion of the program is quite extensive in scope in that it requires analysis of test data derived from subcontractors, NAA test beds and Flight Test. System and component analysis will continue.

Air Vehicle #3 will involve new requirements with the addition of the armament platform hydraulic system, and the changes required to the normal and emergency environmental control systems. Changes to the air induction system will require additional effort.

Airworthiness testing of subsystems is continuing with effort by NAA required as problem areas arise. Close liaison with the subcontractors will continue until the completion of the program.

The effort expended on the systems analysis area will remain the same for the rest of the program.

Future work will include revisions to the second and third air vehicles as contracted. These will include Environmental Control System and Weapon System revisions and/or additions to the third airplane and other lesser system changes.

Additional effort will be required to support Manufacturing. Additional Fluid Power Systems personnel will be permanently transferred to Palmdale to support Fabrication of air vehicles #2 and #3.

NAA technical assistance will be provided to aid the subcontractors during design, manufacture, development and airworthiness testing. In addition to NAA resident representatives stationed at subcontractors to monitor the program, frequent visitations by cognizant NAA personnel will continue.

With procurement for air vehicle #1 complete, anticipated activity in this area until completion of the present XB-70 program will consist of continued surveillance of airworthiness testing, coordination of design changes and/or initiation of procurement for new equipment items resulting from system changes deemed necessary during flight test evaluation. Engineering effort for air vehicle #3 is dependent on finalization of subsystem configurations. However, some new procurement items will be generated with the possibility of new sources for these items being introduced.

CONTROL SYSTEMS GROUPS

The Controls Group will monitor the Flight Control Subsystem in air vehicle #1 and engineer whatever redesign is necessary to keep the control system within the requirements necessary for optimum flying qualities. This responsibility continues on into the flight testing of the air vehicle where additional flight controls data is obtained. During flight test the Controls Group will accomplish changes to the flight controls system as flight data shows that it is warranted.

AICS activity will be directed toward the completion of an operational subsystem using an NAA designed controller. This effort must be accomplished during the Phase II program because of the inability of the Controller supplier (Hamilton-Standard) to meet their commitments with respect to complying with the NA5 specification requirements and the delivery schedule. Toward this end it is anticipated that effort will be expended for analysis and preparation of specification data, design layout and detail (including equipment installation studies), supplier coordination, shop assistance, and the preparation of test procedures, coordination of tests, and preparation of data. Group effort will also include the design of an actuator

(gear box powered by a hydraulic motor) to operate weapons bay doors.

Tests started during Phase I program will be completed.

LANDING GEAR

It is known that certain areas exist in which we may expect modifications. Some of these areas are:

(a) Brake Control System - Experience has shown that in the operation much effort has always been required to integrate the brake and probe control system with the air vehicle. There is no possible way to do this other than actual taxi and flight test.

(b) Nose Wheel Steering - As in the case of brake control systems, the steering control must be integrated with the air vehicle. There is no test method which can be used to do this and it may be expected that there will be changes required.

(c) Tire and Wheel Problems - Here again, there is no method of testing to simulate actual air vehicle conditions. Dynamometer tests are at best an approximation.

(d) Shock Strut Problems - The XB-70 extension and retraction system is no doubt the most complex ever designed into an air vehicle. Seal effectivity in rotation and sliding and pressure bleed off are items for possible investigation.

(e) Indicating and sequencing problems due to structural deflections and other reasons.

(f) Drag Chute - This is another system where simulation of air vehicle characteristics is impossible and the operation will possible show up deficiencies which will require modifications.

(g) Lubrication problems in wheel bearings and other points. New type large diameter bearings and high speed, high temperature operation may become a problem area.

(h) Tire Hot Sensing and Cooling System - This system is a new system in which simulation was and is nonexistent due to austerity. While the system had been optimized through analysis it will be necessary to perform additional work to balance the system once it is in operation.

ARMAMENT

A power operated weapons bay rear door for the third XB-70 is in design and initial stages of release.

A weapon suspension system for the suspension and release of one type of weapon is to be provided for the rear weapons bay of the third XB-70 airplane only. The weapon suspension system for the third XB-70 is in the layout stages with drawing release to start in the latter part of 1962.

The Armament Group work remaining to the end of the XB-70 program consists of drawing release completion for the power operated door, the weapon suspension system and manufacturing support.

PROPULSION SYSTEM

The Propulsion Systems Installation Group will continue development of the engine compartment cooling control system to fulfill necessary specification requirements.

Systems or components which may require refinement during the flight test program are as follows:

(a) Engine compartment cooling air quantity and/or distribution may be shown inadequate requiring revisions to the distribution system.

(b) Thrust control system changes may become necessary to improve engine and inlet duct control system compatability.

(c) The supply of nitrogen may be inadequate if seal leakage becomes greater than anticipated.

(d) The long term endurance of the light weight construction heat shroud is an unknown quantity which may require design changes to improve life and reduce maintenance

(e) The Secondary Power Generating System installation may require extensive revision as further operating experience is gained. Performance of the mounting system components will be closely monitored for effective performance.

(f) Changes to the engine will be required, some of which may affect A/V compatibility and require engineering change effort.

The Fuel Systems Group will be required, for A/V #3, to accomplish redesign of the fuel tank inerting system installation, and to establish the fuel usage sequence for incorporation into the fuel management system.

The Propulsion Systems Test Group responsibilities include support of the AEDC 0.577 scale model tests to program completion including assisting in data analysis and preparation of the test report; conducting the propulsion system test stand program at Santa Susana including reducing and analyzing the test data; modifying the test plan based on test results and preparation of periodic reports; preparation and utilization of an IBM data reduction program for computor processing of air vehicle propulsion system data; analyzing air vehicle propulsion systems test results to determine systems performance and compliance with design objectives; and recommending for and/or coordinating system design changes resulting from test evaluation. Additional activities encompass preparation of periodic propulsion system progress reports; preparing and maintaining propulsion system process specification; monitoring design changes to assure that the testing programs provide desired system evaluation; and preparing and coordinating the propulsion system test plan for air vehicles #2 and #3 which includes instrumentation requirements and testing procedures. The group responsibility also includes coordination with the engine manufacturer of engine instrumentation and testing requirements and processing of the engine portion of the air vehicle data.

The Propulsion Systems Development Group will actively pursue the following systems from the viewpoint of analysis and coordination with suppliers as well as in-house.

This entails support analysis and evaluation of Propulsion Systems function and/or changes for integration and compatibility within each air vehicle.

ENGINE SUBSYSTEM

(a) Continue to be the focal point of all formal technical coordination of the YF93 engine between NAA, GE, and the Air Force.

(b) Perform analysis and evaluation of flight test experiences as related to engine instruments and engine control systems.

(c) Technical coordination with the secondary cooling air subsystem supplier. Also, in-house surveillance, analysis of data, analysis of changes and overall technical support for the integrated secondary cooling air system.

SECONDARY POWER SUBSYSTEM

(a) Continue to be the focal point of all technical coordination between NAA and Sundstrand.

(b) Coordination and analysis for integration of the third generator for A/V #3.

(c) Analytical support for integrated SPGS functional problems and any system changes resulting from flight test.

FIRE PROTECTION

(a) Continued surveillance of the sealing and drainage subsystems for each air vehicle.

(b) Analysis and evaluation for fire safety of flight test data on air vehicle compartment temperatures and pressures. Analysis of inadvertant flight experiences of hazardous potential.

(c) Re-evaluation and analysis of Fire Detection and Extinguisher Systems based on flight data.

ENVIRONMENT SYSTEMS

Completion of the airworthiness testing of 11 remaining components, not yet satisfactorily completed is required. Evaluation of tests made so far and certification to the Air Force will be completed. Design support of system changes considered necessary as a result of flight test finding will be accomplished as required to support the subsequent flight test program.

Certain design changes will be made on equipment to be used on air vehicle #2. Support of the Materiel Division in the procurement and testing programs will be necessary on these redesigned equipment items. Certification to the Air Force will be necessary. Support of Manufacturing during the construction phase is required and additional support as necessary because of flight test experience will be required.

An entirely new Environmental Control System is being designed for air vehicle #3. This design provides added capacity and includes changes in the heat sink, the distribution system, the number of compartments to be cooled and pressurized, and the number of crew members to be cooled. The design effort will be completed in the 1 September 1962 to 1 July 1964 period. Support of Materiel Division in selecting supplier sources, review of testing procedures and programs will be required.

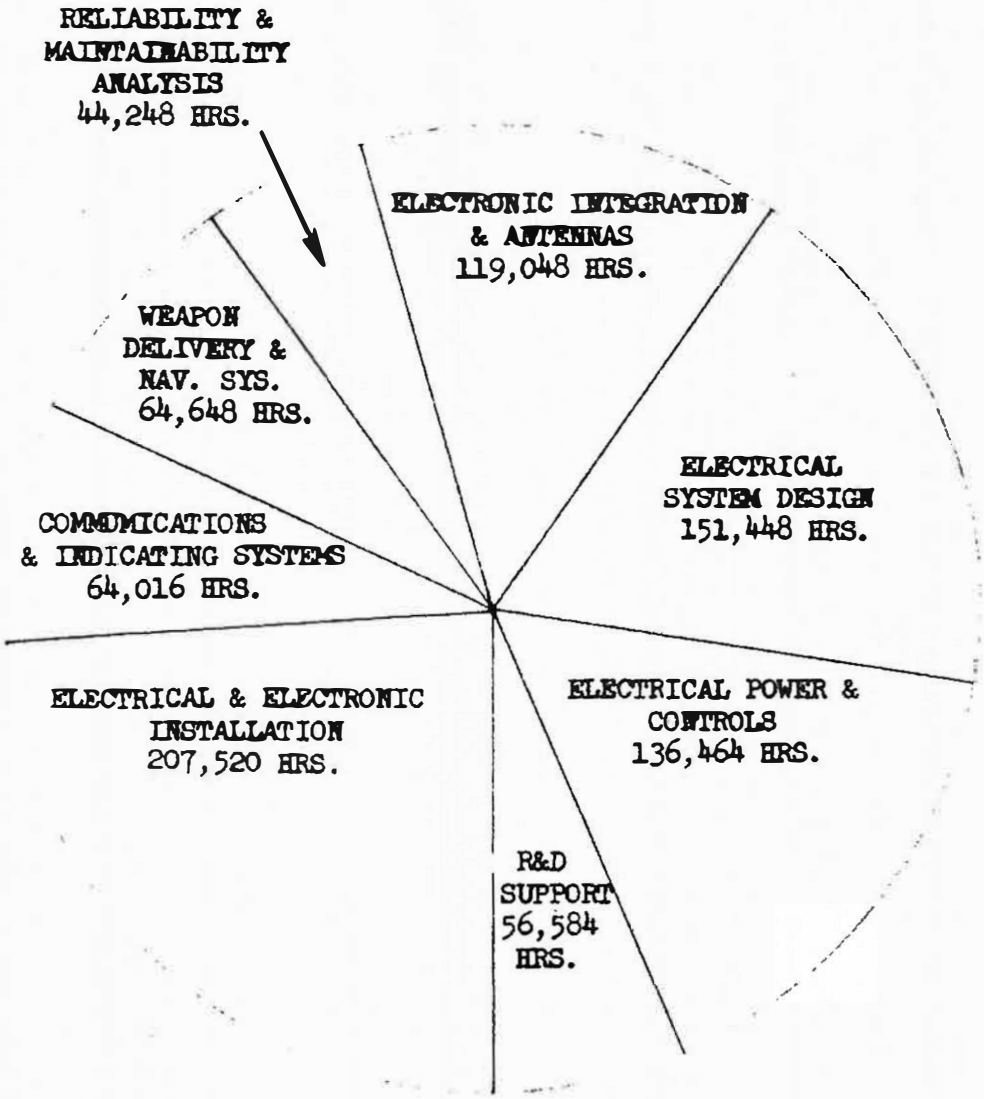
Support of Manufacturing in describing system process and checkout procedures and coordination of installation problems will be accomplished.

SUPPORT FROM R & D DIVISION

It will be necessary to utilize the support of the R & D Division in such areas as airworthiness testing of components and equipment items for all systems. Continued testing in this period will be necessary for new components associated with A/V #2 and #3, in the Environmental Control System, Fluid Power Systems, and Controls System.

DEPT. 183 - H. RAIKLEN, MANAGER
ELECTRICAL & ELECTRONIC ENGINEERING
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY 1962 THROUGH 30 JUNE 1964)

BREAKDOWN BY FUNCTION



TOTAL HOURS - 843,976

TOTAL DOLLARS - $8,416,000

ELECTRICAL & ELECTRONIC ENGINEERING

Following is a discussion of the areas to be covered by Electrical and Electronic Engineering during the remainder of the contract:

ELECTRICAL AND ELECTRONIC INSTALLATION

Continued Electrical and Electronic Installation manufacturing support for subject equipment will be provided at Palmdale for Vehicles 1, 2 and 3. New design, released on a modification basis, will proceed through basic release for Air Vehicle No. 3 to install the increased capabilities specified and will require approximately 550 new drawings, including 45 new installation drawings. Wire routing control will be implemented to comply with separation requirements of sensitive circuits. Major revision of circuit requirements and/or location of equipment and controls in the crew and equipment bays will require extensive layout for equipment rack design. Two additional crew stations will be provided. Shock mounting of a portion of B&N system equipment will be accomplished. Three IBM B/N units of control relays will be repackaged for equipment bay installation. Support by Research and Development for electrical and electronic equipment and processes, thermal and flight control simulators, and for the "SOCKD" tests for Air Vehicle No. 3 will be required. Electronic packaging for the AICS Manual and Automatic Systems, including printed circuit board design will be required. Additional conduits for electrical and electronic wiring will be required in the aft sections of the vehicle. Additional provisions for Flight Test Instrumentation wiring will be designed into Air Vehicle No. 3. Provisions for an additional 60 KVA generator and controls will be provided. Analysis of exterior lighting performance as compared to design parameters will be performed. Analysis of maintainability and serviceability will be conducted on Air Vehicle No. 3 design.

ELECTRICAL SYSTEM DESIGN

The electrical system and circuit design for Air Vehicle No. 2 will require a minimum of redesign. However, as in all projects, certain refinements, improvements, and revisions will be incorporated as new requirements are established. These changes will include both contractor and Air Force changes, which will be made as increased knowledge of the XB-70 is gained as the Mach 3 performance regime is penetrated and better understood. Maintenance of Air Vehicle No. 1 will continue as required to support the program.

Existing Air Vehicle No. 1 electrical diagrams, elementaries, etc., will be utilized for Air Vehicle No. 2 and for Air Vehicle No. 3 in all areas where practical. However, extensive redesign of the electric system and circuits of Air Vehicle No. 3 will be required due to the relocation of equipment and increased power requirements for the IBM Bombing and Navigation System. The increase in power necessitates the addition of a third primary electric generator together with its integration into the electric power and protective systems. This major change to the electric generating system will require close surveillance of the system subcontractor to assure compatibility with the air vehicle requirements.

In addition to the B&N subsystem, the new increased capacity environmental subsystem required for the increased electric loads on Air Vehicle No. 3 will require extensive circuit redesign. Equipment relocation will affect wire lengths, voltage drop, wire gauge, and radio noise and stray signal coupling problems that will require review of all circuit parameters.

The Automatically Processed Wire List will be revised and released approximately 75 times. The total wire will increase by approximately 13,000 segments (an increase of approximately 20 miles). It is considered expedient to issue and maintain separate and distinct APWL lists for each aircraft. This will permit rapid updating to represent each air vehicle without the confusion of

coding and will permit identification of each aircraft configuration at any time.

In support of manufacturing, the APWL will automatically print individual wire tags for use in the fabrication of wire segments. This completely eliminates the manual preparation of such tags by manufacturing departments. The automatic wire ticket program will become effective on fabrication of Air Vehicles Nos. 2 and 3.

ELECTRICAL POWER & CONTROLS

Work effort that will be accomplished by the EPC Group during the period noted, on the XB-70 program, can be divided into several distinct categories. Each category including a brief discussion of the specific effort involved therein is listed below:

Development, testing, and certification for components peculiar to Air Vehicles 2 and 3. This includes extensive supplier, laboratory, and manufacturing coordination and direction. Specific problems encountered during the development and airworthiness testing phase will require timely solutions, (equipment in this category includes connectors, relays, shock mounts, switches, terminations, etc.)

Considerable manufacturing support will be required during fabrication of Air Vehicles 2 and 3. This includes engineering support for the manufacture of NAA designed motors and solenoids, the preparation and implementation of additional process specifications required for Air Vehicle No. 3, and the necessary maintenance, revision, and implementation of all existing XB-70 electrical system process specifications.

Coordination for the procurement of additional component and hardware items required as the result of EWA changes will be supplied.

Continuing effort will be required in the field of failure analysis and reliability with regard to electrical components and hardware. Failures or problems that are encountered during operation will be carefully analyzed. Effort will be applied to determine changes that can be effected that will improve reliability and/or eliminate problem areas.

During the period noted programed laboratory tests such as Socko 3 will be conducted. Extensive coordination will be effected to ensure compatibility between utilization equipment and the Air Vehicle EPGS.

Extensive Air Force/Contractor coordination will be effected with respect to the Air Vehicle Power Generation, Distribution and Lighting Subsystem.

Continued support for AGE will be required to resolve items peculiar to Air Vehicles 2 and 3.

M & TC SUBSYSTEM

The effort during this period will be, essentially, a continuation of the air vehicles No. 1 and No. 2 design maintenance and support effort. Air Vehicle No. 3 will require design modification and system checkout (SOCKO). Finally, design support will be required for all three vehicles for the balance of the program.

Design modification of Air Vehicle No. 3 is occasioned by the addition of two crew stations and the relocation of system components. System installation and wiring changes are required. The intercommunication function is expanded; potential noise problems must be recognized and circumvented. Relocation of equipment requires mechanical and electrical compatibility analysis. The system operational checkout (SOCKO Lab) will provide early recognition and problem resolution.

Design support of Air Vehicles Nos. 1, 2 and 3 will require surveillance of manufacturing, airborne operations and ground maintenance. Both installation

and operation problems will arise; they must be recognized, analyzed and resolved. Engineering changes will be made; drawings will be made, changed and released. Process specifications will be coordinated, changed and released. Changes to operational and ground maintenance documents will be coordinated. Air Force coordination will be maintained to completion of the program.

INDICATING SYSTEMS

During this period, system performance on the Auxiliary Gyro Platform Subsystem, Central Air Data Subsystem, Flight Director Computer, Associated Flight Instruments and Accessory Systems and Displays will continue to be analyzed and reports written. Design information will be up dated from results obtained. Air Force coordination will continue and all design documents will be up dated. Coordination with subsystem suppliers will continue, and subsystem modifications accomplished based on airworthiness test results. Engineering changes necessary for No. 3 air vehicle will be released, and design layouts, installation drawings and detail drawings applicable to all three air vehicles will be up dated. Process specifications will be coordinated and up dated as required. System operation and checkout will be accomplished to assure operation in No. 3 air vehicle. Throughout the duration of the program, close engineering coordination will be continued to expedite solutions to installation, test or ground support problems. IBM 7090 wiring lists applicable to No. 3 air vehicle will be processed and released.

Technical assistance will be provided during the accomplishment of magnetic compass calibration, comprehensive tests to establish the effect of extraneous magnetic fields, airspeed calibration and modification of Central Air Data Computer cams, etc. Technical assistance will be provided for up dating of all procedures, test reports, ground support data, handbooks, parts lists, etc.

WEAPON DELIVERY AND NAVIGATION SYSTEMS

Program/Specifications

The specification effort will be related to: (1) changes to NA5-72076 bomb-navs procurement specification and NA-61-601 XB-70 Air Vehicle No. 3 model specification resulting from laboratory and flight test results; and (2) bomb-navs process specifications for alignment, checkout and installation.

The program effort will involve establishment of a statement of work, review of technical progress and test reports and monitoring of PERT networks.

Bomb-Navs Installation Design

Known problem areas and those not yet defined will be resolved. Engineering drawings will be released and maintained to provide requirements for equipment installation, wire routing, wave-guide routing and supporting details. The installation and wiring requirements will be coordinated with NAA Manufacturing and incorporated in the air vehicle.

Technical Design Control

Effort related to design review, analysis and technical coordination will continue. Laboratory testing for R-F interference control will be accomplished including: formation of a test plan (testing techniques, parameters to be measured, test tolerances, instrumentation), participation in the tests, maintenance of the system, data reduction and evaluation, test reports and resulting effort related to design changes if required (engineering orders, modification wiring diagrams, coordination of fixes, etc.) Technical support will be provided for the C-121 flight test and AN/ASQ-28 bomb-navs acceptance test at IBM.

Air Induction Control System

The development of the buzz control computer will continue with the fabrication and test of the airworthiness test model plus the design development and test of the logic and control function which integrate the entire AICS to provide automatic system operation. This program will consist of system definition, logic design, circuit design, breadboard test, and development and airworthiness tests.

RELIABILITY & MAINTAINABILITY

Future reliability efforts will be included under two main categories. These are: 1) continued reliability analyses of the XB-70 subsystems, components and AGE, and 2) the implementation of the Success and Failure Data program.

Reliability analyses will be done utilizing a total of 123 failure mode analyses which are to be completed by the various design groups. As these failure mode analyses are received, a detailed reliability study will be made and presented in the form of a reliability description of the subsystem, block diagrams and mathematical models. The final results will be written up in report form (15 pages average) and submitted to the responsible design group for review and inclusion in the Design Information Manual.

Corresponding to these reliability analyses of the subsystems will be special analytical studies of various, components and structures. In addition, new methods of predicting reliability through the use of the IBM computer are being developed for use in the XB-70 Program.

Implementing the Success and Failure Data Program will require: 1) the continuous surveillance of the use of the forms and procedures that have been developed for this program, and 2) the processing, storing, analyzing and dissemination of the data received from the reporting agencies. The two forms that the Reliability Group will process and store under this program are the Failure and Usage Data Report (FUDR) and the Historical Test Record (HRT).

Future plans for the maintainability program will include special studies using the IBM computer as an aid in developing techniques for predicting maintenance requirements relative to scheduled flight hours for the XB-70 program. During the forthcoming months, these analyses will be modified as required to keep pace with design changes. In addition to these studies, three status reports will be written.

ELECTRONIC INTEGRATION & ANTENNAS

Electronic Integration effort will consist mainly of the preparation for and the conducting of a SOCKO program for the systems in Air Vehicle No. 3. The actual testing portion of SOCKO will be conducted during the period of October 1963 through approximately May 1964. Preparation consists of the design of the necessary air vehicle simulated racks and wiring harnesses and detail analysis of the test equipment and facilities requirements.

Subsystem interfaces, for those systems new or revised in Air Vehicle No. 3 will be conducted and necessary engineering design changes implemented.

An electro-interference analysis similar to that for Air Vehicle No. 1 will be required for Air Vehicle No. 3 due to the addition of the B/N system and the relocation of equipment. This analysis will cover the same types of interference control and will utilize much of the data gathered for Air Vehicle No. 1. The analysis for Air Vehicle No. 3 will be more complex due to the B/N system which is virtually an interference generator due to program redirection and restrictions.

The antenna and radome effort will include the design, release and installation of the antennas, radomes and necessary supporting RF systems components. Most antennas will be used as presently designed for Air Vehicles Nos. 1 and 2. The Glide Slope/Localizer antenna, however, will require redesign due to the influence of the RSE antenna installation.

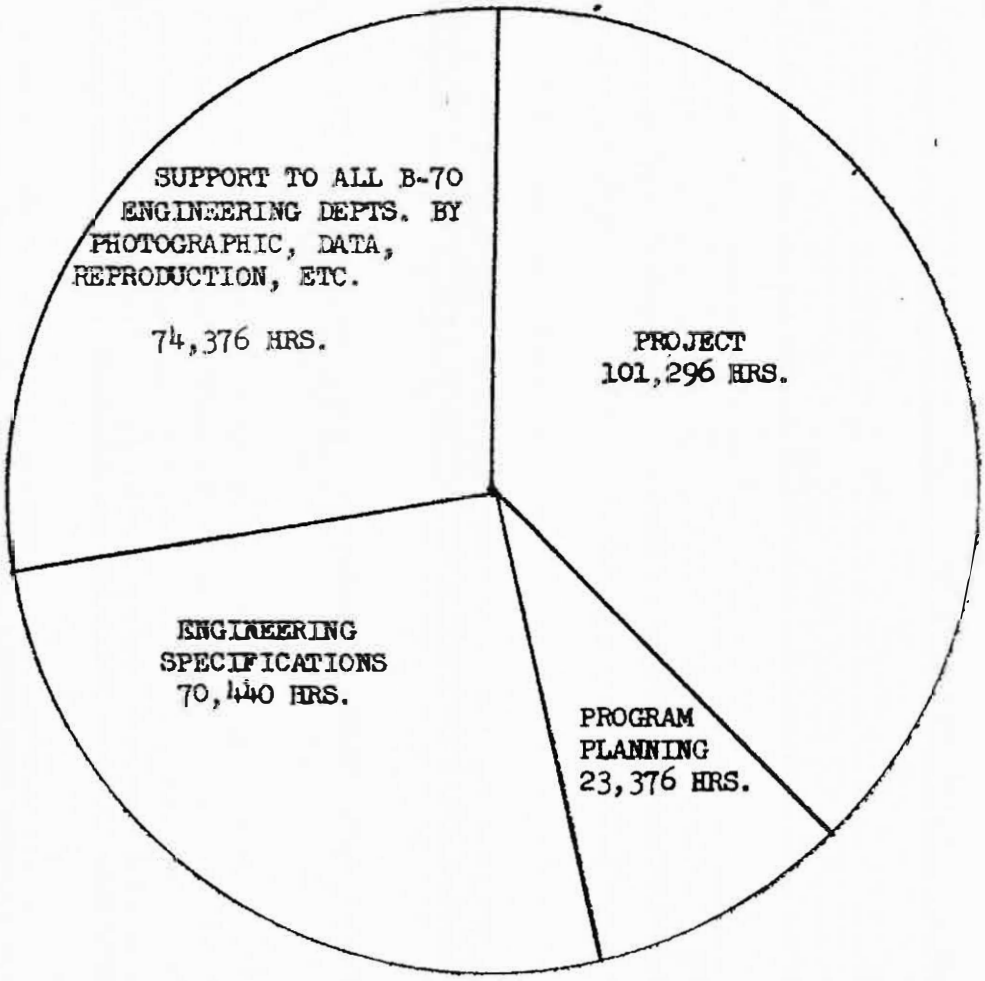
The radome program includes the finalization of the performance calculations (on the 7090 computer) for the DRER and RSER and the analysis of cavity effects on the RSE performance. The major effort will be the completion of the far field test program for the DRER and subsequent correction. This will include setting up the range and the fabrication of mock-up cavity and test fixtures.

Heat rejection data for all Air Vehicle No. 3 installed equipment utilizing electrical power will be collected, reduced to useable form, analyzed and tabulated for use in establishing the requirements and distribution of the environmental control system.

Electro-data Verification of each issue of the automatically processed wire list will be conducted to determine that the designers' electrical circuitry language has been accurately translated into the IBM 7090 produced APWL print-out.

DEPT. 184 - D. B. ROGERSON
CHIEF PROJECT ENGINEER
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY 1962, THROUGH 30 JUNE 1964)

BREAKDOWN BY FUNCTION



TOTAL HOURS - 269,488

TOTAL DOLLARS - $2,686,000

CHIEF PROJECT ENGINEER'S OFFICE

The CPEO is divided into three Project Offices:

Project Administration

Air Vehicle

Electronic Subsystem

PROJECT ADMINISTRATION

The Specifications Group, operating under the cognizance of the Project Administrator, writes and maintains up-to-date approximately 425 specifications.

These specifications are divided into the following categories:

Model Specifications - Contractual instrument describing the air vehicle.

Pre-Flight Specifications - Contractual instrument describing the pre-flight operations and procedures.

Flight Test Specifications - Contractual instrument describing the flight test program.

Flight Test Instrumentation Specifications - Contractual instrument describing instrumentation requirements.

Procurement Specifications - Instrument for procurement of air vehicle and Aero-Ground Equipment subsystems and components.

Process Specifications - Instrument for the checking out of systems and equipment and the description of processes for fabrication.

Associated with the actual writing is the effort required for determination of policy relative to contractual requirements with the Customer and Subcontractors. Personnel are furnished to maintain liaison among the various Subcontractors, Engineering design groups and Materials Division.

It is imperative that an efficient change control system is maintained on all specifications.

In addition to specifications and data requirements, the Specifications Group prepares and maintains the following reports:

Airworthiness Testing Status

Specification Change Notice Status

Master Equipment List

Make or Buy List

Mandatory Inspection and Removal List

Airworthiness Certification List

During the ensuing two-year period, the Engineering Planning organization will make and maintain estimates of required expenditures, budgets, and schedules to insure that the airplanes are built on schedule and within budgetary limitations. A complete surveillance of the entire program is under way at all times with this purpose in mind.

AIR VEHICLE AND ELECTRONIC SUBSYSTEMS

These project offices report to the Chief Project Engineer. In the case of the air vehicle, Assistant Project Engineers are assigned in the areas of the Airframe, Airframe Subsystems, and FTGSE and Training Equipment; and Weapon Delivery and Navigation Subsystems and Command and Control Subsystems in the case of the Electronic Subsystems Project Office. The Assistant Project Engineers with their staff of Design Specialists and/or Senior Staff Engineers conduct the operations of the CPEO under the direction of the Project Engineers heading each respective office. The program is managed and monitored through the CPEO activities which are briefly described as follows:

The Project Engineer's Office directs the development of the systems through the issuance of the basic plans-of-action and direct coordination of the basic requirements established by the Air Force through the media of the Contract and the Model Specifications. This area includes monitoring of design and development schedules, test programs, and resultant data review and status reporting to both NAA Management and to the Air Force. The CPEO personnel conduct the necessary coordination with subcontractors and major system and component suppliers insofar as technical and program requirements are concerned to assure that the design sections, manufacturing, purchasing, etc., are programed in phase and in concept with the overall program schedules and objectives. Programs are monitored via technical data, man-hour allocations, PERT networks, subcontractor and Air Force correspondence and via direct contact in scheduled review meetings.

The Project Engineer's Offices are also the agency responsible for issuing the Engineering authorizations to perform all program effort through appropriate documentation, both formal Contract documents with the Air Force and NAA internal documents. Formal documents are all contract data items which consist of specifications, engineering status reports, test results, analyses, etc., and pass through the CPEO for review and subsequent transmittal to the Air Force. NAA internal documents issued by the CPEO authorizing the Manufacturing, Purchasing, and Supporting divisions to perform contract effort are Engineering Orders, Test Authorizations, Material Procurement items (25R, E.O.'s, etc.) and Engineering Work Authorizations.

The CPEO, in addition to the above activities, participates with the Contracts and Pricing departments in the preparation of all proposal data concerned with the XB-70 whether it be major in nature such as a formal Contract proposal, work statement, etc., or a minor change proposal.

The Engineering portion of status reports and briefings for both NAA and Air Force Management is prepared by the CPEO and presented as requirements occur.

The on-site (Palmdale and Edwards AFB) Project offices also report to the CPEO and provide direct technical engineering support to the manufacturing operations such as MRD action, and will provide the same direct support to the Flight Test Operations. These activities supply the quick reaction in terms of engineering effort to maintain program progress and technical integrity.

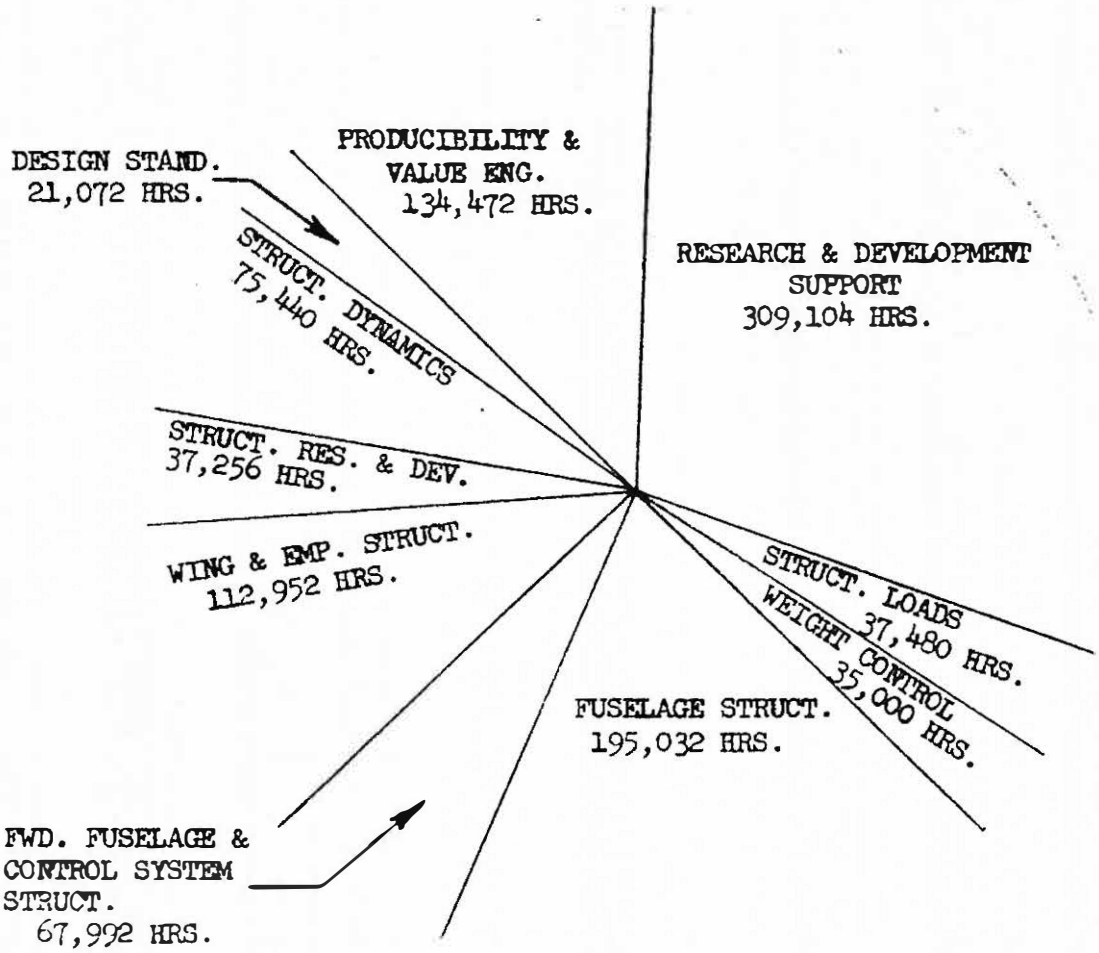
In summary, the CPEO, in authorizing both Engineering, Manufacturing and Purchasing efforts, is responsible for implementing a program which reflects the B-70 Division Managements policies and Air Force requirements. In carrying out this program, the CPEO continually monitors the program to assure that the optimum trade-offs between funds allocations, schedules, subsystem performance and overall B-70 system performance are made.

SUPPORT FROM OTHER DEPARTMENTS

Support for all B-70 Engineering Departments from Photographic, Data Group, or Reproduction Services is charged entirely to CPEO inasmuch as it is not considered feasible to split out the budget by Engineering Departments.

DEPT. 185 - R. L. SCHLEICHER, MANAGER
STRUCTURES ENGINEERING
REMAINING COSTS TO COMPLETION
FIRM CONTRACT AF33(600)-42058
(31 JULY 1962 THROUGH 30 JUNE 1964)

BREAKDOWN BY FUNCTION



TOTAL HOURS - 1,025,800

TOTAL DOLLARS - $10,745,200

STRUCTURES ENGINEERING

Effort to be carried by Structures Engineering forward during the remainder of the contract can be divided into six major areas as shown below:

STRUCTURES SECTION

The activities of the Structures Section will be concentrated for the most part in the calculation of internal loads to be used as a basis for the establishment of the strength envelope for all three XB-70 aircraft, and the preparation of structural analysis reports.

It will also be necessary to strength check any design modifications on Ships No. 2 and No. 3, and to program structural tests to evaluate design modification not covered by previous tests. The planning phase of the proof test program has been completed, and the majority of the test procedures have been approved.

There will be little further support necessary until the proof tests are performed. During proof test continuous consultation with the Structural Laboratory personnel will be necessary and all instrumentation results will be carefully evaluated and compared with analysis computations.

The Material Review support required will continue during the fabrication and assembly of all three aircraft and will remain at an average level of approximately 35% of total time spent for the next year, gradually tapering off over the remainder of the program. The remainder of support activities will be expended in continuing the review of material substitution requests, acting in a consultant capacity on Quality Control procedures, and specifying strain gage installations for residual stress measurement.

R & D Laboratory support will be required for proof testing of the No. 1 airplane and in limited specimen testing still to be conducted.

STRUCTURAL RESEARCH AND DEVELOPMENT

While structural research and development effort necessary for the program to date has been accomplished to the degree required for the integrity of aerodynamic prototype operations, considerable refinement of the data and techniques so far established is necessary for maximum structural efficiency and minimum cost in relation to the second and third air vehicles. For example, continued research into the problems of welded joints and residual stresses will greatly facilitate assembly of these air vehicles and will reduce the number of necessary repairs and their associated costs and schedule delays. It is also to be expected that improved or refined materials, fasteners, and processes will be continually forthcoming, and it will be necessary to evaluate their structural characteristics before they can be utilized. As manufacturing processes are refined, it will be necessary to monitor quality acceptance standards in a similar fashion. It is expected that, as processes improve and further data are acquired, the standards of acceptance can be relaxed without impairing structural integrity. Similarly, significant benefit will be achieved in both cost and schedules by continuing to develop more efficient or more refined repair concepts and techniques. During the flight test program, correlation of measured and calculated loads will require influence coefficient refinement for aerothmoelastic calculations. In addition, it may be assumed that minor alternations to the structural details of the airframe will be found necessary from time to time as structural stability and performance data are returned from the flight program. Many of the changes, although minor in scope, will also require a re-examination of the load distributions and influence coefficients. Finally, extension of the research into acoustic fatigue behavior and crack propagation will point the way to improved techniques for predicting and forestalling fatigue problems and repairs in the flight program.

STRUCTURAL DYNAMICS

Flutter analysis, symmetric and antisymmetric, for subsonic, transonic and supersonic Mach numbers using current stiffness and weight distribution will be completed for the XB-70 No. 1 air vehicle. Similar analyses will be undertaken for Ships No. 2 and 3 to account for the differences in stiffness and mass distributions between the various air vehicles. Reports of analyses are to be written and published for the Air Force.

Correlation of wind tunnel flutter model results with analyses for the model tests completed and the tests remaining are to be done and reported to the Air Force.

A flight flutter testing program is to be performed to verify the flutter safety of the airplane. The measurement system is being installed in the No. 1 air vehicle and the analyzing system to handle the measured data will be completed and ready for both the flutter data and vibration data from tests under consideration for Ship No. 2 and 3.

Ground vibration surveys are to be conducted before first flight. The air support system, data acquisition system and multiple shaker system will be carefully tested separately and as a complete system before actual test. Reporting of results from both ground and flight tests are required by the Air Force.

Vibration and acoustic analysis and test of subsystem components still to be delivered must be continued to insure their safe operation in the air vehicle environment.

Several wind tunnel flutter models must be completed and tested. These will require the continued support of model design and wind tunnel operation groups.

WEIGHT CONTROL

The weight effort remaining will actually determine the weight of components, systems and the air vehicle itself. These results will serve two purposes. First to satisfy the contractual obligations for weight and balance information on air

vehicles No. 1, 2 and 3. Secondly, these results will serve as a base from which to project more advanced and lighter weight configurations. The majority of the systems components on air vehicle No. 1 have yet to be weighed and approximately 10% of structural components have not yet been weighed.

The weight and balance reports for Ships 1, 2 and 3 are required.

Weight accounting, studies and reporting will still be required for Ships 2 and 3. Ship 3 will require an additional inertia report. Fuel calibration will be required on Ship No. 1. Design weight studies will continue to be required, including those studies which invariably result from flight test.

STRUCTURAL LOADS

Structural design loads for the XB-70 will be presented in reports to be published in the near future. These reports will include methods of calculation, ground loads, airplane response to various flight maneuvers and gusts, and structural loads on the various components of the airframe. The information in the reports will be based upon estimated weight data, preliminary aerodynamic data, and structural influence coefficients determined from a preliminary sizing of the structural members.

The structural design loads as published in the above reports do not reflect the recent changes to aerodynamic data, structural influence coefficients, and weight configurations. Further changes are expected throughout the life of the contract. Any special devices such as changes in control system characteristics, aerodynamic configuration, etc, which may be added to improve flying qualities will need to be evaluated for their effects on operating restrictions. It is a contractual requirement that when modifications are made which affect the structural limitations, the Strength Summary and Operating Restrictions Report (Group V) must be revised. This requires additional structural loads analysis to furnish the data required for the determination of the revised flight limits.

Structural operating limits will be determined throughout the length of the contract in compliance with Type I contractual requirements. Operating restrictions will be required for all three XB-70 air vehicles since each air vehicle will be different in structure, instrumentation, equipment and ballast requirements. Each air vehicle will have several sets of operating restrictions which will reflect the significant effects of different fuel loadings and fuel sequencing, addition or deletion of special instrumentation, and changes in location or amount of ballast to achieve a certain C.G.

PRODUCIBILITY & VALUE ENGINEERING SECTION

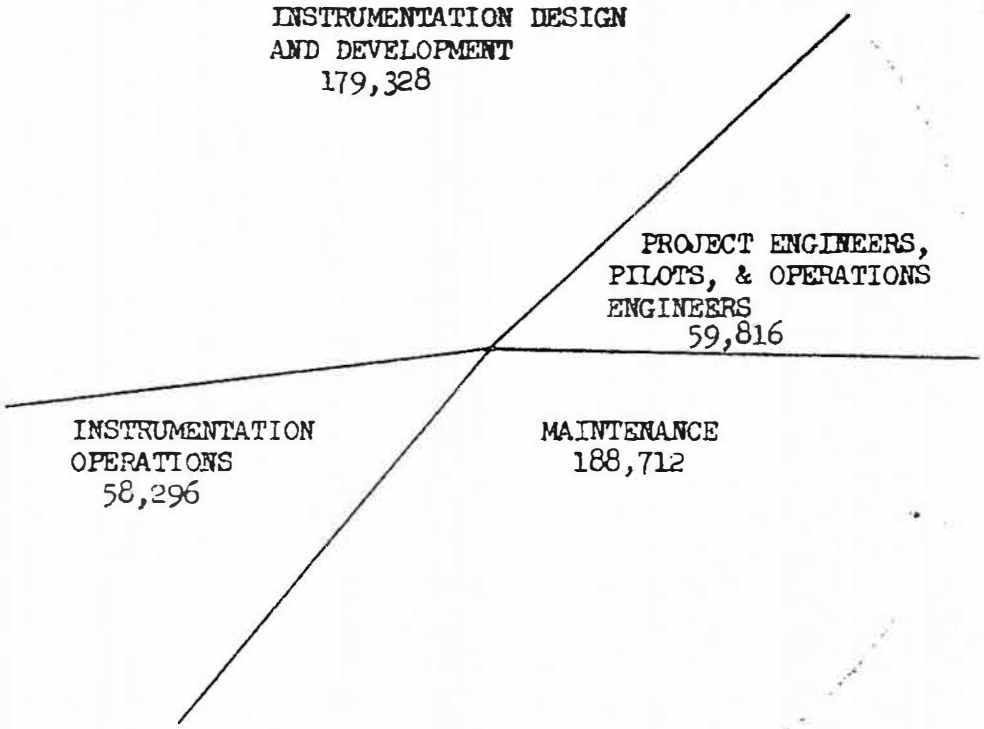
In the materials and fabrication area, a comprehensive evaluation of 18 Ni Maraging steel has just been started. It is believed that use of this steel will avoid many of the problems associated with H-11 steel. Continuing effort will be directed toward improved materials and techniques for corrosion protection, air vehicle sealing, and brazing processes. Intensive effort will be applied to electron beam welding and on improved techniques and their application for weld stress relief. Design support will be provided to complete ship #1 and as required by changes to or additional requirements for ships 2 and 3, including repairs, redesign and new techniques to save weight and simplify construction. Future effort is anticipated in the further refinement of existing standard hardware and on additional electrical and electronic components for ship #3, with its augmented electronic systems. The program of monitoring hydraulic fluid contamination will be continued, with emphasis shifting from component and system testing to the preflight and flight operation of ship #1. Value Engineering effort will be directed toward the search for new products and methods which will reduce program costs; for example, new types of honeycomb core and better core-to-face-sheet matching techniques. In addition, design engineers will be provided with cost analyses on discrepant parts, as to whether it is cheaper to repair or remake. Value analyses will be made of all reported cost reduction suggestions, to determine net savings and to provide final recommendations. Personnel

of the unit will participate in the training of designers and middle management personnel in the techniques of Value Engineering.

Direct assistance to Manufacturing will continue through the completion of ship #1 by on-the-spot assignment of engineers in the areas of welding, brazing, tube joining, and sealing. Similar support is planned for ships #2 and #3, at a reduced level. Assistance will be provided during the final painting and marking of all three air vehicles and in the fabrication of the quartz fabric-silicone resin laminate radome for ship #3. As Material Review Dispositions decrease on ship #1, the effort on ship #2 details is building up, and this activity will be continued until manufacturing is complete on all three air vehicles. Assistance to sub-contract manufacturers and to suppliers of individual parts and components will be maintained.

To the extent that materials and process development continues (e.g.: maraging steel and sealing techniques) laboratory testing will be required. The new or revised standard hardware items (mechanical and electrical) will also require laboratory evaluation and test. In general, a rather low level of activity is anticipated for the remainder of the contract.

DEPT. 186 - G. R. MELLINGER, MANAGER
FLIGHT TEST
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY 1962 THROUGH 30 JUNE 1964)



TOTAL HOURS - 486,152

TOTAL DOLLARS - $4,745,200

FLIGHT TEST ENGINEERING

The Flight Test Engineering Group will Prepare preflight test schedules for air vehicle No. 2 and No. 3 and will direct, coordinate and control the preflight ground test programs.

Detail operational procedures will be established for air vehicle ground operation and in-flight control (normal and emergency), crew briefings and de-briefings, airborne data recovery and transport, on-site Engineering Design Groups, Subcontractors, and Air Force coordination, and for F.A.A. and F.C.C. air space control. Operational procedures will be written for the scheduling of test ranges, telemetering, space position plotting, photo-grid and support air vehicles.

A Data Reduction procedure is being formulated that covers the handling of the airborne and telemetered raw data from the time it leaves the air vehicle to the finished data to be utilized by the Engineering Design and Technical Groups. Coordination with these groups will be accomplished in order to define the parameters required, mode of presentation (plots, tables, tapes) and detail data reading instructions.

A procedure will be established to gather the technical results from the flight test program including data, analysis and crew comments.

Coordination effort will be expended to ensure that (1) the flight handbook operating instructions involving pilot technique and A/V flight characteristics are adequate, (2) flight limitations and instrument markings are complete and accurate, and (3) updating of the handbook information is accomplished on a timely basis.

Effort is required to monitor schedules on CFE-FTGSE and assist in programing fit, form and function checks on a timely basis. GFP-FTGSE shipments will be monitored to assist in refurbishing the equipment to a usable condition. A/V configuration changes must be monitored to provide timely retrofit of the FTGSE.

Engineering test pilots will be used in the remainder of the XB-70 program in the following manner:

(1) Test pilots will continue with their efforts in support of the design groups, in simulator flying, in preparation of Flight Handbooks, check lists and process specifications, in proficiency flying and formal ground schooling.

(2) They will coordinate pre-flight check-out procedures with Flight Test Maintenance in order to eliminate duplication of effort in preflighting the airplane.

(3) They will participate in engine run-up tests during the preflight program to become thoroughly familiar with preflight, engine start and ground operating procedures prior to first flight.

(4) They will conduct taxi tests to determine ground handling qualities of the aircraft, efficiency of brake, steering, and drag chute systems, and to become familiar with 6 engine maximum afterburner operation.

The Instrumentation package for A/V #1 is to be tested in the altitude chamber, shipped to Palmdale and undergo operational testing until it is installed in the vehicle.

The Design Group will complete the remaining 190 drawings and 350 E.O.'s to instrument #2 and #3 A/V. Other drawings will be maintained and design changes made as required by the program progresses.

An automatic checkout system will be assembled from purchased components, installed in trailers and tested before shipment to E.A.F.B.

In order to provide instrumentation packages for #2 and #3 A/V's, 250 additional modules and 1800 more circuit cards will be fabricated.

The packages will be assembled, wired, tested and shipped to E.A.F.B.

Strain gages will be installed on all A/V/'s and calibration of all equipment will continue.

Pre-flight checkout tests will be performed on all A/V's and the Instrumentation System will be maintained, modified and repaired as necessary.

About 500 more purchase requests will be processed to complete the system and evaluation of new and improved equipment will continue.

IBM Programs will be written to instruct the ground readout station as to how to calibrate, edit, and plot the data.

The Maintenance and Support Section of Flight Test will provide personnel to assist in the structural load tests and the vibration and flutter tests on air vehicle No. 1. Flight Test will conduct the various other ground tests on all air vehicles and their subsystems to verify satisfactory system operation and will include all tests requiring fuel in the air vehicle, engine operations and taxi tests. Effort will be expended to install such engineering modifications as required to ensure satisfactory subsystem performance.

Prior to first flight the Maintenance and Support Section of Flight Test will continue to expend effort in planning for the implementation of the flight test program. Expediter personnel will be provided to furnish the Research and Development Laboratories, Engineering Project and Design Groups, Instrumentation Group and Proof Load Group with all materials, parts, tools, etc., required for in-house testing of B-70 components. This work consists of preparing orders, hand-carrying paperwork and parts, trips to vendor facilities, handcarrying test parts from Manufacturing to Lab, etc.

Coordination will be provided for the establishment and occupancy of facilities and setting up of radio, TWX, and telephone communications at EAFB and Palmdale. Review of operational methods, personnel requirements, procedures, Process Specifications, GSE and severable equipment requirements will be continued. Inspection and Maintenance sign-off sheets required for the flight test program are also being prepared, such as preflight, postflight, installations, etc.

Flight Test will continue to receive at the test site the initial lay-in of air vehicle and engine spares as well as those bits and pieces required to support FTGSE. During the preflight operations at Palmdale the aircraft will be supported by the LSS at Edwards AFB. The power plant test stand at Santa Susana will also be supported by the LSS as long as the test stand remains active. The Flight Survival and Equipment Group is assisting Human Factors in procuring and developing the B-70 flight equipment. Flight Test is providing scheduled air transportation between Los Angeles and Palmdale as required to support the B-70 program.

GFP-FTGSE is being received by Flight Test at EAFB and assembled, inspected, repaired, calibrated and records established for control. Additional FTGSE will be obtained at the time of receival of the air vehicle; this will include some Manufacturing equipment. During the preflight ground tests the FTGSE will be checked with the air vehicle for fit and function and modifications will be made as necessary. The equipment will be maintained to provide adequate availability of equipment to support the program.

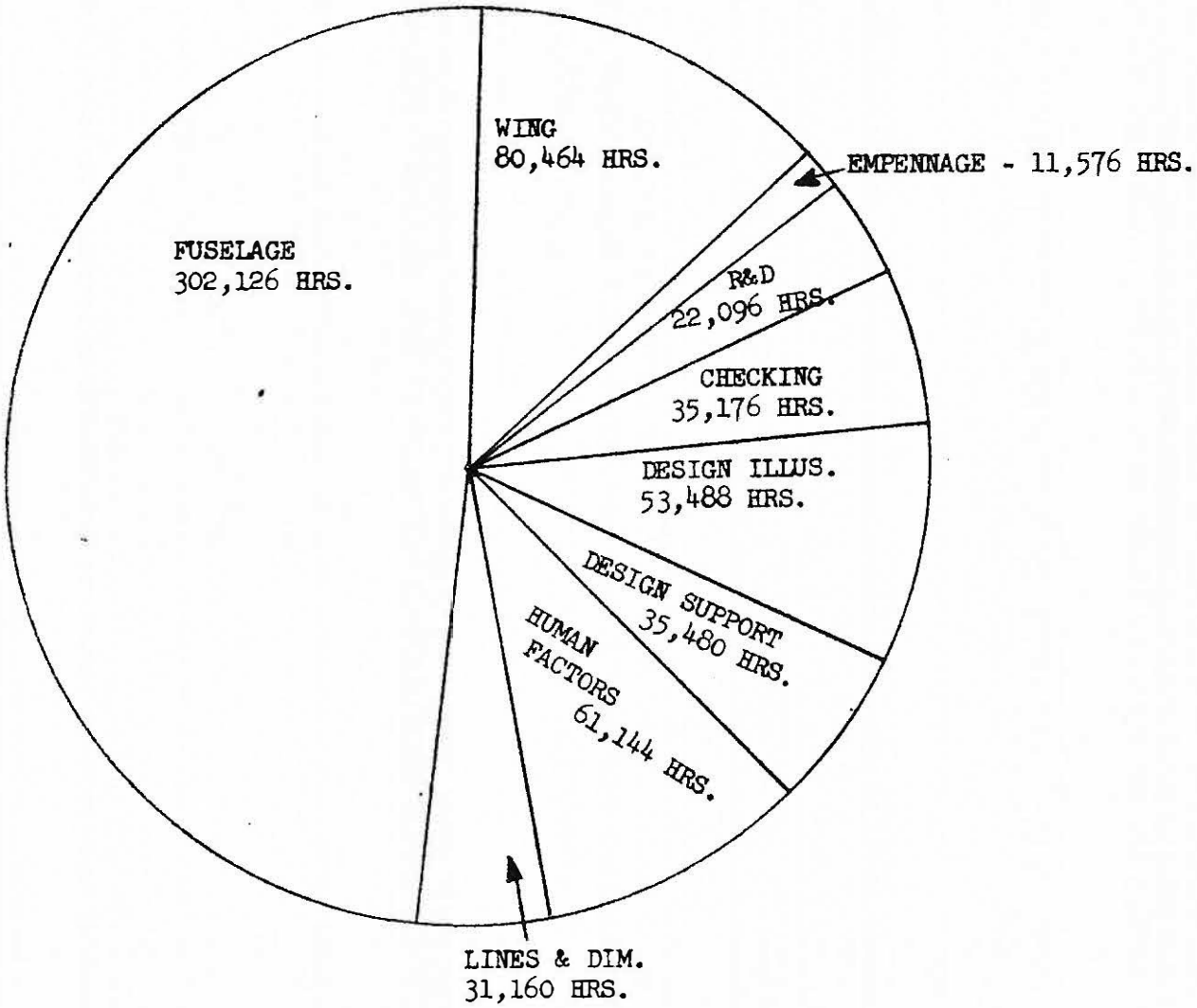
The completion and test of the ground readout station will be accomplished.

A mobile communications van will be assembled from purchased radio equipment and tested. This van will be at the flight line to control all ground tests and taxi out.

The Thermal Simulator Instrumentation is also to be reworked and modified.

DEPT. 187 - R. J. KOCHEVAR, MANAGER
COMPONENTS ENGINEERING
REMAINING COSTS TO COMPLETION
FIRM CONTRACT 42058
(31 JULY 1962 THROUGH 30 JUNE 1964)

BREAKDOWN BY FUNCTION



TOTAL HOURS - 632,720

TOTAL DOLLARS - $6,356,800

COMPONENTS ENGINEERING

Accomplishments by Components Engineering during the balance of the contract will be handled by seven groups in Components design to complete their design objectives as presented in the following paragraphs.

FUSELAGE DESIGN GROUP

One of the major design areas of effort yet to be done by this group is the modification of Ship No. 3 for bomb/nav. capabilities. This work will require approximately 400 new modification type drawings. It involves major redesign of structure in the crew and equipment sections as well as the environmental bay and forward fuel tank area. Many changes to the weapons bay structure will also be required.

Other areas of effort include continued strength revisions as other structural modifications affect load programs, changes to improve reliability and increase fatigue life, changes resulting from additional aerodynamic and technical data, and changes resulting from flight test data. Additional work will be required to improve fuel tank sealing integrity, revise inlet duct porosity, and possibly change material of boundary layer control duct trusses to avoid unpredictable loading conditions, to better fatigue life, and to facilitate fabrication of Ships Nos. 2 and 3. Another area of effort will be required in the incorporation of the bulk of 14,500 E.O.'s into drawing changes.

Considerable effort will be required to support Manufacturing at Palmdale and Los Angeles in the fabrication and assembly of the remainder of Ship No. 1, as well as Ships Nos. 2 and 3. This effort will largely constitute a continuation of the present materials review disposition and liaison activity, welding development changes, design of mechanical joints to replace difficult welded joints,

further cost reduction refinement, simplification of honeycomb structure, and support of integral fuel tank leak testing and sealing programs.

WING-EMPENNAGE DESIGN GROUP

The remaining engineering effort on this program will fall within the following general categories:

1. Support of in-plant manufacturing at Palmdale and Los Angeles

   Included in this item will be design solutions to joint mismatch problems during the final assembly of Air Vehicle No. 1, normal support to review and design dispositions for variations from design drawings on Air Vehicles Nos. 2 and 3, continuing redesign effort to simplify the assembly problems and reduce manufacturing costs, design of heat pass provisions to reduce distortion and minimize residual stresses in joints.

2. Support of Subcontractor Manufacturing

   Service of the same type will also be afforded to those subcontractors who are fabricating structural components and details.

3. Redesign of Structure

   Air Vehicle No. 3 will demonstrate the bomb/nav. system. Therefore, structural revisions to accommodate the equipment in this system will be designed for fabrication on this aircraft. Redesign of the radome and its attachment, the local fuselage nose support structure for radar antenna installation, and a tie rack for precise positioning of navigation equipment are necessary.

HUMAN FACTORS DESIGN GROUP

Remaining engineering work to completion of the escape system include:

1. Nine (9) major test reports will be prepared covering system tests. The operational checkout test program will be completed and testing of components in-house will be conducted. Drawing and specification maintenance will be required including coordination of remaining supplier test programs.

2. Manufacturing support consisting of on the floor liaison at Los Angeles and Palmdale and related design effort will be required.

Remaining work on crew station design include:

1. Engineering Design: Two new crew station designs will be required on Ship No. 3. Existing flight station design of Ships Nos. 1 and 2 will be redesigned to accommodate controls of new systems in Ship No. 3.

   Oxygen system and crew accommodations will be redesigned for Ship No. 3 to accommodate 4 men. One hundred fifteen new drawings are scheduled for basic release for Ship No. 3. System changes will necessitate redesign of various control panels following basic release.

2. Manufacturing Support: One man will be required at Palmdale for Ships Nos. 1, 2, and 3 to cover shop discrepancies and design changes.

   Additional programs for personnel accommodations programed with Life Science and Laboratory support will include: (a) continuation of thermal, airflow, and acoustical tests for solution of engineering design changes and flight test problems and (b) indoctrination of test pilots personnel in the use of normal and emergency system operation for use of escape capsule, oxygen systems, and clothing equipment.

LINES AND DIMENSIONS GROUP

A continuing work requirement is the extensive secondary ducting system of the vehicle which is being redesigned for Ship No. 3.

As a result of wind tunnel tests, as well as empirical data from actual flight testing of Ships 1, 2, and 3, numerous aero-thermo refinements to the basic configuration may normally be expected, requiring the completion of such changes within the existing schedule.

Numerical support of detail redesign is required for Ships Nos. 2 and 3, whether in the interests of weight saving, or to accomplish assembly correction.

A major requirement involves the maintenance of all existing Master Dimensions BDM-10 releases, and the continued funding of the computer programming and computer equipment essential to this effort.

ENGINEERING DRAWING CHECKING GROUP

All of this group's expenditure will be required to check the new and changed drawings to be released from all of the design groups for fit, function, and producibility of parts. Most of the new drawings will result from the redesign of Ship No. 3 forward fuselage into bomb/nav. configuration.

DESIGN SUPPORT GROUP

Upon delivery of the first Air Vehicle to Flight Test it is anticipated the master layout effort will be reduced to new configuration for Air Vehicle No. 3 only. There should be a minimum of effort expended on configuration studies. Configuration control of Flight Test Air Vehicles will account for some of the group's effort and manufacturing liaison on air vehicle hardware and tests is expected to continue at the same rate as expended to date on Ship No. 1.

DESIGN ILLUSTRATIONS GROUP

This group's effort will be required to provide the new and changed perspective drawings required for Ships Nos. 2 and 3, charts required for engineering briefings and process specifications revisions, as well as new process

specifications for Ship No. 3. It is estimated that 350 new drawings, 60 process specifications, 1,700 charts, and 45 reports will be produced by the group in this period.

NA-67-4

SERIAL NO. 20

STRUCTURAL DESIGN OF THE XB-70

R. L. Schleicher, M.Sc.D.
Special Assistant to the Chief Engineer
North American Aviation, Inc.
Los Angeles Division

From B. Pelzer

B-70 AIRCRAFT STUDY

FINAL REPORT

Volume II

April 1972

L.J. Taube
Study Manager
B-70 Aircraft Study

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TABLE OF CONTENTS

		PAGE
VOLUME I		
SECTION I	DATA LOCATION MATRIX	I-3
SECTION II	WORK BREAKDOWN STRUCTURE	I-11
SECTION III	COST DATA DEFINITIONS	I-21
SECTION IV	B-70 PROGRAM SUMMARY COSTS	I-29
VOLUME II		
WBS 1.0 ✓	AIR VEHICLE	II-1
WBS 2.0 \	PROGRAM TECHNICAL SUPPORT	II-127
WBS 3.0 ✓	MAJOR AIRFRAME MATING	II-237
WBS 4.0 ✓	FLIGHT TEST	II-251
WBS 5.0 ✓	FLIGHT TEST GROUND SUPPORT EQUIPMENT	II-487
WBS 6.0 \	SPARES	II-581
WBS 7.0	SPECIAL TEST EQUIPMENT	II-603
WBS 8.0	TOOLING	II-611
WBS 9.0	OTHER PROGRAM ELEMENTS	II-675
VOLUME III		
WBS 1.1	AIRFRAME STRUCTURES	III-1
WBS 1.2	ENVIRONMENTAL CONTROL	III-325
WBS 1.3	PROPULSION	III-469
WBS 1.4	SECONDARY POWER	III-627
VOLUME IV		
WBS 1.5	AIR INDUCTION SYSTEM	IV-1
WBS 1.6	FLIGHT CONTROL	IV-123
WBS 1.7 ✓	PERSONNEL ACCOMMODATION AND ESCAPE	IV-249
WBS 1.8	ALIGHTING AND ARRESTING	IV-369
WBS 1.9 ✓	MISSION AND TRAFFIC CONTROL	IV-469
WBS 1.10	FLIGHT INDICATION	IV-537
WBS 1.11 ✓	TEST INSTRUMENTATION	IV-583
WBS 1.12 ✓	INSTALLATION, CHECKOUT & PRE-FLIGHT	IV-647

AIR VEHICLE WBS 1.0

GENERAL

The B-70 Program, at the onset, was a full weapon system capable of sustained Mach 3 flight for the major portion of its design missions. The weapon system was to enter the SAC inventory as an RS-70 with the first intercontinental reconnaissance/bomber wing scheduled to go operational in July, 1964. After several redirections, a two XB-70 air vehicle program emerged with its prime objective being to demonstrate the technical feasibility of sustained Mach 3 flight.

This section describes the original Weapon System 110A concepts, the evolution of the RS-70 design, and the XB-70 air vehicles which demonstrated the design, fabrication, and technical feasibility of long range Mach 3 flights at high altitude. The data presented shows that a very large step forward in the state-of-the-art of manned aircraft design was achieved during the B-70 development program and that advances were made and incorporated in every area, including design, materials application, and manufacturing techniques.

WEAPON SYSTEM 110A REQUIREMENTS

The operational mission of the full weapon system was the effective accomplishment of the USAF strategic bombardment high-altitude supersonic mission. Particular emphasis was on those portions to which the capabilities of the contemporary strategic missiles were not suited and for which the manned bomber had the only proven capabilities. The man-machine combination was to provide discretionary capabilities for target discrimination, malfunction correction or override, timely evasive maneuvers, judgment in selection and employment of penetration aids, heavy payload of mixed weapons, intelligence collection, damage assessment, best altitude and penetration routes, recallability and recoverability.

The design of the weapon system was to ensure ease of production, easy and rapid installation of subsystems and equipment, and ease of general maintenance with a minimum of elapsed time allowed for maintenance periods. Components and materials were to be selected to reduce the requirements for manpower, skill level, special tools, and ground equipment. The degree of accessibility of the equipment as installed in the air vehicle element was commensurate with the frequency of inspection, servicing, or repair of the item. The offensive subsystem (supported by the defensive subsystem to increase survival probability) was to provide accurate navigation to distant target areas and launch weapons with precision for total target destruction.

In conjunction with the above design requirements, three basic range missions were established as baseline design criteria for the weapon system. These basic range missions are schematically presented on the global picture of

Exhibit 1, page II-11. As shown, two of the missions penetrated the target area at high altitude with total ranges of 6447 nautical miles unrefueled and 7748 nautical miles refueled. The third mission, which was also inflight refueled, had a total range of 5312 nautical miles with an "on-the-deck" target area penetration at Mach 0.95 for 856 nautical miles.

B-70 DEVELOPMENT

In 1955 when the Weapon System 110A design studies were initiated and based on the existing state-of-the-art in aerodynamics, the air vehicle was visualized as being very large with tremendous fuel capacity. As presented by Exhibit 2, page II-12, this design included two floating wing tip auxiliary fuel tanks, each the size of a B-47 medium bomber which had to be jettisoned prior to supersonic flight. At the onset, it was estimated that the vehicle would gross at 650,000 lbs.; however, by mid 1956, the gross weight estimate had increased to 700,000 lbs. Due to the logistics of the expendable wing tip tanks (two for each mission) and the need for additional runway construction (each SAC base), it was evident that this configuration was unacceptable, whereby an extensive aerodynamic and high temperature development program was initiated.

The aerodynamic and high temperature development programs resulted in significant advancements in the state-of-the-art for the basic airframe and subsystems. A summary of the aerodynamic features and arrangements developed is presented by Exhibit 3, page II-13, while Exhibit 4, page II-14, summarizes the advancements made in high temperature development. The B-70 air vehicle, as depicted by Exhibit 3, page II-13, had an estimated gross weight of 550,000 lbs. which did not impact the existing SAC bases or present any unacceptable logistic problems. This arrangement or configuration became "baseline" for the RS-70 and subsequently the XB-70 air vehicles. The configuration is discussed in detail under each applicable subsystem as identified by the WBS.

RS-70 AND XB-70 CONFIGURATIONS

The RS-70 general arrangement is presented by Exhibit 5, page II-15, which evolved into that presented by Exhibit 6, page II-16, for the XB-70 air vehicles. As shown for the RS-70, the nose section contained the radar bomb-sighting antenna, inertial navigation platform, Doppler radar, and an air refueling receptacle. The cabin contained provisions for a crew of four in encapsulated seats and were identified as pilot, copilot, bombardier-navigator, and defense system operator. The electronic equipment compartment aft of the cabin contained the majority of electronic equipment in racks on either side of an aisleway. This compartment, which was pressurized and air conditioned, was accessible in flight. The environmental conditioning equipment was located aft of the electronic equipment bay immediately forward of the integral fuselage fuel tankage. The central portion of the fuselage contained engine air ducts, multiple-weapon bay, landing gear, and integral fuel tankage. The wings, including

the folding tips, provided additional integral fuel tankage and contained six elevons on each side of which the two outboard elevons locked "in-trail" when the tips folded. The aft fuselage supported twin verticals, a cluster of three drag chutes, and six General Electric J-93 engines.

The XB-70 air vehicles, as depicted by Exhibit 6, page II-16, retained the essential configuration, fundamental areas, and basic flight equipment of the RS-70. The XB-70 equipment provisions were different from the production versions in the following important aspects.

1. Radar bomb-sighting antenna, inertial platform, Doppler radar, and air refueling receptacle were omitted from the nose section.

2. The crew consisted of pilot and copilot.

3. The electronic equipment retained was installed in the cabin instead of the electronics equipment bay.

4. Weapon installation provisions were removed from the bomb bay.

5. Wing tip fuel tanks and bomb bay fuel provisions were eliminated.

6. The bombing/navigation/missile guidance (BN & MG) and defensive systems were eliminated.

7. The mission and traffic control system (M&TC) was replaced by available GFP communication, navigation, and identification equipment.

8. Ballast was incorporated in appropriate quantity and location to maintain air vehicle balance and aeroelastic properties that represented the production air vehicle.

FLIGHT TEST PROGRAMS

The RS-70 Flight Test Program was planned to be conducted in four phases identified as Category I, II, III and IV. Category I flight test program was to be the prime responsibility of the contractor and included test beds and all prime vehicle development up to and including the full weapon system demonstration. Category II was a 20-flight hour phase scheduled for air vehicle No. 1 early in the flight test program and was to be conducted by Air Force pilots to establish feasibility of the basic air vehicle. Category III was to be conducted by the Air Force using Air Force airborne crews but with maintenance and on-the-job training provided by the contractor. This phase of testing was to be on the full weapon system conducted by the Air Force Test Center to evaluate operational suitability. Category IV was to be a complete Air Force program where operational type air and ground crews evaluated the full weapon system under simulated operational conditions.

Exhibits 7, 8, 9, and 10, pages II-17, II-18, II-19, and II-20, present a detail breakdown of the planned Category I flight test hours scheduled for the RS-70. Exhibit 7, page II-17, shows the chargeable flight hours to each major task that was to be conducted on the prime air vehicles while Exhibit 8, page II-18, shows the scheduled test bed flight hours. Exhibit 9, page II-19, presents the total chargeable flight hours scheduled for the basic air vehicle development. The RS-70 flight test program was based on the test or time sharing concept which is the most timely and economical means of providing the maximum test experience. This concept requires a large capacity instrumentation system and detail planning starting with wind tunnel tests, ground tests and each air vehicle flight. As shown by Exhibit 10, page II-20, utilizing time sharing, test experience was increased for the basic vehicle from 1575 charge hours to 4280 equivalent test hours. This same percentage increase due to time sharing was used in planning the XB-70 flight test program and was essentially verified during the test program.

The detail breakdown of the XB-70 flight test program is presented by Exhibits 11, page II-21, and 12, page II-22. Exhibit 11, page II-21, shows the charged flight hours for the major subsystems, while Exhibit 12, page II-22, presents the equivalent flight test hours based on the percentage gain due to time sharing. The charged flight hours of Exhibit 11, page II-21, were those planned for the XB-70 program which were within a total tolerance band of less than 6.5 hours when compared to the actual charged hours. Based on this small error and to facilitate analysis, the planned charged hours were used as the basic flight hours charged during the XB-70 program as depicted by Exhibit 12, page II-22. Exhibit 13, page II-23, presents a percentage comparison of the XB-70 program flight hour exposure to that planned for the RS-70 program. The percentages shown are based strictly on flight hours exposure and do not reflect the fidelity of the subsystem tested. The weighing of the percentages shown based on subsystem fidelity and the flight envelope flown is presented in the analysis under each subsystem as identified by the WBS. Exhibit 14, page II-24, presents the flight envelopes of the RS-70 and the XB-70. The maximum allowable speed shown for the XB-70 was essentially 80 percent of the RS-70 maximum "Q" with a plateau at 30,000 ft. to reduce the impact of gust loading. The RS-70 was $\pm$ 2 "g" aircraft designed to also withstand gust loading of $\pm$ 2 "g's", while the XB-70 was limited to + 1.6 "g's" and + 0.4 "g's" in maneuvering flight. Except for total temperature, the XB-70 was essentially limited to 80 percent of the RS-70 maximum allowable loading.

SST FLIGHT RESEARCH

During the XB-70 flight test development program, special instrumentation was installed to obtain supersonic transport flight research data. The instrumentation was designed, manufactured, and installed (mainly on air vehicle no. 2) with data gathering, reduction, and analysis performed on a non-interference basis during the XB-70 development program. The SST flight research data was obtained in various areas as designated by the eight tasks shown below. All of the tasks indicated were sponsored by NASA except for acoustic loads which was sponsored by FAA.

TASKS	A/V #1	A/V #2
1. Aerodynamics (Panel Response)	X	X
2. Structures (Landing Loads)	X	
3. Structures (Gust Loads)		X
4. Structures (Acoustic Loads)		X
5. Aerodynamics (Skin Friction Drag)		X
6. Aerodynamics (Base Drag)		X
7. Thermal Environment (Cabin & Structures)		X
8. Thermal Environment (Fuel System)		X

The instrumentation installed in the XB-70's for the SST flight research program is summarized as follows: (See Exhibit 15, page II-25.)

Panel Response	-	A NASA tape recorder and two microphones in the cockpit area.
Landing Loads	-	Rate of sink trailing arms, landing gear cameras, and NASA VGH recorder.
Gust Loads	-	A gust probe boom, accelerometers, pressure transducers, and yaw and pitch angle instrumentation.
Acoustic Loads	-	Microphones and pressure tape to measure the properties of a turbulent boundary layer.
Skin Friction Drag	-	Wing pressure rakes, static pressure lines, thermo couple wires, and fuselage pressure rakes.
Base Drag	-	Boattail and pressure tapes around engines 4, 5, and 6.
Thermal Environment	-	Thermo couples on cabin windshield and structure, flight control components, landing gear, and fuel system.
Additional Data	-	The VGH recorder was also utilized to obtain fatigue data. The XB-70 development instrumentation, such as aerodynamic and stability and control transducers, were used for program correlation.

FOLLOW-ON RESEARCH ACTIVITY

Subsequent to the XB-70 flight test development program, two flight research programs were initiated on the remaining XB-70 No. 1. The first program was for Sonic Boom Measurements and was sponsored jointly by NASA and USAF. The first flight (No. 1-50) was initiated on 11-3-66 with the program completed on 1-31-67 (flight No. 1-60). The primary purpose of the test program was to determine the proper method of combining the theoretical sonic boom intensity due to lift and due to volume for the far field case. The pressure signatures of several aircraft, but principally the XB-70, were measured on the ground at various distances from the ground track of the air vehicle. The atmospheric effects on the sonic boom intensity were also investigated.

The second follow-on program was sponsored by NASA and was an investigation into the control of structural dynamics. The first flight (No. 1-61) was initiated on 4-25-67 with the program completed on 2-4-69 (flight No. 1-83)

when the No. 1 XB-70 was ferried to WPAF Base Air Museum. To conduct the structure dynamics investigation, the air vehicle was modified for the installation of an Exciter Vane System in the nose section and an elevon control system titled Identically Located Accelerometers and Forces (ILAF).

The Exciter Vane System consisted of two small vanes protruding from both sides of the nose section, tied together through the fuselage by a "sewer pipe," and hydraulically driven. The system was controllable from the cockpit for both frequency and amplitude which provided controlled dynamics to the air vehicle structure. The ILAF system tied into the XB-70 Flight Augmentation Control System which provided elevon control for structural dynamic dampening. The concept was based on locating the input accelerometers near the elevons (for system stability), mixing this input signal with CG signals which cancelled normal flight accelerations and provided a structural dynamics frequency spectrum.

AIR VEHICLES 1, 2 and 3 CONFIGURATION COMPARISON

At the time of program redirection to three XB-70 air vehicles (3-31-61), it was planned that AV's 1 and 2 would be identical in design to demonstrate the technical feasibility of B-70 type aircraft design and AV 3 would include provisions to demonstrate the functional operation of a prototype bombing-navigation system. Subsequent to this redirection, systems development and manufacturing considerations led to further significant differences between AV's 1 and 2, as follows:

1. AV 1 had zero degree wing dihedral versus 5 degree on AV 2.

   This change was issued to correct lateral dynamic stability problems at intermediate supersonic speed and became evident too late in the manufacturing process to be incorporated on AV 1 which utilized a bob weight to provide the capability for pilot compensation.

2. A manual air induction control system was utilized on AV 1 versus an automatic system on AV 2.

   An interim manual system with limited automatic features was flown on AV 1 due to development schedules associated with the automatic system. See WBS 1.5 for additional detail.

3. The wing-to-fuselage joint design differed between AV's 1 and 2.

   Due to wing-to-fuselage mismatch problems encountered on AV 1, the joining transition area was redesigned to facilitate assembly. See page II-26 for display of different design and WBS 3.0 for detail on problems encountered.

4. AV 2 had a 2800 gallon greater fuel capacity than AV 1.

   This fuel capacity difference was primarily attributable to Tank No. 5 being blocked off on AV 1 due to problems experienced in sealing. See WBS 3.0 for further detail.

It was planned that AV 3 would be similar in structure as AV 2 but that modification would be made to include provisions for the bombing-navigation system as follows:

1. Four-man crew on AV 3 versus two-man crew on AV's 1 and 2.

   An observer and system operator position were required in support of bombing-navigation missions and systems operations. See page II-27 for display of crew arrangement.

2. AV 3 required major modifications in the environmental control system.

   Double versus single air cooling loops were required to support the additional crewmen and electronic equipment on AV 3. In addition, a greater cooling capacity and added liquid cooling loops were required. See Exhibit 18, page II-28.

3. Equipment bay variances

   Major electronic equipment additions were required in support of the bombing-navigation system which resulted in rearrangement of the electronic and ECS equipment bays plus the blocking off of the No. 1 fuel tank for ECS water/ice tank.

4. Nose cavity additions

   The AV 3 bombing-navigation required the addition of an inertial navigation platform and radar antenna equipment with associated cooling loops in the nose section. See Exhibit 17, page II-27.

5. Secondary power system additions

   An additional generator on engine No. 5, line contactor, stepdown transformer, secondary bus and the associated controls were required in support of the added electronic equipment on AV 3.

MOCKUPS AND SIMULATORS

Shortly after contract go-ahead, effort was initiated on mockup design and fabrication in support of the Design Engineering Inspection (DEI). Emphasis was placed on the air vehicle mockup and displays, see Exhibit 19, page II-29. Additional mockups such as the over-nose vision (see Exhibit 20 page II-30), cabin lighting, and the Wright Air Development Center unit were being fabricated during this same period (See special chart, page II-31, for display of mockup milestones). Earlier program mockup requirements included those items associated with the weapons systems and mission; that is,

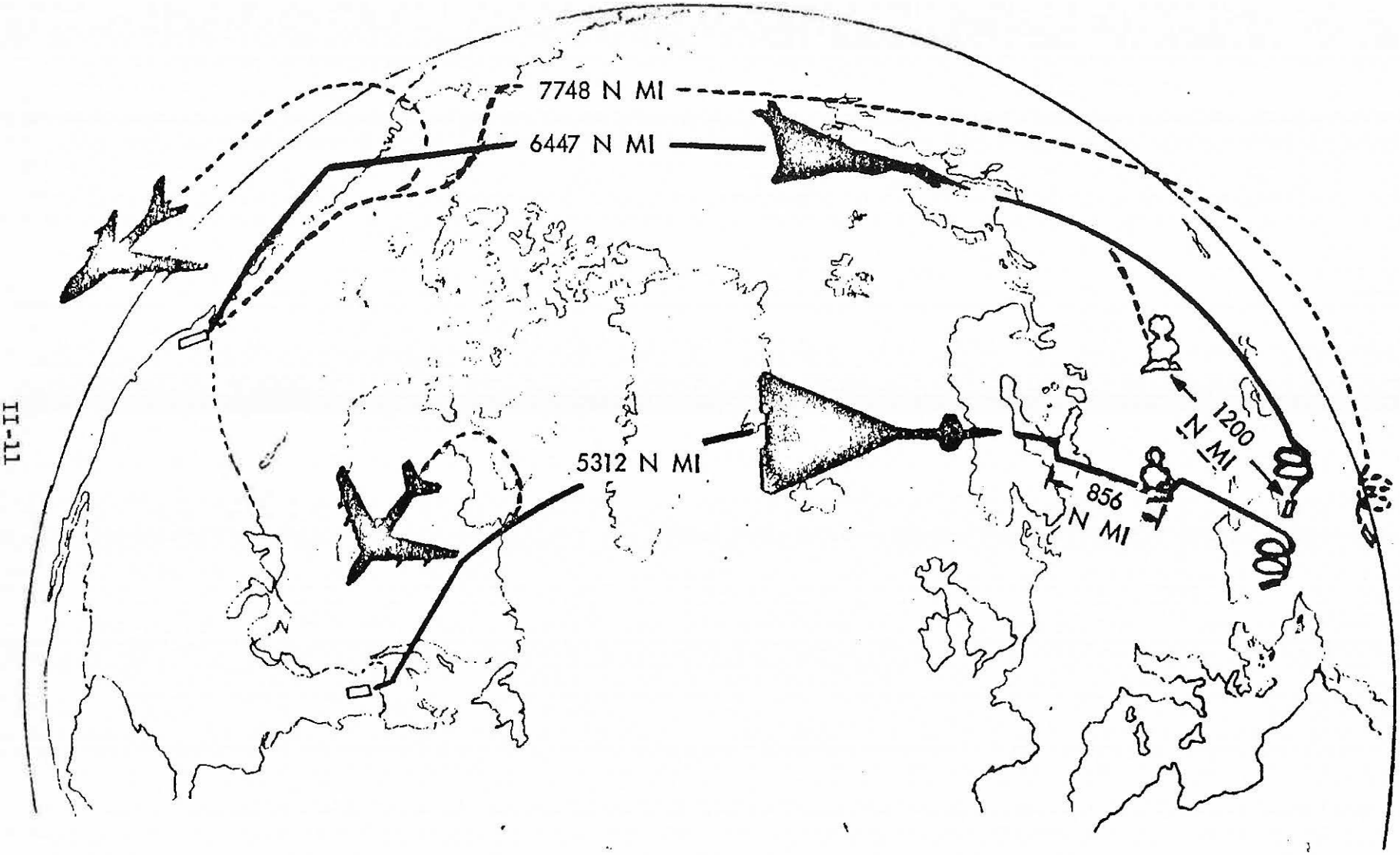
alert pod, bomb displacing gear, rocket package, serial refueling, etc. As of July 1959, 21 individual major mockups and simulators had been identified. At the time of redirection to a 3 air vehicle program (March 1961) this number had increased to 24 and was as follows:

Flight Control	Engine Compartment Fire Tolerance
Elect. Integration	Escape Capsule Test Sled
Rain Erosion Test Sled	Escape Capsule Test Units
Doppler Radome Mockup	Electronic Systems Checkout
ECM Radomes and Antennas	Main Landing Gear
Impedance Model	Nose Landing Gear
Full Scale Vert. Stabilizer	Hydraulic Pumping
Antenna Range Models	Antenna Test Mockup
Radar Back Scatter Models	Bomb/Navigation Radome Mockup
Radar Reflectivity	Engine-Inlet Compatibility
Environmental	Fuel System
Propulsion Test Stand	Fuel Tank Purge and Vent System

Due to the budget limitations and reduced program requirements associated with the 3 XB-70 air vehicle program, the aforementioned 24 items were reduced to the following 11:

Flight Control	Propulsion Test Stand
Doppler Radome Mockup	Escape Capsule Test Units
Impedance Model	Electronic Systems Checkout
.57 Scale Engine-Inlet Compat.	Bomb/Navigation Radome
Antenna Range Models	Fuel System
Environmental	

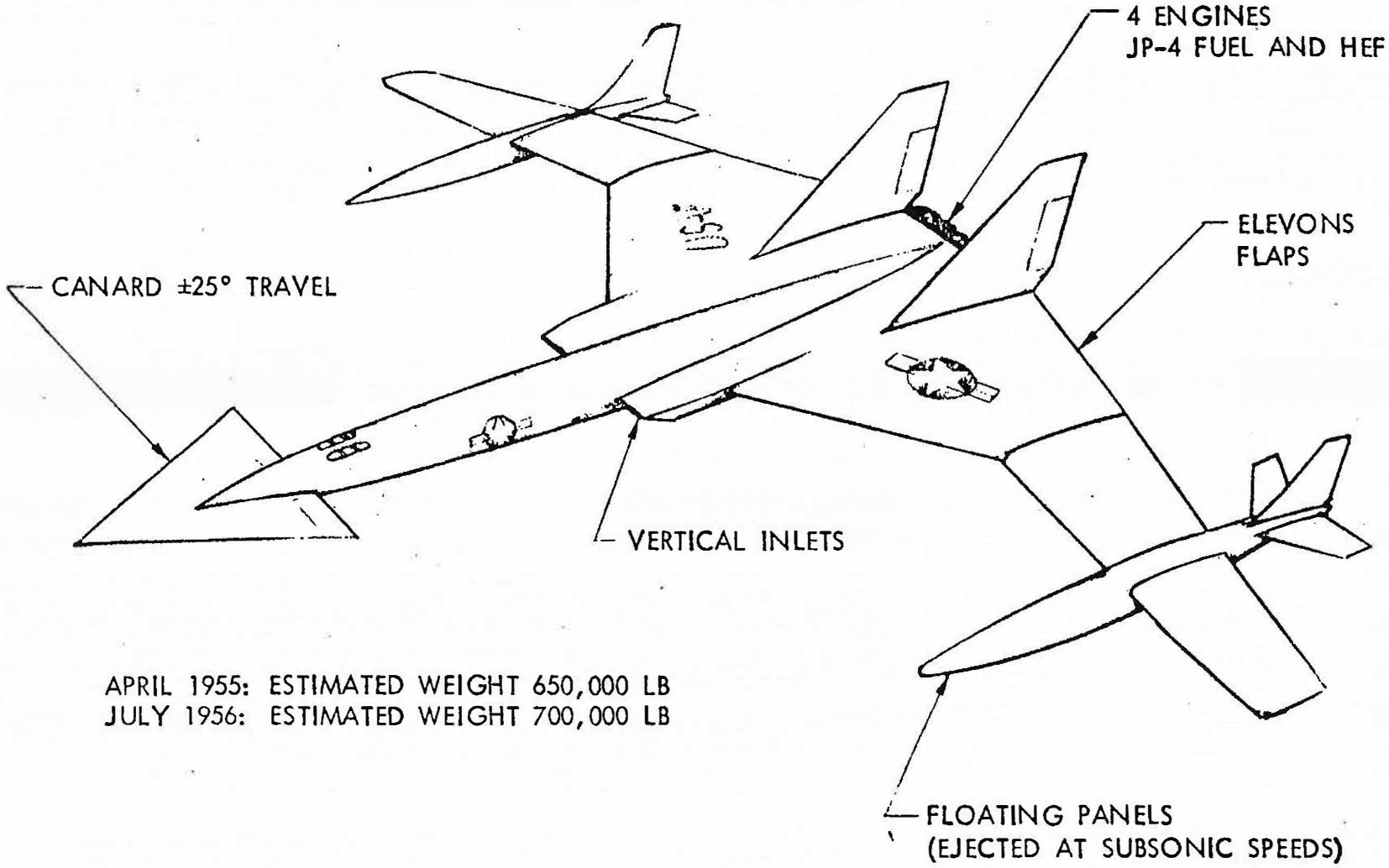
The above units were completed in support of the XB-70 programs and further detail, if historically significant, appears under the individual subsystem in Volumes III and IV of this study.



RS-70 MISSION PROFILES

Exhibit 1

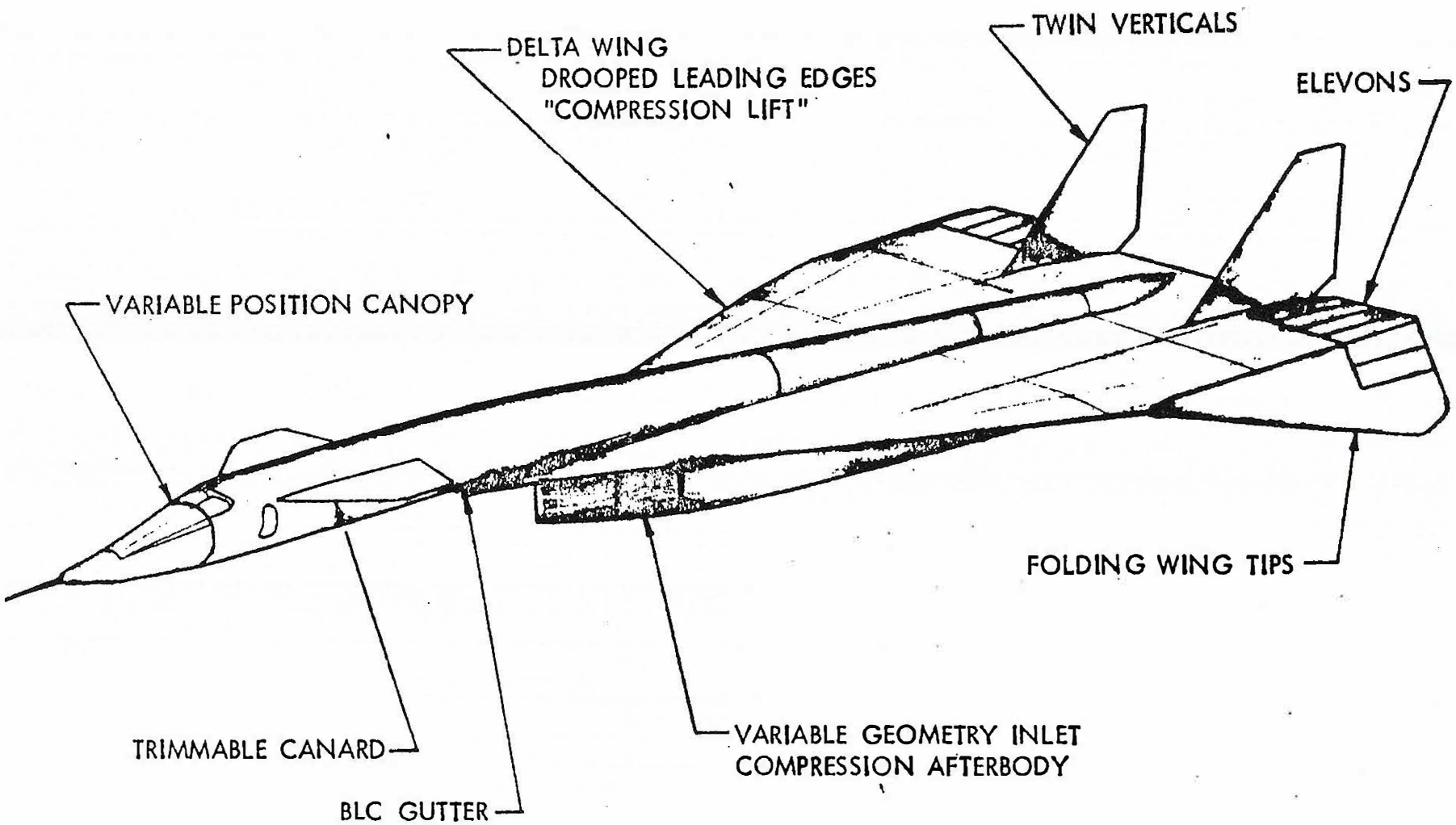
SAC BOMBER ~ AT THE ONSET
CONVENTIONAL CONSTRUCTION, MATERIALS, TECHNOLOGY



APRIL 1955: ESTIMATED WEIGHT 650,000 LB
JULY 1956: ESTIMATED WEIGHT 700,000 LB

EXHIBIT 2

B-70 AERODYNAMIC FEATURES

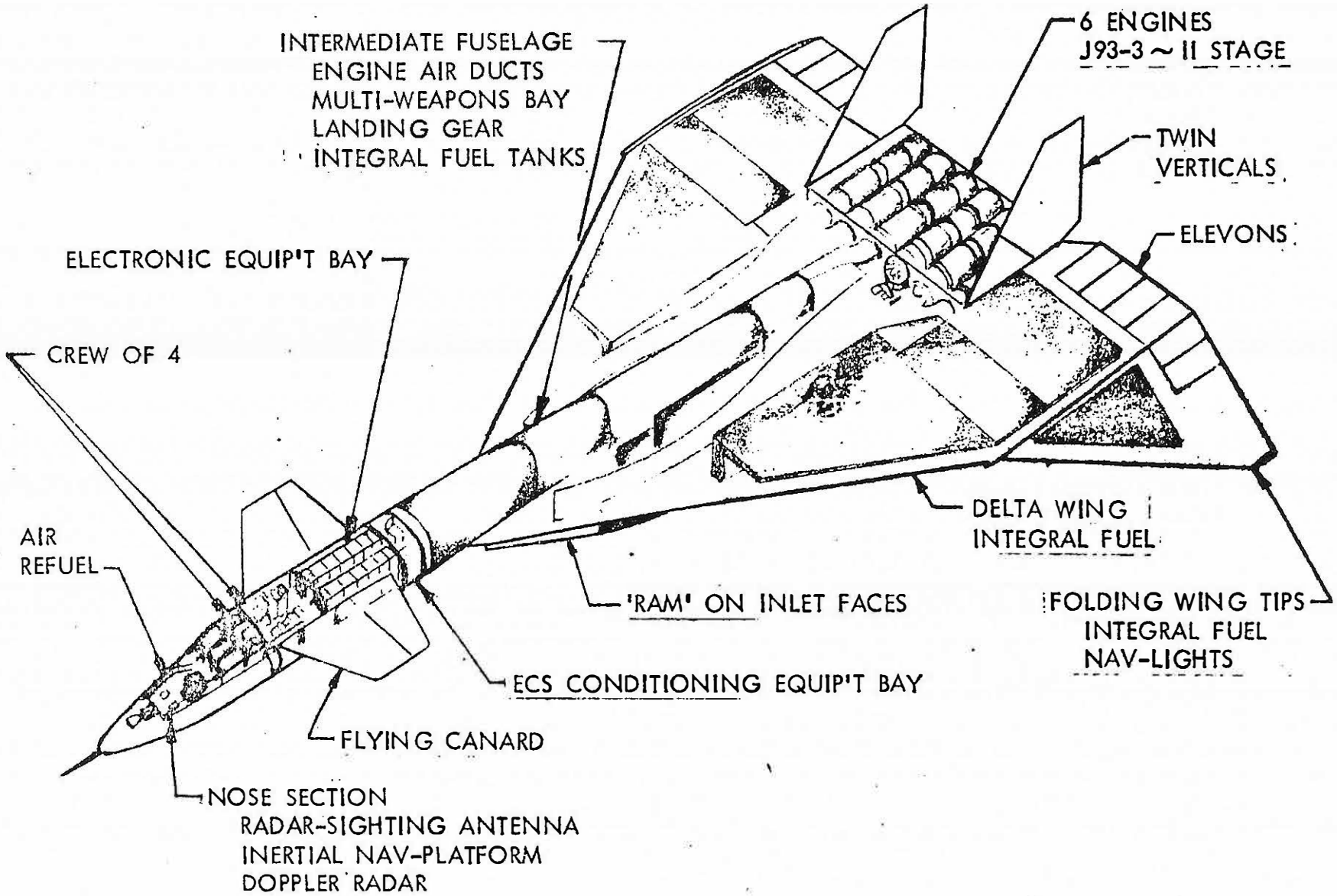


HIGH-TEMPERATURE DEVELOPMENT

	PRIOR TO B-70	B-70 DESIGN
STRUCTURES	240 F	450 TO 630 F
FUELS	JP-4 ~ 200 F	JP-6 ~ 300 F
OILS	300 TO 350 F	UP TO 450 F
ELECTRICAL SYSTEMS	250 F	550 F
HYDRAULIC SYSTEMS	-65 TO 350 F	-65 TO 450 F
BEARINGS	375 F	630 F
SEALS	275 F	500 TO 630 F
GREASES	375 F (25 HR)	450 F (100 HR)
TIRES	200 F (4 HR)	360 F (4 HR)
RADOMES AND WINDOWS	250 TO 300 F	500 TO 530 F

EXHIBIT 4

RS-70 GENERAL ARRANGEMENT



XB-70 GENERAL ARRANGEMENT

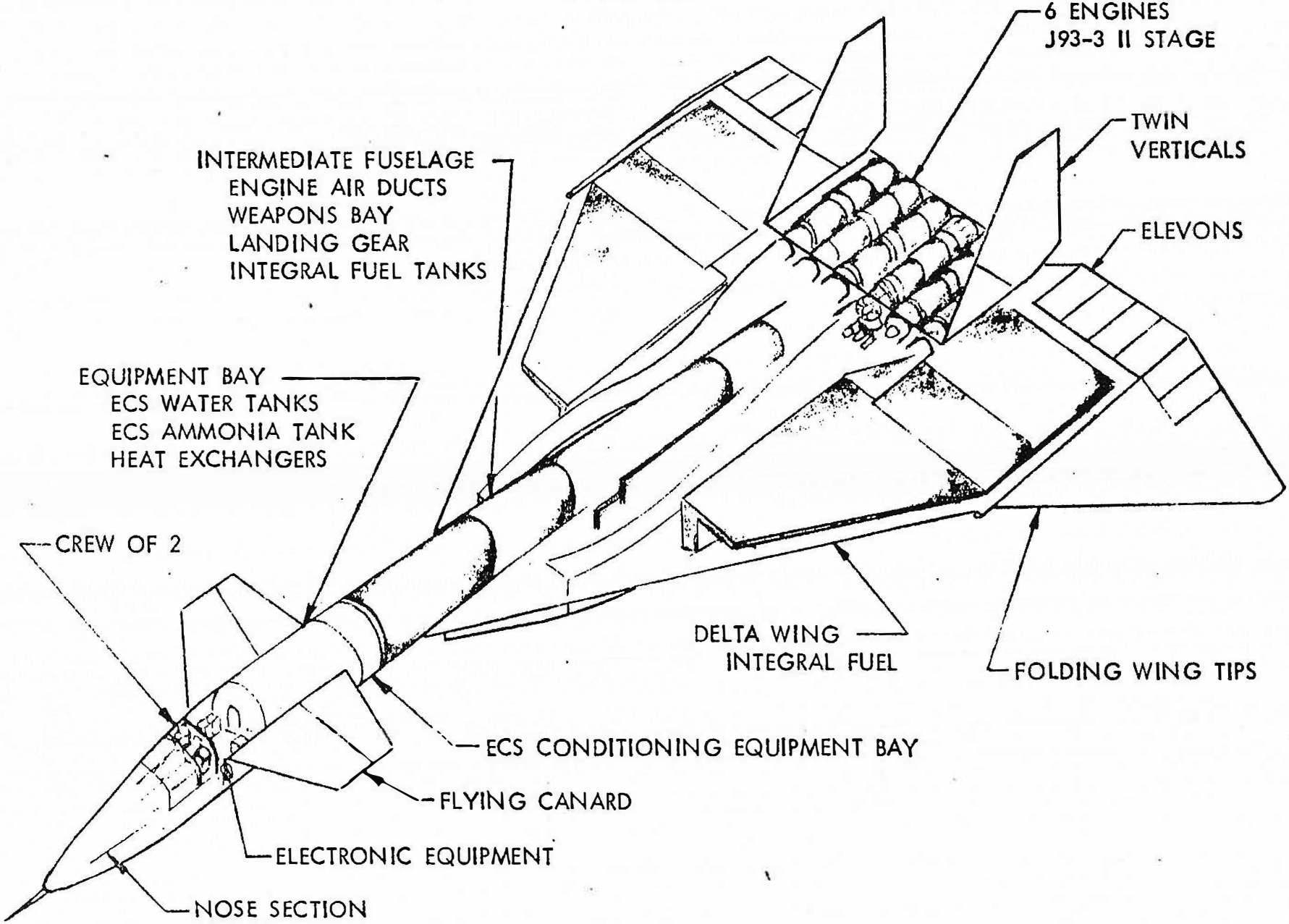
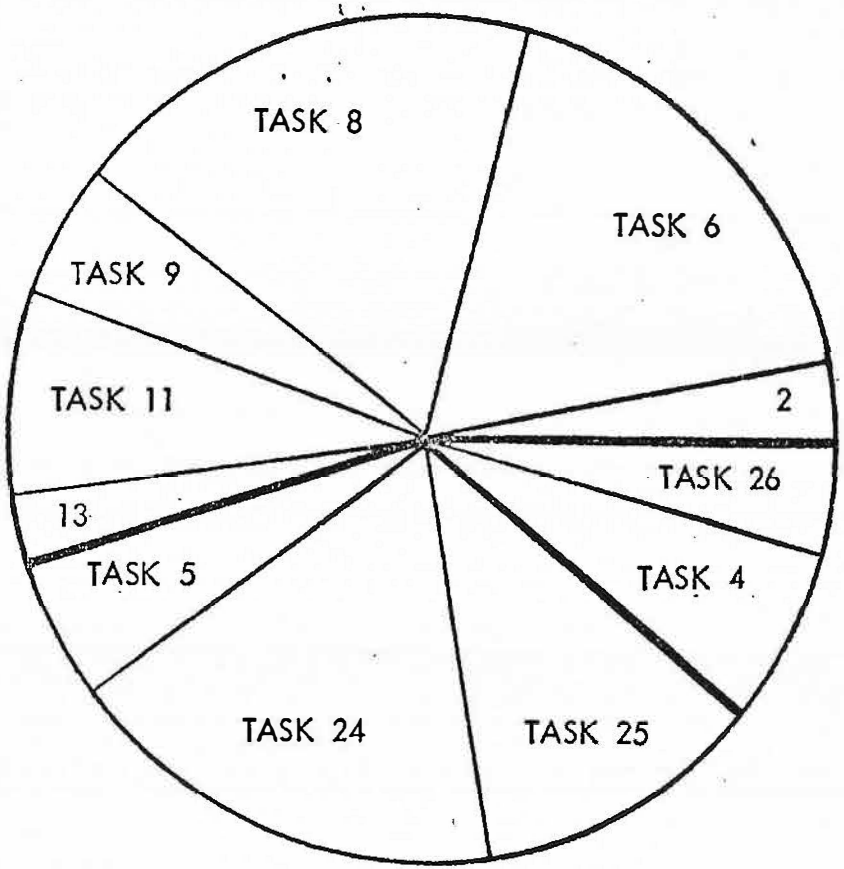


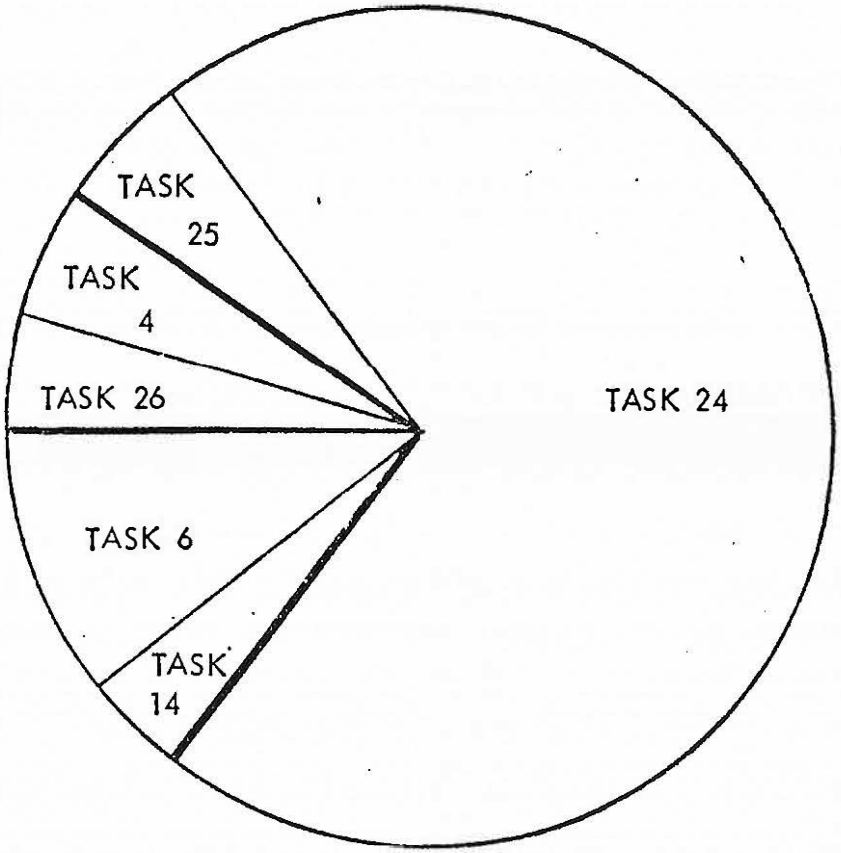
EXHIBIT 6

RS-70 CATEGORY I ~ FLIGHT HOUR SUMMARY
RS-70 TEST AIR VEHICLES



TASK	TITLE	FLIGHT HR
2	AIR VEHICLE	50
6	PROPULSION	315
8	AIR FRAME	575
9	ECS	100
11	FLIGHT CONTROLS	165
13	SECONDARY POWER	35
PRIMARY A/V TESTS: TOTAL		1240
5	M&TC	115
24	OFFENSIVE	400
25	DEFENSIVE	250
MILITARY SUBSYSTEMS: TOTAL		765
4	MISSILES	160
26	PENETRATION	110
AIRBORNE COOPERATION: TOTAL		270
RS-70's FLIGHT TEST HRS: TOTAL		2275

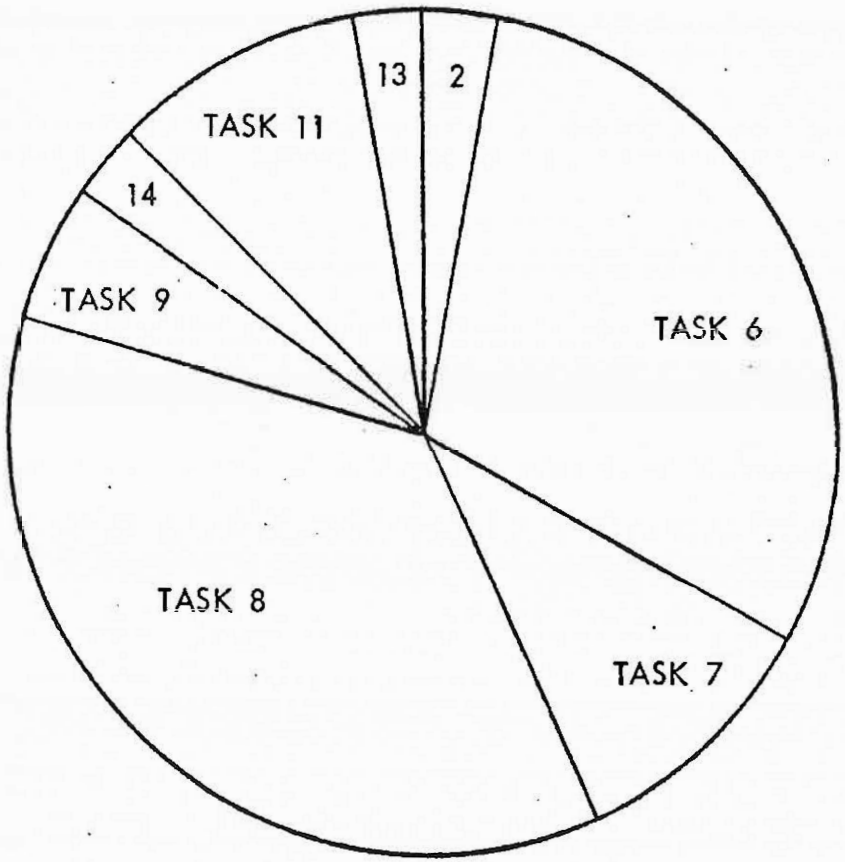
RS-70 CATEGORY I ~ FLIGHT HOUR SUMMARY
FLYING TEST BEDS



TASKS	TITLE	FLIGHT HR
6	PROPULSION	270
14	PERSONNEL ACCOM	65
	PRIMARY A/V TESTS: TOTAL	335
4	MISSILES	150
26	PENETRATION	100
	AIRBORNE COOPERATION: TOTAL	250
24	OFFENSIVE	1925
25	DEFENSIVE	150
	MILITARY SUBSYSTEMS: TOTAL	2075
	FLYING TEST BEDS FLIGHT HR: TOTAL	2660

EXHIBIT 8

RS-70 CATEGORY I ~ FLIGHT HOUR SUMMARY
CHARGEABLE FLIGHT HOURS



TASKS	TITLE		FLIGHT HR
2	AIR VEHICLE		50
6	PROPULSION		435
7	AIR INDUCTION SYS		150
8	AIRFRAME		575
	STABILIZE AND CONTROL	250	
	PERFORMANCE	140	
	STRUCTURES	85	
	A/V DEMO	100	
	ALIGHT AND ARREST	0	
9	ECS		100
11	FLIGHT CONTROL		165
12	FLIGHT INDICATION		0
13	SECONDARY POWER		35
14	PERSONNEL ACCOMMODATIONS		65
	CHARGEABLE FLIGHT HR.: TOTAL		1575

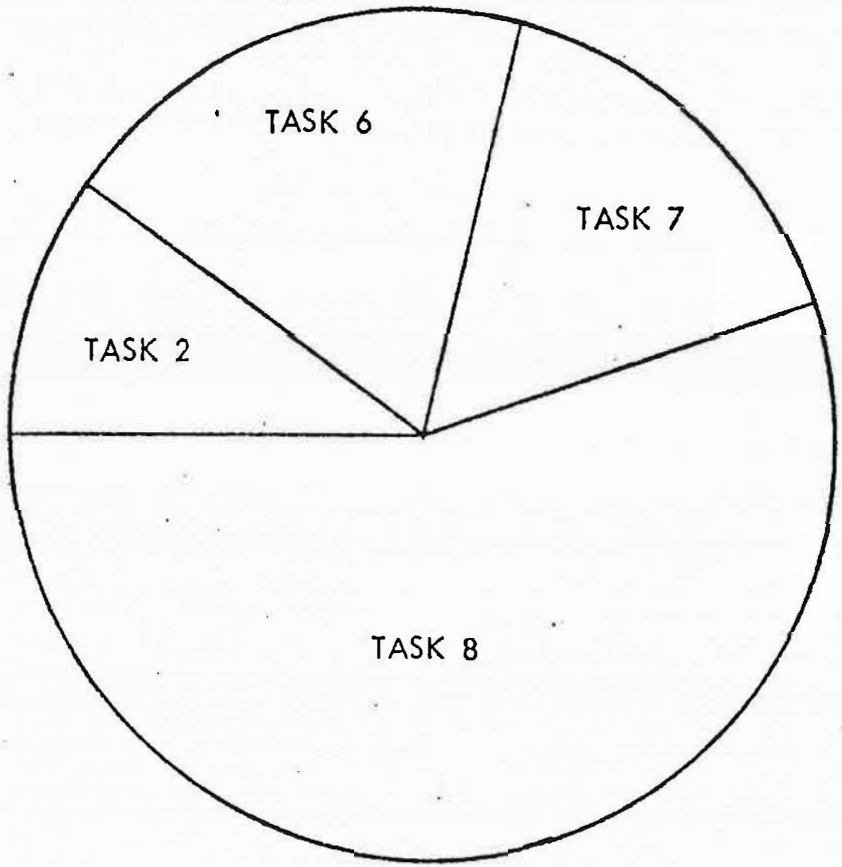
EXHIBIT 9

3

RS-70 CATEGORY I ~ LIGHT HOUR SUMMARY
PRIMARY AIR VEHICLE EQUIVALENT FLIGHT TEST HOURS

PRIMARY AIR VEHICLE SYSTEMS	BASIC FLIGHT HOURS CHARGED PER SYSTEM	PERCENT FLIGHT HOURS ADDITIVE DUE TO TIME-SHARING												NET TIME SHARING (HOURS)	TOTAL EQUIVALENT FLIGHT TEST HOURS
		AIR VEHICLE	PROPULSION	AIR INDUCTION	STABILITY & CONT.	PERFORMANCE	STRUCTURES	A/V DEMO	ECS	FLIGHT CONT.	FLIGHT INDICATION	SECONDARY PWR	PERSONNEL ACCOM		
AIR VEHICLE	50	-	-	-	-	-	-	-	-	-	-	-	-	-	50
PROPULSION	435	-	-	50	10	50	-	10	10	-	-	100	-	225	660
AIR INDUCTION	150	-	60	-	10	50	-	10	10	20	-	-	-	245	395
STABILITY AND CONTROL	250	-	10	10	-	25	50	10	-	60	-	-	-	220	470
PERFORMANCE	140	-	50	50	25	-	-	10	10	-	-	-	-	235	375
STRUCTURES	85	-	20	20	50	25	-	50	25	60	-	-	-	400	485
A/V DEMO	100	-	-	-	-	-	-	-	-	-	-	-	-	-	100
ALIGHT AND ARREST	0	-	20	20	20	20	20	20	-	-	-	-	-	180	180
ECS	100	-	10	10	10	10	50	20	-	10	-	-	-	180	280
FLIGHT CONTROL	165	-	10	10	75	10	25	10	-	-	-	-	-	260	425
FLIGHT INDICATION	0	-	10	10	50	25	25	10	10	50	-	-	-	310	310
SECONDARY POWER	35	-	100	20	10	10	10	10	10	10	-	-	-	295	330
PERSONNEL ACCOM.	65	-	.10	10	10	10	10	10	50	10	-	-	-	155	220
													TOTAL		4280

XB-70 PROGRAM ~ FLIGHT HOUR SUMMARY
CHARGED FLIGHT HOURS"



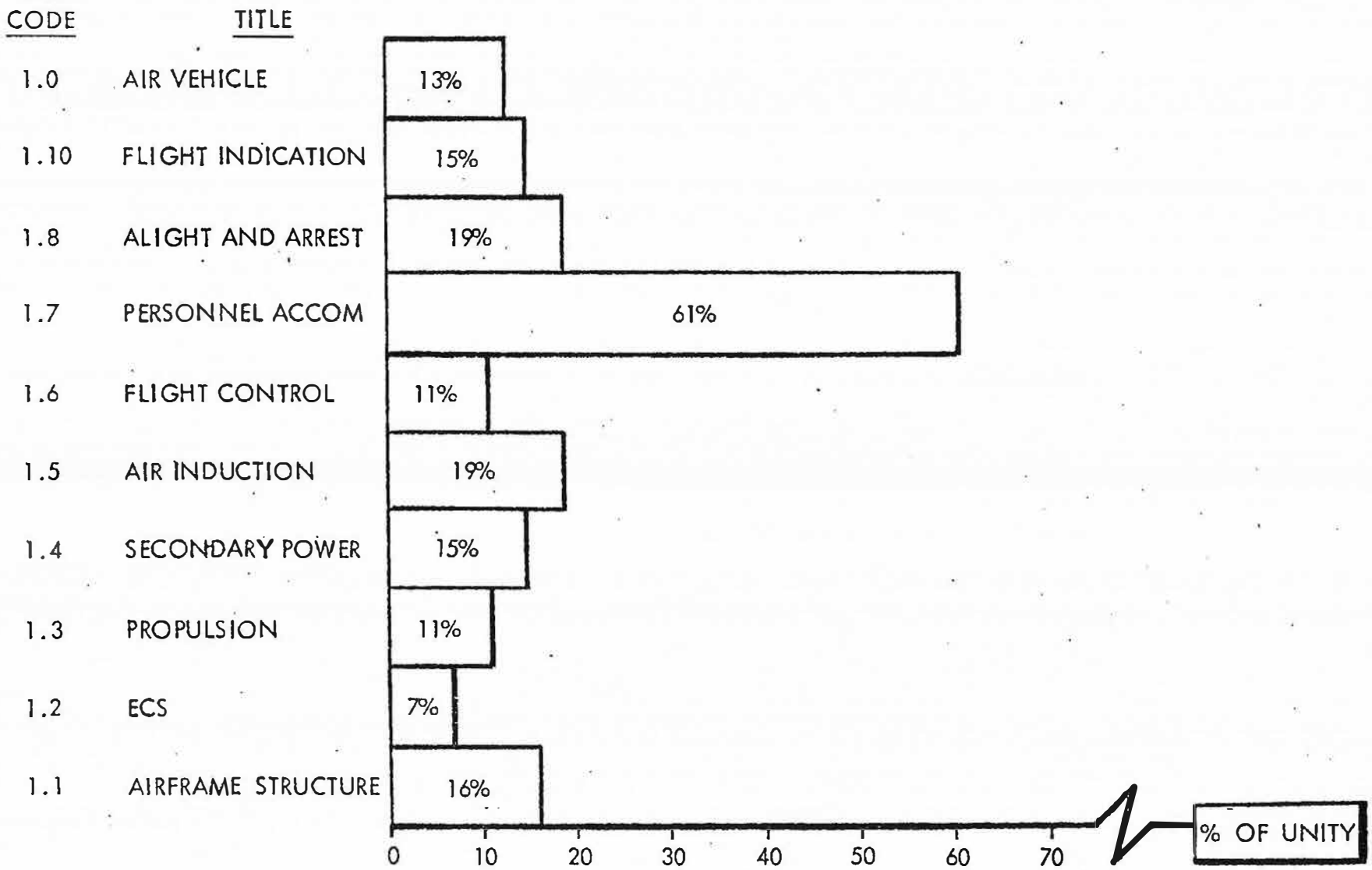
TASKS	TITLE		FLIGHT HR.
2	AIR VEHICLE		20
6	PROPULSION		35
7	AIR INDUCTION		30
8	AIRFRAME		100
	STABILIZE AND CONTROL	50	
	PERFORMANCE	40	
	STRUCTURES	10	
9	ECS		0
11	FLIGHT CONTROL		0
12	FLIGHT INDICATION		0
13	SECONDARY POWER		0
14	PERSONNEL ACCOM		0*

*ESCAPE SYSTEM TEST BEDS = 120 HR. COMPARED TO 65 HR. PLANNED.

XB-70 PROGRAM ~ FL HT HOUR SUMMARY
PRIMARY AIR BEHICLE EQUIVALENT FLIGHT TEST HOURS

PRIMARY AIR VEHICLE SYSTEMS	BASIC FLIGHT HOURS CHARGED PER SYSTEM	PERCENT FLIGHT HOURS ADDITIVE DUE TO TIME-SHARING												NET TIME SHARING (HOURS)	TOTAL EQUIVALENT FLIGHT TEST HOURS
		AIR VEHICLE	PROPULSION	AIR INDUCTION	STABILITY & CONT.	PERFORMANCE	STRUCTURES	ALIGHT & ARREST	ECS	FLIGHT CONT.	FLIGHT INDICATION	SECONDARY PWR	PERSONNEL ACCOM		
AIR VEHICLE	20	-	-	-	-	-	-	-	-	-	-	-	-	-	20
PROPULSION	35	-	-	50	10	50	-	-	-	-	-	-	-	40	75
AIR INDUCTION	30	-	60	-	10	50	-	-	-	-	-	-	-	45	75
STABILITY AND CONTROL	50	-	10	10	-	25	50	-	-	-	-	-	-	20	70
PERFORMANCE	40	-	50	50	25	-	-	-	-	-	-	-	-	45	85
STRUCTURES	10	-	20	20	50	25	-	-	-	-	-	-	-	50	60
ALIGHT AND ARREST	0	-	20	20	20	20	20	-	-	-	-	-	-	35	35
ECS	0	-	10	10	10	10	50	-	-	-	-	-	-	20	20
FLIGHT CONTROL	0	-	10	10	75	10	25	-	-	-	-	-	-	50	50
FLIGHT INDICATION	0	-	10	10	50	25	25	-	-	-	-	-	-	45	45
SECONDARY POWER	0	-	100	20	10	10	10	-	-	-	-	-	-	50	50
PERSONNEL ACCOM	120	-	10	10	10	10	10	-	-	-	-	-	-	15	135
													TOTAL		720

XB-70 PROGRAM ~ FLIGHT HOUR EXPOSURE BASED ON RS-70 PROGRAM TO BE UNITY



FLIGHT ENVELOPE
XB-70 Vs RS-70

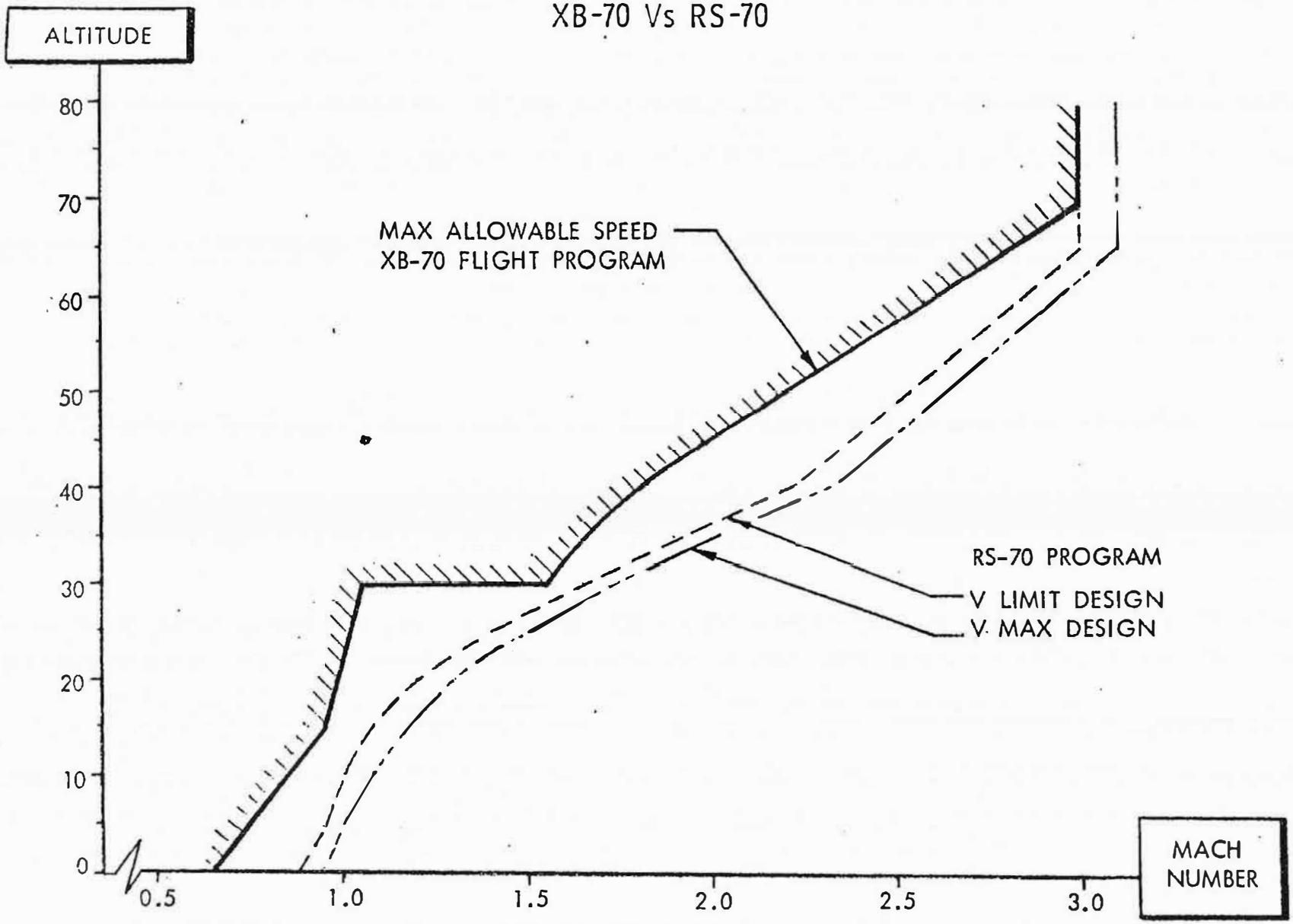


EXHIBIT 14

SST INSTRUMENTATION

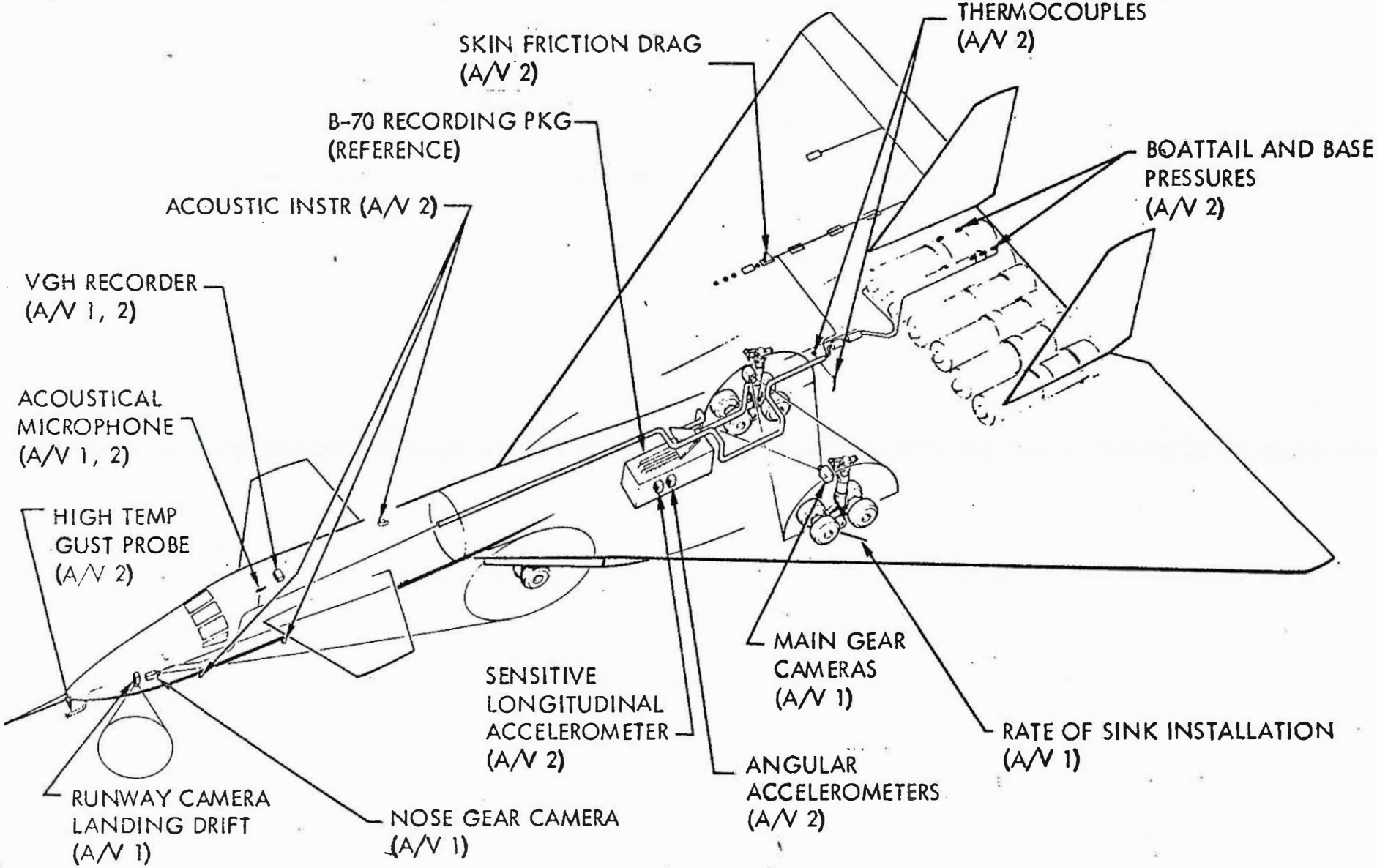
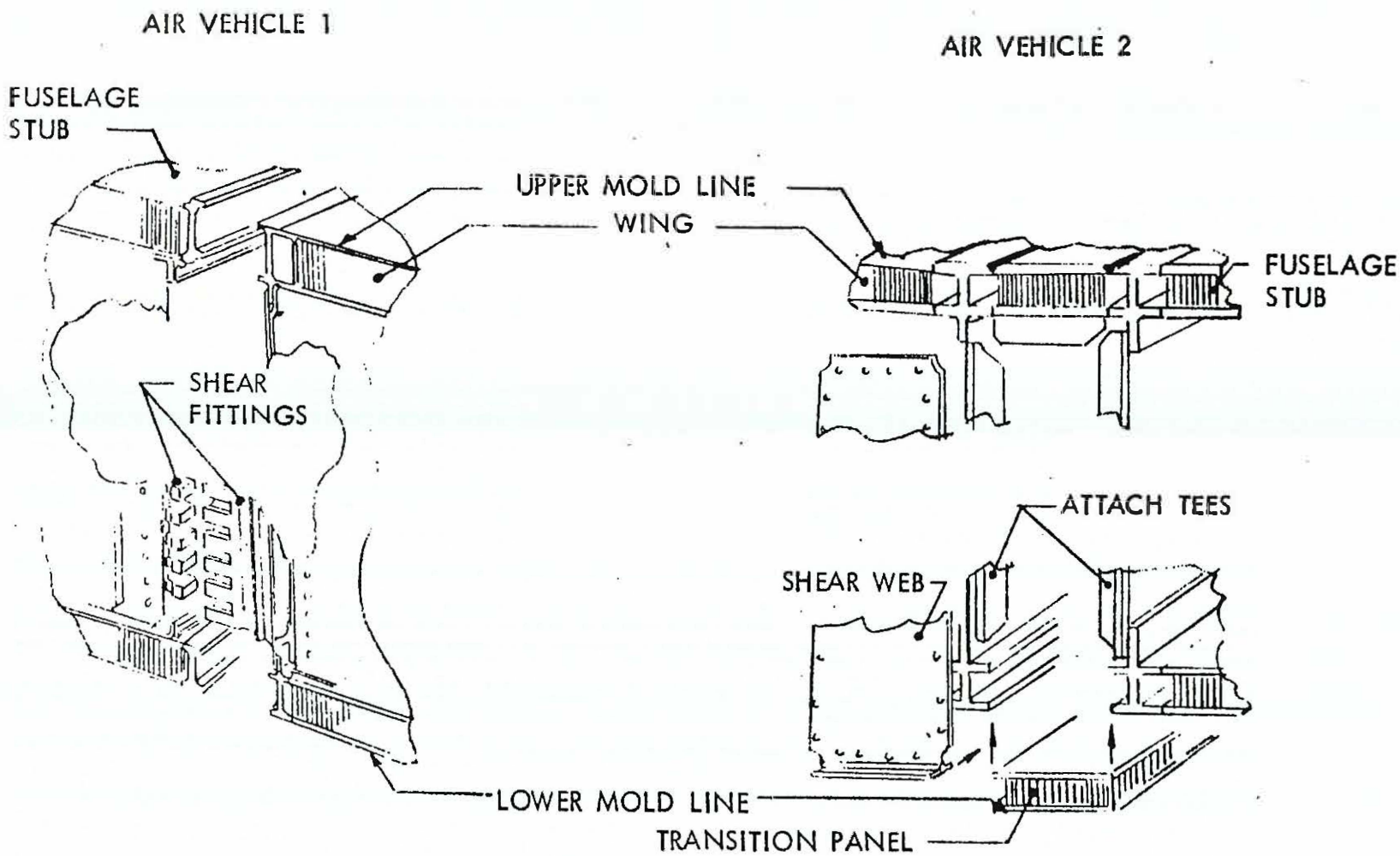
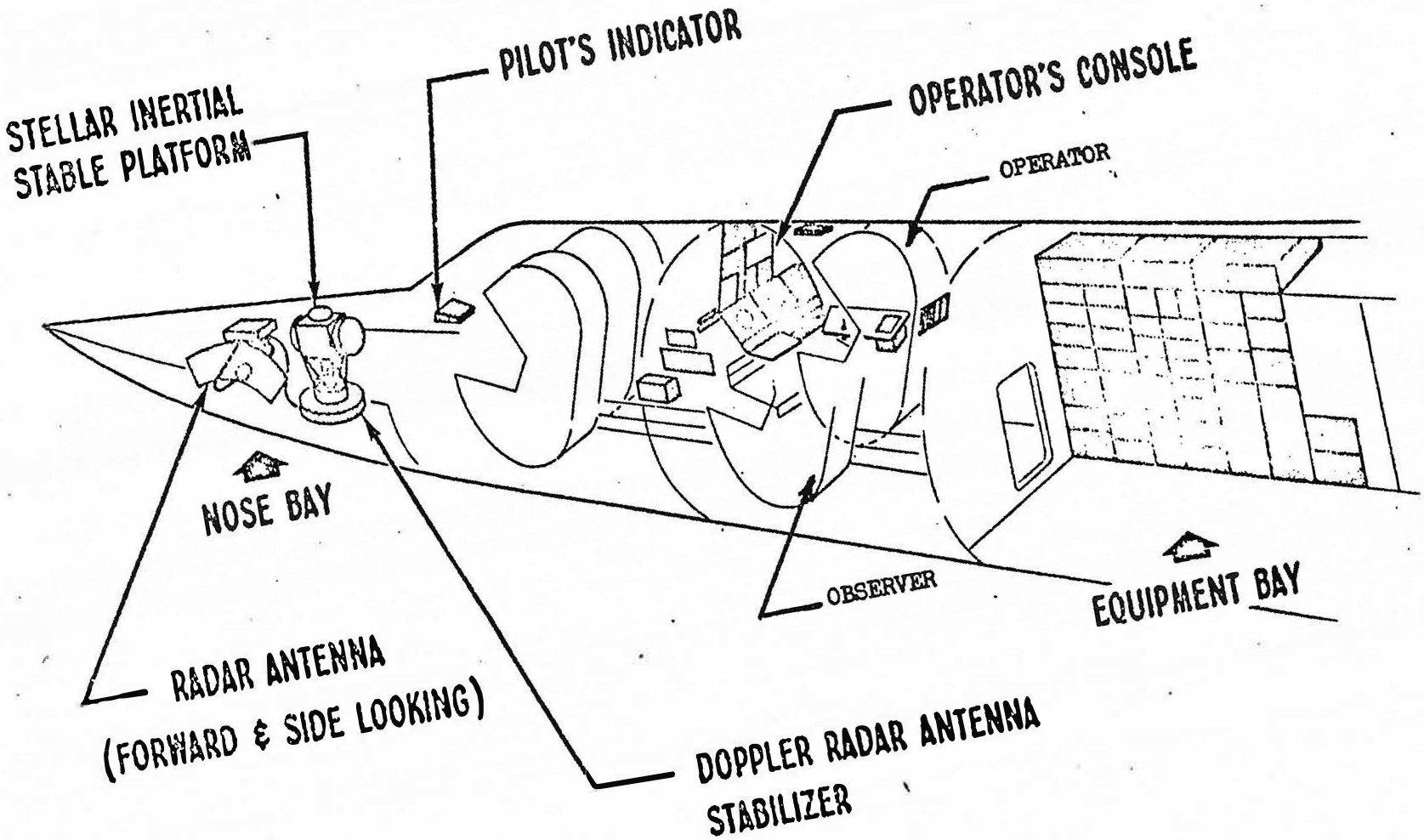


EXHIBIT 15

WING TO FUSELAGE JOINING



BN&MG SUBSYSTEM INSTALLATION
AIR VEHICLE NO 3

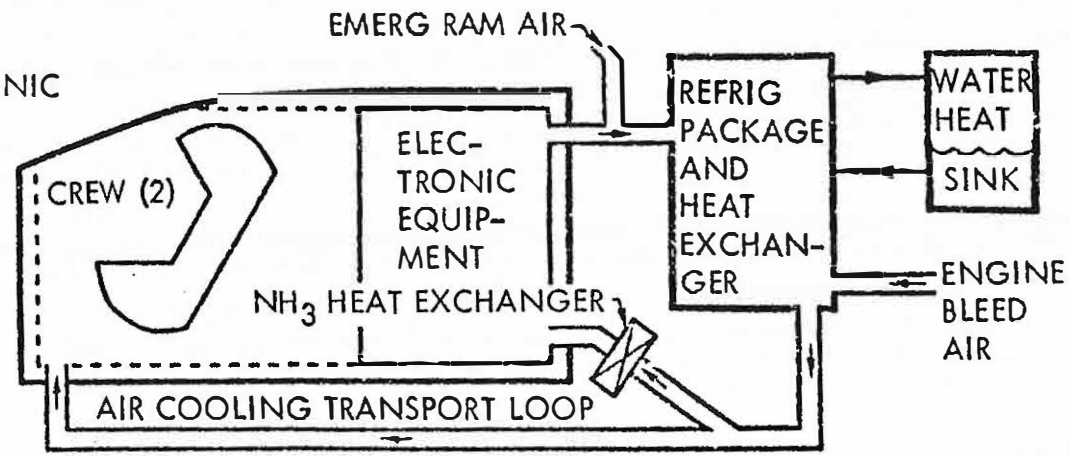


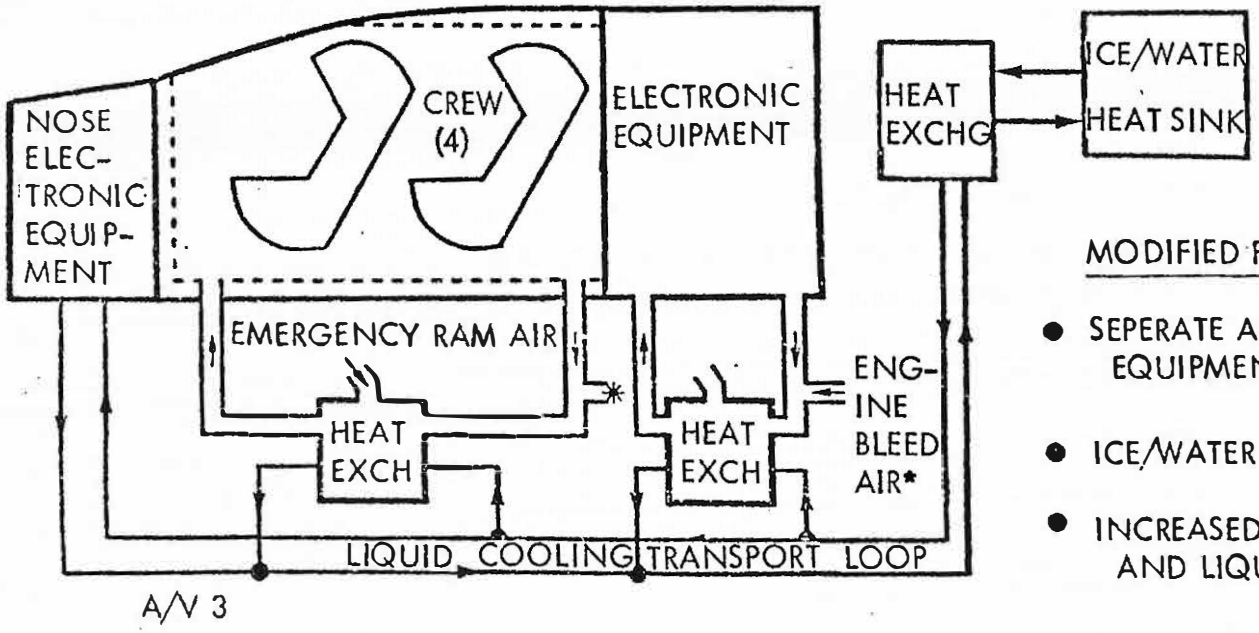
ENVIRONMENTAL CONTROL SUBSYSTEM

BASIC

- SINGLE AIR LOOP-CREW AND ELECTRONIC EQUIPMENT
- PNEUMATIC DRIVE (ENGINE BLEED) -FREON COMPRESSOR
- PRIMARY COOLING-AIR LOOP

A/V 1&2

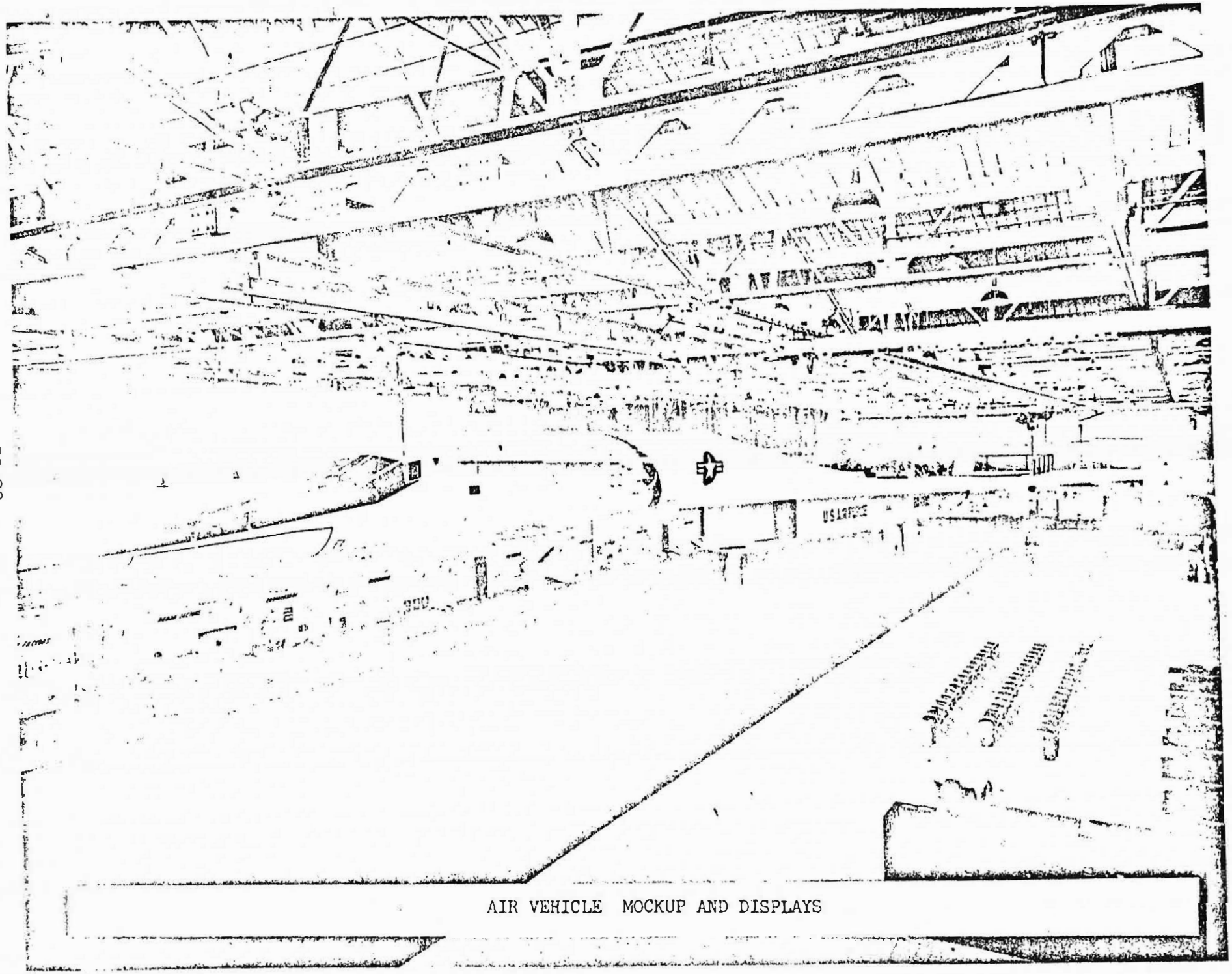




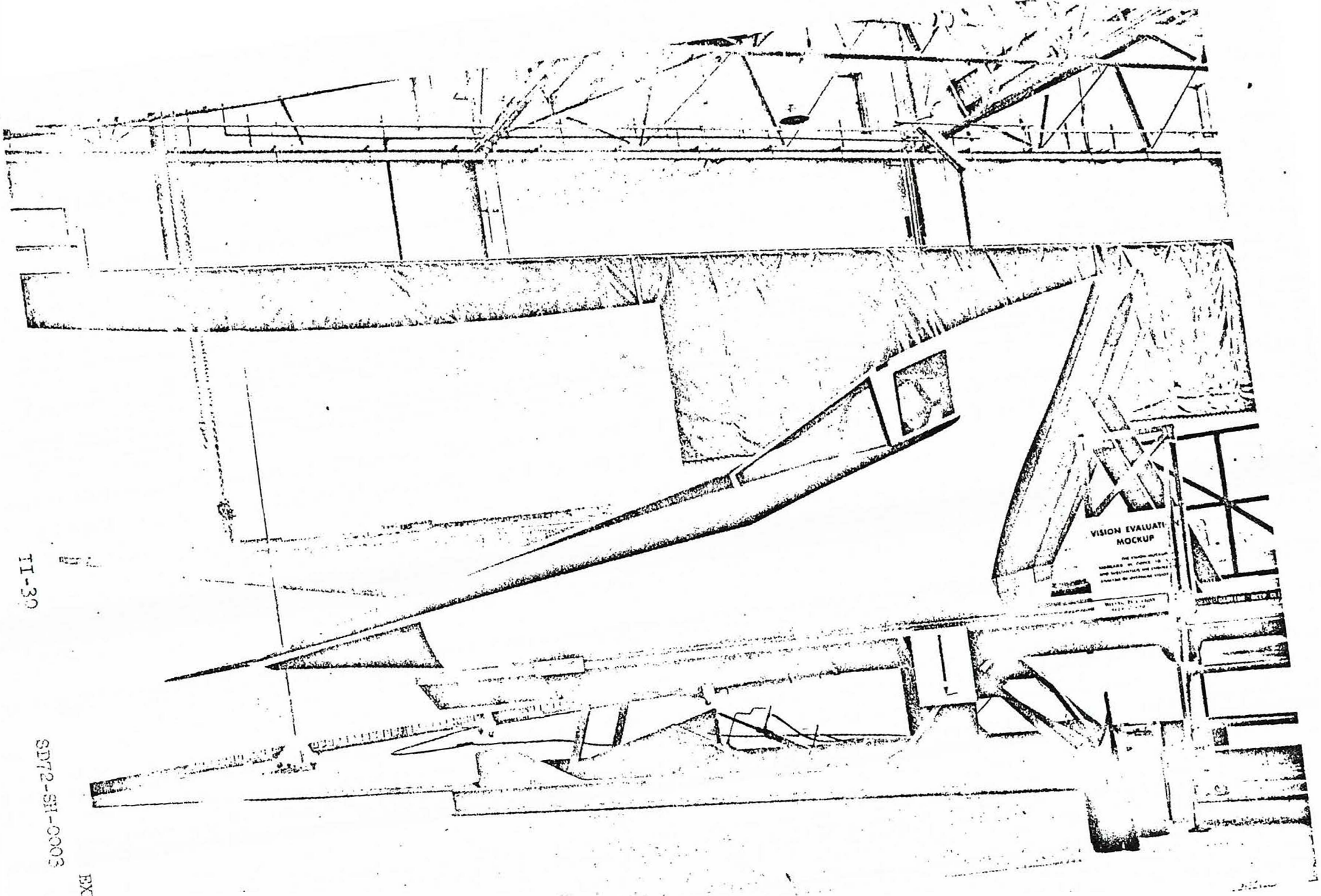
A/V 3

MODIFIED FOR BOMB-NAV SYSTEM

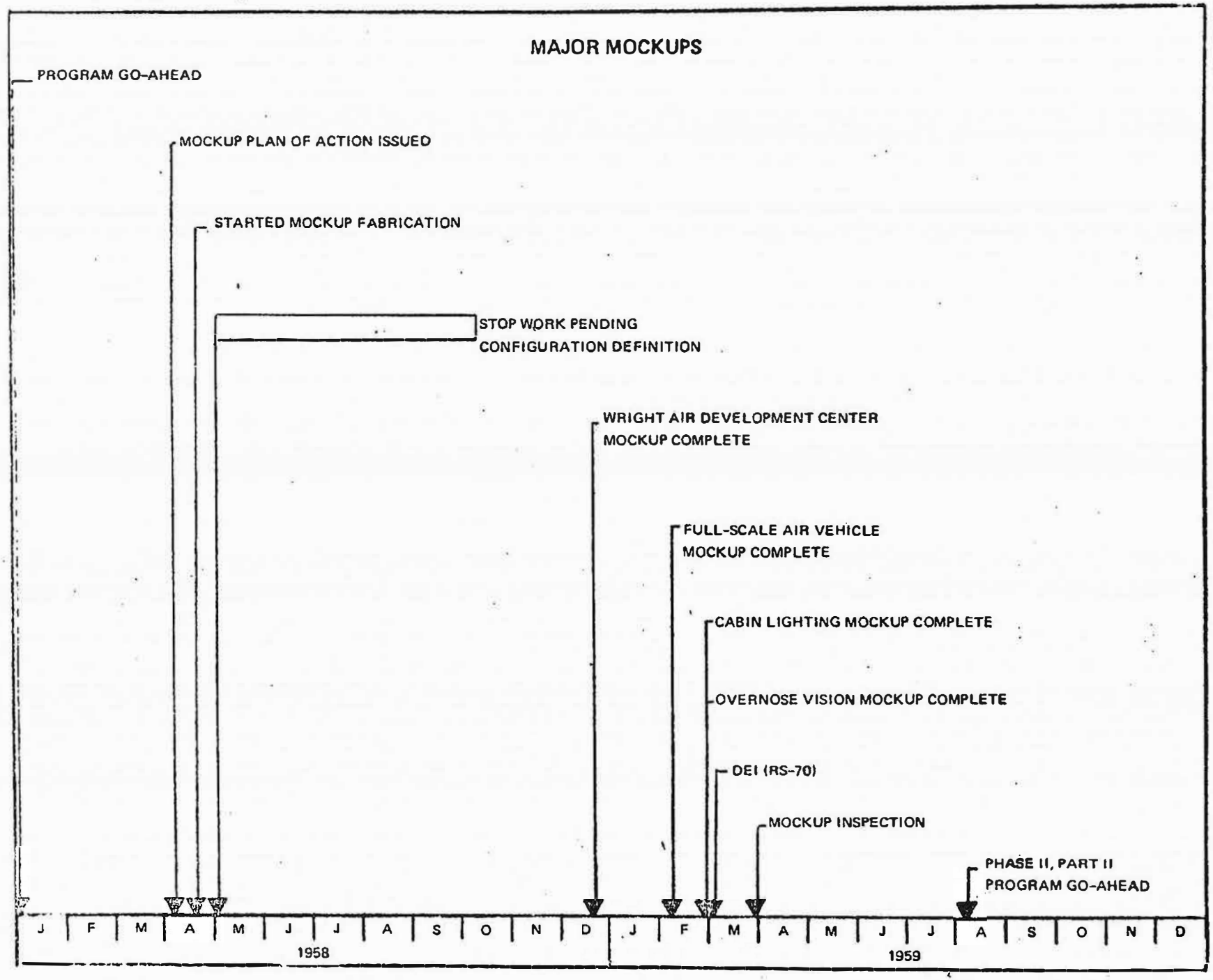
- SEPERATE AIR LOOPS-CREW AND ELECTRONIC EQUIPMENT.
- ICE/WATER HEAT SINK
- INCREASED PRIMARY AIR COOLING CAPACITY AND LIQUID LOOPS



AIR VEHICLE MOCKUP AND DISPLAYS



OVER-NOSE VISION MOCKUP


MAJOR MOCKUPS
PROGRAM GO-AHEAD
MOCKUP PLAN OF ACTION ISSUED
STARTED MOCKUP FABRICATION
STOP WORK PENDING
CONFIGURATION DEFINITION
WRIGHT AIR DEVELOPMENT CENTER
MOCKUP COMPLETE
FULL-SCALE AIR VEHICLE
MOCKUP COMPLETE
CABIN LIGHTING MOCKUP COMPLETE
OVERNOSE VISION MOCKUP COMPLETE
DEI (RS-70)
MOCKUP INSPECTION
PHASE II, PART II
PROGRAM GO-AHEAD
J F M A M J J A S O N D
1958
J F M A M J J A S O N D
1959