d. A sequence timer signal immediately follows as backup to shut off the pitch-and-yaw pneumatic controls. Also, the timer opens the gas-generator arm-and-fire circuits and connects the inertial-reference-package accelerometer to the velocity integrator.

e. The satellite rocket engine achieves steady-state thrust.

f. Shortly before satellite rocket engine shutdown, the sequence timer arms the pitch-and-yaw pneumatic control circuit and activates the engine cut-off safety switch which has been preventing premature engine shutdown command from the velocity integrator. The integrator determines when the satellite has attained the required velocity to be gained and sends a shutdown signal to the engine relay box.

g. The engine relay box cuts off electrical power to cause the gas-generator valve to close and effect satellite rocket engine shutdown. Simultaneously, the engine relay box actuates the pneumatic control circuit to turn on the pitch-and-yaw pneumatic controls.

h. The sequence timer disconnects the accelerometer from the velocity integrator to complete propulsion system sequencing.

4-49. POWER INPUT REQUIREMENTS. The power input requirements utilized during the sequence of system operation is supplied by the 22 to 29.5-volt, unregulated, direct-current, battery power. Peak demand is 9.75 amperes and minimum power requirement for nominal 120-second operation is 500 ampere-seconds.

4-50. PROPELLANT SUBSYSTEM.

4-51. GENERAL. The major propellant subsystem items and the order in which they will be discussed are: Propellant-Tank Assembly and Mount, Propellant Feed-and-Load and Pressurization Systems, Propellant-Tank Ullage Orientation System. The propellant tank assembly, its mount, and the related propellant systems comprise the propulsion system equipment that is utilized to properly supply propellants to the turbopumps of the satellite rocket.

4-52. PROPELLANT-TANK ASSEMBLY AND MOUNT. The propellant-tank assembly is comprised of a forward, spherical tank and an aft, hemispherical section that are connected together by a truncated cone and a tank-support fitting to form a single installation unit. The forward tank has a volume of 49.12 cubic feet and is used to contain the oxidizer. The aft tank, with a volume of 37.80 cubic feet, is for the fuel. The single unit forms an egg-shaped tank assembly. The oxidizer sphere forms the compartment division between the tanks, and the truncated cone completes the aft tank enclosure. The oxidizer tank has a combined pressure inlet and vent, while the fuel tank has a separate pressure inlet and vent. Each tank has a single propellant opening with a T-fitting that serves both as propellant inlet and outlet. The line on one side of the tee connects to the propellant-load-and-dump, quick-disconnect. The line on the other side connects to the satellite rocket engine. Both tank sections have inspection and cleanout covers bolted on opposite ends of the complete assembly. Screen baffles are installed in the tanks to prevent excessive liquid motion. The tank assembly is installed within the satellite midbody structure so that the tank support fitting engages inner midbody structure. Tiedown fittings retain the assembly in this position.

4-53. PROPELLANT FEED-AND-LOAD AND PRESSURIZATION SYSTEMS.

4-54. The propellant feed-and-load system and the pressurization system are integrally related in their respective system functions. This integral relationship exists throughout the time from loading propellants into the satellite and lasts until completion of propellant-tank and helium-sphere venting, subsequent to satellite rocket engine shutdown. The feed-and-load system provides the equipment for routing propellants into and from the propellant tanks, and consists mainly of the satellite portion of the propellant-load-and-dump, quick-disconnect fittings and the lines that connect the fit-tings to the tanks, plus the propellant feed lines that connect the tanks to the engine pumps.

4-55. The pressurization system provides the means of maintaining the de-sired pressure in the tanks from the time of propellant loading until completion of the venting operation that follows satellite rocket engine shutdown. The principle components of the system include the two helium pressurization spheres on the aft equipment rack, the pressurizing lines that interconnect the spheres and the propellant tanks, the lines for tank and sphere venting, the line for pressurizing the oxidizer-pump, double-lip seal, and the various valves and controls installed in the system lines.

4-56. For propellant loading, external propellant-loading lines and external vent lines are connected to the appropriate quick-disconnect fittings of the satellite. One loading line and one vent line is for the fuel tank. This pro-vides a closed-loop loading system between each propellant tank and its re-spective ground-support propellant weighing tank. In this manner, the propellant tanks can be pressurized during the pumping of propellants into the satellite. By means of ground-equipment controls, the propellants can be forced back into the weighing tanks or, alternatively, into the external dump tanks, using gas pressure to effect the reverse flow. The external lines are released from the satellites immediately prior to liftoff by remotely applying pneumatic pressure to release actuators in the quick-disconnect fit-tings. The release system is backed up by an independent lanyard release device.

4-57. The two helium pressurization spheres can be loaded when the external helium source is connected to the helium-fill, quick-disconnect fitting of the satellite. Each sphere has a capacity of 2200 cubic inches and is loaded with dry helium to a pressure of 3000 psi and at a maximum temperature of 120°F.

4-58. Using the closed-loop propellant loading setup, the propellant tanks can be pressurized to full operating pressure either by use of the external vent lines during propellant loading (paragraph 4-56) or through the helium system during the process of loading the helium spheres. With the latter method, the oxidizer tank is pressurized by helium flowing from the spheres through the main pressure regulator; and the fuel tank is pressurized by hel-ium flowing through the small-capacity bypass regulator. Helium-line check valves located between the regulators and the propellant tanks permit helium flow to the tanks but prevent backflow of propellants to the regulators. A normally-closed, squib-operated valve prevents main-regulator gas flow to the fuel tank until an electrical impulse from the guidance-and-control sequence timer ignites the squib. (Refer to sequence of system operation, paragraph 4-48.) The valve then opens to connect the main-regulator gas flow to the fuel tank to supply a greater rate of gas flow to the tank. This increased flow which is needed during engine operation is greater than can be supplied through the bypass regulator.

4-59. The combination of the bypass regulator and squib-operated valve are incorporated into the system to help minimize the possibility of oxidizer and fuel backflowing and mixing in a common pressurization line prior to engine ignition. The two components perform a backup function to the pressurization-line check valves by blocking further backflow, should propellants leak through the valves. After ignition, high gas flow in the lines prevent propellant backflow and therefore any possibility of mixing in these lines.

4-60. After satellite rocket engine shutdown, the propellant tanks, the spheres, and the tank and sphere lines are vented when a signal from the guidance and control sequence timer ignites the squib-operated vent valves, causing them to open. In order to minimize disturbances to the attitude control system, which must hold a fixed orientation of the satellite after engine shutdown, all vent lines terminate in impulse nullifiers, which are simply open-end T-fittings that allow equal amounts of gas to escape in opposite directions.

4-61. A line, which taps off of the low-pressure side of the main regulator, routes helium through a low-pressure regulator to the oxidizer-pump double-lip seal, to force into the overboard drain any oxidizer that leaks past the oxidizer-pump primary seal.

4-62. **PROPELLANT-TANK ULLAGE ORIENTATION SYSTEM.** The ullage orientation system provides a means of orienting any gas in the propellant-tank ullage away from the propellant feed lines during satellite rocket engine starting. This eliminates a source that could interrupt propellant ignition and cause possible engine malfunction. The system is required for this purpose, since, during the satellite coast period to engine starting, there is no gravity field to maintain the gas-phase ullage oriented away from the feed lines. However, as soon as the engine achieves full thrust, an effective gravity field is produced that causes the gas to become buoyant and float to the top of the propellants in the tanks.

4-63. The system consists of two, solid-propellant, ullage-orientation rockets that are mounted on the after side of the aft equipment rack. The rockets are fired by the guidance-and-control sequence timer. (Refer to paragraph 4-48.) Each rocket produces a nominal forward thrust of 128 ± 10 pounds over a burning time of 20 ± 2 seconds. After the rockets have burned for 16 seconds, engine ignition occurs. This provides a 4-second burning-time overlap between rocket thrust and engine thrust and thereby maintains the forward thrust and the artificial gravity produced in the vehicle.

4-64. The rocket-mounting brackets orient the rocket thrust vectors through the Samos Satellite center-of-gravity. Each bracket incorporates a release mechanism that jettisons its rocket casing when rocket thrust drops below a predetermined value, thus lightening the vehicle by approximately 17.5 pounds total weight.

4-65. ENGINE SUBSYSTEM.

4-66. GENERAL. The engine subsystem consists of the satellite rocket engine, its related propellant flow and control systems, and engine mounting provisions. The Turbopump Propellant-Feed Assembly, Gas Generator Assembly, and the Thrust Chamber Assembly are the three major subassemblies of the engine. The Engine Propellant-Flow System, Engine Electrical Control System, and the Engine Mount and Gimbal Assembly are important associated engine subsystem items. Both the major subassemblies and the associated engine subsystem items are discussed in subsequent paragraphs. The engine propellant-flow and electrical-control systems, although separately discussed, are closely related and interconnected to perform properly integrated engine operation and control functions during engine operation.

4-67. TURBOPUMP PROPELLANT FEED ASSEMBLY. The turbopump propellant feed assembly of the engine pumps fuel and oxidizer from the propellant tanks to the thrust chamber of the engine. The assembly consists of a single-stage, impulse-type turbine, an oxidizer pump and a fuel pump which are gear-coupled to the turbine shaft, and a gear housing that serves as the assembly frame. The fuel pump shaft is sealed from the gear case with a primary seal and a double-lip seal. To provide maximum protection against oxidizer leaking into the gear case, this double-lip seal is pressurized with low-pressure helium gas which forces any oxidizer that leaks past the primary seal to flow into the overboard drain.

4-68. The turbine is designed to operate at 24,000 rpm and is driven by hot gases from the gas generator assembly (refer to paragraph 4-70). Exhaust gases are ducted overboard through the turbine exhaust duct located along the right-hand side of the engine.

4-69. The two centrifugal-type propellant pumps, for any given rotational speed, produce a flow rate that is essentially constant over large variations in outlet pressure. This results in essentially constant volumetric mixture ratios of propellants delivered to the engine thrust chamber over the engine operating range. The design speeds for the fuel and oxidizer pumps are 24,570 and 13,946 rpm, respectively, and nominal flow rates are 15.1 pounds per second for fuel and 39.0 pounds per second for oxidizer.

4-70. GAS GENERATOR ASSEMBLY. The gas generator assembly provides a means of starting and maintaining turbine operation of the satellite rocket engine. The generator assembly consists of a small combustion chamber assembly; a solid-propellant, turbine starter assembly; a gas-generator, bipropellant valve and its associated solenoid valve; and a pair of cavitating venturies.

4-71. The solid-propellant container is attached to the combustion chamber. Upon ignition of this charge by a dual-squib igniter, the resultant, hot combustion gases pass through the combustion chamber and start the single-stage turbine. The bipropellant valve subsequently opens (refer to paragraphs 4-75 and 4-76), allowing fuel and oxidizer to enter the combustion chamber where they combine and ignite hypergolically. The venturies regulate the propellant flow through the bipropellant valve to the generator. After the solid-propellant grain is expended, the gases from fuel and oxidizer ignition continue to drive the turbine until engine shutdown. During operation, generator temperature is held to safe limits by film cooling and by regenerative cooling.

4-72. THRUST CHAMBER ASSEMBLY. The thrust chamber assembly provides the medium wherein the propellants, as received from the turbopump feed assembly, unite to produce the desired forward thrust. The assembly is an integral unit consisting of a regeneratively-cooled combustion chamber, a nozzle throat section, and a divergent nozzle section, and contains cooling passages within the walls. The oxidizer, used as a thrust chamber coolant, enters the chamber cooling passages through a manifold ring located slightly aft of the nozzle throat. The flow is divided in this ring by orifices. Part of the oxidizer cools the nozzle section in a double-pass pattern, while both portions are used to cool the throat and combustion chamber sections.

4-73. The thrust-chamber propellant injector is a "one-on-one" impinging type with an additional circle of fuel orifices fed by a separate manifold for film-cooling the combustion chamber walls. The injector design is a cavity in the fuel section into which the fuel valve fits, thus allowing the fuel valve poppet to be located close to the fuel injector orifices. Free or unoccupied volumes are held small so that, when the fuel diaphragm ruptures, fuel injection starts with minimum delay and with minimum "hammer" as the free space fills with propellant. This arrangement is not needed for the oxidizer since oxidizer flow is accelerated gradually, and oxidizer is injected for an interval before the fuel valve opens.

4-74. A nozzle closure is used to assure combustion-chamber ignition when the engine is in a vacuum environment, and consists of a cone sealed to the exit of the nozzle and of a diaphragm installed over the cone and covering the nozzle exit. On the ground, the cone extends forward within the nozzle toward the nozzle throat, but when the vehicle ascends to vacuum environment, the air trapped forward of the cone causes it to collapse against the covering diaphragm. Thus, until the diaphragm is expelled by engine ignition, it retains the sealed cone which sustains the force of air pressure within the combustion chamber at approximately 7-1/2 pounds per square inch absolute.

4-75. ENGINE PROPELLANT-FLOW SYSTEM. (See figure 4-8.) The propellant flow system provides a means of controlling propellant flow from the turbine pumps to the thrust-chamber propellant injector and the gas-generator combustion chamber. The system consists mainly of the plumbing from the pumps to the injector and the gas generator plus the following flow control valves: the oxidizer valve, the fuel valve, the gas-generator, bipropellant valve, the gas-generator solenoid valve, and the pilot-operated, fuel-control solenoid valve. Except for the oxidizer valve, control valve actuation is initiated by the engine electrical-control system (refer to paragraph 4-76) through its interconnection with the two solenoid valves. The oxidizer valve is hydraulically actuated to open and spring-loaded to close whenever the pressure of oxidizer flow respectively exceeds or is less than the valve spring load. Closing of the gas-generator and fuel-control solenoid valves (refer to paragraph 4-76) causes hydraulic pressure in the secondary propellant lines to respectively open the bipropellant valve and the fuel valve, thus admitting propellants to the gas generator and fuel to the thrust-chamber propellant injector.

NOTE

Prior to the opening of these two valves, oxidizer has already started to flow into the propellant injector.

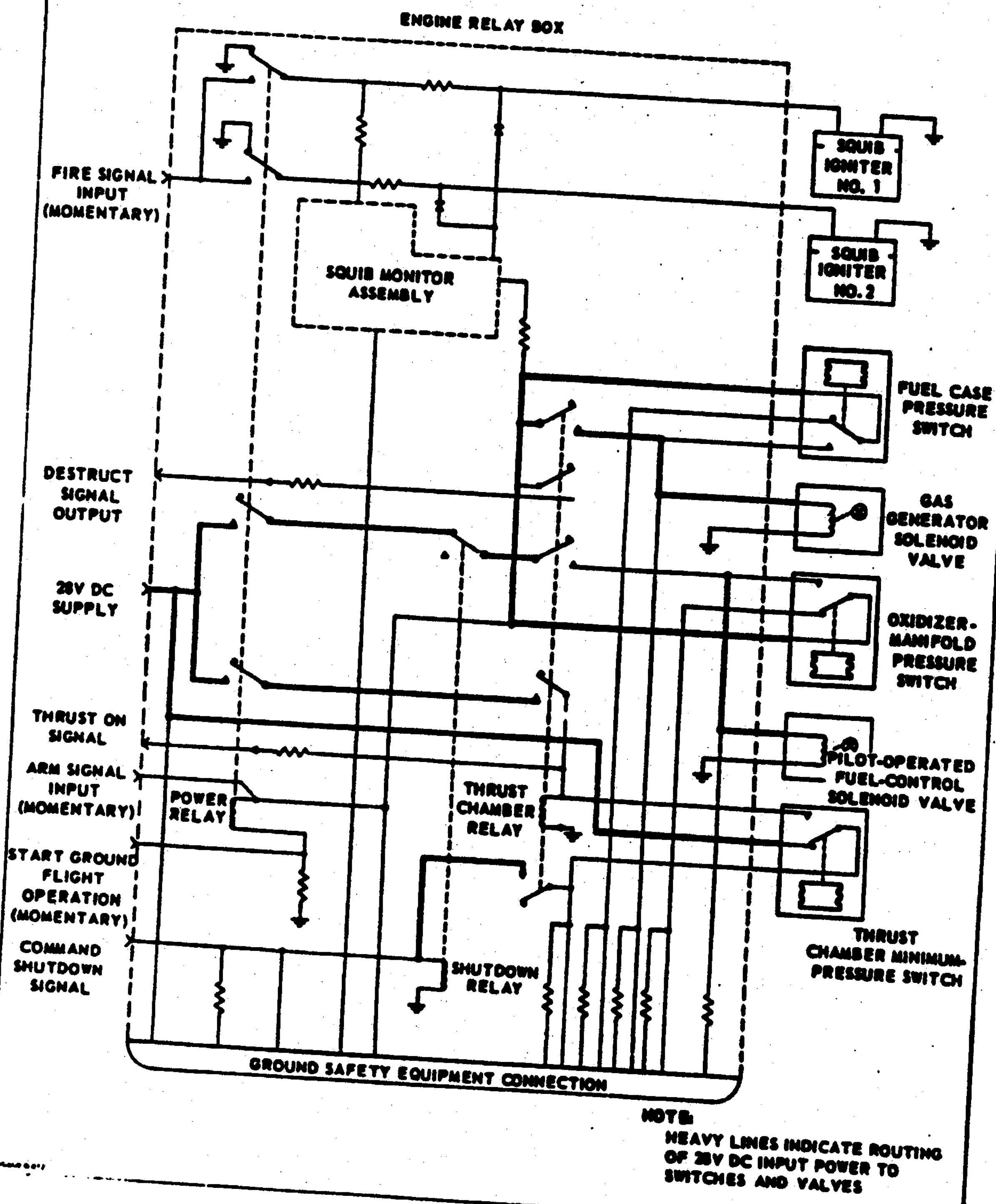


Figure 4-9. Satellite Rocket Engine, Electrical Control System Schematic

Conversely, opening of the solenoid valves (refer to paragraph 4-76) causes hydraulic balance pressure in the secondary lines to close the respective flow-control valves. Thus, combustion stops in both the gas generator and the thrust chamber, and the turbine rapidly decelerates with a drop in pump pressure. The oxidizer valve closes last under spring pressure to provide after-flow of oxidizer during shutdown. The deriving and utilizing of hydraulic actuating power from the propellant system in this manner eliminates the added weight and complexity of an auxiliary hydraulic system.

4-76. **ENGINE ELECTRICAL-CONTROL SYSTEM.** (See figure 4-9.) The electrical-control system provides the electrical power for satellite rocket engine starting and shutdown, and also for initiating the actuation of the flow control valves to establish conditions essential for proper engine operation. The system consists mainly of a simple electrical circuit containing three relays (power, shutdown, and thrust chamber relays) and a squib monitor assembly. Connected to the circuit are the dual-squib igniter assembly for engine starting, three pressure switches (fuel case, oxidizer manifold, and thrust chamber minimum-pressure) for flow-control-valve operation, and the two solenoid valves described in paragraph 4-75. In addition, output circuits, for monitoring the sequence and function of the control system, and signal inputs are associated with the circuit. Provisions are made whereby a ground safety assembly can be plugged into the system for ground testing for the prevention of damage to the engine in the event of malfunction.

4-77. The power relay serves as an arming device for satellite rocket engine starting. While the power relay is de-energized, the squib firing circuits inside the engine relay box receive no external power, but when the relay is energized, the firing circuits can be fired by the sequence timer to ignite the solid-propellant turbine starter charge. Gases from this ignition start the turbine, causing pressure buildup that actuates the three pressure switches. (See paragraph 4-76.) The thrust-chamber pressure switch is the last to be actuated. It is actuated, only after it senses a sure start, to complete the circuit that energizes the thrust chamber relay. Prior to energizing this relay, power is connected through the fuel-case pressure switch and the oxidizer-manifold pressure switch to energize and close the gas-generator solenoid valve and the fuel-control solenoid valve, respectively. This, in turn, causes the bipropellant valve and the fuel valve to be opened (refer to paragraph 4-75). After the thrust chamber relay is energized, power passes directly through the relay to the solenoid valves, thereby bypassing the pressure switches. To meet the fast actuation requirements of the fuel valve, its associated solenoid valve is pilot-operated rather than direct-acting to meet substantial increased fuel flow with only a 70-percent increase in electrical current.

4-78. The energized thrust-chamber relay, in connecting electrical power to the two solenoid valves, also establishes conditions so that now only the shutdown relay or the power relay can de-energize the solenoid valves and thus cause engine shutdown. The engine will then shut down if the power input to the control box is interrupted; the voltage drops sufficiently to allow the power relay to drop out (be de-energized); the shutdown relay is energized by an external 28-volt command signal; or the chamber pressure decreases because of pump cavitation or any other cause that returns the thrust-chamber minimum-pressure switch to its original, de-actuated position. In the de-actuated position, the switch completes a circuit that energizes the shutdown relay. Any of these four actions remove power from the solenoid valves, causing them to open. Thus, the gas-generator valve and the fuel valve will close to effect satellite rocket engine shutdown.

4-79. ENGINE MOUNT AND GIMBAL ASSEMBLY. (See figure 4-21.) The engine mount consists of a tubular frame integral with the satellite rocket engine to attach the engine to the satellite. The engine thrust chamber assembly is attached to the mount and gimbal assembly by the two hydraulic actuators of the gimbal system to thus provide for satellite pitch-and-yaw control. (Refer to the guidance and control system, paragraph 4-143, for a discussion of the actuator control.)

4-80. The gimbal system nominally provides ± 5 degrees of deflection in a square pattern. A ring, containing four equally spaced bearings, surrounds the thrust chamber forward of the injector. The bearings engage four pins, two located on the forward face of the injector, and two, on the engine mount structure. Rotation of two opposite pins provides deflection in one plane. In a similar manner, rotation of the other two pins permit deflection in the perpendicular plane. Thrust is thus transmitted through each pair of bearings to the satellite via the engine mount structure.

SAMOS SATELLITE INTERNAL ELECTRICAL POWER SYSTEM

4-81. INTERNAL ELECTRICAL POWER SYSTEM FAMILIARIZATION.

4-82. GENERAL. (See figure 4-10.) The Samos Satellite internal electrical power system includes the satellite-borne equipment that furnishes electrical power for operating the Samos Satellite and payload reconnaissance equipment from immediately preceding launch and throughout the satellite reconnaissance lifetime. Prior to the use of the satellite-borne equipment, ground power equipment is used to furnish the required power to the vehicle subsystems during the checkout and related activities at the guided missile assembly building and the launch operations building. The ground equipment also provides the means of switching from ground to the satellite-borne equipment at the appropriate time prior to launch.

4-83. DESIGN CONCEPTS OF INTERNAL ELECTRICAL POWER SYSTEM. The major objective of the internal power system is to furnish electrical power in the proper form to the associated Samos Satellite and payload subsystems for a time interval compatible with the vehicle mission. A design which incorporated and universally satisfied the requirements of all satellite subsystems insofar as practicable, while preserving a high degree of efficiency and compatibility between the associated subsystems was employed, since the various satellite systems have electrical load requirements of the same relative magnitude.

4-84. FUNCTIONAL DESCRIPTION OF INTERNAL ELECTRICAL POWER SYSTEM. (See figure 4-11.)

4-85. The internal electrical power system for flight configuration I consists of three major groups of equipment designated as prime energy, power conversion, and power control equipment. The prime energy equipment consists of 12 silver-peroxide/zinc primary batteries. The power conversion equipment includes two 2000-cycle and one 400-cycle inverter, two 2000-cycle and one 400-cycle load limiter, two +28-volt and one 400-cycle regulator,

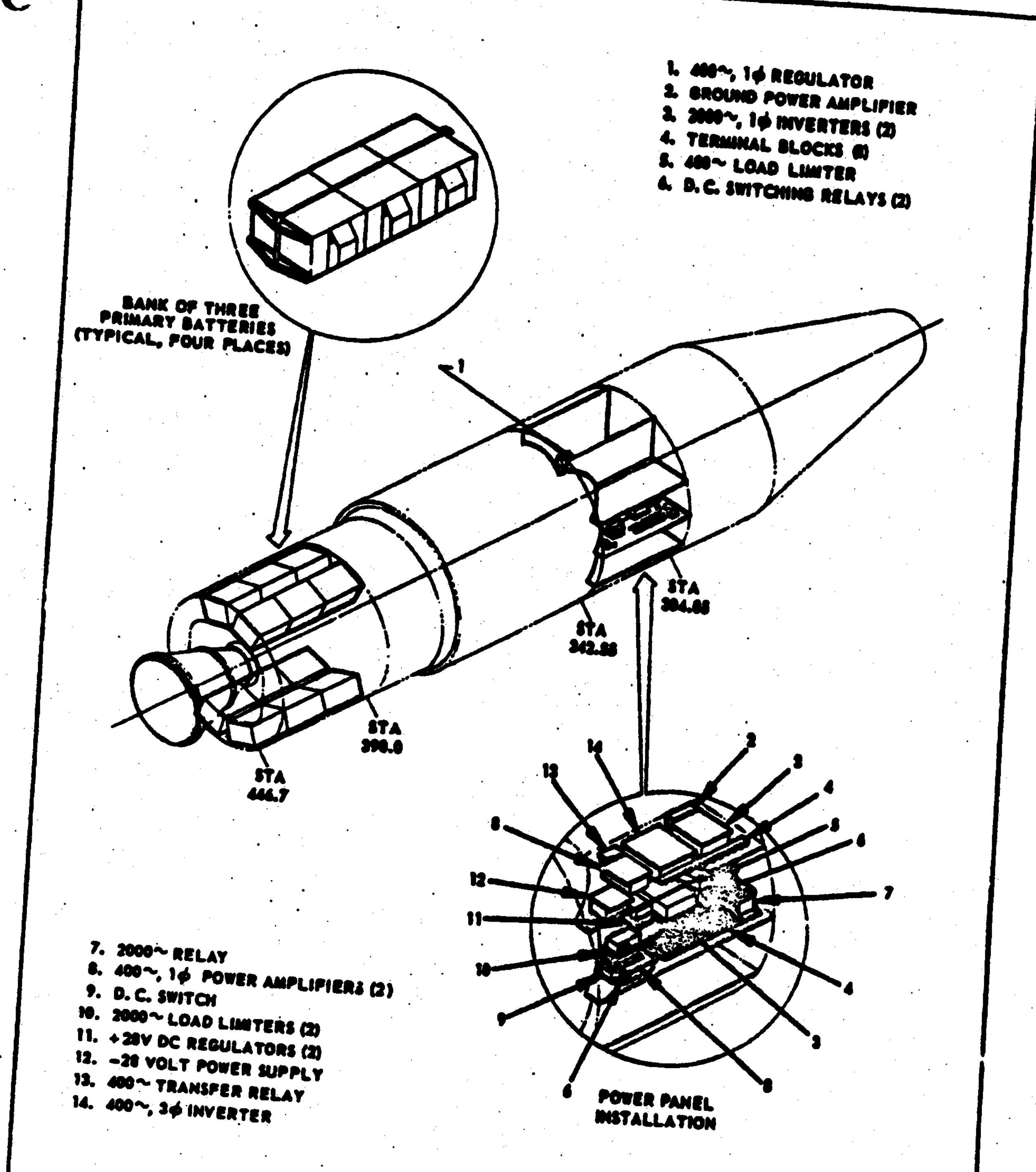


Figure 4-10. Samos Satellite Internal Electrical Power System, Location of Components

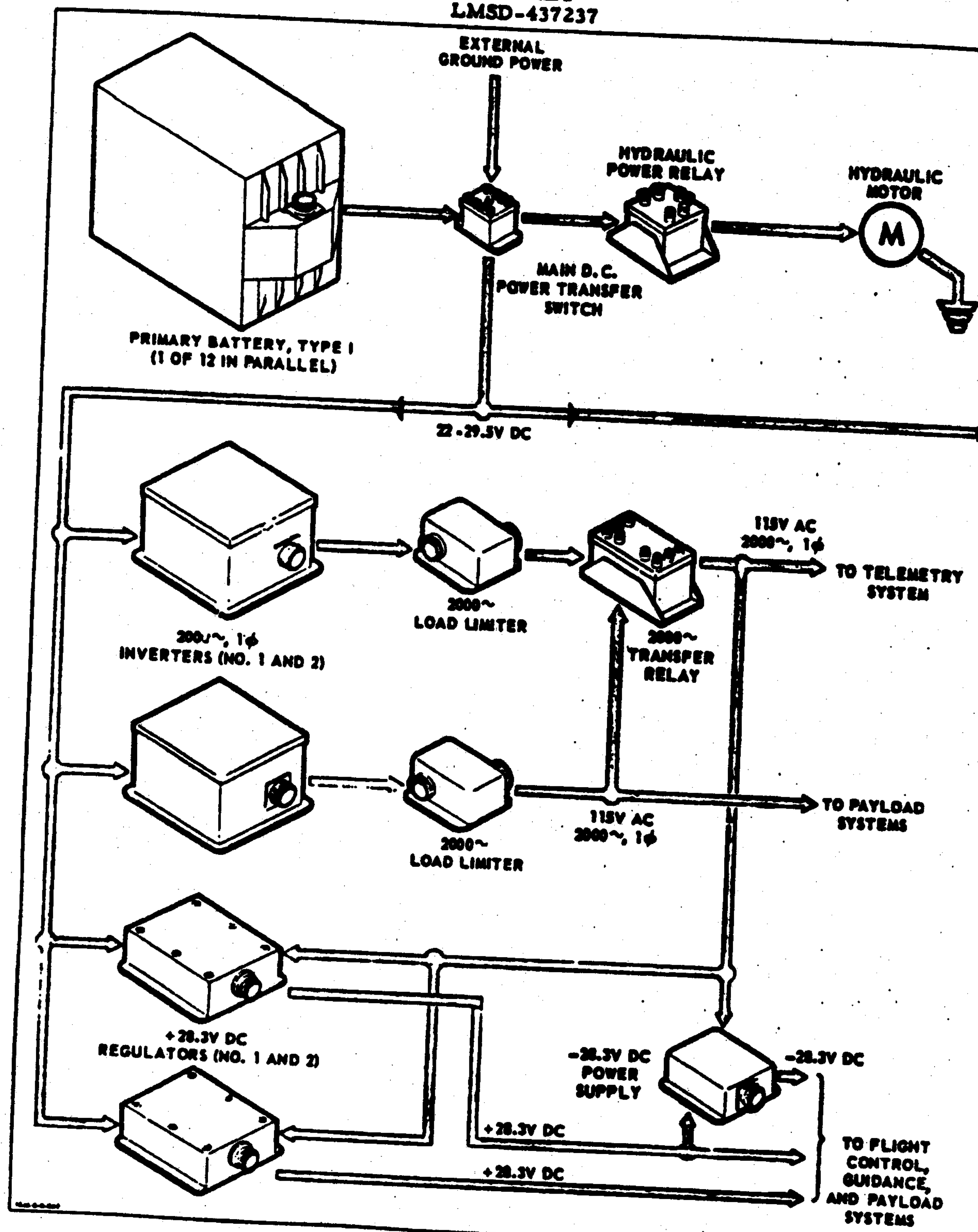


Figure 4-11. Samos Satellite Internal Electrical Power System, Functional Schematic (Sheet 1 of 2)

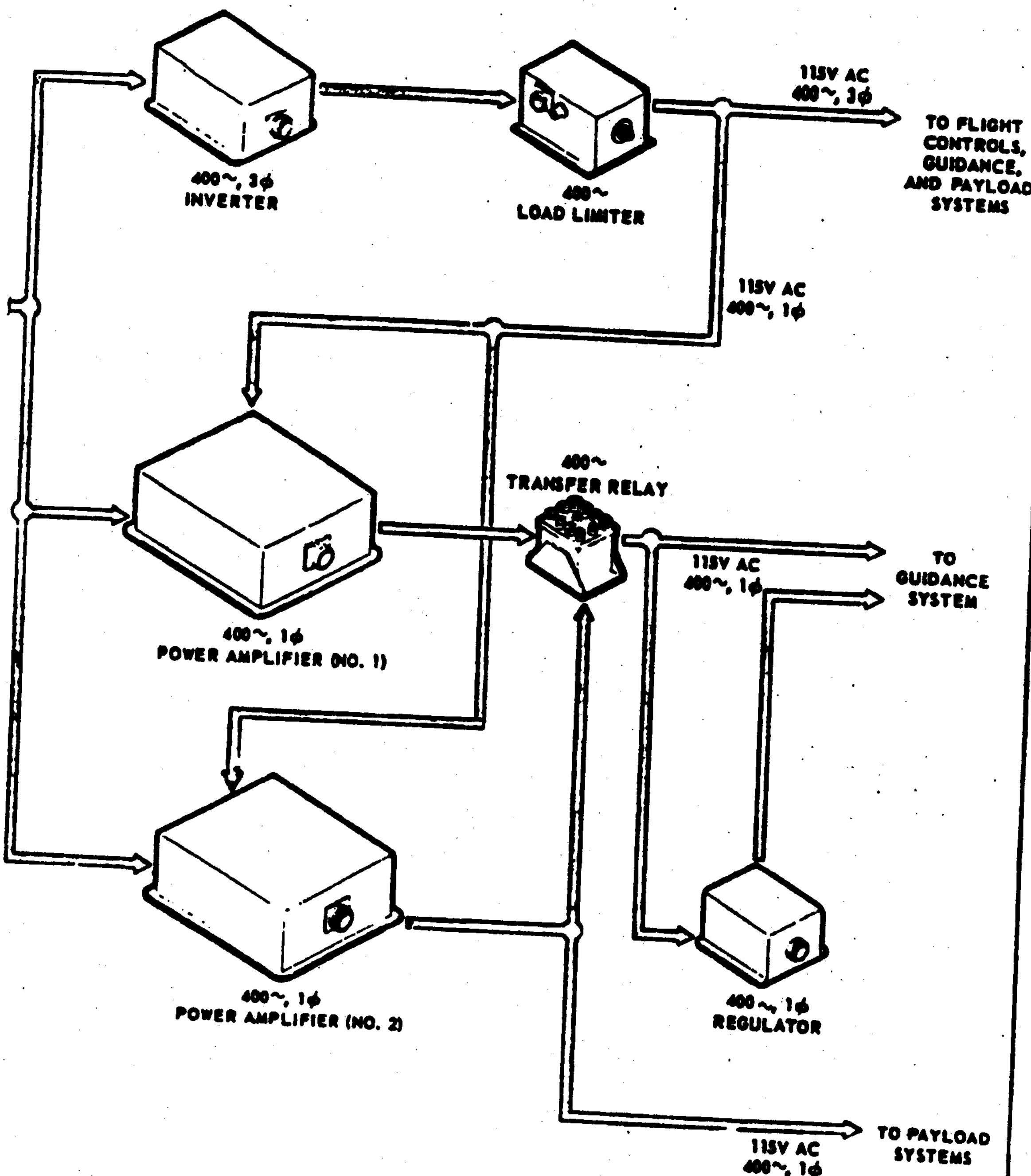


Figure 4-11. Samos Satellite Internal Electrical Power System, Functional Schematic (Sheet 2 of 2)

a -28-volt power supply, and two 400-cycle power amplifiers. The power control equipment includes such items as relays, switches, umbilical connector, wiring harness, and protection devices. (Refer to paragraph 4-89 for major equipment item descriptions.)

4-86. The batteries furnish sufficient primary electrical power to meet the electrical load requirements of the vehicle in figure 4-12. The system supplies both + and -28-volt direct current power, 2000-cycle, single-phase, 115-volt power; 400-cycle, 3-phase, 115-volt power; 400-cycle, single-phase, 115-volt, precision regulated power; and unregulated battery power. The unregulated battery power is directly furnished for satellite equipment, such as the hydraulic pump drive motor, that can utilize the 22 to 29.5 battery voltage range. For equipment that requires more closely controlled voltage, the internal electrical power system utilizes the two +28-volt regulators which operate in series with the unregulated battery source and which also draw power from the 2000-cycle inverters to provide regulated +28-volt direct current. In addition, the -28-volt power supply unit operates from the 2000-cycle system and is arranged to track, in voltage regulation, the +28-volt regulator. Positive and negative direct current from the power supply unit and the regulator are required for the flight control and guidance systems and the payload. The 400-cycle, 3-phase inverter furnishes the basic a-c power to the satellite guidance and control system, the recorders, and payload; the 400-cycle power amplifiers, synchronized with the reference phase from the inverter, furnish the required guidance-and-control system, single-phase, 400-cycle, reference power. During countdown, the outputs of the + and -28-volt regulators and the a-c power inverter are monitored from the launch operations building.

4-87. A power junction box serves to interconnect the system components. The box includes the necessary bus bars and terminal strips for all interconnected components. System terminal grounding is accomplished at the junction box with a ground bus connection to the vehicle frame. Power distribution leads are carried from the junction box to the power distribution box. From the power distribution box, power is distributed to the various subsystems.

4-88. Ground-checkout and performance-monitor leads are taken from the power junction box to the electrical umbilical connector. The internal power system components can be monitored during launch countdown. An external-internal power transfer switch is mechanically designed as an integral part of the umbilical connector. It incorporates an external solenoid which actuates the switch to permit switching from external to internal power during countdown prior to launch. Provisions are also made in the power transfer switch for lanyard operation in the event of failure of the solenoid mechanism or of the pneumatic, umbilical power disconnect. The switch also incorporates contractors to furnish a power-transfer signal to the system-checkout, and to the monitor-console panel in the launch operations building.

4-89. MAJOR EQUIPMENT ITEMS DESCRIPTION.

4-90. GENERAL. (See figure 4-10.) The major equipment items of the internal electrical power system that are discussed in the following paragraphs include the batteries, inverters, regulators, power amplifiers, and negative power supply. With the exception of the batteries which are installed on the aft equipment rack, the major items are located on the power panel of the forward equipment rack.

4-91. PRIMARY BATTERIES, TYPE I. (See figure 4-10.) Twelve primary, silver-peroxide/zinc batteries serve as the prime electrical energy source for flight configuration I Samos Satellites. The batteries are installed on the aft equipment rack (figure 4-4), grouped in four banks of three batteries each. Each battery weighs 106 pounds and consists of 16 series-connected cells enclosed within a magnesium case. Battery capacity rating is 360 ampere-hours at a nominal potential direct current rating of 25.0 volts and with an energy-to-weight factor of 75 watt-hours per pound. Each battery incorporates parallel-connected diodes in series with the discharge lead connection to provide circulating current protection. The diodes are for isolation of a battery unit in the event of malfunction, to thus prevent the discharge of the complete battery bank. Each battery is equipped with a pressure relief valve designed to maintain internal pressures within the range of 5 to 15 pounds per square inch.

4-92. 2000-CYCLE, STATIC INVERTERS. (See figure 4-10.) Two 2000-cycle, single-phase, static inverters, controlled by an inductance-capacitance circuit are used in the internal power system to convert d-c battery power to alternating current power. The two inverters are transistor-oscillator power amplifiers that furnish the main 115 volt, 2000 cycle, single-phase a-c power for the vehicle telemetering equipment and for the payload. Dual inverters are used to meet the heavy electrical loads of such equipment.

4-93. PLUS 28-VOLT REGULATORS. (See figure 4-10.) The internal electrical power system utilizes two 28-volt d-c regulators that operate in series with the unregulated batteries and which draw power from the 2000-cycle inverters to provide regulated 28-volt direct current. The 28.3 d-c voltage regulation is met in the internal power system. A voltage-booster concept is used to hold the efficiency of regulation to the highest degree possible. Regulation is accomplished by sensing the output potential of the batteries plus the booster-series combination. The booster operates from the 2000-cycle inverter power source, thus eliminating the requirement for an associated inverter. The regulator is constructed with efficient heat transfer between diodes and the metallic case structure. All components are mounted mechanically rigid, and the entire unit is potted to provide a sealed construction.

4-94. NEGATIVE 28-VOLT POWER SUPPLY. (See figure 4-10.) The -28-volt power supply is a conventional full-wave transformer-rectifier arranged for operation from the 2000-cycle inverters. Regulation is accomplished through the magnetic-amplifier circuit of the No. 1 +28-volt regulator.

4-95. 400-CYCLE, 3-PHASE INVERTER. (See figure 4-10.) The 400-cycle, 3-phase inverter is a transistorized power inverter. Its frequency is controlled by a 19.2-kilocycle, quartz-crystal-controlled oscillator. The unit incorporates power input filters to restrict noise reflection into the battery circuit. The filters eliminate noise feedback that would pass from the inverter transistor switching circuits through the battery to the low-signal-level electronic equipment.

4-9 . 400-CYCLE, SINGLE-PHASE, A-C REGULATOR. (See figure 4-10.) The 400-cycle, single-phase, a-c regulator accepts and maintains a root mean square output of 115 volts. The voltage output is controlled by means of an input series magnetic amplifier. Integral circuits prevent phase shift between the input and output voltage from exceeding 3.5 percent. All power-handling elements in the unit are located on the base of the assembly for maximum heat transfer. All components are rigidly mounted, and the entire assembly is potted to insure vibration-proof operation.

4-97. 400-CYCLE, SINGLE-PHASE, SYNCHRONIZED, POWER AMPLIFIER. (See figure 4-10.) The power amplifier is a transistorized, static-electronic unit which receives a precision 400-cycle frequency signal from one phase of the three-phase inverter in order to synchronize and maintain its frequency to that of the three-phase power distribution system. One watt of power is drawn from the three-phase supply. The main power output is supplied by the unregulated d-c voltage through a push-pull, transistor switching-circuit. The output voltage is maintained at 115 (±1.15) volts root mean square, and the output current is transformer-sensed so that if the current exceeds the rating of the power amplifier, a current-limiting action occurs to prevent unit damage. All components are mechanically secured, and the entire unit is potted to provide maximum protection against vibration. All heat-producing components are in good thermal contact with the baseplate assemb'; for efficient heat transfer by conduction.

4-98. POWER AND SERVICE REQUIREMENTS.

4-99. ELECTRICAL POWER REQUIREMENTS. During countdown and until just prior to launch, satellite electrical power requirements are met by external auxiliary power supplied by the pad power supply and signal processing set. From just prior to launch, when the external-internal power transfer switch is actuated, until the end of Samos Satellite reconnaissance lifetime, the power requirements of the satellite subsystems and payload subsystems are met by the satellite internal electrical power system. Figure 4-12 lists the estimated electrical loads and energy requirements during the time the internal electrical power system supplies power. Three general groupings are shown: the satellite subsystems, the payload subsystems, and a summation of values indicated in the first two groups.

4-100. SYSTEM SERVICE REQUIREMENTS. Upon verification of internal system operability, no service requirements are needed inasmuch as the satellites are used for single mission purposes.

4-101. AIR CONDITIONING OF SAMOS SATELLITE AND GROUND SUPPORT EQUIPMENT. Air conditioning provisions are utilized when testing and checking out the Samos Satellite electronic equipment at the guided missile assembly building and when the satellite is located at the launch pad complex. During these times, properly conditioned air is delivered to the satellite electronic equipment from a ground air-conditioning unit whose duct is coupled to the satellite connector located on the right-hand access panel of the forward equipment rack. At the launch site, when the ground air-conditioning unit is operating and prior to the electronic equipment being turned on, the conditioned air delivered to the satellite mainly performs a drying function. When the equipment is turned on, in addition to drying, cooling of the equipment begins and continues until separation of the coupling at launch.

4-102. The ground air conditioning unit at the launch pad complex is located in the launch pad and service building. It provides conditioned air for the internal electrical power system of the satellite and for the checkout and service equipment located within the launch pad complex.

ESTIMATED VALUES FOR SATELLITE SUBSYSTEMS:

Component	Ascent Phase, Satellite Electrical Load		
	Duty Cycle (minutes)	Maximum Demand (kilowatts)	Energy (kw-hr)
Ascent Guidance	17.0	0.020	0.006
Engine Ignition	1.7	0.526	0.015
Flight Control	20.0	0.013	0.004
Hydraulic System	2.0	1.960	0.065
Horizon Scanner	10.0	0.012	0.002
Subtotal		2.531	0.092

Component	Orbit Phase, Satellite Electrical Load		
	Duty Cycle (minutes per day)	Maximum Demand (kilowatts)	Energy (kw-hr/day)
Attitude Control System	Continuous	0.440	1.058
Data-Link Transmitter	100	0.100	0.167
Command Transmitter	260	0.100	0.433
Programmer and Timer	Continuous	0.009	0.216
Decoder	262	0.015	0.066
Telemeter	130	0.230	0.500
Tape Recorder	300	0.078	0.390
Subtotal		0.972	2.830

ESTIMATED VALUES FOR PAYLOADS SUBSYSTEMS

Payload Subsystem	Maximum Power Demand (kilowatt)		Energy (kw-hr/day)
	Ascent	Orbit	
E-1 Payload Readout	0	0.076	0.320
F-1 Payload Readout	0	0.601	0.832

SUMMATION OF POWER REQUIRED FOR SATELLITE AND PAYLOADS SUBSYSTEMS

Satellite Subsystems Plus Payloads	Ascent Energy (kw-hr)	Maximum Orbit Power (kilowatt)	Total Energy (kw-hr/day)
E-1	0.092	1.048	3.150
F-1	0.092	1.573	3.662
E-1 and F-1	0.092	1.649	3.982

Figure 4-12. Samos Satellite Internal Electrical Power Requirements

4-103. MAJOR ACCESS AND INSPECTION FEATURES. Four access panels enclose the forward equipment area and form the outer surface of the satellite between stations 304 and 326. The right-hand panel contains the access covers for the air-conditioning coupling and the electrical umbilical connection. Each of the four primary-battery installation areas of the aft equipment rack are enclosed by an access panel.

4-104. INTERNAL ELECTRICAL POWER SYSTEM OPERATIONAL READINESS CHECKOUT CONCEPT.

4-105. GENERAL. A Samos Satellite, upon arrival at the launch base area, is received at the guided missile assembly building in the squadron maintenance area, where it is inspected and tested to verify the readiness of satellite equipment for satisfactory operation prior to transporting the satellite to the launch pad. At the guided missile assembly building, the internal electrical power system undergoes visual inspection followed first by preliminary checkout at the subsystem level and then by integrated systems level testing wherein the overall subsystems are sequentially checked.

4-106. SUBSYSTEM CHECKOUT CONCEPT. The internal electrical power system initially undergoes subsystem checks independent of other satellite subsystem checks. Herein, such equipment as the auxiliary power checkout console, the vehicle power monitor console, and the universal power supply, are used to check the output of system voltages and current. The voltages observed are the plus and minus 28-volt dc; 400-cycle, single- and three-phase ac; 2000-cycle, single-phase ac; and the prime-energy-source voltage of 22 to 29.5 volts. In addition to voltage and current measurements, 400-cycle and 2000-cycle, a-c power frequency plus phase rotation of the 400-cycle, three-phase inverter are measured. A programmed series of load conditions are undergone in order to determine the performance of system inverter and regulator components. The load checkout sequence permits a complete, accurate, and relatively quick checkout of the internal electrical power system under actual Samos Satellite electrical load conditions.

4-107. ELECTRICAL CHECKS DURING SATELLITE SYSTEMS CHECKOUT. The overall Samos Satellite systems checkout is an essentially complete, timed sequence of events check of satellite operations wherein dynamic system testing is performed by automatic sequencing of satellite functions throughout a programmed flight. The extent of the checkout of the internal electrical power system is one of performance monitoring in which the overall output of the system is monitored to assure performance within the required limits.

4-108. In this checkout concept, the Samos Satellite is installed in the vehicle tilt and roll stand and checkout is performed of all the subsystem components while they are operated together as a system during a simulated flight. During this checkout, the output voltages and currents of the internal electrical power system are monitored to check their response under actual load conditions. Provisions are incorporated into the systems checkout equipment to permit the utilization of the equipment used in subsystem checkout should the system monitor program indicate a failure in the internal electrical power system equipment. This provision facilitates the location of a fault in the internal electrical power system at the satellite systems checkout level.

4-109. Upon successful completion of systems checkout, the satellite is then taken from the guided missile assembly building to the launch pad complex.

4-110. LAUNCH PAD AND COUNTDOWN PHASE CONCEPT. The principal activities relating to the internal electrical power system while the Samos Satellite is at the launch pad include primary battery installation prior to hoisting and mating of the Samos Satellite to the Samos Booster. Also, final checkout of Samos Satellite functions is made through auto-sequenced programmer and monitor consoles and continued as required until all equipment checks out properly. During final countdown, internal and external electrical power is monitored during the final testing, servicing, and monitoring of the Samos Satellite and Samos Booster equipment and supporting facilities.

4-111. SUPPORT PERSONNEL. The Samos Satellite during its time at the launch base is handled by a satellite crew, a satellite bench maintenance crew, and a launch pad complex maintenance crew. The satellite crew has complete responsibility over the Samos Satellite from time of arrival at the base until launch. This crew is supported in the bench areas of the guided missile assembly building by the technicians of the bench maintenance crew that are assigned to the internal electrical power system and the various satellite subsystems. At the launch pad, the satellite crew, in preparing the satellite for launch, is supported by the permanent launch pad complex maintenance crew. The Samos Satellite and its adapter are hoisted and mated to the Samos Booster by the satellite crew, which then completes all connections and installations. The launch pad complex crew provides satellite testing during preparation for launch and, therein, is augmented as needed by the satellite crew in preparing the Samos Satellite for launch.

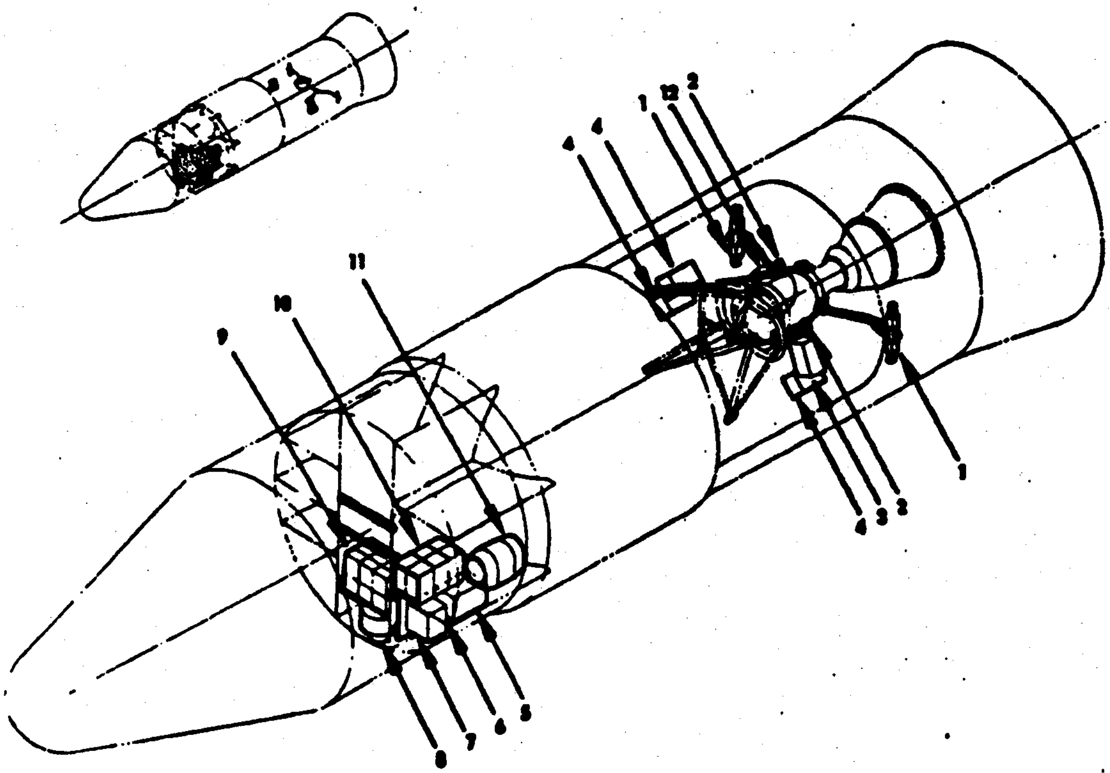
4-112. SUPPORT EQUIPMENT. The various support equipment that is used to check out and prepare the internal electrical power system for launch includes the vehicle power monitor console, the auxiliary power checkout unit, the universal power support, the discharge load tester for primary batteries, the dual battery charger, battery activation and handling equipment, and the overall systems checkout complex.

SAMOS SATELLITE-BORNE GUIDANCE AND CONTROL SYSTEMS

4-113. PURPOSE.

4-114. GENERAL. The Samos Satellite-borne guidance and control equipment positions the Samos Satellite to the correct attitude for all phases of flight after separation of the Samos Satellite from the Samos Booster, and maintains the prescribed attitude by stabilizing the Samos Satellite in pitch, roll, and yaw. A guidance system and a control system which constitute a unique combination of guidance devices and control mechanisms is provided in the Samos Satellite to perform the vital function of satellite attitude control. The guidance system provides the necessary guidance signals for the control system, and the control sytem changes the attitude of the satellite in response to the guidance signals. The location of the major equipment items that form the two systems is shown in figure 4-13.

4-115. Since the operations performed by the guidance and control systems during Samos Satellite ascent are different from those performed while the satellite is in orbit, and since different guidance signals and control mechanisms are used at these different times, the ascent and orbit phases are discussed separately. The ascent phase includes the separation of the Samos Satellite from the Samos Booster, the operation of the satellite rocket engine, and the orbit reorientation of the satellite from its horizontal attitude to a vertical,



1 GAS REACTION JETS
2 HYDRAULIC ACTUATOR
3 HYDRAULIC POWER UNIT AND INTEGRATED HYDRAULIC PACKAGE
4 HORIZON SENSOR
5 CONSTANT-RATE MOMENTUM WHEEL
6 INERTIAL REFERENCE PACKAGE (BEHIND ITEM 5)
7 ATTITUDE DAMPING PACKAGE
8 HORIZON SCANNER
9 COMPUTER
10 FLIGHT CONTROL ELECTRONICS UNIT
11 SEQUENCE TIMER
12 GAS SUPPLY SPHERE

Figure 4-13. Samos-Satellite-Borne Guidance and Control Systems, Location of Components nose-down attitude. The orbit phase begins after orbit reorientation, it includes the ejection of the ferret payload, and continues until the electrical power of the satellite is exhausted. There are also several significant differences between the guidance and control equipment scheduled for the initial Samos flights and that scheduled for later Samos flights. The equipment scheduled for the initial flights is discussed in this section, and the changes to be made for the later flights are indicated in the appropriate discussion. The operations performed by the guidance and control systems are the same for all flights.

4-116. GUIDANCE SYSTEM. The guidance system provides three types of guidance signals: attitude error signals, pitch and roll attitude reference signals, and pitch attitude program command signals. The attitude error signals correspond to the amount that the Samos Satellite has deviated in pitch, roll, and yaw about the pitch, roll, and yaw axes that are established by the guidance system. The pitch, roll, and yaw axes are established by the guidance system to coincide with the reference pitch, roll, and yaw axes described in paragraph 4-117. The attitude error signals continually command the control system to correct for random deviations in satellite attitude. The pitch and roll attitude reference signals correspond to the amount that the satellite is being consistently held off course due to a constant error between the pitch and roll axes established by the guidance system and the reference pitch and roll axes. The pitch and roll attitude reference signals continually correct the guidance system to eliminate any such constant error. The pitch attitude program command signals correspond to the amount that the attitude of the satellite must be changed in pitch for different phases of flight. The pitch attitude program command signals are applied to the guidance system at scheduled times to rotate the nose of the satellite downward with respect to the reference pitch axis. The guidance system also measures the velocity gained by the satellite during the operation of the satellite rocket engine and cuts off the engine. The equipment that forms the guidance system and the functions they perform during the ascent and orbit phases are described in paragraphs 4-120 and 4-133.

4-117. The reference pitch, roll, and yaw axes for the Samos Satellite are defined with respect to the earth as shown in figure 4-14. These reference axes are independent of the satellite and they are in no way affected by its attitude. The reference yaw axis is always along a line drawn from the center of the earth to the satellite. The reference roll axis is always perpendicular to the reference yaw axis and pointed in the direction that the satellite is moving. The reference pitch axis is always perpendicular to both the reference yaw axis and the reference roll axis. When the satellite is changed from its horizontal attitude to a vertical, nose-down attitude, the reference pitch, roll, and yaw axes remain unchanged with respect to the earth. Notice in figures 4-14 and 4-15 that the X-X, Y-Y, and Z-Z axes are determined with respect to the satellite and remain fixed within the satellite.

4-118. CONTROL SYSTEM. The control system actually consists of three control systems: the pneumatic control system, the hydraulic control system, and the orbital attitude damping system. These three systems control the pitch, roll, and yaw movements of the Samos Satellite about the reference pitch, roll, and yaw axes during the ascent and orbit phases. The pitch, roll, and yaw movements for both phases are illustrated in figure 4-15. The pneumatic control system is located at the rear of the satellite and the six gas reaction jets of the system are mounted on the aft

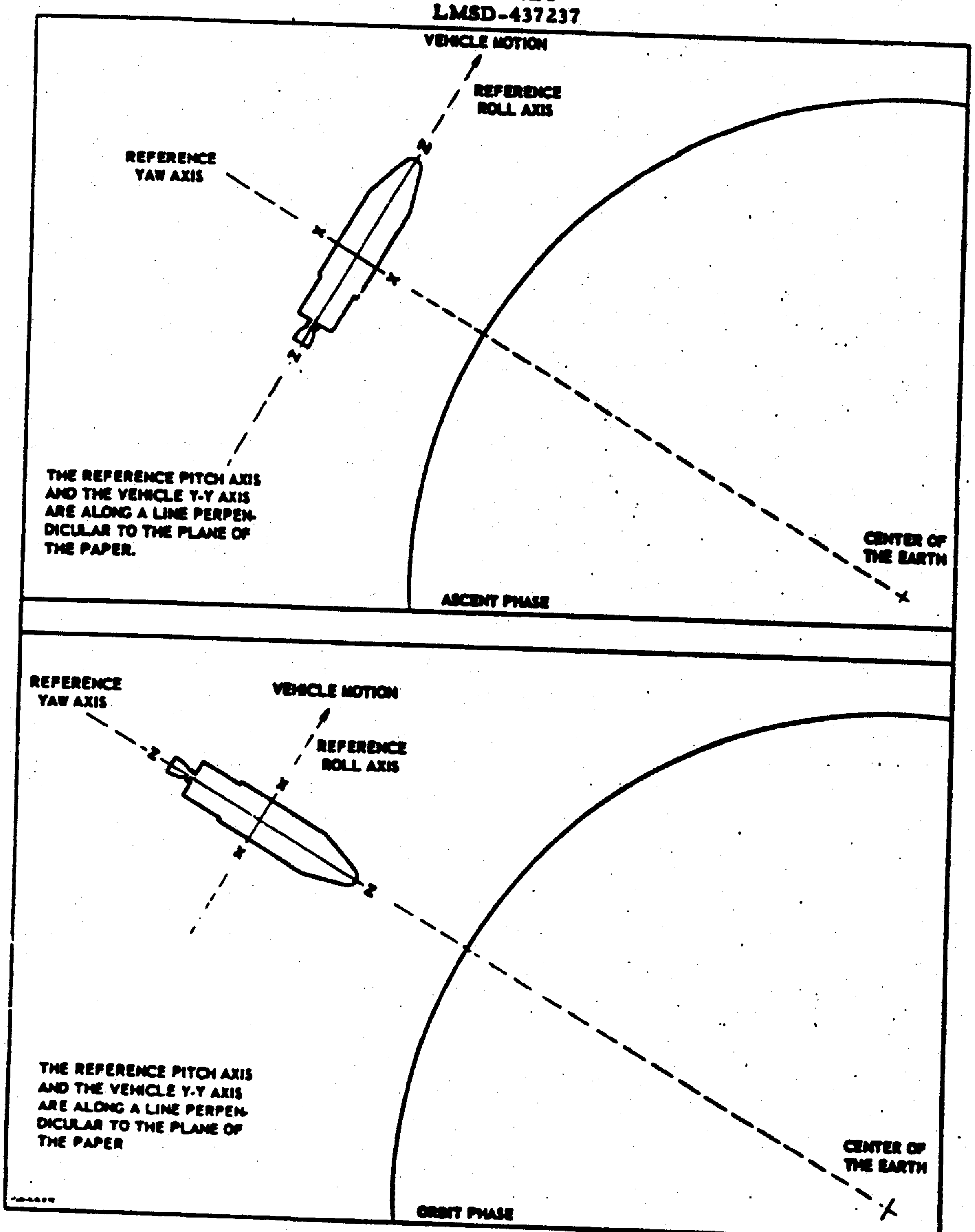


Figure 4-14. Definition of Reference Pitch, Roll, and Yaw Axes

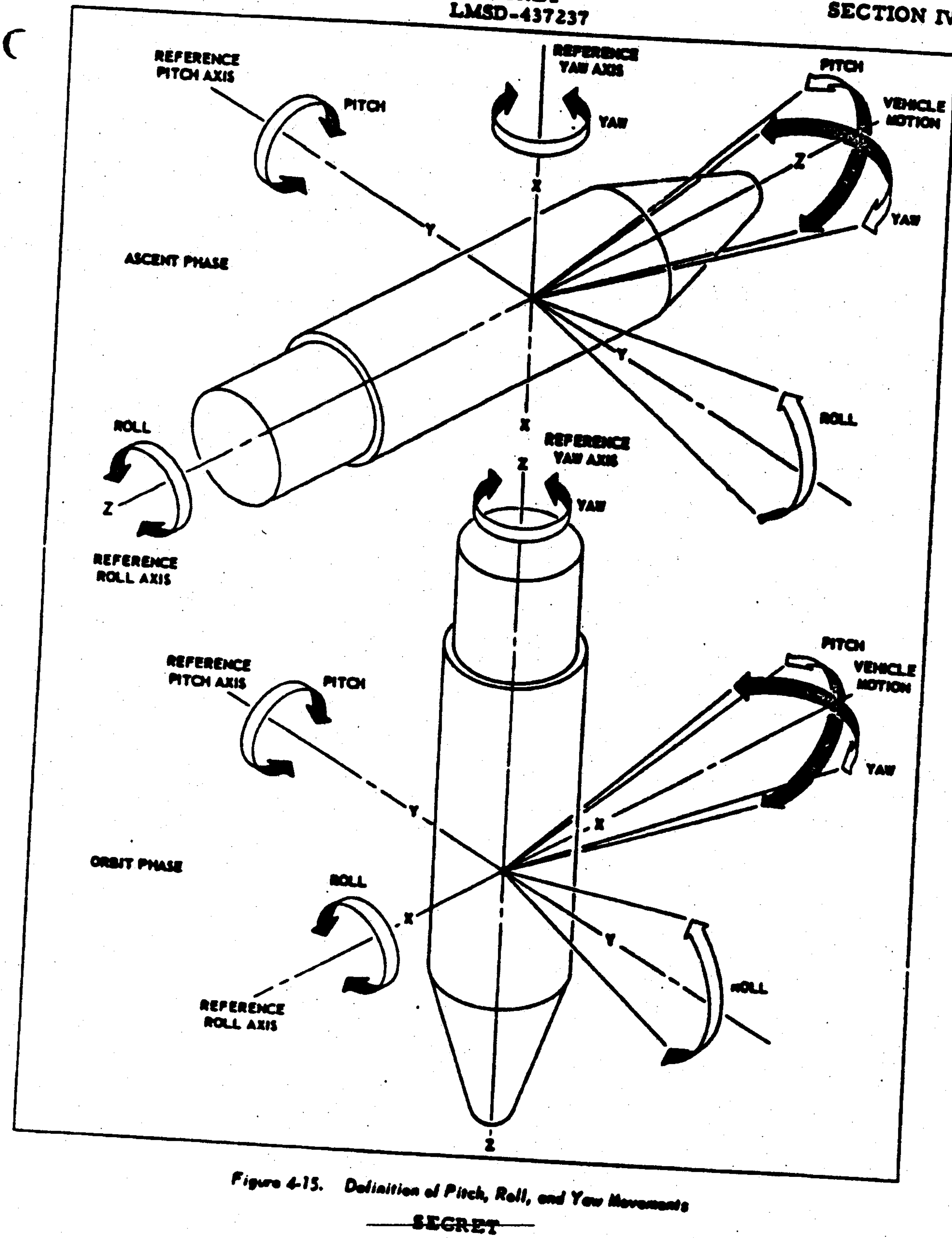


Figure 4-15. Definition of Pitch, Roll, and Yaw Movements

equipment rack. The pneumatic control system is activated throughout the ascent phase and for a brief period during the orbit phase when the ferret payload is ejected. The hydraulic control system is located at the rear of the satellite and the two hydraulic actuators of the system are mounted on the satellite rocket engine. The hydraulic control system is activated only when the satellite rocket engine is firing. The orbital attitude damping system is located at the front of the satellite and the two inertial reaction wheels are mounted in the forward equipment rack. The orbital attitude damping system is activated only during the orbit phase. The equipment that forms the control system and the functions they perform during the ascent and orbit phases are described in paragraphs 4-137 and 4-145.

4-119. OPERATION OF GUIDANCE AND CONTROL SYSTEMS. The operation of the guidance and control systems is illustrated in figure 4-16. The pitch, roll, and yaw gyros in the inertial reference package provide attitude error signals to the flight control electronics unit during the ascent phase. The attitude error signals are amplified by the flight control electronics unit and distributed to the pneumatic and hydraulic control systems which maintain the Samos Satellite at the prescribed attitude. The sequence timer in the computer provides the starting signal for the satellite rocket engine, and the accelerometer in the inertial reference package is connected to the integrator in the computer to measure the velocity gained by the satellite. When the velocity of the satellite is correct, the integrator cuts off the satellite rocket engine. The sequence timer and the integrator both provide pitch attitude program command signals to the inertial reference package. The horizon scanner provides pitch and roll attitude reference signals to the inertial reference package. During the orbit phase the attitude error signals from the inertial reference package are applied to the orbital attitude damping system which damps disturbances in the attitude of the satellite. The horizon sensor performs no guidance function, but provides attitude telemetry signals.

4-120. GUIDANCE DURING ASCENT PHASE.

4-121. GENERAL. Guidance during the ascent phase is provided by the inertial reference package, the flight control electronics unit, the computer, and the horizon scanner. The operation of these major equipment items is described in paragraphs 4-124 through 4-132.

4-122. During the coast period following separation, the gyros in the inertial reference package provide attitude error signals which are amplified by the flight control electronics unit and distributed to the pneumatic and hydraulic control systems. The horizon scanner provides pitch and roll attitude reference signals to the gyros to ensure that they hold the Samos Satellite horizontal. The sequence timer in the computer provides a pitch attitude program command signal to turn the nose of the satellite downward at prescribed times. The sequence timer also performs switching functions throughout the ascent and orbit phases.

4-123. During the operation of the satellite rocket engine, the gyros, the flight control electronics unit, and the horizon scanner operate as they did during the coast period. However, the pitch attitude program command signal is provided by the integrator in the computer rather than the sequence timer. The integrator also detects the velocity gained as the Samos Satellite accelerates by measuring the input from the accelerometer in the inertial reference package. The integrator cuts off the satellite rocket engine when

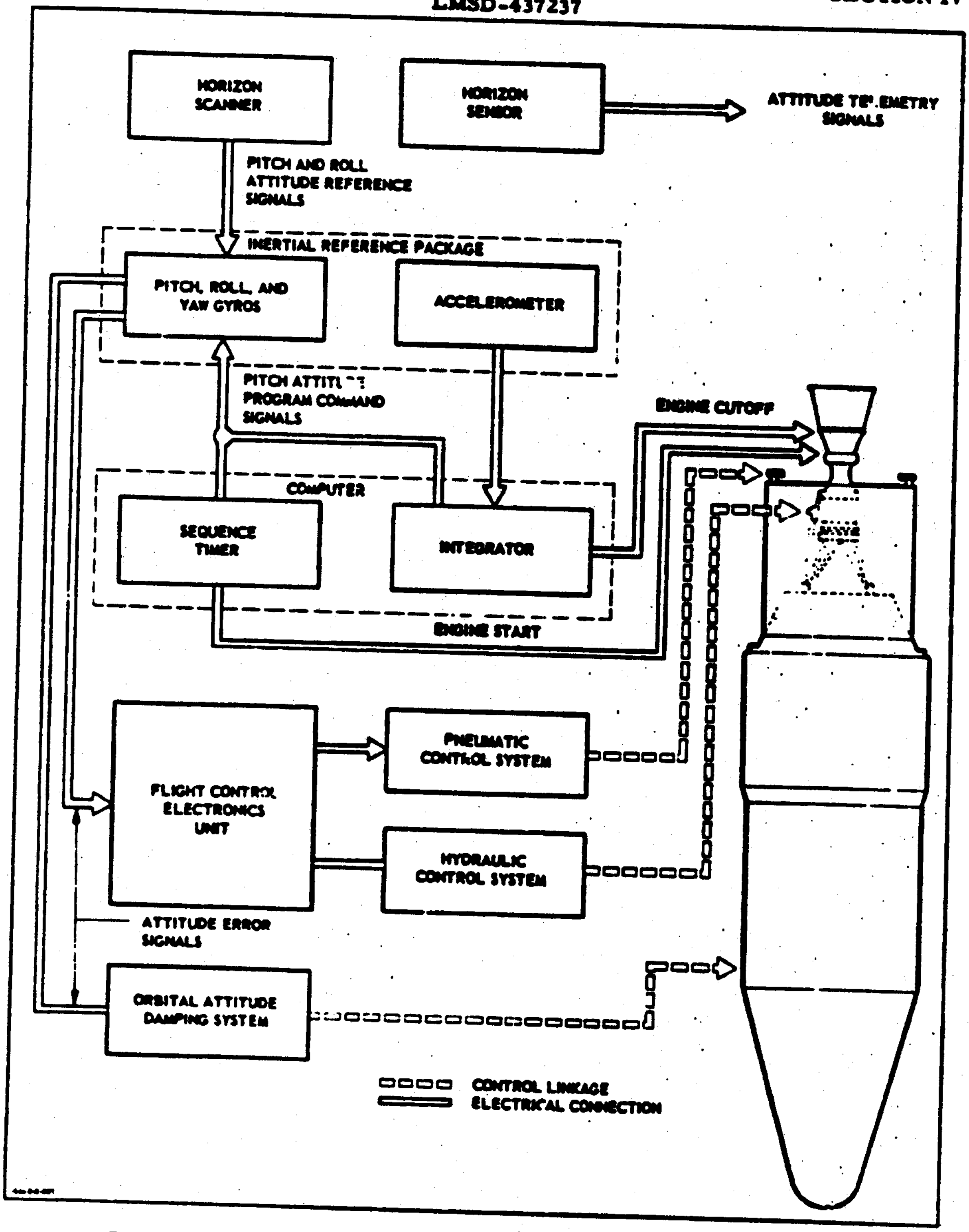


Figure 4-16. Samos-Satellite-Borne Guidance and Control Systems, Functional Schematic

the satellite reaches the correct velocity. After the satellite rocket engine is cut off, the satellite is changed from its horizontal attitude to a vertical, nose-down attitude for the orbit phase. During this orbit reorientation the horizon scanner is deactivated and the gyros in the inertial reference package are controlled by the pitch attitude program command signal from the sequence timer. The attitude error signals from the gyros are still amplified by the flight control electronics unit and distributed to the control system. Guidance after orbit reorientation, during the orbit phase, is described in paragraph 4-133.

4-124. INERTIAL REFERENCE PACKAGE. The inertial reference package provides three guidance gyros and an accelerometer. Transistor amplifiers in the inertial reference package are used to amplify the signals that are sent to the gyros from the computer and the horizon scanner. They also amplify the signals that are sent from the gyros to the control system and the signal that is sent from the accelerometer to the integrator in the computer.

4-125. The three gyros in the inertial reference package are operated as integrating, displacement gyros during the ascent phase and they are electrically caged during the orbit phase and operated as rate gyros. See figure 4-17 for an illustration of the gyro parts and for the general orientation of the gyros in the Samos Satellite. Each gyro is mounted on a rotor perpendicular to the spin axis of the gyro. The rotor is along the output axis of the gyro. The input axis of the gyro is perpendicular to both the spin axis and the output axis. When the gyro is twisted about its input axis, it reacts by twisting about its output axis. This reaction is gyroscopic precession. Each of the three gyros is oriented in the satellite so that the motion that the gyro is assigned to detect will be about its input axis. For example, the input axis of the pitch gyro is parallel with the reference pitch axis. Therefore, any pitch movement of the satellite about the reference pitch axis is detected about the input axis of the pitch gyro.

4-126. The output axis rotor of each gyro passes through a torque generator on one side of the gyro, and through an a-c signal generator on the other side. The a-c signal generator provides attitude error signals proportional to displacements of the output axis rotor. For example, when a pitch movement of the Samos Satellite attempts to twist the pitch gyro about its input axis, the gyro reacts by twisting (precessing) about its output axis. Since the gyro is rigidly mounted on the output axis rotor, it displaces the rotor when it precesses, and an attitude error signal is produced by the a-c signal generator to correct for the pitch movement. The torque generator provides a way to control the gyro directly with the pitch and roll reference signals from the horizon scanner and the pitch attitude program command signals from the computer. For example, when the nose of the Samos Satellite is being consistently held too high by the action of the pitch gyro, the horizon scanner will detect the constant error in pitch and send a pitch attitude reference signal to the torque generator. The torque generator will turn the output axis rotor directly, and an attitude error signal is produced by the a-c signal generator to correct the constant pitch error. The roll reference signal and the pitch attitude program command signals also produce attitude error signals in this way.

4-127. The accelerometer is a pendulum that is electrically restrained by a restraint motor. The unbalanced weight of the pendulum is free to move around a rotor that also passes through the restraint motor and an a-c signal generator. As the Samos Satellite is accelerated by the satellite rocket engine, the pendulum is swung back from its static position to cause an output from the a-c signal generator. The restraint motor ensures that the movement of the pendulum is proportional to the acceleration, since with no restraint the pendulum would swing the maximum amount with only a slight acceleration. The output from the a-c signal generator is amplified by the transistor amplifiers in the inertial reference package and sent to the integrator in the computer. When the integrator determines that the satellite has reached the correct velocity, it cuts off the satellite rocket engine.

4-128. FLIGHT CONTROL ELECTRONICS UNIT. The flight control electronics unit processes the attitude error signals from the inertial reference package and distributes them to the control system. Processing consists of amplifying the a-c attitude error signals from the pitch, roll, and yaw gyros in the inertial reference package, converting the amplified a-c signals to d-c rate signals, and amplifying the d-c rate signals. The amplified d-c rate signals are applied to the control mechanisms of the pneumatic and hydraulic control systems to adjust the attitude of the vehicle in accordance with the guidance attitude error signals from the inertial reference package. Separate channels are provided for the pitch, roll, and yaw mechanisms of the pneumatic control system and the pitch and yaw mechanisms of the hydraulic control system. The roll channel for the pneumatic control system and the pitch channel for the hydraulic control system are shown in the diagrams of figures 4-18 and 4-20. Feedback signals from position sensors in the hydraulic control system are returned to the d-c rate amplifiers in the flight control electronics unit to improve the response of the hydraulic actuators to the signals from the amplifiers. The a-c amplifiers, the demodulators and rate networks that convert the a-c attitude error signals to d-c rate signals, and the d-c amplifiers that constitute the flight control electronics unit are completely transistorized.

4-129. COMPUTER. The computer includes the sequence timer and the integrator. The sequence timer provides switching signals during the ascent and orbit phases to perform such functions as firing the ullage rockets and connecting the accelerometer in the inertial reference package to the integrator. It also provides a pitch attitude program command signal to the inertial reference package. The integrator provides a pitch attitude program command signal to the inertial reference package and detects the velocity gained by the Samos Satellite during the operation of the satellite rocket engine.

4-130. The sequence timer is a set of mechanical counters and switches that is driven by a synchronous motor. There are 24 mechanical counters. They are driven by the synchronous motor and each can be set to actuate from one to five switches at any time throughout an operational range of from 0.1 second to 1600 seconds after the start of the sequence timer. The initial Samos flights require a maximum time span of less than 700 seconds. There are twelve banks of switches with six switches in each bank. Two of the 24 mechanical counters are associated with each bank. One counter is set to actuate from one to five of the switches in the bank at a specific time, and the other counter is set to actuate the remaining switches, usually at a different time. One of the functions of the sequence timer is to connect a pre-determined fixed voltage to the inertial reference package at the proper time. This voltage is the pitch attitude program command signal from the sequence timer.

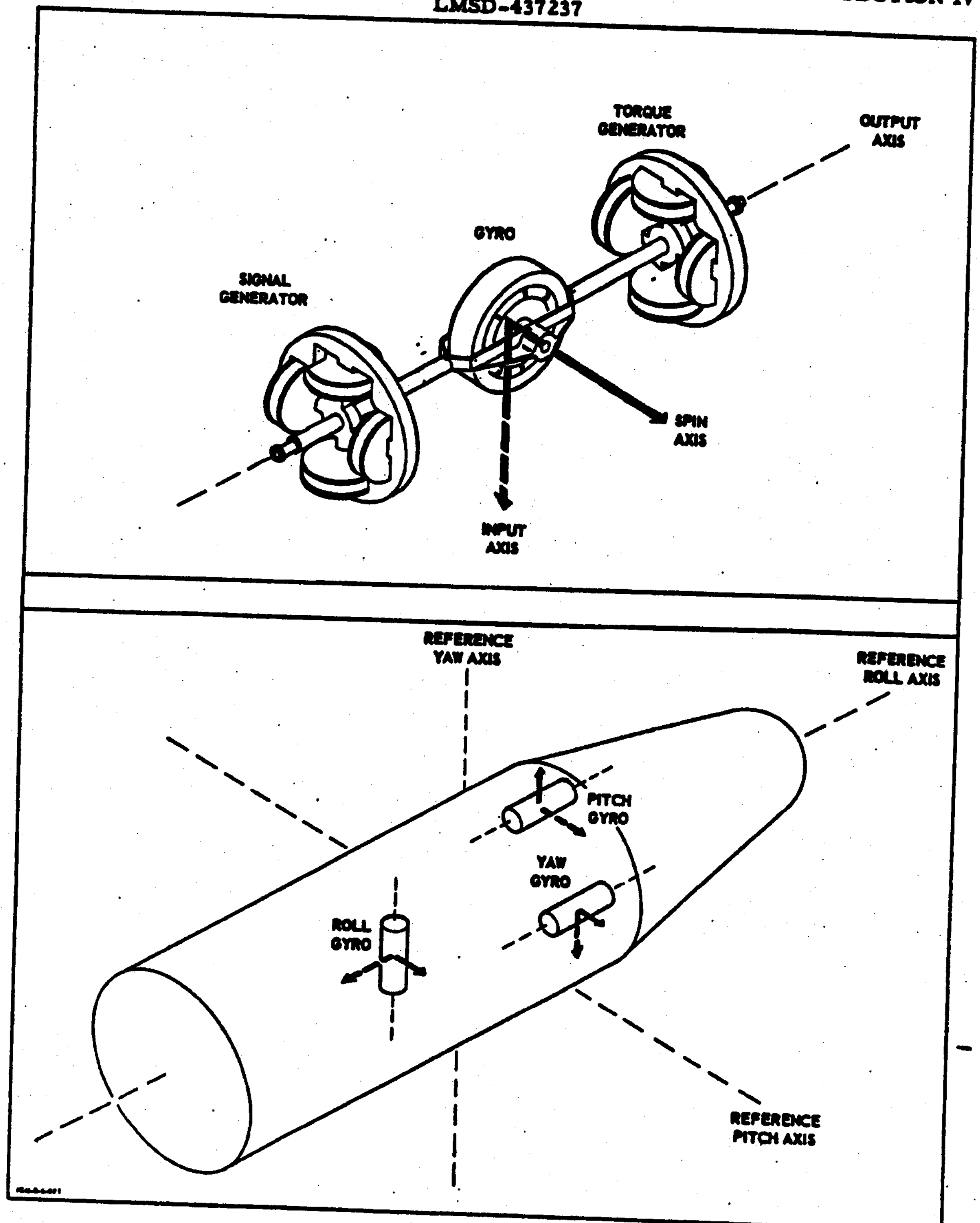


Figure 4-17. Essential Features of Gyro and Orientation of Gyros in Samos Satellite

The synchronous motor is supplied with a 28-volt, d-c clutch/brake. The brake can stop the running motor within 0.05 second, and when it is released, the motor gains full speed within 0.1 second.

4-131. The integrator is a motor-tachometer unit that is controlled by the signal from the accelerometer in the inertial reference package. The signal from the accelerometer is amplified by transistor amplifiers in the integrator package and applied to the integrator motor. The torque on the motor is proportional to the amplitude of the input signal, and the number of revolutions it turns is proportional to the velocity gained by the Samos Satellite. After the motor has completed a pre-determined number of revolutions, a switch is closed through a gear train to cut off the satellite rocket engine. The motor also adjusts, through another gear train, a pre-determined, variable voltage that is sent to the inertial reference package. This voltage is the pitch attitude program command signal from the integrator. The tachometer senses the speed of the motor and provides a voltage signal proportional to the speed. This voltage signal is returned to the transistor amplifiers in the integrator package as feedback to improve the response of the motor to the signal from the accelerometer. A velocity meter is scheduled to replace the accelerometer on later Samos flights. The velocity meter will also be controlled by an accelerometer signal, but it will be capable of handling more than one velocity setting.

4-132. HORIZON SCANNER. The horizon scanner is an optical, infrared device used to detect the position of the earth in relation to the attitude of the Samos Satellite. It consists of a scanning mirror, an infrared radiation detector, and an electronic circuit to generate signals proportional to any infrared radiation that is detected. The amount of infrared radiation detected from the earth, horizon to horizon, is greater than that detected from space. When the Samos Satellite is horizontal, the total radiation field on the left of the reference roll axis is equal to that on the right, and the total radiation field in front of the reference pitch axis is equal to that behind. Using these infrared radiation fields, the horizon scanner detects any constant deviation about the reference pitch and roll axes from the required horizontal attitude and it generates voltage signals proportional to the deviation. These voltage signals are the pitch and roll attitude reference signals that are sent to the gyros in the inertial reference package to correct for constant pitch and roll attitude errors. The horizon scanner is used on the initial Samos flights, but it is scheduled to be replaced by the Model 2 horizon sensor on later flights.

4-133. GUIDANCE DURING ORBIT PHASE.

4-134. GENERAL. Guidance during the orbit phase is provided entirely by the gyros in the inertial reference package. Throughout the orbit phase, except for the brief period when the ferret payload is ejected, the gyros are electrically caged and operated as rate gyros, and the attitude error signals from the pitch and yaw gyros are applied directly to the orbital attitude damping system. When the ferret payload is ejected the sequence timer and the flight control electronics unit are reactivated to distribute attitude error signals from the gyros to the pneumatic control system. The operations of the inertial reference package, the flight control electronics unit, and the sequence timer in the computer are the same as described in paragraphs 4-124 through 4-130. The horizon sensor, which performs no guidance functions, is operated during the orbit phase. Its operation is described in paragraphs 4-135 and 4-136.

4-135. HORIZON SENSOR. The horizon sensor used on the initial Samos flights is the Model 1 which consists of three optical, infrared devices. It is used after orbit reorientation to provide attitude telemetry data but performs no guidance function. The horizon sensor used on later Samos flights is the Model 2 which consists of two optical, infrared devices. It replaces the horizon scanner on the later flights and provides the pitch and roll attitude reference signals that were provided by the horizon scanner.

4-136. The operation of the horizon sensor is similar to that of the horizon scanner described in paragraph 4-132. Each optical, infrared device consists of a scanning germanium prism, an infrared radiation detector, and an electronic circuit to generate signals proportional to any infrared radiation that is detected. The three optical, infrared devices of the Model 1 horizon sensor measure the total infrared radiation field around the reference pitch and roll axes and generate pitch and roll attitude telemetry signals that correspond to the measured radiation. Consequently the pitch and roll attitude telemetry signals correspond to the attitude of the Samos Satellite in pitch and roll. One of the two optical, infrared devices of the Model 2 horizon sensor measures the total infrared radiation field on the left of the reference roll axis, and the other one measures it on the right. The voltage signal generated by the combined operation of the two devices is the roll attitude reference signal. Each device measures the total infrared radiation field around the reference pitch axis independently, and the two measurements are averaged to generate the pitch attitude reference signal.

4-137. CONTROL DURING ASCENT PHASE.

4-138. GENERAL. Control during the ascent phase is provided by the pneumatic control system and the hydraulic control system in response to guidance signals from the guidance system. During the coast period following separation, the gas reaction jets of the pneumatic control system maintain the attitude of the Samos Satellite in pitch, roll, and yaw. During the operation of the satellite rocket engine, the hydraulic control system maintains the attitude of the satellite in pitch and yaw, and the gas reaction jets control the attitude in roll. This is the only time that the hydraulic control system is operated. After the satellite rocket engine is cut off, the gas reaction jets change the satellite from its horizontal attitude to a vertical, nose-down attitude for the orbit phase. Control after orbit reorientation is described in paragraph 4-145. The operation of the pneumatic and hydraulic control systems are described in paragraphs 4-139 and 4-142.

4-139. PNEUMATIC CONTROL SYSTEM. The pneumatic control system exerts torques on the vehicle by forcing gas through gas reaction jets to control the attitude of the satellite in pitch, roll, and yaw. The system consists of the gas supply sphere and the pressure regulating package; six gas valves and gas reaction jets that are mounted on the aft equipment rack; and the necessary pneumatic connections. The components are represented in figure 4-18. A diagram is also included in figure 4-18 to illustrate the operation of the pressure regulating package with two of the roll gas reaction jets, and to show how the jets are controlled by guidance signals from the flight control electronics unit.

4-140. The gas used in the pneumatic control system is a gaseous combination of dry nitrogen (N_2) and tetrafluoromethane (CF_4). Tetrafluoromethane is commonly known as Freon. It is stored in the gas supply sphere at a

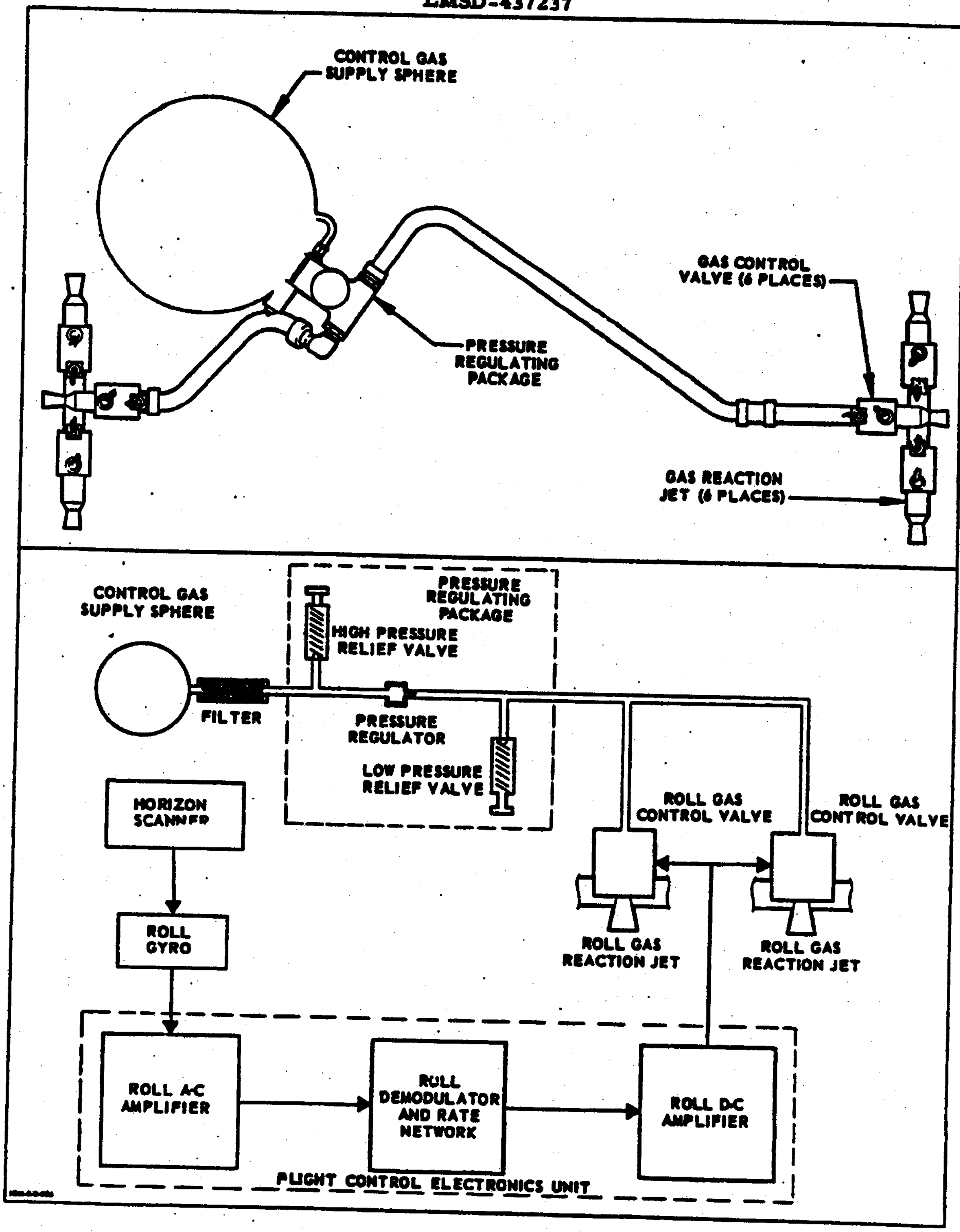


Figure 4-18. Pneumatic Control System, Functional Schematic

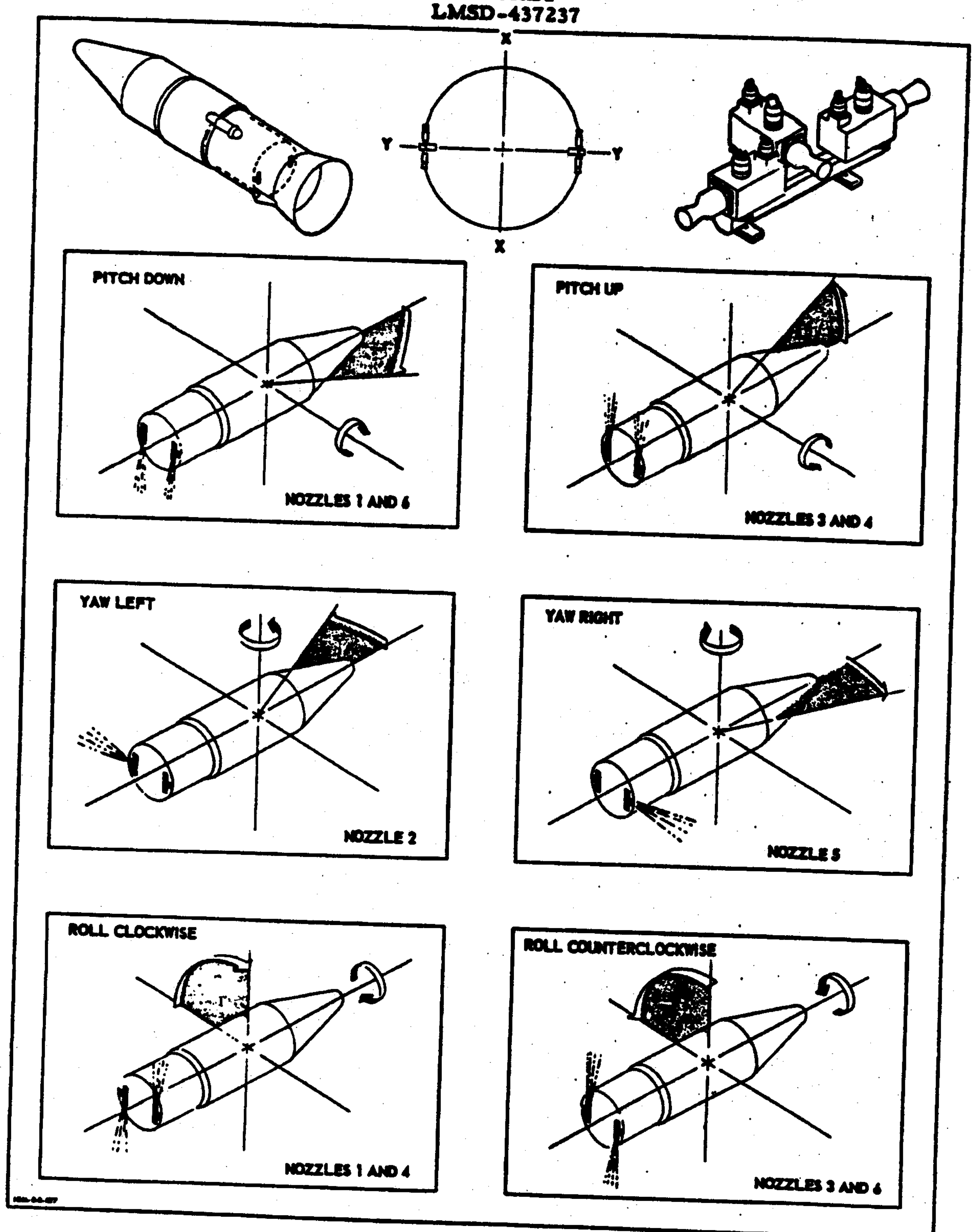


Figure 4-19. Pneumatic Control System, Principles of Operation

pressure of approximately 3500 psig. The pressure regulator in the pressure regulating package applies the gas, as shown in the diagram of figure 4-18, to the roll gas control valves at a pressure between 150 to 190 psig. Of the six gas control valves and gas reaction jets, two are used exclusively for yaw control, and the other four are used for both pitch and roll control. Only two of the roll gas reaction jets are shown in the diagram. When a roll torque is commanded by the d-c rate signal, the correct pair of roll gas control valves are opened. Gas is expelled through the roll gas reaction jets to correct the attitude of the satellite in roll. The operation is the same for the pitch and yaw gas reaction jets. The principles of operation of the pneumatic control system are illustrated in figure 4-19.

4-141. The high pressure relief valve opens if the supply pressure to the pressure regulator exceeds 3500 psig. The low pressure relief valve opens if the regulated pressure to the gas control valves exceeds 200 psig. The two relief valves are used to prevent damage to the system due to thermal expansion of the gas or surges of pressure caused by rapid cycling of the gas control valves. The filter removes particles from the gas that exceed 25 microns in size.

4-142. HYDRAULIC CONTROL SYSTEM. The hydraulic control system positions the satellite rocket engine while the engine is operating to control the attitude of the Samos Satellite in pitch and yaw. The system consists of the hydraulic power unit and integrated hydraulic package; two servo valves, hydraulic actuators, and position sensors; and the necessary hydraulic connections. These components are represented in figure 4-20. A diagram is also included in figure 4-20 to illustrate the operation of the hydraulic power unit and integrated hydraulic package with the pitch actuator, and to show how the actuator is controlled by guidance signals from the flight control electronics unit.

4-143. The hydraulic control system is pressurized by the 28-volt d-c motor which drives a hydraulic pump. The MIL-H-5606 hydraulic fluid is applied, as shown in the diagram of figure 4-20, to the pitch servo valve at a pressure of approximately 2400 psi. When a change in the pitch position of the satellite rocket engine is commanded by the d-c rate signal, the pitch servo valve is opened and the pressurized hydraulic fluid drives the pitch actuator. Movement of the pitch actuator turns the satellite rocket engine on its gimbal to correct the attitude of the satellite in pitch. The operation is the same for the yaw actuator. The principles of operation of the engine gimballing system are illustrated in figure 4-21.

4-144. The position sensor in each actuator detects the position of the actuator and provides a voltage signal proportional to the position. This voltage signal is returned to the d-c amplifiers in the flight control electronics unit as feedback to improve the response of the actuator to the guidance signals. The accumulator and reservoir in the integrated hydraulic package ensure an adequate and steady supply of hydraulic fluid into the system. The high and low pressure relief valves are used to prevent damage to the system, and the check valve prevents a reversal of fluid flow during checkout of the system. The filter removes contaminants from the hydraulic fluid that exceed ten microns in size. The pressure transducer provides a pressure telemetry signal.

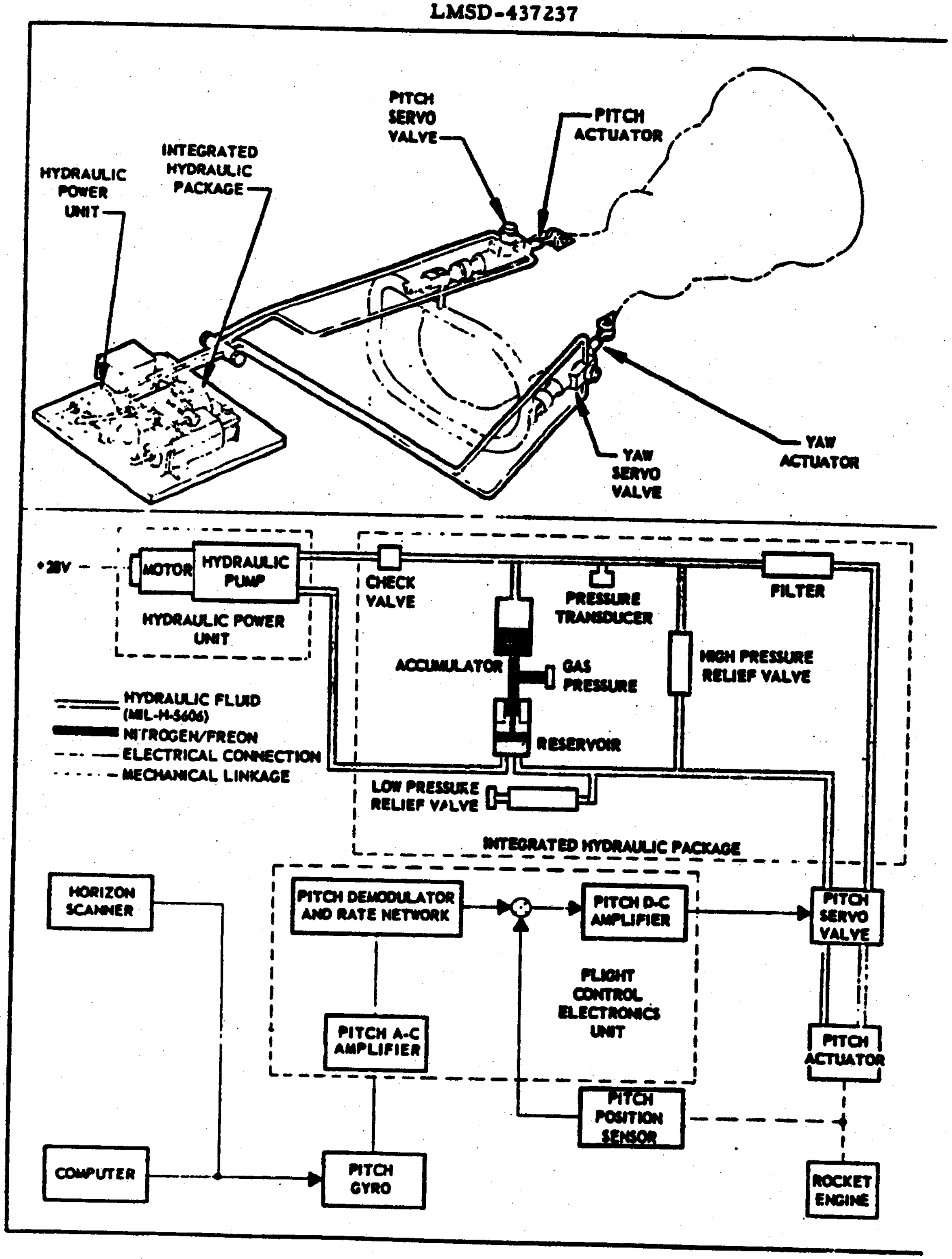


Figure 4-20. Hydraulic Control System, Functional Schematic

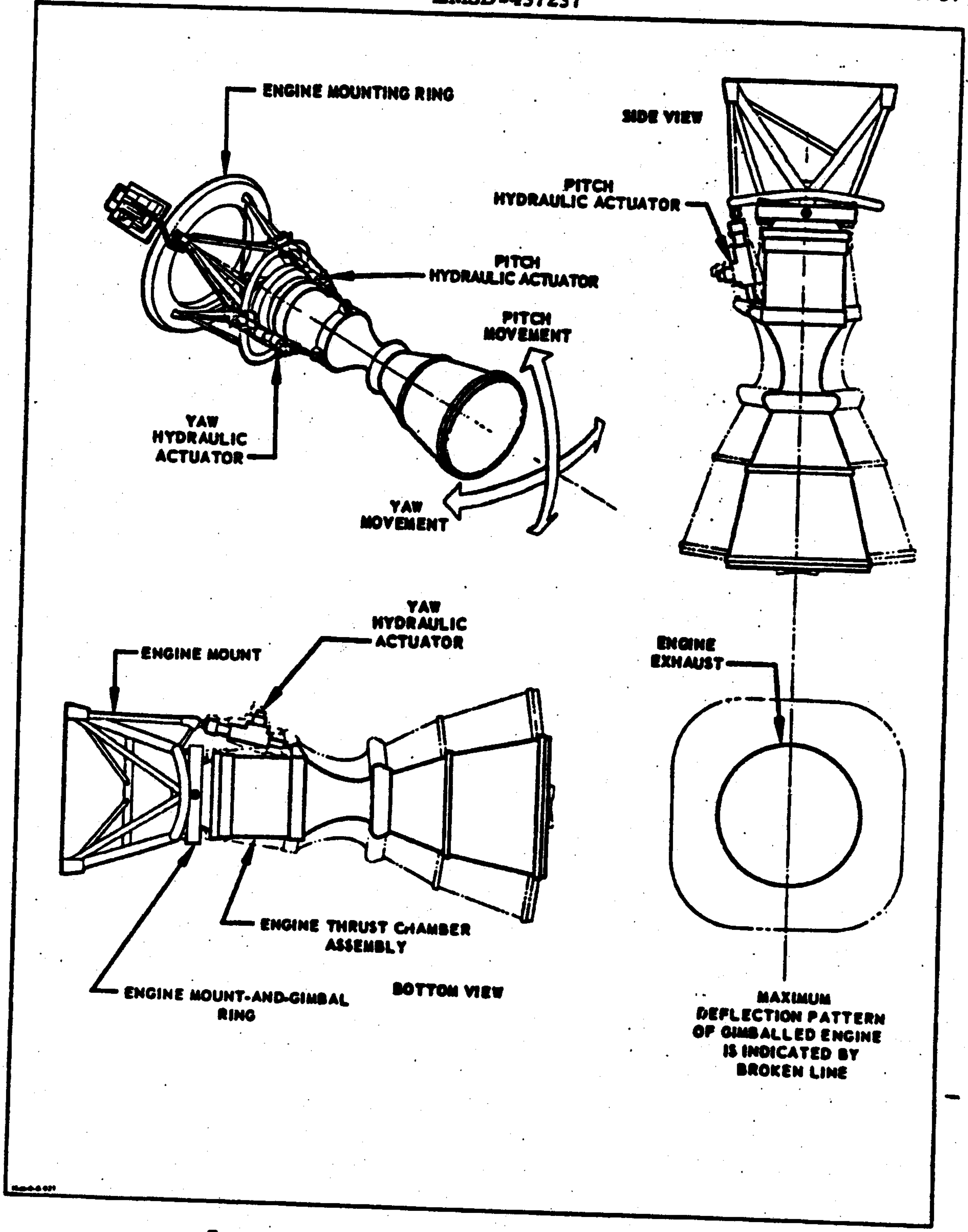


Figure 4-21. Hydraulic Control System, Principles of Operation

4-145. CONTROL DURING ORBIT PHASE.

4-146. GENERAL. Control during the orbit phase is provided by the gravity gradient, the orbital angular momentum of the Samos Satellite, and the orbital attitude damping system. The vertical, nose-down attitude of the satellite is established and maintained as the equilibrium position by the gravity gradient and the orbital angular momentum. The gravity gradient tends to pitch the orbiting satellite so that its Z-Z axis continues to point toward the center of the earth. The Z-Z axis is the axis of minimum moment inertia. The orbital angular momentum which is given to the satellite by the pneumatic control system during orbit reorientation also pitches the orbiting satellite to reinforce the action of the gravity gradient. Disturbances about the equilibrium position are controlled by the orbital attitude damping system. The orbital attitude damping system operates in response to guidance signals from the guidance system throughout the orbit phase except for the brief period when the ferret payload is ejected. When the ferret payload is ejected, the pneumatic control system is reactivated to handle the large disturbances that result from the ejection. The operation of the pneumatic control system is the same as described in paragraph 4-139. The operation of the orbital attitude damping system is described in paragraph 4-147.

4-147. ORBITAL ATTITUDE DAMPING SYSTEM. The orbital attitude damping system exerts torques on the Samos Satellite by changing the angular velocity, and consequently the momentum, of inertial reaction wheels. These torques damp irregular motions of the satellite in pitch, roll, and yaw by opposing the disturbing torques that caused the motions. The system consists of two attitude damping packages and a constant-rate momentum wheel for the initial Samos flights. These components are represented in figure 4-22. A diagram is also included in figure 4-22 to illustrate the operation of the components and to show how they are controlled by guidance signals from the pitch and yaw gyros. An orbital attitude control system is scheduled for the later Samos flights which consists of one attitude damping package, a constant-rate momentum wheel and a large gyro, and, for backup, a low-amplitude gas reaction jet system.

4-148. The effectiveness of the orbital attitude damping system depends on the momentum characteristics and reaction times of the orbital attitude control mechanisms. The optimum values of these parameters have been determined by computer analysis at Massachusetts Institute of Technology. The results of the analysis dictate the size of the inertial reaction wheels, the minimum momentum that must be maintained about the reference pitch axis, and the time delay that is required in the pitch attitude damping package. The constant-rate momentum wheel is used to ensure that the minimum pitch momentum is maintained, and a time-lag integrator is provided in the pitch attitude damping package to delay the pitch reaction time for twenty minutes. A time delay is not required in the roll/yaw attitude damping package since the momentum characteristics in roll and yaw differ from those established in pitch and they are satisfactory. The tachometer in each package senses the speed of the motor driving the inertial reaction wheel and provides a voltage signal proportional to the speed. This voltage signal is returned to the servo amplifiers in the package as feedback to improve the response of the motor to the guidance signals.

4-149. The pitch attitude damping package is controlled by an attitude error signal from the pitch gyro which is electrically caged during the orbit phase

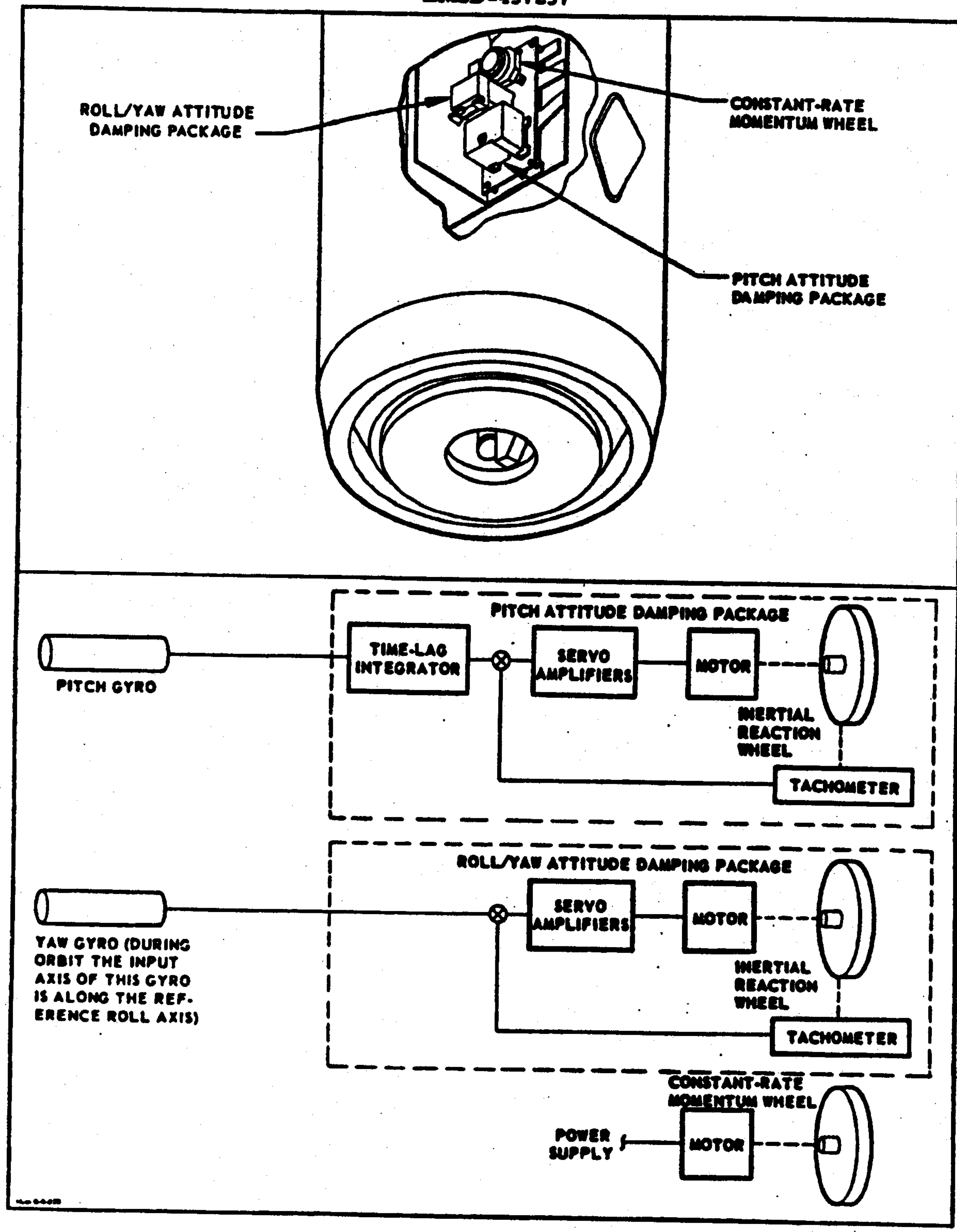


Figure 4-22. Orbital Attitude Damping System, Functional Schematic

to operate as a rate gyro. The input axis of the pitch gyro is parallel with the reference pitch axis when the vehicle is horizontal, and, because of its orientation in the Samos Satellite, it remains parallel with the reference pitch axis when the satellite is turned to a vertical, nose-down attitude. The attitude error signals from the pitch gyro are applied, as shown in the diagram of figure 4-22, through the time-lag integrator and the servo amplifiers to the motor that drives the pitch inertial reaction wheel. The spin axis of the wheel is also parallel with the reference pitch axis. When pitch damping is commanded by the attitude error signal, the pitch inertial reaction wheel is accelerated in the direction of the disturbing torque. The wheel housing reacts to the accelerating torque on the wheel and produces an equal and opposite torque on the satellite that opposes the disturbing torque in pitch. The principles of operation of the pitch attitude damping package to provide damping in pitch are illustrated in figure 4-23.

4-150. The roll/yaw attitude damping package is controlled by an attitude error signal from the yaw gyro which is operated as a rate gyro also. The input axis of the yaw gyro is parallel with the reference yaw axis when the Samos Satellite is horizontal, but, because of its orientation in the satellite, it is parallel with the reference roll axis when the satellite is turned to a vertical, nose-down attitude. The yaw gyro will generate an attitude error signal if a disturbing torque causes an irregular motion of the satellite in either roll or yaw. The attitude error signal is applied through the servo amplifiers to the motor that drives the roll/yaw inertial reaction wheel. The spin axis of the wheel is parallel with the reference yaw axis. The principles of operation of the roll/yaw attitude damping package to provide damping in yaw and roll are illustrated in figure 4-23.

4-151. When yaw damping is commanded by the attitude error signal, the roll/yaw inertial reaction wheel is accelerated in the direction of the disturbing torque. The wheel housing reacts to the accelerating torque on the wheel and produces an equal and opposite torque on the satellite that opposes the disturbing torque in yaw. This action is identical to that used to damp disturbances about the reference pitch axis.

4-152. When roll damping is commanded by the attitude error signal, the angular velocity of the roll/yaw inertial reaction wheel is changed to produce a restoring torque. The restoring torque results from gyroscopic precession of the wheel as it reacts to the constant orbital pitching of the satellite. When a gyro is twisted, it reacts by twisting about an axis which is perpendicular to the axis of the original motion. So, as the constant orbital pitching of the satellite tends to twist the roll/yaw inertial reaction wheel about the reference pitch axis, the wheel reacts by twisting about the reference roll axis. Since the wheel is not free to twist about the reference roll axis, it exerts a restoring torque on the satellite that opposes the disturbing torque in roll. The amount of twist, and consequently the restoring torque, depends on the angular velocity of the wheel.

4-153. SEQUENCE OF GUIDANCE AND CONTROL EVENTS.

4-154. GENERAL. The sequence of guidance and control events for the Samos Satellite includes most of the events that are necessary to place the satellite in orbit. Since the guidance and control events are so important, and since a discussion of them summarizes the functions of the satellite-borne guidance and control equipment, the sequence is described in paragraphs 4-155 through 4-172.

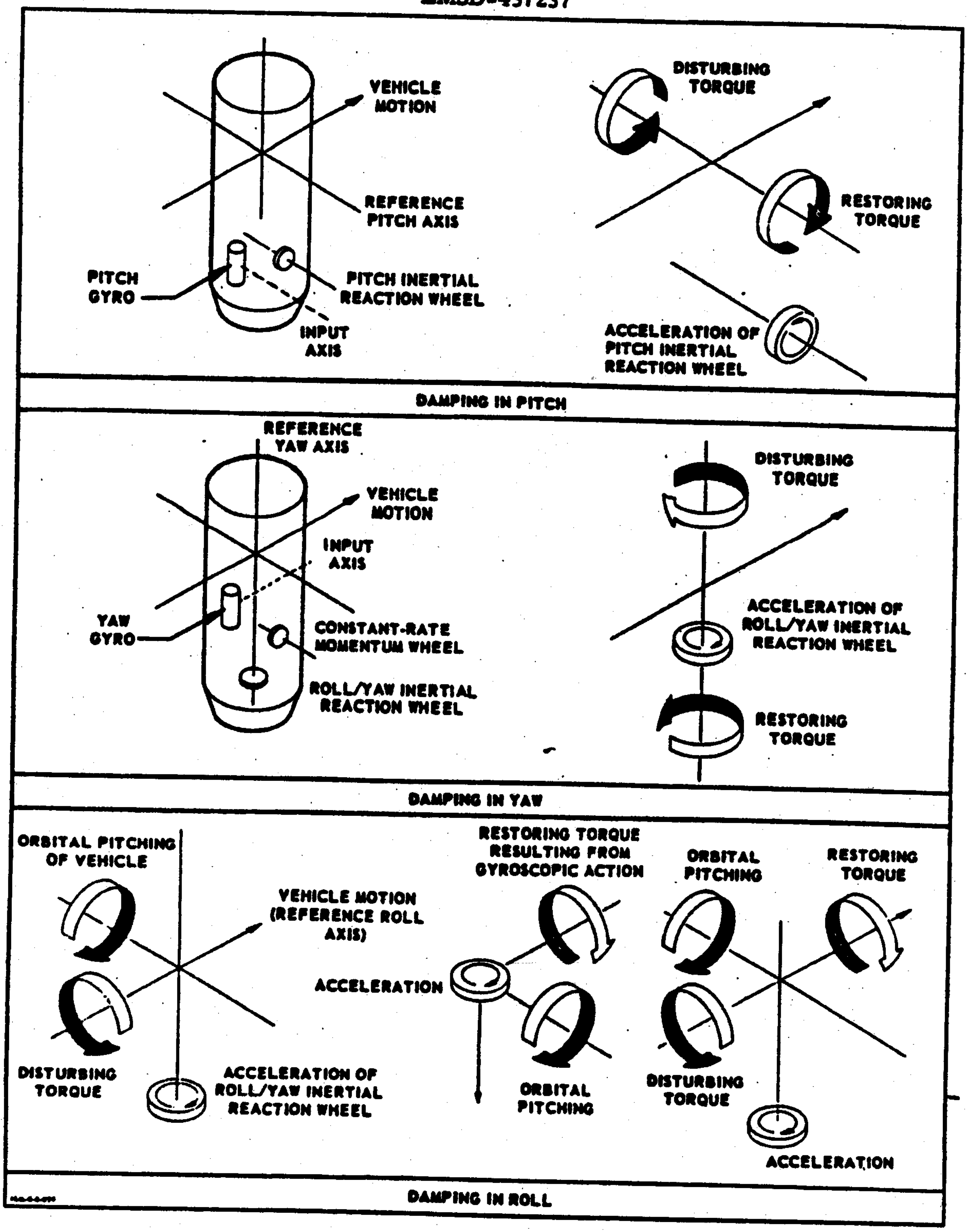


Figure 4-23. Orbital Attitude Damping System, Principles of Operation

APPROXIMATE TIME OF EVENTS IN MINUTES AND SECONDS	EXACT TIME OF EVENT IN SECONDS	GUIDANCE AND CONTROL EVENT
	BEFORE LAUNCH	
-2 minutes; before launch	. . .	Power is applied to Samos Satellite guidance and control equipment.
	FROM LAUNCH TO SEPARATION	
Time zero; at launch	0	a. Samos Booster engines are started. (The Samos Booster operates for 4 min, 20 sec.) b. Power remains applied to Samos Satellite guidance and control equipment, but the equipment performs no function until after separation.
+ 4 minutes and 10 seconds; after launch	248	Sequence timer brake is released.
+ 4 minutes and 20 seconds	259.6	Separation of Samos Satellite from Samos Booster is commanded.
FROM SEPARATION TO START OF SAMOS SATELLITE ROCKET ENGINE		
+ 4 minutes and 20 seconds	260.6	a. Samos Satellite vehicle is separated from Samos Booster. (The satellite coasts for 4 min.) b. Guidance system and pneumatic control system are activated.
+ 4 minutes and 35 seconds	274	a. Samos Satellite is turned from attitude 25.6 degrees above horizontal to horizontal attitude by sequence timer. b. Nose cone and horizon scanner fairings are ejected.
+ 5 minutes and 15 seconds	315	Horizon scanner and integrator are connected to inertial reference package.

Figure 4-24. Sequence of Guidance and Control Events (Sheet 1 of 4)

A simplified listing of the guidance and control events is provided in figure 4-24. The times given in figure 4-24 are typical and given for example only. The events and times may be changed at any time before a Samos flight to ensure optimum performance of the satellite equipment. The timing of each event is adjusted to ensure compatibility with the characteristics of the particular booster used for the flight. The periods before launch and from launch to separation are discussed separately. The ascent phase is divided for discussion into three periods: from separation to start of the satellite rocket engine, from satellite rocket engine start to cutoff, and from satellite rocket engine cutoff through orbit reorientation. The orbit phase and the ejection of the ferret payload are discussed separately.

4-155. BEFORE LAUNCH. Before launch, power is applied to the Samos satellite guidance and control systems but the equipment does not perform any guidance or control functions until after separation of the Samos Satellite from the Samos Booster. Approximately two minutes before launch, power is applied to the inertial reference package, the computer, and the flight control electronic unit. A 28-volt "keep alive" voltage is applied to the orbital attitude damping system. The gyros are operated in the caged mode, and the sequence timer is held by its brake until just before separation. The horizon scanner, the horizon sensor, the pneumatic control system (the gas reaction jets), and the hydraulic control system are not connected to perform their guidance and control functions. The accelerometer in the inertial reference package is not connected to the integrator in the computer.

4-156. FROM LAUNCH TO SEPARATION. From launch to separation, power remains applied to the Samos Satellite guidance and control systems and they remain ready for operation. After launch, the Samos Booster's sustainer and booster engines operate for approximately four minutes. The vernier rocket engines operate for an additional twenty seconds. During this time the Samos Booster guidance and control systems perform the guidance and control functions that are required. After the Samos Booster engines have operated for four minutes and twenty seconds, a ground separation command cuts off the vernier rocket engines and initiates the separation of the Samos Satellite from the Samos Booster. Earlier, ten seconds before cutoff of the vernier rocket engines, a ground command released the brake on the sequence timer and started the sequence of Samos Satellite guidance and control events.

4-157. During the ten seconds between the release of the sequence timer brake and the beginning of separation, the sequence timer performs two back-up operations that duplicate steps performed earlier to ensure that the steps have been done. The two back-up operations consist of disarming the destruct system and applying power to the guidance and control systems. Also at this time the sequence timer pressurizes the pneumatic control system. At separation, the gyros in the inertial reference package are uncaged and the pneumatic control system is activated as described in paragraph 4-159. The Samos Satellite is prepared for self guidance.

4-158. The following back-up signals are provided at separation. Approximately 4 minutes and 10 seconds after launch, a ground command is sent to the Samos Satellite to release the brake on the sequence timer, and ten seconds later a back-up signal to release the brake is generated when the pull-away plug opens during separation. The ground separation command uncages the gyros in the inertial reference package and fifteen seconds later a back-up signal to uncage them is provided by the sequence timer. In the event the

APPROXIMATE TIME OF EVENTS IN MINUTES AND SECONDS	EXACT TIME OF EVENT IN SECONDS	GUIDANCE AND CONTROL EVENT
FROM SEPARATION TO START OF SAMOS SATELLITE ROCKET ENGINE (Continued)		
+8 minutes and 20 seconds	498	a. Hydraulic control system is activated. b. Ullage rockets are fired.
FROM SAMOS SATELLITE ROCKET ENGINE START TO CUTOFF		
+8 minutes and 30 seconds	511	a. Satellite rocket engine is started by sequence timer. (The satellite rocket engine fires for 2 min.) b. Accelerometer is connected to integrator. c. Pneumatic control system is deactivated in pitch and yaw.
+10 minutes and 30 seconds	629.1	Satellite rocket engine is cut off by integrator.
FROM SAMOS SATELLITE ROCKET ENGINE CUTOFF THROUGH ORBIT REORIENTATION		
+10 minutes and 40 seconds	638	a. Pneumatic control system is reactivated. b. Hydraulic control system is deactivated. c. Horizon scanner is disconnected from inertial reference package. d. Samos Satellite is turned from horizontal attitude to vertical, nose-down attitude by sequencer timer. (This orbit reorientation requires 2 min, 20 sec.)
+13 minutes and 10 seconds	788	Orbit reorientation is completed and Samos Satellite is pitched at orbital rate by pneumatic control system to maintain vertical, nose-down attitude.

Figure 4-24. Sequence of Guidance and Control Events (Sheet 2 of 4)

APPROXIMATE TIME OF EVENT IN MINUTES AND SECONDS	EXACT TIME OF EVENT IN SECONDS	GUIDANCE AND CONTROL EVENT
ORBIT PHASE		
+13 minutes and 40 seconds	818	a. Pneumatic control system is deactivated. b. Gyros in inertial reference package are electrically caged. c. Samos Satellite is pitched at orbital rate by gravity gradient and orbital angular momentum to establish and maintain vertical, nose-down attitude as equilibrium position. d. Signal from computer is applied to pitch gyro to compensate for orbital pitching of Samos Satellite.
+13 minutes and 50 seconds	828	a. Orbital attitude damping system is activated to control disturbances about equilibrium position. b. Sequence timer turns itself off. c. Orbital attitude damping system continues to control disturbances about equilibrium position until ejection of ferret payload.
EJECTION OF FERRET PAYLOAD		
Ejection time zero (ETZ); chosen to be approximately one and one-half days after launch. (See par. 4-171.)	ETZ + 0	a. Sequence timer is re-started by sequence programmer. b. Pneumatic control system is reactivated. c. Orbital attitude damping system is deactivated. d. Cable wires to ferret payload are cut.

Figure 4-24. Sequence of Guidance and Control Events (Sheet 3 of 4)

APPROXIMATE TIME OF EVENT IN MINUTES AND SECONDS	EXACT TIME OF EVENT IN SECONDS	GUIDANCE AND CONTROL EVENT
EJECTION OF FERRET PAYLOAD (continued)		
Ejection time zero plus 40 seconds	ETZ + 40	Ferret payload is ejected.
Ejection time zero plus 50 seconds	ETZ + 50	Pneumatic control system is deactivated.
Ejection time zero plus 60 seconds	ETZ + 60	a. Orbital attitude damping system is reactivated. b. Sequence timer turns itself off. c. Orbital attitude damping system continues to control disturbances about equilibrium position until electrical power of Samos Satellite is exhausted.

Figure 4-24. Sequence of Guidance and Control Events (Sheet 4 of 4)

ground separation command does not successfully initiate separation, a back-up signal to initiate separation is provided by the sequence timer 25 seconds after its brake is released. Also, the pneumatic control system is activated at separation by a mechanical switch that is tripped as the Samos Satellite moves out of the Samos Satellite and Samos Booster adapter.

4-159. FROM SEPARATION TO START OF SATELLITE ROCKET ENGINE. From separation to the start of the satellite rocket engine, the Samos Satellite coasts through space for approximately four minutes. During this time its attitude is controlled in pitch, roll, and yaw by the gas reaction jets of the pneumatic control system. At separation, the nose of the satellite is at an angle of 25.6 degrees above the horizontal. Within fifteen seconds after separation, the gas reaction jets damp any satellite oscillations about this attitude in response to attitude error signals from the pitch, roll, and yaw gyros in the inertial reference package. The Samos Satellite will be maintained within 0.3 degree in pitch and yaw, and within 0.6 degree in roll about the stable attitude of 25.6 degrees above the horizontal.

4-160. Immediately after the Samos Satellite has been stabilized following separation, a pitch attitude program command of 40 degrees per minute from the sequence timer is applied to the inertial reference package. The satellite is then turned from its attitude 25.6 degrees above the horizontal to a horizontal attitude. When the satellite is horizontal the pitch attitude program command signal of 40 degrees per minute is replaced by a pitch attitude program command signal of 2.8 degrees per minute from the integrator in the computer. The gas reaction jets respond to this signal and pitch the orbiting satellite at the rate of 2.8 degrees per minute so that it remains horizontal. After the satellite rocket engine is started, the pitch attitude program command signal from the integrator is increased by the integrator from 2.8 to 3.82 degrees per minute as the velocity of the satellite increases.

4-161. The horizon scanner fairing and the nose cap are ejected while the Samos Satellite is being turned to a horizontal attitude. After the satellite has been stabilized in the horizontal attitude, the horizon scanner establishes the reference yaw axis within 0.6 degree and detects any constant error in horizontal attitude about the reference pitch and roll axis. The horizon scanner provides the pitch and roll attitude reference signals that are sent to the inertial reference package to adjust the pitch and roll gyros and correct for the constant error.

4-162. Approximately eight minutes and twenty seconds after launch, which includes four minutes and twenty seconds of Samos Booster boost and four minutes of coast, the sequence timer activates the hydraulic control system and fires the ullage rockets. The ullage rockets propel the Samos Satellite forward to ensure that the oxidizer and fuel are at the inlets to the satellite rocket engine. This is the first step in starting the satellite rocket engine. The hydraulic control system does not perform a control function until thirteen seconds later when the satellite rocket engine is started.

4-163. FROM SATELLITE ROCKET ENGINE START TO CUTOFF. From satellite rocket engine start to cutoff, the horizontal attitude of the Samos Satellite is controlled in pitch and yaw by the hydraulic control system and in roll by the gas reaction jets of the pneumatic control system. Eight and one-half minutes after launch, thirteen seconds after the ullage rockets are fired, the sequence timer starts the satellite rocket engine, and changes the pitch and yaw attitude control function from the gas reaction jets to the hydraulic control system. The pitch and yaw gyros in the inertial reference package continue to provide error signals for guidance in pitch and yaw. The hydraulic control system maintains the pitch and yaw attitude within 0.4 degree of the reference pitch and yaw axes, and the gas reaction jets maintain the roll attitude within 1.5 degrees of the reference roll axis. Throughout the time that the satellite rocket engine is firing, the pitch attitude program command signal from the integrator and the pitch and roll attitude reference signals from the horizon scanner continue to be applied to the inertial reference package.

4-164. When the satellite rocket engine is started the sequence timer connects the accelerometer in the inertial reference package to the integrator in the computer to measure the velocity gained by the Samos Satellite. When the velocity gained by the satellite matches the value preset in the integrator, the integrator provides a cutoff signal to the satellite rocket engine. The performance of the Samos Booster is so predictable that it is not necessary to provide a way to adjust the velocity setting in the integrator after launch. The satellite rocket engine operates for slightly less than two minutes when the integrator cutoff signal is received. Ten seconds after this nominal time a back-up cutoff signal is provided by the sequence timer.

4-165. FROM SATELLITE ROCKET ENGINE CUTOFF THROUGH ORBIT REORIENTATION. From satellite rocket engine cutoff through orbit reorientation, the attitude of the satellite is controlled about the pitch, roll, and yaw axes by the gas reaction jets of the pneumatic control system. Ten seconds after satellite rocket engine cutoff, the sequence timer changes the pitch and yaw attitude control function from the hydraulic control system to the gas reaction jets. At this time the pitch and roll attitude reference signals from the horizon scanner are removed from the inertial reference package.

4-166. Orbit reorientation is performed by removing from the inertial reference package the pitch attitude program command signal of 3.82 degrees per minute which was applied from the integrator and re-applying the pitch attitude program command signal of 40 degrees per minute from the sequence timer. The Samos Satellite is turned from its horizontal attitude to a vertical, nose-down attitude within two minutes and twenty seconds. Orbit reorientation is ended by removing from the inertial reference package the pitch attitude program command signal of 40 degrees per minute and re-applying the pitch attitude program command signal of 3.82 degrees per minute from the integrator.

4-167. For thirty seconds after orbit reorientation, the gas reaction jets respond to the pitch attitude program command signal and pitch the orbiting Samos Satellite at the rate of 3.82 degrees per minute so that its nose continues to point toward the center of the earth. After thirty seconds, the pneumatic control system is depressurized. The vertical, nose-down attitude of the satellite is established and maintained as the equilibrium position by the gravity gradient, the orbital angular momentum of the satellite, and the orbital attitude damping system.

4-168. During the orbit reorientation, which is completed approximately thirteen minutes and ten seconds after launch, the UHF omni-directional antenna boom is swung out and any remaining oxidizer or fuel is released by opening vents in the oxidizer and fuel tanks. Thirty seconds after orbit reorientation when the sequence timer de-pressurizes the pneumatic control system it also electrically cages the gyros in the inertial reference package to operate as rate gyros with the orbital attitude damping system. Forty seconds after orbit reorientation the sequence timer switches from ascent guidance and control equipment to the orbital attitude damping system, and then it turns itself off. The Samos Satellite is prepared to perform its orbit functions.

4-169. ORBIT PHASE. (See figure 4-25.) During the orbit phase the vertical, nose-down attitude of the Samos Satellite is established and maintained as the equilibrium position by the gravity gradient and the orbital angular momentum of the Samos Satellite. Disturbances about the equilibrium position are controlled by the orbital attitude damping system in response to guidance signals except for the brief period when the ferret payload is ejected. The pneumatic and hydraulic control systems are deactivated, and power is removed from the horizon scanner and the flight control electronics unit. The horizon sensor is activated to provide attitude telemetry data, but it does not perform any guidance function on the initial Samos flights.

4-170. The pitch and yaw gyros in the inertial reference package are operated as rate gyros to provide guidance signals for the orbital attitude damping system. A signal from the computer is applied to the torque generator of the pitch gyro to turn the gyro at the orbital pitch rate of the Samos Satellite. This compensates for the constant orbital pitching of the satellite so that the gyro does not detect the orbital pitching as a disturbance. The orbital attitude damping system is capable of damping the anticipated peak disturbances about the equilibrium position to less than two degrees within six hours. Such disturbances are held to a rate of 0.4 degree per minute. The orbital attitude damping system operates until the ferret payload is ejected. It does not operate during the ejection sequence but it is reactivated afterwards and continues to operate until the electrical power of the satellite is exhausted.

4-171. EJECTION OF FERRET PAYLOAD. (See figure 4-25.) Ejection of the ferret payload from the dual payload configuration is initiated by a stored program command from the satellite-borne communications equipment. The time for ejection is determined at the Satellite Test Center. If telemetry data verifies that the ferret and visual payloads are operating satisfactorily, the ferret payload will be scheduled for ejection after the Samos Satellite has completed 24 orbits following launch. This will allow the ferret payload approximately one and one-half days to successfully perform the functions. The chosen time is transmitted to the satellite and stored in the sequence programmer of the satellite-borne communications equipment. At the time chosen for ejection, the sequence programmer re-starts the sequence timer (which had turned itself off after orbit reorientation) and the ejection sequence is started.

4-172. When the sequence timer is turned on, power is re-applied to the flight control electronics unit, the pneumatic control system is again pressurized, and cable wires to the ferret payload are cut to prepare it for ejection. Forty seconds later, the sequence timer switches the signals being transmitted from the ferret payload antenna to the visual payload antenna, and the ferret payload is ejected. Ten seconds after ejection, the sequence timer de-pressurizes the pneumatic control system. Twenty seconds after ejection the sequence timer removes the power from the flight control electronics unit, reactivates the orbital attitude damping system, and then turns

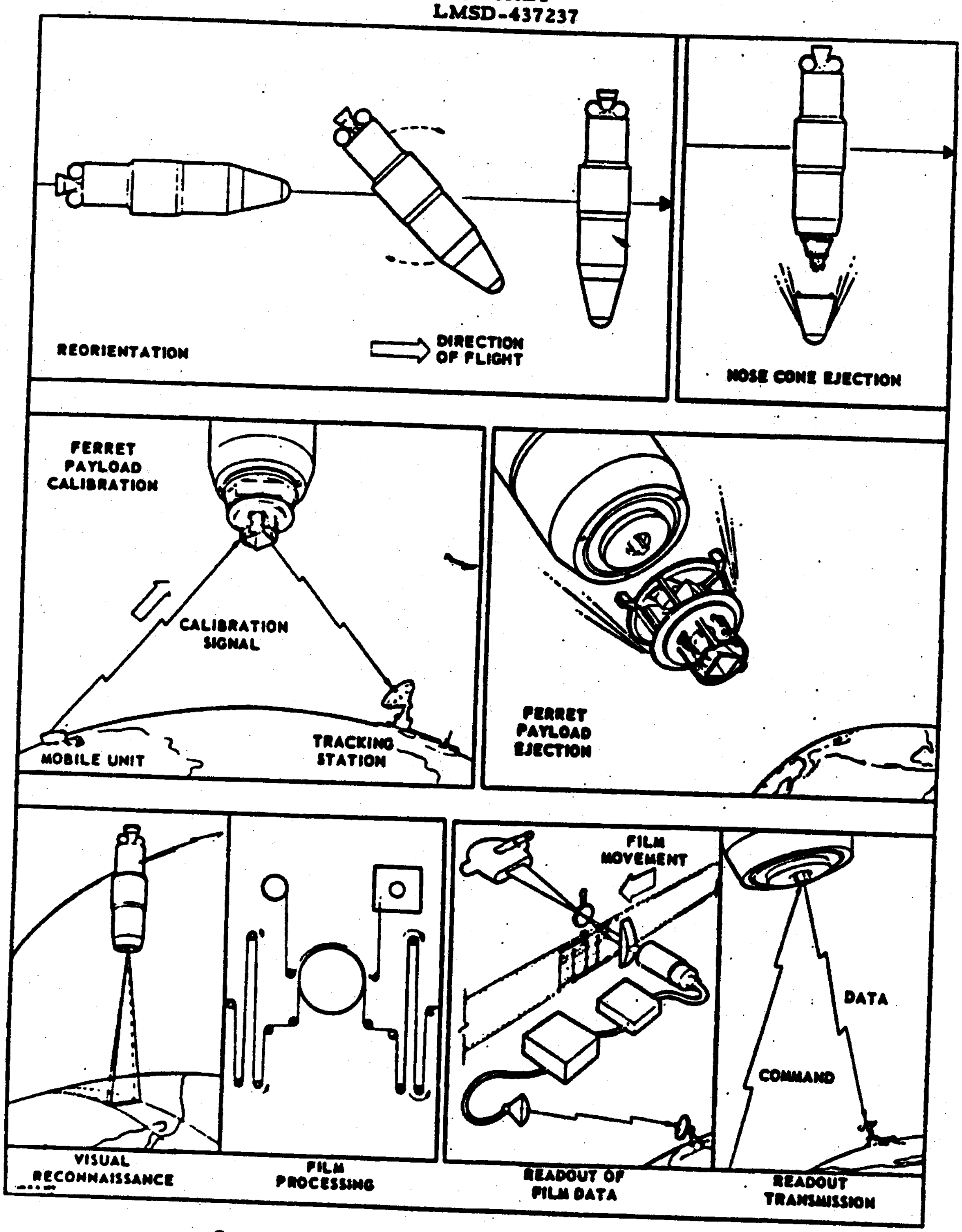


Figure 4-25. Samos Satellite Sequence of Events During Orbit

itself off. The orbital attitude damping system continues to control disturbances about the equilibrium position until the electrical power of the Samos Satellite is exhausted.

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4-302. The satellite-borne communications equipment special test equipment used for the subsystem checkout is tabulated below:

SPECIAL TEST EQUIPMENT	FUNCTION
Rolling Ground Station	Calibrates and checks VHF FM/FM unitized telemeter circuits. Measures input and output signals of subcarrier channels and VHF transmitters.
Rolling Power Console	Supplies all power required by VHF FM/FM unitized telemeter circuits during checkout.
Rolling Pressure Console	Applies variable pressures to pressure-sensing transducers of telemetry instrumentation to provide known inputs to subcarrier channels.
UHF Command Receiver, and Telemetry and Data Transmitters Checkout Console	Provides method of radio-frequency communication with satellite UHF equipment for ground checkout. Checks operation and performance of UHF command receiver, UHF narrow band transmitter, and UHF wide band transmitter. Measures frequency, power, bandwidth, and noise figure.
PAM/FM Data Link Checkout Console	Tests operation of PAM multiplexer and UHF telemetry FM circuits. Receives and demodulates radio-frequency telemetry signals, and records results.
PAM Demultiplexer Equipment	Used with PAM/FM data link checkout console to demultiplex telemetry signals received by console.
Sets of Antenna Couplers	Used to couple radio-frequency energy between radio-frequency checkout consoles and Samos satellite. Prevents scattered and spurious radiation throughout checkout area.
Command Decoder-Sequence Programmer and Clock Checkout Console	Tests operation of command decoder and sequence programmer, and checks frequency of satellite timing generator. Injects messages into command decoder with punched paper tape and monitors response of command decoder and sequence programmer logic circuits. Furnishes d-c and a-c power required by components.

(Continued)

SPECIAL TEST EQUIPMENT	FUNCTION
Beacon Transponder/ Decoder Checkout Console	Interrogates transponder, measures parameters of transponder responses, and checks operation of decoder. Monitors voltages and currents of transponder, decoder, and acquisition transmitter. Furnishes d-c and a-c power required by components.
Secondary/Interim Programmer Checkout Console	Ensures Fairchild interim programmer is prepared to receive transmitted commands. Checks all modes of programmer operation. Furnishes d-c and a-c power required by programmer.
Command Programmer Checkout Console	Checks stored program command function of sequence programmer and intermediate storage unit.
Intermediate Storage Unit Checkout Console	Simulates commands to position relays within intermediate storage unit and monitor response of the relays. Also commands relay closures in power control unit.
Tape Recorder Checkout Console	Provides simulated, commutated telemetry signals to each recorder and monitors output signals and performance of each recorder. Furnishes d-c and a-c power required by recorders.

4-303. Subsystem checkout of the satellite geophysical environmental instrumentation components is also accomplished at the guided missile assembly building. The sensing devices that constitute the instrumentation are assigned by the Geophysical Research Directorate, and checkout is performed in accordance with its specifications. Tests are performed for the following geophysical environmental instrumentation components: radiometer, densitometer, cosmic ray monitor, electric field meter, ion gage, micrometeorite detector-grid type, and the micrometeorite detector-acoustic type.

4-304. SYSTEM CHECKOUT AT GUIDED MISSILE ASSEMBLY BUILDING. System checkout at the guided missile assembly building is performed with special systems test equipment that enables all test operations to be completed semi-automatically in a single, integrated procedure. The major elements of the special systems test equipment are the system checkout complex 2A, the Lockheed automatic checkout equipment (LACE), and the vehicle function generator console. These major elements, the checkout consoles which compose them, and the specific functions they perform are listed in paragraph 4-306.

4-305. In general the special systems test equipment is used to control the subsystems and payloads of the satellite during a complete, simulated flight. The equipment monitors, measures, and records all signals and responses generated during the procedure. The power required during the procedure is provided by the system checkout complex 2A. Items of special subsystem test equipment may be used to isolate malfunctions detected during system checkout.. After system checkout is completed satisfactorily, the satellite and the payloads are transported to the launch pad complex.

4-306. The special system test equipment used for system checkout is tabulated below:

SPECIAL TEST EQUIPMENT	FUNCTION
SYSTEM CHECKOUT COMPLEX 2A	
Signal Distribution and Monitor Console	Provides test points for each umbilical signal and functions as a central distribution point of signals and control functions for system checkout equipment and satellite. Monitors and simulates actual squib firing and records measurements. Enables LACE to select various umbilical and test plug signals during system checkout.
Control and Indicator Console	Provides for control and metering of operating time of guidance and control equipment and satellite-borne communications equipment during system checkout by using two running time indicators which correspond to the two timers in the satellite. Measures power levels of various satellite power supplies. Remotely controls power distribution console. Controls and monitors tests of guidance and control equipment.
Command Decoder Sequence Programmer Console	Checks command decoder and sequence programmer by generating 47-bit command words at a rate of 1000 bits/second. Compares response to commands with specified standard. Gives "GO" or "NO GO" indication.
UHF Telemetry and Data Link Console	Provides circuitry for checkout of completely assembled satellite-borne communications equipment. Selects and tests various telemetry signals and routes video and payload signals to recorders.

(Continued)

SPECIAL TEST EQUIPMENT	FUNCTION
SYSTEM CHECKOUT COMPLEX 2A	
Pulse Amplitude Modulation Telemetry Console	Displays and records analog information content of 36 selected channels. Records reference and timing data.
Power Distribution Console	Controls and distributes 208/120-volts, three-phase, 60 cps a-c power to various consoles of system checkout complex 2A.
Command Beacon Console	Provides for transmitting, receiving, analyzing, and measuring input and output signals of beacon system.
VHF/FM/FM Telemetry Data Processing Console Assembly	Consists of four consoles: telemetry data link and monitor console, discriminator console, decommutator console, and video recording console. Measure, monitors, and records all signals of VHF telemetry system.
E-1 Visual Payload Interface Console	Receives wide band UHF signals from satellite transmitter. Detects modulation from carrier and applies to ground reconstruction system for checkout. Provides remote control of E-1 visual payload.
F-1 Ferret Electronics Payload Interface Console	Receives narrow band UHF signals from satellite transmitter. Detects modulation and records for later evaluation. Provides remote control of F-1 ferret electronics payload.
Recording Consoles	Monitor and record guidance and control signals during system checkout. Monitor and record d-c power supply voltages.
LOCKHEED AUTOMATIC CHECKOUT EQUIPMENT (LACE)	
Measurements Console	Provides automatic switching to each sequential checkout function. Maintains proper signal levels for converters. Measures voltages, resistances, frequencies, and time intervals. Digitizes voltages, frequencies, and time intervals. Operates ten-line code alphamerical printer and bank of nixie tubes to enable visual monitoring of voltages.

SPECIAL TEST EQUIPMENT FUNCTION

LOCKHEED AUTOMATIC CHECKOUT EQUIPMENT (LACE)
(Continued)

Control and Monitor Console	Provides visual indication of test quantities. Controls other checkout consoles in addition to components being tested. Provides time base. Programs test with punched cards. Detects correct sequencing and indexing of each punched card. Monitors operation of card reader and facilitates card search. Controls input power. Selects mode of operation. Provides means of self-check against internal standards.
Vehicle Function Generator Console	Checks cabling from checkout equipment to satellite, and simulates various satellite functions. Simulates satellite patch system, squib actuator, battery and destruct circuitry, hydraulic reservoir circuit, and guidance potentiometers and resolvers. Monitors and checks satellite telemetry position, compartment pressure and temperature circuitry, gas valve circuitry, pitch-yaw actuator circuitry, and other guidance and control and payload circuits and components.

4-307. CHECKOUT AT LAUNCH PAD COMPLEX. Checkout at the launch pad complex is performed with special control and monitoring equipment located in the launch operations building and in the launch pad and service building. The operation of each subsystem is controlled by consoles in the launch operations building, and the performance of each subsystem is monitored by measuring critical subsystem voltages. The special control and monitoring equipment used in the launch operations building is listed in paragraph 4-310. The required signal interconnection circuits between the launch operations building and the Samos Satellite, and the required external power distribution equipment are provided in the launch pad and service building. Since the Samos Satellite is located near the launch pad and service building immediately prior to launch, it is convenient to station certain items of special test equipment there. The signal interconnection, power distribution, and special test equipment used in the launch pad and service building is listed in paragraph 4-311.

4-308. The checkout operations performed at the launch pad complex includes those performed before the Samos Satellite is mated with the Samos Booster and those performed afterwards. Before mating, checkout signal and power connections are made between the satellite and the equipment in the launch operations building and in the launch pad and service building. Because of the inspection and access features of the satellite, detailed checkout and, if necessary, component replacement can be accomplished at this time. Special subsystem test equipment from the guided missile assembly building can be used to assist in isolating any malfunctions. After mating, many signal and power connections are still provided, but they are fewer in number than those used previously. These connections enable monitoring of all critical voltages and many additional ones until the launch pad and service building is evacuated.

4-309. Approximately two hours before launch, when the launch pad and service building is evacuated in preparation for launch, all test connections other than umbilical cable connections are removed from the satellite and the Samos Satellite access doors are installed. From this time until launch, all control and monitoring functions are performed in the launch operations building. The umbilical cable connections enable continued monitoring of all critical voltages until launch. The groundspace communication links are verified, under the control of the launch operations building, first by the equipment in the guided missile assembly building, and, finally, by the Vandenberg tracking station. Minutes before launch, a command from the launch operations building removes the external power from the Samos Satellite and applies the internal battery power. Except for the monitoring, which continues until launch, the Samos Satellite checkout is completed at this time.

4-310. The launch operations building special control and monitoring equipment is tabulated below:

CONTROL AND MONITORING EQUIPMENT	FUNCTION
Electrical and Guidance Console	Controls and monitors electrical power equipment in satellite, launch operations building, and launch pad and service building. Controls and monitors guidance and control components and functions.
Facilities and Propulsion Console	Controls facilities water deluge system, missile service tower, and umbilical mast. Controls and monitors propulsion subsystem fueling and propulsion components and functions.
Communications and Payload Console	Controls and monitors satellite-borne communications equipment and E-1 visual payload.
Launch Conductor, LMSD, Console	Provides Samos Satellite countdown status and launch status control. Provides destruct control and monitoring devices.
Operations Interconnection Box	Provides circuit distribution center at launch operations building.

(Continued)

CONTROL AND MONITORING EQUIPMENT	FUNCTION
Operations Power Supply Set	Supplies d-c and a-c power to equipment in launch operations building.
Signal Data Recording Set	Records data modulated signals of control and monitoring functions.
Countdown Clock System	Provides countdown time in real time.

4-311. The launch pad and service building signal interconnection, power distribution, and special test equipment are tabulated below:

EQUIPMENT	FUNCTION
Pad Interconnection Box	Provides circuit distribution center in launch pad and service building. Enables making connections between Samos Satellite and launch operations building for any satellite configuration.
Pad Power Supply and Signal Processing Set	Supplies d-c and a-c power to equipment in launch pad and service building, and to Samos Satellite.
Battery Power Supply	Provides backup for d-c power supplied by pad power supply and signal processing set.
Destruct Squib and Simulator Test Set	Checks squib elements of all pyrotechnic devices. Measures resistance of squib elements on "GO, NO GO" basis. Monitors destruct primer circuit.
R-f Data Link	Establishes r-f communications links between Samos Satellite at launch pad complex and guided missile assembly building and Vandenburg tracking station.

4-312. OPERATIONAL MAINTENANCE CONCEPT.

4-313. GENERAL. The operational maintenance concept for the Samos system specifies that no unreliable or substandard component or part shall be included in any Samos Satellite. All essential repair and modification functions shall be performed within the squadron maintenance area if the necessary service equipment and replacement parts are on hand. Generally, the repair functions shall not exceed the component or "black box" level.

4-314. SAMOS SATELLITE MAINTENANCE. Samos Satellite maintenance includes repair of a specific category of defects, and installation of required modifications. All repair work is performed within the guided missile assembly building which is located in the squadron maintenance area. The category of defects that may be repaired within the guided missile assembly building includes only those that may be done correctly and efficiently using the facilities available there. No repairs are to be accomplished within the guided missile assembly building if they require special replacement parts, installation tools, or assembly fixtures. Instead, "black box" replacement is performed and the defective or substandard component is returned to the manufacturer for repair. An adequate supply of spare components is to be maintained to provide this level of maintenance capability.

POWER AND SERVICE REQUIREMENTS

4-315. POWER REQUIREMENTS.

4-316. SATELLITE ELECTRICAL POWER REQUIREMENTS AT GUIDED MISSILE ASSEMBLY BUILDING. The satellite electrical power requirements at the guided missile assembly building are for the voltages that are necessary to operate the system and subsystem components during checkout. The electrical power required for checkout consists of a variety of d-c and a-c voltages: +28 and -28 volts, d.c.; 115 volts, 400 cps, single-phase; 115 volts, 400 cps, three-phase; and 115 volts, 2000 cps, single-phase. These voltages are provided by power supplies associated with the special test equipment used for the checkout procedures at the guided missile assembly building.

4-317. SATELLITE ELECTRICAL POWER REQUIREMENT AT LAUNCH PAD COMPLEX. The satellite electrical power requirement at the launch pad complex is exclusively for 28 volts, d.c. This voltage is required to substitute for the satellite internal battery power during the days before launch. It is used to operate the system and subsystem components while the final preparations are being completed and the performance of the components is being monitored. The required 28-volt, d-c power is provided at 100 amperes by power supplies in the pad power supply and signal processing set at the launch pad and service building.

4-318. SERVICE REQUIREMENTS.

4-319. ACCESS AND INSPECTION FEATURES FOR SAMOS SATELLITE SERVICING. The access and inspection features for Samos Satellite servicing consist of removable access panels and covers, and spring-loaded doors which cover fluid and electrical quick-disconnect fittings. Four removable access panels (figure 4-1) are located over the forward equipment rack to make all the components there available for assembly, checkout, and maintenance. Each of the four primary battery installation areas on the aft equipment rack is enclosed with an access cover. These areas are not accessible after the satellite is mated with the booster because they are inside the adapter. However, six access doors in the adapter allow adjustment of the adapter separation rollers after mating. The six roller adjust doors are shown in figure 4-37.

4-320. All ground servicing lines connect to the Samos Satellite through the quick disconnect fittings that are covered by spring-loaded doors. (See figure 4-37.) The electrical fitting is located directly over the electronic

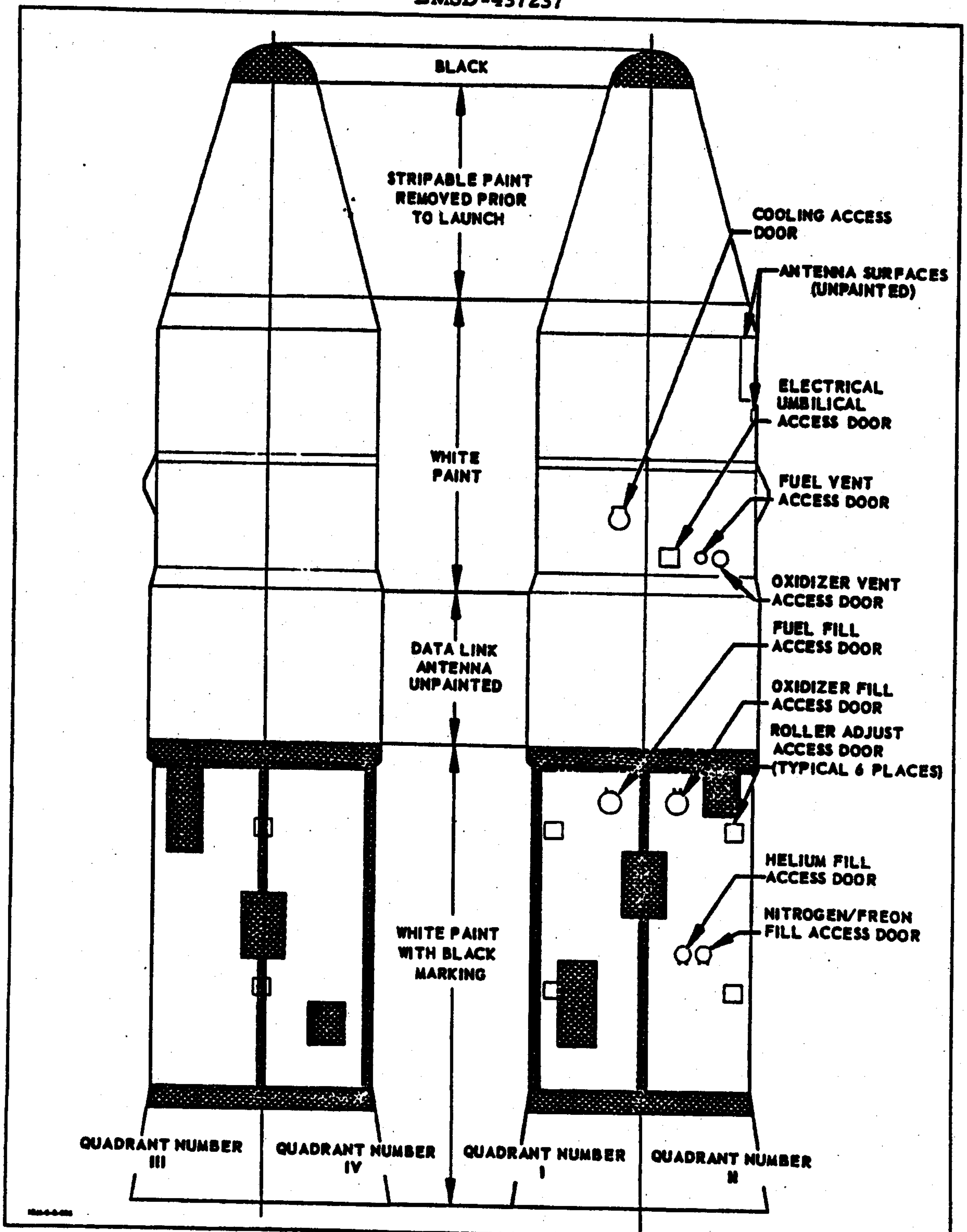


Figure 4-37. Samos Satellite Markings and Access Features

components in the forward equipment rack. The fluid fittings include four for propellant filling and venting, and one each for helium filling, nitrogen/freon filling, and air conditioning. The fittings are made of stainless steel and aluminum, and they are provided with internal sealing materials that are compatible with their individual applications. The couplings are disconnected at launch by a lanyard pull system. All fittings except the air conditioning duct, which is covered by the cooling access door, are self-sealing when disconnected.

4-321. SATELLITE SERVICE REQUIREMENTS. The satellite service requirements include loading the propellants into the satellite tanks, filling the helium and nitrogen/freon spheres, conditioning the air and maintaining the temperature within the satellite, and connecting the satellite pyrotechnic devices. Provisions are also required for removing satellite fluids in the event of an aborted flight.

4-322. The only satellite service requirement at the guided missile assembly building is for air conditioning during system checkout when the electronic components are being operated in place within the satellite spaceframe. During this time, conditioned air is provided by a type 14, mobile, air conditioning trailer. The conditioned air maintains the temperature within the spaceframe below 80°F.

4-323. All satellite service requirements mentioned in paragraph 4-321 are met at the launch pad complex by the special ground servicing equipment discussed below in paragraphs 4-324 through 4-327. This equipment is stationed at the launch pad and service building.

4-324. Loading the propellants into the satellite tanks is accomplished with the use of two propellant transfer sets. One is used for the UDMH fuel, and the other is used for the IRFNA oxidizer. Each one transfers its propellant from the propellant transport trailer into a propellant weighing tank and, upon command from the launch operations building, pumps the weighed amount of propellant into the satellite propellant tank. The approximate maximum weight is 1850 pounds of fuel and 4800 pounds of oxidizer. In addition to weighing the propellant, each transfer set has provisions for maintaining the propellant temperature at 45°F. The transfer sets are also used for removing the propellants from the satellite in the event of an aborted flight, and for flushing the loading lines after propellant loading is completed.

4-325. Filling the helium and nitrogen/freon spheres of the satellite is accomplished with the use of gas pressurization equipment located at the launch pad and service building. The equipment is capable of delivering helium and nitrogen/freon to the satellite spheres at pressures up to 3500 psi. The helium and nitrogen/freon fittings that are used for filling are specially designed to prevent high shock loading when the couplings are disconnected at these high pressures.

4-326. Air conditioning at the launch pad complex is accomplished with the use of a type 60M air-conditioning system located at the launch pad and service building. This system provides conditioned air for the Samos Satellite, the Atlas booster, and the Convair and Lockheed checkout equipment racks. The conditioned air for the Samos Satellite is routed into the satellite via the cooling access door, and it flows from the forward equipment rack, around the outer surface of the propellant tanks, to the aft equipment structure. The conditioned air performs a drying function when the electronic components are not operating, and when they are turned on, the air performs a cooling function also. The temperature within the satellite is maintained between 30°F and 65°F. The temperature of the payload compartment is especially critical, and it is maintained between 45°F and 85°F with the use of a temperature control blanket. The temperature control blanket, which consists of a network of passageways for conditioned air, is fitted over the nose cone of the assembled satellite. Conditioned air from the type 60M air conditioning system is forced through the passageways of the blanket to control the temperature within the payload compartment.

4-327. Connecting the satellite pyrotechnic devices is accomplished after the squib circuits have been checked for electrical continuity and when the absence of transient and spurious voltages is ensured. Pyrotechnic servicing consists of connecting the Samos Satellite rocket engine arming plug, the ullage rockets plug, and installing and connecting the destruct unit. The destruct unit arming plug and safety wire are connected and the fairing is installed over the destruct unit to complete the pyrotechnic servicing procedure.

GROUND SUPPORT EQUIPMENT

4-328. GENERAL. Ground support equipment for the operational Samos system is stationed at the guided missile assembly building and the launch pad complex and includes all ground equipment involved in checking out, servicing or handling the Samos Satellite. The ground checkout equipment is discussed under Operational Checkout and Maintenance Concept, paragraphs 4-291 through 4-311. The ground servicing equipment is discussed under Power and Service Requirements, paragraphs 4-321 through 4-327. The ground handling equipment is discussed below, paragraphs 4-329 and 4-330.

4-329. GROUND HANDLING EQUIPMENT. The ground handling equipment is used to transport, hoist, and position the Samos Satellite. It is used to facilitate the checkout and preparation operations that are performed on the Samos Satellite at the guided missile assembly building and the launch pad complex. Certain items of ground handling equipment are necessary in order to check out the satellite thoroughly. All items of ground handling equipment and the specific functions they perform are listed in paragraph 4-330.

4-330. The ground handling equipment used at the guided missile assembly building and the launch pad complex for the Samos Satellite is tabulated below:

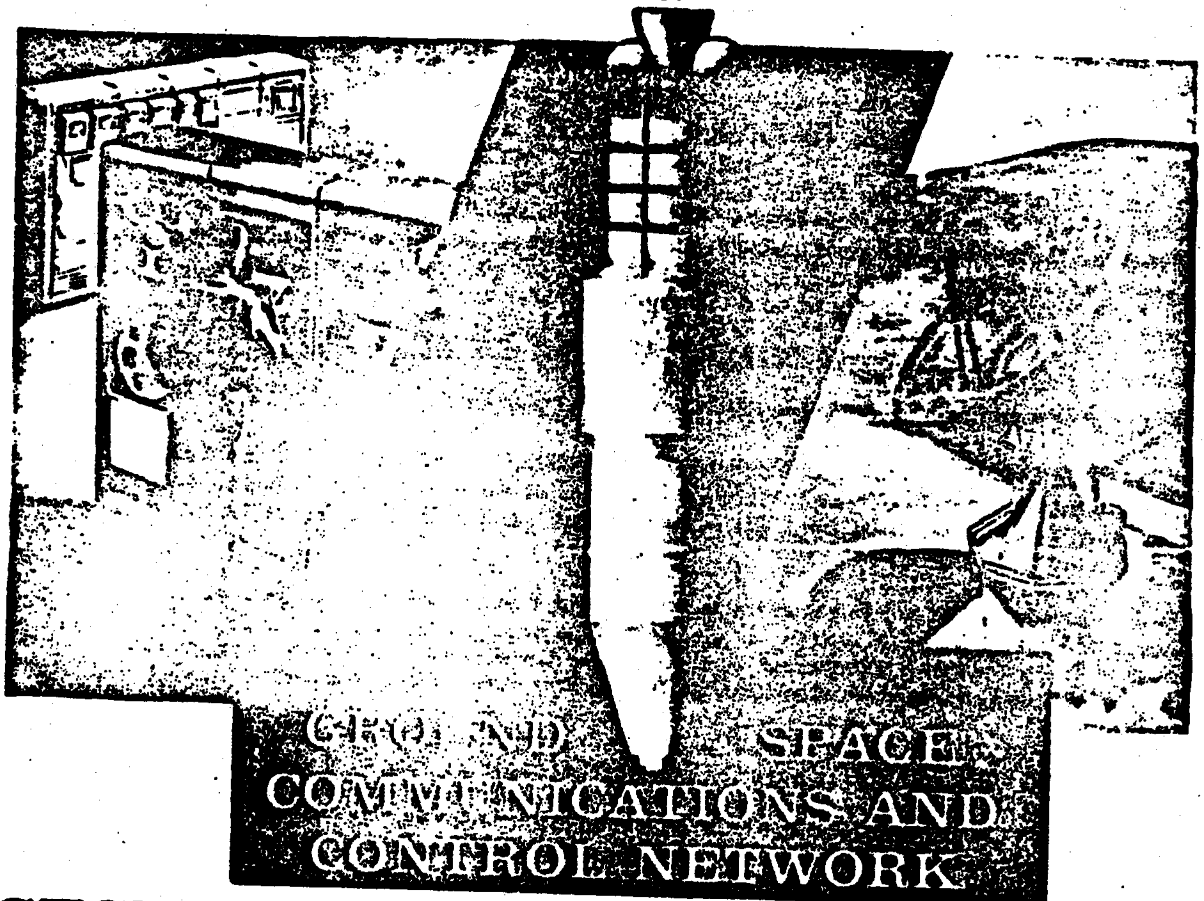
GROUND HANDLING EQUIPMENT	FUNCTION
Vehicle Transporter	Used to carry satellite over primary and secondary roads.
Vehicle Protective Cover	Waterproofed cover to enclose satellite and handling yoke during transportation and storage.
Vehicle Handling Dolly	Positions satellite for horizontal hoisting. Used to carry satellite within buildings for checkout and mating with adapter.

(Continued)

GROUND HANDLING EQUIPMENT	FUNCTION
Vehicle Handling Yoke	Fits around satellite for support during transportation and hoisting. Used with vehicle transporter, handling dolly, and hoisting equipment.
Yoke Removal Slings (Horizontal and Vertical)	Used to remove vehicle handling yokes while satellite is either horizontal or vertical.
Vehicle Hoisting Slings (Horizontal and Vertical)	Attach to vehicle handling yoke to hoist satellite in either horizontal position or tilted, vertical position.
Adapter Handling Dolly	Used to carry adapter within buildings. Holds adapter in horizontal position.
Adapter Protective Cover	Waterproofed cover to enclose adapter while mounted on adapter handling dolly for transportation or storage.
Tank Handling Dolly	Used to carry empty fuel tanks within buildings before mounting in satellite.
Tank Sling	Hoists empty fuel tanks during removal from or installation into satellite.
Engine Handling Dolly	Used to carry satellite rocket engine in horizontal position for movement within buildings. Used to install or remove engine from satellite.
USAF Type B-1 Propellant Transport Trailer	Transports UDMH fuel from storage area to launch pad and service building. Has capacity of approximately 220 cubic feet, or 11,000 pounds of UDMH fuel.
USAF Type B-2 Propellant Transport Trailer	Transports IRFNA oxidizer from storage area to launch pad and service building. Has capacity of approximately 350 cubic feet, or 35,000 pounds of IRFNA oxidizer.
Payload Shipping Containers	Enclose and protect payloads during transportation.

(Continued)

GROUND HANDLING EQUIPMENT	FUNCTION
Payload Hoisting Slings	Lift payloads from shipping containers. Mount payloads in satellite in either horizontal or vertical position.
Payload Dollies	Used to carry payloads within buildings, or to support them for storage.
Nose Cone Handling Dolly	Used to carry nose cone portion of satellite spaceframe for movement within buildings.
Vertical Work Stand	Used in launch area for handling, assembling, and disassembling satellite. Supports satellite in vertical position. Enables measurements of center of gravity.
Vehicle Tilt and Roll Stand	Supports satellite during system checkout of guidance and control subsystem. Enables arbitrary motions of the satellite to be made.



SECTION V

INTRODUCTION AND SECTION ARRANGEMENT

5-1. Section V presents a brief description of the Ground-Space Communications and Control Network, Subsystem H, of the Samos Flight Test Program. The information in this section is general and presents Subsystem H in terms of its eight subsystems: Angle Tracking, Range Measurement, Timing, Command, Digital Data Handling, Ground Communication, Data Receiving, Alignment and Calibration. A more comprehensive discussion of Subsystem H can be found in document LMSD-446936.

GROUND-SPACE COMMUNICATIONS AND CONTROL SYSTEM

5-2. GROUND-SPACE COMMUNICATIONS CONCEPT.

5-3. The overall mission of Subsystem H during the test phase of the Samos Program is two-fold: to control the operation of reconnaissance equipment carried by Samos Satellites, and to obtain and record data gathered by this equipment.

5-4. Satellite-borne Subsystem H equipment receives from the ground the commands that control operations of satellite equipment, directs these commands to the proper equipment at the proper time, and transmits reconnaissance and operational/environmental telemetry data to the ground.

5-5. Ground-based Subsystem H equipment acquires and tracks the satellite, up-dates predicted orbital parameters on the basis of tracking data, and generates and transmits up-dated data, in the form of commands, to the satellite. The ground equipment also receives, records, and distributes reconnaissance and telemetered operational/environmental data, and provides interstation and intrastation communication facilities.

5-6. ANGLE TRACKING SUBSYSTEM.

5-7. The Angle Tracking Subsystem acquires and automatically tracks the satellite, and generates precision antenna position data. The position data are used by a computer, a part of the Digital Data Handling Subsystem, to correct the predicted satellite orbit. The data are also used by the Antenna Slave Data Equipment to slave the Data Receiving and the Command Transmitter Antennas to the Angle Tracking Antenna. The Angle Tracking Subsystem includes an Angle Tracking Antenna, an Angle Tracking Receiver, Angle Tracking Antenna Servos, and an Angle Tracking Console.

5-8. In the automatic tracking mode of operation, the Angle Tracking Antenna servos position the antenna by means of satellite-transmitted error signals, which the Angle Tracking Receiver derives from the narrow-band data signal. The antenna can also be slaved to the tracking station computer to follow the predicted path of the satellite, or the antenna can be positioned manually, or be made to search in a preset pattern about the predicted point-of-arrival of the satellite. Angle Tracking Antenna position data are supplied to the Digital Data Handling Subsystem by means of a mechanical connection.

5-9. RANGE MEASUREMENT SUBSYSTEM.

5-10. The Range Measurement Subsystem measures the slant range from the tracking station to the satellite. The subsystem continuously generates four ranging tones that are transmitted to the satellite by the Command Transmitter and transmitted back to the tracking station as part of the narrow-band baseband signal. The received tones are continuously compared with the tones being generated. Because of the time required for the round trip, there is an apparent phase difference between the received tones and the reference tones. The phase difference is measured at regular intervals and converted to slant range. The measured range is supplied to the station computer, which uses slant range as part of the data necessary to correct predicted orbital parameters. Range measurement is also displayed, in nautical miles, on the Master Control Console.

5-11. TIMING SUBSYSTEM.

5-12. The Timing Subsystem generates time signals for indexing data and for display at operating positions. The subsystem also synchronizes signals that are used to synchronize Subsystem H operations to a common reference. The operation of the Timing Subsystem is in turn synchronized with the timing signals broadcast by the National Bureau of Standards radio station, WWV.

5-13. COMMAND SUBSYSTEM.

5-14. The Command Subsystem transmits to the satellite the commands that control satellite equipment operation. A synchronized signal and four ranging tones are also included in the command signal baseband. Two types of commands are sent to the satellite: real-time and stored program commands. Real-time commands are intended for immediate execution. Real-time commands are generated by the tracking station computer and by the sequence programmer in the satellite.

5-15. Stored program commands, time indexed for execution while the satellite is over the reconnaissance area, are generated by the tracking station. These commands are stored in the station computer, or other command buffer storage, and supplied to the Command Subsystem for transmission to the satellite during a pass.

5-16. Command verification signals, denoting receipt of the narrow-band data signal, are routed to the Command Subsystem by the Data Receiving Subsystem. The Command subsystem includes the Command Encoder, the Command Multiplexer, the Command Transmitter, the Command Transmitted Antenna and its servos, and two bays of the Master Control Console.

5-17. The Command Encoder sequences the flow of commands through the Command Multiplexer (which adds the synchronizing signal and ranging tones) to the Command Transmitter. The Command Transmitter Antenna can be positioned manually, but it is normally slaved to either the station computer or the Angle Tracking Antenna.

5-18. DIGITAL DATA HANDLING SUBSYSTEM.

5-19. The Digital Data Handling Subsystem performs arithmetic operations upon data in the digital form, converts digital data to analog data and vice versa, programs and controls the flow of digital data through Subsystem H equipment at the tracking station, and provides intrastation digital data transmission facilities. The Digital Handling Subsystem includes the station computer (a large capacity, high speed digital machine) and its input-output equipment, the time comparator equipment, the central timing and data distributor equipment, three remote timing and data distributors, and three antenna slave data loops.

5-20. The computer converts the predicted satellite orbit parameters to antenna positioning data and to visual display signals relative to local station coordinates and estimated time of acquisition, time indexes the stored program commands with reference to the vehicle time cycle, generates certain real-time commands, and converts the corrected vehicle path to a corrected vehicle orbit.

5-21. The time comparator equipment compares the vehicle time code word with the ground time code word and supplies the computer with corrected time information needed to time index the stored program commands.

5-22. The central timing and data distributor equipment controls the flow of signals and of antenna slave data, to and from the remote timing and data distributors, one of which is located at each antenna site.

5-23. Each of the remote timing and data distributors separates and routes, to the using equipment, signals received from the central timing and data distributor equipment. The remote timing and data distributor equipment associated with the Angle Tracking Antenna also supplies the master timing and data distributor equipment with antenna position data.

5-24. Each of the antenna slave data loops compares the position of its associated antenna with the slaving signals and generates error signals that are used by the antenna servos to position the antenna.

5-25. GROUND COMMUNICATION SUBSYSTEM.

5-26. The Ground Communication Subsystem provides facilities for interstation and intrastation ground communications. Interstation facilities include leased toll telephone lines and leased teletype lines between the Satellite Test Center and other stations for administrative and operational control. This network will eventually include special wideband facilities for the transmission of reconnaissance data from certain tracking stations to the Satellite Test Center. The intrastation facilities include an administrative telephone net, various maintenance and operational telephone nets, and a voice paging system.

5-27. DATA RECEIVING SUBSYSTEM.

5-28. The Data Receiving Subsystem receives signals transmitted from the vehicle to the ground. The subsystem includes the Telemetry and Data Receiving Antenna and its servos, the wideband data receiving channel, the narrow-band data receiving channel, and the receiver and antenna control panels.

5-29. If the vehicle being tracked is equipped for visual reconnaissance, wideband and narrow-band data signals are transmitted simultaneously by the Subsystem H equipment in the vehicle and are picked up by the Telemetry and Data Receiving Antenna.

5-30. Filters in the receiver input circuits route each signal to the appropriate receiving channel. The wide-band channel output (visual reconnaissance data) is sent directly to the visual reconnaissance user equipment.

5-31. Since the narrow-band data signal is a composite of several signals, the narrow-band data channel includes equipment for separating the composite signal into its various components and routing them to the proper destinations. If the vehicle being tracked is equipped for electromagnetic reconnaissance only, the reconnaissance data is included in the narrow-band data signal, and the vehicle equipment does not transmit a wideband data signal.

5-32. Although the Telemetry and Data Receiving Antenna can be positioned manually, it is slaved during a pass to the Angle Tracking Antenna, if the latter is tracking. Otherwise, it is positioned in accordance with computer-predicted data by the antenna slave data network.

5-33. ALIGNMENT AND CALIBRATION SUBSYSTEM.

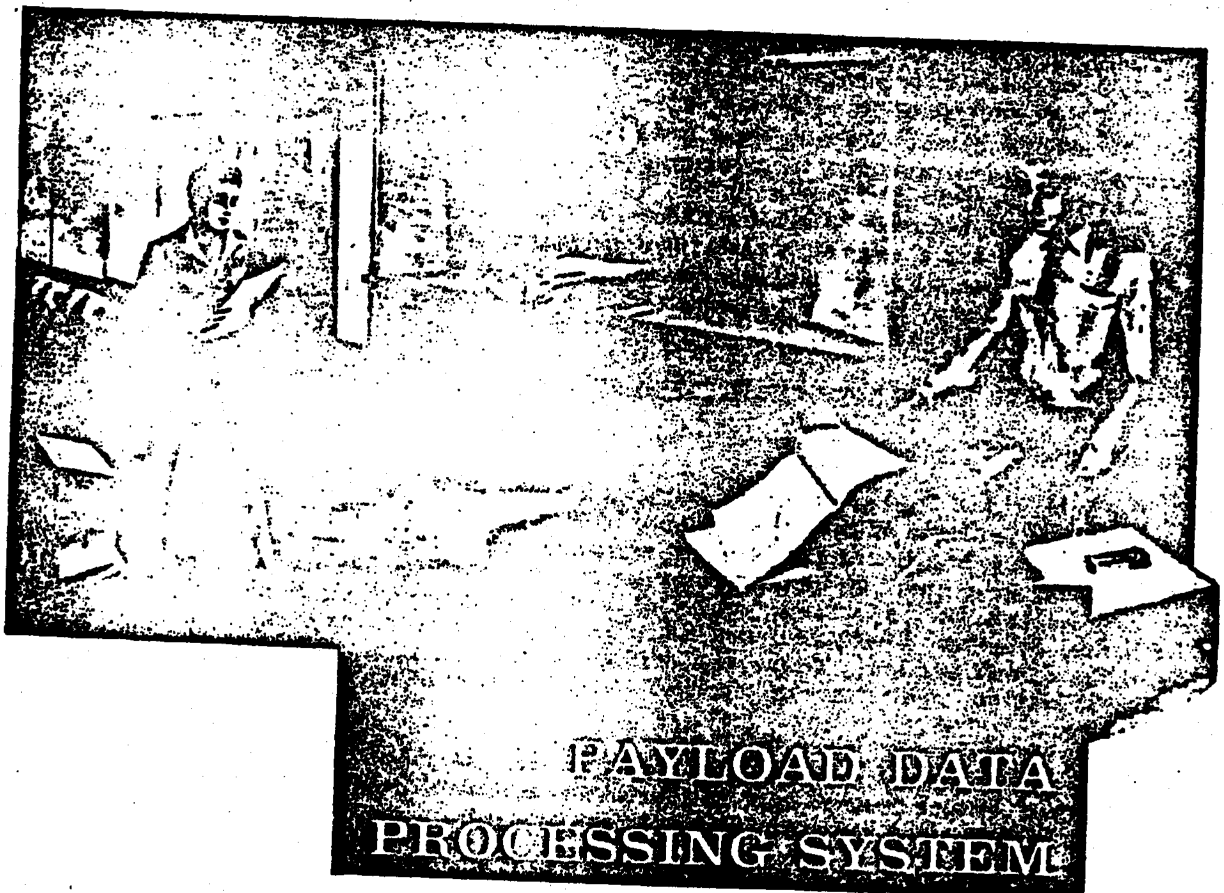
5-34. The Alignment and Calibration Subsystem provides a means of checking and adjusting the accuracy of Subsystem H antennas and range measurement equipment. It includes the following: photogrammetric triangulation equipment, boresighting equipment, and Up-Converter.

5-35. The photogrammetric triangulation system provides a means of checking the dynamic tracking accuracy of the Angle Tracking Subsystem and the accuracy of widely separated cameras. The cameras take simultaneous night photographs of a flashing lamp mounted on an airplane, and the airplane is tracked by the tracking station being calibrated. Since the photographs have a background of stars, and the star positions are precisely known, the photographs can be used as the basis for an equally precise computation of target position. The target position thus calculated is compared with the target position as determined by the tracking station equipment. In this manner, tracking station equipment operating errors can be ascertained.

5-36. The boresighting equipment provides a means of measuring and adjusting each Subsystem H antenna so that its position-data take-off devices read out the true pointing direction of the antenna beam pattern. A boresight tower located in the vicinity of each antenna supports an optical target and a small antenna that radiates the output powered transmitter. Basically, the boresighting procedure consists of pointing the antenna being boresighted toward the associated tower, and adjusting the antenna feed system to achieve the desired accuracy.

5-37. The Up-Converter provides a means of operating the Range Measurement Subsystem in a closed-loop configuration in order to compensate for phase shifts introduced by components in the ground path of the ranging tones. The Up-Converter is a combination receiver and low-power transmitter. The receiver, which is tuned to the frequency of the Command Transmitter, receives its input from a small antenna on the base of the Data Receiving Antenna.

5-38. The Up-Converter Transmitter, which is modulated by the output of the receiver, is tuned to the frequency of the Narrow-Band Data Receiver and supplies its output to a small antenna located on the Data Receiving Antenna Boresight Tower. By pointing the Command Transmitter Antenna toward the Data Receiving Antenna and pointing the latter toward its boresight tower, the Range Measurement loop is closed (the Up-Converter in effect replaces the equipment in the vehicle) and it is possible to make the necessary compensatory adjustment.



SECTION VI

INTRODUCTION AND SECTION ARRANGEMENT

6-1. Section VI presents a brief description of the Payload Data Processing System. This description is necessarily incomplete at this time because of the developmental nature of the system and equipment. Additional information and a more comprehensive discussion of this system will be furnished in the forthcoming revisions of this manual. The description presently contained in this issue includes both a breakdown of the system into its major operating groups, and a summary of the system inputs and outputs. In the interim period preceeding the inclusion of the additional data, in an early revision,reference may be made to LMSD-821036 for a more comprehensive discussion of the Payload Data Processing System.

PAYLOAD DATA PROCESSING SYSTEM

6-2. GENERAL.

6-3. Purpose of the Payload Data Processing System is to provide processing and initial analysis of satellite-derived data, and also to convert these data to a format which is compatible with standard Air Force usage. An important additional function of the system is to aid in proper evaluation and control of the satellite collection system by furnishing feedback information to the Samos System. Feedback consists principally of reports to other parts of the Samos System. These reports relate mission accomplishment, satellite collection, orbital correction data, and ferret calibration and control data.

6-4. The Payload Data Processing System interacts principally with the Visual Reconnaissance System and the Ferret Reconnaissance System by processing the data received from both of these systems.

6-5. The Payload Data Processing System functions are accomplished by three major operating groups: the Operations Group, Support Group, and Management Group. These groups and the Payload Data Processing system outputs and inputs are described in the following paragraphs.

6-6. OPERATIONS GROUP.

6-7. The Operations Group consists of sections responsible for preparing output information. Sections within the group are the Photo Reduction Section and the Electronic Intelligence Data Reduction Section. The Photo Data Reduction Section converts and processes photographic and printed material. Its products are reports and various photographic materials. The Electronic Intelligence Data Reduction Section performs initial interpretation of simulated Samos-derived Electronic Intelligence Data.

6-8. SUPPORT GROUP.

6-9. The Support Group has three sections which perform processing, display and storage functions. These sections are identified as the Data Processing Central Section, Display Section, and the Reference Section.

6-10. The Data Processing Section processes and stores large volumes of data that have many different characteristics. Processing and storage is accomplished by an automatic data processing data storage and computing facility. The Display Section supports both the Operations Group and the Management Group by providing large-screen, rapidly updated displays of dynamic information. The Central Reference Section supports all groups by storing and retrieving large volumes of information and reference materials. The section is partly automated and includes flexible organizational procedures and equipment for indexing, storage, and retrieval.

6-11. MANAGEMENT GROUP.

6-12. The Management Group contains only one section, the Control Section. This section plans and directs the activities of the Data Processing System. It plans subsystem operations, supervises technical personnel, inspects output products before their release, and reviews the general subsystem performance.

6-13. SYSTEM INPUTS.

6-14. System inputs consist of reconnaissance data, simulated auxiliary satellite data, and reference data.

6-15. The reconnaissance data includes the 35mm, positive film strip, primary records recorded by visual equipment, and the digital magnetic tape records of electronic activity recorded by the ferret equipment. Simulated auxiliary satellite data consists of digital magnetic tape records for each satellite type. These include vehicle navigational data and calibration data for the cameras and the ferret equipment. For a given mission, these data will enter the system test and evaluation program sufficiently in advance of the visual and electronic intercept data in order to make the preselection of reference materials and system programming possible.

6-16. Input reference data for photo data reduction include the best map coverage available, geodetic control data, selected photography, and photo interpretation keys. For electronic intelligence data reduction, reference data consist of external reports and documents that are useful to an Electronic Intelligence Analyst. Reference data for photo data reduction and electronic intelligence data reduction will, in many cases, be useful in correlating these two functions.

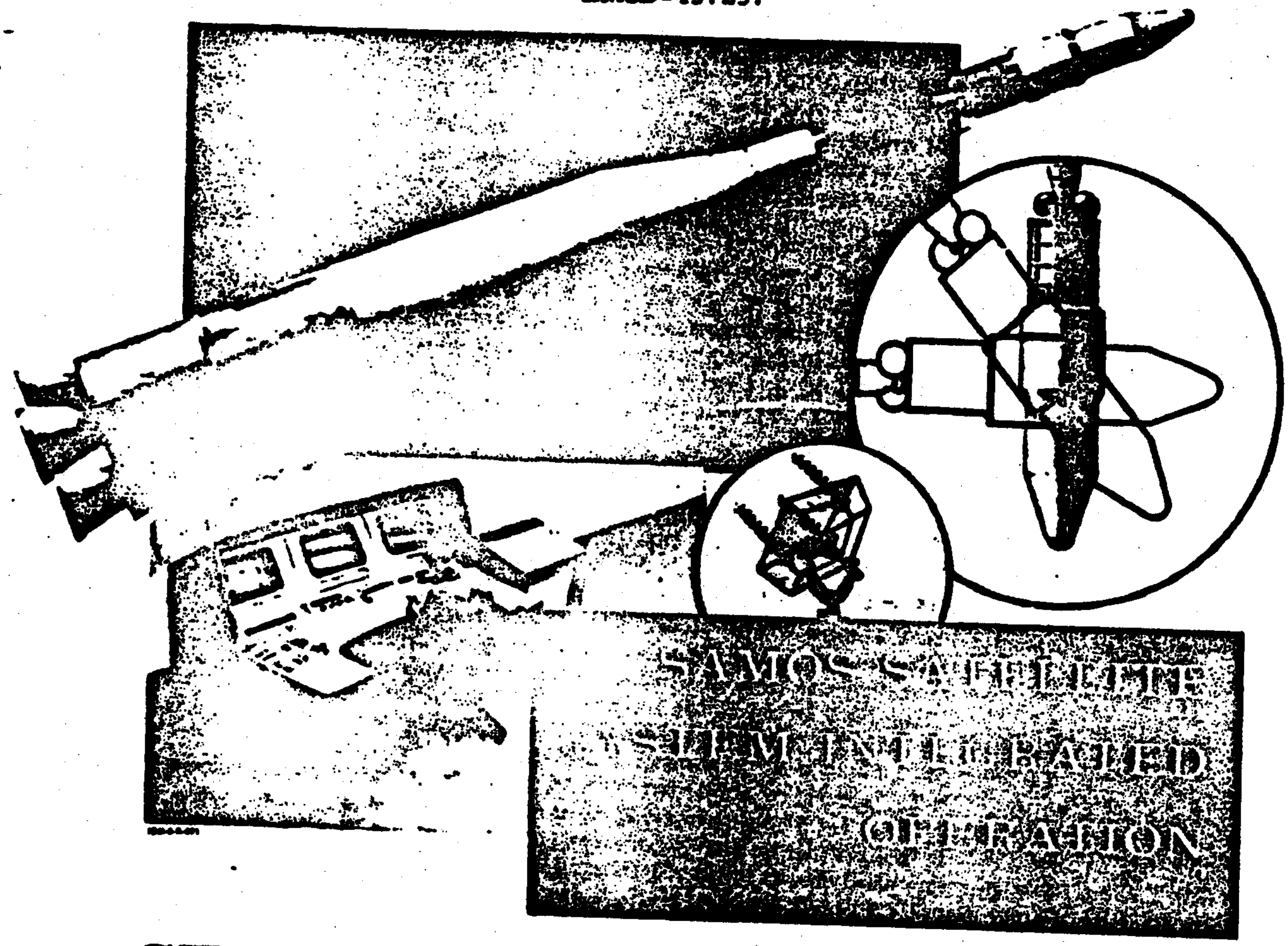
6-17. SYSTEM OUTPUTS.

6-18. System outputs include data processing products, duplicate reproductions of satellite reconnaissance data, and feedback information (refer to paragraph 6-3).

6-19. Data processing products include photographs, initial photo interpretation reports, target position analysis reports, and electronic intelligence initial analysis reports.

6-20. The photographic products include copies of the Data Processing Section records, reproductions of reassembled primary records, selected frames from these rolls, and annotated photography. The photographic products are appropriately titled and produced in proper formats.

6-21. The photo interpretation reports produced include the first-phase intelligence reports in formats that can be readily utilized by using agencies. Indexed overlays and machine-readable tapes containing information derived from photo data reduction are also produced. Electronic intelligence analysis reports include flash reports, immediate reports, and detailed interpretation reports, similary conforming with the anticipated operation requirements of the using intelligence agencies.



SECTION VII

INTRODUCTION AND SECTION ARRANGEMENT

7-1. The information in this section is a summation of the various phases of the Samos Satellite System that have been described in more detail in Sections I through VI, and is intended to provide an integrated description of overall system concept and sequence of operation. The major phases of the system are presented in descriptive sequence, beginning with system coordination by the Air Force Ballistic Missile Division (AFBMD) and concluding with the evaluating and utilizing of reconnaissance data obtained during a Samos flight. The phases of operation include: initial programming for the Samos System and the Samos Satellite, Samos Booster and Samos Satellite checkout and preparation at the Guided Missile Assembly Building, system prelaunch operations, countdown, launch and ascent phases of the Samos Satellite, orbit and reconnaissance phases of the satellite, command and readout of satellite data, plus evaluation and use of the data. The principal agencies for coordinating and instrumenting system activities are also presented.

SAMOS SYSTEM COORDINATION AND CONTROL

7-2. AIR FORCE BALLISTIC MISSILE DIVISION.

7-3. The responsibility for overall coordination of the Samos Satellite System is delegated to Headquarters of the Air Force Ballistic Missile Division (AFBMD) at Inglewood, California. The program goal is to produce and obtain reconnaissance data by means of photographic and electronic detection equipment installed in an orbiting satellite. In order to execute program planning, the Air Force has delegated authority to two groups. These are the System Test Working Group)STWG) and the Flight Test Working Group (FTWG). (Additional information regarding these two groups is presented in paragraph 7-18 under initial programming.) Also, supporting facilities have been established to help implement efficient coordination and function of system operations. The principal coordinating and control facilities are the Satellite Test Center in Sunnyvale, California and Vandenberg Air Force Base near Lompoc, California.

7-4. CONTROL OF SAMOS SYSTEM OPERATIONS.

7-5. GENERAL. Control of system operations is discussed in terms of central control exercised by the Satellite Test Center, the launch base personnel and organization, particularly prior to launch, and the coordination of operation and control between these two facilities. Refer to Sections I and II for additional information regarding bases, centers, and stations and their related personnel.

7-6. CENTRAL CONTROL BY SATELLITE TEST CENTER. The Satellite Test Center (STC) serves as the central facility for command and control of all operational phases of a Samos flight. Specific command and control prerogatives are further delegated to the launch base and tracking stations under the control of the Test Center. Direction and control of flights are effected jointly by a Lockheed System Test Director and an Air Force System Test Controller at the Test Center. The Test Director has overall responsibility for implementing the flight test program and for directing all elements of the system in the prelaunch, launch, and orbit phases of operation. He keeps the Test Controller informed of overall system status, and, as the countdown approaches the terminal point, advises him that the orbital portion of the test complex is ready to support operation. The Director informs the Controller of conditions which could deter launch. The Controller ascertains Lockheed compliance with applicable directive documents. He acts upon requests for aircraft to perform aerial pickup of data from the telemetry ship. All official information on flight operations released by Lockheed is presented to the Controller for transmittal to AFBMD Headquarters.

7-7. LAUNCH BASE OPERATION AND CONTROL. Launch base operation and control, in preparation for a Samos flight, is conducted by Air Force, Lockheed, and associated contractor personnel who cooperate under control of the Satellite Test Center. Key personnel include a Launch Operations Coordinator and an Operations Director located in the Launch Operations Control Center, plus a Launch Controller, two Launch Conductors (one each for the satellite and the booster), and a Pad Safety Officer, all located in the Launch Operations Building. A Tracking Station Commander (AFBMD) and a Tracking Station Manager (LMSD) are located at the Vandenberg Tracking Station. Provision is made to locate the Range Safety Officer in this building.

7-8. The Launch Operations Coordinator (AFBMD) is responsible for controlling prelaunch and launch operations. He receives recommendations from the key representatives in the Launch Operations Building and the Vandenberg Tracking Station upon which he makes decisions; these are relayed, when applicable, to the System Test Controller at the Satellite Test Center. The Coordinator and the Launch Director (LMSD) serve bilaterally in directing prelaunch and launch operations.

7-9. The Launch Controller has overall supervision of the launch phases at the Launch Operations Building. He is the direct contact between all members of the AFBMD/contractor launching team, launch base, and Satellite Test Center. During a launch operation, he receives recommendations from the Launch Conductor/Booster regarding the Samos Booster and from the Launch Conductor/Agena regarding the Samos Satellite. He weighs these recommendations against the status of the local range and makes decisions accordingly. For coordination of the launch phase with other phases of Samos operations, he is subject to direction by higher Air Force authority.

7-10. The Launch Conductor for the Samos Satellite is located adjacent to the Launch Controller, and has both technical and operational supervision of the Satellite portion of the launch operation. He is responsible to the Launch Controller for technical readiness of the Samos Satellite System and accomplishment of Satellite Test Objectives. He makes technical recommendations relating to satellite readiness and test objectives. He is also responsible for preparation and checkout of the satellite during test and countdown operations. He conducts the satellite countdown, monitors activities of the Agena Senior Launch Engineers, makes operational decisions relative to the satellite and reports progress periodically to the Launch Controller.

7-11. The Launch Conductor/Booster is located adjacent to the Launch Controller and has both technical and operational supervision of the booster portion of the launch operation. He is responsible to the Launch Controller for technical readiness of the booster system and accomplishment of booster test objectives. He makes technical recommendations relating to booster readiness and test objectives. He is also responsible for preparation and checkout of the booster and launch complex during test and countdown operations. He conducts the booster countdown, monitors activities of Booster Senior Launch Engineers, makes operational decisions relative to the booster, and reports progress periodically to the Launch Controller.

7-12. Pad safety is under cognizance of the Pad Safety Officer, an Air Force representative who operates within a framework established by Pacific Missile Range and is monitored by that facility. The Pad Safety Officer is responsible for evaluating pad operations during countdown to assure maximum safety of personnel, the launch complex, and vehicle. He advises the Launch Controller on pad safety matters during the countdown.

7-13. Overall flight safety is under cognizance of the Range Safety Officer for the Pacific Missile Range. He is responsible for evaluating range status to determine whether or not the launch meets all safety requirements. Through the media of the Missile Flight Safety System, he follows the trajectory from launch and may command destruct if it deviates from the prescribed safe path. He advises the Launch Controller and is the final authority on launch-countdown holds necessitated by unsafe range conditions. He carries full responsibility for commanded destruct.

7-14. SATELLITE TEST CENTER AND LAUNCH BASE COORDINATION. The Satellite Test Center (STC) and the Launch Operations Control Center (LOCC) exercise command and control of prelaunch and launch coordinated operations. Vandenberg launch control is executed in accordance with the applicable Flight Test Directive. The tracking stations are involved in the prelaunch and launch phase to the extent that they relay information and participate in time checks and checkouts as directed by the Satellite Test Center. During these times the Test Center maintains overall command and control of system operations; however, specific command prerogatives are delegated to the Launch Operations Control Center. During launch, sole responsibility for range safety and destruct of the Samos Vehicle rests with the Range Safety Officer of the Pacific Missile Range, who may command destruct at any time between liftoff and sustainer engine cutoff of the Samos Booster.

7-15. During the orbit phases of operation, command and control over a Samos flight are executed by the Satellite Test Center in accordance with the System Test Directive. Control over the tracking stations is accomplished through a communications network of which the Test Center is the hub. A ground-space communications system is used whereby the tracking stations relay commands and readout satellite and reconnaissance data. In this capacity, the stations serve as instruments of the Test Center.

INITIAL PROGRAMMING

7-16. GENERAL.

7-17. For convenience of presentation, initial programming is discussed under two main categories: first, the planning and preparation that is required on an overall Samos Satellite System basis, and secondly, the programming which is directly applicable to a Samos Satellite. Of necessity, a close relationship exists between system programming and vehicle programming.

7-18. SAMOS SATELLITE SYSTEM PROGRAMMING.

7-19. Initial programming for the Samos Satellite System is performed by such functioning groups as the System Test Working Group and the Flight Test Working Group. Various documents are prepared to effect proper planning, coordinating, and implementing of system flight objectives. Such documents include the Detailed Test Objective, the System Test Directive, the Countdown Manual, the Readout Plan, the Satellite Program System Procedures, and the Communications Operations Procedures.

7-20. SYSTEM TEST WORKING GROUP. The System Test Working Group at Lockheed in Sunnyvale is delegated the authority for preliminary planning and coordination of the overall system activity and is composed of Lockheed (LMSD) and Air Force (AFBMD) representatives, with an AFBMD representative serving as chairman. The group is responsible for preparing the System Test Directive document. The document is based upon the Detailed Test Objective document which is previously coordinated at AFBMD Headquarters with all contractors involved in the program. Major emphasis of the document is on the orbit phase of the program.

7-21. FLIGHT TEST WORKING GROUP. The Flight Test Working Group at Vandenberg Air Force Base is delegated the authority for launch and prelaunch planning and coordination. The group is composed of Air Force, Lockheed, Pacific Missile Range, and associated contractor personnel. A representative of the AFBMD field office at Vandenberg Air Force Base serves as chairman. The group is responsible for preparing the Flight Test Directive, a document based on Pacific Missile Range requirements and on information of the Detailed Test Objective to cover detailed launch requirements.

7-22. DETAILED TEST OBJECTIVE. The Detailed Test Objective is the formal planning source for use by the working groups, Satellite Test Center, launch base, and tracking stations in planning flight operation procedures. The document provides such information as test objectives, vehicle configuration, flight plan for launch and orbit, telemetry instrumentation schedules, and nominal orbit tracks.

7-23. SYSTEM TEST DIRECTIVE. The System Test Directive is used in the conduct of the flight define in the corresponding Detailed Test Objective. It provides a general description of the overall flight program and specific details regarding tracking, data recording and instrumentation, and vehicle command operations under the direction of the Satellite Test Center.

7-24. COUNTDOWN MANUAL. The Countdown Manual outlines the tasks to be completed during the countdown for launch of a specific vehicle. The sequence of tasks and the nominal time spans for completion of each function are shown.

7-25. READOUT PLAN. The Readout Plan provides planning information to establish acquisition and data reception and readout procedures for the system. The specific details are included in the System Test Directive for the appropriate operations during the flight program.

7-26. SATELLITE PROGRAM SYSTEM PROCEDURES. This document defines in detail the communications required to conduct system flight tests and include system countdown, weather reporting, discrepancy summaries, system time checks, system runs, acquisition messages, tracking data, and command and performance summaries.

7-27. COMMUNICATIONS OPERATIONS PROCEDURES. The Communications Operations Procedures document defines the procedures to be used in the operation of the communications network of the Satellite Test Center. The procedures include teletype procedures for 60- and 100-word-per-minute links, voice communications, and operational mode communications.

7-28. SAMOS SATELLITE PROGRAMMING.

7-29. Programming of Samos Satellite activities is effected through the command equipment of the satellite-borne communication system. The command program for the Samos Satellite is based on the mission schedule, in that specific commands must be given to the satellite on a programmed basis in order to accomplish the scheduled missions. The individual commands are based, first, on the mission to be accomplished, second, on the vehicle equipment, and third, on the vehicle orbit. The command equipment controls the orbital operation of systems that comprise the satellite and payload equipment based on prelaunch inset programming. These stored program commands, and those introduced by tracking station during vehicle orbit, form the basic cyclic programming of events. This programming may be modified by subsequent introduction of ground-station-orginated, real-time commands if additions, deletions, or revisions of the stored program content is required.

7-30. The sequence programmer is the command programming device in the satellite. It is turned on during countdown by Samos ground operations command and stores program commands fed into it during countdown and during useful orbital life. The programmer reads out these commands to the affected satellite system and payload equipment for execution of the required equipment operations. Refer to pertinent, subsequent discussions in this section for sequential operation of programmed events, and to Section IV for details relating to each pertinent system of the Samos Satellite.

SAMOS VEHICLE CHECKOUT AT VANDENBERG

7-31. A Samos Vehicle is not received by Vandenberg Air Force Base in the assembled state, but rather, the Samos Booster, the Agena portion of the Samos Satellite, the dual Samos payloads, and the vehicle adapter are independently shipped from the respective contractor facilities. Upon arrival at Vandenberg, a series of checkouts and inspections are conducted at the Guided Missile Assembly Building to ascertain operational readiness of all systems that collectively comprise a Samos Vehicle. Initially, the vehicles (booster and Agena) are separately checked at the subsystem level. Upon satisfactory completion of these checks, a final system checkout is then conducted at this location. For this system check, both vehicles are completely assembled to assure complete systems operation. The Samos payloads are installed in the Agena vehicle (thus constituting a Samos Satellite) and are operated to also permit full evaluation of these systems. After successful system checkout of the Samos Booster and Samos Satellite, the payloads are removed from the Agena. The vehicles, payloads, and adapter are then separately transported to the launch complex at Point Arguello. Refer to Section IV for detailed information regarding the checks and tests conducted at the Guided Missile Assembly Building.

SAMOS SYSTEM PRELAUNCH OPERATIONS AND COUNTDOWN

7-32. GENERAL.

7-33. Samos System prelaunch operations are presented under the following phases of flight preparation: the initial vehicle preparation conducted at the launch complex which provides final verification of Samos Booster and Samos Satellite readiness for launch; the integrated facility prelaunch operations that are conducted to prepare Samos System equipment and facilities for applicable system function; the precountdown operations that are conducted during the six days prior to launch; and finally, countdown operations, which are considered to commence approximately 290 minutes before launch of the Samos Vehicle.

7-34. INITIAL VEHICLE PREPARATION AT LAUNCH COMPLEX.

7-35. Although both the Samos Booster and Samos Satellite have completed a system checkout in the Guided Missile Assembly Building, extensive re-testing is required at the launch complex using the launch facilities and ground-support equipment. Interface and mating tests between the vehicles and between the vehicles and range tracking facilities are performed for the first time. Between the time the vehicles arrive at the complex and the final mating during precountdown, the series of subsystem and system tests are performed to confirm that vehicles and ground components are operating properly. The satellite-borne r-f communications, guidance, telemetry and data transmission subsystems, and the payloads are tested through the r-f links to the Vandenberg Tracking Station and to the Guided Missile Assembly Building. Other vehicle parameters are evaluated through the telemetry link. The tests assure complete operation and compatibility between the spaceborne and ground equipment. R-F interference between various contractor and range-controlled equipment is also checked.

7-36. The Samos Booster is the first vehicle to be transported to the launch complex. Here, after initial facilities and ground support equipment preparation, the booster is erected within the pad service tower and tests are conducted over a period of several days. The special booster transport adapter is removed and replace with the satellite adapter. When booster tests have been completed, the Samos Satellite (less payloads) is then transported to the complex where tests are conducted on that vehicle. Upon successful completion of vehicle testing, preparations are then essentially complete for erecting and mating the satellite. Booster and satellite interface connections are completed and the umbilicals are connected.

7-37. After vehicle testing, a flight readiness firing test is performed using a flight checkout vehicle hoisted and installed atop the Samos Booster. The flight checkout vehicle is similar in construction to the Agena portion of the Samos Satellite, but does not contain propulsion components and certain electrical equipment. The principal purpose of the flight readiness firing test is to check the booster propulsion system, and consists of a 10-second, static, hot firing of the booster. The booster tests include simulated countdown and normal launch sequence operations within limits of the captive conditions, and are programmed through the automatic launch sequencer or the Samos Booster.

7-38. Interface tests between the booster and satellite consist of adapter mechanical and electrical mating tests; range safety command destruct tests;

guidance discrete command tests; instrumentation and telemetry cross-checks; and backup separation signal tests. In addition to these interface tests, numerous launch control interconnection test are required, such as liftoff signal and tone tests; start booster countdown enable switch; proceed with commit signal and control; launcher power on signal; commit start signal; countdown clock interconnection and control; and liftoff, loop test start, and countdown clock interconnections to ground station equipment.

7-39. The range safety tests establish that the spaceborne components meet requirements for flight safety. Destruct simulators are used in both vehicles and the receipt of destruct command is monitored at both vehicles. Launch Operations Building remote control of the vehicle safe-arm function is checked.

7-40. Before proceeding with the initial launch sequence preparations, a complete dress rehearsal is conducted. This simulates a launch (without engine firing) with all contractor and range personnel participating. The success of this rehearsal is a major factor in determining flight readiness and the flight date.

7-41. INTEGRATED FACILITY PRELAUNCH PREPARATIONS.

7-42. During the prelaunch period, the Vandenberg Communications Center is responsible for monitoring and coordinating those operations at Vandenberg Air Force Base which relate to launch. Prelaunch activities are continuously monitored by the Air Force field office at Vandenberg. Tracking equipment at all tracking stations is independently and repeatedly calibrated and adjusted during prelaunch. Independent calibration is required to assure that accuracy of tracking data acquired during orbital tracking is within established limits of accuracy for measuring orbital parameters. In general, primary tracking system calibration is accomplished by the use of fly-by aircraft which carry equipment to permit tracking by tne tracking station. During prelaunch preparations, the Vandenberg Communications Center monitors status of the launch complex and the Vandenberg Tracking Station. During the precountdown period of 6 days prior to launch, the Communications Center maintains the direct communications link to the telemetry ship and to the Satellite Test Center, and also reports on weather forecasts and conditions at Vandenberg. Before commencement of the countdown, at approximately 8 hours before launch, all local control and coordinating responsibility at Vandenberg is vested in the Launch Operations Control Center with the Vandenberg Communications Center performing necessary communications functions under jurisdiction of the Launch Operations Control Center. Starting at 6 days prior to launch the Satellite Test Center directs a program of checkout procedures to assure station readiness for tracking. Procedures include direction of simulation tests and exercises at each station, limited interstation communications checks, and dress rehearsal communications routines simulating the mission requirements which exercises all station functions under the direct control of the Satellite Test Center. The intra-station communications checks consist of both the voice-teletype and digital data communications links. Each tracking station conducts independent, simulated communications exercises within its respective areas under the direction of the System Test Director at the Satellite Test Center. Typical mission operating procedures are emphasized. The interstation communications check includes both voice-teletype and digital data communications links to each station under direction of the System Test Director.

7-43. PRECOUNTDOWN OPERATIONS.

7-44. Precountdown activities during the 6-day period prior to launch are briefly presented. The days are indicated in consecutive order, beginning with the sixth day,indicated as X-6 days,and continuing in sequence to X-0 day, the day of launch.

7-45. X-6 DAY ACTIVITIES. The activities during this day include Satellite Test Center and tracking station simulation tests performed for tracking and communications systems; Vandenberg Control Center voice, teletype, and timing checks are performed with the Satellite Test Center and Vandenberg Tracking Station; Vandenberg Control Center reports on Samos Booster and Samos Satellite launch complex status; the satellite is demated and lowered to the pad for final flight preparations; the umbilical mast is lowered; mast and connections are checked; final launch preparations are begun for the Samos Booster. Any descrepancies in booster, launch controls, tanking, and launch-related equipment are corrected and modifications are completed.

7-46. X-5 DAY ACTIVITIES. Tracking station aircraft fly-by tests are performed. Telemetry ship departs for downrange position. The Vandenberg Communications Center performs communications checks with the telemetry ship for position, weather, and equipment status reports. The checks of the previous day are repeated. Internal inspection and final preparation of the Samos Satellite are started, the engine is functionally checked, final check of pyrotechnic circuits is begun, and tanking and pneumatic systems are serviced.

7-47. X-4 DAY ACTIVITIES. The Satellite Test Center and tracking station tests are repeated. The Vandenberg Communications Center repeats the X-6- and X-5-day tests. The Vandenberg Communications Center receives status from the telemetry ship and relays the report. The Samos Satellite engine checks are completed. The pyrotechnic circuits are tested with guidance programmer and squib simulator. The launch control functions are checked. The umbilical release functions on the launch pad are checked. Propellant and pneumatic loading systems are functionally checked.

7-48. X-3 DAY ACTIVITIES. The Satellite Test Center and tracking station tests are repeated. The Vandenberg Communications Center repeats the functions of the previous day. In respect to the Samos Satellite, complete guidance and control function tests are run; propellant loading tanks are filled; final leak tests are performed; the hydraulic system is recharged and serviced; blockhouse control functions are checked; and air conditioning checks are performed. The Samos Booster final premating tests are completed.

7-49. X-2 DAY ACTIVITIES. The Satellite Test Center transmits predicted command and acquisition messages, and exercises tracking station equipment. The Vandenberg Communications Center repeats communication checks, and the status of the telemetry ship, tracking stations, launch preparations, weather, and other pertinent data revelant to launch are maintained current for general distribution. Satellite squibs, ullage rockets, and turbine starter are installed. Final premating inspections and safety wiring are completed. Satellite batteries are installed Payload components are installed in the satellite and the vehicle is then hoisted and mated to the Samos Booster. The umbilical tower is raised and umbilicals and test plugs are installed.

Air conditioning control is checked. The launch complex communications are checked. The Automatic Programmer Checkout Equipment (APCHE) for the booster is checked. The launch sequencer is checked. The engines and autopilot of the Samos Booster are checked.

7-50. X-1 DAY ACTIVITIES. The Satellite Test Center and tracking stations conduct detailed simulation and communication checks. The Vandenberg reports telemetry ship on-station, the current status of the launch complex, tracking systems, and weather are reported. Post-mating of pyrotechnic installations are completed on the satellite. The destruct circuit functions are checked. Telemetry and command and controls checks are made. Data links are checked via r-f monitoring. Beacons and tracking station response are checked. Launch-complex cameras are tested and loaded with film. Recorders in the Launch Operations Building are calibrated and serviced. Complex communications and the countdown clock are checked. Booster APCHE system tests are performed. Guidance commands from the ground station equipment and discrete command loop tests are performed. Batteries, engine igniters, and charge accumulators are installed in the booster, and range safety destruct command tests are performed.

7-51. X-0 DAY ACTIVITIES. Range clearances are obtained for launch. Vandenberg Communications Center control is assumed by the Launch Operations Control Center. The Satellite Test Center and tracking stations perform final simulated tracking exercise and boresight checks. All stations and telemetry ship report readiness hourly. Weather forecasts and reports are transmitted at 6 and 2 hours before launch. Countdown activities commence at approximately 290 minutes before launch.

7-52. COUNTDOWN.

7-53. Following receipt of Air Force approval to proceed with the launch, and also verification that the items in this paragraph have been accomplished, countdown can then proceed. The Satellite Test Center verifies the ready condition of the tracking systems. Weather conditions must be satisfactory and above the minimum specified conditions. Control of the Vandenberg Communications Center has been assumed by the Launch Operations Control Center. Verification that the telemetry ship is ready and is on station. Range safety clearance has verified that the land, sea, and air conditions are satisfactory and that the range safety system is operational. The booster-guidance-system ground-station equipment has been programmed for a Samos launch at Point Arguello. The contractor launch conductors (Launch Conductor/Agena and Launch Conductor/Booster) have verified systems readiness.

7-54. The Air Force Launch Controller initiates the countdown after obtaining the clearances described. Detailed countdown is published in the Samos Preliminary Countdown Manual, LMSD-445944, and consists of 14 tasks. The 14 tasks, their respective designations, and the inclusive times for each task are indicated herein. Time of countdown is in terms of the 290-minute period prior to launch. The minutes are indicated in consecutive order, beginning with 290 minutes, designated as T-290 minutes, and terminating at T-0 minutes, the time of Samos Vehicle release for liftoff from the pad.

7-55. Task 1: Countdown Initiation, from T-290 to T-275 minutes. Task 2: Electronic Warmup, from T-275 to T-225 minutes. Task 3: Samos Booster

Telemetry Checks, from T-255 to T-225 minutes. Tasks 4 and 5: Samos Satellite Guidance and Flight Control Checkout, and Samos Satellite R-F Checkout, both from T-225 to T-215 minutes. Task 6: Range Safety Command Tests, from T-215 to T-185 minutes. Task 7: Samos Satellite Arming, from T-185 to 155 minutes. Task 8: Samos Vehicle Flight Safety System Connect and Arm, from T-185 to T-165 minutes. Task 9: Countdown Evaluation, from T-155 to T-125 minutes. Task 10: Plug Disconnect and Tower Removal, from T-125 to T-90 minutes. Task 11: Samos Satellite Tanking, from T-90 to T-60 minutes. Task 1?: Samos Satellite Pressurization, from T-60 to T-40 minutes. Task 13: Countdown Evaluation, from T-40 to T-25 minutes. Task 14: Terminal Count (which includes Samos Booster fueling and pressurization), from T-25 to T-0 minutes.

SAMOS SATELLITE SYSTEM LAUNCH AND PREORBIT PHASES

7-56. GENERAL.

7-57. Ascent operations begin at liftoff, which is the first, two-inch, vertical motion of the Samos Vehicle. This motion actuates the launcher release mechanism, releases the umbilicals, starts retraction of the umbilical tower, and supplies a tone or signal to all support facilities to indicate zero time. At this instant all control is divorced from the launch complex. Then, only the ground station equipment of the booster guidance system and the range safety have control over the vehicle. The principal activities that relate to launch and preorbit phases of operation is presented under two areas of coverage: those activities that relate to the ground facilities and those that relate to the Samos Vehicle.

7-58. BASES, CENTERS, AND STATION ACTIVITIES.

7-59. Exit tracking of the Samos Vehicle commences at Vandenberg Tracking Station. Three basic tracking systems are involved: VERLORT tracking, VHF tracking using tri-helix and TLM-18 antennas, and optical tracking. Starting with liftoff, the optical tracker follows the vehicle, and through the slave data bus, positions the VERLORT and TLM-18 antennas until the vehicle is high enough to permit lock-on by radar autotrack equipment. The three systems track during ascent to the limit of their respective ranges. The VERLORT radar tracks through separation and the initial coast phase. The TLM-18 antenna tracks to the limit of line-of-sight. Both position data and telemetry readout are monitored by this antenna. The tri-helix antenna and Doppler system are used during launch to monitor and record satellite telemetry and to derive velocities from the associated Doppler receivers and readout equipment.

7-60. The Pacific Missile Range (PMR) facilities at Point Arguello and Point Mugu, plus the telemetry ship positioned some 1500 miles downrange by PMR, are also used for tracking during launch and ascent. The ascending vehicle is tracked by skin-tracking radars and metric optical equipment at Point Mugu and Point Arguello, with the optic equipment tracking to the limit of visibility. The ship collects and records FM/FM telemetry and provides Doppler and angular tracking of the Doppler beacon in the Samos Satellite.

7-61. The Range Safety Officer monitors tracking and, if necessary, commands destruct of the vehicle during the ascent phase. He uses facilities of both the Vandenberg Tracking Station and the Pacific Missile Range.

7-62. SAMOS VEHICLE ACTIVITIES.

7-63. LAUNCH AND BOOST PHASE. (See figure 7-1.) After release of the Samos Vehicle from the pad, and continuing through retro-rocket ignition, all Samos Booster sequences are controlled by the booster flight programmer and by guidance commands and discrete commands, which are gated by the programmer. After 42 inches of vertical motion, the booster autopilot is activated, providing attitude control. The Samos Vehicle ascends vertically for the first 15 seconds of flight. Starting at 3 seconds and continuing through 14 seconds, the vehicle executes a programmed 35-degree roll. At the end of 15 seconds, a programmed pitchover is initiated and continues until cutoff of Samos Booster power.

7-64. The Samos Satellite performs no guidance and control functions of its own until immediately before vehicle separation. The booster guidance system then disarms the command destruct system, starts the satellite guidance timer, and uncages the attitude gyros. The satellite guidance timer applies backup signals to disarm the command destruct system, turn on the flight control power relay, activate command separation, and open the control gas supply valve.

7-65. SEPARATION AND COAST PHASE. (See figure 7-1.) Following the command for separation and the firing of the retro-rockets, the Samos Satellite pulls away from the Samos Booster and continues in a coast period of flight. During coast, the inertial reference package gyros deliver attitude error signals to the control system, and initial satellite rotation rates are damped out through pneumatic system operations. After this period, the satellite maintains pre-established attitude values in respect to pitch, yaw, and roll reference. In response to a signal from the pitch programmer, the pitch gyro is torqued to give the satellite the desired pitch rate. Error signals from this gyro cause the flight control pneumatic system to pitch the satellite over until the roll axis is nominally horizontal, at which time the command pitch rate is reduced to maintain this satellite attitude relative to the earth. The satellite guidance timer then connects the horizon scanner, optically establishes the local vertical, and then resolves the angle between the satellite yaw axis and the local vertical. The angle is resolved into pitch and roll component signals and transmitted to the inertial reference package.

7-66. ORBITAL BOOST PHASE. (See figure 7-1.) The flight control hydraulic system for engine gimbaling is activated prior to ignition of the satellite engine. However, satellite attitude is controlled by the pneumatic system until this time, at which, pitch and yaw pneumatics are turned off. Prior to engine ignition, the ullage rockets fire. Then, during engine firing, engine gimbaling provides pitch and yaw control, and roll control is by the pneumatic system. The longitudinal accelerometer output is connected to the integrator to determine velocity gained and to maintain the satellite attitude relative to the earth. Engine shutdown is commanded by the integrator at a predetermined vehicle velocity. The pitch and yaw pneumatic control is turned on again, the hydraulic system is turned off, and the longitudinal accelerometer is disconnected from the integrator. Engine shutdown occurs at an altitude of approximately 300 miles. The vehicle then enters the orbit phase of operation.

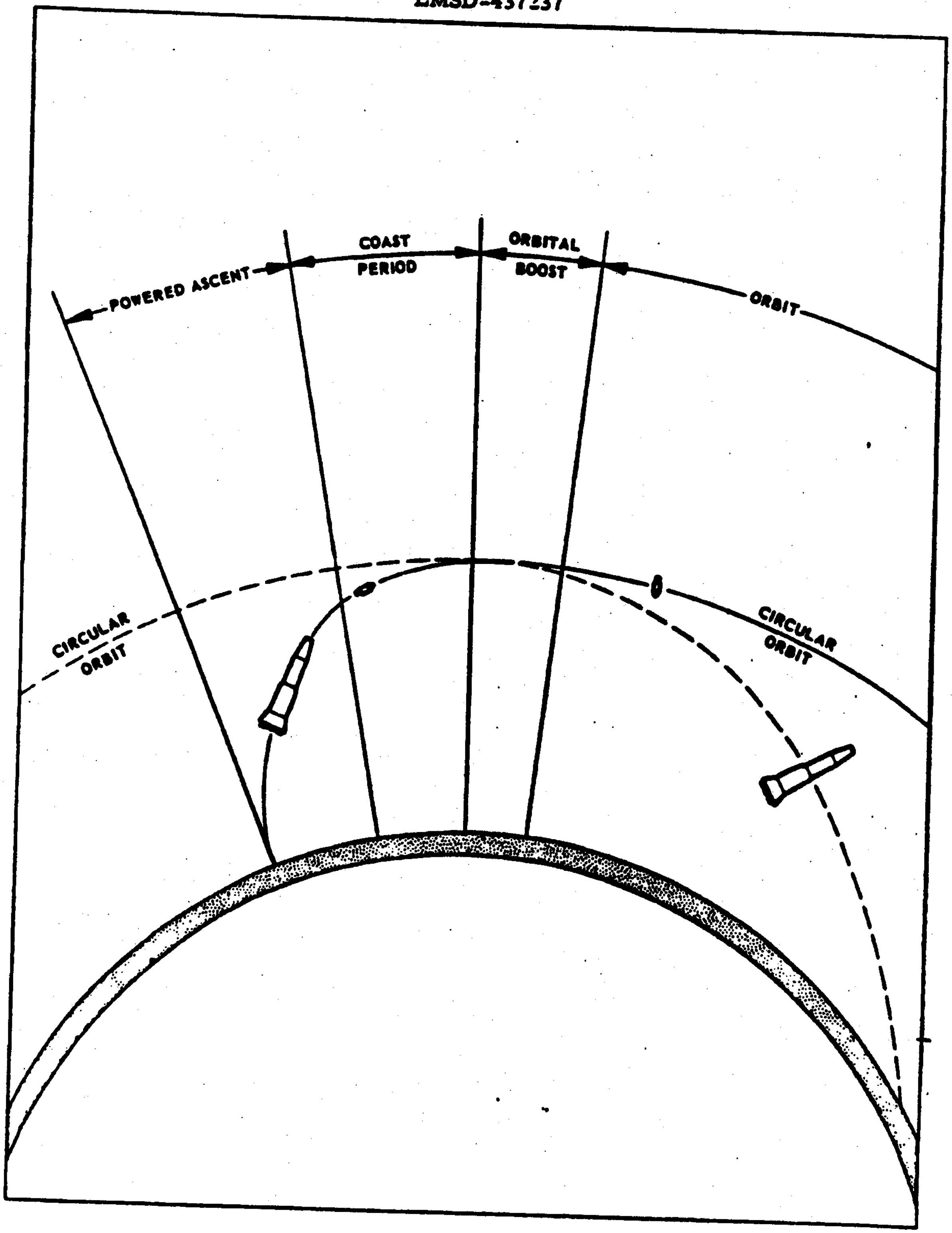


Figure 7-1. Samos Vehicle Flight Profile

SAMOS SATELLITE ORBITAL AND RECONNAISSANCE PHASES

7-67. GENERAL.

7-68. At the time of this writing, the planned sequence of events during the orbit phase includes a nosedown reorientation of the vehicle from the horizontal attitude, as established during the coast phase, followed by steady-state orbiting. However, modifications to this sequence are considered for the first three Samos Satellites wherein they are to maintain their horizontal attitude during initial portions of the first orbit until after helium, oxygen, and fuel venting. Then, reorientation would be established. The pertinent information that follows is presented on the basis of the modified events which are discussed as pre-nosedown and then post-nosedown orbiting.

7-69. PRE-NOSEDOWN ORBITING PHASE.

7-70. Following engine shutdown, the satellite enters pre-nosedown orbiting. During this phase the helium, oxygen, and fuel vent squibs are fired, telemetry calibration starts and stops, the antenna boom squibs are fired, the Geo-Physics Research Directorate (GRD) equipment is armed, 28-volt power is removed from the engine cutoff relay, and the tape recorder is armed. The satellite retains a horizontal attitude until receiving a real-time command for nosedown reorientation during the first orbital pass over Hawaii.

7-71. POST-NOSEDOWN ORBITING PHASE.

7-72. During this phase of operation, the satellite maintains a nosedown attitude and a steady-state condition. The vehicle is maintained in the nose-down position by the attitude damping system which becomes activated during orbit. The flight control and pneumatic systems are turned off. The pitch and yaw gyros of the inertial reference package are switched to the rate mode for operation in conjunction with the attitude damping system. The damping system, by controlling the angular momentum of the inertia wheels, minimizes satellite oscillations within six hours to predetermined deflections. The horizon sensor operates and periodically provides indications by means of telemetry. Also during this orbital phase, the nitrogen valve is closed, 2000- and 400- cps inverter control is provided, the gyros are caged, the pneumatic system is vented, switch is made to orbit functions, the attitude damping system is activated, switch to orbit antennas is made, and initial shutdown of guidance timer is effected.

7-73. RECONNAISSANCE PHASE. (See figure 7-2.)

7-74. The payloads are activated after nosedown of the satellite over areas of predetermined interest by the pre-programmed commands stored in the satellite-borne programmer. Visual and ferret reconnaissance data, geo-physical environment data, and equipment performance parameters are recorded on satellite-borne storage media. When a satellite passes within a range of tracking stations at Vandenberg and Kaena Point, the area programmer activates the command receiver. The tracking station then commands readout of all payload and telemetry data and dispatches real-time commands and new stored commands to the satellite programmer.

7-75. Under nominal conditions, complete functional checking of the payloads and the satellite command and control equipment occurs within the

[redacted]

first 12 hours after launch. Dual payload configuration restricts initial checks of visual payload function to qualitative evaluations only. These limitations are imposed by the joint usage of the sequence programmer, the restricted view of the camera in looking through the ferret payload antenna horn, and the obscuring of the horizon optics field-of-view by the ferret payload structure. Quantitative testing of the ferret payload and qualitative evaluation of the visual payload are completed in the first four days of orbital operation. The ferret payload is then ejected within range of the Vandenberg Tracking Station, and quantitative testing of the visual payload occupies the remaining satellite life.

7-76. Paragraphs 7-77 through 7-87 indicate the nominal sequence of system events during the first 10 orbits. Figure 7-2 supplements the information in these paragraphs by showing a schedule of the orbits during the first 24 hours of orbital operation.

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7-105. DATA READOUT.

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7-109. TELEMETRY READOUT. Readout of the telemetered data is under the control of the Master Controller and is received on both the VHF and UHF links. The VHF telemeter modulation is activated prior to contact withthe station and continues to replay the recorded data throughout the pass. Recording of these data is started as soon as best reception is attained. The UHF telemeter signal is recorded through the pass as a matter of course.

7-110. POST-PASS ANALYSIS.

7-111. Certain portions of the telemetry data received during each pass are displayed on oscillographs for review and analysis as soon as possible. This analysis includes nominal tolerance checks to permit determination of satellite equipment status and evidence of equipment malfunctioning. Results of postpass analysis are transmitted to the stored program command for coordination with reports from all tracking stations.

DATA EVALUATION

7-112. GENERAL.

7-113. Lockheed Missiles and Space Division has the overall responsibility for Samos System evaluation. The scope of this evaluation encompasses all system tests and test activities as they may affect the achievement of ultimate program goals and objectives. Major emphasis, however, is devoted to the rapid evaluation of system flights as required to properly redirect the program. As prime contractor, Lockheed is also responsible for operations evaluation of all satellites systems, with particular emphasis placed on operations evaluations of the ferret and visual payloads.

7-114. Payload, telemetry, and tracking data collected by the tracking stations are forwarded by communication links to the Satellite Test Center. Payload data are analyzed for engineering evaluation, and copies are forwarded to cognizant Air Force agencies. Telemetry and tracking data are processed and analyzed to establish system performance. Computers at the tracking stations and the Satellite Test Center are utilized to refine the orbit ephemersis, establish new tracking stations, and generate updated acquisition messages and realtime and stored program commands for the next orbit pass.

7-115. The associated booster contractor is responsible for evaluation of the Samos Booster and its related guidance system. The data processing contractor is responsible for analysis of the ferret and visual payload reconnaissance data. To assure the rapid incorporation of these results in planning and conducting subsequent flights, a complete evaluation of each launch and test must be accomplished within the time span occurring between launches. Because of the scope of Samos test operations, a most stringent time factor is placed on the tasks associated with post-test handling and evaluation.

7-116. DATA REDUCTION.

7-117. GENERAL. Satellite telemetry data requiring reduction to suitable form are processed by Lockheed data services. Certain metric data (optics) and FPS-16 launch data are reduced by Pacific Missile Range. Engineering surveillance and documentary launch films are processed by the Air Force Lookout Mountain Facility. Payload visual data are reduced to the form of primary records by Vandenberg Tracking Station and are reassembled and analyzed by Lockheed at the Satellite Test Center and by the associate contractor for data processing. Raw ferret data tapes are delivered to the Satellite Test Center and to the data processing contractor. In order to permit an early evaluation of Samos test results, the satellite data (excluding payload data) reduction process is accomplished in two parts, launch quick-look data and final data. Following the quick-look and final data aspects of data reduction, a Samos Subsystem Critique Meeting is conducted wherein the Samos Satellite systems undergo detailed review and qualification of available final data. Following this meeting, detailed analyses of satellite flight trajectory and vehicle system are conducted. All factors involving possible readjustment or refinement of satellite hardware are thoroughly investigated. Results of these analyses and investigations are compiled and published in specified reports (refer to paragraph 7-131).

7-118. LAUNCH QUICK-LOOK DATA. Data reduction required to support quick-look launch evaluation activity is accomplished on a first priority basis within 24 to 36 hours after receipt of metric data and telemetry tapes. Copies of launch data are distributed to participating Lockheed organizations 12 hours in advance of a quick-look meeting. The meeting is called to initiate a preliminary evaluation of Samos Satellite flight results and is attended by representatives of all contractors and Air Force organizations directly concerned. Additional data requirements, which may be necessary because of flight events, are specified after a preliminary review of real-time and operational telemetry records within 24 hours following launch.

7-119. FINAL DATA. A final comprehensive compilation of all data required for detailed satellite and payload data are accomplished in the three-to-five-day period following launch and subsequent payloads tests.

7-120. LAUNCH BASE EVALUATION.

7-121. Within four hours following a launch, available launch data are assembled by the Flight Test Working Group at Vandenberg for preliminary review. During this time the group conducts a post-launch meeting to permit an accurate reconstruction of launch events and to examine launch results. The ultimate product of the group effort is the Launch Report.

7-122. EVALUATION OF BOOSTER AND SATELLITE.

7-123. Detailed analyses of the Samos Booster are conducted by the booster contractor. To facilitate planning of subsequent tests, problems revealed by these analyses are coordinated with Lockheed on a day-to-day basis. The results of these analyses are made available to Lockheed and cognizant Air Force organizations in the various test reports produced (refer to paragraph 7-131). If necessary, design representatives for the booster contractor attend the Samos Subsystem Critique Meeting conducted at Lockheed Missiles and Space Division at Sunnyvale, California.

7-124. PAYLOAD EVALUATION.

7-125. Samos payload evaluation may be considered to be in four areas of evaluation: operations and real-time evaluation, on-line data evaluation and analysis, off-line data evaluation and analysis, and data quality and payload-product analysis.

7-126. Operations and real-time evaluation is conducted during the development phases of the Samos program by representatives of the Lockheed Operations Integration organization at the tracking stations and at the Satellite Test Center. This evaluation consists of monitoring the payload consoles and recommending commands to be issued to the payloads as required. Evaluation and analysis of on-line data includes that data used in real time, or close to real time, in making analyses. Off-line data evaluation and analysis are conducted jointly by Lockheed Test Data and Reports organization and the Samos Satellite subsystems personnel, using raw and processed data. Data quality and payload-product analysis is conducted by the data processing contractor, which furnishes reports to cognizant Air Force agencies and to Lockheed.

7-127. OVERALL SYSTEM EVALUATION.

7-128. The Operations Management organization of Lockheed Missiles and Space Division proceeds with investigation of problems revealed by preliminary evaluation and detailed analysis activity, and completes an integrated evaluation of overall system operation. Necessary remedial actions affecting the planning and conduct of future tests are coordinated as early as possible with all organizations concerned.

7-129. PROGRAM EVALUATION AND REDIRECTION.

7-130. The System Operations Integration organization of Lockheed Missiles and Space Division maintains accurate and complete records of program test activity and results, and conducts a continuing evaluation of system operations on a flight-to-flight basis. Pertinent records and statistical data concerning countdown, flight operations, ground-support equipment operations, logistics, and overall system serviceability are constantly complied and analyzed. Operations concepts, equipment, and procedures are modified as necessary for proper program redirection.

7-131. TEST REPORTS.

7-132. Test reports that are required for official distribution are divided into four groups--launch reports, booster contractor reports, Samos reports, and tracking station reports.

7-133. LAUNCH REPORTS. The types of launch reports that are prepared by the Flight Test Working Group and transmitted to the Air Force Ballistic Missile Division include a flash report, a follow-on report, and a final report. The flash report briefly describes launch operations, and the results are transmitted by teletype. The follow-on report gives a more complete description of launch operations and flight results, and it is transmitted by teletype after a preliminary review of raw launch data. The final launch report provides formal documentation and Flight Test Working Group evaluation of launch operations and results, including pertinent launch data.

7-134. BOOSTER CONTRACTOR REPORTS. The booster contractor prepares a quick-look report and a final flight test report. The quick-look report contains results of a preliminary review of Samos Booster launch data, with particular emphasis on indicated problem areas. The report is transmitted by teletype. The final flight test report provides a final analysis of booster equipment operation and performance during countdown, launch, and flight, and encompasses all factors involving possible modification of equipment, plans, or procedures on future flights. It is due 20 days after launch.

7-135. SAMOS REPORTS. The types of Samos reports include a preliminary flight information report, a preliminary system test report, and a performance analysis and system test report. The preliminary flight information report contains a brief description of flight operations and results bases on the flash report plus the latest inputs from the tracking stations. The preliminary system test report is based on the system quick-look evaluation activity by Lockheed at Sunnyvale, the final launch report, the booster contractor quick-look report, and internal Lockheed reports from the tracking stations and the Satellite Test Center. The report includes a brief summary of system test results, a complete account of test conduct, and a preliminary operational evaluation of the flight in terms of achievement of test objectives, problems encountered, and overall system performance. The performance analysis and system test report is based on a complete analysis of boost and orbital trajectory and Samos Satellite subsystems performance. It contains test data analysis of all factors involving possible hardware refinement or revision of test procedures. The report provides a documentation of the flight test through the first two weeks of orbit. It also contains a final operations evaluation of overall system performance and makes specific recommendations regarding possible program redirection. A monthly addenda supplements this report.

7-136. TRACKING STATION REPORTS. All tracking stations report on operation of their equipment, by teletype, to the Satellite Test Center within 36 hours following launch or within 4 hours after a premature termination of the flight.

GLOSSARY

ACQUISITION AND TRACKING–The searching for, locating, and subsequent continuous observance of satellite flight position during a limited span of time.

ARM–To prepare a fuze or detonator for ignition; to complete an electrical circuit to a fuze or detonator so that an electrical impulse can cause ignition.

ATTITUDE–The position of a vehicle or satellite, expressed in terms of pitch, roll, and yaw.

BOOSTER SECTION–A jettisonable aft portion of the Samos Booster; contains the booster engine of the Samos Booster and associated equipment.

BORESIGHT TOWER–A fixed target used for visual alignment of a radar tracking antenna used in conjunction with a sighting telescope to adjust the orientation of the antenna to correspond with the direction of the radiation pattern.

BLACK BOX–A combination of parts that performs a particular function. (See Component.) Refers to an enclosed component, usually electronic, that can be readily inserted or removed from a group of interconnected components.

BOOSTER ENGINE–The dual-chamber rocket engine of the Samos Booster that assists in accelerating the Samos Vehicle from launch. It is a part of the jettisonable booster section.

CAVITATION–The formation and collapse of vapor bubbles in a liquid when the local static pressure is less than the head pressure created by a moving object.

CHECKOUT–The performance of a test, or series of tests, designed to verify and validate that the operational characteristics of vehicle equipment and structures are within specified limits.

COTAR–Correlation tracking and ranging. A phase-comparison radio measuring system for determining vehicle location.

COUNTDOWN–A controlled sequence of events ending in the launching of a vehicle.

COMPONENT–A combination of parts that performs a particular function. The parts are either joined together to form a rigid unit, or they are assembled on a common mounting base. The parts may be exposed for inspection and maintenance, or they may be enclosed for protection from the environment.

DIPLEXER–A mechanical or electronic component which enables two transmitters to use a single antenna; prevents either transmitter from dissipating a large portion of its transmitted energy in the other transmitter.

GLOSSARY (Continued)

DISPLACEMENT GYRO—A gyro that provides an electrical signal proportional to the angular displacement of the gyro from a reference point.

DUPLEXER—A mechanical or electronic component which enables a transmitter and a receiver to use a common antenna; prevents a large portion of the transmitted energy from being dissipated in the receiver, and prevents the received energy from being dissipated in the transmitter.

EPHEMERIDES—Tables that show the geographical location of the Samos Satellite as a function of time. The location of the satellite can be determined for any past, present, or future time.

GANTRY—A crane-type structure, with platforms on different levels, used to erect, assemble, and service large rockets or missiles. It may be placed directly over the launching site and rolled away before firing.

GIMBAL—A mounting that uses universal joint suspension to permit inclination of the mounted item to a desired position.

GIMBALLING—The action of moving, or inclining, an item mounted in a gimbal.

GYRO—A rotating mass mounted so that it may turn about either one or both of the remaining two orthogonal axes; a gyroscope. A significant characteristic is that the spin axis remains fixed in space when the rotation is maintained above the operating level.

HYPERGOLIC PROPELLANT—A rocket fuel that ignites spontaneously upon contact with an oxidizer.

IGNITER—A pyrotechnic device that is electrically ignited to start the burning of an explosive charge or a quantity of propellant.

INVERTER—An electrical device for converting direct current to alternating current.

INFRARED—Electromagnetic radiation in a frequency range slightly below the frequencies of visible light. The frequency range is approximately one thousand million megacycles (10^9 mc) to ten thousand million megacycles (10^{10} mc). The wavelength range, from shorter to longer wavelengths, is approximately 3 to 30 microns.

IRFNA—Inhibited red fuming nitric acid; an oxidizing propellant.

LAUNCH COMPLEX—The area immediately surrounding the vehicle launch pad; includes the buildings and support equipment directly associated with countdown and launch operations.

GLOSSARY (Continued)

LAUNCH PAD—A hard surface area on which a missile launcher is positioned.

MISSILE LAUNCHER—A structural device which supports and holds a missile in position for launch.

MONOCOQUE—A type of airframe construction characterized by stressed skin and the absence of stiffening framework.

MONITOR—To continuously receive and analyze information to confirm that a specific condition is being maintained or that a particular action is performed.

MULTIPLEXER—A mechanical or electronic component which converts a number of voltage signals into a single output voltage signal that consists of a successive series of voltage samples. Under certain circumstances of pulse inputs and appropriate timing, the single output voltage signal can contain all the input voltage signals applied to the component.

PITCH—Motion of the satellite about the reference pitch axis.

PROGRAM—A predetermined sequence of events, provided as a series of instructions, that is executed by an automatic device or computer.

RATE GYRO—A gyro that provides an electrical signal proportional to the rate of change in angular displacement of the gyro from a reference point.

RF—Radio frequency. Electromagnetic radiation in the frequency range from 15 kc to 50,000 mc.

ROLL—Motion of the satellite about the reference roll axis.

REFERENCE PITCH AXIS—Refer to paragraph 4-117 regarding Samos Satellite.

REFERENCE ROLL AXIS—Refer to paragraph 4-117 regarding Samos Satellite.

REFERENCE YAW AXIS—Refer to paragraph 4-117 regarding Samos Satellite.

REORIENTATION—The action of pitching the Samos Satellite from a horizontal attitude to a vertical, nosedown attitude.

REAL-TIME COMMAND—A command that is transmitted to the Samos Vehicle and executed immediately. Used to initiate an equipment function when the vehicle is within range of the ground command station.

RECONNAISSANCE SATELLITE—An earth satellite launched from earth; designed to obtain strategic information through such means as photography and detection of electromagnetic emissions.

GLOSSARY (Continued)

RETROGRADE ROCKET—A device, that when fired, retards forward movement of the Samos Booster.

SQUIB—An electrically detonated explosive device.

SUSTAINER ENGINE—The main rocket engine permanently attached to the Samos Booster.

SAMOS BOOSTER—A Convair Atlas missile (SM-65D) modified to mate with a Samos Satellite and provide first-stage thrust for placing the satellite in orbit.

SAMOS SATELLITE—A Lockheed Agena orbital vehicle (Agena) containing a Samos payload and using a Samos Booster for first-stage thrust. A satellite rocket engine that is part of the Samos Satellite provides second-stage thrust for placing the satellite in orbit.

SAMOS VEHICLE—The combination of a Samos Satellite mated with a Samos Booster.

SAMOS SATELLITE SYSTEM—An array of equipment, personnel, and facilities designed to obtain and process electronic and photographic reconnaissance data. The array includes the Samos Vehicle, the launch complex, the operating bases and tracking stations, and the world-wide, ground-space communications network.

SUBSYSTEM—A combination of components that performs a single function or a number of related functions. A subsystem is interrelated with other subsystems to form a system.

S-BAND—Electromagnetic radiation in the radio-frequency range from 1550 mc to 5200 mc.

STORED PROGRAM COMMAND—A command stored within the Samos Vehicle and executed at some later time. Used to initiate an equipment function automatically.

TELEMETER—The function of measuring a quantity and transmitting the measurement to a station some distance away. Such measurements include those of temperature, pressure, velocity, and voltage. Also, an electronic instrument designed to perform this function.

THRUST CHAMBER—The combustion and expansion chamber of a rocket engine, in which propellants are burned to produce thrust.

ULLAGE—In a propellant tank, that part of the volume not occupied by propellant.

GLOSSARY (Continued)

UMBILICAL—Connections that allow fluids and electrical signals to flow between a vehicle and the ground support equipment at the launch complex.

UHF—Ultra high frequency. Electromagnetic radiation in the radio-frequency range from 300 mc to 3000 mc.

UDMH—Unsymmetrical dimethylhydrazine; a fuel propellant.

VHF—Very high frequency. Electromagnetic radiation in the radio-frequency range from 30 mc to 300 mc.

VERNIER ENGINES—Two rocket engines of the Samos Booster that perform two functions: control of Samos Vehicle attitude, and adjustment of Samos Vehicle velocity before separation.

YAW—Motion of the satellite about the reference yaw axis.

ALPHABETICAL INDEX

Systems and major headings concerned with the Samos System are listed alphabetically in the following index. Items in the index are listed in alphabetical groupings under each system or major heading and correspond to titles and subjects covered in the manual.

As an example: To find information on the Missile Service Tower, first look up POINT ARGUELLO LAUNCH BASE under the major heading of OPERATING BASES, CENTERS, AND STATIONS; under the Launch Base listing, find the Launch Pad and Service Building group, and the Missile Service Tower is listed in alphabetical order in that group.

Cross references are listed throughout the index and refer to major headings and groups. An asterisk (*) preceding a listed item indicates the location of an illustration.

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