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LM SYSTEM DESCRIPTION

The following sections describe the major systems of the Lunar Module.

COMMUNICATIONS SECTION

The Communication Subsystem is made up of redundant 3-band transceivers and power amplifiers, redundant VHF transceivers, and signal processing equipment with associated antenna systems. These equipments provide the following capabilities: (1) S-band for transmission of PCM telemetry, TV, voice, emergency key and range data between LM and earth; (2) VHF for linking LM and Command Module, and the LM and astronaut of the lunar surface; (3) VHF telemetry capability from LM to Command Module on the far side of the moon; (4) EVA (Extravehicular Astronaut) link to earth via VHF/S-band relay.

PROPULSION SYSTEM

The LM spacecraft uses separate descent and ascent propulsion systems, each of which is complete and independent of the other. Each consists of a liquid-propellent rocket engine with its propellant, storage, pressurization and feed components. The descent propulsion system is contained within the descent stage and uses a throttleable, gimballed engine that is first fired to inject the LM

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spacecraft into the descent transfer orbit. It is then used in the final descent trajectory as a retrorocket to control the rate of descent and to enable the LM to hover and move horizontally. The ascent propulsion system is contained within the ascent stage and uses a fixed, constant-thrust engine to launch the ascent stage from the lunar surface and place it into lunar orbit. The ascent engine can also provide any gross orbit adjustments that may be necessary for rendezvous with the Command Service Module (CSM).

Both propulsion systems use hypergolic propellants consisting of a 50-50 fuel mixture of hydrazine (N_2H_4) and unsymmetrical dimethylhydrazine (UDMH) with nitrogen tetroxide (N_2O_4) as the oxidizer. The mixture ratio of oxidizer to fuel is 1.6 to 1 by weight, at injection. In both stages, the propellants are fed from tanks, with helium as the tank pressurant.

The descent propulsion system consists of two fuel and two oxidizer tanks with the associated propellant pressurization and feed components, and a throttleable rocket engine that develops a maximum thrust of 9710 pounds and can be operated at any power setting down to a minimum thrust of 1050 pounds. The engine can also be shut down and restarted as required.

The engine is mounted in the center compartment of the descent stage cruciform, suspended at the throat of the combustion chamber on a gimbal ring which is an integral portion of the engine assembly. The gimbal ring is pivoted in the descent stage structure along an

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axis normal to that of the engine pivots so that the engine can be gimballed 6° in any direction by means of gimbal drive actuators to provide trim control in the pitch and roll axes during powered descent.

The ascent propulsion system uses a fixed, constant-thrust rocket engine installed along the center line of the ascent stage midsection and includes the associated propellant supply components. The engine developes 3500 pounds of thrust, in a vacuum, sufficient to launch the ascent stage from the lunar surafce and place it into orbit. Two main propellant tanks are used, one for fuel and the other for oxidizer. The tanks are installed on either side of the ascent stage structure. The propellant supply sections in this system include provisions for fuel and oxidizer crossfed to the reaction control system as a backup propellant supply for the latter.

GUIDANCE, NAVIGATION AND CONTROL SYSTEM

The Guidance, Navigation and Control (GN&C) system provides the measuring and data processing capabilities and control functions necessary to accomplish lunar landing and ascent, and rendezvous and docking with the Command/Service Module (CSM). The GN&C system comprises two functional loops, each of which is a completely independent guidance and control path. The primary guidance path performs all functions necessary to complete the LM mission. If a major failure in the primary guidance path necessitates mission abort, the abort guidance path performs all functions necessary to

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effect a safe rendezvous with the orbiting CSM.

The primary guidance path comprises a Primary Guidance and Navigation Section (PGNS) and a Control Electronics Section (CES). The PGNS is an aided inertial guidance section whose principal aids are the Landing Radar (LR), the Rendezvous Radar/Transponder (RR/T), and the Alignment Optical Telescope (AOT). The CES processes the guidance and navigation data from the PGNS and applies them to the descent engine, the ascent engine, and selected RCS jets.

REACTION CONTROL SYSTEM

The Reaction Control System (RCS) provides small rocket thrust impulses to stabilize the LM during descent and ascent, and to control the LM attitude and translation about or along all axes during hover, rendezvous, and docking maneuvers. The RCS consists basically of 16 thrust chamber assemblies supplied by two separate propellant pressurization and supply sections made up of parallel, independent systems (A and B). The 16 thrust chamber assemblies are mounted in cluster of four, the clusters being equally spaced around the LM ascent stage. Each of the clusters is fitted with a plume deflecting shield under the downward firing thrusters to prevent flame impingement on the descent stage surface.

The arrangement is such that two of the thrust chamber assemblies in each cluster are mounted parallel to the vehicle's X axis, facing in opposite directions (up and down); the other two are spaced 90° apart (one facing to the side, the other facing

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forward or aft) in a plane normal to the X axis. Two thrust chamber assemblies in each cluster are supplied by System A; the other by System B.

ELECTRICAL POWER SYSTEM

The Electrical Power System (EPS) interfaces with all major LM systems. Primary d-c power is provided by two storage batteries in the ascent stage, and by four storage batteries in the descent stage. Primary a-c power is supplied by two redundant solid-state inverters.

The Guidance, Navigation and Control System (GN&CS) uses d-c power from the EPS for operation of the Primary Guidance, Navigation and Control Section; the Abort Guidance Section; and the Computing and Radar Sections.

The Reaction Control System (RCS) uses 28-volt d-c power for activation of fuel and oxidizer valves that feed each of the thrust chamber assemblies (TCA's). Shutoff and crossfeed valves are used to interconnect lines between the ascent stage propulsion system and RCS.

The Main Propulsion System (MPS) uses 28-volt d-c power for operation of solenoid operated and electroexplosive valves that govern the flow and combustion of fuel and oxidizer required for ascent and descent engine operation. Primary a-c power is used for operation of the descent engine control assembly and the gimbal drive actuator.

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The Environmental Control System (ECS) uses 28-volt d-c power for activation of LM cabin pressurization and emergency oxygen valves and operation of the primary and secondary glycol coolant pumps that provide thermal stabilization and control of LM equipment and environment.

The Communication System (CS) uses EPS d-c power for operation of all CS voice, television and telemetry transmitting and receiving devices, which include the VHF section, the S-Band section transform input EPS power necessary for the operation of the S-Band radiofrequency power amplifiers and modulation equipment.

The Instrumentation System (IS) uses 28-volt d-c power for operation of IS timing equipment and the Caution and Warning Electronics Assembly (CWEA), which processes and routes LM systems status information to various audio and visual indicating devices.

ENVIRONMENTAL CONTROL SYSTEM

The Environmental Control System (ECS) interfaces with the Electrical Power System (EPS) and Instrumentation System (IS). It controls the atmosphere entering the cabin and Pressure Garment Assemblies (PGS's). It also provides coolant for the batteries, Electronic Replaceable Assemblies (ERA's) and instrumentation. The ECS interfaces with the EPS through the circuit breakers for activation of ECS components and controls and displays. The ECS interfaces with the IS through the controls and displays panels and

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the Explosive Devices System (EDS) through the explosive separations of umbilicals and hardlines of LM descent staging.

EXPLOSIVE DEVICES SYSTEM

The Explosive Devices System (EDS) interfaces with most of the LM systems. The EDS aids in landing gear deployment; pressurization of the RCS, descent engine and ascent engine; interrupts the electrical circuits during staging and provides the means of separating the descent and ascent stage, explosively, for a normal staging operation or for an abort.

Helium is used to pressurize the descent engine propellant tanks, ascent engine propellant tanks and reaction control propellant tanks. Helium isolation valves, after explosive initiation of these valves, provide the helium for the pressurization.

There are three circuit interrupters in the ascent stage, with two Apollo standard initiators, which when explosively initiated, remove all electrical power from the interstage umbilical and provide positive de-energization before the electrical umbilical is cut.

INSTRUMENTATION SYSTEM

Most all inputs to the instrumentation system (IS) are routed from surrounding system sensors. These sensors continuously check system status by sensing temperature, valve action, pressure, switch position, voltage, current, water quantity and state separation distance. These sensed data are changed into electrical signals and routed to the signal conditioning electronics assembly (SCEA),

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the pulse code modulation and timing equipment assembly (PCMTEA), and to the controls and displays. The SCEA converts all unconditioned system and transducer signals and events to proper voltage levels required by the PCMTEA, CWEA and controls and displays. The preconditioned parallel digital and high level analog data that is routed directly to PCMTEA for sampling is converted to one serial digital output signal for transmission to Manned Space Flight Network (MSFN) or CSM. Controls and displays also receive preconditioned data from system sensors and monitor system status with flag indicators or lights.

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