2

GE-RESD Proposal N-72469

FINAL REPORT FOR THE STUDY OF A BIORESEARCH MODULE DESIGN DEFINITION AND SPACE SHUTTLE VEHICLE INTEGRATION

VOLUME 3
MANAGEMENT AND FUNDING PLAN

15 December 1971

Distribution of this report is provided in the interest of information exchange. Responsibility for the contents resides in the author or organization that prepared it.

Prepared under Contract No. NAS2-6523
by General Electric Company
Re-entry & Environmental Systems Division
Philadelphia, Pennsylvania

for

Ames Research Center
National Aeronautics and Space Administration

GENERAL ELECTRIC

Re-entry & Environmental Systems Division

III

TABLE OF CONTENTS

Section		Page
	INTRODUCTION	I-1
I	MANAGEMENT PLAN	1-1
	A. Summary	1-1
	B. Organization and Management	1-2
	1.0 Corporate Organization	1-2
	2.0 Division Organization	1-3
	3.0 Bioresearch Module Project Team	1-4
	C. Communications, Documentation and Reports	1-5
	1.0 Communications	1-5
	2.0 Documentation and Reports	1-5
	3.0 Quality Assurance and Reliability Plans	1-7
	4.0 Interface Definition and Control	1-7
	5.0 Technical Reports and Data	1-8
	6.0 Technical Progress Reporting	1-8
	7.0 Technical Meetings and Reviews	1-8
	D. Project Planning, Direction, and Control	1-9
	E. Related Experience and Facilities	1-11
	1.0 Introduction	1-11
	2.0 Related Experience	1-11
	3.0 Facilities	1-20
II	FUNDING PLAN	2-1
	A. Ground Rules and Assumptions	2-1
	B. Program Schedule	2-6
	1.0 Scope	2-6
	2.0 Equipment Development	2-7
	3.0 Program Schedule	2-7
	C. Manpower Plan	2-7
	D. Estimated Costs Summary	2-14
III		

LIST OF ILLUSTRATIONS

Figure		Page
I. B-1	General Electric Corporate Organization	1-3
I. B-2	General Electric Re-entry and Environmental Systems Division Organization	1-4
I. B-3	Bioresearch Module Project Organization	1-6
I. E-1	Major General Electric Space Vehicle Programs	1-12
II-B-1	Bioresearch Module Prototype Development Program Schedule	2-8
II-B-2	Bioresearch Module Development Plan Option I	2-9
II-B-3	Bioresearch Module Development Plan Option II	2-10
II-B-4	Bioresearch Module Development Plan Option III	2-11
II-B-5	Bioresearch Module Development Plan Option IV	2-12
II-C-1	Manpower Loading Plan (Option II)	2-13

LIST OF TABLES

Table		Page
I. E-1	Major Tests and Planned Facilities Usage	1-23
I. E-2	Digital Computer Systems and Peripheral Equipment	1-24
II. D-1	Time-Phased Estimates of Design, Development, Fabrication, Procurement, Assembly and Test Through Prototype System Qualification	2-15
II. D-2	Time-Phased Estimates for Four Optional Program Plans for Flight Module Processing	2-16
II. D-3	Cost Estimates for Type II Attitude Control, Mission III, S-Band, Television/MSFN and Reduced Power Options	2-17

INTRODUCTION

The Re-entry and Environmental Systems Division (RESD) of the General Electric Company is pleased to submit this document covering the Final Report for the Study of a Bioresearch Module Design Definition and Space Shuttle Vehicle Integration. This document has been prepared under NASA/ARC Contract NAS 2-6523 and submitted in response to contract Specification and Work Statement A-17193 and related specifications and attachments.

The objective of the study was to use the baseline preliminary design developed for the Bioexplorer spacecraft under the previous NASA/ARC Contract NAS 2-6027, and devote further study effort in areas of thermal control, attitude control and power subsystem design, and evaluate the use of the Space Shuttle Vehicle (SSV) as a potential launch and recovery vehicle for the Bioresearch Module (formerly called Bioexplorer).

The results of the study are to include: a refinement of the baseline design definition of a Bioresearch Module as a Scout-launched payload to accomplish Missions I and II as defined in the specification; an evaluation of the design impact of using the SSV to launch the Bioresearch Module for Missions I, II and III and recover Missions I and II; and a preliminary definition of the Space Shuttle Vehicle/Bioresearch Module interfaces involved in the conduct of the missions defined.

The Final Report is submitted in three (3) volumes. Volume 1 contains the results of the technical work performed during the study in accordance with the contract work statement. Volume 2 presents the updating and modifications to the Preliminary Spacecraft Development Program Plan developed under Contract NAS 2-6027, as influenced by the results of the changes or revisions to the design, development, fabrication and test programs as determined and evaluated during the conduct of this Bioresearch Module Study. Volume 3 - the Management and Funding Plan - provides a description of the proposed project organization; communications; documentation and reports; project planning, direction and control; related experience and facilities; and cost estimate data and options for the implementation of the Bioresearch Module development program.

This volume is Volume 3 - Management and Funding Plan.

The experienced systems engineering and design and analysis personnel, as well as senior quality assurance, manufacturing and test personnel, who were available at GE-RESD from the recently completed NASA Bioexplorer Study Program were utilized to conduct and support the study phase and spacecraft development planning for the Bioresearch Module Project.

Besides fulfilling the final report requirements of the Bioresearch Module Study Contract, GE-RESD hopes that the material furnished in these three volumes can serve as a basis for continued work and planning leading to the crystallization and implementation of a viable and on-going Bioresearch Program. To any future development phases, GE-RESD offers its unique resources of experienced technical and management personnel, facilities and flight-proven hardware designs resulting from the development and flight of numerous space systems programs, including its demonstrated performance and directly applicable experience from NASA's series of Biosatellite space biology missions.

GE-RESD welcomes the opportunity to be of additional service to the Bioresearch Module Project in terms of preparing and/or conducting presentations and proposals which NASA/ARC may consider useful to the interpretation of the material furnished herein or to the contribution of follow-on program implementation planning.

I. MANAGEMENT PLAN

A. SUMMARY

The General Electric Company has been in business for almost eighty years and has evolved a diverse product line involving many technologies. Because of the corporate structure, the resources of the total company are available to assist in the successful implementation of the Bioresearch Module Program.

The Re-entry and Environmental Systems Division is uniquely qualified to manage and direct the Bioresearch Module Program because it has broad experience in space systems ranging from re-entry systems to orbiting spacecraft, thus involving all of the technology areas associated with the space program. In addition, it is currently involved in non-aerospace areas of work actively applying space technology to such things as water and air pollution, housing, ocean systems, and medical and health care problems.

GE-RESD offers the capability of the team that developed the Biosatellite spacecraft/experiment system for the conduct of the Bioresearch Module Program. This team benefitted from six years of design, development, integration, and operations experience in conjunction with the NASA/Experimenter team. A considerable portion of the funds expended on this program were devoted to development of the team capability to perform the specialized task of biological experiment/spacecraft equipment design, development and operations. This team is now on the most cost-effective portion of the learning curve required to perform the Bioresearch Module Program.

From the Biosatellite Program, GE-RESD has learned how to provide the management and technical resources to meet the stringent requirements of space biology flight missions. In the process, rapport and respect between the engineer and biologist has been established which greatly enhanced the efficient implementation of this space biological research program.

The management plan furnished herein includes the proposed project organization for the conduct of the Bioresearch Module Program, communication and documentation procedures, methods for controlling project planning and direction, and additional GE-RESD qualifications in terms of related experience and facilities. The funding plan provides time-phased funding requirements for various elements and options of the proposed program compatible with: (1) the Bioresearch Module designs modified from the baseline Bioexplorer preliminary design, as discussed in Volume 1; (2) the Bioresearch Module Development Program Plan furnished in Volume 2; and (3) the Cost Analyses Guidelines provided in NASA/ARC Letter PEF-204-5(169L), dated September 3, 1971.

B. ORGANIZATION AND MANAGEMENT

1.0 CORPORATE ORGANIZATION

The General Electric Company is organized into 11 product groups reporting to the Corporate Executive Office. Each group is composed of a number of divisions which are charged with the responsibility of fulfilling their business objectives and obligations. The Bioresearch Module Project will be performed within the Re-entry and Environmental Systems Division (RESD) of the Aerospace Group (see Figure I. B-1). Mr. Mark Morton, a General Electric Vice President, is the Aerospace Group Executive and the RESD division is under the leadership of Mr. Otto Klima, Jr., Corporate Vice President and Division General Manager.

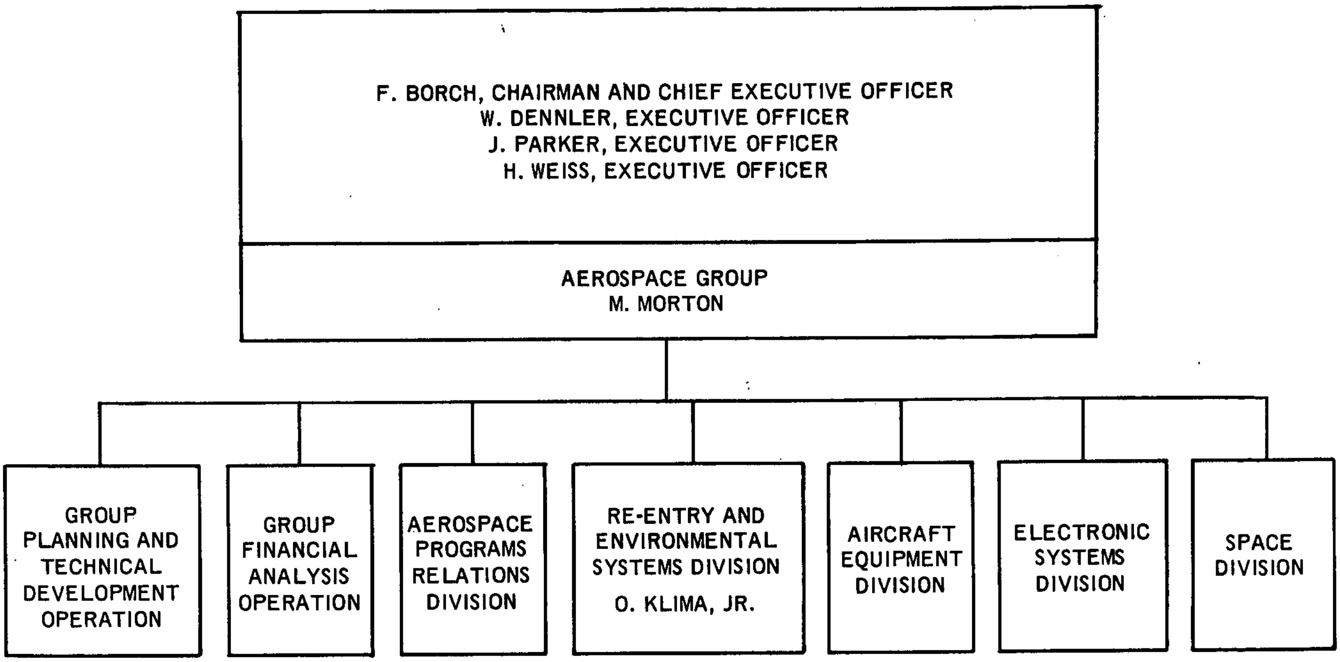


Figure I. B-1. General Electric Corporate Organization

2.0 DIVISION ORGANIZATION

In the Program Management/Functional Organization structure of GE-RESD, as illustrated in Figure I. B-2, a number of Program Management Sections have been established: Space Re-entry Systems, Strategic Systems, Ocean Systems, Urban Systems and Operational Systems. These sections are supported by the functional organizations of Research and Engineering, Operations and Evaluation (which includes Systems Test and Operations, Manufacturing, and Quality Assurance) as well as the service organizations such as Finance, Legal, and Contracts.

Space re-entry systems programs are performed under the direct management of Mr. Walter D. Smith, General Manager, Space Re-entry Systems Programs. This organization contains all of the technical and management people who performed the Biosatellite Program, the Bioexplorer Study Project, the Bioresearch Module Study, the Mars Lander Studies, and who are managing the Military Space Re-entry Programs, the Viking Support Program, NASA MAN-MATE Space Manipulator Program, and the Space Transport System Studies.

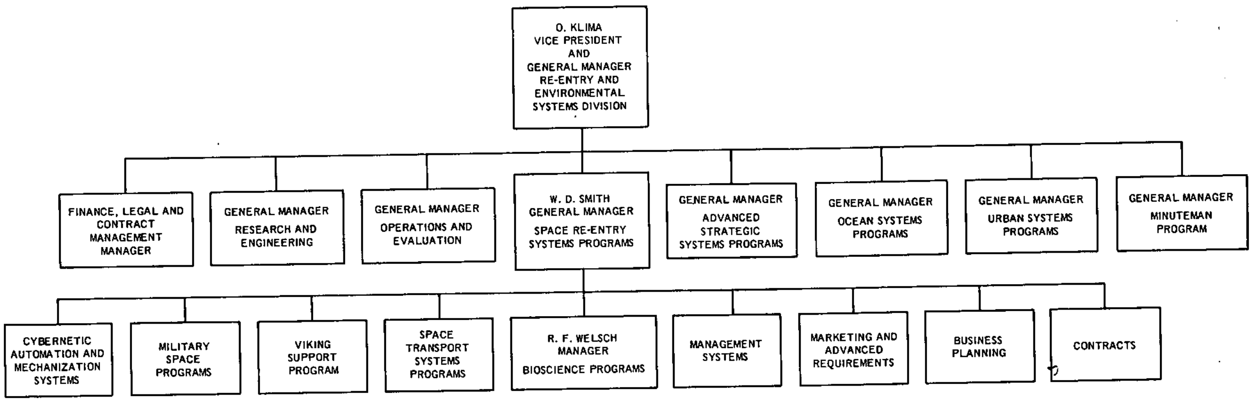


Figure I.B-2. General Electric Re-entry and Environmental Systems Division Organization

As evidence of the importance placed by GE-RESD on the Bioresearch Module Study Project, it has been placed in the Bioscience Programs office managed by Mr. Raymond F. Welsch, which is at the same organizational level as such major prime contract programs as the recently completed Biosatellite and the Minuteman Mark 12 Re-entry Systems, with Mr. Welsch reporting directly to the General Manager, Mr. Walter D. Smith.

3.0 BIORESEARCH MODULE PROJECT TEAM

Mr. Vincent C. Deliberato has been assigned as the Bioresearch Module Project Manager. He reports directly to Mr. Raymond F. Welsch and is responsible for performance of the Bioresearch Module development project proposed herein. He was selected because of his directly applicable technical and management experience developed on previous space re-entry programs, including his extensive participation in and overall management of the NASA Biosatellite Program.

Mr. Deliberato's project team which will conduct the Bioresearch Module development is shown in Figure I. B-3. Experienced personnel, who have participated in the Biosatellite Program which involved the design, test and flights of the sophisticated and complex automatic spacecraft with extensive experiment interfaces, are available and will be assigned to the project team as required; including personnel from Engineering, Quality Assurance, Reliability, Manufacturing, Test, Operations and Finance and Contract Management support.

To enhance the efficient conduct of the project and provide for effective communications, the project team will be located in a centralized area set aside at the GE Re-entry and Environmental Divisional Headquarters at 3198 Chestnut Street, Philadelphia, Pa.

C. COMMUNICATIONS, DOCUMENTATION AND REPORTS

1.0 COMMUNICATIONS

Technical communication lines shall be established and maintained between the NASA/ARC Technical Monitor's office and the GE-RESD Project Manager's office to monitor and track the free exchange of engineering data between NASA and GE. These procedures are primarily required to ensure that all technical direction is consistent with contractual direction, and that required technical data is identified, assigned and available in a timely and efficient manner. To assist in these important areas, project meetings and required documents will be identified and scheduled during the Bioresearch Module Development Program.

2.0 DOCUMENTATION AND REPORTS

2.1 Project Development Plan

Within 60 days from contract, a Project Development Plan (PDP) shall be submitted to NASA/ARC for review and approval. It shall be the purpose of the PDP to provide a complete and comprehensive plan for accomplishing the Bioresearch Module development; including the design, fabrication and test efforts leading to the delivery of a fully tested and qualified spacecraft for the Bioresearch Module missions.

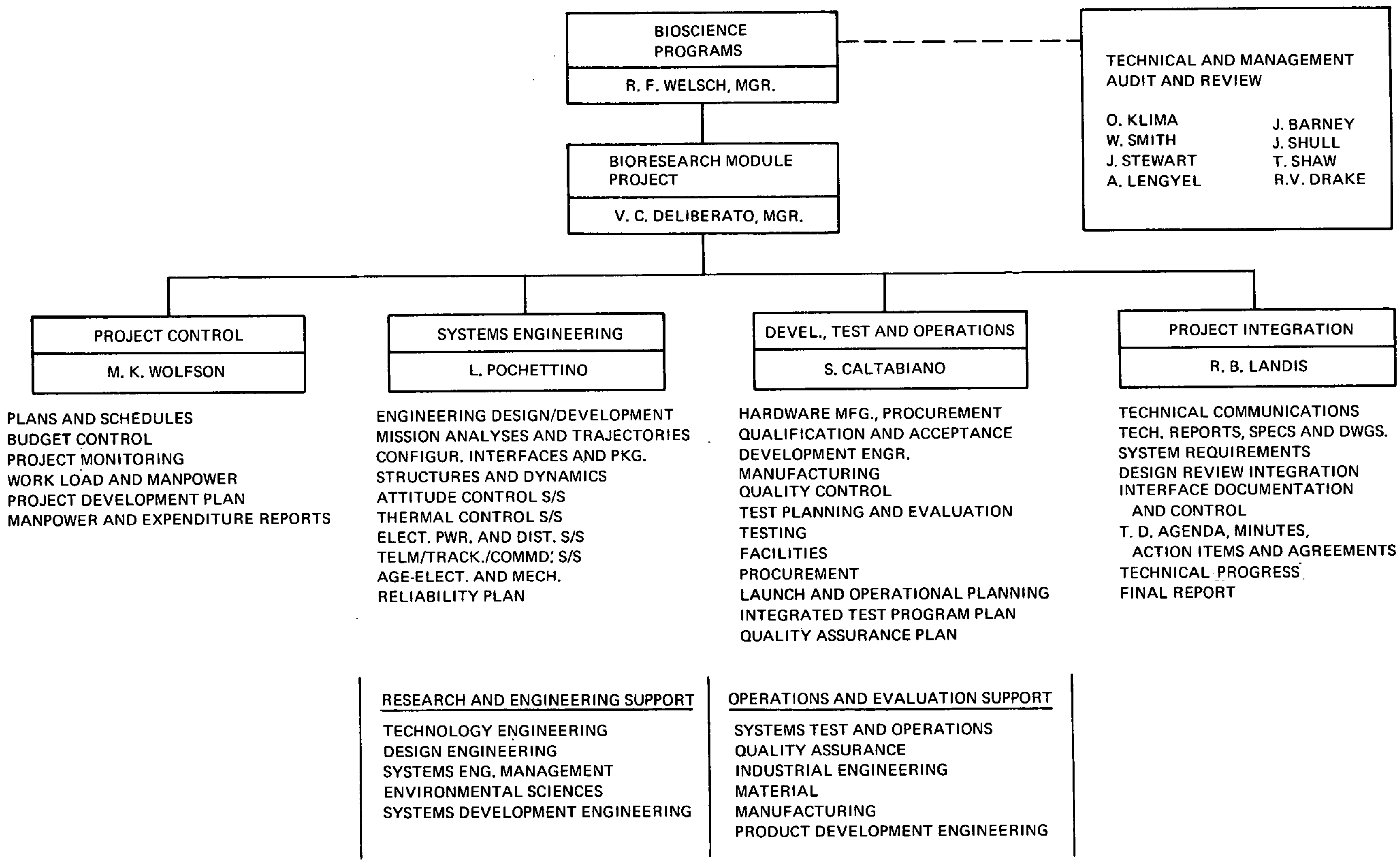


Figure I. B-3. Bioresearch Module Project Organization

Once approved, subsequent revisions of the PDP shall also be submitted for NASA review and approval.

2.2 Integrated Test Program Plan

Within 90 days from contract, an Integrated Test Program Plan (ITPP) shall be submitted to NASA/ARC for review and approval. This comprehensive plan shall describe all of the testing to be conducted on the Bioresearch Module system, subsystem, components, and parts, and shall list all of the items to be tested at the development, qualification, and acceptance test levels.

A test flow sequence shall be included, showing the planned sequence of testing of all hardware through the development, qualification and acceptance phases. The flow chart shall include components, subsystems, and systems, as well as covering interface compatibility and verification tests. The ITPP shall also make reference to procedures for special testing required by such items as "one shot" devices (e.g., batteries, pyrotechnics, etc.) or for the effects of shelf life, diagnostic performance tests or similar screening. On approval of the ITPP, all revisions, deletions or additions will also require NASA review and approval.

3.0 QUALITY ASSURANCE AND RELIABILITY PLANS

Plans for implementing both Quality Assurance and Reliability procedures for the Bioresearch Module shall be prepared and submitted within 90 days from contract for NASA review.

4.0 INTERFACE DEFINITION AND CONTROL

In conjunction with NASA/ARC, General Electric will designate a point of contact to be specifically responsible for developing interface definition and control procedures for the Module/Experiment interface and the Module/Launch Vehicle interface. Authority will be vested in the GE representative to accept, by signature, the defined interfaces or changes thereto and, should untimely changes affect existing design and fabrication schedules and thereby increase costs, it shall be the responsibility of the interface control representative to obtain and report such affects to NASA in lieu of accepting the proposed change to the interface.

5.0 TECHNICAL REPORTS AND DATA

All technical reports, specifications and data pertaining to the development of the Bioresearch Module shall be forwarded to NASA/ARC for review and/or approval. Such documents include system, subsystem and component specifications, drawings, analyses, test data and discrepancy reports. A listing of such reports categorizing those requiring NASA approval, as opposed to those forwarded for information, shall be negotiated on award of contract.

6.0 TECHNICAL PROGRESS REPORTING

Informal Monthly Technical Progress Reports shall be prepared and forwarded to NASA/ARC for each month from the start of the contract through completion. Such reports shall contain a summary of the work accomplished covering significant events, problem areas, proposed resolution of problems, and planned work. A final technical report covering the complete development of the Bioresearch Module program shall be prepared and submitted within 90 days from program completion.

7.0 TECHNICAL MEETINGS AND REVIEWS

7.1 Design Reviews

Two major and comprehensive design reviews shall be held at GE-RESD for NASA/ARC approval during the Bioresearch Module design phase. The Preliminary Design Review (PDR) shall be held approximately 3 months from contract award; a Critical Design Review (CDR) shall be held approximately 10 months later. Two weeks prior to each design review, a data package, consisting of the technical material to be presented at the meeting, will be forwarded to NASA/ARC for their information. Action items resulting from the meeting shall be assigned, scheduled, tracked, and reported through the Project Manager's office.

7.2 Technical Direction Meetings

Technical Direction (T. D.) Meetings shall be held at 8 to 10 week intervals starting 90 days from contract award and held alternately at GE-RESD and NASA/ARC. Items to be presented and an agenda for the meeting will be recommended by General Electric to NASA two weeks prior to the meeting date. Minutes of the meeting, including all assigned action items and agreements, shall be prepared by GE and issued within two weeks following the meeting.

7.3 Pre-Ship Review

On completion of the Bioresearch Module testing, and prior to shipment from GE-RESD, a Pre-Ship Review Meeting will be held at GE-RESD for NASA/ARC.

All credentials for acceptance of the Bioresearch Module will be presented, reviewed, and supported by inspection and test data. The cognizant quality assurance manager shall co-chair the meeting with the project manager to provide complete supporting data for NASA review.

D. PROJECT PLANNING, DIRECTION, AND CONTROL

The Bioresearch Module Project Manager's responsibility for planning, direction, and control will be greatly facilitated by the team concept, which will permit efficient centralized planning, scheduling, and program execution in one location.

A key feature of this one-location team concept is that the Project Manager can, by direct communication with his team members, plan and implement the varied tasks involved to produce a well-integrated engineering design. The walls of this centralized area will be utilized for network charts similar to those employed for the Biosatellite Control Room (scoped, of course, for the Bioresearch Module Program requirements). A logic network of significant events, along with contractual schedule constraints, will be developed from which optimum schedules for program tasks can be determined, as well as identification and interdependencies of critical paths. The system provides excellent visibility on status, progress, and problem areas, is easily modified and updated and provides an excellent method for defining, planning, and identifying action plans to ensure their compatibility with overall objectives and requirements.

Two basic documents, issued and controlled by the Project Manager, will be used to provide and confirm official planning for program objectives, requirements, execution, and cost control. These documents are as follows:

(1) Program Planning Instruction (PPI) - This document defines what is to be done and when, in accordance with contractual and specification requirements. It provides the overall Program guidelines and baselines to the functional organizations for their detailed planning. The detail planning, in turn, is fed back to the Project Manager for review and updating during the life of the program.

(2) Program Directives (PD) - These directives are issued to the functional organizations to provide definition of the work to be performed, the time period during which it is to be done, and the authorized funding level. The PD's establish the shop order structure, tasks to be performed, milestone schedule, and time-phased funding to provide an integrated control function between the Project Manager and the performing operations. The PD is the official document by which the Project Manager exercises cost and schedule baseline definition and control.

In addition, the Project Manager will receive weekly manpower and financial reports from which he will determine variances in manpower and costs and in turn initiate and implement any corrective actions necessary to fulfill the requirements of the PPI and PD.

E. RELATED EXPERIENCE AND FACILITIES

1.0 INTRODUCTION

GE-RESD has extensive experience and capabilities in spacecraft design, development and flight operations. In addition, the Division may draw upon the many specialized resources of the Company thus broadening these capabilites and assuring the fulfillment of program requirements in an expeditious manner.

The facilities required are currently available and include those necessary for office and laboratory space, manufacturing, assembly and test.

This section provides a summary of related experience and the facilities available.

2.0 RELATED EXPERIENCE

2.1 Systems Management

GE-RESD has been involved in the space program for fifteen years and has in-depth experience in the design, development and operation of complex systems. Programs have included the development and production of both ballistic and re-entry (or out-of-orbit) systems.

During this period, contracts for more than 30 separate flight vehicle programs were awarded and involved more than 500 spacecraft flights. The breadth of experience gained in these programs is summarized in Figure I. E-1.

Systems management has been a key factor in many of these programs. For example, on the Air Force 698BJ Recoverable Satellite Program, GE-RESD was responsible for design integration of the payload, vehicle and Agena Booster, command and control systems, engineering qualification tests, vehicle flight test program, reliability program, personnel subsystem, MAB systems test, operational mission support, on-station AGE, recovery support and data reduction.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

ENTRY VEHICLES

SYSTEM	RE-ENTRY MEASUREMENT VEHICLE	NERV RECOVERY VEHICLE BIOS I RECOV. VEH. (EXPERIMENTAL)	NIKE-ZEUS TARGET RE-ENTRY VEHICLE (PRODUCTION)	MARK 3C TP (EXPERIMENTAL)	TRAILBLAZER BOOSTER RE-ENTRY VEHICLE (EXPERIMENTAL)	MK. 6 BALLISTIC MISSILE RE-ENTRY VEHICLE (PRODUCTION)	MK. 7 SKYBOLT RE-ENTRY VEHICLE	MK. 3 BALLISTIC MISSILE RE-ENTRY VEHICLE (PRODUCTION)	RVX-2 & 2A RE-ENTRY VEHICLE (EXPERIMENTAL)
GE CONTRACT	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO NASA	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	SUBCONTRACTOR TO MIT - LINCOLN LABS.	PRIME CONTRACTOR TO USAF	SUBCONTRACTOR AND PRIME TO DOUGLAS TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF
MISSION OR PAYLOAD	EXPERIMENTAL EVALUATION TARGET VEHICLE TO EVALUATE NIKE X RADAR.	NUCLEAR EMULSION PACK FOR RADIATION MEASUREMENTS.	ICBM RE-ENTRY VEHICLE SIMULATOR.	RADAR, PHOTOGRAPHY SYSTEM AND VIDEO FOR TERMINAL GUIDANCE VIA MAP MATCH.	HYPERVELOCITY RE-ENTRY RESEARCH RADAR TARGET PAYLOAD.	ICBM WARHEAD.	AIR-TO-SURFACE BALLISTIC MISSILE WARHEAD.	ICBM WARHEAD.	SPACE LAB. EXPERIMENTS, PHOTO SYSTEM, BIO-SPECIMENS, RADIATION, FUEL CELL, E M PROPAGATION, RE-ENTRY MATERIAL, AND ENVIRONMENT.
SYSTEM RESPONSIBILITY	DESIGN, DEVELOP, FAB., TEST VEHICLE SYSTEM AND RADAR POSITION REFERENCE SYSTEM; INTEGRATE WITH NIKE-X SYSTEM; SUPPORT LAUNCH, CONTROL AND RANGE OPERATIONS, PHOTO COLLECTION AND POST FLIGHT DATA REDUCTION AND ANALYSIS.	DESIGN, DEVELOP, FAB., TEST VEHICLE SYSTEM; INTEGRATE WITH EXPERIMENTERS AND LAUNCH SYSTEM; SUPPORT LAUNCH, CONTROL, AND RECOVERY OPERATIONS; POST FLIGHT ANALYSIS OF FLIGHT DATA.	DESIGN, DEVELOP, FAB., TEST COMPLETE VEHICLE SYSTEM WITH COMPLEX ATTITUDE AND ENVIRONMENT SENSING SYSTEM; INTEGRATE WITH NIKE-ZEUS SYSTEM; SUPPORT LAUNCH, CONTROL, AND RECOVERY OPERATIONS, POST FLIGHT DATA ANALYSIS.	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE AND GUIDANCE SYSTEM; SUPPORT LAUNCH AND CONTROL OPERATIONS; DATA COLLECTION, REDUCTION AND ANALYSIS. RESPONSIBLE COMPLETE PROGRAM INCLUDING LAUNCH, INTEGRATION.	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE; COMPLETE INSTRUMENTATION FOR ENVIRONMENT AND MATERIALS STUDY; SUPPORT LAUNCH OPERATIONS; ANALYSIS OF DATA.	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE AND PENETRATION AID EJECTION SYSTEM; INTEGRATE PAYLOAD; SUPPORT LAUNCH SITE; POST FLIGHT DATA REDUCTION AND ANALYSIS; PROVIDE COMPLETE OPERATIONAL SYSTEMS.	DESIGN, DEVELOP, FAB., TEST RE-ENTRY VEHICLE AND PENETRATION AIDS; INTEGRATE PAYLOAD; SUPPORT LAUNCH OPERATIONS; POST FLIGHT DATA REDUCTION AND ANALYSIS; PROVIDE OPERATIONAL SYSTEMS. (PROGRAM CANCELLED.)	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE; INTEGRATE PAYLOAD; SUPPORT LAUNCH, CONTROL SITES; POST FLIGHT DATA REDUCTION AND ANALYSIS; PROVIDE COMPLETE OPERATIONAL SYSTEMS.	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE; MULTI TYPE EXPERIMENT INTEGRATION WITH COMPLETE INSTRUMENTATION; FIELD SUPPORT AT LAUNCH, CONTROL AND RECOVERY SITES; DATA COLLECTION REDUCTION AND ANALYSIS.
ASSOCIATE CONTRACTORS (REQUIRES SYSTEM INTEGRATION)	GENERAL DYNAMICS/ CONVAIR – BOOSTER BELL TELEPHONE LABS – GUIDANCE MIT – LINCOLN LABS – GUIDANCE AEROSPACE CORP. – SETD	AERO LAB – BOOSTER USN/PMR – LAUNCH 8 EXPERIMENT MULTI-UNIT PACKAGES FROM VARIOUS INDUSTRIES AND UNIVERSITIES.	MARTIN CO. – BOOSTER GENERAL DYNAMICS/ CONVAIR – BOOSTER BELL TELEPHONE LABS – GUIDANCE MIT – LINCOLN LABS – GUIDANCE RCA – MISS DISTANCE INDICATOR PHILCO/AERONEUTRONICS AEROSPACE CORP. – SETD	SPERRY/THIOKOL – BOOSTER NASA/LANGLEY/ WALLOPS (LAUNCH) U. S. ARMY (RECOVERY) U. S. NAVY (RECOVERY) STL – SETD	MIT – LINCOLN LAB. ATLANTIC RESEARCH – PROPULSION NASA/LANGLEY/ WALLOPS – BOOSTER/LAUNCH OPERATIONS.	MARTIN CO. – BOOSTER AC SPARK PLUG – GUIDANCE AERONEUTRONIC DIVISION OF FORD AEROSPACE CORP. – SETD	DOUGLAS A/C – SKYBOLT ASSY. SANDIA – W/H BOEING – B52 UNITED KINGDOM – INTERNATIONAL WARHEAD INTERFACE AND BRITISH AIRCRAFT INTERFACE	GENERAL DYNAMICS/ CONVAIR – BOOSTER SANDIA CORP. – WARHEAD MARTIN – BOOSTER AVCO – ALTERNATE R/V STL – SETD	GENERAL DYNAMICS/ CONVAIR – BOOSTER BOTH PHASES 28 EXPERIMENTS FROM EXPERIMENT AGENCY STL – SETD
SIGNIFICANT SUBCONTRACTORS (DIRECT AND INTEGRATE)	H. I. THOMPSON CO. BRUSH BERYLLIUM NORTHRUP/ NORTRONICS GARLOCK GE – OD	NONE	H. I. THOMPSON CO. RADIATION, INC. GE – M & AD	GOODYEAR A/C WESTINGHOUSE	NONE	GRUMMAN A/C WYMAN – GORDON ATLANTIC RESEARCH AMERICAN CELLULOSE GE – M & AD, LMED	FAIRCHILD STRATOS	NIMCO HAVEY CO. B. F. GOODRICH ATLANTIC MANUFACTURING GE – M & AD LADISH ROLLE	COOK ELECTRIC HAVEY CO. KELLET A/C PIASECKI AVCO SPEIDEL
BOOSTER	ATLAS	ARGO D-8	TITAN I AND ATLAS	SARGEANT TX20-6	TRAILBLAZER	TITAN II	SKYBOLT	ATLAS	ATLAS
SYSTEM SIGNIFICANCE	FIRST RV WITH STABLE PLATFORM TO OPERATE THRU ENTRY ENVIRONMENT.	DEMONSTRATED 1ST DISCONTINUOUS HEAT SHIELD, I.E., PORT IN SHIELD MECHANICALLY OPENED AND CLOSED PRIOR TO ENTRY.	DEMONSTRATED FIRST UNINTERRUPTED COMMUNICATION THROUGH PLASMA SHEATH DURING ENTRY.	ESTABLISHED FEASIBILITY OF TERMINAL GUIDANCE FOR ENTRY VEHICLES.	DUPLICATED HYPERVELOCITY RE-ENTRY PHENOMENA FOR ADVANCED STUDIES IN RE-ENTRY PHYSICS.	LARGEST AND HEAVIEST U. S. ENTRY VEHICLE AT DATE, INTERFACE WITH TITAN II AND ASSOCIATED AGE.	QUALIFICATION FOR MANNED VEHICLE, QUALITY CONTROL AND RELIABILITY.	FIRST OPERATIONAL ABLATION ENTRY VEHICLE. FLEW OVER 9000 MILES.	RVX-2 LARGEST RECOVERED ICBM ENTRY VEHICLE SCIENTIFIC PAYLOADS, TEST BED FOR ADVANCED ABLATION MATERIALS. RVX-2A FIRST COLOR PHOTOS FROM SPACE.

ENTRY VEHICLES (continued)

SYSTEM	RVX-1 RE-ENTRY VEHICLE (EXPERIMENTAL)	ABLE RE-ENTRY VEHICLE	MK. 2 SPACE LAB RE-ENTRY VEHICLE (PRODUCTION)	MK. 2 BALLISTIC MISSILE RE-ENTRY VEHICLE (PRODUCTION)	CLASSIFIED SPACE PROBE (CLASSIFIED CONFIGURATION)	MANEUVERABLE BALLISTIC RE-ENTRY VEHICLE (CLASSIFIED CONFIGURATION)	MK. 12 BALLISTIC MISSILE RE-ENTRY VEHICLE (CLASSIFIED CONFIGURATION)
GE CONTRACT	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF
MISSION OR PAYLOAD	VARIOUS SPACE LABORATORY EXPERIMENTS. INTEGRATION OF ALL EXPERIMENTS.	RE-ENTRY MATERIALS EXPERIMENTS; INSTRUMENTATION OF ALL EXPERIMENTS.	SPACE EXPER. HIGH ALTITUDE PHOTOGRAPHY STABILIZATION CONTROL, RADIATION MEASUREMENTS, ETC.	ICBM/IRBM WARHEAD PLUS INSTRUMENTATION FOR TEST FLIGHTS.	CLASSIFIED MISSION AND PAYLOAD	DEMONSTRATE AERODYNAMIC MANEUVERING DURING HYPER-VELOCITY ENTRY REGIME.	ICBM WARHEAD
SYSTEM RESPONSIBILITY	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE MATERIALS. EXPERIMENT INTEGRATION WITH COMPLETE INSTRUMENTATION: FIELD SUPPORT AT LAUNCH, CONTROL AND RECOVERY SITES; DATA COLLECTION REDUCTION AND ANALYSIS.	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE; INSTRUMENT FOR MATERIALS AND ENVIRONMENT SENSING; FIELD SUPPORT AT LAUNCH, CONTROL AND RECOVERY SITES. DATA COLLECTION REDUCTION AND ANALYSIS.	DESIGN, DEVELOP, FAB., TEST ENTRY VEHICLE, STABILIZATION, PHOTO AND RADIATION EXPTS.; FIELD SUPPORT AT LAUNCH, CONTROL AND DATA RECOVERY SITES; DATA COLLECTION REDUCTION AND ANALYSIS.	DESIGN, DEVELOP, FAB., TEST COMPLETE VEHICLE SYSTEM; DESIGN & FAB. DATA COLLECTION VANS; AGE; FIELD SUPPORT AT LAUNCH, CONTROL AND DATA RECOVERY SITES; INTEGRATE WITH PAYLOAD; COLLECTION AND ANALYSIS OF FLIGHT DATA; PROVIDE COMPLETE OPERATIONAL SYSTEMS.	DESIGN, DEVELOP, FAB., TEST COMPLETE SPACE PROBE INCLUDING COMMAND AND CONTROL SYSTEM; AGE; FIELD MAB AND PAD SUPPORT; POST FLIGHT ANALYSIS.	DESIGN, DEVELOP, FAB., TEST VEHICLE SYSTEM, INCLUDING ACTIVE FLIGHT STABILIZATION AND CONTROL SYSTEM; FLIGHT COMMAND SYSTEM; AGE; FIELD SUPPORT AT LAUNCH CENTRAL AND RECOVERY SITES, POST FLIGHT DATA ANALYSIS. INTEGRATION OF ALL ASSOCIATES.	MISSION ANALYSIS; DESIGN, DEVELOP, FAB., TEST RE-ENTRY VEHICLES AND ENTIRE PENETRATION AID SYSTEM; INTEGRATE PAYLOAD; SUPPORT LAUNCH SITE AND RANGE OPERATIONS; POST FLIGHT DATA REDUCTION AND ANALYSIS; PROVIDE COMPLETE OPERATIONAL SYSTEM.
ASSOCIATE CONTRACTORS (REQUIRES SYSTEM INTEGRATION)	GENERAL DYNAMICS/ CONVAIR – BOOSTER AVCO – HEAT SHIELD MATERIAL SPECIMENS GE RADIO GUIDANCE BOTH PHASES STL – SETD	DOUGLAS A/C – BOOSTER	DOUGLAS A/C – BOOSTER GENERAL DYNAMICS/ CONVAIR – BOOSTER RAMO WOOLRIDGE – SETD A C SPARK PLUG – GUIDANCE GE RADIO GUIDANCE – ATLAS	DOUGLAS A/C – BOOSTER GENERAL DYNAMICS/ CONVAIR – BOOSTER SANDIA CORP. – WARHEAD RAMO WOOLRIDGE – SETD A C SPARK PLUG – GUIDANCE GE RADIO GUIDANCE – ATLAS	DOUGLAS A/C BELL TELEPHONE LABS.	GENERAL DYNAMICS/ CONVAIR – BOOSTER UNIVAC – COMPUTER PROGRAMS LING TEMCO VOUGHT	LOCKHEED MISSILE AND SPACE CO. – BOOSTER BOEING AEROSPACE COMPANY NORTH AMERICAN AUTONETICS
SIGNIFICANT SUBCONTRACTORS (DIRECT AND INTEGRATE)	COOK ELECTRIC LAVELLE A/C LOCKHEED MISSILE & SPACE CO.	COOK ELECTRIC LAVELLE A/C LUDWIG HONOLD	AMERICAN BRASS RAYMOND ROSEN LUKINS STEEL REPUBLIC A/C BARNES GE – LMED, M & AD BENDIX	AMERICAN BRASS RAYMOND ROSEN LUKENS STEEL REPUBLIC A/C GE – LMED, M & AD BENDIX	AMERICAN GYRO YARDNEY GE – SEMI-CONDUCTOR	GENERAL PRECISION SPERRY AIRESEARCH LING TEMCO VOUGHT TRW GE – SEMI-CONDUCTOR	GENERAL MOTORS DEFENSE RESEARCH LABORATORIES LEESONA MOOS LABORATORY GE – M & AD, SEMICONDUCTOR
BOOSTER	ATLAS	THOR/ABLE	ATLAS AND THOR	ATLAS AND THOR	THOR	ATLAS	MINUTEMAN II POLARIS
SYSTEM SIGNIFICANCE	RVX-1 FIRST VEHICLE EVER RECOVERED AFTER ICBM FLIGHT DISTANCE DEMONSTRATED ABLATION HEAT SHIELD AT ICBM RANGE.	SIX WEEKS FROM "GO AHEAD" TO SUCCESSFUL FIRST FLIGHT. PAYLOAD INCLUDED "MIA" MOUSE IN ABLE WITH MINIATURE LIFE SUPPORT SYSTEM.	SCIENTIFIC PIGGY-BACK EXPERIMENTS CARRIED IN LIEU OF WARHEAD. FIRST DEMONSTRATION OF THREE AXIS STABILIZATION IN SPACE.	FIRST SUCCESSFUL ICBM RE-ENTRY VEHICLE. CARRIED ROCKET EJECTED DATA CAPSULES FOR RECOVERY OF RESEARCH DATA.		FIRST RV WITH COMPLETE FLIGHT CONTROL DURING HYPERVELOCITY ENTRY AND AERODYNAMIC MANEUVERING.	ADVANCED GENERATION OPERATIONAL BALLISTIC MISSILE.

SATELLITE/ENTRY VEHICLES

SYSTEM	DISCOVERER RE-ENTRY VEHICLE	CLASSIFIED SPACE SYSTEM (CLASSIFIED CONFIGURATION)	CLASSIFIED SPACE SYSTEM (CLASSIFIED CONFIGURATION)	BIOSATELLITE
GE CONTRACT	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO NASA
MISSION OR PAYLOAD	VARIOUS SPACE EXPERIMENTS AND RECOVERY TECHNIQUES.	CLASSIFIED MISSION AND PAYLOAD.	CLASSIFIED MISSION AND PAYLOAD.	BIOLOGICAL RESEARCH DURING PROLONGED SPACE FLIGHT.
SYSTEM RESPONSIBILITY	DESIGN, DEVELOP, FAB., TEST COMPLETE SPACECRAFT, AND LIFE CELL; AGE; FIELD SUPPORT MAB, PAD AND FLIGHT (DEVELOPMENT PHASE), POST FLIGHT ANALYSES (AS REQUIRED).	DESIGN, DEVELOP, FAB., TEST COMPLETE SPACECRAFT, AGE; OPERATIONAL SYSTEM DESIGN. COMMAND AND CONTROL, MAB AND PAD, FLIGHT OPERATIONS SUPPORT, RECOVERY PLANNING AND SUPPORT, POST FLIGHT ANALYSIS.	DESIGN, DEVELOP, FAB., TEST OVERALL SPACECRAFT; INTEGRATE RECOVERY SYSTEM AND PAYLOAD, SUPPORT LAUNCH AND MISSION CONTROL CENTER, POST FLIGHT DATA ANALYSIS.	MISSION ANALYSIS, DESIGN, DEVELOP, FAB., TEST SPACECRAFT; RE-ENTRY SYSTEM AND MAST EXPERIMENTS; INTEGRATE ALL EXPERIMENTS: SUPPORT LAUNCH SITE, TRACKING NETWORK AND CONTROL CENTER; POST FLIGHT DATA REDUCTION AND ANALYSIS.
ASSOCIATE CONTRACTORS (REQUIRES SYSTEM INTEGRATION)	LOCKHEED MISSILE AND SPACE CO. – AGENA AND SETD DOUGLAS – BOOSTER AFSAM – BIOASTRONAUTICS/BIO MED AEROMEDICAL FIELD LABS, HOLLOMAN AFB	LOCKHEED MISSILE AND SPACE CO. – BOOSTER GENERAL DYNAMICS ASTRONAUTICS – BOOSTER AEROSPACE CORP. – SETD CLASSIFIED PAYLOAD	LOCKHEED MISSILE AND SPACE CO. – BOOSTER GENERAL DYNAMICS ASTRONAUTICS – BOOSTER SYSTEMS DEVELOPMENT CORP. – COMPUTER PROGRAMS AEROSPACE CORP. – SETD	DOUGLAS/GSFC NORTH AMERICAN AVIATION SCIENTIFIC COMMUNITY (12-BIO. EXPTS.) AMES RESEARCH LABS. SETD
SIGNIFICANT SUBCONTRACTORS (DIRECT AND INTEGRATE)	THIOKOL – RETRO ROCKETS BULOVA MENASCO ATLANTIC RESEARCH BERMITE IRVING AIRCHUTE CO.	GE – MCD, DSD, LMED, M & AD BENDIX CUBIC CORP. – ACF ELECTRONICS GIANNINI AMPEX HUGHES AIRCRAFT CO. CLASSIFIED PAYLOAD	LOCKHEED MISSILE AND SPACE CO. RADATDYNE EAGLE PITCHER BARNES BORG WARNER GE – LMED CLASSIFIED PAYLOAD	HAMILTON STANDARD AIRESEARCH GE – MCD, DECO, SD
BOOSTER	ATLAS/AGENA AND THOR/AGENA	ATLAS/AGENA	ATLAS/AGENA	IMPROVED TAD
SYSTEM SIGNIFICANCE	1ST VEHICLE RECOVERED AFTER ORBITAL FLIGHT. DEMONSTRATING BETTER THAN 90% RELIABILITY ON OPERATIONAL FLIGHTS.	DEMONSTRATED SUCCESSFUL SOPHISTICATED COMMAND SYSTEM. SYSTEMS INTEGRATION OF COMPLEX VEHICLE SYSTEM.	HIGHLY SUCCESSFUL PROGRAM.	PLANNED EXTENDED ORBIT PLUS RECOVERY OF BIOLOGICAL SPECIMENS THRU PRIMATES. TWO-GAS LIFE SUPPORT SYSTEM.

ORBITERS

SYSTEM	NIMBUS WEATHER SATELLITE	ADVENT COMMUNICATION SATELLITE	OAO ASTRONOMICAL SATELLITE	GRAVITY GRADIENT STABILIZATION SUBSYSTEM	GRAVITY GRADIENT TEST SATELLITE	GRAVITY GRADIENT STABILIZATION FOR APPLIED TECHNOLOGY SATELLITE	SYSTEM
GE CONTRACT	PRIME CONTRACTOR TO NASA (INTEGRATION)	PRIME CONTRACTOR TO USAF	SUBCONTRACTOR TO GRUMMAN	PRIME CONTRACTOR TO USN	PRIME CONTRACTOR TO USAF	PRIME CONTRACTOR TO NASA	GE CONTRACT
MISSION OR PAYLOAD	WEATHER SATELLITE TV AND IR SENSORS.	600-CHANNEL COMMUNICATION SYSTEM.	CONTROL MISSION, PROVIDE POSITION CONTROL AND POINTING ACCURACY WITHIN 0.1 SECONDS ARC.	LOW EARTH ORBIT – CLASSIFIED PAYLOAD.	GRAVITY GRADIENT STABILIZED SATELLITE AT NEAR SYNCHRONOUS ALTITUDES.	SATELLITE TESTS OF COMMUNICATION, METEOROLOGICAL EQUIPMENT AND ATTITUDE CONTROL EQUIPMENT AT MEDIUM AND SYNCHRONOUS ALTITUDES.	MISSION OR PAYLOAD
SYSTEM RESPONSIBILITY	OVERALL SPACECRAFT SYSTEM DESIGN INTEGRATION AND TEST; DESIGN, FAB., TEST STABILIZATION AND CONTROL SYSTEMS; PLAN AND OPERATE TECH. CONTROL CENTER AT GSFC; PLAN, SUPPLY HARDWARE, OPERATE NIMBUS DATA HANDLING CENTER IN ALASKA; LAUNCH INTEGRATION.	DESIGN, DEVELOP, FAB., TEST COMPLETE VEHICLE SYSTEM INCL. POWER, STABILIZATION SUBSYSTEMS; INTEGRATE WITH COMMUNICATION PACKAGE; DETAILED RELIABILITY PROGRAM, SUPPORT AT LAUNCH SITE AND COMMAND CENTER; FLIGHT DATA REDUCTION AND ANALYSIS.	DESIGN, DEVELOP, FAB., TEST STABILIZATION AND CONTROL SYSTEM; SUPPORT AT LAUNCH SITE AND COMMAND CENTER.	DESIGN, DEVELOP, FAB., TEST GG SYSTEM AND QUALIFY THREE AXIS PASSIVE DAMPER; SUPPORT AT LAUNCH SITE; FLIGHT DATA REDUCTION AND ANALYSIS.	DESIGN, DEVELOP, FAB., TEST COMPLETE VEHICLE SYSTEM; INTEGRATE WITH INTERIM MIL COM SAT AND DISPENSER; SUPPORT AT LAUNCH SITE; POST FLIGHT DATA REDUCTION AND ANALYSIS.	DESIGN, DEVELOP, FAB., TEST GG AND THREE AXIS PASSIVE DAMPER. SYSTEM. INTEGRATE WITH VEHICLE; SUPPORT AT LAUNCH SITE; POST FLIGHT DATA REDUCTION AND ANALYSIS.	SYSTEM RESPONSIBILITY
ASSOCIATE CONTRACTORS (REQUIRES SYSTEM INTEGRATION)	LOCKHEED MISSILE AND SPACE CO. DOUGLAS AIRCRAFT CO. RADIO CORP. OF AMERICA RADIATION INCORPORATED CALIFORNIA COMPUTER CORPORATION, INTERNATIONAL TELEPHONE & TELEGRAPH, GODDARD SFC – SETD	BENDIX CORP. – COMMUNICATIONS PHILCO CORP. – GND STATUS LOCKHEED MISSILE AND SPACE CO. – BOOSTER GENERAL DYNAMICS/ CONVAIR – BOOSTER	INTERNATIONAL BUSINESS MACHINES RADIATION INCORPORATED GSFC/KALLSMAN (EXPT.) SMITHSONIAN INSTITUTE (EXPT.) UNIV. OF WISCONSIN (EXPT.) GRUMMAN A/C – SPACECRAFT	USN/NRL	PHILCO SPACE TECHNOLOGY LABORATORY – USAF/SSS/MARTIN	HUGHES A/C	ASSOCIATE CONTRACTORS (REQUIRES SYSTEM INTEGRATION)
SIGNIFICANT SUBCONTRACTORS (DIRECT AND INTEGRATE)	(SEE ASSOC. CONTRACTOR LIST) DOUGLAS AIRCRAFT CO. GE–ATL; E–LAB; RSD	MARQUARDT UNITED SHOE MACHINERY ELMER PERKINS GE–LMED, MCD, M & AD GEL POWER TUBE DEPT.	KOLLSMAN INSTRUMENT CO. TELECOMPUTING CORP. BENDIX CORP.	NONE	DE HAVILLAND AIRCRAFT OF CANADA	DE HAVILLAND AIRCRAFT OF CANADA ADCOLE LEAR SIEGLER CO.	SIGNIFICANT SUBCONTRACTORS (DIRECT AND INTEGRATE)
BOOSTER	THOR/AGENA B	ATLAS/AGENA ATLAS/CENTAUR	ATLAS/AGENA	TAT/AGENA	TITAN III C	ATLAS/AGENA	BOOSTER
SYSTEM SIGNIFICANCE	THREE-AXIS STABILIZED LONG LIFE SATELLITE.	3 YEAR LIFE REQUIRED. RELIABILITY PROGRAM STARTED UNDER ORIGINAL PROGRAM HAS BEEN EXPANDED AND CONTINUED.	MOST ACCURATE STABILIZATION SYSTEM EVER BUILT. FIRST SYSTEM DELIVERED ON SCHEDULE TO PRIME.	HIGHLY SUCCESSFUL FLIGHT. SYSTEM STABILIZED IN FOUR DAYS. FIRST FLIGHT OF COMPLETELY PASSIVE GRAVITY GRADIENT STABILIZATION. EXTREMELY LOW COST, VERY RELIABLE.	FIRST PASSIVE STABILIZED NEAR SYNCHRONOUS SATELLITE.		SYSTEM SIGNIFICANCE

Figure I. E-1. Major General Electric Space Vehicle Programs

2.2 Spacecraft and Spacecraft Systems

2.2.1 Biosatellite Program

During the last several years, GE-RESD has been engaged in a number of programs with NASA and the medical community in the biological and medical fields. In the NASA Biosatellite Program, GE-RESD designed and built a number of space laboratories to study the effects of relatively long-duration flights on a wide variety of plant and animal specimens in controlled environments that could not be duplicated on earth. Ames Research Center managed this project for NASA.

Flights were made in December 1966 and September 1967 to study the effects of weightlessness and radiation on several simple organisms. A third flight was made during June and July 1969 to study the effects of prolonged weightlessness on a primate; specifically, its brain functions and performance, cardiovascular functions, metabolic functions, and the bone density changes in various sites of the skeletal anatomy.

The primate mission of Biosatellite was fully successful throughout every subsystem, although the well-being of the primate necessitated deorbit and recovery of the capsule after 8 days in orbit. The service module, or adapter, continued to perform all functions completely satisfactorily for 38 days while exercising all operating conditions. The Biosatellite spacecraft had a 40-inch base diameter recovery capsule with a suspended weight of 325 pounds at recovery. The service module or adapter containing the telemetry, command, power, tankage, attitude control, and basic environmental control subsystems, extended the length of the spacecraft to 82 inches with a 55-1/2-inch diameter at the base. Other than the Apollo Command and Service Modules, Biosatellite is the most sophisticated spacecraft yet flown by the United States.

2.2.2 Discoverer Orbital Re-entry/Recovery Spacecraft

The Discoverer recoverable satellite, designed, developed, and fabricated by GE-RESD, was the first space vehicle in the world to be recovered from orbital flight.

The Discoverer vehicle was 33 inches in diameter, 40 inches long, and weighed approximately 300 pounds. The design consisted of an outer ablating heat protection system and an inner recoverable capsule system. The payloads varied from instrumentation to a complete, active, closed-loop life support system for biological subjects. The Discoverer successfully flew in August 1960, and the program subsequently demonstrated a 99-percent recovery success score.

2.2.3 NIMBUS

Under contract to NASA-GSFC, GE's Space Division was responsible for the design and development of selected vehicle subsystems (e.g., attitude control and structure), vehicle integration and overall systems testing of the fully oriented Nimbus weather satellite. This program has been highly successful with in-orbit operations exceeding the six-month requirement by many months.

2.2.4 Orbiting Astronomical Observatory

General Electric was responsible for the design and development of the stabilization subsystem on a subcontract to Grumman for the NASA Orbiting Astronomical Observatory (OAO). This highly precise subsystem has performed very successfully on OAO flights.

2.2.5 Mariner '71 Attitude Control

GE's Space Division has completed a subcontract with JPL for the Mariner '71 attitude control subsystem.

2.2.6 ERTS - A and B

The design and development phase for the Earth Resources Spacecraft system is in progress at GE Space Division which is scheduled for first launch in 1972 under contract to NASA/GSFC.

2.3 Manned Systems

2.3.1 Space Shuttle Vehicle (SSV)

Another project organization under the Space Re-entry Systems Programs Section of GE-RESD is the Space Transport Systems Programs which has been actively teamed with the North American Rockwell Corporation under NASA contract for the Phase B Space Shuttle Vehicle Studies. The prime area of responsibility of the GE project teams is the design/development of the reusable surface protective insulation paneling for the SSV Orbiter. This also affords a current knowledge of the SSV mission planning, operational scheduling and orbiter configuration as applicable to the Bioresearch Module.

2.3.2 Space Manipulator

The Cybernetics Automation and Mechanization Systems Operation is a Schenectady, N. Y. based section of GE-RESD reporting directly to Mr. Walter D. Smith, General Manager of Space Re-entry Systems Programs. This organization has been actively involved in the development, design and application of several manipulator and handling systems. A current NASA program is a Man-Mate boom for use in a NASA simulation facility. This system will be used to demonstrate the feasibility of handling major assemblies in space such as in-orbit assembly or servicing of spacecraft or the transfer or retrieval of material by the Space Shuttle Orbiter Vehicle. Such programs afford an insight to the SSV manipulator system configuration and capability as applicable to the Bioresearch Module.

2.3.2 Manned Orbiting Laboratory (MOL)

General Electric was an associate prime contractor for the Air Force MOL, with complete responsibility for experiment integration. Of particular interest to the Biopayload Integration Task is the work done in the areas of crew man-mission time-line analysis and simulation. In addition, General Electric developed techniques for dynamic computer control of experiment execution.

Work on the MOL began in September 1965 and continued until project cancellation in May 1969. At its peak, approximately 2,500 GE people were engaged on the project.

2.3.4 Space Station Integration

General Electric's Space Division at Valley Forge, Pennsylvania, is a team member and major subcontractor to the North American Rockwell Space Division in the conduct of the Phase B Space Station Study. General Electric's effort involves two major tasks: experiments definition and integration, and information management. In addition, GE is responsible for certain other subordinate subsystems, such as waste management, solar and/or nuclear power, and control moment gyros.

General Electric's experiment definition and integration responsibility encompasses all scientific disciplines. On the advice of NASA, candidate experiments are selected from the "Blue Book" for conceptual hardware implementation and integration into the station complex. In the context of experiment definition, General Electric has complete responsibility for biomedical and behavioral measurement studies.

2.3.5 TEKTITE I and II

The Tektite undersea exploration program is conceived for a dual purpose. The first is to establish the feasibility of manned operations for long duration in confined environment, investigating both physiological and psychological problems. The second is concerned with the conduct of a comprehensive marine biological research program.

Tektite I was a highly successful 50-day program, concluded in April 1969. Four aquanauts were "housed" at 50-foot depth off St. John in the Virgin Islands. The habitat was supplied and partially outfitted by GE-RESD. The Navy Department, NASA, and the Department of the Interior participated in the program.

Tektite II, the successor program, involved a much broader governmental and academic institutional support. The program was of seven-months duration, with seventeen separate "missions" accomplished during this period. Although overall objectives were the same, research was more sophisticated and far broader in scope. The Department of the Interior was the lead governmental agency in Tektite II. GE-RESD again supplied personnel and the underwater "habitat" at 50-foot depth.

2.4 Biomedical Programs

2.4.1 Patient Monitoring Study

GE-RESD recently completed a study of the application of bio-space technology to patient monitoring systems under contract to NASA. In this study, NASA-developed technology was applied to cardiovascular and pulmonary patient monitoring in order to improve the availability, reliability, and utility of data for medical diagnosis and training. General Electric has been working in conjunction with the Lankenau Hospital and Hahnemann Hospital to develop the specific equipment and techniques for such a system. A portion of the study was devoted to a survey of existing patient monitoring systems currently in operation at various hospitals. The merits of each were then analyzed and the requirements established for an advanced system which utilizes bio-space technology. Currently a supplementary program is in progress to adapt and evaluate a urine transport, measurement and storage system based on the Biosatellite Primate Urine System.

2.4.2 Health Communications System

Improved health care communication systems have been proposed for several states (e.g., Arizona, Pennsylvania, and Missouri) for the demonstration and implementation of communications systems which will link remote areas of the state to medical centers located in the metropolitan areas. These systems utilize space-developed technology to improve health care in areas with more limited medical personnel or diagnostic capabilities.

2.4.4 IMBLMS

General Electric has been performing on a NASA/MSC contract to develop an Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS). IMBLMS is intended for use in early space station complexes and the subsequent space, lunar, and inter-planetary craft that progressively evolve. The IMBLMS will be initially used in the conduct of biomedical and behavioral experiment measurements, and with normal evolution, will progressively develop diagnostic, therapeutic, and remedial measurement capability for systems incorporation.

Phase B-3 (NASW-1630), completed in February 1970, was for the design, fabrication, and delivery of a functional breadboard. Included in the contract were tasks for the limited testing, data analysis, and delineation of requirements for design of an engineering development unit.

IMBLMS Phase B-4 (NAS-9-10741), started in May 1970, is intended to produce preliminary flight design and planning in sufficient depth that the C and D phases can be accurately costed. The system not only includes capability for some 130 medical, behavioral, and laboratory analysis measurements, but also through its biopotential signal conditioners, data acquisition and display subsystem, and computer, provides a capability for supporting bioscience experiments. This phase is presently nearing completion and follow on work is anticipated.

2.5 Program Support Capability

2.5.1 Quality Assurance and Reliability

GE-RESD procedures relating to quality assurance and reliability are fully compliant with the NASA requirements contained in the NCP 200 series and NPC 250-1. These procedures were instituted at GE-RESD in 1963 in anticipation of the Biosatellite Program and have been continually refined and further elaborated while in use in the ensuing period.

GE-RESD has available, the Biosatellite Quality Assurance, Reliability, and Test Evaluation team, procedures, facilities, and equipment that demonstrated a successful Biosatellite Primate Mission, including a no-hold countdown to launch, under the difficult restraints of the experiment integration. This capability was developed from the quality and reliability of the system from the component level through system tests and prelaunch checkout of the spacecraft.

2.5.2 Fabrication

GE-RESD has fabricated the basic structural components and heat shields of more than 30 re-entry and recovery vehicle systems developed over the last 15 years. In addition, the Division makes its own electrical harnesses, components, sensors, and aerospace ground equipment. Extensive experience has been gained in integration and assembly of complex subsystems and systems; this experience is further enhanced by electronic miniaturization programs currently underway that result in considerable savings in weight and power requirements. The Biosatellite Program, because of its high degree of sophistication, added immeasurably to these highly developed experiences in fabrication and assembly. The life support system, along with its detailed requirements for gas management, food and water supplies, and waste handling, further developed the RESD capabilities in material selection and handling, process developments including sterilization, and meticulous fabrication and assembly techniques from piece-parts through components and subsystems to the system itself.

All of the plans and procedures developed during the accumulation of this extensive fabrication and assembly experience will be directly applicable. It is envisioned that an optimum Bioresearch Module Development Plan will result from using these proven plans and procedures in a sound and efficient manner.

2.5.3 Testing

The General Electric Company has organized progressive test programs for its systems to establish confidence and eventual flight readiness. The testing of the

Biosatellite spacecraft is an example of a progressive test program starting with development testing through qualification testing. On such programs, the test plan is used to define the test building blocks, and test specifications are developed to provide the instructions for implementation. Data processing requirements are defined to provide the best formats for analysis and evaluation of the test results. On the Biosatellite Program, these programs included high-speed reformatting, limit checking, high-speed printer display, and automatic changing of limits according to the test requirements. The systems are analyzed in a Failure Modes and Effects Analysis, and any component failures during test are studied, firstly, from the aspect of component quality/reliability; and secondly, from the potential operational impact in a Mission Critical Function Analysis. From these evaluations, confidence matrices are developed for each critical and major function as the basis for pre-launch and in-flight contingency plans.

An Integrated Test Program Board is always organized by General Electric to have cognizance over all qualification testing including the design of the test plan and test specifications, and the implementation, data analysis, and acceptance. These in-place test plans and procedures which are use-proven from the cited extensive test experience can be directly tailored to the Bioresearch Module Program.

3.0 FACILITIES

3.1 General

General Electric Re-entry and Environmental Systems Division (GE-RESD) maintains a variety of facilities which have been used for many study, analysis, research, and development activities and which are available for continuing application to spacecraft, re-entry systems, urban systems, ocean systems, health systems, and aerospace-oriented programs. The same basic facilities used for the Biosatellite Program would be allocated to the Bioresearch Module.

The GE-RESD Center, located at 3198 Chestnut Street, Philadelphia, Pennsylvania serves as the Division's headquarters. The Center provides approximately 670,000 square feet of laboratory, developmental manufacturing, test and office area. GE-RESD also maintains 385,000 square feet of offices and laboratories in the nearby suburbs at the GE-owned Valley Forge Space Center, Valley Forge, Pennsylvania, and the Cabot, Cabot and Forbes Industrial Park, King of Prussia, Pennsylvania.

Extensive technical and specialized facility resources of the General Electric Company are available to support the diversified activities of GE-RESD. These facilities include such well-known organizational components as General Electric's Space Sciences Laboratory, Valley Forge, Pennsylvania; General Electric's Research and Development Center in Schenectady, New York; and the Electronics Laboratory, Syracuse, New York.

3.2 Laboratories

The Division operates a number of specialized laboratories which conduct research and exploratory development in support of various programs.

The Environmental Sciences Laboratory provides support in the areas of bio-medical research, environmental pollution, weather prediction, lasers, radiation and shock physics, oceanography, and hypervelocity flight.

The Experimental Biology and Biochemical Laboratory has, in addition to standard biological and chemical investigation equipment, a complex of biological, chemical and radiobiological equipment. Work is currently being conducted in the areas of bacterial sensors, coliform detectors, electron capture gas chromatographic analysis, and electrocoagulation of waste water.

3.3 Manufacturing and Assembly

GE-RESD maintains a modern manufacturing, fabrication and assembly capability which is equipped and staffed to meet the quality and reliability standards for space programs.

A machine shop, sheet metal shop, and heavy machining area are all tooled to satisfy the requirements for hardware at typical R&D production rates. Other manufacturing facilities include; a complete plastics fabrication and bonding facility, an electronics wiring and assembly shop, and a model and template fabrication shop. Supporting these activities are; manufacturing engineering, production control, tool and equipment design, purchasing, stock control, and the traffic and shipping units.

Assembly of the Bioresearch Module will be done in the former Biosatellite assembly area. This is a laminar flow facility. An air conditioning and absolute filter bank system, separated from other building systems, maintains a positive pressure within the area preventing the inward flow of particles and other contaminants. Maximum cleanliness levels are attained by performing assembly operations adjacent to the air inlet filter bank with personnel and equipment downstream from the hardware. Dressing rooms are separated from the assembly area and access to the assembly area is via an air shower.

3.4 Test Facilities

The test facilities required for the development and qualification testing of the Bioresearch Module system and its components are currently in existence at GE-RESD, with the exception of a centrifuge suitable for conducting the acceleration tests. For this test, it is recommended that a centrifuge located at the Sandia Corporation in Albuquerque, New Mexico, be used. General Electric has used this facility on several re-entry vehicle programs in the past.

In addition to the environmental facilities that are required, system tests will be conducted in the clean manufacturing assembly area mentioned previously. A central ground station supports testing in this area as well as the environmental test areas.

Table I.E-1 is a summary of the major tests and the test facilities which will be used to perform these tests.

TABLE I. E-1. MAJOR TESTS AND PLANNED FACILITIES USAGE

Tests	Facility
System Electrical Performance Tests	• Assembly Area • Central Ground Station (Linked to all System Test and Operations Laboratories)
Vibration	C-200 Vibration Facility
Shock (System)	Shock Test Facility
Thermal-Vacuum	T/V Chamber - Working size - 84" dia. x 108" height
Spin	Spin Table with Programmable Spin Profile
Mass Properties	Miller Machine (Airdyne Type 861A)
Pneumatic Proof Tests	Pneumatics Laboratory
Acceleration	Centrifuge located at the Sandia Corp., Albuquerque, N. M.

3.5 Computer Facilities

To meet the requirements of both technical and business elements, the Re-entry and Environmental Systems Division has established a total capabilities computer complex which offers the combined advantages of both digital and analog equipments. GE-RESD thus has available the rapid data acquisition capabilities, the simulation and mathematical computation equipment, and the instant information retrieval techniques required to support its varied systems and programs. This complex allows the efficient gathering and reporting of business information and, more importantly, it is capable of application to even the most difficult technical problems. Many tested and proven realtime flight and re-entry simulation programs have been developed, such as those utilized for the Biosatellite and Nimbus satellite projects and for the Maneuvering Ballistic Re-entry Vehicle and Mark 12 (Minuteman) programs. The systems and equipment which constitute this complex are identified in Table I. E-2.

TABLE I. E-2. DIGITAL COMPUTER SYSTEMS AND PERIPHERAL EQUIPMENT

	Core Memory		Disc Units		Tape Drives						
Computer Systems	Capacity thousand words	Access Time micro-seconds	Qty.	Capacity million char. each	Qty.	Transfer Max. Rate thousand char/sec	Card Readers	Card Punches	Typewriters	Printers	DATANET see notes
GE 635	131	1.0	3*	18.8	12	60	1	1	1	2	30
GE 605	65	1.0	2	67.1	4	120	1	1	1	1	30
GE 445	33	5.1	4	18.8	8	60	1	1	1	1	30
GE 445	33	5.1	4	18.8	8	60	1	1	1	1	30
GE 415	8	5.1			4	30	1	2	1	2	
GE 415	8	5.1			4	30	1	2	1	2	
GE 255	16	18.0	5	18.8	4	42	1	1		1	30
GE 235	8	6.0			4	42	1	1		1	63
GE 235	16	6.0			4	42	1	1		1	
GE 235	16	6.0			6	42	1	1		1	
GE 11[illegible]	8	6.5					1	1		1	10
GE 115	8	6.5					1	1		1	10
IBM 7094	33	2.0			16	90	1			1	
IBM 7094	33	2.0			12	90	1			1	
IBM 360-44	131	1.0	2	0.3	4	90	1	1		1	
IBM 1460	8	6.0			3	60	1	1		2	
IBM 1130	8	3.6					1	1	1	1	
IBM 1130	8	3.6					1	1	1	1	
DDD 224	16	1.9	1	1.2	4	25	1		1		
DDP 24	8	5.0			2	25	1		1		

Special Purpose Systems Not Listed Above

UNIVAC 1004 Mod-3	PDP-8S	Recomp II
IBM 1620 Mod-1	SDS-910	

NOTES	*Plus 4.6 million character capacity drum unit. DATANET 30: Time sharing communications terminal; 24 channel multiplexor DATANET 15: Time sharing communications terminal; single access DATANET 10: Batch processing communications terminal; single access DATANET 63: Hybrid system communications terminal

	Qty.	Equipment	Qty.	Equipment	Qty.	Equipment
Off-Line Peripheral Equipment	106	Card Punches	4	Card Reproducers	6	Document Systems
	22	Verifiers	3	Collators	2	Summary Punches
	10	Sorters	4	Interpreters	1	Multi-selector
	4	Accounting Mach.	3	Card Processors		
	**95	Remote Teletype terminals				
	** ?	Remote DATANET 760 CRT keyboard terminals				
	1	Computer Recorder, SC-4020: records 12,000 characters/second, transfers 60,000 characters/second, prints film at 5,6000 lines/min.				

** Approximate

II. FUNDING PLAN

A. GROUND RULES AND ASSUMPTIONS

The ground rules and assumptions are as follows:

(1) The funding requirements were estimated for the design, development, test, qualification, pre-launch and launch support and operational flight support for two each Type I Bioresearch Modules and two each Type II Bioresearch Modules.

(2) Launch of the four modules is to be accomplished by use of the Scout Launch Vehicle at one year intervals starting in February 1975, with the Type I to be launched first and second in the series and Type II to be launched third and fourth in the series.

(3) Prototype system design, development, test and systems qualification cost estimates are furnished for the Type I system; for the Type II mission, the attitude control subsystem would be qualified as a subsystem module.

(4) The design and development definitions and requirements for estimating purposes were based on the following sources:

a. The baseline design of the Bioexplorer spacecraft as defined under the previous Contract NAS 2-6027, modified by the results of this Bioresearch Module Study as documented in the Design Review Reports Nos. 1 and 2 of this contract and Volume 1 of this final report.

b. The updated development program plan as defined in Volume 2 of this final report.

c. The overall network schedule for the prototype Bioresearch Module development program as presented in Section II-B of this volume.

(5) Assumed program go-ahead is July 1, 1972, with completion of the prototype system qualification by May 31, 1974. (Note: Attitude Control Subsystem Module qualification extends to June 30, 1974).

(6) Pre-launch support at Wallops Island has been estimated for a maximum of six weeks prior to each launch, and flight support estimates are for an average of four months per flight at NASA/ARC and NASA/GSFC.

(7) Mission III requirements serve as a design commonality restraint, but estimates for Mission III peculiar tasks are not included.

(8) The program schedules presented in Section II-B of this volume, reflecting various program milestones, events and activities, were used to time-phase the funding requirements.

(9) No estimates are furnished for any Bioresearch Module AGE once the Module is attached to the last stage of the Scout and turned over to the launch vehicle contractor for final pre-launch processing.

(10) The S-band system is the baseline for the TT&C subsystem for all missions. For in-house testing, it is planned to utilize the MK-12 S-band ground station. For field testing, it is assumed that a GFE S-band ground station will be made available.

(11) Estimates for Experiment AGE and handling equipment are not included.

(12) Four program options for flight Bioresearch Modules fabrication, assembly and acceptance testing were identified, analyzed and evaluated as presented in Section II-B of this volume.

a. Option I — Conduct the program through prototype system qualification, retain the prototype as a ground system, fabricate and procure all the parts and components for four flight modules during the same early period, and assemble and test the four flight modules on the most efficient accelerated schedule.

b. Option II — Same as Option I except assemble and test the four flight modules consistent with the yearly launch schedules.

c. Option III — Same as Option I except that the prototype system would serve as the first flight Module. (The remaining three flight modules would be processed on the accelerated schedule.)

d. Option IV — Same as Option III, except the remaining three flight modules would be processed consistent with the yearly launch schedules.

Note: The four optional plans are presented for purposes of report completeness. However, at the Bioresearch Module Design Review No. 2 conference, held at NASA/ARC on November 9, 1971, it was jointly determined that Options II and IV should be actively considered, and that no further investigations or evaluations of Options I and III be conducted.

(13) For the Bioresearch Module development and qualification test program, a GFE experiment package simulator will be provided; and for system flight acceptance testing, a GFE flight experiment package will be furnished.

(14) For vendor items, quotes were updated from the data acquired during the previous Bioexplorer Study in response to seventeen (17) individual work statements and specifications prepared for each of the following items currently planned for procurement:

Rate Gyro	Hi-Pressure Transducer
Momentum Wheel	Lo-Pressure Transducer
Sun Sensor	Nitrogen Tank
Deployable Rods	Decoder
Solenoid Valve	Receiver, S-Band
Latch Valve	Transmitter, S-Band
Regulator	Tracking Receiver
Filter	Data Storage Unit
	Solar Cell Panels

(15) Funding requirements were estimated by calendar quarter, by labor class, and by material.

(16) The ground rule established for qualification testing is that such tests will be conducted on the component and system levels. The acceptance testing program ground rules are:

a. Components: In-process, functional performance, and operability assurance (OA) testing.

b. Subsystems: In-process and functional performance testing.

c. System: In-process, functional performance, and operability assurance (OA) testing.

(17) For estimating purposes, the following component hardware requirements ground rules were utilized.

a. New Design Components

Quantity	Purpose
1	Component Development Test
1	Subsystem and System Development Test
1	Component Qual Test
1	System Qual Test
4	Flight Units
1	Spare
Total 9	

b. Major Modification Components

Quantity	Purpose
1	Component Development Test
1	Subsystem and System Development Test
1	Component Qual Test
1	System Qual Test
4	Flight Units
1	Spare
Total 9	

c. Existing or Minor Modification Components

Quantity	Purpose
1	Subsystem and System Development Test
1	System Qual Test
4	Flight Units
1	Spare
Total 7	

d. Structure

Quantity	Purpose
1	Mock-up
1	Subsystem and System Development Test
4	Flight Units
1	System Qual Test
Total 7	

e. Harnesses

Quantity	Purpose
1	Mock-up
1	Subsystem and System Development
4	Flight Units
1	System Qual Tests
Total 7	

(18) Major Equipment Requirements

a. Mock-up Unit — Early model built to engineering sketches using soft tooling. This model will consist of:

(1) Service module

(2) Adapter

(3) Attitude control, thermal control, elec, power and distribution, and telemetry tracking and command module structures.

(4) Set of dummy components

(5) One deployment mechanism

(6) Eight simulated solar panels

(7) One simulated experiment package

b. System Structural Development Unit — Structural module built to near final design requirements. Module will contain dummy components (mass property simulated) and solar panels which will only contain cells at selected locations to demonstrate structural integrity.

The purpose of this unit will be to:

(1) Demonstrate structural integrity of module design. Environmental test levels will in all cases be the maximum expected for all type missions.

(2) Gather the hard environmental data necessary to verify component/module test requirements.

(3) Demonstrate solar panel deployment.

(4) Verify thermal control system performance including structural effects.

(5) Develop fabrication techniques, equipment, test methods and check out facilities which will later be used for prototype/flight module fabrication and testing.

(6) Develop the electrical system within the vehicle, following structural testing.

c. Subsystem Development Units — Each subsystem module will be built to near final design requirements. The purpose of these modules will be to:

(1) Determine electrical and mechanical compatibility between components while interconnected and operating as a subsystem.

(2) Evaluate the adequacy of the design to function within the requirements of the controlling specifications.

(3) Establish compatibility with test equipment and verify the ability of the AGE to control and test the subsystem.

d. Electrical System Development Unit — The subsystem modules used in subsystem development tests (see paragraph (18)c.) will be assembled into a near final design structure (system development unit - see paragraph (18)b., and subjected to electrical system development tests.

The objectives of these tests are to:

(1) Verify and establish subsystem/system electrical and mechanical interface compatibility.

(2) Verify and evaluate the performance characteristics of the system during controlled changes of primary power.

(3) Verify that system performance is within specified design limits.

(4) Evaluate the capability of the AGE to control and monitor electrical system performance.

(5) Evaluate the performance of the system during simulated failure modes.

e. System Prototype Qualification Unit — This unit would be the complete spacecraft system, fabricated to the final released design, to the same drawings, specifications and requirements of quality assurance, as would be the flight Bioresearch Modules. The prototype Bioresearch Module will be subjected to specified stresses, both environmental and functional, to verify design margins, and assure reliable operation of the system. The proposed test program for the system prototype is shown in the program schedule provided in Section II-B of this Volume.

B. PROGRAM SCHEDULE

1.0 SCOPE

The Bioresearch Module prototype development plan is directed at the accomplishment of the complete design, development, fabrication and test efforts leading to the delivery of a fully tested and qualified prototype Module by the end of May, 1974; and the fabrication, procurement, assembly, acceptance test, pre-launch, launch, and flight support for four (4) flight Modules (2 each of Types I and II) for launches at one-year intervals beginning in February 1975.

2.0 EQUIPMENT DEVELOPMENT

The equipment development plan and schedule provided herein covers a period of six years starting with an assumed contract go-ahead of July 1, 1972. During the prototype development program, the final design will be established; detailed manufacturing drawings will be prepared and issued; a mock-up will be made available; engineering development equipment will be built/procured and tested; and the prototype Bioresearch Module will be fabricated, tested, qualified and delivered, including associated ground support equipments.

3.0 PROGRAM SCHEDULE

The Bioresearch Module Development Program Schedule shown in Figure II. B-1 reflects the planning data to date. The schedule illustrates the over-all phasing of the planning, design, manufacture, and test efforts into the established delivery schedule of the prototype system. Completion of the design phase is scheduled for July, 1973, (1 year after go-ahead), with the availability of the full prototype Bioresearch Module for start of system qualification testing by the end of December, 1973 (1-1/2 years after go-ahead). The prototype system qualification is scheduled for completion five months later, the end of May, 1974 (23 months after go-ahead). The additional attitude control subsystem module qualification testing for Type II missions would be completed by the end of June 1974 (2 years after go-ahead).

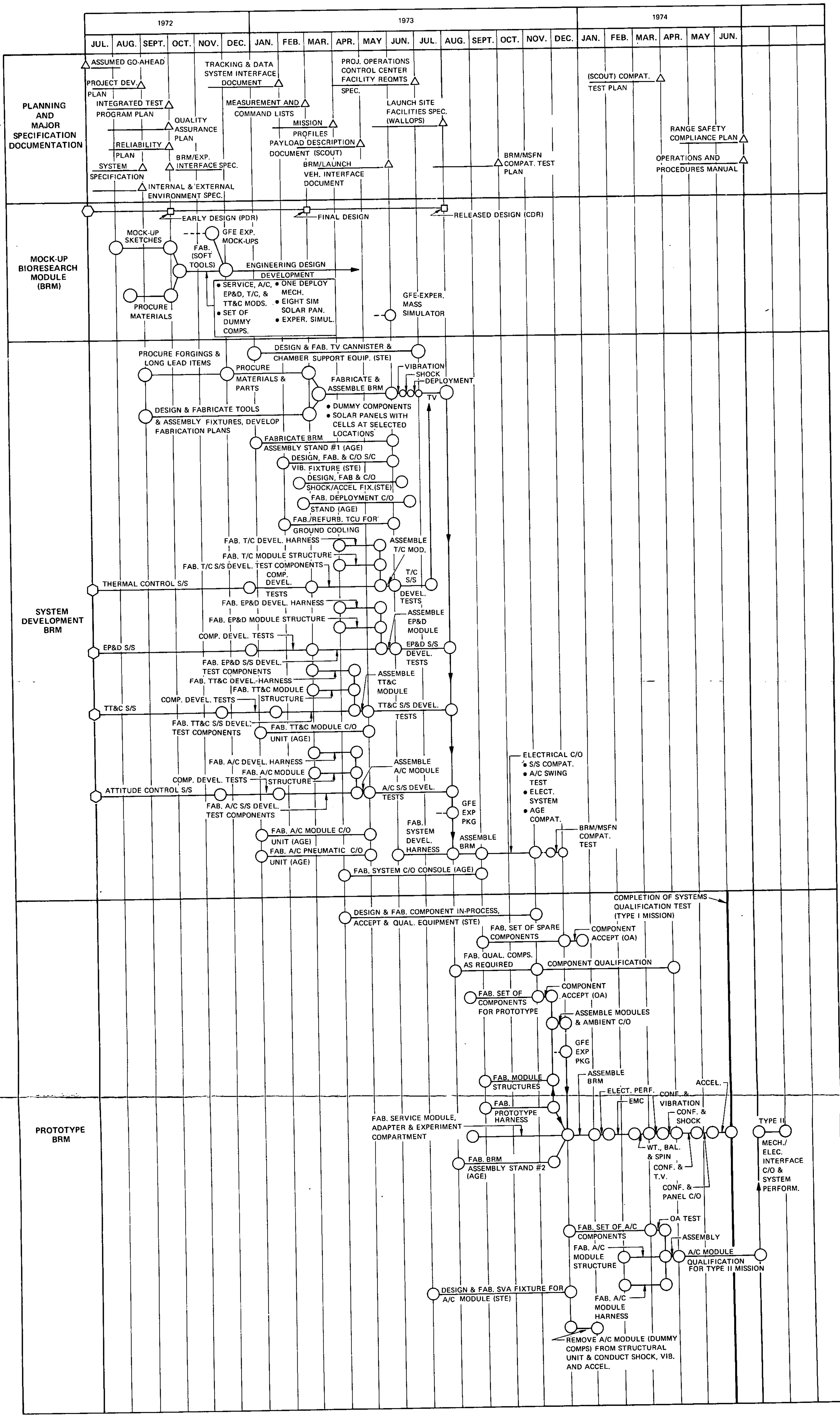
The summary schedules for the four optional program plans for flight Module processing, as described in Section II-A-12, are presented in Figures II. B-2 through II. B-5.

C. MANPOWER PLAN

The anticipated manpower loading for the implementation of the Bioresearch Module Development Program is shown in Figure II. C-1. This manpower curve was generated from the estimated funding data furnished in Section II-D of this Volume. The manpower profile selected for presentation in Figure II. C-1 is for development plan Option II.

FOLDOUT FRAME 1

FOLDOUT FRAME 2



III

Figure II-B-1. Bioresearch Module Prototype Development Program Schedule

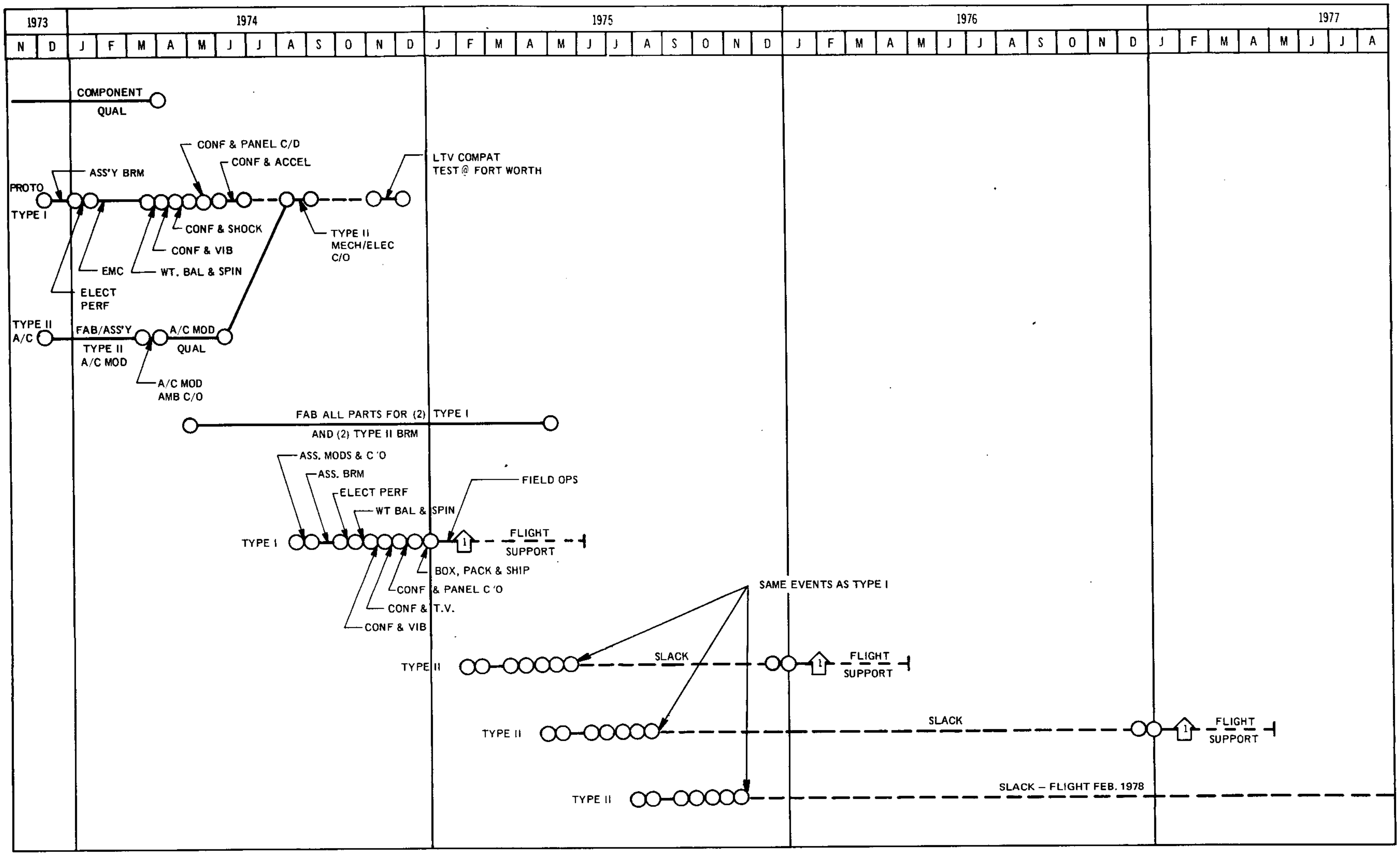


Figure II-B-2. Bioresearch Module Development Plan Option I

FOLDOUT FRAME 1

FOLDOUT FRAME 2

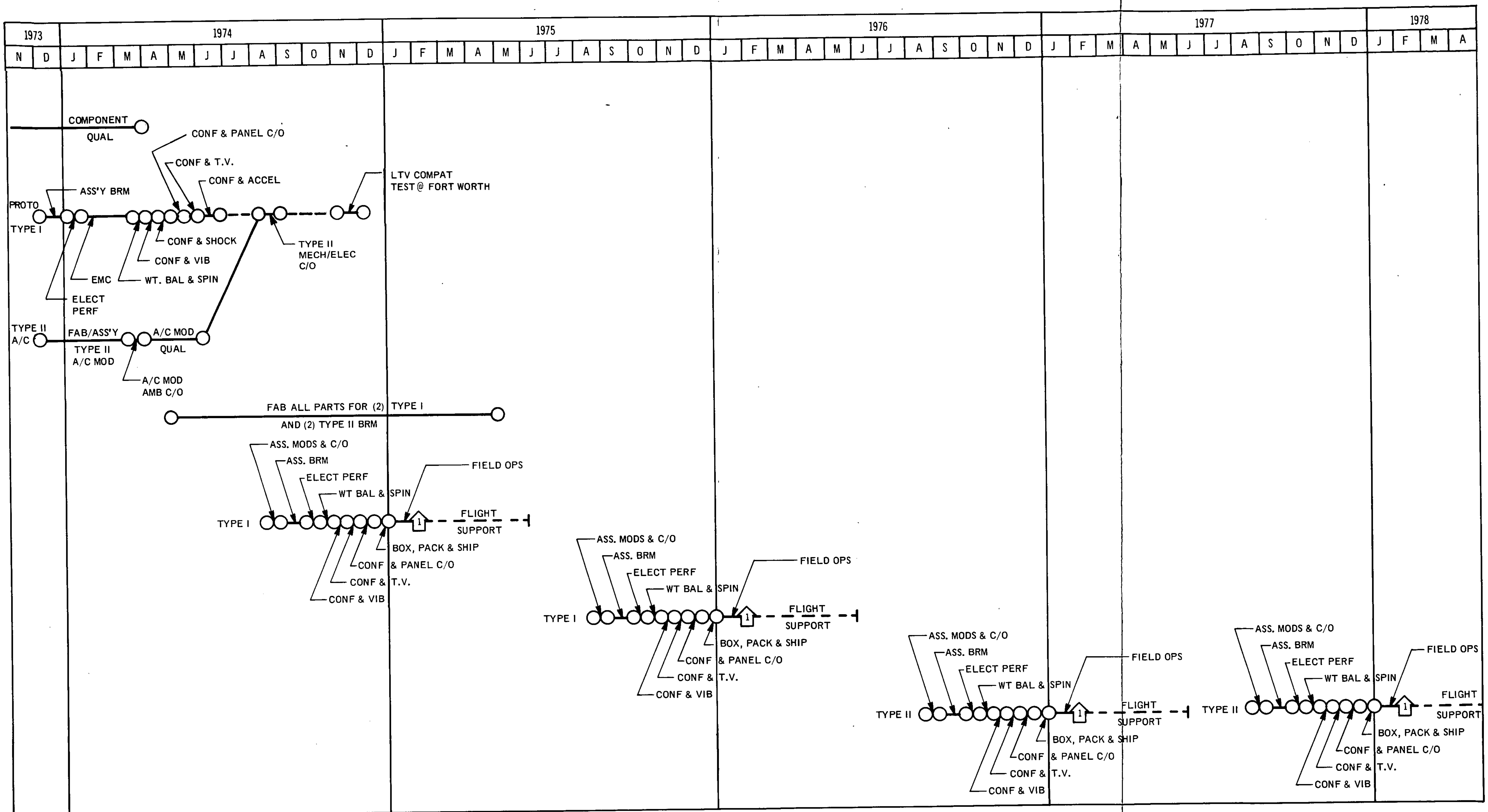


Figure II-B-3. Bioresearch Module Development Plan Option II

III

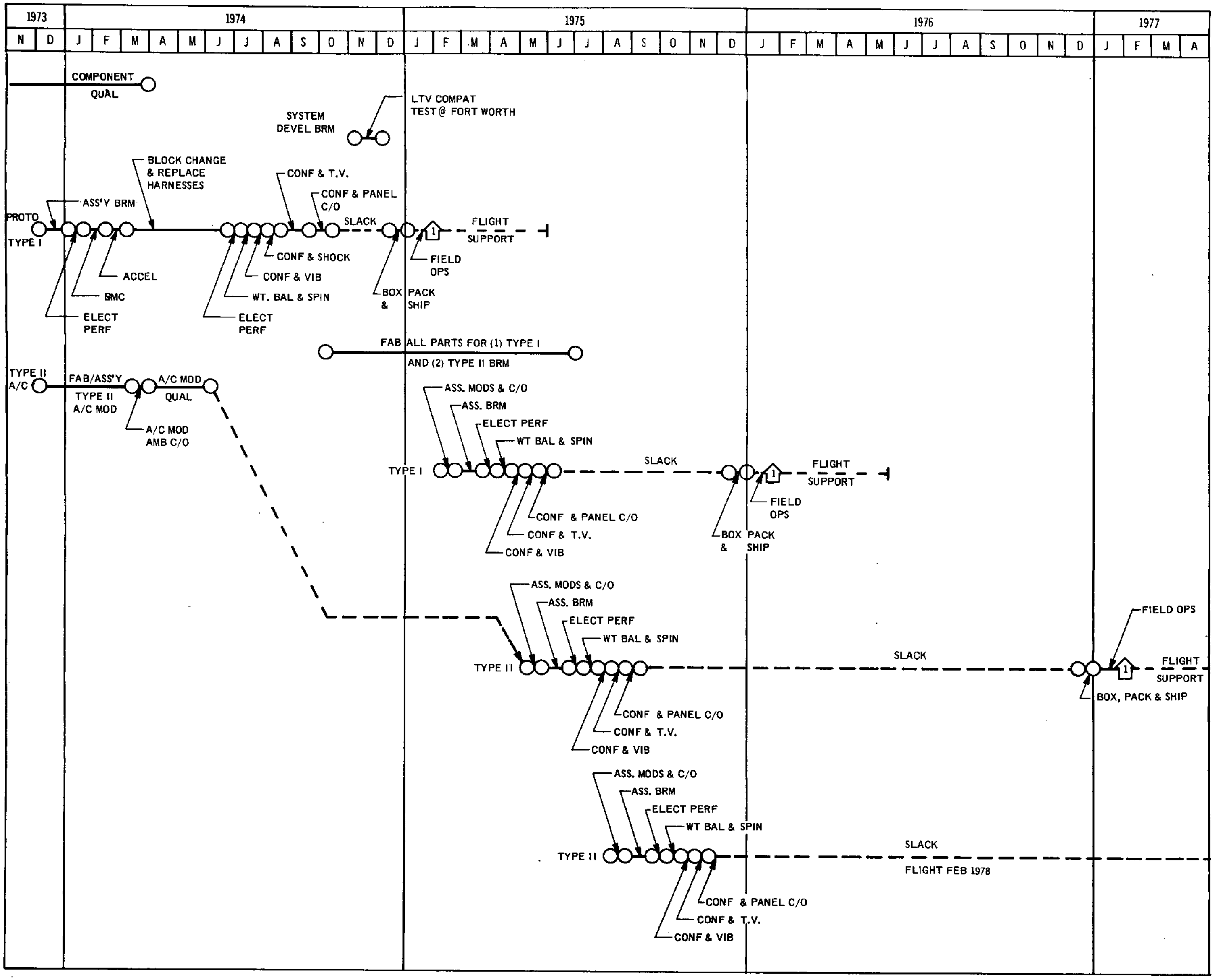


Figure II-B-4. Bioresearch Module Development Plan Option III

FOLDOUT FRAME 1

FOLDOUT FRAME 2

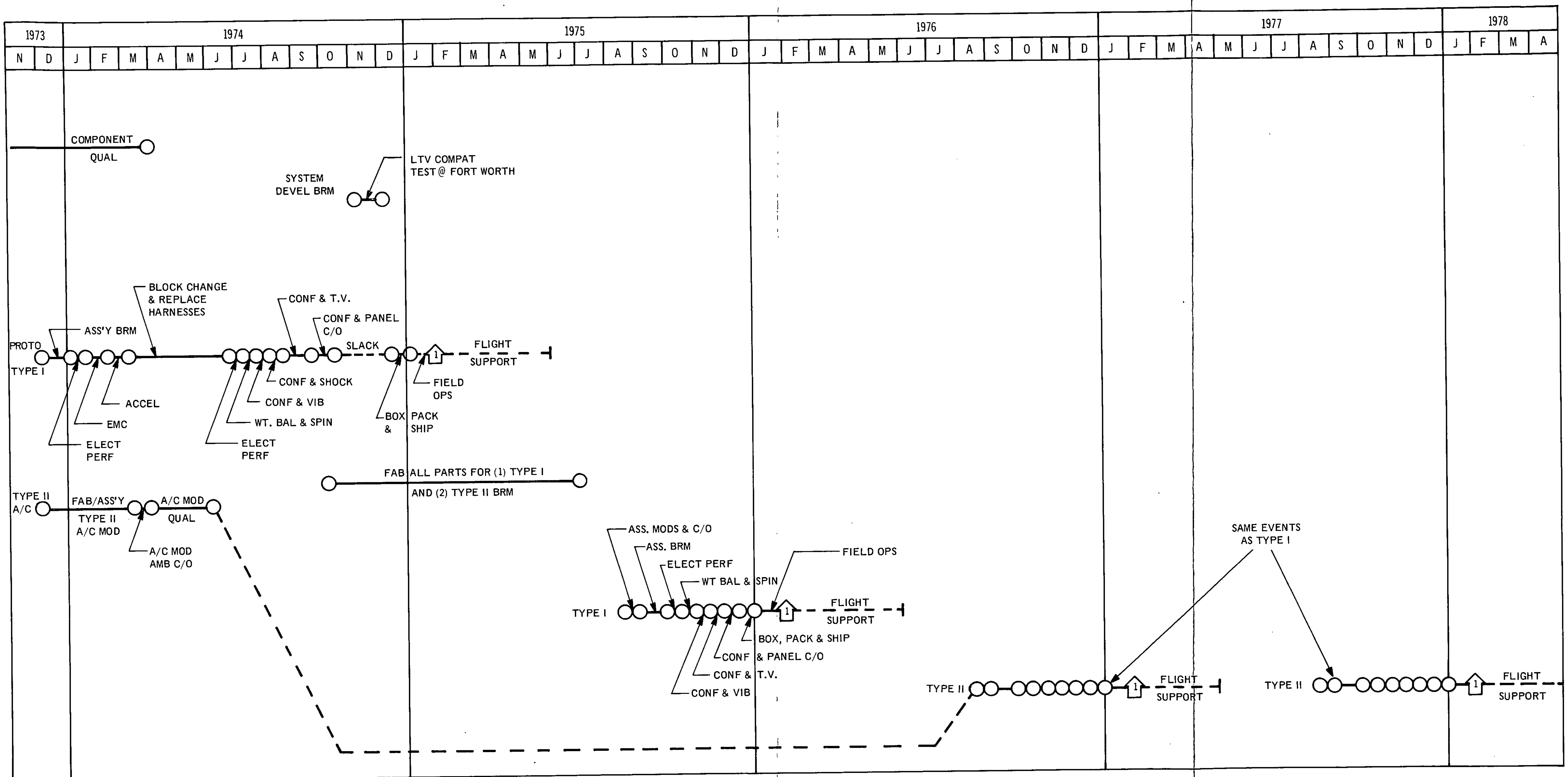


Figure II-B-5. Bioresearch Module Development Plan Option IV

III

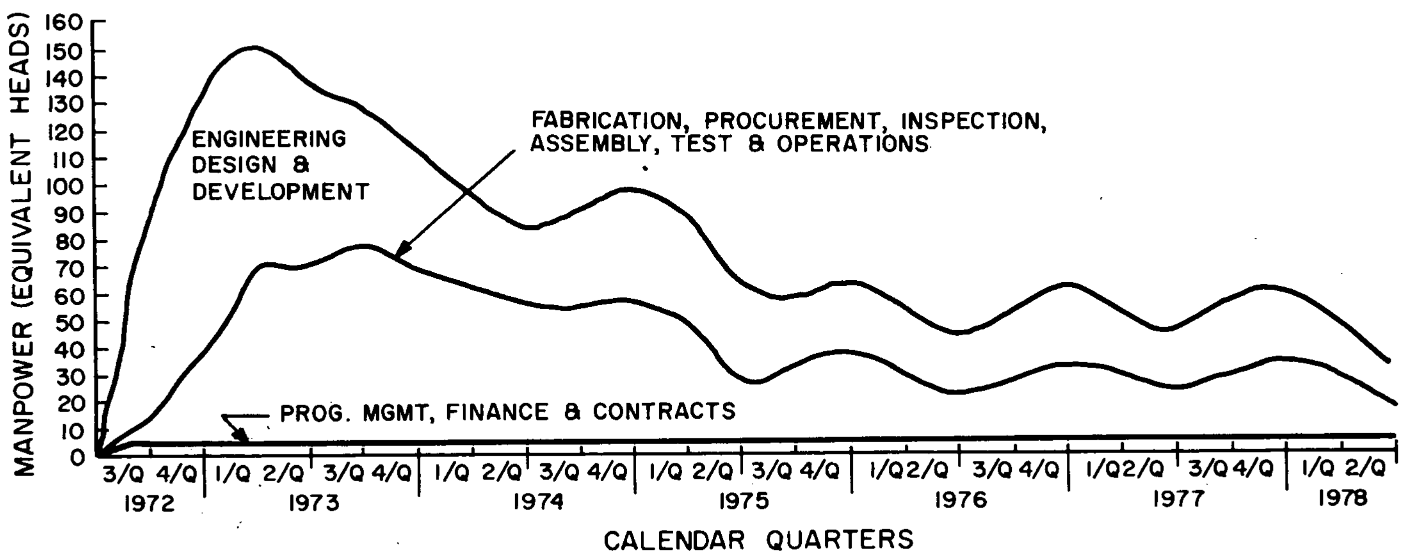


Figure II. C-1. Manpower Loading Plan (Option II)

D. ESTIMATED COSTS SUMMARY

The time-phased and total estimated funding requirements for various program elements are summarized in Table II.D-1 through II.D-3. The detail breakdowns by labor class and material supporting and justifying these summaries were prepared on some 50 detail, time-phased sheets and documented in the Design Review Report No. 2, dated November 9, 1971, and incorporated herein by reference.

TABLE II.D-1. TIME-PHASED ESTIMATES OF DESIGN, DEVELOPMENT, FABRICATION, PROCUREMENT, ASSEMBLY AND TEST THROUGH PROTOTYPE SYSTEM QUALIFICATION

		DOLLARS IN THOUSANDS								
		1972		1973				1974		
		3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	TOTAL
Program Management	Labor	26.4	26.4	27.0	27.0	27.4	27.4	28.0	28.0	217.6
	Mat'l	--	--	--	--	--	--	--	--	--
Systems Design	Labor	244.0	228.0	193.5	125.2	56.0	49.1	35.0	29.6	960.5
	Mat'l	21.1	37.5	24.2	13.3	--	--	--	--	96.1
Design	Labor	460.0	500.0	348.0	262.0	85.6	65.5	20.7	3.3	1745.1
	Mat'l	2.4	2.4	1.8	1.2	0.6	--	--	--	8.4
Development	Labor	37.7	138.5	238.0	217.5	300.0	263.0	272.0	250.0	1716.7
	Mat'l	--	--	--	--	0.6	1.8	1.2	1.8	5.4
Component Qualification (Engineering & O&E)	Labor	27.8	83.5	26.0	34.0	121.8	188.6	132.0	--	613.7
	Mat'l	--	--	--	--	27.4	147.5	198.5	--	373.9
Engineering Support	Labor	80.0	110.1	136.0	139.0	112.4	102.9	90.0	60.5	830.9
	Mat'l	--	--	1.2	1.2	1.2	1.2	1.2	0.8	6.8
Mock Up	Labor	7.4	29.0	21.0						57.5
	Mat'l	1.9	1.2							3.1
Tools & Fixtures	Labor	--	71.9	41.3	6.5					119.6
	Mat'l	--	7.1	2.5	0.2					9.8
Special Test Equipment	Labor	--	53.4	205.4	101.8	10.6	22.2	23.3	3.3	420.0
	Mat'l	--	--	59.7	70.1	3.0	--	--	--	132.8
Mechanical AGE	Labor	--	18.6	23.4	19.7	14.7	14.7	--	--	91.2
	Mat'l	--	35.7	43.5	48.1	--	--	--	--	127.3
Electrical AGE	Labor	--	5.4	29.1	60.4	32.4	30.7	21.2	--	179.3
	Mat'l	--	23.8	45.2	14.3	15.5	--	--	--	98.8
Systems Development	Labor	35.5	7.77	245.6	224.9	112.8	32.9	--	--	729.4
	Mat'l	138.6	389.8	219.8	228.2	5.4	1.2	--	--	983.0
Spares	Labor	--	--	--	--	77.2	58.6	--	--	135.9
	Mat'l	--	--	--	--	255.7	142.8	--	--	398.5
Prototype	Labor	--	--	--	--	148.4	234.6	163.1	155.4	701.5
	Mat'l	--	--	--	--	84.7	279.1	104.7	12.5	481.0
Mission II Attitude Control (Fabrication & Qual)	Labor	--	--	--	--	--	21.5	58.5	41.3	121.3
	Mat'l	--	--	--	34.8	46.5	84.7	80.2	1.5	247.9
O&E Management	Labor	64.5	55.4	55.4	52.4	65.9	64.4	64.4	64.4	486.8
	Mat'l	--	--	--	--	--	--	--	--	--
Operational Documentation	Labor	12.3	16.9	23.5	29.5	46.5	44.4	37.7	35.9	246.8
	Mat'l	--	1.0	3.0	3.0	2.0	2.0	3.0	4.0	18.0
Totals	Labor	995.6	1414.8	1613.2	1299.9	1211.7	1220.5	945.9	671.7	9373.3
	Mat'l	164.0	498.5	400.9	414.4	442.6	660.3	389.2	20.6	2990.5
	Labor & Mat'l	1159.6	1913.3	2014.1	1714.3	1654.3	1880.8	1335.1	692.3	12363.8

TABLE II.D-2. TIME-PHASED ESTIMATES FOR FOUR OPTIONAL PROGRAM PLANS FOR FLIGHT MODULE PROCESSING

	DOLLARS IN THOUSANDS																TOTAL
	1974			1975				1976				1977				1978		
	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	
OPTION I																		
Program Management		41.8	41.8	42.4	42.4	43.0	43.0	43.6	43.6	44.0	44.0	44.6	44.6	45.2	45.2	46.0	46.0	701
Engineering		440.0	486.0	480.0	405.0	320.0	282.0	239.0	224.0	219.0	219.0	236.0	222.0	228.0	228.0	222.0	162.0	4612
O & E	222.0	364.0	453.0	480.0	216.0	210.0	209.0	161.0	71.5	68.9	68.5	153.5	71.5	68.9	68.5	153.5	69.4	3109
Material	468.0	470.0	510.0	510.0	9.5	9.5	9.5	11.3	4.2	5.3	3.0	11.3	4.2	5.3	3.0	11.3	7.7	2053
TOTAL	690	1316	1491	1512	673	583	544	455	343	337	335	445	342	347	345	433	285	10475
OPTION II																		
Program Management		41.8	41.8	42.4	42.4	43.0	43.0	43.6	43.6	44.0	44.0	44.6	44.6	45.2	45.2	46.0	46.0	701
Engineering		426.0	471.0	382.0	279.5	295.0	287.5	226.0	205.0	306.0	304.0	240.0	214.0	290.0	293.0	203.5	151.0	4574
O & E	222.0	373.0	412.0	375.0	104.0	150.0	191.5	162.5	94.2	142.5	186.5	153.5	94.9	141.5	179.0	137.0	83.0	3201
Material	468.0	467.0	507.0	512.0	7.7	10.1	10.7	13.6	7.7	10.1	10.7	13.7	7.7	10.1	10.7	13.7	6.5	2088
TOTAL	690	1308	1432	1309	434	498	533	446	351	503	545	452	361	487	528	400	287	10564
OPTION III																		
Program Management		41.8	41.8	42.4	42.4	43.0	43.0	43.6	43.6	44.0	44.0	44.6	44.6	45.2	45.2	46.0	46.0	701
Engineering		315.0	360.0	435.0	374.0	304.0	277.0	236.0	222.0	224.0	224.0	252.0	230.0	232.0	232.0	231.0	182.0	4330
O & E	--	156.5	356.0	495.0	448.0	218.0	197.5	161.0	71.5	68.9	68.7	151.8	71.5	68.9	68.7	151.5	69.5	2822
Material		15.5	472.0	336.0	508.0	8.3	5.9	11.3	4.2	5.3	3.0	11.3	4.2	5.3	3.0	12.5	10.1	1416
TOTAL		529	1230	1308	1372	573	523	452	341	342	340	460	350	351	349	441	308	9269
OPTION IV																		
Program Management		41.8	41.8	42.4	42.4	43.0	43.0	43.6	43.6	44.0	44.0	44.6	44.6	45.2	45.2	46.0	46.0	701
Engineering		305.0	356.0	332.0	270.0	296.0	290.0	230.0	209.0	312.0	306.0	242.0	215.0	298.0	292.0	210.0	156.0	4320
O & E		187.0	405.0	356.0	334.0	143.0	203.0	155.0	96.1	141.0	199.0	153.0	94.5	140.0	198.0	136.8	80.6	3023
Material		14.9	470.0	336.0	505.0	6.6	11.3	14.9	6.5	8.9	11.3	13.7	6.6	8.9	11.9	11.3	3.0	1439
TOTAL		549	1273	1066	1151	489	547	444	355	506	560	453	361	492	547	404	286	9483

TABLE II.D-3. COST ESTIMATES FOR TYPE II ATTITUDE CONTROL, MISSION III, S-BAND, TELEVISION/MSFN AND REDUCED POWER OPTIONS

	Dollars in Thousands	
Type II Attitude Control	Labor Mat'l Total	826.5 261.8 1088.3
Mission III Design Constraints	Labor Mat'l Total	154.3 11.0 165.3
S-Band, Television/Otolith Exp. MSFN	No significant cost impact identified; S-Band is Baseline	
Reduced Power Requirements	150.0 Cost Reduction	