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V.3
15 JAN 1960

SPACE SYSTEM DEVELOPMENT PLAN

EXEMPTED FROM
DECLASSIFICATION IAW EO 12958
REVIEW DATE________ REVIEWER________
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EXEMPTION (S): 1 2 3 4 5 6 7 8 9

TURN TO
HISTORIAN'S OFFICE
AFBMD

DISCOVERER PROGRAM

HEADQUARTERS,
AIR FORCE BALLISTIC MISSILE DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND

[redacted]

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3-680-42
00920412

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NOFORN

HEADQUARTERS
AIR RESEARCH AND DEVELOPMENT COMMAND

(UNCLASSIFIED TITLE)
DISCOVERER
SPACE SYSTEM DEVELOPMENT PLAN

See Chronology
Change 1
&
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REVIEW ON 31 Dec 1990

B. A. Schriever
Lt. General, USAF
Commander

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AIR FORCE BALLISTIC MISSILE DIVISION **NOFORN**

AIR RESEARCH AND DEVELOPMENT COMMAND

15 January 1960

REVIEW ON 31 Dec 1990

FOREWORD

Under the basic guidance provided by Hq USAF in AFDAT message 98212, the program described herein provides for a 29-vehicle series. The objectives of the Discoverer program are to demonstrate the feasibility of the design, the structural integrity, and the function of the Agena vehicle and operating subsystems which include guidance and control, stabilization of vehicle on-orbit, and the closed-loop command system; and to determine the techniques and procedures for tracking, acquisition, and command of the vehicle on orbit, and recovery of capsule from orbit. In addition to the above, conduct biomedical experiments which include the recovery of living specimens from orbit by capsule ejection, re-entry, and recovery. Determine the compatibility of the Thor-Agena combination. In the Agena "B" vehicle, develop the single restart capability; and demonstrate the double size tankage, and the extended-burn engine. Increased orbit life will be achieved by design improvements, increased emphasis on reliability and engineering feedback as a result of increased experience.

A description of the ground facility network and a funding statement of the FY 1960 financial plan and the FY 1961 Budget Estimate is included in this development plan.

This development plan provides for the timely, economical and logical accomplishment of the Discoverer R&D Program consisting of 29 vehicles. The Discoverer program provides a broad experimental base in equipment developments and operating technique for the SAMOS and MIDAS programs.

Adequate funding (FY 1960, $71.1 millions and FY 1961, [redacted] as described in the funding section of this development plan is recommended in order to comply with the Hq USAF guidance for the continuation of the Discoverer program.

R. Curtin for

O. J. RITLAND
Major General, USAF
Commander

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AIR FORCE BALLISTIC MISSILE DIVISION (ARDC)

DISCOVERER

DEVELOPMENT PLAN

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DISCOVERER

BACKGROUND

The concept for using an Earth satellite as a platform for detecting, measuring, and transmitting significant scientific data to ground-based stations was a natural outgrowth of progress here and abroad with research rockets. The need for timely and continuous scientific research utilizing instrumented rockets and Earth satellites after the close of the International Geophysical Year was also emphasized by the first conference on the International Geophysical Year held in the United States. The impetus which motivated the United States Government to support new methods for collecting otherwise unattainable scientific information was man's rapidly increasing ability to view the world as a whole. From these observations will come a vast body of scale aspects of the Earth: its exterior, the lower and upper atmosphere, gravity and magnetism, and extraterrestial features.

The results of numerous studies conducted since 1946 by American scientists established that a satellite used as a scientific data gathering medium was feasible and would satisfy to a great extent the requirements of the scientist for information.

The concept of the satellite research system is a result of studies conducted at the Rand Corporation. A study completed in 1947 together with similar investigations by other contractors concluded that such a satellite system was feasible. In subsequent years, further studies were conducted by the Government leading to the award in October 1956 of a contract to Lockheed Aircraft Corporation for the development and test of a satellite research system. The following month, Massachusetts Institute of Technology was awarded a contract for the research and development of the guidance and orbital attitude control equipment for the system.

As the result of the Advanced Research Projects Agency (ARPA) Order No. 17-59, dated 4 September 1958 with three subsequent amendments, the program structure was established to provide for fifteen (15) ARPA funded flights.

ARPA Order No. 48-59, dated 16 December 1958 confirmed previous instructions to identify this program as DISCOVERER: thus, separating this development from the overall WS 117L program structure. A Discoverer Development Plan, dated 30 January 1959, providing for a fifteen (15) vehicle program was prepared and submitted for ARPA approval.

The 30 January 1959 Discoverer Plan was approved for a Thirteen (13) vehicle program by Amendment No. 2 to ARPA Order 48-59, dated 24 March 1959.

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In compliance with USAF message, AFDAT 59353, dated 27 April 1959, a new Discoverer Development Plan, dated 30 April 1959, calling for a twenty-five (25) vehicle program was prepared and submitted to the ARPA for approval. The 25-vehicle program was approved by Amendment No. 4 to ARPA Order 48-59, dated 20 May 1959.

Amendment No. 6 to ARPA Order 48-60, dated 20 July 1959, increased the Discoverer Program from a 25-vehicle series to a 29-vehicle series. This Amendment included instructions to submit a revised Development and Funding Plan to reflect the program increase.

As the result of Department of Defense programming actions the Discoverer Program was transferred from the ARPA to USAF cognizance on 17 November 1959.

In response to Hq USAF, AFDAT message 1328/59, which required the preparation of a new development plan for the transfer of the Discoverer program from the ARPA to the Air Force, two Discoverer Development Plans were prepared. The first plan dated 1 December 1959 described a 29-vehicle Discoverer program. The second dated 15 December 1959 provided for a 22-vehicle Discoverer program within the funding ceiling established by Hq USAF in the above AFDAT message. As a result of the presentation given to Hq USAF during 14-15 December 1959, additional guidance was received from Hq USAF in an AFDAT message 98212 dated 21 December 1959 to proceed with a 29-vehicle program, and to reduce the program funding rate where possible. The funding rate has been reduced by terminating operation of the Annette Tracking Station, reduction of the Spare Parts Program, and the removal of the light weight thrust chamber for the Agena vehicle.

The plan to follow has been prepared in accordance with the guidance cited above for the continuation of the program.

DESIGN CHARACTERISTICS

I. INTRODUCTION

A. DISCOVERER MISSION

The Discoverer program is a research and development program encompassing the development of a complex ground environment for the design, development, testing, launch, orbit injection and an orbit tracking and control of a large satellite vehicle, the Agena, with the following immediate objectives:

1. The achievement of orbital capability of the basic satellite vehicle.

2. The development of operational system techniques and procedures.

3. The recovery of biomedical and other data from orbit through the utilization of a suitable recovery capsule.

4. The execution of nonrecoverable advanced engineering tests,

The results of the Discoverer Program in the form of experience, techniques, procedures, facilities, the Agena vehicle and vehicle subsystems, and items of hardware will be directly applicable in whole or in part to the Space weapons systems of SAMOS and MIDAS. Thus, Discoverer provides a broad experimental base for future space programs.

A unique and integral part of the Discoverer Program is the 6594th Test Wing (Satellite). This Air Force unit is charged with the responsibility of preparations for and launch of the satellites, tracking and command of the satellites on orbit, receiving satellite data from on orbit and recovering receovery capsule from orbit.

B. OVERALL OPERATIONAL CHARACTERISTICS

Discoverer is composed of an Agena satellite and a Thor booster. In direct support of the Discoverer are launch, tracking and communications facilities.

After Thor burnout, the Agena and Thor sections separate. As the booster falls away, the satellite vehicle continues in a self stabilized, predetermined coast. At the termination of the coast phase the internal satellite power plant activates, supplying the orbital

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velocity increment required to establish a substantially circular orbit. The internal controls then reorient the vehicle to the proper attitude. The most common orbits pass within a few degrees of the poles.

As the vehicle orbits the earth and passes within range of the ground tracking and acquisition stations, telemetry signals are received from the orbiting vehicle and command signals are sent from the ground station to exercise the command and control portion of the Discoverer.

The orbit time of the Discoverer is approximately 90 mintues. Because the orbit is essentially fixed in space and the earth rotates inside it, successive passes over the earth's surface will be displaced approximately 22½ degrees at the equator. Useful operation of the Discoverer will terminate upon recovery, when drag slows the vehicle and causes it to plunge into dense atmosphere, when the electrical power supply is exhausted, or when a failure of equipment takes place.

II. DESIGN OBJECTIVES AND GENERAL OPERATING DATA

A. SATELLITE VEHICLE

The Agena satellite vehicle is being developed over a period of years and will include a variety of configurations, capabilities, and useful satellite life spans. Development of the system will proceed from a simple design of limited capability to a more refined version capable of greater scientific investigation.

B. SUBSYSTEMS

1. General:

The over-all system development has been divided into eight subsystems which are identified as follows:

Airframe, Subsystem A
Propulsion, Subsystem B
Auxiliary Power, Subsystem C
Guidance and Control, Subsystem D
Command and Control, Subsystem H
Geophysical Environment, Subsystem J
Personnel, Subsystem K
Recovery System, Subsystem L

2. Airframe, Subystem A.

a. The Airframe Subystem will consist of the propellant and pressurization tankage, structures, aerodynamic fairings for the satellite, a destruct system, and all mechanical and electrical installations in the satellite not specifically included in the definition of other subsystems.

b. The Airframe will include a 60-inch diameter cylinder adapter (which will be attached to the booster and remain with it after separation), and the orbiting vehicle. The vehicle will be a 60-inch diameter, load-carrying cylinder about 14 feet long, containing or supporting all other subsystems. This cylinder will be inclosed for about half its length in the adapter. The payload and structure on the front of the vehicle will be protected from aerodynamic effects by a conical nose section. The engine and pressurized gas storage will be carried at the rear of the vehicle making an overall lenght of about 18 feet. Maximum utilization of structural material will assure the highest possible ration of payload weight to gross weight. The overall length will be increased to approximately 26½ feet when the extended burn and large tanks are introduced into the program.

c. There are two general airframe configurations in the Discoverer program:

(1) Single size propellant tanks used for flight vehicles numbers one through 17.

(2) Double size propellant tanks for use with Vehicles 18 through 29.

d. Reliability: To assure maximum reliability, the Airframe Subsystem is designed with a Safety Factor in accord with good engineering practice. Further assurance of high reliability is attained by subjection of the Airframe Subsystem to qualification testing under the appropriate structural and environmental specifications. The most severe test conditions are simulated as accurately as possible to that which the vehicle will encounter in use. Continuous reliability design reviews will be conducted to improve reliability.

3. Propulsion, Subsystem B.

a. The Propulsion Subsystem will consist of the rocket engine; pressurization; feeding and loading systems (other than propellant and gas tanks); the engine gimbals (but not gimbal actuators); and the equipment required to start, stop, and control thrust magnitude in response to an electrical signal from the ground or from the guidance subsystem; and the equipment required to control the propellant flow mixture ration. It will also include any auxiliary devices required to establish proper ullage orientation in the fluid system prior to and during start of the main rocket engine, including the equipment required to operate these devices.

b. The Project Hustler XLR-81, 15,150-pound-thrust, pump-fed engine will be used for the main satellite rocket power plant. The XLR-81-BA-3, using IRFNA (inhibited red fuming nitric acid) and JP-4 propellants, having a 263-pound-second/pound vacuum specific impulse, will be used in the first two Thor-boosted flights. The XLR-81-BA-5 modified to use IRFNA and UDMH (unsymmetrical Dimethylhydrazine) as propellants, has a 277-pound-second/pound vacuum specific impulse and will be used on subsequent flights. The final engine configuration will incorporate a 240 second burn time, a restart capability, a 45:1 area ratio nozzle, and a triplet propellant injector which will give a 288-pound-second/pound vacuum specific impulse. Forces required to provide proper fuel orientation prior to firing the main rocket engine at the completion of the coast phase will be provided by small 20-second duration, 120 pound thrust, solid-propellant rockets (ullage rockets).

c. There are four general engine configurations in the Discoverer Program:

(1) The XLR-81-BA-3 is used on the flight Vehicles 1 & 2.

(2) The XLR-81-BA-5 is used on flight Vehicles 3 through 17.

(3) The XLR-81-BA-7 is used on flight Vehicles 18 through 21.

(4) The XLR-81-BA-9 is used on flight Vehicles 22 through 29.

d. Reliability: Primary and auxiliary propulsion devices for this Subsystem will be developed, improved, and modified as necessary to provide the degree of reliability for successful accomplishment of the mission. The highest degree of reliability assurance possible prior to flight will be attained through logical, timely, and extensive development testing of components, subassemblies, assemblies, and the entire subsystem under applicable environmental conditions, to the degree that it is possible to duplicate such conditions. Air Force technical management of this program will emphasize utilization of suitable test facilities and experience available at ARDC Centers as well as other institutions, civilian or military, during the prelaunch development and qualification phase.

4. Auxiliary Power, Subsystem C.

a. The Auxiliary Power Subsystem consists of equipment required to supply electrical power to all subsystems within the satellite vehicle from a time just prior to launch until the end of the vehicle's lifetime.

b. The Discoverer Auxiliary Power System will be based on the use of a nominal 28-volt battery power source, a 2-KC, 115-volt, single-phase, general power ac distribution system, a 400-cycle, 3-phase, precision ac power system and a ≠28 volt supply. The 2000-cycle ac inverter furnishes power for the ≠28 volt supply as well as power for a + 28-volt series booster regulator, operating from the prime energy source. The auxiliary power system will incorporate silver peroxide-zinc batteries of refined design, yielding 72 watt-hours per pound. Power conversion equipment will utilize power transistor inverters and static transformer rectifier components; due to the limitation of available electrical energy power, conversion equipment of exceptionally high efficiency is a requirement. Early power inverters have an efficiency of 65 percent and are adequate for initial test flights. An improvement program will be initiated for the development of controlled diode inverters that show promise of considerably higher efficiency for later flights. The initial utilization of a photovoltaic power supply will be made on at least one flight to furnish 14-volt dc power to the acquisition beacon.

c. There are two general configurations of Auxiliary Power used on the Discoverer. They are:

(1) Auxiliary Power for 30 hour lifetime used on flight Vehicles 1 through 17.

(2) Auxiliary Power for 100 hour lifetime used on flight Vehicles 18 through 29.

d. <u>Reliability</u> of the Auxiliary Power Subsystem will be maintained and improved by:

(1) Analyzing and rectifying the high failure rate known to exist for auxiliary power systems components, particularly the 400 cps and the 2000 cps inverters.

(2) Conducting diagnostic tests of these components operated on the bench into actual loads with realistic on-off cycling and with suitable instrumentation to observe internal transients and abnormal behavior.

(3) Conducting component and subsystem design improvement program, utilizing redundancy, derating parts, minimizing stress, reducing complexity and incorporating such other features as will extend lifetime without significantly degrading performance.

(4) Isolating shorted or defective loads, loss of which will not be catastrophic, so that power will continue to be supplied to operable portions of the load.

(5) Conducting component life tests in all significantly different modes of operation, including on-off cycling, programmed power levels, and/or continuous operation as applicable. Performing of these tests with actual or suitably simulated loads and environment.

(6) Broadening component specifications without ambiguity to insure that all anticipated duty cycles and application conditions are covered.

(7) Determining the extent to which quality control has been a factor in component failures, and thus instituting more rigorous inspection procedures. Initiating a back-up production source if warranted.

(8) Instituting more rigorous procedures for reporting the circumstances associated with inverter failures, and maintaining historical summary of experience with each model indicating operating time, repair, or rework accomplished, and known or probably cause of failure.

(9) Extending cycle life testing of secondary batteries to 10,000 cycles with appropriate depth of discharge and period; and determining the engineering changes necessary to meet specified cycle life.

5. <u>Guidance and Control, Subsystem D.</u>

a. The Guidance and Control Subsystem will be comprised of those items of equipment required to sense and direct vehicle attitude and velocity so as to establish a satisfactory orbit.

b. In addition, it will:

(1) Provide self-contained means for the initial alignment and maintenance of the desired vehicle attitude during orbital operation.

(2) Provide an indication of attitude, and rate of change of attitude, to other subsystems in the vehicle as necessary.

c. There are two general configurations:

(1) 30 hour life

(2) 100 hour life

d. Reliability: Maximum reliability of the Guidance and Control Subsystem is being attained in the following manner:

(1) Require all components such as gas jets, horizon scanners, timers, etc. to perform satisfactorily under simulated environmental conditions, and thus demonstrate a mean-time-to-failure (MTTF) compatible with required life.

(2) Use redundant components and circuits where weight is tolerable and sufficiently great MTTF cannot be adequately assured. For example, by use of back-up "D" timer signal for vehicle separation from the booster and by programmed lock-out signal to preclude premature engine shutdown in case of accelerometer integrator malfunction.

(3) Require component failure reports during all phases of testing to indicate failure areas, overhaul time, and replacement times.

6. Command and Control, Subsystem H.

a. The Command and Control Subsystem ground equipment consists of those items of equipment required to perform the following functions:

(1) Determine the position of a satellite vehicle relative to the earth, as a function of time, by a process of observation and computation.

(2) Command and program the functioning of the vehicle payload and auxiliary devices on a time-sequence basis or in real time.

(3) Provide a means for communicating with the vehicle from ground stations and for receiving and encoding environmental, vehicle functional and telemetry data from other vehicle subsystems.

(4) Provide communications facilities and terminal magnetic tape recording equipment ground installations for efficient and reliable recording and transmission of received information.

(5) Provide a common time reference for the vehicle and ground complex and a reference date-time index for the orbital passes.

b. Subsystem ground equipment at tracking and acquisition sites includes all non-airborne specialized equipment required to transmit, receive, checkout and test, record, process, store, and decode indexed information and to safeguard or otherwise perform functions at the tracking and acquisition sites immediately subsequent to launch and throughout the Discoverer's orbiting life.

c. The Discoverer ground-space communications program will be based on a VHF/S-band system.

7. Vehicle-Borne Communications

The vehicle-borne communications subsystem shall consist of:

a. S-Band-Transponder. The vehicle S-band transponder supplies response pulses to the VERLORT radar coded interrogations which are used at the interrogating radar as a means of determining vehicle position. The transponder also receives, decodes, and delivers ground-to-air real-time commands for operation of vehicle functions. The S-band transponder equipment includes a decoder and an antenna.

b. Acquisition Beacon. The acquisition beacon provides a means for acquisition and tracking. This unit will operate continuously providing an acquisition signal for "back-up" in the event that other acquisition methods prove unsuccessful. The transmiter is a low power, crystal controlled, VHF, CW transmitter, the output of which is duplexed into a common antenna with the VHF telemetry transmitter. The acquisition beacon is isolated from the telemetry transmitter by means of a two-channel diplexer.

c. Vehicle Timer-Programmer. The elementary timer-programmer is intended to turn on a limited number of units of vehicle equipment cyclically. Provisions are incorporated to include an initial cycle of different composition from the normal cycle. Commands from the ground shall be capable of resetting and changing periods.

d. Vehicle Antennas. The vehicle shall be equipped with an S-band transponder antenna and VHF antennas for both the ascent and orbit phases. The VHF ascent and orbit antennas shall be multiplexed to serve both the telemeter transmitter and the acquisition beacon transmitter.

e. FM/FM Telemeter. The FM/FM telemeter shall be installed to obtain and transmit vehicle functional, environmental, and other scientific data.

8. Geophysical Environment, Subsystem J.

a. This subsystem consists of the studies, equipments, both rocket-borne and satellite-borne, required to provide environmental data considered essential to insure and simplify the design of a successful Advanced Reconnaissance System. This subsystem also includes the ground equipment required to maintain, service, calibrate and checkout prior to flight, those equipments described above.

b. Insufficient data exists on geophysical environment to insure successful design and test of the satellite vehicles in the following areas:

(1) Atmospheric density

(2) Cosmic radiation

(3) Thermal environment

(4) Meteor physics

(5) Solar ultraviolet radiation

(6) Atmospheric composition

9. <u>Personnel, Subsystem K.</u>

A personnel subsystem exists whenever any other subsystem, or the booster subsystem, require the interaction of personnel. A properly designed personnel subsystem consists of the following components:

a. Human engineering to insure optimum man-machine compatibility.

b. Determination of the kinds and number of personnel required to operate and maintain the associated hardware subsystem.

c. Training and training equipment required to obtain suitably trained personnel.

10. <u>Recovery System, Subsystem L.</u>

The Recovery Subsystem consists of a satellite-borne capsule, suitable payloads, and equipment that will collect and transmit data by telemetering and that will insure successful re-entry and recovery from orbit.

Design modifications shall be accomplished as required to maintain the Recovery Program current.

The recovery force in Hawaii will participate in a continuous training exercise which will be designed to develop to the highest possible degree their searching proficiency, co-ordination, and air snatch, and to provide a continuous testing mode for new recovery gear.

C. GROUND SUPPORT EQUIPMENT

1. The term "Ground Support Equipment" refers to any or all non-airborne implements or devices which are required at the launch complex to inspect, test, adjust, calibrate, appraise, gage, measure, repair, overhaul, assemble, disassemble, service, transport, safeguard, record, store, actuate, or otherwise perform a function in support of the air-borne vehicle prior to launch.

2. The test ground support equipment shall be prototype ground support equipment. That equipment required for the Discoverer Program is essentially the equipment already built and on hand. Continuous redesign, fabrication and test effort is necessary to modify, as required, existing equipment to correct deficiencies as they arise .

D. RELIABILITY PROGRAM

1. Reliability Design Review

Continuous reliability design reviews are being conducted within the funds available to assure equipment design for maximum reliability. The major objectives of these reviews are: (a) To maintain a reliability prediction for the system concept so that decisions can be made regarding the total permissible complexity at system level; (b) To establish complexity values down to the equipment level; and (c) To assure that each equipment will meet its reliability goal.

The prediction techniques and part failure rates outlined in such reports as RCA-TR 1100, RACC TN 58-81, and VIRTO 98 are used to accomplish the foregoing objectives. The early prediction will be based on the use of currently available parts, and assumed proper applications. Some of the benefits obtained by use of the reliability review are as follows:

a. Isolates marginal application of parts

b. Identifies marginal engineering design

c. Provides a basis for considering redundancy

d. Provides a measure of mean-time-to-failure (MTTF)

e. Provides a detailed thermal evaluation of packaging

f. Establishes areas of thermal penalty

g. Evaluates fail-safe features

h. Identifies parts for additional research and development

i. Provides a measure of mean-time-to-repair (MTTR)

j. Defines probable modes of failure

k. Reveals use of non-standard fabrication processes

l. Reveals usage of unacceptable parts; i.e., parts known to have unacceptable failure rates.

Experts in many specialties including parts, parts application, design, and fabrication are being used to effect reliability design reviews.

2. Parts Program.

A comprehensive parts program is in progress to increase the average life of piece parts used in the satellite equipment. This program includes parts evaluation and establishment of application criteria for the orbital environment. The major efforts to reduce part failure rates include the following:

a. Selection of source and exact production line

b. Analysis of part instabilities

c. Circuit design to minimize the effects of these instabilities

d. Optimum derating

e. Improved inspection techniques

A survey of parts application and development programs at governmental agencies, subcontractors and vendors is presently being made. This survey will be intensified. In addition, participation in the Reliable Electronic Parts Program of Battele Memorial Institute will continue, and the IMSD Data Interchange Program will be expanded to include parts test data, specifications, and test plans. Information obtained from these sources, and other test data, will be used to prepare parts list. This list and application data to be developed from the parts study will be given to design personnel for their use in development work. The quality of all approved parts will be monitored and maintained by the quality control program. It is anticipated that improved quality control acceptance criteria will permit ordering optimum production batches from part suppliers. Acceptance Test Specifications and Acceptance Test Procedures will be analyzed to assure that only the highest quality parts which meet stringent performance requirements are purchased.

The part testing program is being oriented toward establishment of failure modes, development of application data, and formualtion of accelerated life tests. One task to be initiated will be to establish the effects of cyclic and of continuous operation of active parts such as transistors and microwave tubes. This study will be correlated with the effects of voltage transients, if possible. Efforts will also be undertaken to develop techniques for detecting latent failures. Parts are presently being evaluated in critical application areas and high failure rates have been observed in the following parts:

a. Microwave tubes

b. Tantalum Capacitors

c. Connectors

d. Relays

e. Potentiometers

f. Diodes

g. Power transistors

h. Electron Tubes

i. Motors

The use of rotating parts such as motors, slip rings, and coding wheels will be minimized. In addition, solid state devices will be developed to replace relays where feasible.

A failure reporting system is being used to identify problem areas in part applications. Some failed parts are selected for dissection and analysis so that fabrication defects can be determined and test and application criteria can be established.

3. Materials and Processes Program

A study will be made to determine the degradation of materials in a vacuum. Such processes as wire wrap, solderless connectors, and spot welding instead of soldering for part lead attachment, will also be investigated.

Assembly techniques will be developed to reduce stresses to a minimum during assembly. The need to alter the configurations of present parts to ease problems in this area will also be studies.

Specifications will be reviewed to prevent undesirable reliability performance traceoffs.

4. Reliability Tests

A considerable effort will be made to ascertain and measure the environment of equipment. An extensive effort has already been made to define the ground and launch environment of Discoverer. Studies will continue on the effects on the following:

a. Electromagnetic Radiation

b. Cosmic Radiation

c. Radiation Belts

d. Interplanetary Dust

e. Vacuum

f. Weightlessness

The effects of these environmental factors on materials, parts and components will be evaluated in LMSD ground laboratory and space laboratory programs using the criteria established in above study of the unique space environment.

Reliability tests will be conducted at part, component and subsystem levels. The types of tests that will be conducted are as follows:

Accelerated life (parts)
Nominal life (system level)
Elevated environmental stress limits (parts and components)
Thermal cyclic and shock (parts and components undergoing orbital thermal change)
Vacuum life (materials, parts, components)
Radiation life (particularly organic materials)

5. Communications Subsystem Reliability (Subsystem H). Effort will continue to establish and meet realistic time-phased reliability requirements for SS/H. It is essential that the ultimate configuration of SS/H meet operational requirements in regard to loss and distortion of data, time inoperative, and accuracy of ephemeris determination. It is also recognized that substantially accelerated SS/H reliability growth and higher ultimate reliability goals can require markedly higher funding.

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6. <u>Redundancy vs Weight Penalty Analysis Program</u>.

Where the state-of-the-art part life precludes achieving the desirable equipment reliability goal, the use of redundant components will be considered. It is realized that the use of redundancy is a poor substitute for mature design and, therefore, duplicate components will not be considered unless no other solution is feasible. The weight of each redundant component and its associated contribution to enhance satellite reliability will be considered in reaching a decision on each problem.

A study will be completed which will determine the optimum use of redundant components with reference to the weight penalty. Some components which may be considered for redundancy are as follows:

a. Inverters SS/C

b. Voltage limiter circuits

c. Electronics of the attitude control system SS/D

d. Data transmitter SS/h

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SUMMARY DESCRIPTION OF CONTRACTS

A. AF 04(647)-97 and AF 04(647)-347 Lockheed Aircraft Corporation

1. Management

LMSD: The central direction and control of concepts, studies analyses, expenditures, programming, scheduling and reporting; the administrative support required to provide manning, funding and coordination of all activities of the program; the source of evaluation and progress information to the customer. The responsibility for initiating, organizing, and maintaining an adequate reliability program.

2. Systems

LMSD: Perform analyses, design studies and flight tests (and basic development tests not applicable to a particular subsystem) in determining compatibility of systems, establishing system concepts, design criteria and constraints to ensure: compliance of space bound system components with the concepts for each successive system and complete systems integration. This includes design, development and/or provision and operation of ground equipment systems, ground-space tracking, communications, command systems and related test, servicing, calibration and logistical support equipment (both contractor and/or government furnished) embracing human engineering and Q.P.R.I. studies as well as engineering research and required manufacturing.

Subcontract: Conduct a program of analytical study and system simulation and conduct A&E studies.

3. Airframe Subsystem

LMSD: Develop and produce satellite airframe. Provide: propellant and pressurization tankage; aerodynamic fairings; structural supports, brackets and fittings; mechanical and electrical fittings not included in other systems; environmental controls; and ground equipment required for transporting, servicing, erecting and launching.

4. Propulsion Subsystem

LMSD: Obtain and integrate the orbital thrust rocket engine. Develop and provide propulsion subsystem including: feed and loading systems, engine gimbals, and equipment required to start and stop rocket engine in response to command (or program) ullage orientation requirements, and ground based items for testing, calibrating and servicing.

Subcontract: Bell Aircraft Corporation: Modification and development of XLR-81 rocket to YLR-81-BA-3 (IRFNA and JP-4 propellants) engine; performance of PFRT and delivery of ground and flight engines, including spares, engine rework, engine repair and handbooks. Modification and development of YLR-81-BA-3 to IRFNA and UDMH propellant configuration, perform PFRT and delivery of ground and flight engines including spares, engine rework, engine repair and handbooks. Modification and development of improved engine to higher specific impulse, and restart capability.

Aerojet-General: Design, develop and manufacture of solid propellant ullage orientation rockets.

5. Auxiliary Power Subsystem

LMSD: Develop and/or provide and integrate: energy source and power conversion equipment required to furnish electrical power for all subsystems within satellite from time just prior to launch to mission's ending and equipment required for testing and servicing.

Subcontract: Design, development and production of prime energy sources and power conversion equipment, including power inverters, voltage regulators, photovoltaic collectors, control relays and design, development and production of primary and secondary batteries.

6. Guidance and Control Subsystem

LMSD: Develop and/or provide and integrate: ground based and on board guidance and control (command) equipment required to stabilize, direct, separate and boost orbiting vehicle and equipment required for servicing, testing and calibration.

Subcontract: Design, development and production of horizon scanners, inertial reference package, control valves and nozzles, and MIT inertial guidance system.

7. Ground-Space Communications Subsystem

LMSD: Develop and/or provide and integrate and operate: Space-ground and ground communication and tracking equipment required by contractor to coordinate and monitor all flights and assist the government in determining, equipping and manning facilities required for service controlled activities. This includes all ground support equipment required for servicing, testing and calibrating.

Subcontract; Philco Corporation: Conduct a program for research, design, development and fabrication effort for the ground space communication subsystem and early operation of subsystem; manning and planning of ground stations; and installation of Subsystem H ground equipment.

8. <u>Biomedical Subsystem</u>

LMSD: Develop a recoverable capsule to accomodate an aero-medical package for use with the Thor-boosted vehicles.

B. <u>AF 04(647)-165 - Space Technology Laboratories, Ramo-Woolridge Corp</u>

1. Since Lockheed Aircraft Corporation has the prime contract under the direction of AFBMD, contribution of the Space Technology Laboratories lies primarily in the area of consulting services and technical studies. These services are performed for, and at the specific request of AFBMD.

2. The STL studies are general in nature and indicate trends rather than highly detailed final results. STL is not responsible for technical direction, quality of design, contractor performance, or contractor evaluation.

C. <u>Letter Contract Designated as Supplemental Agreement #15, Contract AF 04(645)-65 Douglas Aircraft Company</u>.

Responsible for providing such services as are required to adapt the SM 75 booster, its facilities, ground support equipment, etc., to the Discoverer and launch the combined SM 75 - Discoverer vehicle into orbit.

D. <u>OA 58 - 10, Air Force Cambridge Research Center</u>

Responsible for conduct of a program of research and development on equipments, techniques and methods for the collection of geophysical environmental data. AFCRC has been delegated the responsibility for the conduct of the program for the Geophysical Environment Subsystem.

E. <u>MIPR 58 - 54, Naval Air Station, Moffett Field, California Helium for Lockheed</u>.

F. <u>CSO 58 - 33, Ballistic Research Laboratory, Aberdeen, Maryland Wind Tunnel Tests</u>.

G. <u>MIPR 59 - 73, Navy, For Restoration and Modification of USNS Pvt. Joe E. Mann</u>.

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PROGRAM SCHEDULE C.T.L.O.

		FY 59												FY 60												FY 61												FY 62											
DISCOVERER		CY 58						CY 59												CY 60												CY 61												CY 62					
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
LAUNCH SCHEDULE (VAFB)								1	1		1		2		2		0	2	0	1	2	2	2	2	2	1	2	2	2	2																			
LAUNCH FACILITIES (VAFB)																																																	
.Thor Pad #4						A																																											
.Thor Pad #5							B						X																																				
.Hlm Bldg Addition												B	X																																				
GROUND STATIONS																																																	
*VAFB	(I)					A																																											
Pt. Mugu	(I)						A																																										
Chiniak	(I)					A																																											
Annette	(I)					A														D																													
*Hawaii	(I)					A																																											
Development Control Center	(I)					A																																											
Recovery Control Center	(I)								A																																								
Telemetry Ships						A																																											
Doppler Stations																					I						X																						

LEGEND

. Available from 315A Program
* Available from SAMOS Program
I Interim Capability
B BOD
X Need Date
A Available
D Deactivated

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SUMMARY OF FLIGHT TESTS
As of 30 Sep 59

Flight Vehicle No	Agenda Vehicle No	THOR Serial No	Discoverer No	Launch No	
1	1019	160	0		Agena stage malfunctioned on ground destroying vehicle. THOR Booster 160 to be used at later date.
2	1022	163	I	28 Feb 59	Orbit attained, but no communication with satellite.
3	1018	160	II	13 Apr 59	Orbit attained, ejected over Norway. No recovery.
4	1020	174	III	3 Jun 59	Orbit not achieved.
5	1023	179	IV	24 Jun 59	Orbit no achieved.
6	1029	192	V	13 Aug 59	Good orbit, no recovery.
7	1028	200	VI	19 Aug 59	Good orbit, no recovery.
8	1050	206	VII	7 Nov 59	Low orbit and 400 cycle power failure. No chance at recovery.
9	1052	212	VIII	20 Nov 59	Excessive eccentricity caused by accelerometer malfunction, resulting in impossible conditions for recovery. Capsule was ejected from orbit.

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TEST PROGRAM

DESCRIPTION OF TEST PROGRAM

A. GENERAL

1. Test Philosophy

In any research and development program, the bridge from pure theory to practical and reliable hardware rests upon the keystone of an adequate and balanced testing program. That which provides both form and substance to the keystone is the test philosophy. Thus, a worthwhile testing program must begin with a strong test philosophy. The test philosophy must have its origin in good engineering practice and previous experience modified to meet the problem under consideration.

The development of a test philosophy for Discoverer has, as a point of departure, the fund of knowledge resulting from the following:

a. The Ballistic Missile Programs. These programs have provided test philosophy, procedures, equipments, testing techniques; and the boosters themselves which are used as the prime movers for the space programs.

b. The Manned Aircraft Programs. These programs have provided test philosophy, basic engineering and scientific principles of demonstrated effectiveness.

From this storehouse of knowledge a space system test philosophy has been derived which assures the rigorous testing of individual parts, components, and subsystems up to and including the complete weapons system. The major difference between previous test programs and space test programs; hence, the test philosophy, is the problem of continued vehicle operation in a spatial environment. Up to the point of orbital injection, the facilities, concepts and techniques of the ballistic missile programs are directly applicable to the test of space systems; once a space vehicle is placed in orbit, the environmental and time functions become unique to space and produce unique problems. Thus, many new system elements must be considered; therefore, generating many new and varied testing procedures for military space system.

Development testing of a space system has a single purpose; which is to achieve a highly reliable system that will fully satisfy the system functional design objective. In a new space system such as Discoverer, involving many new techniques and operating in a new environment; the system design must be determined through an iterative design and test redesign process. The test program must be designed to insure the prompt and complete engineering feed-back of test information at all development stages into the design and redesign phases. Both ground and space system testing are developed on the building-block principle. For

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example, in the early phases of testing the simplest parts and components of an invidual subsystem are tested; as the testing program proceeds in scope and complexity, additional subsystems are added until the ultimate configuration is reached.

Primary dependence on flight testing to obtain design and system parameters information is recognized as inefficient and extremely costly. Consequently, a comprehensive system of ground tests have been initiated as a prerequisite to flight test. These tests, described later in this test annex, have proven that ground testing of the space elements of the system can be effective and economical. This requirement has, however, established the requirement for new test facilities and techniques in simulating system test environment. Many of these facilities are located in the contractor's "backyard" and many are Government owned facilities used as they are available and suitable for the tests to be conducted. These facilities also include new Government facilities and equipments required to test the system. In this type of testing the system can be operated over long periods of time providing masses of statistical information to aid in the development of a reliable system. Ground testing under simulated system test environment has limited usefulness, however, in that all of the system environment cannot be simulated particularly as they apply to the space vehicle and its functional subsystem. Temperatures, pressures and shock caused by variations in these parameters can be simulated, however, many parameters cannot be simulated, i.e., solar radiation characteristics, Van Allen radiation belts affects - infinite-volume vacuum, etc., these items must be tested on orbit. These factors plus many others have lead to the conclusion that a balance of testing must be established between ground simulation and actual system tests on orbit.

No testing is accomplished at any level if it can be done more effectively at a lower level. However, the cost of a bit of additional design data becomes increasingly expensive as a test at a specific level is repeated over and over, until a point is reached wherein the collection of a needed bit of design data becomes more expensive to achieve in ground testing than it would by an actual systems test. For example, early flight tests demonstrate the compatibility of the booster; the space vehicle; the guidance and control; and ground space communications systems - in addition specific design and operating data are collected on the operation of other functional subsystems. Relating the flight test program to the ground test program, the number of tests on the ground will represent an order of magnitude more testing than the flight test program. Thus any flight system test represents tens of thousands of tests on parts, components subsystems, and system simulation testing. Therefore, the test program looks like a pyramid, schematically, with its broad base resting on the part and component test program. The types of testing accomplished are described in the following sections.

2. <u>Test Description</u>

The basic test philosophy is that in all tests the progression will be from the simple to the complex. This approach will be followed in the verification of components, equipments, subsystems, and the complete vehicle system and ground facilities.

Another aspect to the Discoverer test program is that all vehicle equipments will undergo complete environmental, proof, and qualification tests prior to installation in the vehicle. Further, the vehicle itself will undergo static test firing prior to delivery to the flight test base.

Certain flight tests will be concerned with the collection of geophysical and environmental data for the design of future vehicle configurations. These will include requirement for optical tracking to provide precise orbital characteristics. Other tests will be concerned with verification of components, equipments and systems for future configurations.

The Discoverer Flight Test Program involves flights using the Thor booster for launching from Vandenberg AFB on a polar orbit. The objectives for Discoverer Program are divided into four broad categories, namely, Agena vehicle and system operation testing, Agena/Thor compatibility, and recovery capsule operation and testing.

The first flights are primarily engineering tests to establish orbital capability and to determine Agena/Thor compatibility, as well as the first test of the complete system, including the tracking stations.

The following flights will provide a gradual increase in the test complexity by the addition of experimental capsules carrying a variety of payloads and by more advanced engineering tests. The test objectives will be governed in large part by the results of previous experience and flight results, primarily refinement of recovery of unique payloads from orbit.

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3. System Testing Responsibilities

a. Support Testing. In support of the development design of payloads and consequent vehicle design, the following design support testing will be accomplished as required:

(1) Wind tunnel tests

(2) Environmental Tests

(3) Recovery system tests

(4) Propellant tank tests

(5) Telemetry system tests

(6) Ground support equipment tests

(7) Roll control tests (Simulation)

(8) Propulsion system altitude start tests

(9) Aircraft/ship data package snatch test

b. Captive Testing. Douglas Aircraft Company will have the responsibility for any component and captive testing on the Thor booster. LMSD will provide captive testing for the Discoverer satellite vehicle in the form of an inplant systems run and a captive firing of each satellite vehicle, less its recoverable payload, at the Santa Cruz Test Base. From Santa Cruz, each vehicle will be delivered to the flight test launch area at Vandenberg AFB.

c. Flight Testing. The responsibility for over-all technical flight test direction and planning falls on LMSD. Preflight checkout responsibility will be shared, however, by LMSD and Douglas Aircraft for their respective vehicles and equipment. Douglas Aircraft Company will have primary responsibility for design and construction of the launch pad as the booster contractor. Discoverer system control will be vested in the STC, Palo Alto, under direct Government cognizance, from which control will be subrogated to other LMSD stations as the need arises during an operation. Control functions will be transferred from Palo Alto to the new Sunnyvale Satellite Test Center facility in January 1960.

B. FLIGHT TEST OBJECTIVES

1. Over-all Program Objectives

The primary objectives of the Discoverer Program will be to demonstrate orbital capability and to obtain biomedical and advanced engineering test data from the recoverable payload capsules.

2. Detailed Test Objectives

Detailed test objectives will be prepared for each flight.

C. FLIGHT TEST PLAN

1. Vehicle

The Discoverer Program utilizes six different vehicle configurations as described in Tab 2, "Design Characteristics."

2. Facilities

a. Over-all control of the Discoverer flight operations will be exercised by the Satellite Test Center (STC). Two UNIVAC Scientific 1103 large-scale digital computers in Palo Alto will support the STC, converting binary tracking data to an ephemeris, issuing acquisition data to tracking stations for subsequent passes, and predicting the recovery area. The control functions carried on at the STC will be transferred to the new facility at Sunnyvale, California, in January 1960. Stations reporting directly or indirectly to the STC will be:

(1) The Vandenberg Control Center located at Vandenberg AFB, which controls blockhouse launch operations and Stations 2, 3, and 8 below.

(2) The Vandenberg Tracking Station.

(3) The Vandenberg Auxiliary Tracking Station located at Pt. Mugu (Pt. Mugu Tracking Station).

(4) Chiniak Tracking Station, Kodiak Island, Alaska.

(5) Hawaii Tracking Station, Oahu Island, T.H.

(6) Hawaiian Control Center, Oahu Island, T.H.

(7) Telemetry Ships.

(8) Space Track, Radar, Doppler and Optical Tracking.

b. The Vandenberg and Hawaii Tracking Stations will use the following equipment:

(1) VERLORT (Modified Mod II) radar.

(2) TLM-18 self-tracking telemetering antenna.

(3) Tri-helix antenna.

(4) Doppler range detection equipment.

(5) Telemetry tape recording equipment.

(6) Telemetry decommutators for real time data presentation.

(7) Plot boards for radar and TLM-18 tracking data.

(8) Conversion equipment for teletype transmission of radar, TLM-18, and doppler tracking data in binary format.

(9) Acquisition programmer for pre-acquisition direction of antennas.

(10) Equipment for transmission of satellite commands.

c. The Chiniak Tracking Station will use the equipment listed in 2 above, except that the TLM-18 antenna and associated equipment are not provided. The radio signal reception functions of the TLM-18 antenna will be shifed to the tri-helix antenna already installed.

d. The Pt. Mugu Tracking Station will have the same configuration as Chiniak above, and in addition will be equipped with a guidance computer which determines and issues the necessary commands to initiate and terminate second-stage buring at optimum times.

e. To provide more accurate orbital positional information for the later flights of the Discoverer series, supplementary doppler tracking methods will be employed. The exact time at which this additional capability will be available is under study. It is planned to add appropriate doppler beacons to the Agena vehicles. Ground equipments will be provided by the modification of existing Discoverer facilities, use of the cooperating facilities, or the use of trailer mounted receiving equipment.

f. A Recovery Force, presently consisting of nine C-119J aircraft equipped with search gear, is stationed and is being maintained at Hickam AFB, Hawaii. Two Victory ships equipped with radio search gear are also stationed in Hawaii. As needed, the Air Force will assign four RC-121 radar picket aircraft to assist in the recovery operation.

D. TEST ORGANIZATION

1. GENERAL

Subject to the over-all management by the Air Force Ballistic Missile Division, the Lockheed Missile System Division (LMSD) has been assigned responsible technical direction of the Discoverer Development Program. In accordance with ARDC Regulations, the AFBMD Weapons System Project Office (WSPO) exercises technical test control of Discoverer Systems tests. The Commander, 6594th Test Wing, is the Systems Test Controller who is assigned responsibility for exercising control of the technical tests of the Discoverer during the test planning phase and flight test operations. Within the broad direction established by AFBMD for Discoverer development, system requirements are generated and integrated by LMSD, and appear as general and detailed test plans and support requirements. Following project approval at AFBMD, the documents become official test plans with which all participants in the program comply. The test operations are executed by LMSD and Douglas Aircraft Company (DAC), the booster contractor, under the control of the Systems Test Controller. In general, systems test direction and execution is accomplished by LMSD personnel. In the case of the SM-75 booster, DAC personnel have been assigned responsibility for direction and execution of booster activities. Test control and direction has been established at each Discoverer field site, with the center of operations located at the Satellite Test Center (STC). Major decisions concerned with such items as launch under marginal conditions will be made at STC based on recommendations made by various field stations. In all cases, final authority in the areas of test control and direction is at the STC.

E. PROGRAM SYSTEM OPERATION

1. GENERAL

The system consisting of orbiting vehicle, launch and checkout facilities, tracking stations, control centers, and computing facilities, is considered as an operating entity and the functioning of each element of the system is discussed as that element becomes active in the test.

2. PRELAUNCH PLANNING

The basic planning, initiated several months prior to the scheduled launch date, includes an adequate description of the test configuration and test objectives. In addition, the specific plans for attaining the objectives are explained. These plans thus represent a summary discussion of the vehicle booster combination and the ground station configuration as they are planned for any given flight.

F. SYSTEM TEST AND CHECKOUT

1. Vehicle

a. The complex nature of the satellite requires a constant checkout of components, subsystems, and systems to ascertain flight readiness to attain the flight objectives. Equipment has been developed for this checkout. From manufacturing, the vehicle goes through a checkout period at STC during which components, subsystems, and the system are checked to determine that they are operating properly and that the vehicle is flight ready.

b. At Santa Cruz Test Base the vehicle is installed in a test stand and the engine operated. In the contractor facility at Vandenberg AFB, the vehicle is again checked out, using equipment similar to that at STC to determine flight readiness. The Vandenberg AFB facility is also equipped to do major disassembly of the vehicle should the need arise. On the launch pad, the blockhouse consoles maintain parameter checks of the vehicle operating systems until the vehicle is launched.

c. The checkout equipment will be modified to suit changing flight objectives and will be improved as test results permit operation evaluation.

2. Tracking Stations

The tracking stations undergo a continuous program of checkout to maintain operational readiness. Local checks consist of internal checks and aircraft "flyby" to assist in calibration. Prior to a flight, or an anticipated orbit pass, the tracking station is checked out in conjunction with the STC. As the Discoverer Program progresses, the tracking station equipment will be optimized, based on test results, to increase reliability for tracking and data acquisition.

3. Satellite Test Center

The Satellite Test Center (STC) maintains a constant program of checkout with Vandenberg AFB launch base facilities and the tracking stations. In addition, STC utilizes as part of the testing the STC Computer Center to generate an orbit ephemeris which is transmitted to the tracking stations for equipment checkout.

4. Recovery Force

The air recovery of the capsules ejected from orbit requires a separate test program to develop the direction finding and air snatch equipment and procedures. An additional program of checkout and continued training of this recovery force has been initiated. The recovery equipment and direction finder must undergo testing and checkout prior to each flight to maximize the probability of recovery. In addition, aircraft crews will participate in a continuous training program.

5. Recovery Capsule

The recovery capsule is to be supplied by General Electric to suit the Discoverer configuration. The test and checkout of the capsule is a coordinated effort by G.E. and LMSD.

G. COMMUNICATION SYSTEM COUNTDOWN

Communication system countdown is initiated five hours before launch, with a communication check to each station which also provides a station readiness report and a time synchronization. Throughout the countdown the STC directs major activities of individual tracking stations, the recovery force, and the launch base activities system condition from individual status reports, and integrates separate efforts into a coordinated, unified operation. The time relationship of individual station operations are planned for a simultaneous readiness condition of launch and tracking support equipment.

H. LAUNCH, EXIT AND ORBIT INJECTION PHASES

1. The operation of the complete system from the instant of launch to the end of attitude stabilization on orbit is beyond the scope of this Plan; only a representative description is given here.

2. At the instant of lift-off, all booster/vehicle systems will be operating.

3. Commencing with lift-off, the booster will be programmed to roll until it attains its nominal flight path azimuth. During this period, the booster/vehicle will be in vertical flight.

4. After the roll programming is completed, the booster will be programmed in pitch to hold a zero-lift trajectory until the separation attitude is reached. From then until separation a constant-attitude trajectory will be programmed into the Discoverer control system.

5. Separation occurs on attaining the proper altitude and attitude. As the booster falls away, the satellite vehicle continues in a self-stablized, predetermined coast. At the termination of the coast phase, the internal satellite power plant activates, supplying the required orbital velocity increment to establish a substantially circular orbit. The internal controls will then erect the vehicle to the proper attitude.

I. ORBITAL PHASE

1. The operations of the entire system during the period after the vehicle is on orbit and stablized in attitude, and before the time when the capsule is ejected, is described as the orbital phase.

2. All tracking stations of the Discoverer system conduct a systematic equipment check prior to each vehicle contact. This exercise serves to indicate the readiness of the station and verifies the operability of its equipment.

J. RECOVERY OPERATION

Present planning provides that the recovery capsule will be ejected from orbit to be air-recovered by C-119J aircraft, in the ocean area southwest of Hawaii.

SECTION II - TEST ANNEX

COMMAND AND CONTROL RESPONSIBILITIES AND PROCEDURES

A. GENERAL

1. System command and control is a world-wide problem requiring an extensive communication network. The actual functions of command and control are not complex in themselves. The problem is made complex because of the geographic separation of the various ground stations and the need for reliable transmission of tracking and system status data on a 24-hour basis.

2. The tasks to be accomplished in the command and control of the Discoverer test configurations include:

a. The collection and presentation of various types of data that can serve as the basis for command generation.

b. The refinement and analysis of selected data to permit its employment in the decision or command determination process.

c. The definition and selection of emergency operational modes in the event of system component failure.

d. The transmission of system commands.

e. The evaluation of system response to the commands and the determination of required modifications to scheduled command flow.

3. Central control authority will be vested in the Satellite Test Center (STC). A portion of this authority will be delegated to the Vandenberg Control Center and to the Hawaiian Control Center for the control of operations in thie local areas.

4. The degree to which control can be exercised over the system is limited by the capability of the ground-to-vehicle command link and by the high degree of system automaticity.

B. PRELAUNCH

1. The STC monitors the system checkout and the countdown during the prelaunch phases. Specifically, during the system dry-run at X-2 days and again during the system countdown at T-5 hours, the STC initiates the following activities:

a. Communication system checkout

b. Simulation transmissions from tracking stations to the computer center

c. Dry-run orbit calculation

d. System component repair and test rerun.

2. During the system countdown, the launch facilities aspects of the countdown are under the direct control of the Vandenberg Control Center. The STC in its direction of the over-all countdown, is continually receiving and retransmitting system status information and other pertinent data such as weather and recovery force status. Vandenberg Control Center plots the important data received from STC. In turn, Vandenberg Control Center continuously advises STC of the status of the launch countdown.

3. The Hawaiian Control Center is also in constant contact with STC during the countdown. Of particular concern to Hawaiian Control Center is the estimated time of launch and the weather condition in the planned impact area. The mission of all control centers during this phase clearly is to establish the readiness of the system for the planned flight. The decision to initiate or delay a launch is made at the STC. This decision can be made only after all the major system components have been verified as operative.

C. <u>LAUNCH AND ASCENT</u>

1. The STC functions during this phase are concerned primarily with system coordination as follows:

a. The tracking stations are alerted and notified of initial orbit parameters.

b. The Computer Center receives the times of vehicle engine start and termination of orbital boost.

c. The recovery force is informed of orbit achievement and redirected if required.

2. The Vandenberg Control Center functions are the direct control of the launch facilities and vehicle command during this phase of the test operation.

D. ORBIT

1. The exercise of control over the vehicle in orbit is limited to the following commands:

a. Reset of the orbit timer

b. Adjustment of the orbit timer

c. Control of orbit attitude and period

d. Initiation of the recovery sequence.

2. The intervals at which these commands are given are controlled by the vehicle position in orbit relative to the tracking stations. Therefore, the STC has very little freedom in command choice or determination insofar as the vehicle, itself, is concerned. However, it must continuously monitor the Discoverer system during the orbital phase. Unexpected component failure in the vehicle or on the ground will dictate a redetermination of the normal operational sequence.

E. RECOVERY

1. The decision to initiate recovery is made by the STC and the command issued to the vehicle on orbit by one of the Discoverer tracking stations. The ships of the recovery force will previously have been deployed to the predicted impact area prior to launch. The aircraft will have departed shortly before the dump command is sent. From this point on, Hawaiian Control Center becomes the focal point for the exercise of system control as delegated by STC.

2. Progress of the search and recovery operation is plotted against a predetermined time schedule. Appropriate periods, which have been established following rigid safety standards, are allowed for air and sea search. Changes in weather conditions are carefully evaluated in terms of these predetermined standards. The STC is continuously informed of the progress of the recovery operation. Any decision to postpone or halt the recovery attempt of the capsule search will be made at STC on the basis of the information received from Hawaiian Control Center.

F. SYSTEM TEST EVALUATION

A comprehensive evaluation of test results will be accomplished at all appropriate levels.

G. DATA FLOW

1. System test data generated will be initially observed and recorded at seven geographical locations as follows:

a. Vandenberg Air Force Base, California

b. Point Mugu, Naval Air Missile Test Center, California

c. Telemetry Ship, 950 nautical miles downrange

d. Kaena Point Tracking Station, Hawaii

e. Chiniak Tracking Station, Alaska

f. Recovery Force, East of Hawaii

2. The types of data involved are:

a. Telemetry data

b. Radar tracking and control data

c. Launch (umbilical) data

d. Weather data

f. Prelaunch servicing notes

g. Recovery data

h. Operations data (range interference, communications).

3. Data will be recorded and transmitted as follows:

a. Radar, TLM-18 tracker (where provided) and Doppler range-tracking precise digital data will be punched on teletype tape in binary format and transmitted to the STC for computer analysis and computations.

b. Radar and TLM-18 tracker (where provided) data will be presented at the tracking stations as analog plots for station on-the-spot evaluation of operations.

c. Telemetry data will be recoreded on magnetic tape which will be transmitted to Sunnyvale for analysis for the fastest available means.

d. Critical telemetered data will be decommutated if necessary and presented in real time at the tracking stations.

e. Space track data - radar data will be transmitted directly to the STC in real time; optical data will be appropriately reduced by Space Track and then transmitted to STC.

4. To insure the rapid incorporation of test results in the planning and conduct of subsequent operations, it is imperative that a complete evaluation of each test be accomplished within the time space occurring between flights. Because of the scope of Discoverer test operations, this places a most stringent time factor on the tasks associated with post-test data handling and evaluation. Every effort will be made, therefore, to streamline the data flow process so that lag times may be minimized.

H. DATA HANDLING PROCEDURES

1. General

Each item of the above types of data will be correlated with system timing and will be clearly identified as to source, content, and test number. Other items not listed, but which are pertinent to test results, will be included in written reports. Because of the many individual pieces of information which must be assembled within a short period of time, every attempt will be made to deliver each item of data within a specified time. Deviations dictated by conditions peculiar to an individual flight will be covered in the detailed test objectives. Other necessary deviations resulting from conditions arising during or subsequent to a test will be coordinated through the STC. Designated representatives from DAC and LMSD will be present at Vandenberg AFB for each flight to collect and handcarry the required launch data to Santa Monica and STC.

2. Thor Launch Data

Douglas (Vandenberg AFB) will be responsible for supplying booster data which included launch data, telemetry data, prelaunch servicing notes and operation data.

3. Discoverer Data

Lockheed (Vandenberg AFB) will be responsible for supplying Discoverer data items as listed above. Delivery of radar and telemetry tapes generated during orbit flight will be the responsibility of the tracking station managers utilizing the communication network to STC.

I. DATA REDUCTION

1. Discoverer Data Reduction

a. With the exception of data derived from metric optics, all raw Discoverer test data requiring reduction to usable forms will be processed by LMSD. Since nearly all quantitative information derived from a flight will be of this category, rapid processing of such data is essential to the timely flow of information. Also, because of the large volume and the random order of arrival of many separate items of data, the processing scheme must be both expedient and highly flexible. To permit an early evaluation of results, the data reduction process will be accomplished in two parts in the manner described below.

(1) "Quick Look" Data. Data reduction required to support "Quick Look" evaluation activity will be accomplished on a first priority basis within 24 to 36 hours after receipt of pertinent radar and telemetry tapes. Nomial "Quick Look" data requirements will be specified in detail 60 days prior to each flight. Additional data requirements which may be necessary because of flight events will be specified after a preliminary review of real time records within eight hours following the test.

(2) Final Data. A final, comprehensive compilation of data as required for detailed subsystem analysis will be completed within a period of three to five days after launch.

2. Thor Data Reduction

The reduction of booster data will be accomplished by Douglas Aircraft Company at Santa Monica. These data will be transmitted to cognizant organizations.

J. SYSTEM EVALUATION

1. A complete operational evaluation of test results will be made. This evaluation will encompass all weapon system test activities as they affect the achievement of ultimate program goals and objectives. Major emphasis, however, will be devoted to the timely evaluation of system flight tests as required to properly redirect the program. The areas to be covered will include:

a. Over-all system performance in terms of predicted versus actual results.

b. Validity of test plans and conduct in terms of the timely achievement of test objectives.

c. Techniques and procedures employed in the conduct of system test operations.

d. Adequacy and suitability of systems communications, ground support equipment, facilities and logistics.

2. Detailed follow through action will be taken on investigation of problem areas revealed by preliminary evaluation and detailed analysis. A completely integrated evaluation of over-all system operation will be performed. Necessary remedial actions affecting the planning and conduct of the next test will be coordinated with all organizations concerned and fully implemented at the earliest possible date.

3. Accurate and complete records of program test activity and results will be maintained. A continuing evaluation of system operations on a flight-to-flight basis will be performed. Operations concepts, equipment, and procedures will be modified as necessary for proper program redirection.

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DEPARTMENT OF THE AIR FORCE
DISCOVERER PROGRAM
FY 1961 BUDGET ESTIMATE
AND
REVISED FY 1960 FINANCIAL PLAN

SUMMARY OF REQUIREMENTS

	PRIOR YEARS	FY 1960	FY 1961
LMSD	111,150,000	51,200,000	[redacted]
Management and Systems Engineering	(41,100,000)	(19,200,000)	[redacted]
Vehicle Subsystems	(33,800,000)	(16,200,000)	[redacted]
Communications and Control	(18,300,000)	(9,800,000)	[redacted]
Payload Subsystems	(7,850,000)	(4,100,000)	[redacted]
GSE	(10,100,000)	(1,900,000)	[redacted]
THOR Booster	20,500,000	18,700,000	[redacted]
AFCRC	1,200,000	-0-	[redacted]
Miscellaneous	1,800,000	1,200,000	[redacted]
TOTAL	134,650,000	71,100,000	[redacted]
FUNDING SOURCE:			
FY 1959 - P684 (AF) - Bio-Med	1,250,000		
FY 1959 - ARPA Order #48	132,300,000		
FY 1959 - ARPA Order #60 - Telemetry Ship	1,100,000		
	134,650,000		
FY 1960 and 1961 - P630 (AF)		71,100,000	[redacted]

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DEPARTMENT OF THE AIR FORCE
DISCOVERER PROGRAM
FY 1961 BUDGET ESTIMATE
AND
REVISED FY 1960 FINANCIAL PLAN

JUSTIFICATION OF REQUIREMENTS

	FY 1960	FY 1961
1. Management and Systems Engineering.	19,200,000	[redacted]

Funds requested in this category are for design studies, establishing criteria, manufacturing costs, and testing the vehicle. Included under manufacturing costs are those expenses resulting from tooling, planning, mockup, vehicle fabrication, manufacturing services, and quality assurance. Under testing are included the operation of tracking sites and the Development Control Center, along with inplant, static test firings and flight testing.

The Lockheed Program Management Cost is also included in this estimate.

	FY 1960	FY 1961
2. Vehicle Subsystems.	16,200,000	[redacted]

The basic vehicle subsystems including airframe, propulsion, auxiliary power and guidance are included in this estimate. It covers the cost of research and development on these subsystems and the production of these subsystems for the 29 flight vehicles.

	FY 1960	FY 1961
3. Communications and control	9,800,000	[redacted]

Work to be accomplished in the Communications Subsystem consists of providing equipment for the 4 tracking sites, the Satellite Test Center and the 29 flight vehicles. The work consists of research, development, and production work as follows:

A. To provide vehicle-borne CW Acquisition Beacon, S Band Transponder, Telemetry Transmitters, Command Decoder, Programmer, Antenna, Multiplexers and Antenna system.

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DEPARTMENT OF THE AIR FORCE
DISCOVERER PROGRAM
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JUSTIFICATION OF REQUIREMENTS

	FY 1960	FY 1961
3. b. To provide inter-and intra-station communication equipment as required. c. To conduct subsystem analysis, checkout, and performance evaluation. d. To provide doppler equipment to outfit tracking stations not inlcuded in the present Discoverer tracking network.	4,100,000	[redacted] 1002
4. Payload Subsystem The payload subsystem in the Discoverer Program is a recoverable capsule. To accomplish this objective it is necessary to conduct high altitude separation tests of the re-entry capsule, develop the structure and conduct aero and thermal analysis of the payload. Included are component design, development of the retrosystem and recovery system.	1,900,000	

5. Ground Support Equipment

The GSE requirement is associated with the need of equipping a blockhouse, two pads and a missile assembly building at the launch site. In addition, one set of checkout equipment and a set of blockhouse and pad equipment is required-inplant. Also required and funded under this category are various handling dollies, slings, acid and fuel trailers, air conditioning units, and transporters erectors. Replacements of certain items will be necessary during FY 1960.

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DISCOVERER PROGRAM
FY 1961 BUDGET ESTIMATE
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REVISED FY 1960 FINANCIAL PLAN

JUSTIFICATION OF REQUIREMENTS

	FY 1960	FY 1961
6. THOR Booster.	18,700,000	[redacted]
7. Miscellaneous	1,200,000	[redacted]

6. THOR Booster. 18,700,000

The estimate covers the basic missile, spare parts, GSE costs and flight test costs to support the 29 flight schedule.

7. Miscellaneous 1,200,000

Funds stated in this category are to satisfy unforeseen work accomplished primarily by other DOD agencies.

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SECTION III

MILITARY CONSTRUCTION PROGRAM

GENERAL STATEMENT

1. The Discoverer program requires facilities to support the following essential functions; test direction, booster and satellite assembly, and checkout maintenance and repair; launch and launch instrumentation; satellite tracking, control, and telemetry; capsule recovery; and data interpretation and dissemination.

2. All facilities required for the Discoverer program are existing. These facilities, with exception of the SM-75 Launch Complex at Vandenberg AFB, were programmed under the Sentry (WS 117L) Development Plan in the FY 1958 Military Construction Program.

3. The existing facilities required to support the Discoverer program and their functions are as follows:

LOCATION	FACILITY DESCRIPTION	FUNCTION
Vandenberg AFB Launch Base	Administration Building Bldg. T-11356 1,475 sq ft	Program Direction
	Admin. and Storage Bldg. Bldg. T-11363 1,350 sq ft	LMSD Base Services
	Engineering Building Bldg. T-11364 2,500 sq ft	LMSD Base Engineering
	Flight Test Opns. and Supply Bldg. T-11362 1,940 sq ft	Test Opns. and Supply
	G.H.E. Bldg. Bldg. T-11354 2,950 sq ft	Maintenance and Storage G.H.E.
	Sub-system "L" Bldg Bldg. T-11345 2,400 sq ft	Biomedical and Recovery Package Maintenance and checkout
	G/M Assembly Bldg (Addn Bldg Nr 9227) 9,000 sq ft	Booster Checkout
	Shop and Administration Bldg 3200 sq ft	GSE Maintenance

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LOCATION	FACILITY DESCRIPTION	FUNCTION
Vandenberg AFB Launch Base	Receiving and Storage Bldg. Bldg. T-11344 2,100 sq ft	LMSD Base Services
	Interim MAB Bldg. T-11352 15, sq ft	Agena Check-out
	SM-75 Launch Complex Thor Launch Pads 4 and 5 associated Blockhouses and Service Structures	Launch Thor-boosted Discoverer vehicles at maximum rate of two per month
Vandenberg AFB Tracking Station	VHF Telemetry Receiver Bldg 2,300 sq ft	Launch and Orbital Tracking and Telemetry Date Reception, trajectory measurements and calculations to determine time to initiate boost.
	VERLORT Radar Van Installation	
	Mark II Optical Tracker	
Kaena Point Tracking Station Oahu, T.H.	Administration 6400 sq ft and VHF Telemetry Receiver Bldg. with 60 foot Antenna	Orbital Tracking and Telemetry Data Reception
	VERLORT Radar Van Installation	
Point Mugu Tracking Station N.A.M.T.C. Pt. Mugu, Calif.	VHF Telemetry Van Installation with Tri-Helix Antenna	Launch Ascent Tracking and Telemetry Data Reception
Pvt. Joe E. Mann (Ship)	VHF Telemetry Van Installation with Tri-Helix Antenna	Final Stage Launch Tracking and Telemetry Data Reception
Chiniak Tracking Station Cape Chiniak, Alaska	VHF Telemetry Van Installation with Tri-Helix Antenna	Orbital Tracking and Telemetry Data Reception Including First Pass Acquisition and Recovery Package and Impact Prediction
	Existing AC&W Composite Bldg.	

LOCATION	FACILITY DESCRIPTION	FUNCTION
Hawaiian Control Center Hickam AFB	Wing E of Hale 6,000 sq ft Makai Bldg.	Center for Direction of Capsule Recovery Operations.