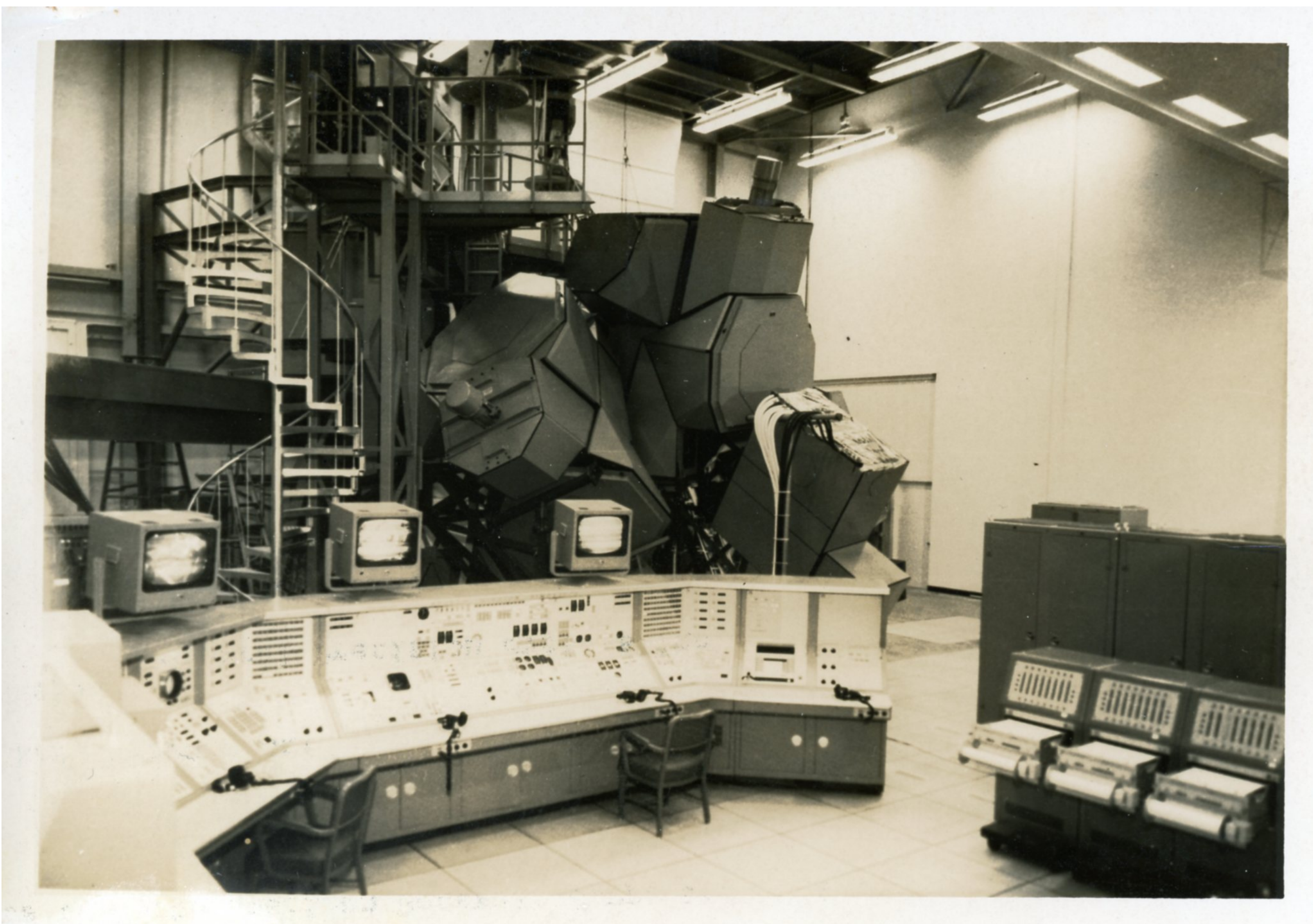
GENERAL PRECISION SYSTEMS INC.

LINK GROUP

Houston: U. S. astronaut John W. Young adjusts frontpiece in the Apollo Mission Simulator. The equipment, which will be used to simulate the mission, was built by Link Group of General Precision Systems Inc. under contracts to North American Rockwell Corp. and NASA. Partially visible in the photo are astronauts Thomas P. Stafford, left, and Eugene A. Cernan, right.

For further information:
Dan Walsh
Link Group, General Precision Systems Inc.
Nassau Bay Hotel
NASA Blvd., Houston, Texas



Houston: The Apollo Mission Simulator (AMS) was unveiled here today (Jan. 23, 1968) at the National Aeronautics & Space Administration's Manned Spacecraft Center. The equipment was built by Link Group of General Precision Systems Inc. under contracts to North American Rockwell Corp. and NASA.

For further information:

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Houston: U. S. astronauts, from left to right, Thomas P. Stafford, John W. Young and Eugene A. Cernan, are shown in the Apollo Mission Simulator at NASA's Manned Spacecraft Center. The equipment was built by Link Group of General Precision Systems Inc. under contracts to North American Rockwell Corp. and NASA.

For further information:
Dan Walsh
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Nassau Bay Hotel
NASA Blvd., Houston, Texas

Houston: U. S. astronaut John W. Young, wearing pressurized suit, is shown in the Apollo Mission Simulator, built by Link Group of General Precision Systems Inc. Partially visible in the photo are astronauts Thomas P. Stafford, left, and Eugene A. Cernan, right.

For further information:

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news release

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FOR ADDITIONAL INFORMATION: R. A. Lyons

For release January 23, 1968

ASTRONAUTS BEGIN FULL-SCALE TRAINING IN APOLLO AND LUNAR MISSION SIMULATORS

Houston: U.S. astronauts will begin full-scale training for the lunar mission in the Apollo and Lunar Mission Simulators which were unveiled here today at the National Aeronautics & Space Administration's Manned Spacecraft Center.

The astronauts will spend hundreds of training hours in simulated flights prior to the first manned flight scheduled for later this year.

The Apollo Mission Simulators (AMS) were built by Link Group, General Precision Systems Inc., under contracts to the Space Division of North American Rockwell Corp. and NASA. The Lunar Mission Simulators (LMS) were made by Link under contract to Grumman Aircraft Engineering Corp. and NASA. Apollo and Lunar Mission Simulators have also been installed at NASA's Cape Kennedy facility.

Link's parent firm, General Precision Systems Inc., is a subsidiary of General Precision Equipment Corp., Tarrytown, N. Y.

- 30 -

INFORMATION ON
APOLLO MISSION SIMULATOR
&
LUNAR MISSION SIMULATOR

Before the Apollo astronauts leave for their first mission to the moon, they will be old hands at making the trip.

They will have spent hundreds of training hours in simulated flights prior to the mission and will have learned, in detail, all aspects of the mission in the Apollo Mission Simulator (AMS) and the Lunar Mission Simulator (LMS). The AMS simulator was built by Link Group of General Precision Systems Inc. under contracts to the Space Division of North American Rockwell Corporation and NASA, and the LMS to Grumman Aircraft Engineering Corp. and NASA. AMS and LMS complexes each have been installed at NASA's Houston and Cape Kennedy facilities.

The technical challenge of the manned lunar mission has presented the most advanced space undertaking ever attempted. Consequently, the training requirements for the astronauts, who must be familiar with every detail of both the spacecraft and mission, are phenomenal.

The interiors of the AMS and LMS are replicas of the actual spacecraft, containing all panels, controls, switches and equipment. The essential life-support systems are simulated and were designed so that a full 14-day lunar mission could be practiced realistically.

It is possible to simulate the entire mission beginning at T minus 60 seconds and including all phases - launch boost, earth orbit, translunar coast, lunar orbit, descent, lunar stay, ascent, rendezvous, docking, transearth coast and re-entry. Both visual and acoustical effects are simulated. Simulation is complete except for the sensations of weightlessness and the gravitational forces of launch and re-entry.

In the design of the simulators, Link places great emphasis on the formulation of mathematical models and computer programs to provide rigorous functional simulation of on-board spacecraft systems, the equations of motion, controls and displays as well as visual simulation.

The AMS employs four digital computers which have been integrated into a single complex to provide real-time simulation of all Apollo sub-systems. The LMS employs three computers. Each of the seven computers is capable of performing as many as 500,000 mathematical operations per second. The Apollo Mission Simulator computer complex contains 208,000 memory core locations and the Lunar Module Simulator complex, 180,000. Computer solution rates as high as 20 times per second are provided when required.

Each Link simulator is programmed to provide normal, emergency and abort flight conditions. Over 1,000 training problems can be inserted into the simulated spacecraft systems with a Malfunction Insert Unit, thus enabling the crew to prepare for nearly every type of emergency situation. The computers also generate telemetry information in actual mission format for transmission to ground station equipment.

Precise computation of trajectories, orbits and re-entry corridors are extremely important to the success of the mission; hence, these are some of the most exacting aspects of the simulation. To provide such accuracies, the computers are programmed to determine the effect of even minor variations in earth, sun and moon orbits relative to the projected flight of the spacecraft. The simulators are tied in with the Mission Control Center in Houston by way of the Simulation Checkout and Training Systems (SCATS). Thus, the complete Apollo Mission from lift-off to final earth re-entry can be realistically simulated.

Simulator Master Control allows instructors to choose from several modes of operation. In addition to the normal operating mode, there are three other primary modes - problem reset, step ahead and problem freeze.

The problem reset mode enables the instructor to initialize or return the trainer to a predetermined mission point. The step-ahead mode allows the simulator to operate at nearly 30 times its normal speed so that certain portions of the mission during which there is little astronaut activity can be accelerated if they do not have to be emphasized. Problem freeze enables the mission to be stopped and restarted at any point in real-time during the simulated flight.

The AMS and LMS visual systems, each of which contains over five tons of lenses and curved glass, present realistic external environments that change accordingly with the position of the spacecraft. Objects ranging from six feet to infinity are simulated. Separate units simulate the views seen through each of the four command module and three lunar module windows.

Both the AMS and LMS also have visual systems that simulate the telescope and sextant views, enabling the flight crew to make navigational measurements.

Presently, the simulator configuration is tailored to the first manned flight. After the training needs for that mission have been fulfilled, it can be updated for subsequent flights.

FACT SHEET

APOLLO MISSION SIMULATOR
&
LUNAR MISSION SIMULATOR

APOLLO MISSION SIMULATORS (AMS)

.. Built by Link Group, General Precision Systems Inc., under contract to Space Division of North American Rockwell Corp. and NASA.

.. Dimensions - 65 feet wide
103 feet long
30 feet high
40 tons — weight

.. Computers - Four DDP 224 digital computers with 208,000 word core memory. Solution rates up to 20 times per second.

.. Malfunction Insertion Unit - 1,000 malfunction capability.

.. Visual System - Five tons of glass - lenses and mirrors. Simulates objects from distances of six feet to infinity.

LUNAR MISSION SIMULATORS (LMS)

.. Built by Link Group, General Precision Systems Inc., under contract to Grumman Aircraft Engineering Corp. and NASA.

.. Dimensions - 60 feet wide
103 feet long
30 feet high
45 tons — weight

.. Computers - Three DDP 224 digital computers with 180,000 word core memory. Solution rates up to 20 times per second.

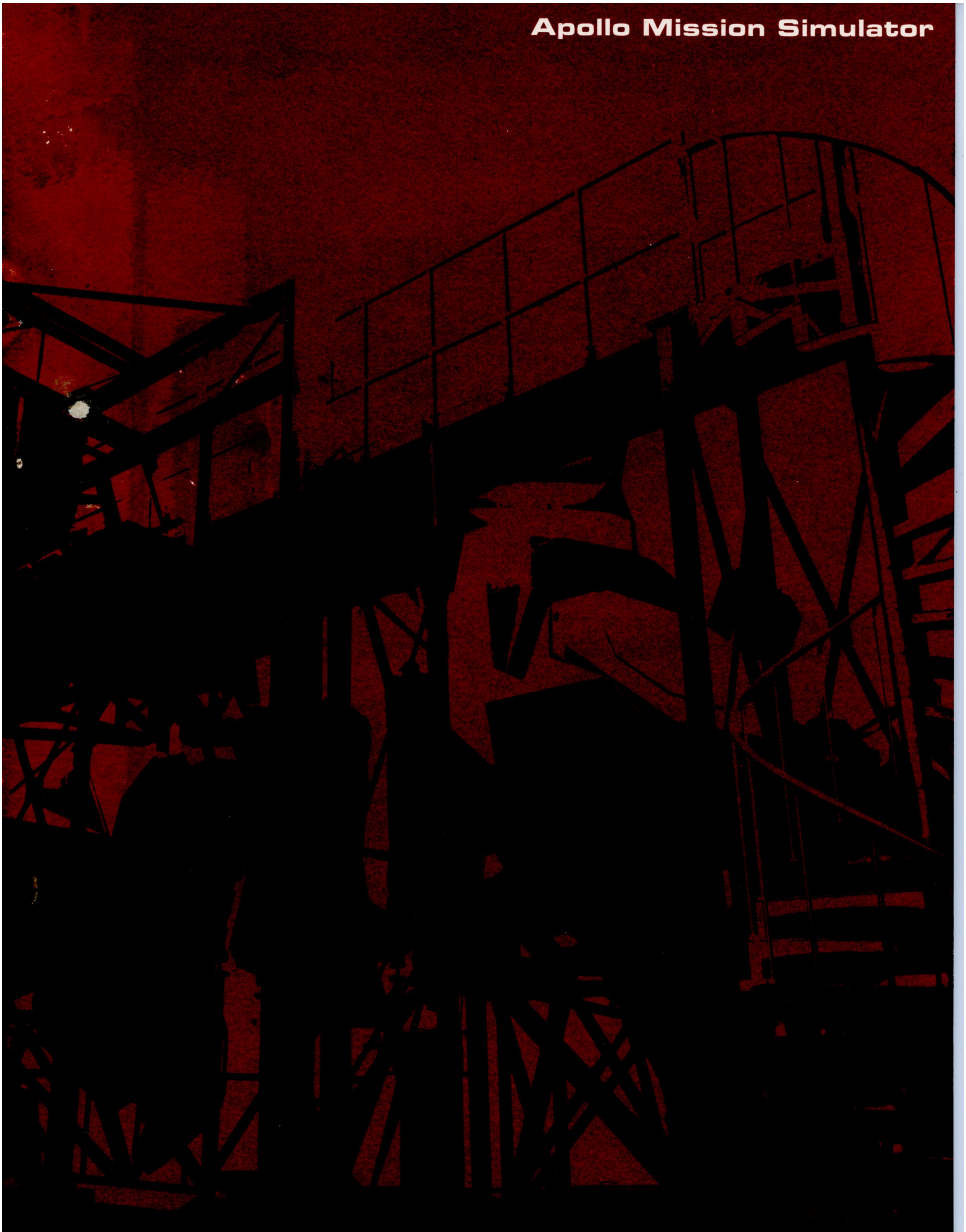
.. Visual System - Five tons of glass - lenses and mirrors. Simulates objects from distances of six feet to infinity.

.. Landing Site Simulator - A three dimensional model, 16 feet in diameter, reflecting lunar terrain at a scale of 1,000 to 1.

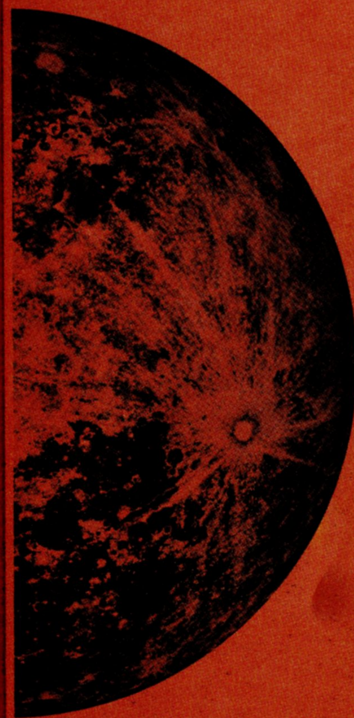
SUBCONTRACTORS ON APOLLO AND LUNAR MISSION SIMULATORS

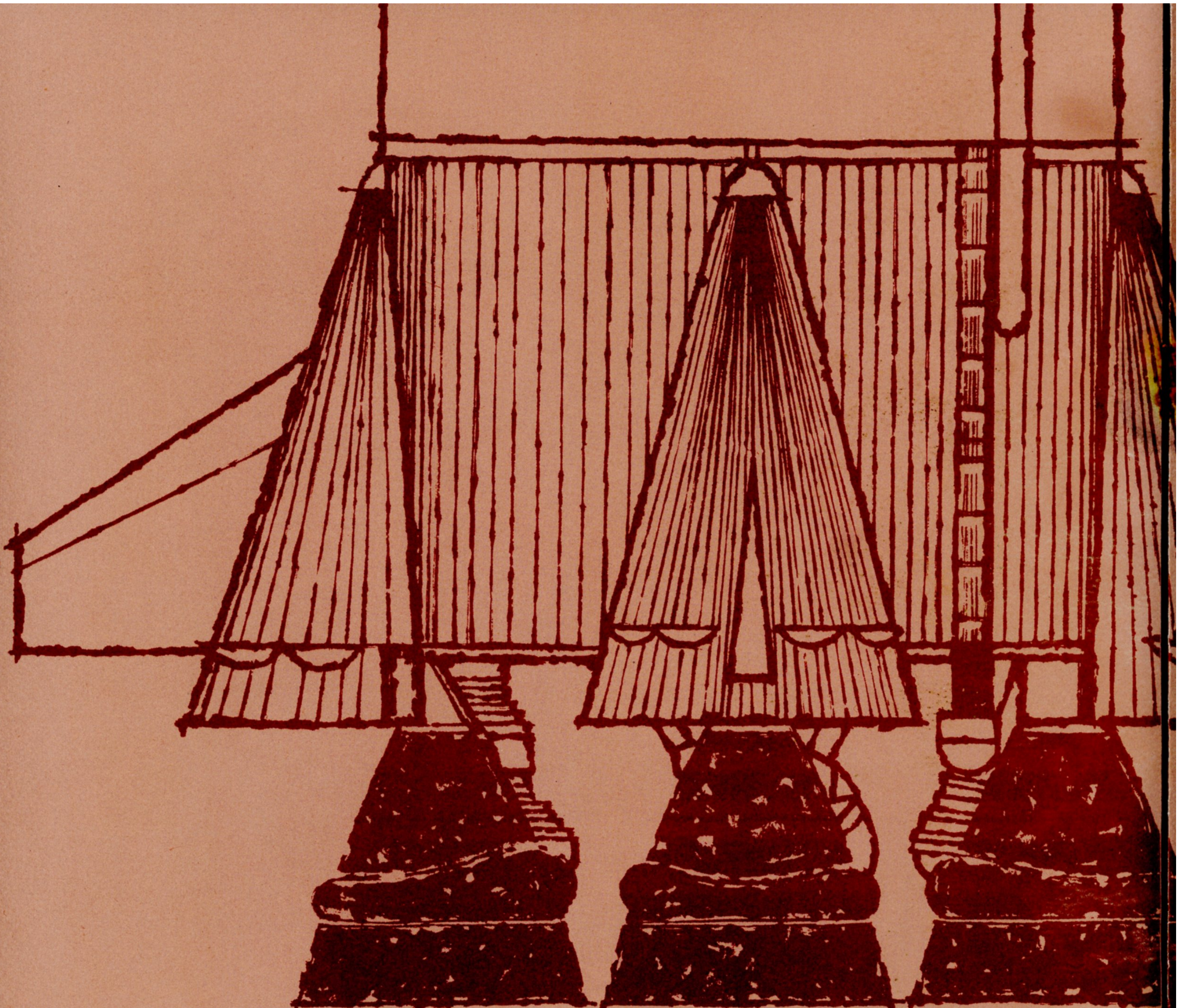
Of the more than 650 suppliers that Link Group of General Precision Systems Inc. utilized for the AMS and LMS programs, 70 per cent were small businesses of 500 employees or less. The major subcontractors are:

Collins Radio - Dallas	Communication & Data Systems Equip.
Computer Control Div., The Honeywell Corp.	Computer Systems
Con Serv Inc.	Lift Table
Control Data Corp.	Magnetic Tape Units
Decision Systems, Inc.	Diagnostics & Programming Services
Farrand Optical Company, Inc.	Visual Systems
General American Research Div., General American Transportation Corp.	Waste Management Support Assembly
Graflex, Inc.	Technical Services
Hughes Aircraft Co.	Engineering Services
Kollsman Instrument Corp.	Indicators
Librascope Group, General Precision Systems Inc.	Slide Frames, Digital to Resolver Converters
Liskey Aluminum, Inc.	Raised Mooring
North Atlantic Industries	Digital to Resolver Converters
Opcalite	Special Electroluminescent Panels
Patwin Electronics	Circuit Breakers
Photics Research Corp.	Moon Scenes, Earth Slides
Paul Rosenberg Associates	Technical Consultation
Simmonds Precision	Flight Instruments
Thomas Electronics	Special Cathode Ray Tubes
Wilding, Inc.	Special Graphic Art Work and Film


Apollo Mission Simulator

Sometime prior to 1970, it is expected that the U.S. goal of an American on the moon will be realized. The magnitude and implications of such a journey far surpass any past adventure of the human race. For the first time, man will leave his home planet and set foot upon another world. In his venture into the unknown, he will undoubtedly face various unexpected events. However, many aspects of the flight will be very familiar, they having been rehearsed many times in the Apollo and Lunar Module Mission Simulators produced by the Link Group of General Precision, Inc. Two Apollo Mission Simulators (AMS) are being built under contract with the Space and Information Systems Division of North American Aviation. One unit will be used at the Manned Spacecraft Center—Houston, Texas and another at NASA Kennedy Space Center.





The actual Apollo mission requires lifting about 45 tons of equipment into lunar orbit, which means that this mass must be accelerated to about 24,200 miles an hour, the speed necessary to escape earth and enter the gravitational field of the moon. To accomplish this feat, a launch vehicle composed of three stages, first (S-1C), second (S-II), and third (S-IVB), will support the Instrument Unit, Lunar Module, and the Apollo spacecraft. The Instrument Unit houses the launch vehicle's guidance and control systems. A Command Module, Lunar Module and Service Module make up the Apollo craft. Assembled and fueled, the three-stage rocket will weigh 3,000 tons, about the weight of the nuclear submarine Nautilus.

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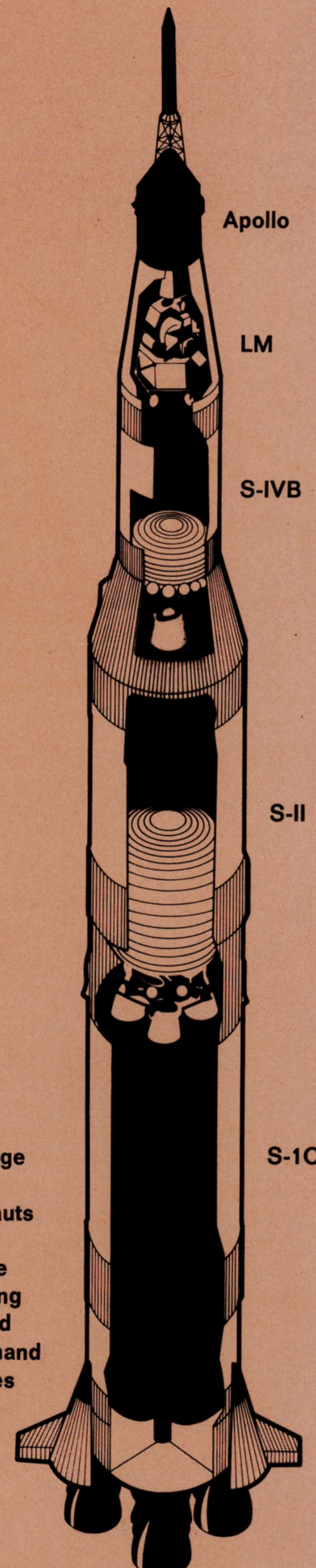
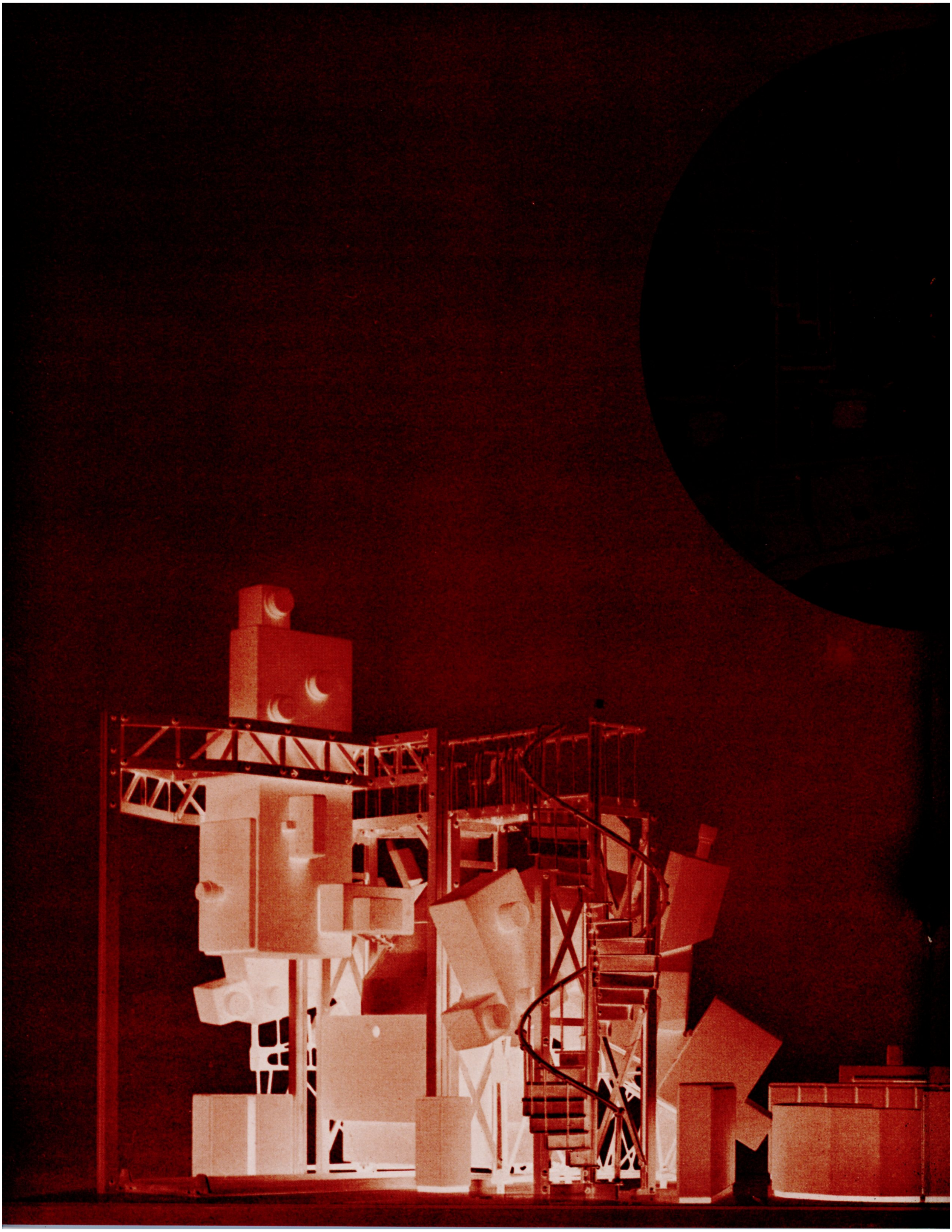
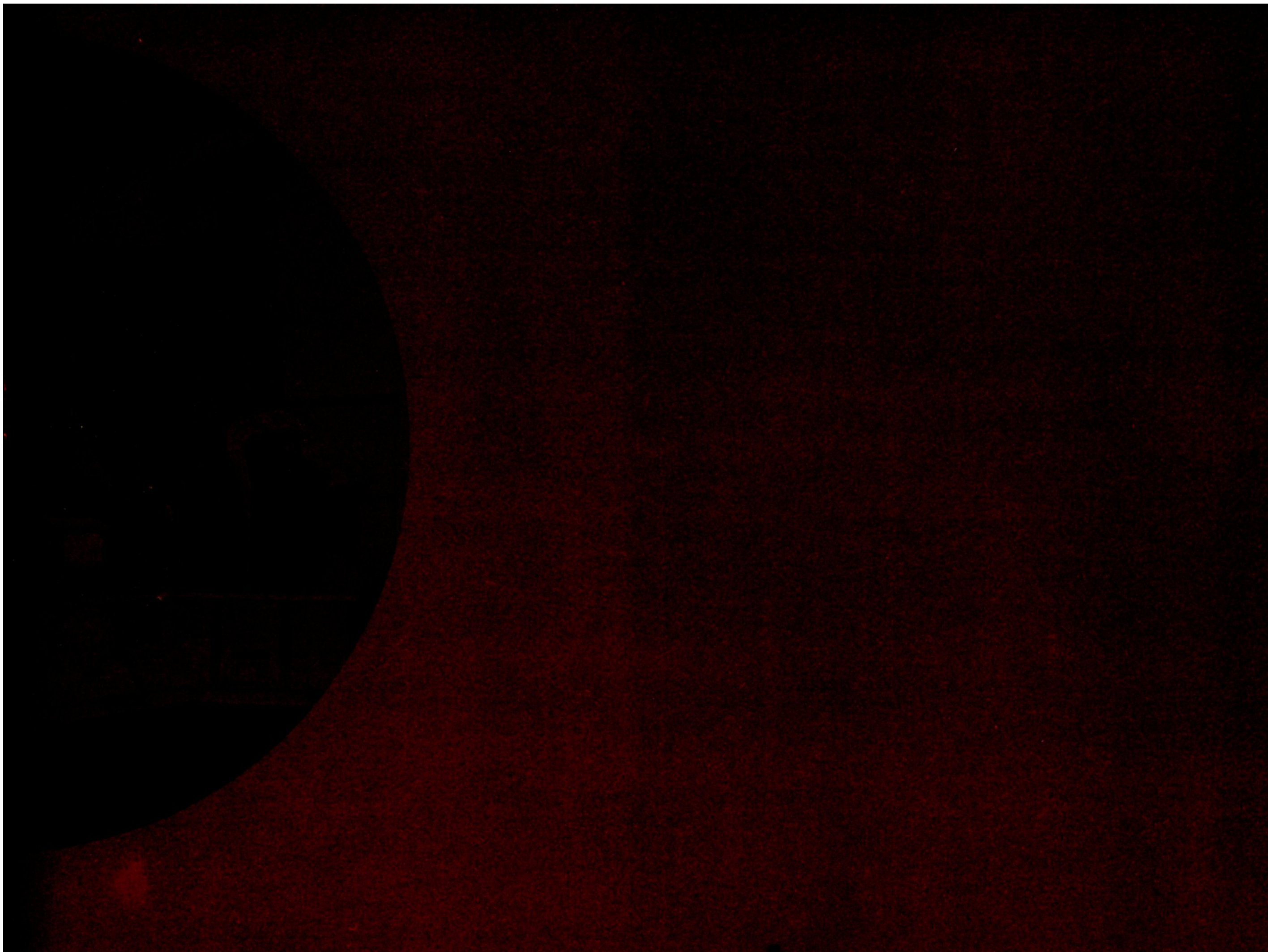
The first two Saturn stages (S-1C and S-II), developing 7.5 and 1.0 million pounds of thrust, respectively, will place the Saturn Apollo system on the threshold of earth orbit. Firing for a duration of approximately 2.5 minutes with a thrust of 200,000 pounds, the third stage will provide the final thrust to place it, the Instrument Unit, Lunar Module and the Apollo spacecraft into earth orbit.

After one to three orbits, the third stage will re-ignite placing the package on a trajectory to the moon. When the third stage is burned out, Apollo will separate from the rest of the package and be maneuvered through an 180-degree turn into position to dock with the Lunar Module/third stage combination. The third stage will then be jettisoned, leaving the Apollo spacecraft in the translunar trajectory. When about 220,000 miles from earth, Apollo will start to be significantly affected by the moon's gravity. Retrorockets are then used to slow Apollo's



travel towards the moon and to enter a circular orbit of about 80 miles above the lunar surface. In lunar orbit, two of the astronauts will enter the Lunar Module, disengage from Apollo, and proceed with the descent stage to the moon landing while the remaining astronaut continues in lunar orbit aboard Apollo. Fuel aboard the LM will allow the astronauts to hover above the moon's surface during which time they must make the critical decision of completing the landing or returning to the mother ship. Having landed and completed the assigned scientific and exploratory tasks, LM blasts off the moon, leaving behind the landing gear and descent stage. The astronauts in LM ascent stage then control its rendezvous and docking with Apollo, which has remained in lunar orbit, and transfer into the Apollo Command Module. The LM is separated and left in lunar orbit. The service propulsion engine provides the thrust necessary to propel the Service Module/Command Module combination out of lunar orbit back toward the earth. Engines of the Service Module provide the necessary control for course corrections during the 70-hour return trip. A critical part of their journey, their entrance into the earth's atmosphere must be accomplished within a predetermined corridor approximately 300 miles wide by 40 miles deep. When this has been accomplished, the Service Module is jettisoned and Apollo returns to earth.

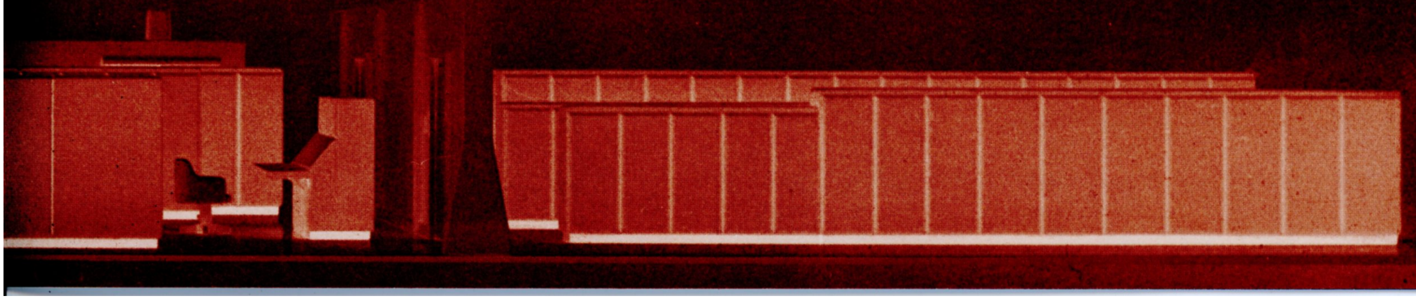




Training for this task is the design goal of the Apollo Mission Simulator. To fully satisfy these training requirements, the simulator must represent the actual mission conditions and the internal and external environment as closely as possible.

Visual simulation has particular significance in training for the Apollo Mission. The visual system must be able to simulate objects varying in distance from 6 feet (LM) to many light years (stars to the 6th magnitude). In addition, the images to be generated (sun, earth, moon, LM, clouds, etc.) must be varied in real time. On an actual mission, what the astronauts see depends on what action is taken. This creates a dynamic simulation task in which images must be projected upon four spacecraft windows located in various parts of the simulated Apollo Command Module and on a sixth unit which simulates the telescope and sextant views.

Computation, which is the basis of this type of simulation, is accomplished by a complex of several digital computers acting as a single unit. It provides, through mathematical models, real time simulation of all Apollo subsystems throughout the mission. By simulating the Saturn subsystems, it provides a realistic assessment of the launch-booster and translunar injection portions of the mission. Through the use of specially designed equipment and spacecraft flight hardware, it generates telemetry information in actual format for simulated transmission to ground station equipment. The computer adapts to changes in routines caused by malfunctions and other special inputs. Solution rates as high as 50 times per second are provided when required.



Three simulation engineers at the Simulator Operator Console use a variety of displays, indicators, and controls to operate the simulator, monitor crew action, provide cues for system management, direct crew action, insert malfunctions and initial conditions, and record flight parameters and crew reactions. Among the displays are duplications of all Command Module displays with indicators, lights and dials to indicate the positions of the spacecraft switches and controls. Means of communicating with the crew are provided, as well as means of television monitoring of the crew during simulated missions. In addition to the normal "Operate" mode, a "Problem Freeze" mode (holding all computing time) is programmed and can be inserted into the system at the Simulator Operator Console. If, during the training mission, a Simulator Engineer observes a point in the mission to which he wishes to return, he can store the necessary information onto computer tape.

The simulated command module is patterned after the actual spacecraft. Motion is not simulated physically, but the sensations are provided by the visual system. Realism of the mission is maintained by simulation of aural effects such as those of booster engine and thruster firings, pyrotechnic noises, and by the injection of smoke into the Command Module to simulate electrical fires or fires resulting from chemical reactions. To complete the realism, food storage, refrigeration, and water injection and food warmer equipment, as well as other life support equipment are provided.

Two modes of operation, integrated and non-integrated, are part of the simulator capability. In the integrated mode, the simulator, operating in conjunction with the Mission Control Center, is tied to another computer complex (the Ground System Simulation Computer), which is programmed to simulate portions of the ground support such as radar and remote sites. Actual Control Center equipment is used in this mode, providing training for both flight and ground crews. In the non-integrated mode, the Apollo Mission Simulator operates independently of any ground personnel or support equipment. Its aim is to train only the flight crew by familiarizing them with the vehicle and its operation. In this mode, the simulator engineer must portray the ground crew to provide realistic responses to queries.

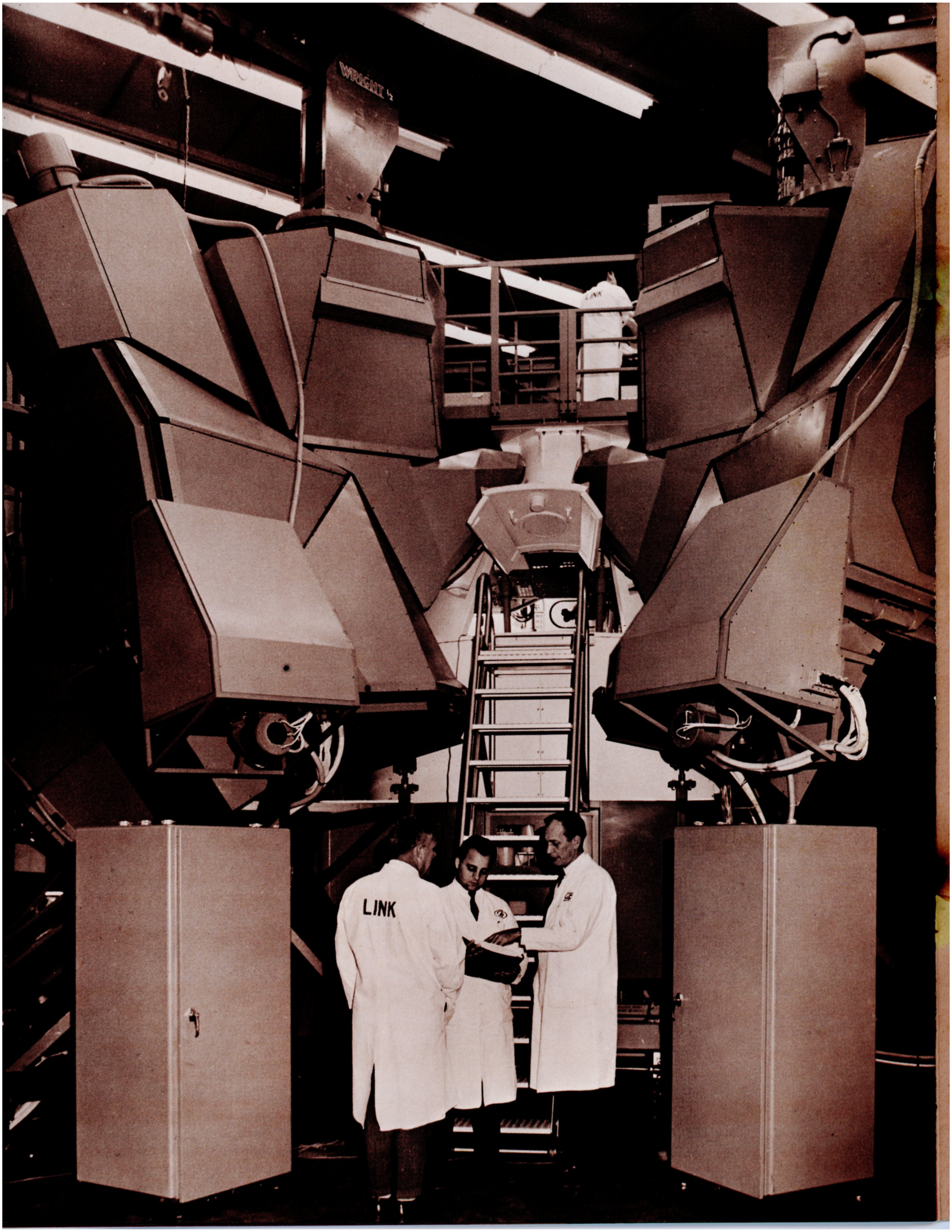
Simulator training not only monitors astronauts' physical reactions to abnormal situations, but also greatly ex-

pands their judgment capability. Most of the simulated malfunctions are of such a nature as to require an "abort or continue" judgment. Others will create automatic aborts which provide abort task training.

During the launch-boost phase, the astronauts will be primarily concerned with the tasks of monitoring and analyzing booster performance. Included in these tasks will be the monitoring of booster-engine ignition sequences, status, cutoff, and stage separation. Also included are monitoring of liftoff, pitchover, jettisoning of the launch escape system, and the emergency detection system displays and indicators. The crew will be required to analyze, through command module displays, the vehicle's trajectory, position, and velocity. They must also maintain communications with the ground computers. Communications with the ground is important, as the abort-continue decision is a cooperative decision in most cases. The ground personnel will be quite busy fulfilling their portions of the responsibilities. They will maintain communication with the spacecraft to relay vehicle performance data and make recommendations based on tracking data as well as performance.

Failure of two booster engines on the same stage, excessive vehicle rotation rate, or failure of the launch vehicle guidance system are malfunctions causing automatic aborts. In these cases, the astronauts will be trained to recognize the situations and prepare themselves for return to earth. However, the failure of a single booster engine (a malfunction which can be inserted at random) is not an automatic abort situation, but it will affect the vehicle's performance and it is this type of situation which requires the crews to exercise "Abort or Continue" judgment. It is here that the simulator's value is at its highest. Malfunctions of the booster vehicle control system and spacecraft systems such as electrical power, environmental control and communications will also require quick decisions from the astronauts. The results of their actions can be immediately evaluated. They will have the advantage of learning from mistakes and the opportunity to continually repeat the simulation of the phase until they are capable of meeting and overcoming any situations that threaten success of the critical first phase.

During the earth orbit phase, the astronauts will be most concerned with orienting the spacecraft for alignment of the Inertial Measurement Unit, orbital navigation sight-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ings, and translunar injection.

Frequent simulation gives the astronauts proficiency in making orbital navigation sightings. The spacecraft telescope provides 1X magnification and a corresponding 60-degree field of view. Directed scanning of a circular field of 200-degrees or scanning resulting from spacecraft attitude changes are simulated by driving scenes past the telescope aperture with a gimballed earth-moon-cloud-cover projection system and/or gimballed celestial sphere mechanism. The spacecraft sextant is slaved to the telescope. When a selected landmark or navigational star is acquired by the telescope and after it is centered in the telescope field of view, it will appear in the narrow field of the sextant. The astronaut then shifts attention from the telescope to the sextant eyepiece to complete the navigation task.

During the earth orbit phase, the astronaut in the simulator would use the telescope to scan the terrain below for known landmarks as navigational checkpoints. The image generating and display system would provide a continuously changing scene of the earth below with changing cloud cover synchronized with the orbital rate. Cloud cover may obscure some of the checkpoints requiring the use of alternates, as may occur in the actual mission. Having selected a checkpoint, the astronaut may switch to the sextant for an accurate determination of the angle between the checkpoint and a known star. Continuous training with emphasis on the use of alternate navigational reference points will increase the astronaut's proficiency in navigational sightings.

During this earth orbit phase, the astronauts will also monitor the performance of the third stage Thrust Vector Control and Propulsion Systems. During this phase, they will continuously use the third stage's Auxiliary Propulsion System for attitude control. Fuel management under normal and abnormal conditions is an important lesson to be learned from this phase of the simulation.

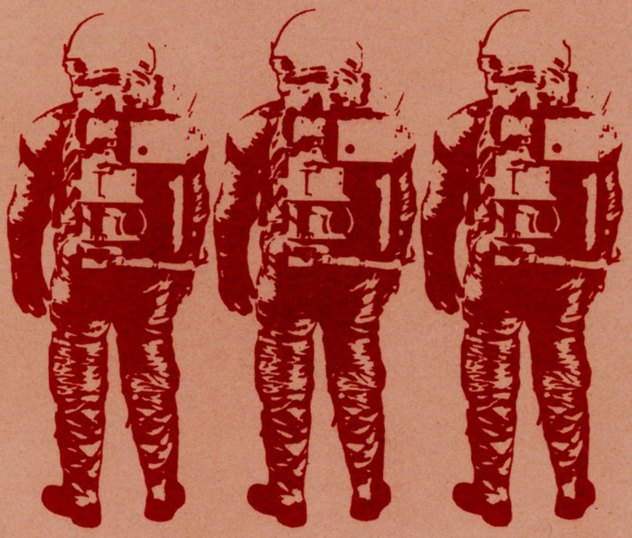
In simulation of the translunar trajectory, the Apollo Mission Simulator becomes unique. Simulation of the spacecraft systems and the selective insertion of malfunctions will serve to expand the capability and sharpen the acuity of the crew to a greater extent than in the previous phases. In the translunar phase, with the Instrument Unit stage and its guidance system gone, the Apollo will rely on a single guidance system with only ground based backup. This system must be monitored very closely since relatively minor errors can cause major changes in trajectory parameters with possibly disastrous consequences. The judgment of the crew will be constantly required in evaluating the status of the Apollo vehicle and its systems.

With the translunar trajectory and lunar orbit successfully achieved, the astronauts will be prepared to carry out their remaining duties via both the Apollo and the LM Mission Simulators. Upon completion of lunar landing and surface exploration, the remaining phases of the mission involve ascent of the simulated LM from the moon's surface, rendezvous and docking with the orbiting Apollo, return to earth orbit, and re-entry. Each task must be learned to ensure success of the mission.

Each of the different actual Apollo missions, culminating in a manned landing on the moon, has a different objective. As a result, the Command Module for each mission objective will entail a certain number of modifications. Similarly, the simulated Command Module will have to reflect those modifications. The configuration presently in use is not that of the one which will take the astronauts to the moon, but represents a typical earth-orbital vehicle and has all of the functional displays and controls that the actual first manned vehicle will have. The simulator will be updated for each airframe configuration corresponding to the vehicle used for each mission objective. This, in turn, involves changing some of the on-board systems and hardware.

The simulators are therefore designed with extreme modification flexibility. The computer complex is readily adjustable to changing mission objectives which require a change in a Command Module subsystem. Any alteration of a particular system or of a mathematical model is programmed and fed into the computer. No variation in the computer hardware itself is required.

The Apollo Mission Simulator has another built-in feature which permits changes to be made quickly. Should a modification be so great that it is impractical to modify an existing simulated Command Module, it can be replaced by another. The simulated space vehicle is mounted on rails to facilitate removal. The old vehicle can be rolled off and a new one rolled into its place. The required updating is thus accomplished with a minimum loss of astronaut training time which is a critical factor in the Apollo program.



While it is the object of the Apollo program to put a man on the moon, the mission is completed only when the crew has safely returned to earth. The National Aeronautics and Space Administration has taken the position that mission simulator practice and experience is required for flight crew and Mission Control Center personnel before a launch is possible. This view is taken with regard to the preparedness and safety of all concerned in the mission and can be accomplished through continuous rehearsing in the Apollo Mission Simulator. ☆

GENERAL PRECISION INC.

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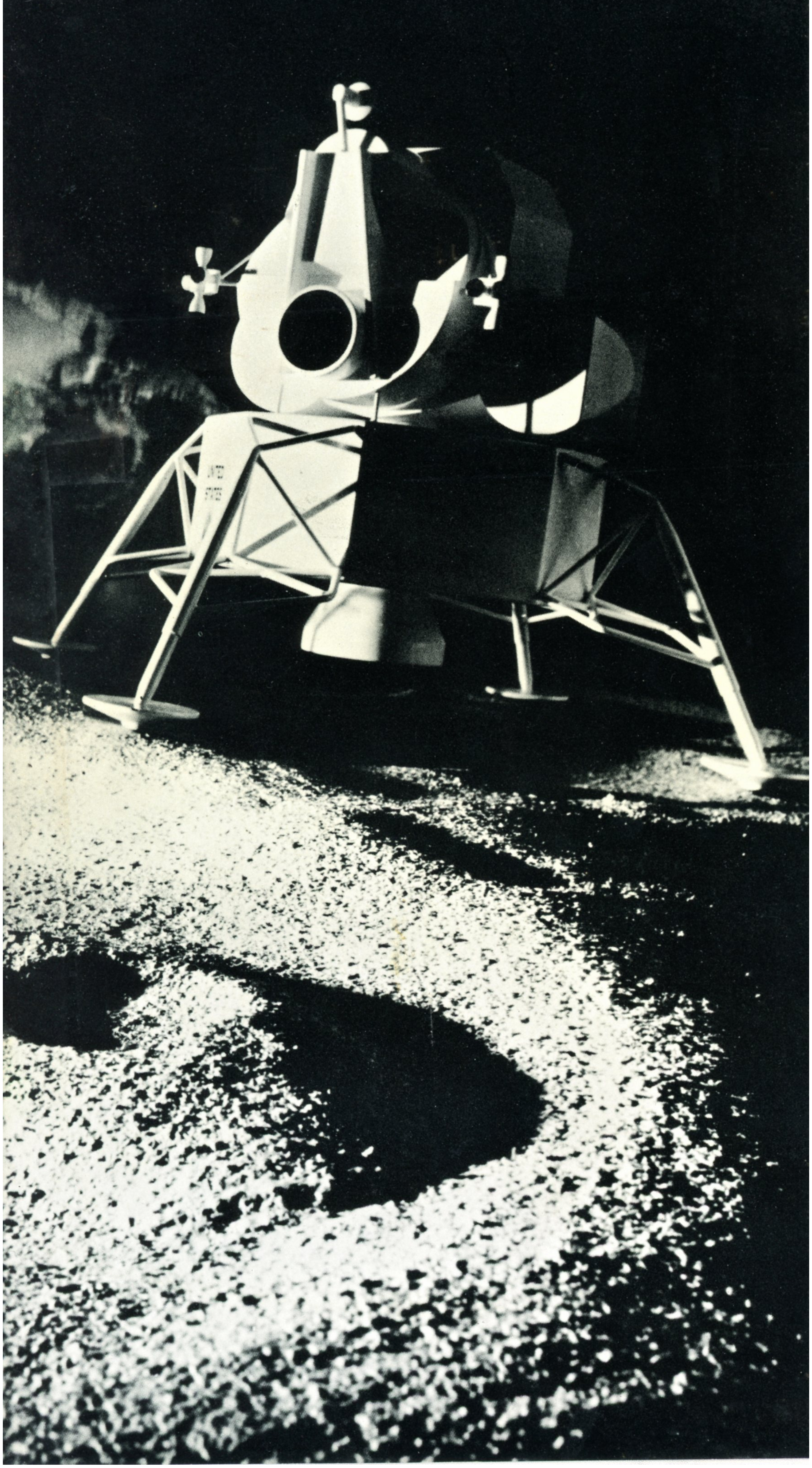
Lunar Module Mission Simulator



SOMETIME prior to 1970, it is expected that the U.S. goal of an American on the moon will be realized. The magnitude and implications of such a journey far surpass any past adventure of the human race. For the first time, man will leave his home planet and set foot upon another world. In his venture into the unknown, he will undoubtedly face various unexpected events. However, many aspects of the flight will be very familiar, since they will have been rehearsed many times in the Lunar Module Mission and Apollo Mission Simulators produced by the Link Group of General Precision Systems Inc.

The actual landing of the astronauts on the moon will be effected by a vehicle known as the Lunar Module (LM), which will be put into lunar orbit together with the Command Module. Although this vehicle is designed exclusively for transport of the astronauts, it differs in various ways from the Command Module, particularly in the shape. It is the first manned U.S. spacecraft designed to operate exclusively in the space environment. As a result, it was not necessary to take aerodynamic factors into account in the design; and as the landing of the vehicle will not be made by parachute but by use of a rocket motor, the shock-absorbing parts of the vehicle are of an entirely different design. The basic concept, however, remained the same: all parts no longer of use are to be jettisoned. The lunar landing vehicle was therefore separated into a descent stage and an ascent stage. The former unit, which serves to brake and land the LM, remains on the moon; the latter stage is left in lunar orbit as soon as the two-man crew has transferred to the Apollo Command Module for return to earth.

After the Apollo spacecraft has been launched and is placed in lunar orbit, the spacecraft commander and pilot will enter the LM and check out its systems. From this point the astronauts will perform the mission as they have practiced it in the simulators built by Link Group.

LM separation from the Command and Service Module will take place during the latter part of the third lunar orbit, each complete orbit taking about two hours. The LM guidance and navigation system will be used to calculate the required velocity change, correct attitude, and time for engine firing for the descent to the moon's surface from the parking orbit.

The descent engine will be fired and the LM slowed down. Descent will be made to an altitude of about 50,000 feet above the lunar surface.

The LM will be guided into the lunar surface approach maneuver, which will begin at an altitude of 50,000 feet and a range of about 170 nautical miles from the landing site. During this maneuver, vector and attitude control will be automatically controlled by the LM navigation and guidance system.

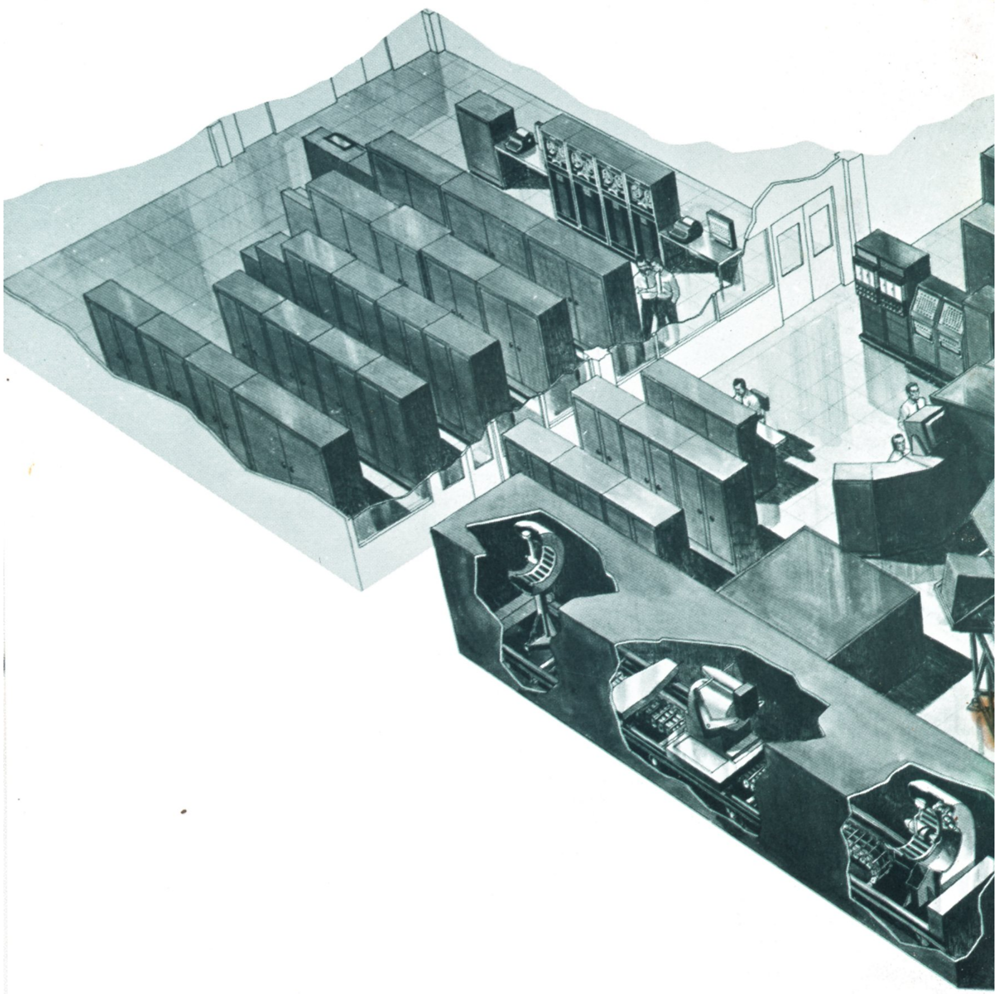
At the conclusion of the descent phase, a flare maneuver will bring the LM to a hover about 200 feet above the lunar surface. At the hover point, manual control of the LM will be assumed by the commander, who will select a desirable landing area. The LM will be manually landed on the moon.

After landing, the two astronauts will check out all of the LM systems necessary for lunar stay and prepare the LM for future launch. When surface activities are completed, the astronauts will coordinate launch plans with the astronaut who remained in the orbiting Command-Service Module, and start the countdown for ascent from the moon.

At completion of the countdown, the LM ascent engine will be ignited and the LM will lift off the lunar surface, leaving the descent stage behind. Launch and ascent of the LM into a lunar orbit at about 50,000 feet will be controlled by the LM navigation and guidance system. In this orbit, the LM will pass slightly behind the orbiting Command-Service Module combination at an altitude of about 80 nautical miles, and will accomplish all maneuvers necessary for rendezvous and docking while the Command-Service Module remains passive.

Once docking is complete, the commander and Lunar Module pilot will transfer back to the Command Module, the LM will be released to stay in lunar orbit, and preparations will be made for return to earth and reentry to the earth's atmosphere.

The Lunar Module Mission Simulator, produced under contract to Grumman Aircraft Engineering Corporation, is a complex consisting of the crew station, instructor station, equipment cabinets, and the Farrand-built external visual display system; all arranged to provide direct lines of personnel communication, computer communication, and ease of maintenance. The crew station and the instructor station are located in one room area, while the computer is located in another.

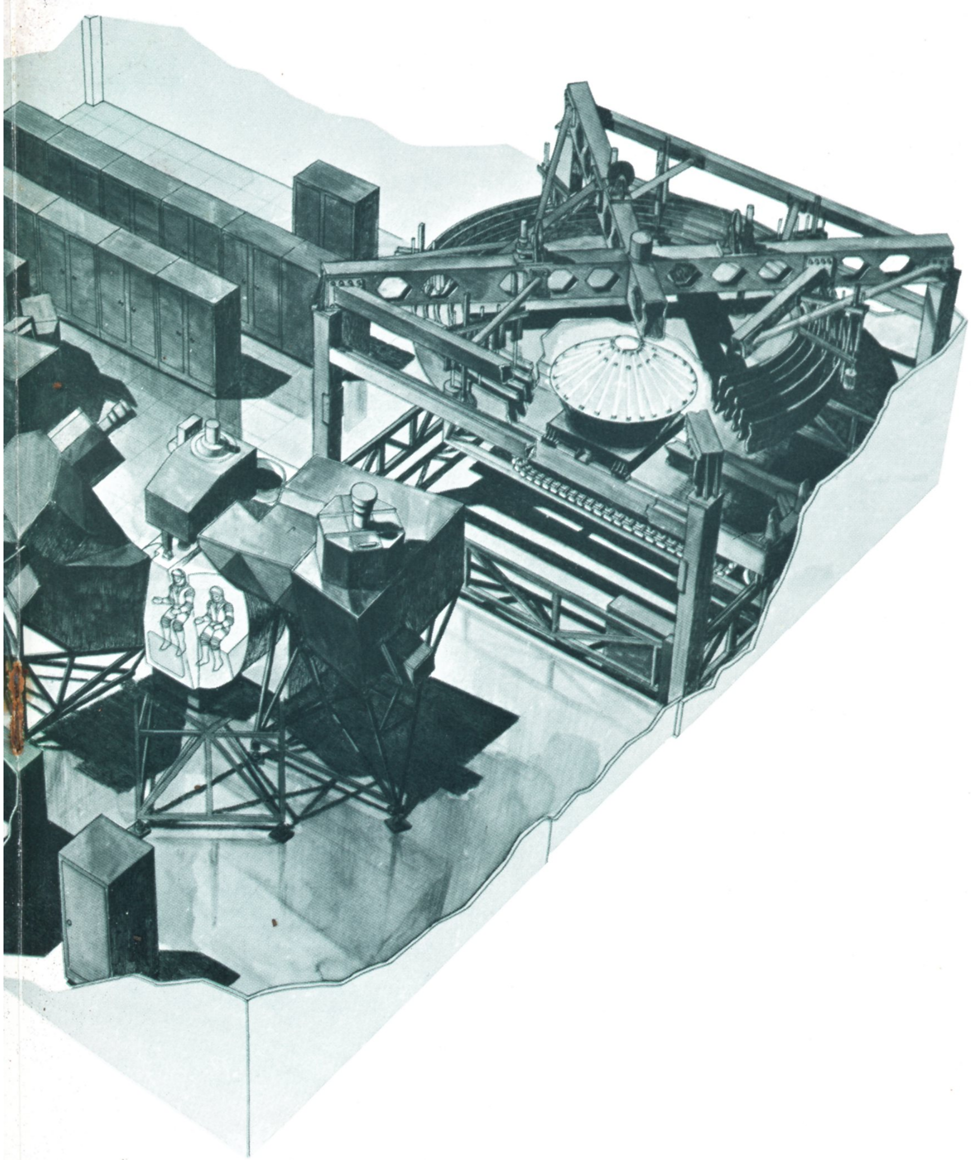


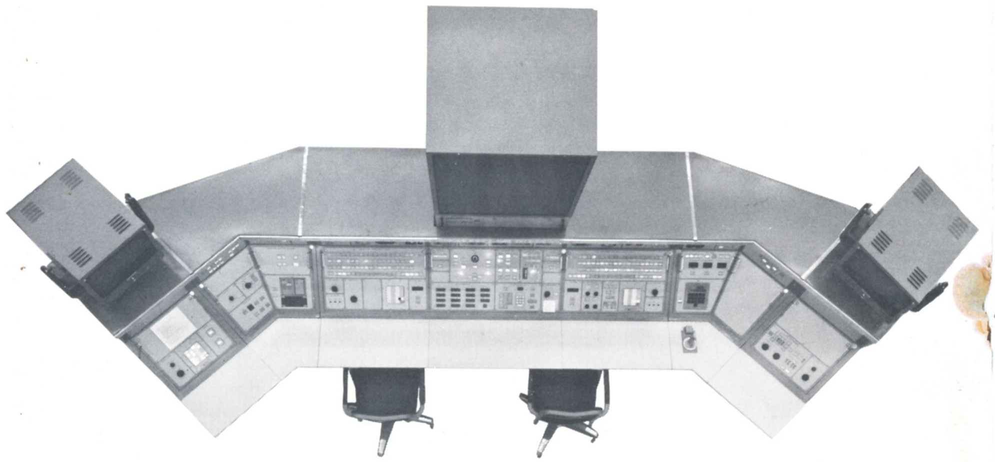
COMPUTATION SYSTEM

The single, most important hardware item of the entire simulator complex is the computation system. Three Computer Control Corp. DDP-224 computers are used, each expandable to 49,152 words and sharing a common block of 8,192 words of memory. The logic of each computer treats the common block of memory as if it were its own. Most inter-computer communication during normal operation is through the common memory.

A major feature of the basic system is that all high-speed, repetitive data transfers between any or all of the LMS computers and certain external points (i.e., Apollo Mission Simulator, Input/Output Conversion Equipment, Magnetic Tape Recorders) are all implemented by block transfers in the common memory through a fully-buffered channel. In this manner, data blocks being transferred out of the computer complex can be filled up directly by the three computers, and similarly, data blocks transferred in may be accessed by the three computers.

The digital peripheral equipment consists of four dual-magnetic-tape units, a card reader, a card punch, and a line printer. In addition, a typewriter and a control/maintenance console are standard equipment with the computers.





INSTRUCTOR STATION

The instructor station has been designed to accommodate five instructors. The use of an open arrangement allows freedom of movement for each instructor and clear viewing by observers, and provides for the addition of personnel if needed by future mission requirements. The station is provided with a spacecraft position indicator which consists of an optical-mechanical projection system with spot projectors to project trajectory traces. Spot projectors are used to indicate present vehicle position while background projectors provide the necessary mission-related information. The system uses rear projection on a 30- x 36-inch screen. The system offers simplicity—no requirement for electronic information storage, color, availability, flexibility, and ease in viewing from a console position.

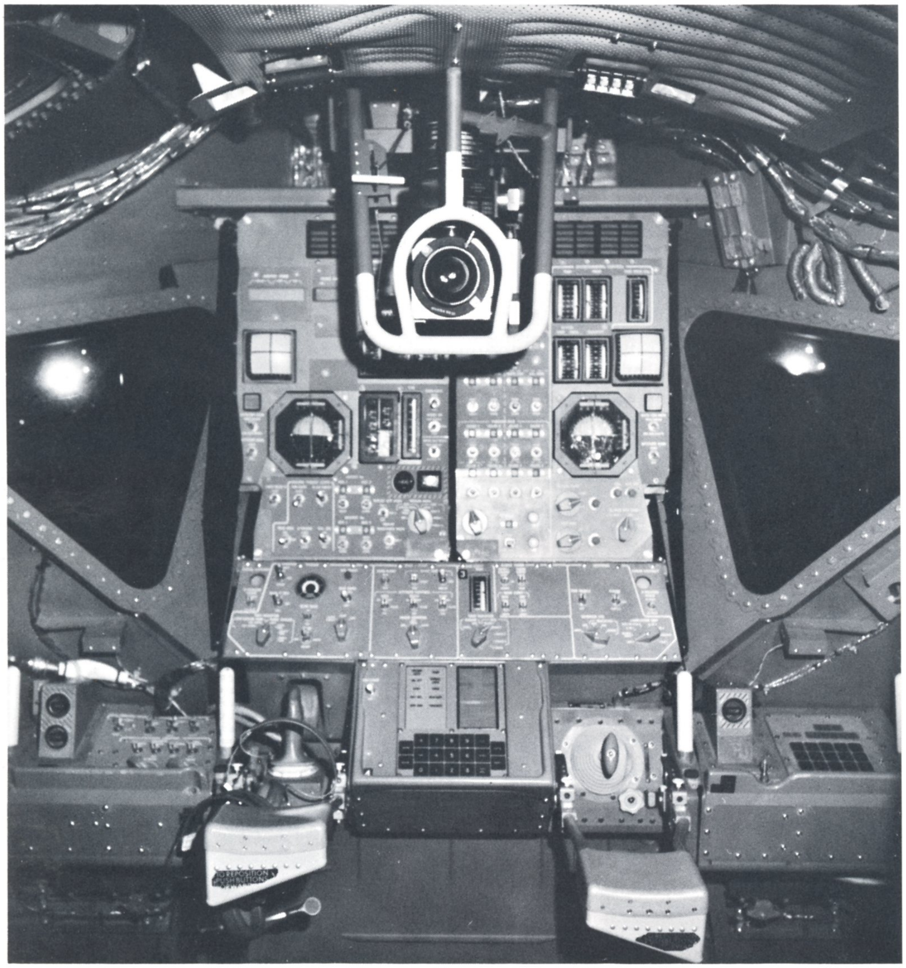
The telemetry operator is provided with a separate console located in a convenient relationship with respect to the instructor station. The telemetry operator has the capability to malfunction and monitor the various system parameters being converted to telemetry data.

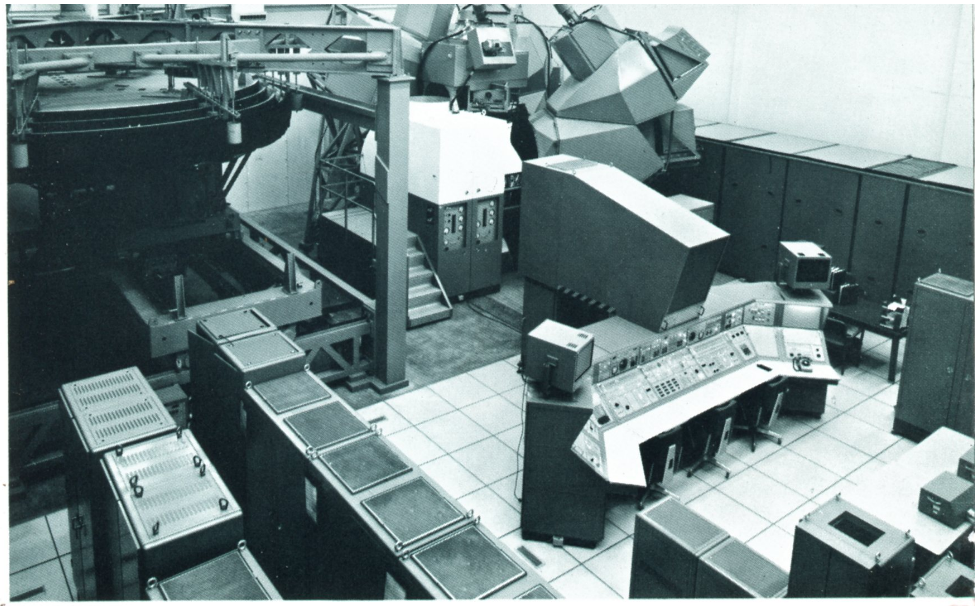
SIMULATOR CABIN

The LMS crew station is designed to meet the functional needs of the simulator while still retaining the characteristics of the Lunar Module spacecraft. The interior is an authentic replica of the LM-2 interior. The external configuration is coordinated with the visual equipment to provide an integrated training device. The interior of the crew station contains all items of equipment found in the actual vehicle. These items, as required for simulator performance, are either operational or mock-ups. The operational units are indiscernible in appearance, function, and response from spacecraft units. The mockup items are non-functional and are used for stowage practice or merely for general appearance. The simulator cabin is designed with Z axis horizontal. This places the astronauts in a standing position at their control stations as in the LM spacecraft.

VISUAL DISPLAY SYSTEM

The External Visual Display System for the Lunar Module Mission Simulator employs a combination of display techniques. Film, optics, models, and TV are used in appropriate combinations for presentation of lunar surface, earth, star-field, sun, and Command-Service Module. In many respects, the LM visual system is similar to those used in the Apollo Mission Simulators and the Air Force Space Flight Simulator.





SYSTEMS SIMULATION

The scope of the digital programs which are necessary to meet the LMS requirements is apparent in the following logical, but somewhat arbitrary, division into five types:

Mechanics—These are the programs for the equations which represent the effects of natural phenomena acting upon the spacecraft and the equations describing the mechanics of the spacecraft itself. These include such equations as those of motion, ephemeris data, the center of gravity, and inertia computations.

Simulator Effects—These programs are required to drive the simulator equipment which produces sensory effects such as visual displays and aural cues. The visual programs are closely related to the mechanics programs.

On-Board Systems—This large category includes the programs required to simulate all on-board systems: propulsion, reaction control, stabilization and control, navigation and guidance, electrical power, environmental control, communications, instrumentation, and pyrotechnics.

Simulator Control—These programs are necessary to control and operate the simulator. They include malfunction control, executive routines, on-line input and output for the digital peripheral equipment, on-line error detection, freeze and reset modes.

Interface—AMS, MCC—Certain programs are required to allow the LMS to operate in integrated modes. These programs generate the data necessary for transmission to the Command Module Simulator and to the Mission Control Center—when integrated missions are run.

SIMULATOR OPERATION

During a simulated mission, the instructor can change the operating mode from the "run" condition to one of several other modes. He might freeze the simulation—that is, essentially stop time—and discuss certain aspects of control or operation with the crew member and then return to the run condition. Mode control switching from run to freeze to run, from the computational standpoint, appears only as a hold in the time domain; when the computer is switched from the freeze mode to run, it continues all its computations with the conditions which existed prior to the freeze.

During some phases of the simulation, the instructor may put the computer complex in fast time. In this mode of operation, the translational equations are computed at a rate faster than real time, whereas the rotation equations are held constant. Such consumables as fuel and oxidizer will be used at a rate comparable to that which would be expected if the computation were done in real time.

The most important task confronting the instructor is the insertion of malfunctions in the simulation and evaluating the astronaut response. These failures will be inserted through the Malfunction Insertion Unit; the instructor will monitor the astronaut response on repeater instruments at the instructor console as well as the analog time history recorders.

During the course of the simulated mission, the instructor may be required to act as the astronauts communication link with the outside world. He will, in some cases, provide communications from the Command/Module, in others, from the ground station voice-links. The instructor is also expected to monitor a large number of status readouts (e.g., trainer environment, visual system data, aural system, power distribution system).

While it is the object of the Apollo program to put a man on the moon, the mission is completed only when the astronauts have safely returned to earth. The National Aeronautics and Space Administration is providing Command Module and Lunar Module Mission Simulators for the training of flight crew personnel before the actual launch is attempted.

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