

PHILCO CORPORATION

TECHREP DIVISION

MANNED SPACEFLIGHT CONTROL CENTER

MAINTENANCE AND OPERATIONS ACTIVITY

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PART I OVERALL DESCRIPTION OF THE MANNED SPACEFLIGHT CONTROL CENTER

1.1 PURPOSE OF THE MSCC

The MSCC, supported by a world-wide network of tracking and voice-data communications stations, provides centralized mission control of NASA manned space flight programs. MSCC functions include full mission control from launch through recovery, and technical management in the areas of vehicle systems, flight dynamics, life systems, flight crew activities, recovery support, and MSCC and GOSS (ground operational support systems) operations. (The GOSS network is composed of the aforementioned tracking and voice-data handling stations.) Initial planning calls for use of the MSCC during the Gemini and Apollo programs. Brief descriptions of these programs are included as attachments to the booklet.

1.2 PHYSICAL PLANT

The MSCC physical plant comprises buildings 30 and 48 of the NASA Manned Spacecraft Center. Building 30 is referred to as the MSCC building. Building 48 is the MSCC emergency power building. An underground utility tunnel, which is an extension of the MSC central tunnel system, connects buildings 30 and 48.

The MSCC building is a three-story structure consisting of a Mission Operations Wing, an Operations Support Wing, and an interconnecting Lobby Wing. The Mission Operations Wing (MOW) contains all the technical equipment and facilities required to support the mission control and monitoring functions of the MSCC. The MOW is equipped with two mission operations control rooms for detailed control of two missions simultaneously. Both may be real missions or one may be real and the other simulated. The Operations Support Wing (OSW) contains office, laboratory, and technical support areas for the NASA-MSC Flight Operations Division. The Lobby Wing provides an interconnection wing between the MOW and OSW and contains several offices, dormitory facilities, and technical support areas. The emergency power building is a single-story structure housing all standby electrical power, air conditioning, and ventilation facilities for exclusive use by the MOW. An electrical power substation pad, cooling towers, and a diesel fuel and oil storage area are located adjacent to the emergency power building.

1.3 FUNCTIONAL SYSTEMS

All MSCC equipments that contribute directly to the actual or simulated mission control capabilities of the MSCC are grouped into four functional systems; Communications System; Display and Control System; Simulation, Checkout, and Training System (SCATS); and a data processing system called the Real-Time Computer Complex (RTCC). These four systems incorporate all the technical equipment in the MOW with the exception of telephone termination and distribution equipment. The systems also include components, in the immediate vicinity, of mission simulators (Flight Crew Trainers), which are housed in a separate building.

The functional systems are composed of complex electronic or electro-mechanical equipment that enable the MSCC to communicate with spacecraft and the GOSS network, initiate commands, display large quantities of data in numerous formats, and to conduct simulated missions (in which all the preceding capabilities will be utilized, using simulated spacecraft, data, etc.). The equipment in each system is further grouped into subsystems, each of which performs a specific function(s).

1.4 OPERATION

The MSCC is the focal point for a world-wide manned spacecraft tracking, data acquisition, command, and voice communications network, called the GOSS network. During the course of a manned space flight mission, this network feeds quantities of information in various forms into the MSCC, the MSCC returns information back to the network, to maintain cognizance of the current status of a manned spacecraft and its occupants. A by-product of the exchange is the compilation of data for historical purposes and post-flight analysis.

There are five basic types of spacecraft data interchange required between the MSCC and the GOSS network: ephemeris, tracking, acquisition, telemetry and command. Ephemeris data giving the computed positions of certain spatial bodies for a given period of time are constantly transmitted to the Kennedy Space Center (KSC) through the prelaunch and launch phase of a mission. The guidance systems of launch vehicles require this data to achieve the proper trajectory for orbital insertion. Tracking data are obtained by following the spacecraft with tracking antenna and noting its spatial position and velocity. In this way, the exact position of the spacecraft is known at all times and may be predicted in advance. Acquisition data giving the computed point at which a particular tracking site should pick-up (acquire) and start tracking a spacecraft are sent to each tracking station. These data tell the station where to point its tracking antenna for initial pick-up of the spacecraft. Telemetry data are obtained by making selected measurements on the spacecraft crew members, life support systems, and vehicle systems throughout a mission and transmitting (telemetering) the measured data to data acquisition stations to the GOSS network. These data enable the MSCC Flight Controllers and associated specialists to monitor and analyze the performance of the Flight Crew and the spacecraft, since the normal parameter of each measurement is known and any abnormal deviation can be quickly detected. Some of the telemetered data are bi-level (on-off) event information that indicate the occurrence of certain events, which are normally scheduled to occur at a certain time during a mission. The Flight Controllers monitor the status (too early, too late, on time) of the events and initiate appropriate actions as necessary. At various times during a mission, it may be necessary to issue command data to control certain vehicle system functions. If so, the necessary command is initiated by the responsible Flight Controller (either at the MSCC or a GOSS network station) and transmitted to the spacecraft.

All ephemeris, tracking, telemetry, and command data are exchanged in digital coded form except selected biomedical telemetry measurements,

which are transmitted from certain GOSS stations to the MSCC over specially assigned audio lines in frequency-modulated form. All other telemetry measurements arrive at the MSCC in pulse-code-modulated form. The basic difference between the two is that the frequency-modulated data is frequency divided (each measurement occupies a different frequency band) and the pulse-code-modulated data is time divided (each measurement occupies different intervals of time). In the first case, each measurement is allocated to a different frequency band and all measurements are multiplexed at the GOSS station onto a single audio line for transmission to the MSCC. In the latter case, each measurement is allocated to different periods of time and binarily coded. The resultant time-multiplexed stream of "ones" and "zeros", which represent in binary notation the specific voltage levels of measured data, are fed onto a single wide-band data, high-speed data, or teletype line (depending upon the GOSS station) for transmission to the MSCC.

The pulse-code-modulated data transmission technique is used for telemetering all measurements including biomedical data from the spacecraft to the data acquisition stations. Then each station picks out the biomedical data and routes it to the MSCC in either frequency-modulated or pulse-code-modulated form depending upon the transmission capabilities of the station. All the other data, as indicated previously, are routed to the MSCC in pulse-code modulated form; whether it is routed over a wide-band data, high-speed data, or teletype line. Only the data acquisition station at the KSC is equipped with a wide-band data link to the MSCC. This link provides for almost instantaneous transmission of telemetry data on a real-time basis to the MSCC. Two stations, one located at Bermuda and the other at Corpus Christi, Texas, are equipped with high-speed data link to the MSCC. These links provide for near real-time transmission of all data, except biomedical telemetry data, to the MSCC. The biomedical data are routed over audio lines from these sites as well as the remaining sites of the GOSS network, which summarize and route all other telemetry data over teletype links to the MSCC.

During the launch phase of a mission, televised images of the space vehicle are transmitted from KSC to the MSCC. Also, at certain periods during the mission, selected televised images may be transmitted from the spacecraft via a tracking station equipped for television reception to the MSCC. These television signals are routed to the MSCC over video lines.

To accomplish its assigned functions, the MSCC requires numerous other types of information exchange between the GOSS network and certain governmental agencies, during a manned spacecraft mission. This information includes meteorological data, GOSS network equipment status, and status of recovery forces, to cite a few examples. A great deal of this information is obtained through voice communications with the appropriate station or agency. Teletype and facsimile message traffic between the MSCC and the appropriate station or agency satisfy all other information flow requirements.

All information comes into and leaves the MSCC over commercial common carrier communication lines. The communication lines are classed in five categories: wide-band data, high-speed data, teletype, video, and audio. The wide-band data lines handle the transmission of telemetry data exclusively. The high-speed data lines carry command, tracking acquisition, telemetry, and ephemeris data. The teletype lines carry command, tracking, acquisition, telemetry, and textual message traffic. The video lines transmit television signals only. The audio lines mainly handle voice communication interchanges between the MSCC, the GOSS network, and spacecraft. Specially assigned audio lines carry meteorological data to and from facsimile machines at the MSCC and the National Meteorology Center at Suitland, Maryland. Other specially assigned audio lines transmit biomedical data to the MSCC. Direct audio lines are available from the MSCC to the Department of Defense and the Department of State to carry priority voice communiques when necessary.

All communication lines from sources external to the MSC that interface with the MSCC come through the MSC telephone central exchange building to the MSCC telephone termination and distribution equipment room and then, with two exceptions, converge on the Communications System. The two exceptions are video transmission lines and private telephone lines. Video transmission lines are routed directly to the Display and Control System. Private telephone lines are routed to individual telephone sets situated throughout the MSCC. Some of these private lines are routed through the Communications System during a mission so that incoming calls may be intercepted and delayed, if desired. Also, if necessary, the Communications System can tie into the private telephone system during periods of emergency operations.

All incoming or outgoing wide-band data, high-speed data, teletype, and audio communications are monitored for quality within the Communications System, recorded, processed as necessary, and routed to their assigned destination. The system is the terminus for all incoming voice communications, facsimile messages, teletype textual message traffic, and provides for internal voice and hard-copy communications. All other incoming communications are routed to other systems for generation of data displays. Incoming telemetry data are processed through telemetry ground station equipment and sent to the RTCC for data display and telemetry summary message generation. Some of the processed data (such as telemetry event and biomedical data) are routed directly to the Display and Control System for direct monitoring by various Flight Controllers and specialists. Incoming tracking data are sent to the RTCC for generation of dynamic display data and to aid the computation of acquisition data. All outgoing voice communications, facsimile messages, and teletype textual messages originate within the system as do most command data. The remaining outgoing communications are routed through the system for conversion to the proper transmission format, if necessary, and assignment to an outgoing communication line. The Display and Control System presents large-scale and individual console data displays, and provides a data display and control capability to MSCC mission control and support personnel. The system

also generates timing pulses that are distributed within the system and to other systems for time-correlation and synchronization purposes. In addition, the system provides edited public affairs television outputs for group viewing in the OSW auditorium and for broadcasting via commercial television networks. Data is presented via digital readout display devices, plotting and television projection displays, and individual console television monitors. The system generates data displays upon receipt of display and control data from the RTCC or upon receipt of selected telemetry data from the Communications System. The display and control data from the RTCC are all fed out upon request only except for digital readout display data which are fed out automatically at a specific, programmed time.

The Simulation, Checkout, and Training System provides realistic simulation of manned space flight missions for training of mission control including remote site Flight Controllers and support personnel in several different modes. The system also provides the capability to integrate the MSCC functional systems with Flight Crew Trainers located at MSC and KSC during simulation exercises, and also to control and monitor the exercises. The simulation is accomplished by routing and displaying simulation data to the simulation exercise participants (determined by the simulation exercise modes).

The RTCC accomplishes real-time processing of incoming data and feeds display and control data on request to the Display and Control System. Digital display data (such as telemetry event status indications) are sent out automatically to the Display and Control System for direct readout. The RTCC also computes acquisition, ephemeris, and command data for transmission to GOSS network stations. In support of simulated missions, the RTCC executes dynamic simulation programs and real-time control of data inputs to the Simulation, Checkout, and Training System. The simulation programs are tailored to specific mission plans and expected contingencies defined in the mission plans. Like all other functional systems, the RTCC is equipped to support real and simulated missions simultaneously. During certain periods, the RTCC utilizes a special checkout program to conduct dynamic system checkout in conjunction with the Simulation, Checkout, and Training System.

1.5 TYPICAL OPERATIONAL MISSION INFORMATION FLOW BETWEEN GOSS NETWORK AND MSCC

An operational manned space mission consists of several consecutive phases; launch, earth orbit, translunar, etc., depending upon the mission objectives. The MSCC Flight Controllers must know during all phases of a mission where the spacecraft involved in the mission are and how the spacecraft and their crews are withstanding the changing environment imposed upon them.

From the moment of liftoff, as a spacecraft is being launched into the proper trajectory to meet mission requirements, control personnel must be supplied with exact information regarding the acceleration, speed, and direction of the spacecraft to enable them to make an almost immediate

decision as to whether or not a satisfactory trajectory is possible. Less than a minute is available to make the decision because if re-entry and impact are to occur before the spacecraft reaches Africa, its retro rockets must be fired while it is over Bermuda. To accomplish this, high-speed data lines carry radar tracking data from KSC to the real-time computers at the MSCC. The computers, in turn, cause displays of the spacecraft trajectory parameters to be plotted only a few thousandths of a second behind the actual spacecraft position. The predicted impact point of the spacecraft is also displayed during this time so that recovery forces can quickly converge on the spacecraft landing area in the event of mission termination during the launch (abort).

During the launch phase, the condition of the spacecraft crew and critical vehicle systems, and the status of critical mission events must also be known. These data are telemetered from the spacecraft, received at KSC, and routed from there over wide-band data lines at extremely high transmission rates to the MSCC; where they are used to produce event displays, biomedical data displays, and other pertinent displays required for immediate evaluation.

After the spacecraft has been successfully launched, the MSCC computers establish the exact spatial position of the spacecraft. If the next mission phase is an earth orbit, the computers will establish the precise orbital track of the spacecraft utilizing tracking data coming from the GOSS network. The computers maintain a plot of the exact position of the spacecraft and predict where it will be at any pre-determined time in the future. The computers send out acquisition messages to each tracking station, which tell the station exactly where to point its tracking antenna and at what time it can expect to acquire the spacecraft. The computers also cause predicted impact points to be displayed throughout the orbital phase of the mission so that recovery forces will have maximum reaction time in the event of an abort, and to enable them to conduct efficient recovery operations for a successfully terminated mission.

Throughout the mission, the physical well-being of the flight crew is monitored via telemetry data and voice communications. Telemetry data also enable the performance of the spacecraft and its equipment to be evaluated. Thus, the multitude of data coming in to the MSCC keep the mission control personnel in a fully informed status, ready at any moment to make recommendations and initiate commands to assure mission success.

1.6 MSCC M&O ACTIVITY

In order to maintain the many varied equipments within the MSCC, over two hundred Philco personnel will be assigned as a part of the M&O Activity. These maintenance and operations personnel will be assigned to the various systems to assure that the systems are maintained in an operational condition.

H. L. Neely is the Maintenance and Operations Activity Manager responsible for the direction and performance of the MSCC M&O Activity.

The MSCC M&O Activity consists of four functional departments under the direction of the Activity Manager. Each department consists of a department manager and his supporting staff. The four departments are listed below:

A. Logistics Department - The Logistics Department operates the MSCC Technical Supply facility and maintains equipment accountability records and inventories.

B. Maintenance Department - The Maintenance Department schedules and manages all maintenance efforts, conducts failure reporting and analysis programs, implements quality control programs and recommends product improvements.

C. Operations Department - The Operations Department prepares operational plans, procedures and schedules, coordinates operations with the RTCC and GOSS, and analyzes overall technical operations.

D. Training Department - The Training Department determines training requirements, prepares schedules and training material, and provides training aids and facilities in support of the overall Training Program.

The M&O Activity "on-line" organization for the MSCC consists of the three MSCC Systems for which Philco is responsible. These systems are listed below:

1. Communications System
2. Display Control System
3. Simulation, Checkout and Training System (SCATS)

Maintenance of each of these systems is the direct responsibility of an assigned system superintendent. The individual systems are further broken down into subsystems, each with a supervisor in charge. Subsystem supervisors may be designated "lead technician", "engineer", or "supervisor" depending upon the equipment involved and the M&O support staff configuration for that equipment.

As a general rule, MSCC equipments will be both operated and maintained by the same personnel. Equipment operators, without maintenance responsibilities are provided for in only a few instances such as voice switchboard operators and teletype operators. Therefore, personnel with specific assigned MSCC equipment responsibilities are jointly responsible to both the Operations and the Maintenance Department Managers.

Mission Control is a NASA function. Flight Control positions are manned by NASA personnel at the Flight Control Consoles in the Mission Operations Control Room (MOCR).

In support of missions, simulations, system tests, etc., the Philco M&O Supervisor is stationed at the M&O console in the MOCR. The M&O Supervisor is directly responsible for the operational readiness of all MSCC equipments supporting the Flight Control functions. Philco M&O personnel are responsible to the M&O Supervisor for the maintenance checkout, and operation of the equipment. Equipment status is reported to the M&O Supervisor for inclusion in the overall GOSS readiness report.

Either the Operations Manager or the Maintenance Manager fill the position of M&O Supervisor during operations.

The M&O organization is responsible during non-mission periods to accomplish the necessary maintenance of MSCC equipments to assure the capability of supporting manned spaceflight operations.

Organizational charts and brief job descriptions for personnel assigned to the M&O Activity are included as an attachment to this booklet.

PART II FUNCTIONAL DESCRIPTION OF MSCC SYSTEMS

1.0 GENERAL

The areas of interest within the MSCC, for the M&O Activity, include the Communications, Display/Control, and SCATS Systems. Organizationally and functionally these systems are further broken down into the following subsystems:

- a. Communications System
 - (1) Voice Facility S/S
 - (2) Comm Process Center S/S
 - (3) FACS S/S
 - (4) PCM S/S
 - (5) MDCCS S/S
- b. Display/Control System
 - (1) TV S/S
 - (2) D/C Interface S/S
 - (3) Group Display S/S
- c. SCATS System

2.0 COMMUNICATIONS SYSTEM

The MSCC Communications System contains the necessary equipment for performing three general functions, these are: internal and external communications, digital commanding, and telemetry ground station operations. The integrated Communications System consists of five subsystems.

2.1 Voice Facility Subsystem. The Voice Facility Subsystem enables MSCC mission operations personnel to talk directly to the occupants of manned spacecraft via the remote stations of the GOSS network, provides and controls a variety of internal voice communications services, controls and terminates voice communications between the MSCC and the GOSS network, provides access to the MSC telephone dial system, and provides historical recording and playback for selected voice communications.

The Voice Facility Subsystem is divided into five areas of responsibility. These five areas are internal voice communications (voice intercom), communication line monitoring and switching, local verbal announcement broadcasting, tying into private telephone network on an as-required basis, and recording and playing back selected voice communications. The voice intercomm area of responsibility includes the keying of remote ground-to-air transmitters for MSCC to spacecraft voice transmission.

The voice intercom equipment constitutes an internal voice communications network with operational control provided by station keyset units. These units are operated by pushbutton keys; operation of the pushbuttons

connects one station to another station, a station in the MSCC to an external station, one conference loop to another loop within the MSCC, a station to specific public address network zones, and specific conference circuits to voice recorder-reproducers.

Each station keyset unit is provided with a headset and a headset push-to-talk switch or a push-to-talk foot switch. Illuminations provided in the keyset pushbuttons consist of lamp signals exhibited as flutter, flash, and wink indications and a steady-on signal.

An outgoing-call procedure requires pressing the talk-listen key, which connects the station telephone circuit to the associated line or loop and causes the associated lamp signal to flutter. All other multiple appearances of the lamp circuit display a steady-on signal while the line is in use.

Incoming calls from private automatic branch exchange lines, intersite loops and other private lines or distant-end connections are indicated by a flashing signal in the lamp associated with the line key. The talk-listen key connects the station transmission circuit to the line or loop and changes the lamp signal to a flutter indication. Other multiple line appearances display a steady-on signal for the duration of the call. The operator is released from an established call connection by pressing the release key or when another talk-listen or private automatic branch exchange key is actuated, but the release key has no effect on circuits under control of a monitor key. A monitored circuit can only be released by pressing the monitor key a second time.

The multiaccess key, in conjunction with talk-listen keys, provides access to a maximum of three lines or conference loops simultaneously. Operation of the private automatic branch exchange hold key places the selected private automatic branch exchange line in a hold condition, changes the incoming call flashing lamp indicator signal to a winking signal, and releases the private automatic branch exchange line key circuitry.

Talk-listen access to local voice intercom loops may be acquired through the use of jack-only positions by means of a headset jack. The jacks are permanently wired across the loops eliminating the need of talk-listen keys. Single loop access is obtained by inserting the headset plug into the jack; selection of one of three loops is accomplished by use of a common headset jack and 3-position switch. Although no signaling capability is provided, talking is accomplished by operation of the push-to-talk key on the headset.

The voice intercom network is divided into six major groups of line and loop circuits, each operationally independent of the other and, with the exception of minimal interfacing with communication control equipment, each group is electronically isolated from the other. The major groups of line and loop circuits are as follows: local conference loops, intersite conference loops, public address loop, private automatic branch

exchange lines, MSCC to spacecraft conference loop, and point-to-point (private) lines.

The local conference loop provides two-way communications and monitoring capability for local stations included in the loop, which is essentially a closed-loop network with no capability of interconnection with other loops or lines associated with the subsystem.

The intersite conference loop is, basically, a local conference loop with additional facilities incorporated to interconnect the loop to a similar loop or single station at a remote location over a land-line or radio-link voice channel. The loop is arranged for automatic or manual signaling.

The public address loop is a two-wire, transmit-only circuit providing talk access to public address speakers.

The private automatic branch exchange lines provide the station keyset units access to private telephone network circuits through the telephone central exchange for those stations equipped for dial service to outside communications.

The MSCC to spacecraft conference loop is an intersite conference loop that provides for voice communications with manned spacecraft. This loop does not have signaling capability, but a ground-to-air control circuit allows certain station keyset units to be connected to and control the ground-to-air control unit included with the communication line switch console. This unit enables a remote transmitter to be keyed by the station keyset units.

Private point-to-point lines are used for direct communication between two stations within the MSCC or between a station in the MSCC and an external station.

Patch and test bays included with the voice intercom equipment provide a monitor, an equipment substitution, and a line substitution capability for each circuit. Also included is a patching capability to connect any one loop from simulation areas to any one conference loop associated with MOCR 1 and MOCR 2. A switching panel containing 130 2-position switches furnishes switching capability on 130 loops from either MOCR 1 or MOCR 2 to certain conference loops being used for recovery operations.

An intercom loop similar to the local conference loop having jack-only positions is assigned as a maintenance loop for internal communications between maintenance personnel. The difference between this loop and the local conference loop is that selective signaling from the master station to other stations within the loop is provided in the form of one-digit dialing.

Communication line monitoring and switching is accomplished through the use of a communications line switch console. The console includes the equipment necessary to interconnect, in any combination, the following

types of communication circuits: single party voice circuits within the MSCC, conference circuits within the MSCC, long line circuits from GOSS stations, extensions from the MSCC private automatic branch exchange appearing at the console switchboard, and local MSCC circuits used for mission simulation and training. The console is capable of simultaneous and independent control of a real mission operation and a simulated mission operation.

The basic function of the communication line switch console is to monitor and control 150 4-wire line circuits, utilizing a communication line switchboard. This is accomplished with 46 separate links, which make up the communication line switching matrix. A link is defined as the internal circuitry that connects a line to any other line(s). The two console switchboard positions are multiplied and provide independent line access from either position to the switching matrix. The switching capabilities of the switchboard include connections of any line to either of two pre-assigned keys that have the capability of conferencing 30 parties, any line to any 2-party or 12-party link, and any line as a talk-listen or listen only circuit. The conference connections provided by the switchboard allow lines to be added or dropped from an established conference without affecting other lines on the conference circuit.

Biomedical telemetry data from the Communications System are fed into the communication line switch console for assignment to specific audio lines. The data are then fed to the Pulse-Code-Modulated Telemetry Subsystem for processing, recording, and audible monitoring.

Total voice broadcast coverage of the MSCC is provided by a public address network comprised of audio amplifiers, ceiling-mounted loudspeakers, control circuitry, and voice input components. The audio amplifiers receive verbal inputs either from station keyset units or microphones. The audio inputs are amplified and distributed by the amplifiers to the loudspeakers, which are located in various zones throughout the MSCC. Speaker selection, keying, muting circuits comprise the controlling circuitry for the public address network.

Broadcasting access to the public address network is provided at specific console positions and keyset units. Receive and monitor capabilities, not broadcast, are extended to the two visitors viewing areas of the MOW second and third floors.

Tying into the MSC private telephone network on an as-required basis is a function of the private automatic branch exchange equipment. The private automatic branch exchange circuits are routed from the MSC telephone central exchange to the station keyset units of the voice intercom network. Any private automatic branch exchange station is capable of being connected to any other private automatic branch exchange station through the means of dial circuitry. These stations also have access to stations external to the MSC telephone central exchange anywhere within range of commercial switching. Sixty of the private automatic branch exchange circuits are fed through an intercept switchboard, which affords operator control of selected external

lines. The primary function of the intercept position is to provide a capability of intercepting incoming calls or allowing uninterrupted completion to the called station. On an interrupted call, the operator can converse with the calling party and deny or complete the call to the affected station.

Voice recorder-reproducers and associated equipment provide a central voice recording facility capable of making a permanent record of conversations from selected loops of the voice intercom network. The voice recorder-reproducers allow the following services to be accomplished: continuous historical recording of selected MSCC loops, playback of recorded tapes at normal speeds for stenographic copying, and at higher speeds to allow rapid production of multiple copies on duplicating equipment, copying a recording at four times normal speed and playback at normal speed, and delaying transmission of a selected conversation by 5 seconds. Timing pulses are always recorded along with the voice information for time-correlation purposes.

Historical recording is accomplished by magnetic tape recorders, each containing two tape transports so that one transport may be reloaded or act as a standby while the other is recording. The recording function may be transferred from the active transport to the idle transport, manually or automatically, in the event of tape breakage, loss of tape motion, or low tape supply.

Playback (reproduction) of recorded tapes is done by two playback transports with operating speeds the same as the recorder or at four times recorder speed. The playback equipment will playback a single audio channel and one time channel, playback two audio channels and one time channel at a high rate of speed, or produce these functions simultaneously. The output of the time channel is fed to a digital time readout device. Stenographic monitoring is accomplished through the means of a headphone or loudspeaker, channel selection switch, a foot switch to control the tape deck for forward, stop, or reverse speed operation.

Tape copying equipment provides the capability of feeding the output of the playback reproducer to as many as three recorders simultaneously. One of the operating speeds of this equipment is four times that of normal recording speed and is compatible with playback reproducer equipment, which can reproduce tape at four times normal speed, allowing tape copies to be made in one-fourth the normal recording time.

The voice recorder-reproducer facility includes public affairs officer equipment that supplies a 5-second time delay in the transmission of a recorded conversation by means of a continuous-loop, combination recorder-reproducer, which also has tape-erasing capabilities. The time delay is controlled by the tape speed between the recording head and the reproducing head. This equipment selects the output from one of the public affairs officer loops to be fed to a news media line and allows broadcasts to the news media from the public affairs officer console via microphone.

2.2 COMM PROCESS CENTER SUBSYSTEM

The Communications Process Center subsystem is responsible for automatically routing all MSCC incoming or outgoing communications (except video, direct voice, weather, and military communications) to the proper destination in real time or as near-to-real time as possible. The subsystem also functions as a message switching center for various MSCC internal communication lines. To backup these functions, the subsystem also provides message statistics, continuous circuit assurance testing, indications of detected errors, and information regarding individual circuit status.

MESSAGE ROUTING. The Communications Processor Subsystem interfaces with the Communications Facility Control Subsystem and the RTCC. Basically, there are four routes into the Communications Processor Subsystem from these two sources. These four basic routes are (1) from the Communications Facility Control Subsystem into the Communications Processor Subsystem to the RTCC, (2) from the Communications Facility Control Subsystem into the Communications Processor Subsystem back to the Communications Facility Control Subsystem, (3) from the RTCC into the Communications Processor Subsystem to the Communications Facility Control Subsystem, and (4) from the RTCC into the Communications Processor Subsystem back to the RTCC. The first circuit is for routing both low-speed and high-speed command, telemetry, tracking, ephemeris request, and simulation data to the RTCC where it is fed out to users as requested. The second circuit is for routing remote site teletypewriter (low-speed) message traffic to the teletype and facsimile subsystem via the Communications Facility Control Subsystem. This circuit also handles messages originated within the teletype and facsimile subsystem and intended for the remote sites. The third circuit routes RTCC generated commands, ephemeris, acquisition, and telemetry summary data to the Communications Facility Control Subsystem, which routes the data to outgoing lines for distribution to remote sites. The fourth circuit is used for data exchange between the RTCC computers. Numerous communication lines, associated with each of these four routes, interface with the Communications Processor Subsystem establishing a full two-way of data between the Communications Facility Control Subsystem, the Communications Processor Subsystem, and the RTCC.

The subsystem accomplishes message routing functions using a store and forward technique. This means that if a message is received for a specific address and the addressed line is busy, the message is stored and then forwarded as the individual line becomes available. The messages sent to a specific address are consecutively numbered to help ensure receipt of all messages sent to that address. All messages are recorded, hence a "lost" message may be quickly retrieved and retransmitted from the subsystem upon request.

In the event degraded data is obtained from the subsystem, the transfer switch allows quick switching from one processing component to its backup component, thus preserving an almost uninterrupted flow of data.

The day clocks automatically initiate various computer operations at predetermined times and time stamp all messages as to time of receipt and time of transmission (this timing information may be utilized for hourly traffic analysis).

The Communications Processor Control Console enables the status of the Communications Processor Subsystem to be monitored and controlled at one central location. The console includes two transmit and receive printers (one operational, one spare), communication line terminal monitor lights for each communications line interfacing with the subsystem, and two receive-only printers. The transmit and receive printer is used for controlling the input-output functions of the Communications Processor Subsystem. It provides inputs to and accepts outputs from both processor channels simultaneously. The communication line terminal monitor lights verify when a given line is busy or idle, thereby providing a quick visual indication of the traffic load at any time.

The major purpose of the teletype components that form a portion of the teletype and facsimile components is to provide clear text, page-printed copy to mission operations and support personnel of teletype messages received from the GOSS network, major military relay centers, U.S. Weather Bureau, military weather networks, and commercial telegraph outlets; and to transmit teletype messages back to these locations. A secondary function of the teletype components is to support simulated mission exercises. The facsimile equipment contained in the subsystem receives meteorological data (e.g., weather maps) from the National Meteorology Center at Suitland, Maryland and transmits meteorological data back to the center. The teletype components are of a varied nature, including receive-only page printers, transmitter-distributor units, receive-only typing reperforators, automatic send-receive sets, and teletype loop switchboards, physically grouped in various areas of the MOW.

The teletype message center contains automatic send-receive sets with auxiliary receive-only typing reperforators, transmitter-distributor units, receive-only typing reperforators, and receive-only page printers. The automatic send-receive sets are used for message preparation and editing, and as backup equipment.

Except for additional automatic send-receive sets and, consequently, additional teletype circuits, the message center simulation annex essentially duplicates the operational teletype message center. The main difference between the two is that the simulation annex normally handles teletype messages in support of simulation exercises. Two switchable loops at the Communications Facility Control Subsystem teletype patchboard terminate receive-only page printers in both the operational message center and the simulation annex. This provides the capability for the simulation annex to monitor the second floor SSR loops while the operational message center monitors the third floor SSR loops, or vice versa. The automatic send-receive sets (without auxiliary receive-only typing reperforators) in the simulation annex are used to terminate two commercial telegraph loops and an administrative teletype loop. The two commercial loops are not routed

through the Communications Processor Subsystem and do not appear at the Communications Facility Control Subsystem teletype patchboard. The administrative loop is a half-duplex (send and receive one direction at a time) circuit from the MSC communications center in building 2. This circuit is routed through the Communications Processor Subsystem via the Communications Facility Control Subsystem teletype patchboard.

The RCR teletype equipment includes a teletype loop switchboard, receive-only typing reperforators, transmitter-distributor units, and automatic send-receive sets. One of the automatic send receive sets (with an auxiliary receive-only typing reperforator) terminates an end-to-end secure circuit from the MSC cryptographic center in building 2. Other automatic send-receive sets (with and without auxiliary receive-only typing reperforator) function as backup equipment and terminate circuits from the Communications Facility Control Subsystem teletype patchboard. The other components respectively terminate full-duplex and half-duplex circuits from the Defense Communications Agency switching center at Fort Detrick, Maryland and the KSC Launch Control Center. These circuits are not routed through the Communications Processor Subsystem, but are routed directly to the telephone termination and distribution equipment (room 127) via the Communications Facility Control Subsystem teletype patchboard. All the teletype circuits tied into the teletype loop switchboard are patchable at the switchboard as well as at the Communications Facility Control Subsystem teletype patchboard.

The Meteorology Center contains a teletype loop switchboard, an automatic send-receive set, receive-only page printers, and transmitter-distributor units. The automatic send-receive set, which includes an auxiliary receive-only typing reperforator, is included only for preparation of message tapes. The automatic send-receive set and the majority of receive-only page printers are equipped with standard weather symbol keyboards, typing wheels, and type boxes for exchange of weather information. A special circuit is provided to operate at 75 words-per-minute for information exchange between the MSCC and RAWARC (severe weather warning net); all others operate at 100 words-per-minute. One full-duplex circuit extends from the Communications Facility Control Subsystem teletype patchboard to the teletype loop switchboard to function as a backup loop. All circuits are patchable at both the teletype loop switchboard and the Communications Facility Control Subsystem teletype patchboard.

Automatic send-receive sets are in the simulation equipment room to receive digital commands originated by the Simulated Remote Sites Subsystem and to route these commands to page printers in the Simulated Remote Site room. Equipment included in the Simulation Data Subsystem, also located in the simulation equipment room, routes telemetry summary messages to a typing reperforator in the simulated remote site message center and telemetry data (which has been converted to engineering units) to page printers in the Simulated Remote Site rooms. The routing and processing of the messages in each case is accomplished similarly to the routing and processing of operational (non-simulated) messages.

Each of the two Simulated Remote Sites is provided with a loop from the Communications Processor Subsystem for reception of simulated mission message traffic. A page printer is also located in each Simulated Remote Site room to monitor the digital command loop associated with each Simulated Remote Site. Each of the vehicle system consoles in each of the Simulated Remote Sites contains a receive-only page printer that terminates a circuit from the Simulation Data Subsystem, which carries telemetry data that has been reduced to engineering units.

Facsimile equipment is used in the Meteorology Center to transmit and receive meteorological data. The equipment and associated circuits are a part of end-to-end service. The facsimile machines terminate, via a transfer switch, a space flight meteorology circuit and a national meteorology center circuit; both from Suitland, Maryland. The transfer switch permits the facsimile machines to be switched to different on-line and off-line configurations.

PNEUMATIC TUBE. The function of the pneumatic tube component is to transmit and receive hard copy messages by means of cylindrical message carrier that is vacuum propelled through a network of air-tight tubing.

The central exchanger is a major component of the automatic system and functions as a tube interchange and loop selector. The exchanger receives inbound carriers, holds the carriers (thereby spacing them to a proper time interval), releases them one at a time in sequence, and shuttles them to their outbound destination loop. All carrier traffic passes through the exchanger enroute to a station. The exchanger processes the carriers in four stages, starting with the storage section, which is located in the tubing directly above and connected to the exchanger. The carriers are deflected from the main tube runs by deflection switch Y's and gravity dropped into the storage section. Line limit switches; located in the tubing above the exchanger, are activated by carrier passage and, after the carrier enters the storage section, signal the master control panel which places the affected inbound dispatch tube in a no-operation mode until the exchanger processes the carrier. In this condition, a second carrier placed in the dispatch tube at a station terminal is held there until the exchanger has cleared the storage section of the first carrier. As the carrier drops into the storage chamber, it comes to rest on ejector arms and makes contact with a storage chamber limit switch that initiates the electrical sequence in the master control panel, which takes control at this point and directs the carrier. The air-operated ejector arm holding the carrier is retracted and the carrier drops to a shoulder in the spacer section. At the end of its back stroke, the ejector arm contacts a limit switch that reverses the air flow to the piston, which drives the arm to its original position and pushes the carrier into the loop selector section. The loop selector mechanism, an air-operated hopper, moves to the correct outbound loop as the ejector arm retracts and the carrier is deflected directly to the outbound loop. As the carrier leaves the loop selector section and enters the outbound loop, it trips a reset switch, resetting the exchanger for subsequent carrier operation for that particular loop.

The console send/receive stations perform loop station selection by means of station-designated pushbuttons which, when pressed, cause the dispatch door to open permitting the insertion of a carrier. After the carrier is inserted, the door closes and the control panel designates carrier dispatch when the dispatch line is clear. A 3:1 priority send sequence has been established for the Assistant Flight Directors line, which means that this station has the capability of dispatching three carriers to a single carrier dispatch from each of the other three stations on the loop.

The wall send/receive stations provide station selection by means of dual-digital dialing, which consists of two rotary knobs, one on each side of a digit display mounted on the station control panel. A station number is dialed by turning the knobs until the station's 2-digit number appears on the display. Dialing at the station actuates telephone-type switching relays at the master control panel, which also sets up the sequence of carrier operation by directing the carrier to the dialed station in its proper turn.

Three turbo-compressors, installed in room 130, provide the compressed-air flow for carrier operation. A fourth compressor, used as backup, is connected to all three systems by a network of piping and valves and can replace any other compressor in the system. The central exchangers contain air-compressors for their operation only. Air lines from the turbo-compressors are connected to the dispatch and receive lines at appropriate locations to provide sufficient air at a 12-ounce vacuum to maintain average carrier velocity of 25 feet per second in all systems. Pneumatically operated windgates and slidegates control the air flow to each station or group of stations.

The manual Pneumatic Tube component is a twin-tube, point-to-point system independent in operation from the automatic system. The air supply for the transmission tubes and slidegates and windgates is the same as for the automatic system. Dispatching at the central desk is accomplished by an open-end, up-send dispatcher and receiving by a down-delivery, air-cushion terminal. Carrier arrival is designated by arrival lights displayed on opposite sides of the central desk. Entry and removal of carriers from the tubes at all MOCR terminals is in the no-air mode. The stations at the MOCR terminals operate the same as in the automatic system, except that selective pushbuttons are not required. A single push-button opens the send door. Carriers dispatched at the central desk for MOCR stations Nos. 3 and 4 trip a limit switch that opens a normally closed windgate, which is closed by a reset switch after carrier passes the windgate.

2.3 FACS SUBSYSTEM

The Communications Facility Control Subsystem provides centralized operational control, monitor, and test access to all high-speed data, teletype, video, and audio communication lines (except for a few end-to-end secure circuits) entering and leaving the MSCC. The subsystem maintains and ensures dependable performance of each critical circuit by providing

interconnection flexibility, monitor and test access, and current circuit status indications.

SUBSYSTEM OPERATION. The Communications Facility Control Subsystem is functionally and physically divided into two sections. The Communications Control Facility contains the communication line termination, monitor, and patching equipment that does the actual interfacing with the GOSS network high-speed data, teletype, and audio communication lines. The Communications Controller Facility contains the equipment for displaying the status of the entire GOSS network and for issuing supervisory directives to control the operation of the Communications Control Facility.

High-speed data test and patch equipment receives and transmits high-speed data signals between the MSCC and KSC, and between the MSCC and the Bermuda and South Texas tracking stations. The high-speed data test and patch equipment also provides the high-speed data interface link between certain operational areas within the MSCC, and between the MSCC and the MSC Flight Crew Trainers via the Simulation Interface Subsystem and the telephone termination and distribution equipment.

High-speed data signals enter the Communications Facility Control Subsystem on leased telephone lines. The telephone lines terminate in high-speed data modulator-demodulator units via normal-through jack circuits in the high-speed data patch bays. The receive modulator-demodulator units demodulate the telephone line carrier on each receive circuit and route demodulated data to the appropriate destination. Received high speed data signals include pulse-code-modulated telemetry messages from Bermuda and South Texas and launch data messages from KSC and Bermuda.

Prior to demodulation in the receive modulator-demodulator, each high-speed data signal is recorded on magnetic tape by the high-speed data recorder-reproducers. The recorder-reproducers also record the outputs of each transmit modulator-demodulator, and time correlation signals originated by the timing equipment. Tape recording of all incoming and outgoing high-speed data signals provides historical records for post-mission playback and analysis.

The high-speed data patch bays route received pulse-code-modulated telemetry signals from Bermuda and South Texas through normal-through jack circuits to the Pulse-Code-Modulated Telemetry Subsystem. The Pulse-Code-Modulated Telemetry Subsystem applies formatted high-speed telemetry data back through the high-speed data patch bays to the Communications Processor Subsystem.

Launch trajectory and guidance data signals from KSC and Bermuda are applied by the high-speed data modulator-demodulator units through the high-speed data patch bays to the data control unit-receivers. The data control unit-receivers identify received data, detect transmission errors (if any) in each data message, and then route the received signals to the Communications Processor Subsystem via the high-speed data patch bays. One data control unit - transmitter transmits pre-launch ephemeris data

via the high-speed data patch bays, transmit-modulator - demodulator units, and telephone lines to KSC. This data comes from the RTCC via the Communications Processor Subsystem.

The Communications Processor Subsystem applies high-speed data signals to the teletype circuit assurance decommutator (located in the Communications Controller Facility). These signals, which contain teletype circuit status data, are decommutated and applied to the communications controller wall display, and to radar data traffic indicators at the teletype patch bays.

The Communications Processor Subsystem feeds all outgoing high-speed data signals through the Communications Facility Control Subsystem. These transmitted high-speed data messages include digital commands to Cape Kennedy, Bermuda, and South Texas, and ephemeris data to KSC. The Communications Processor Subsystem transmits these signals through the high-speed data patch bays and modulator-demodulator units onto telephone lines, except for the ephemeris data, which is transmitted via the data control unit-transmitter.

The Communications Processor Subsystem also sends and receives digital command traffic, via the high-speed data patch bays and line driver termination units, to and from the Master Digital Command Subsystem and the Simulated Remote Sites Subsystem.

The high-speed data patch bays also provide patching capabilities to allow simulated digital commands and simulated spacecraft trajectory data signals to pass between the MSC Flight Crew Trainers and the Communications Processor Subsystem.

The high-speed data test bay contains test message generation and reception equipment that is used to analyze the quality of each high-speed data circuit. Also, error counters are included in the test bay to tabulate any errors contained in the high-speed data messages handled by the data control units.

The teletype test and patch equipment provides cross-patching, monitoring and testing access to all receive, send, and internal teletype circuits within the MSCC, except for certain end-to-end secure circuits. The teletype circuits appear at the teletype patch bays via the communications cable termination cabinet. Normal-through patch circuits route most teletype traffic to the Communications Processor Subsystem. Certain traffic, such as weather messages and military messages, is routed directly to user equipment in the teletype and facsimile subsystem.

The test bay and monitor console provides a test and monitor facility that can analyze the operational characteristics of each teletype circuit.

The audio frequency test and patch equipment provides cross-patch, monitor, and test access to all audio circuits entering and leaving the MSCC, except for certain end-to-end secure circuits. The audio circuits enter and leave the audio patch bays through the communications cable termination cabinet.

Normal-through jack circuits in the audio patch bays route voice circuits to and from the communications line switch console in the Voice Communications Subsystem, or to and from direct user areas, such as recovery, meteorology, etc., of the Voice Communications Subsystem.

The audio patch bays also provide voice circuit status signals to the GOSS network status wall display in the Communications Controller Facility. The test bays contain all the equipment needed to make routine transmission and signaling tests on the audio-frequency lines and equipment mounted in the audio patch bays. The audio test bays also provide test signals to the communications line switch console in the Voice Communications Subsystem.

Biomedical telemetry data inputs are received through the audio patch bays, on specially assigned voice circuits, from remote sites of the GOSS network. These are frequency-modulated subcarrier multiplex inputs that contain telemetered biomedical data. The voice circuits terminate in the audio patch bays, which apply the subcarrier multiplex signals to the Voice Communications Subsystem for subsequent routing to subcarrier discriminators in the Pulse-Code Modulated Telemetry Subsystem.

The Communications Controller Facility maintains supervisory cognizance over the entire GOSS network. The communications controller exercises no direct control from this facility, but issues verbal directives to control operations of the Communications Facility Control Subsystem. A wall display in the Communications Controller Facility receives teletype and voice circuit status signals from the teletype circuit assurance decommutator and from manually operated switches at the audio patch bays. Other circuit status indications are entered into the wall display at the console-mounted control panel.

2.4 PULSE-CODE-MODULATED TELEMETRY SUBSYSTEM

All telemetry data signals, with one exception, are routed through the Pulse-Code-Modulated Telemetry Subsystem. The one exception is the telemetry summary messages, which are received by the Communications Facility Control Subsystem and routed directly to the Communications Processor Subsystem. All the telemetry data signals are in pulse-code-modulated form, except those containing frequency-modulated biomedical data. The Pulse-Code-Modulated Telemetry Subsystem must process, sort out, and distribute the telemetry data before it can be used by mission operation and support personnel. Simulated pulse-code modulated telemetry data from the Simulated Remote Sites Subsystem are fed to the subsystem for switching purposes only.

SUBSYSTEM OPERATIONS. All telemetry data signals, except simulation data from the Simulated Remote Sites Subsystem, and biomedical data from the Voice Communications Subsystem are applied to input transfer switch equipment. The simulation data from the Simulated Remote Sites Subsystem are fed to output transfer switch equipment. The biomedical data signals are fed to frequency-modulated ground station equipment and, an operational telemetry monitor and control console.

The input transfer switch equipment terminates pulse-coded-modulated telemetry input signals in data input line terminator-drivers, which are used to convert input signals levels to the levels required by down-line equipment. Following conversion of signal levels, the drivers apply input data via an input patch panel to a crossbar data transfer switch, and to wide-band data recorder-reproducer equipment. Operation of the data transfer switch applies received signals to selected output channels through a direct-playback transfer switch. During direct operation, the selected signals contain real-time data from KSC, Bermuda, or South Texas, or simulated data from the Simulation Interface Subsystem or KSC. During playback (or reproduce) operation, the input transfer switch equipment receives previously-recorded data from the wide-band data recorder-reproducer equipment. (All direct input signals are recorded for historical and post-flight analysis purposes.) Two output channels feed signals directly to the Pulse-Code-Modulated Telemetry Ground Station equipment. All other output channels apply selected data signals over transmission lines to the Simulated Remote Sites Subsystem Pulse-Code-Modulated Telemetry Ground Stations and the computation and data reduction facility located in a separate building.

The Pulse-Code-Modulated Telemetry Ground Station equipment receives input telemetry data in one long stream of "ones" and "zeros". This serial data bits arrive from KSC at a maximum rate of 40,800 bits (ones and zeros) per second, and from Bermuda and South Texas at 2000 bits per second. Each ground station tunes automatically to the selected input bit rate and synchronizes the ground station decommutation circuitry to the incoming bit train. Each ground station contains a program memory that is already set up to process incoming data with a given format. The program memory controls every step of the decommutation process.

As indicated in the preceding paragraph, the pulse-code-modulated input signal to each ground station is a serial train of ones and zeros. This serial bit train is generated by commutation equipment at the data source. The commutation equipment takes a given number of data signals and feeds them one after another on to one line. Periodically, at specific intervals, the commutation equipment inserts synchronization and data identification patterns (ones and zeros) between appropriate and specific groups (words) of data bits. This combined train of data, synchronization, and identification bits appear at the selected ground station in a certain sequence.

After the ground station synchronizes to the incoming bit rate, the serial bit train is regenerated and "conditioned" (i.e., converted to bit-logic levels that are compatible with the decommutation circuitry requirements). The converted signal train is cut into words again and lined up with the bits in parallel so that the decommutation synchronization circuits can examine each word separately.

When the decommutation synchronization circuits recognize the commutation synchronization patterns, commands from the program memory transfer associated data words to the ground station output circuits. Certain data words, which contain signals that have high fluctuation rates, are converted at once into analog or bi-level (on-off) event signals. Other data

words undergo no further processing in the ground stations.

As each data word is shifted from serial to parallel and transferred to output circuits by the decommutation logic, the program memory unloads an identification word that accompanies the associated data word. In addition, the decommutation synchronization logic generates transfer command pulses that accompany individuals or groups of data words, and other signals that indicate the operating status of the synchronization logic circuitry.

Each ground station applies decommutated data, control, and synchronization signals to the output transfer switch equipment. The output transfer switch equipment also receives decommutated output data from both Pulse-Code-Modulated Telemetry Ground Stations to the Simulated Remote Sites Subsystem. These outputs can be substituted for the outputs of either one or both of the operational pulse-code-modulated telemetry ground stations when desired.

The operational ground stations also apply regenerated serial data signals to the input transfer switch equipment, where they may be selected for outputs in lieu of the "raw" data (e.g., for recording).

The frequency-modulated telemetry ground station receives biomedical telemetry data from the Voice Communications Subsystem over specially assigned audio lines. The subcarrier discriminators, which comprise the bulk of the ground station, demultiplex and demodulates the individual subcarrier signals and apply the recovered data to the output transfer switch equipment.

The output transfer switch equipment channels decommutated data from the real or simulated pulse-code modulated telemetry ground stations and demultiplexed data from the frequency-modulated telemetry ground stations to the Computer-Display and Control Interface Subsystem, the Master Digital Command Subsystem (partially through the time converters), and to the RTCC via the buffer formatter equipment and the Communications Facility Control and Communications Processor Subsystems.

The time converters receive spacecraft multiplex data and stripping commands from the appropriate ground station via the output transfer switch. The stripping commands extract the spacecraft time-to-retrofire signals that appear in the data multiplex stream. The converters then time-compensate the signals for time lost during transmission and convert them to special logic levels for transmission to the Master Digital Command Subsystem.

The buffer formatter equipment accepts data outputs from the pulse-code-modulated telemetry ground stations via the output transfer switch and control outputs from the operational telemetry control and monitor console. The buffer formatter equipment puts these inputs into the proper format for entry into the RTCC via the Communications Facility Control and Communications Processor Subsystem.

The auxiliary display equipment provides the capability for recording or visually monitoring selected analog signals and for recording bi-level event signals.

The telemetry operational control and monitor console provides a control and display facility for the Pulse-Code-Modulated Telemetry Subsystem. The console provides the following control and display capabilities: control and status of input transfer and output transfer switches, ground stations, recorder-reproducers, time converters, and buffer formatters; Greenwich Mean Time display; audible monitoring of biomedical telemetry data signals; and voice annotation of data recordings.

A pulse-code-modulated telemetry signal simulator is provided for generating test signals to exercise both operational Pulse-Code-Modulated Telemetry Ground Stations. If desired, the test signals may also be routed to the Simulated Pulse-Code-Modulated Telemetry Ground Stations.

2.5 MASTER DIGITAL COMMAND SUBSYSTEM

During mission operations, the MDCS transmits digital command data messages to orbiting spacecraft via the modulator-transmitter equipment at the real-time sites of the GOSS digital command network. The MDCS also transmits prepass command data to the Digital Command System equipment at the remote sites of the GOSS digital command network. The MDCS receives command verification data from the spacecraft via the telemetry down-link.

Prior to missions, the RTCC feeds stored program command (SPC) data to the MDCS memory via the Communications Processor and Communications Facility Control Subsystems. The MDCS accepts and verifies the validity of this data, and stores properly formatted commands in the memory. Prior to each mission, Real-Time Command (RTC) data is entered manually into the MDCS memory to supplement, correct, or update previously stored SPC data.

During a mission, Flight Control personnel in the operational MOCR transmit control signals to the MDCS to initiate the transmission of stored or Real-Time Commands to the orbiting spacecraft. Control and status indication signals pass between the MOCR and MDCS via the data transfer switching equipment.

The MDCS formats, transmits, and verifies the transmission of commands to the real-time sites via the Communications Processor. The Communications Processor channels the command messages to each real-time site over two diversely routed HSD circuits via the Communications Facility Control Subsystem. Command messages destined for a remote site are re-formatted by the Communications Processor and transmitted via teletype.

The spacecraft verifies received command data via the telemetry down-link. The MDCS receives command verification data words and event signals via the PCM Telemetry Subsystem and/or from the PCM ground stations in the Simulated Remote Sites Subsystem of SCATS. The telemetry ground stations send decommutated command verification data to the MDCS via the data transfer switching equipment.

3.0 DISPLAY/CONTROL SYSTEM

The Display/Control provides facilities for displaying both computer-derived and unprocessed data originating from the Ground Operational Support System (GOSS), and the spacecraft. Mission control personnel in the MSCC must have quick access to large quantities of information in order to successfully direct the Gemini and Apollo missions. The Display/Control System provides the mission control personnel with information concerning AMR operations, booster and vehicle systems, flight dynamics, life systems, recovery, GOSS network, operations and procedures, and other pertinent functions. This information is made available to specific areas, or as desired to several areas for combined evaluation and/or general interest. The data required is real time, near real time, historical, and reference material selection of the desired information and the resultant presentation is such that minimum operator action and interpretation is required so as not to interfere with the controller's primary responsibility of data evaluation and decision making.

The Display/Control System is divided up into three major subsystems in terms of the M&O Activity manning requirements:

- a. Television S/S
- b. Computer Display/Control Interface S/S
- c. Group Display

3.1 MSCC TELEVISION SUBSYSTEM

The complete subsystem provides a capability to generate, distribute and display high resolution, monochrome video information with pictorial, graphic and alpha-numeric content. Signal generation devices include pick-up cameras which generate high quality video signals from both 3-dimensional scenes and/or 2-dimensional opaque and/or transparent graphic materials via suitable optics. In addition to camera equipment which is part of this subsystem, the subsystem accepts compatible video inputs from the digital-to-television converters, covered as part of the Computer - Display/Control Interface Subsystem.

Suitable video switching and distribution, synchronizing pulse generation and distribution and all terminal, auxiliary and test facilities are provided to furnish appropriate high quality video signals to the display output devices. These devices consist of precision CRT displays for console operators, general utility CRT displays for less critical viewing purposes and group display projectors. The group display projectors forms a part of the Group Display Subsystem.

A large portion of the total display information available to Mission Control and Support personnel is generated, distributed and displayed by means of high quality television facilities.

TV displays are generated by three (3) signal sources:

- a. TV cameras within the MSCC
- b. Digital-to-TV Converters
- c. Remote video inputs received via the common carrier

The resulting video signals are distributed on demand to system users by means of video switching equipment and video distribution amplifiers. On demand, distribution is effected by automatic addressing of the video switching system via appropriate equipment (Video Switching Matrix Control). After appropriate distribution, the video signals are applied to individual CRT displays which are located in the various operator consoles and to a limited number of CRT displays for general purpose viewing. Video signals are also distributed to large screen projectors which are part of the Group Display Subsystem. Appropriate synchronizing signals are generated and distributed to drive all TV signal sources and all TV displays within the MSCC.

To form a complete functional subsystem, a number of special purpose terminal, auxiliary and test equipments are provided and include:

- a. TV Standards Converter - This equipment is required to make standard EIA TV signals compatible with the high-resolution standard specified for the TV Subsystem.
- b. Hardcopy Recording Equipment - This equipment is required to provide paper copy of selected TV displays with minimum time delay.
- c. Magnetic Recording Equipment - Provides intermediate and permanent storage of TV picture sequences with playback capability through the subsystem.
- d. Program Switching Equipment - Provides an editing capability for assembly of a variety of TV displays which may be recorded and/or released to public information and special viewing facilities.
- e. Control, Test and Monitoring Equipment - Provides an integrated capability for optimum subsystem maintenance and operation.
- f. Auxiliary Equipments and Facilities - Provides all items of accessory equipment to assure proper subsystem operation.

The TV Subsystem includes the following equipments:

- a. High Resolution Camera Chains
- b. Console TV Display Monitors
- c. Utility TV Display Monitors
- d. Set-up Video Waveform Monitors
- e. Video Switching Matrix

- f. Video Program Switchers including manual selection controls and special effects amplifier.
- g. Manual Video Selection Control Panels and Indicators
- h. Synchronizing Pulse Generation and Distribution Equipment including:
 - High-Resolution Synchronizing Generators Change-over Switch
 - EAI Synchronizing Generator
 - High Resolution Pulse Distribution Amplifiers
 - EAI Pulse Distribution Amplifiers
- i. Standards Conversion Equipment
 - High Resolution to EIA Video
 - EIA to High-Resolution Video
 - Slow-Scan to High-Resolution Video
- j. TV Control Consoles
- k. Video Tape Recording Equipment
- l. TV Hardcopy Recorder
- m. Test Signal Generator Set
- n. Video Distribution Amplifiers
- o. Video Processing Amplifiers
- p. Video Signal Patching Equipment
- q. Video Switching Matrix Control
- r. Auxiliary Switching Matrix
- s. Auxiliary Switching Matrix Control

3.2 COMPUTER - DISPLAY AND CONTROL INTERFACE SUBSYSTEM

The Computer-Display and Control Interface Subsystem is composed of computer request equipment, encoder-multiplexer equipment, plotting display equipment, slide file equipment, digital-to-television converter equipment, digital display driver equipment, telemetry event drivers, chart recorders, and MOCR Switch unit. Also, the timing and console equipment is discussed within the S/S. Some of the computer request, encoder-multiplexer, digital-to-television converter, and converter slide file equipments are used strictly to support the functions of the Simulation, Checkout, and Training System. Those components that are used exclusively in this manner are grouped together as auxiliary display equipment. The majority of the equipment comprising the subsystem is located in rooms 216, 316, and 319. Additional equipment, such as console keyboards, is located in the MOCR's and associated SSR's, in the second floor simulation areas, the RCR, the RTCC, and rooms 118B, 227A, and 324.

COMPUTER REQUEST EQUIPMENT. The computer request equipment consists of console-mounted keyboards and modules that permit mission control operators to request information from the RTCC and perform control functions. This equipment includes manual selection keyboards, display request keyboards, forced display keyboards, phase control keyboards, summary message enable keyboards, and event sequence override modules.

ENCODER-MULTIPLEXER EQUIPMENT. The encoder-multiplexer equipment is comprised of computer request encoder (in general, one for each computer request keyboard) and a computer input multiplexer. The encoders detect and encode into a digital format the requests initiated on the computer request keyboards. The computer input multiplexer transmits the encoded requests to the RTCC on a controlled access basis.

PLOTTING DISPLAY EQUIPMENT. The plotting display equipment includes a plotting display data distributor and X-Y plotboards. The data distributor controls the distribution of plotting data from the RTCC to the X-Y plotboards and Group Display Subsystem projection plotting equipment. The X-Y plotboards contain dual pen and arm assemblies to permit simultaneous plotting of two independent sets of data.

SLIDE FILE EQUIPMENT. The slide file equipment consists of a converter slide file data distributor, converter slide files, reference slide files, and a set of slide-making equipment. The data distributor controls distribution of slide selection data to the slide files and control data to the video switching matrix of the Television Subsystem. The converter slide files permit random access to photographic slides, which provide background information for digital data included in composite video displays produced by the digital-to-television converter equipment. The reference slide files are identical to the converter slide files except that the slides contain reference information which is converted directly into video signals without the addition of dynamic digital data. Generation of slides for the slide files is accomplished with the slide-making equipment.

DIGITAL-TO-TELEVISION CONVERTER EQUIPMENT. The digital-to-television converter equipment includes a digital-to-television converter data distributor, storage buffers, display generators, and a test generator. The data distributor controls the distribution of display data from the RTCC to the display generator buffers. The buffers act as storage devices and store the display data until an associated display generator is ready to receive the data. The display generators produce composite video displays for television presentation consisting of computer derived digital data and background information. The test generator generates test signals to simulate the RTCC digital data for checking the operation of the digital-to-television converter equipment.

DIGITAL DISPLAY DRIVER EQUIPMENT. The digital display driver equipment is comprised of a digital display driver data distributor and digital display drivers. The data distributor controls the distribution of computer generated timing pulses to the timing equipment and of digital data to the digital display drivers, which control the various computer driven lamps in the Computer-Display and Control Subsystem equipments.

TELEMETRY EVENT DRIVERS. The telemetry event drivers receive telemetry event signals from the pulse-code-modulated operational telemetry subsystem and uses the signals to drive event indicators.

CHART RECORDERS. Chart recorders are utilized to enable personnel in the vehicle and life systems SSR's to evaluate trend data during a mission. The recorders contain channels for recording analog and event data signals received from the pulse-code modulated operational telemetry subsystem.

MOCR SWITCH UNIT. The MOCR switch unit permits various areas of the MOW that are common to both MOCR's (e.g., the Communications Controller Facility) to operate with either MOCR. The switch unit consists of preprogrammed patchboards for each area. Switching from one MOCR to the other is accomplished by changing patchboards.

AUXILIARY DISPLAY EQUIPMENT. The auxiliary display equipment consists of various computer request keyboards, an encoder-computer input multiplexer combination, converter slide file and data distributor, digital-to-television converter data distributor, buffer, and display generator. These components are identical to equipment previously described, but handle only simulation data.

TIMING COMPONENT. The timing component is comprised of master instrumentation timing equipment, a launch countdown processor, two relative time accumulators, two stop clock modules and associated control units, a timing simulator, a digital command time converter, and numerous wall clocks associated with a master control unit. All of the equipments, except the relative time accumulators, stop clock modules, digital command time converter, and wall clocks, are located in room 319. One relative time accumulator is in room 216; the other in room 316. The digital command time converter is in room 227, a stop clock module is in each MOCR, and wall clocks are mounted throughout the MSCC.

MASTER INSTRUMENTATION TIMING EQUIPMENT. The master instrumentation timing equipment is a dual master timer synchronized to the National Bureau of Standards radio station WWV. The master instrumentation timing equipment generates pulse rate signals and time code words for distribution throughout the MSCC to time index and synchronize actual and simulated mission operations.

LAUNCH COUNTDOWN PROCESSOR. The launch countdown processor decodes countdown and liftoff signals from the Kennedy Space Center and processes this data for the relative time accumulators.

RELATIVE TIME ACCUMULATORS. The timing equipment uses two identical relative time accumulators to accumulate countdown, mission, and general purpose timing signals. One relative timing accumulator serves user equipment on the second floor of the MOW; the other serves user equipment on the third floor.

STOP CLOCK MODULE EQUIPMENT. The timing equipment includes two digital stop clock modules operating in conjunction with remote control units for precise, manual stop clock functions. Each stop clock module is mounted in a spacecraft communicator console (one in MOCR 1, one in MOCR 2).

TIMING SIMULATOR. The timing simulator accepts, processes, and distributes timing signals from the master instrumentation timing equipment to the appropriate simulation equipment.

DIGITAL COMMAND TIME CONVERTER. The digital command time converter accepts timing signals from the master instrumentation timing equipment and supplies these signals to the Master Digital Command Subsystem at special logic levels.

WALL CLOCK EQUIPMENT. The wall clock equipment consists of a master control unit wall-mounted in room 319 and associated wall clocks spaced throughout the MSCC. The master control unit is synchronized with radio station WWV and supplies correction signals for the wall clocks.

CONSOLE EQUIPMENT. The console equipment provides display and control consoles for the Mission Operations Control Room (MOCR), Staff Support Room (SSR), and common areas in the MSCC. The console equipment interfaces with the Communications System, Simulation Checkout and Training System (SCATS), Master Digital Command System (MDCS), and equipment in the Display/Control System.

3.3 GROUP DISPLAY SUBSYSTEM

The Group Display Subsystem is composed of components located in five areas of the MSCC: the two MOCR's, the RCR, the RTCC, and the MBOA. The components comprise four functional equipment groups as follows: projection plotting, projection television, transparency projection, and group time and data.

PROJECTION PLOTTING. The projection plotting display equipment consists of various types of slide projectors and associated control devices (automatic and manual). These equipments work in conjunction with one another to produce high accuracy, wall-type displays of computer and manually generated data, plotted against static backgrounds. Slide-making equipment is included with the projection plotting displays for producing background reference slides.

PROJECTION TELEVISION. The projection television display equipment consists of large screen television projectors and, in the RCR, a reference slide file and video monitor equipment. The television projectors receive video signals from the Television Subsystem or the reference slide file (in the RCR only) and project the signals, as pictures, onto group viewing screens. The slide-making equipment included with the Computer-Display and Control Interface Subsystem is also used to produce slides for the RCR reference slide file.

TRANSPARENCY PROJECTION. The transparency projection display equipment is composed of transparency projectors, transparency-making equipment, and a data file. This equipment permits rapid generation of transparencies for reference purposes during a mission or rapid access to previously generated transparencies. A simple manual operation is all that is then required to project the transparencies onto group viewing screens.

GROUP TIME AND DATA. The group time and data displays consist of large-scale, alphanumeric readout units and display driver units. The time displays present various types of reference timing and event indications to

the MSCC control areas. The data displays present information concerning telemetry, tracking, and command data to the MOCR's and the RTCC. A video channel indication for the MOCR projection television displays is also provided by the group time and data display equipment.

4.0 SCATS (SIMULATION, CHECKOUT AND TRAINING SYSTEM)

The SCATS System is designed to provide realistic simulation of Gemini and Apollo Missions for training of Flight Control and support team personnel by support of training exercises in the seven modes:

1. Closed loop MSCC
2. Closed loop Remote Site
3. Closed loop integrated
4. GOSS
5. Open loop MSCC
6. Open loop Remote Site
7. Open loop integrated

The simulation is accomplished through realistic real-time telemetry and tracking data to the Flight Controller display within the MSCC and at the Ground Operational Support System (GOSS) Remote Sites. The SCATS also provides means for directing and monitoring the MSCC and Simulated Remote Sites for training, and provides during simulation the capability to integrate the MSCC systems and Real-Time Computer Complex (RTCC) with the Flight Crew Trainers (FCT's) at Houston and Cape Kennedy.

The SCATS design constraints require maximum utilization of operational communications links, Flight Crew Trainers, Mission Operational Control Room (MOCR) with its associated Staff Support Room, and the Communications System.

The SCATS functions are allotted to four subsystems, which are described below.

4.1 SIMULATION INTERFACE SUBSYSTEM

The Simulation Interface Subsystem (SIS) provides centralized termination for SCATS lines to and from external systems. Many of the data lines within the SCATS are also routed through the distribution frames and patchboards of the SIS. Interconnection between the Houston Flight Crew Trainer (FCT) and the SCATS is accomplished by means of patchboards.

Line amplifiers are provided for the telemetry data originating in the Houston FCT, and also for the telemetry data link between the PCM input transfer switch to the MSCC Communications System and the patching facilities of the SCATS.

The SIS also provides video amplifiers for the closed-circuit TV used within the Houston FCT.

4.2 SIMULATION DATA SUBSYSTEM

The Simulation Data Subsystem (SDS) performs all SCATS digital data handling functions, and provides the capability to interface simultaneously with one or two Ground Support Simulations Computers (GSSC)

(one GSSC in open-loop simulation mode, and the other in closed-loop simulation mode). The SDS provides the capability for SCATS operation without the GSSC in open and closed-loop simulated remote site exercise modes, and performs routing of GSSC outputs and inputs. The SCATS data users and data sources are capable of transferring data to and from the SDS at their own speed and in accordance with their priority assignment.

The heart of the SDS is a general purpose computer. This computer is referred to as the Process Control Unit (PCU), which accepts the inputs from two PCM Ground Stations and provides decommutated data for displays on the instructor consoles and the receive only (RO) printers of the SRSS. Telemetry summaries are generated by the PCU and provided as outputs to the Communications Processor at TTY rates.

Wide band and High-Speed Data interfaces between the PCU, GSSC's transmission links, and PCM Ground Stations are provided by the Exchange Control Logic (ECL). The Display/Control interfaces are provided by the Control and Status Logic (CSL). The CSL provides nearly all digital display data for the Simulation Control Subsystem (SCS).

The ECL is used for checkout in conjunction with the Dynamic Checkout Computer (DCC), which is the IBM 7094 computer loaded with a special program. During this period, only one GSSC can be used for simulation. The ECL output is either 2 kbps or simulated buffer multiplex checkout data that originates in the DCC. In addition to these outputs the 2 kbps input from the Communications Processor is routed to the DCC.

4.3 SIMULATION CONTROL SUBSYSTEM

The Simulation Control Subsystem (SCS) allows the monitoring of the GSSC, Mission Operations Control Rooms (MOCR's) and the SRS's during simulations. The MOCR's on the second and third floors of the MSCC have associated monitoring consoles. Each SRS has an independent console for monitoring and control purposes.

Television displays are provided for displaying selected data at the MOCR control console set. In addition to TV displays, status displays keep the instructor personnel informed of mission progress. Keyboards are provided for display selection and entry of data into the GSSC.

The SRS system monitor consoles provide independent monitoring and control for each SRS. Both faulted and unfaulted telemetry data is displayed along with the necessary status displays.

The Dummy Remote Sites (DRS) are an integral part of the SCS. Flight Control teams in each DRS monitor the simulated mission by TV time display data and by teletype test data provided by means of a teletype printer in each DRS. The Flight Controllers have no control capability in the DRS.

4.4 SIMULATED REMOTE SITES SUBSYSTEM

The Simulated Remote Sites Subsystem (SRSS) consists of three major equipment groups: Telemetry ground stations, Gemini Display Systems, and

Simulated Digital Command System Units (SDCSU). Each group is duplicated to provide for simulation of two complete remote sites, except the telemetry group which is designed to drive two Gemini display systems with only two PCM Ground Stations.

TELEMETRY GROUND STATIONS. The selected serial telemetry data is delivered to the PCM Ground Station (GS) through the PCM GS simulation adapter. Noise and output interrupt faults, simulating air-to-ground transmission path characteristics, can be introduced into the data stream at the PCM GS simulation adapter and telemetry output buffer.

The PCM data is decommutated by the PCM Ground Stations which provide the following outputs:

- a. Analogs
- b. Parallel multiplexed data
- c. 12-bit parameter address
- d. Transfer and stripping commands
- e. Sync status

The analog data is provided to the distribution and patching facilities of the Simulation Interface Subsystem (SIS) and then to the PCM output buffer for distribution of SCATS and MSCC data users. Output interrupt control of the telemetry data can be initiated by an instructor or by proper control words from the Ground Systems Simulation Computer (GSSC). The interrupt control is used to provide simulation of acquisition (AOS) and loss of signal (LOS) to the Flight Controller operating the Gemini display consoles. A wide band tape recorder is available for recording or play back of selected and annotated telemetry data.

Faulting of telemetry data is provided by the telemetry display fault logic. Both pre-selected analogs and events can be faulted or cleared under manual control by an instructor.

GEMINI DISPLAY SYSTEMS. Two Gemini Display Systems are used by the remote site Flight Controllers for training. The Gemini Display System consists of a set of five consoles, as follows:

- a. Agena System Monitor Console
- b. Gemini System Monitor Console
- c. Command Communicator Console
- d. Aeromedical Console
- e. M&O Console

These consoles are identical to the consoles provided at the Remote Sites. By proper selection of data and by rotating the Flight Controllers, these two display systems can simulate all GOSS Remote Sites containing flight control displays around the earth.

In addition to these consoles, three distribution frames are provided:

- a. Timing Distribution Frame (TDF)
- b. Telemetry Data Distribution Frame (TDDF)
- c. Digital Command System Distribution Frame (DCSDF)

SIMULATED DIGITAL COMMAND SYSTEM UNITS. To facilitate command of the space vehicles a SDCSU is provided for each Simulated Remote Site (SRS). These units are identical to the units delivered to the Remote Sites except that provisions have been made to allow command loading by means of High Speed Data (HSD) lines from the Communications Processor (CP), and manual interrupt has been included to simulate command transmission failure.

Commands transmitted may be either Real-Time Command (RTC) or Stored Program Command (SPC) or Computer Words (CW).

The SDCSU is a core memory device that stores commands prior to acquisition of a space vehicle. Commands can be selected from memory for transmission (RTC's) or a complete set of commands can be transmitted by a single execute (SPC's) or computer words. The commands are checked prior to loading into memory and are subbit encoded as they are transmitted to a vehicle simulator.

The vehicle simulator is either the FCT or Gemini or the GSSC for Agena. Commands are routed through the Communications Processor to either the GSSC or the FCT.

PHILCO CORPORATION

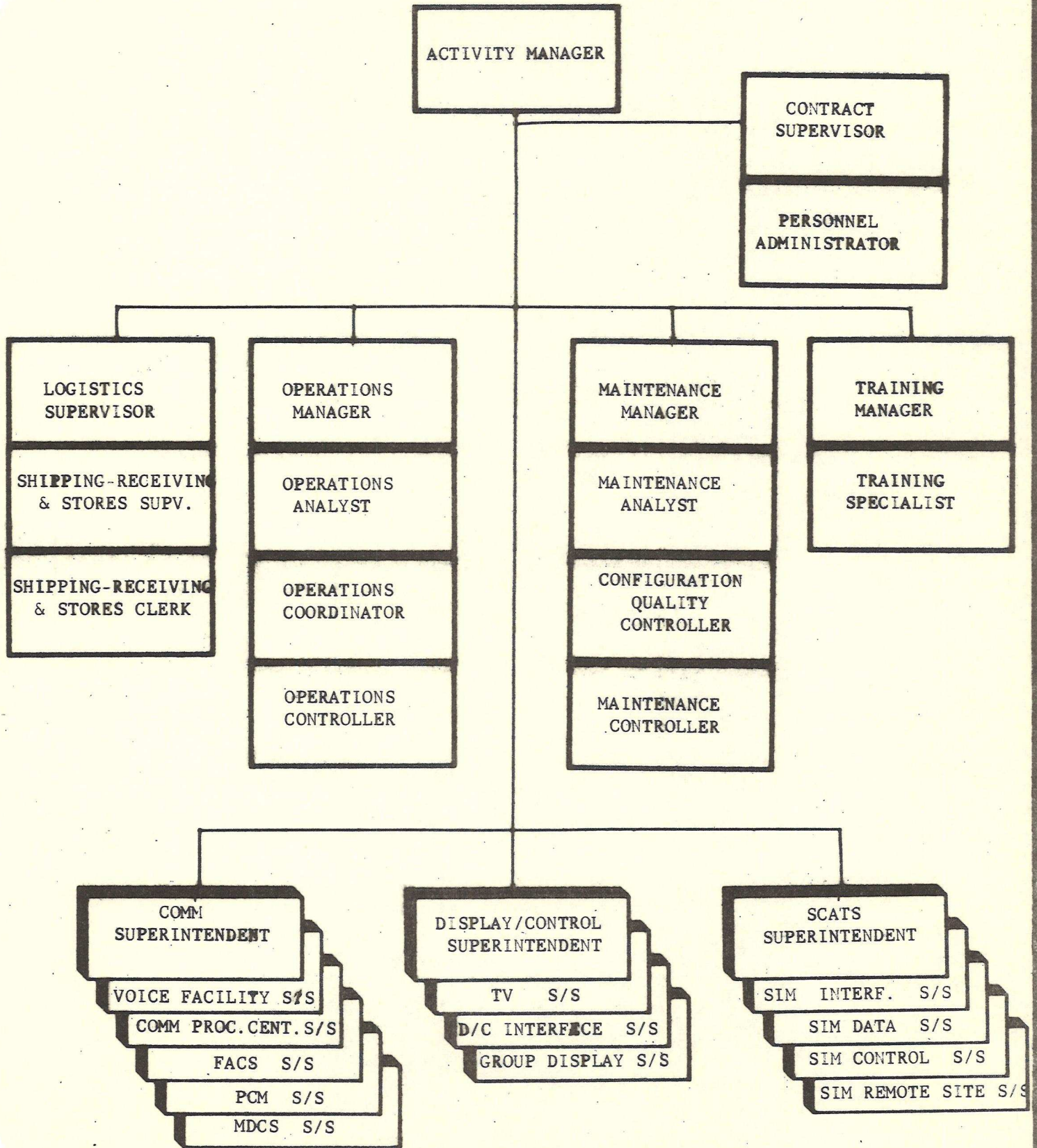
TECHREP DIVISION

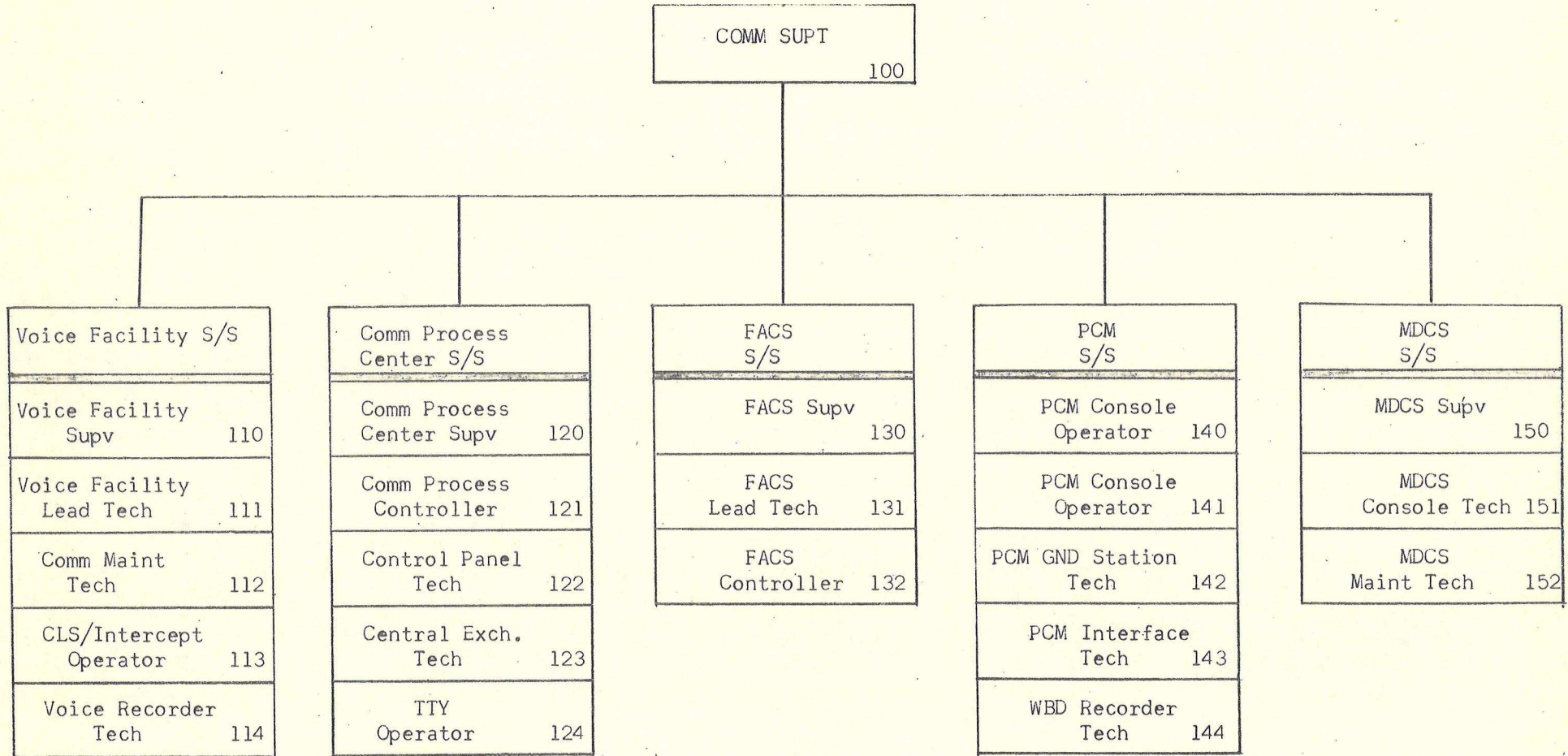
M&O ACTIVITY

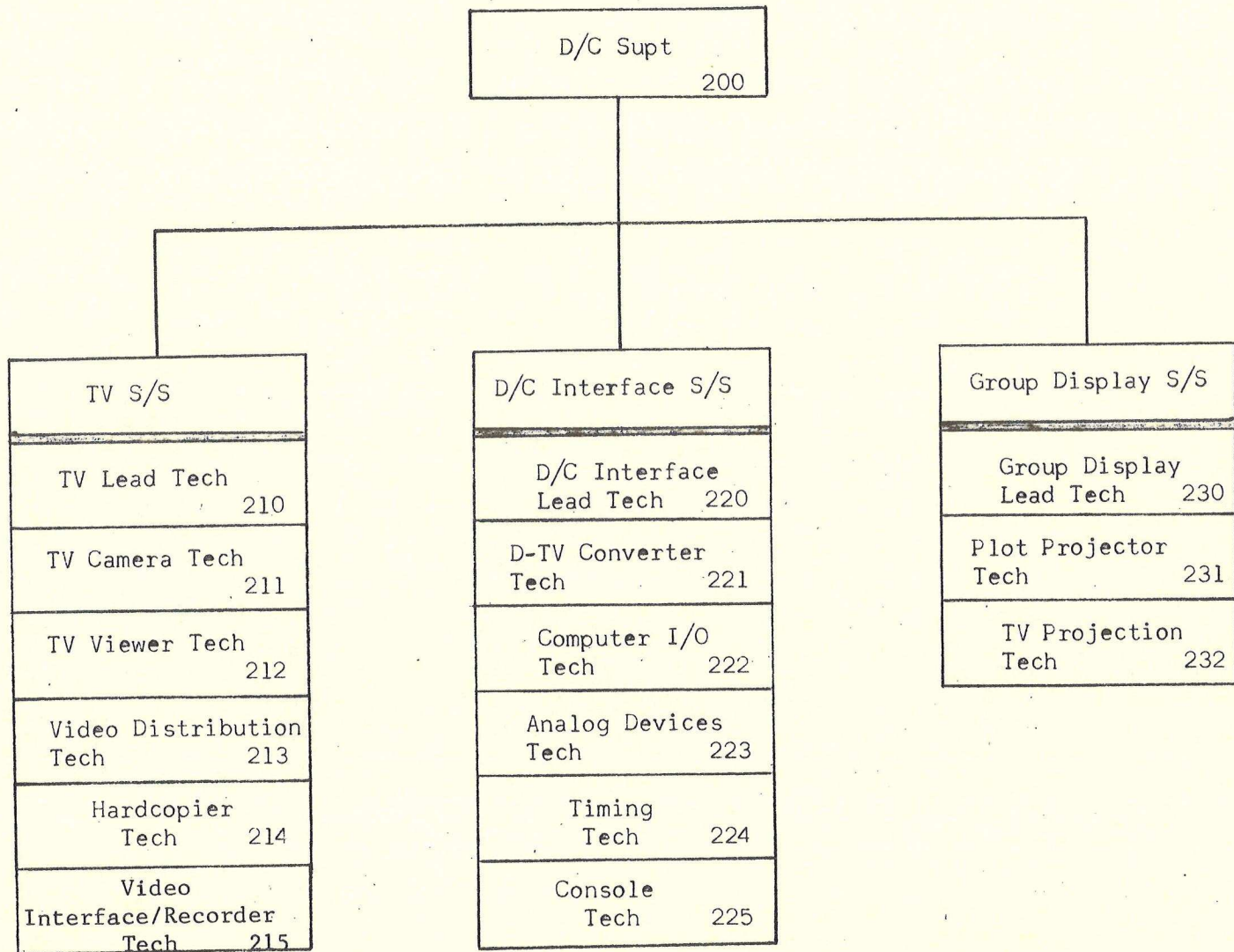
ORGANIZATIONAL CHARTS

AND

BRIEF JOB DESCRIPTIONS







SCATS SUPT.

300

SIM Interface
S/S

SIS Engineer

310

SIS Maint Tech

311

SIS/FCT Maint Tech

312

SIM Data
S/S

SDS Engineer

320

ECL/CSL Maint Tech

321

PCU Tech/Oper.

322

SIM Control
S/S

SCS Engineer

330

SCS Maint Tech

331

SIM Remote Site
S/S

SRSS Engineer

340

SRSS Console Maint

341

PCM Maint

Tech 342

DCS Maint

Tech 343

VOICE FACILITY S/S POSITIONS

110-VOICE FACILITY SUPERVISOR

Responsible for technical supervision of Voice Facility Subsystem personnel and the monitoring of equipment operation and readiness. Reports any change of equipment status to the Comm Superintendent. Coordinates trouble analysis and repair.

111-VOICE FACILITY LEAD TECH

Monitors operation of the Comm common equipment; specifically mans the test and patch position and operates the CCS key set at this position. Reports status of the subsystem and coordinates the activities of the voice facility equipment technicians. Coordinates trouble analysis and equipment technicians. Coordinates trouble analysis and equipment repair.

112-COMM MAINTENANCE TECH

Monitors operation of the console communications, Comm line switch and PA systems and informs the lead tech of equipment status, or impending change of status. Investigates all reports of equipment malfunction and effects repair of malfunctions.

113-CLS/INTERCEPT OPERATOR

Operates the Comm Line Switch Console in support of the mission. Operates Intercept Switch Board, intercepting calls on designated lines, arranging call back, return call, re-routing or completing calls as determined by established procedures. Becomes part of operator pool to provide continuous operation of the Comm line switch and the intercept board.

114-VOICE RECORDER TECH

Maintains operational readiness of recording and playback equipment. Records voice communications as directed by operational procedures. Records and plays back special voice events as directed by Flight Control personnel. Maintains tape files and operates Historical Playback equipment.

COMM PROCESS CENTER S/S POSITIONS

120-COMM PROCESS CENTER SUPERVISOR

Exercises operational control of the Communications Processing Center. During mission support periods, both UNIVAC 490 consoles will be manned by UNIVAC maintenance and programming operators reporting to the Center Supervisor through the Comm Process Controller.

121-COMM PROCESSOR CONTROLLER

Exercises control of the communications processor, monitoring the model 35 RO to determine immediate status of the comm processing equipment. During mission support periods, both UNIVAC 490 consoles will be manned by UNIVAC maintenance and programming operators reporting to the Comm Processor Controller, who in turn is under the supervision of the Comm Process Center Supervisor.

122-CONTROL PANEL TECH

Resolves pneumatic tube electronic control problems. Monitors control panel for changes in equipment status, reporting any changes of status to the tube operator.

123-CENTRAL EXCHANGE TECH

Resolves pneumatic tube mechanical/pneumatic problems. Monitors control panel for changes in equipment status, reporting any changes of status to the tube operator.

124-TELETYPE OPERATOR

Operates teletype equipment in direct support of the Comm Process Center. Teletype operators will be assigned to monitor incoming RO machines for garbled text or errors, and to initiate prompt distribution for file addressee; to tape perforator equipment to prepare properly edited and verified tapes prior to transmission; and to on-line transmission equipments.

FACS S/S POSITIONS

130-FACS SUPERVISOR

Responsible for technical supervision of all Facilities Controllers, the operation of facilities control equipment and specifically monitors the GLDS component. Reports any changes of equipment status to the Comm Supt. and Comm Process Controller.

131-FACS LEAD TECH

Responsible for components of the termination subsystem and performs the necessary monitoring, testing, operation and maintenance of the facility.

132-FACS CONTROLLER

Responsible for the HSD Components, DCU, voice frequency line termination and video test and patch equipment.

PCM S/S POSITIONS

140-PCM CONSOLE OPERATOR

Responsible to the Comm Supv. and Flight Controllers for the functional readiness of all PCM equipments. In addition, assumes an active role as an operation control-and-monitor console operator for setting up and operating the console equipment, malfunction analysis, and the manual insertion of control data.

141-PCM CONSOLE OPERATOR

Responsible to the M&O Supervisor and Flight Controllers for PCM data formatting control, data selection and distribution within the MSCC, and the insertion of control bits and formatting of data routed to the RTCC. Maintains all PCM and support equipments.

142-PCM GROUND STATION TECH

Responsible to the Maintenance Supervisor and Flight Controllers for the operation of the PCM ground stations. Reporting data parameter values when required, and providing general support of the wide band components.

143-PCM INTERFACE TECH

Responsible to the Maintenance Supervisor and Flight Controllers for the operation of the PCM output buffers, analog displays, and event status recorders.

144-WIDE BAND DATA RECORDER TECH

Responsible to the Maintenance Supervisor for the recording of all PCM data received at the MSCC, and the search and playback of data as required to support mission objectives.

MDCS S/S POSITIONS

150-MDCS SUPERVISOR

Responsible to the Comm Superintendent, M&O Supervisor and Flight Controllers for the functional readiness of all MDCS equipments and consoles. In addition, the MDCS Supervisor will assume an active role as Console Technician, responsible for command link failures, manual alteration and transmission of command data.

151-MDCS CONSOLE TECH

During the absence of the MDCS Supervisor, the Console Tech is responsible for the supervision of MDCS personnel, and assumption of all other duties, administrative and technical, normally assigned to the MDCS Supervisor.

152-MDCS MAINTENANCE TECH

Responsible to the MDCS Supervisor for operational capability of MDCS equipment and consoles; reporting of apparent equipment discrepancies and/or failures; monitoring of all equipment rack indications pertinent to mission performances.

TV S/S POSITIONS

210-TV LEAD TECH

Operating from the video engineer's console, monitors TV subsystem performance. Initiates and follows through with diagnostic and corrective action as required to resolve problems or troubles.

211-TV CAMERA TECH

Restores TV Camera service by most expedient method, such as unit replacement. Assists the shift TV Lead Technician at the video engineer's console. Advises on the quality of video signals in the system as indicated on the console displays.

212-TV VIEWER TECH

Attends the scan converter equipment and is available to go to the location of any faulty TV monitors, performing necessary maintenance or replacement.

213-VIDEO DISTRIBUTION TECH

Responsible for maintenance and operation of switching, matrix, scanner, distribution and stabilizing amplifiers.

214-HARDCOPIER TECH

Operates and maintains the photo hardcopiers. Hardcopies are taken from the machine and routed by pneumatic tube to requestors. Makes adjustments necessary to maintain acceptable quality of photo reproduction. Responsible for producing reference and converter slides and maintaining the slide library.

215-VIDEO INTERFACE/RECORDER TECH

Serves as interface for technical requirements of incoming and outgoing TV. Adjusts video levels as required and monitors video levels. Operates the video tape recorders and takes appropriate action to keep recorders in operation.

COMPUTER D/C INTERFACE S/S POSITIONS

220-D/C INTERFACE LEAD TECH

Monitors the performance of D/C interface equipments from the D-TV converter engineer's console. Initiates corrective action to resolve any problems or troubles in the system.

221-D-TV CONVERTER TECH

Monitors the performance of the D-TV converters; investigates indicated and reported problems relative to the converters. Makes on line adjustments and repairs to provide maximum in-service operation of the equipment. Coordinates with the Video Engineer and RTCC interface contact when required to resolve and isolate problems in the general computer, converter, and TV chain.

222-COMPUTER INPUT/OUTPUT TECHNICIAN

Responsible for operation and maintenance of the keyboards, console modules, computer input multiplexers, MOCR switch unit, data distributors and slide files.

223-ANALOG DEVICES TECH

Operates and maintains the X-Y plotboards and chart recorders. Insures that the charts are legibly marked by styli; reloading chart paper as required.

224-TIMING TECH

Responsible for the Master Instrumentation Timing Equipment, Relative Time Accumulators, AMR Countdown Processors, MDCS Time Converters, Remote RTA Control, Mercury Timing Simulator, Stop Clock Module, Group Time Displays, and Data Source Display. Monitors the timing outputs, responding to indicated or reported trouble in the timing equipment by taking corrective action on-line or by replacing units.

225-CONSOLE TECH

Responsible for the maintenance of all MSCC console shells, wiring distribution, lamp test, AC distribution and digital display modules.

GROUP DISPLAY S/S POSITIONS

230-GROUP DISPLAY LEAD TECH

Responsible for all group display equipment, including TV projectors, scribing projectors, spotting and background projectors, character generators, and controls.

231-PLOT PROJECTOR TECH

Responsible for the operation and maintenance of the projection plotting displays, background projector, scribing projector, spotting projector, screens, mirrors, daylight/darkness indicator, manual plot generator, reference file projector and overhead projector.

232-TV PROJECTION TECH

Responsible for the operation and maintenance of the TV projectors and projection TV control modules.

SIM INTERFACE S/S POSITIONS

310-SIS ENGINEER

Responsible for placing the SIS in operational condition, resolving any unusual patching or data flow problems. May repatch SCATS configuration to circumvent certain equipment malfunctions. Reviews SIM Data Acquisition Plan to determine equipment patching and data routing requirements.

311-SIS MAINTENANCE TECH

Responsible for installation and checkout of appropriate patchboards, resolving patch and data flow problems. Maintains interface equipment in the Simulation Equipment Area, Room 219. Assumes the duties of 310 during the absence of the SIS Engineer.

312-SIS FLIGHT CREW TRAINER MAINTENANCE TECH

Responsible for installation and checkout of appropriate FCT selection patchboards, resolving patching and data flow problems. Monitors operation of the FCT building interface equipment. Performs corrective and preventive maintenance. Assists 311 in open loop simulations.

SIM DATA S/S POSITIONS

320-SIM DATA SUBSYSTEM ENGINEER

Responsible for placing the SDS in an operational condition. Serves as interface between the PCU operator and all other subsystems and systems, thereby allowing the PCU operator to properly perform his operational duties. Reviews SIM Data Acquisition Plans to determine equipment and program requirements.

321-ECL/CSL MAINT. TECH

Responsible for placing the Exchange Control Logic and the Control and Status Logic in operational condition.

322-PCU TECH/OPERATOR

Responsible for the operation and maintenance of the PCU (UNIVAC 1218 Computer). Assumes the duties of position 320 during the absence of the SDS Engineer.

SIM CONTROL S/S POSITIONS

330-SCS ENGINEER

Responsible for placing the SCS in operational condition, resolving any equipment problems in the SCS. Reviews SIM Data Acquisition Plans to determine equipment requirements.

331-SCS MAINT. TECH

Maintains SIM control equipments and assumes responsibility of position 330 during the absence of the SCS Engineer.

SIM REMOTE SITE S/S POSITIONS

340-SRSS ENGINEER

Responsible for placing the SRSS in operational condition. Reviews the SIM Data Acquisition Plan to determine equipment and data routing requirements.

341-SRSS CONSOLE MAINTENANCE

Responsible for SIM remote site console maintenance. Serves as SIM M&O Supervisor during remote site simulations. Controls the operation of all SRSS hardware with the exception of the SIM control subsystem during simulations.

342-PCM MAINTENANCE TECH

Responsible for the operation and maintenance of the PCM ground station. Reports data parameter values when required.

343-DCS MAINTENANCE TECH

Responsible for maintenance and operational capability of the SDCSU equipment.

BRIEF JOB DESCRIPTIONS
OF
M&O MANAGEMENT/ADMINISTRATIVE STAFF

500-M&O ACTIVITY MANAGER

Responsible for the direction and performance of the MSCC M&O organization. Assures that M&O resources are effectively developed and utilized to provide NASA with the required maintenance and operation of the MSCC to support manned spaceflight missions.

510-MAINTENANCE MANAGER

Responsible for directing and administering the maintenance activities of the M&O organization. Directs and schedules maintenance activities and the necessary inspection, reporting and analysis of maintenance performance. During mission periods, functions as the M&O Supervisor of the Mission Operations Control Group, alternately with the Manager of Technical Operations.

511-MAINTENANCE ANALYST

Establishes procedures for reporting, investigating, and correcting equipment performance discrepancies. Responsible for establishing procedures for compiling historical information on MSCC equipment operation and maintenance, on a daily basis. Implements and controls a scheduled maintenance program to minimize interruption of system operation and marginal performance.

512-CONFIGURATION QUALITY CONTROLLER

Responsible for the control of the MSCC configuration, the maintenance of records and drawings pertaining to the configuration, and modifications of the configuration. Establishes procedures for the control, issue, storage and revision of documentation provided for the use of the M&O Activity.

513-MAINTENANCE CONTROLLER

Prepares and distributes quarterly and monthly maintenance schedules and changes. Coordinates maintenance scheduling with RTCC Supervisor and System Superintendents. Assists in resolving technical problems regarding maintenance, operation and modifications. Maintains surveillance over maintenance programs in progress to assure equipment availability when operationally required.

520-MANAGER OF TECHNICAL OPERATIONS

Responsible to NASA Flight Operations for the operational support provided by MSCC M&O personnel. Accomplishes personnel scheduling and administration of continuously operated facilities and participates in the development of operating procedures, countdowns, and formats to be employed during mission periods. Functions as the M&O Supervisor of the Mission Operations Control Group during mission periods.

521-OPERATIONS ANALYST

Responsible for the scheduling of Philco MSCC equipment and M&O personnel during simulations, special tests, and mission operations. Observes operations and submits reports to the Technical Operations Manager with appropriate comments and recommendations. Responsible for the development of M&O Countdown Procedures.

522-OPERATIONS COORDINATOR

Confirms that all operational documents and directives are on hand and that all revisions and amendments have been incorporated for each mission. Conducts final review of MSCC requirements with all supervisors and superintendents to insure proper MSCC configuration and performance.

523-OPERATIONS CONTROLLER

Responsible for the M&O participation in the preparation of M&O DST/BST procedures and mission records. Coordinates procedure development with appropriate NASA office. Assists the Technical Operations Manager at the M&O Supervisor's Console during simulations and mission operations.

530-TRAINING MANAGER

Directs and administers the internal training activities of the M&O organization. Responsible for the formulation of training plans, evaluation of training needs and documentation of training accomplishments.

531-TRAINING SPECIALIST

Accomplishes the necessary evaluation of training requirements. Maintains records of course materials, personnel training and performance histories, and other pertinent data of value for improving the existing training programs and development of future programs.

540-LOGISTICS MANAGER

Directs and administers the local supply activities of the M&O Logistics Department. Responsible for maintaining adequate local supply levels and the necessary records to assure availability of supply for the M&O Activity.

541-SHIPPING/RECEIVING & STORES SUPERVISOR

Responsible for the acquisition, receipt, storage and issue of technical electronics equipment and spares in support of the M&O program.

542-SHIPPING/RECEIVING & STORES CLERK

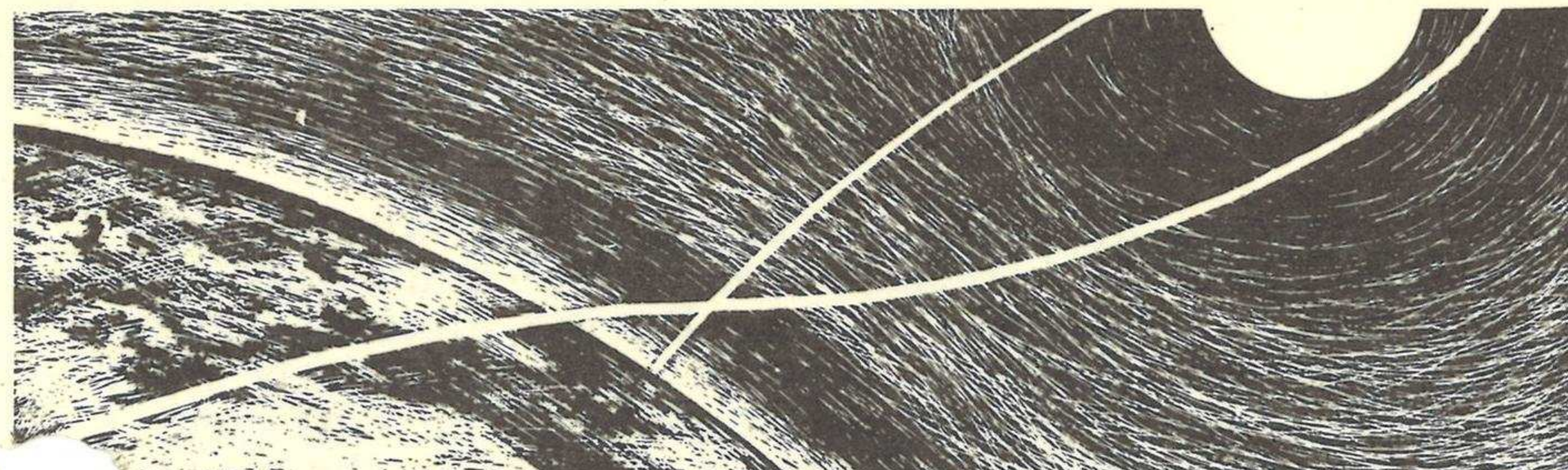
Assists the Shipping/Receiving & Stores Supervisor and maintains proper record cards in support of the M&O program.

550-CONTRACT SUPERVISOR

Accomplishes the necessary administrative functions associated with the administration of M&O personnel. Responsible for the administration of assignments, leave policies, security, personnel services and personal considerations associated with the administration of M&O personnel.

553-PERSONNEL ADMINISTRATOR

Assists the Contract Supervisor with the administrative responsibilities of the M&O Activity.



MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT GEMINI

On December 7, 1961, a plan "to extend the Project Mercury effort with the development of a two-man spacecraft," was approved and on January 3, 1962, the program was officially designated as "Project Gemini" after the third constellation of the zodiac featuring the twin stars, Castor and Pollux.

OBJECTIVES

As an intermediate step between Mercury and Apollo, the objectives of Project Gemini are:

1. To provide early manned rendezvous capability by (a) developing techniques, (b) assessing pilot functions, (c) developing propulsion, guidance and control, (d) developing pilot displays, and (e) training pilots and providing them with rendezvous experience.

2. To provide long-duration manned flight experience by (a) studying effects of weightlessness, (b) determining physiological and psychological reactions to long-duration missions, (c) determining psychological reactions to the missions, and (d) developing performance capabilities of the crew.

GEMINI SPACECRAFT

Basically, the Gemini spacecraft will be similar in shape to the Mercury craft. It will be based on the current Mercury configuration, but it will weigh approximately twice as much as Mercury, will be about 20 percent larger and will have about 50 percent more volume. The Mercury craft was about six feet wide at the base as compared with the Gemini vehicle which will be about seven and one-half feet wide at the base (16 inches wider).

The Manned Spacecraft Center's Project Mercury experience has enabled its scientists and engineers to improve the new vehicle's design in many ways. Many of the advanced concepts in systems engineering for spacecraft have already been explored.

A space between the outside of the pressurized crew compartment and the external surface of the craft will house instrument packages, electronics gear and landing gear. This double construction will also serve effectively against micro-meteorite damage.

Only the systems directly connected with the crew, such as, the environmental control system, ejection seats, food and waste equipment, microphones, speakers, the instrument panel and guidance controls will be housed inside the crew compartment, within the pressurized area.

With many of the flight systems placed outside the crew's pressure vessel, major components will be arranged in easily-removed, replaceable modules, thereby reducing maintenance and checkout time. Whole systems, even the Environmental Control System, can be pulled out, in the event of malfunction, and replaced with another "packaged" system without the crew compartment being opened and without the countdown being interrupted for long periods of time.

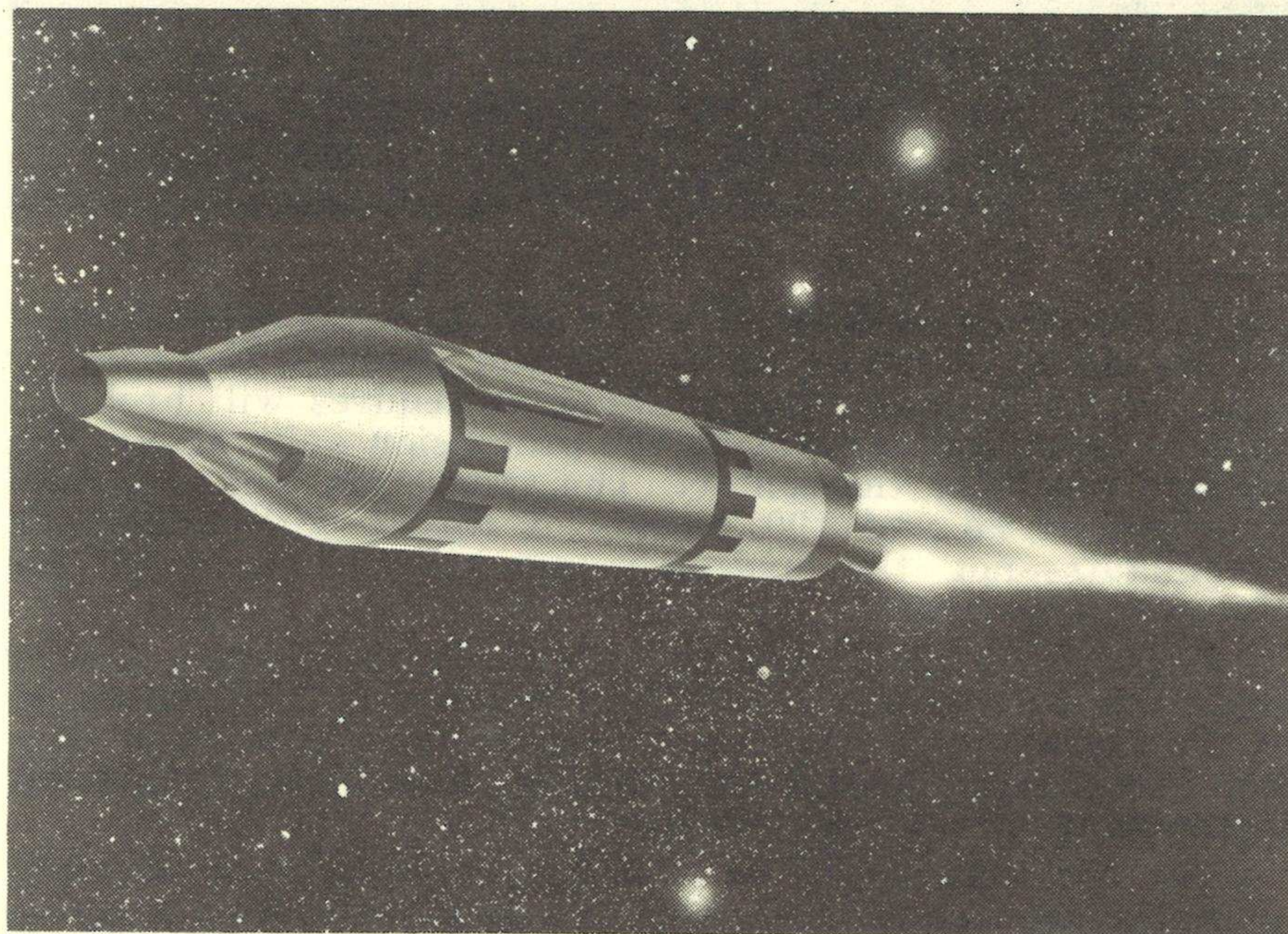
The Gemini spacecraft should, therefore, require a little over two and one-half months testing prior to a mission, instead of the six to seven months, which has been the experience with the Mercury spacecraft.

TITAN II

The Gemini launch vehicle will be a slightly modified Titan II, a second-generation launch vehicle. Titan II employs storable hypergolic (self-igniting upon mixing) propellants, permitting a much shorter countdown period prior to launch than presently required in the Mercury-Atlas program. Shorter countdowns are necessary because of the close schedule which must be followed in order to successfully complete the rendezvous mission after the rendezvous target is orbited.

Problems of launch vehicle-spacecraft integration between the Titan II and the Gemini craft should be somewhat less than in the Mercury-Atlas program because of the experience gained from the Mercury program.

The overall length of the Gemini-Titan II combination will be 110 feet. The Titan II alone is 90 feet long; its first stage is 70 feet long and its second stage is 20 feet long. The vehicle is ten feet in diameter from the thrust section to the spacecraft adapter section.



AGENA D

The Agena D vehicle will be used as the target vehicle for Gemini rendezvous and docking. The vehicle is about 32 feet long and 60 inches in diameter.

Since the Atlas launch vehicle used does not provide sufficient power to insert the Agena into orbit, the Agena will power itself into orbit, using the Atlas as a launch platform. When desired orbital conditions are obtained, the Agena engine will be shut down for later use.

After the Agena target is in orbit, Mercury ground tracking stations will determine whether or not the Agena is operational and is in the proper orbit for rendezvous. There will be a several-minute "window" when Gemini might be launched and be in close proximity to the Agena. But by firing up the Agena and changing its orbit to conform more closely with the Gemini orbit, the window can be extended to more than four hours. The Gemini will either be launched during this window or will wait for a corresponding window at least one day later.

If the two vehicles were launched into their orbits 180 degrees apart—on the opposite sides of the earth from each other—it would take the Gemini 36 orbits (54 hours) to overtake the Agena. Thus, launching of the Gemini within the prescribed window is necessary.

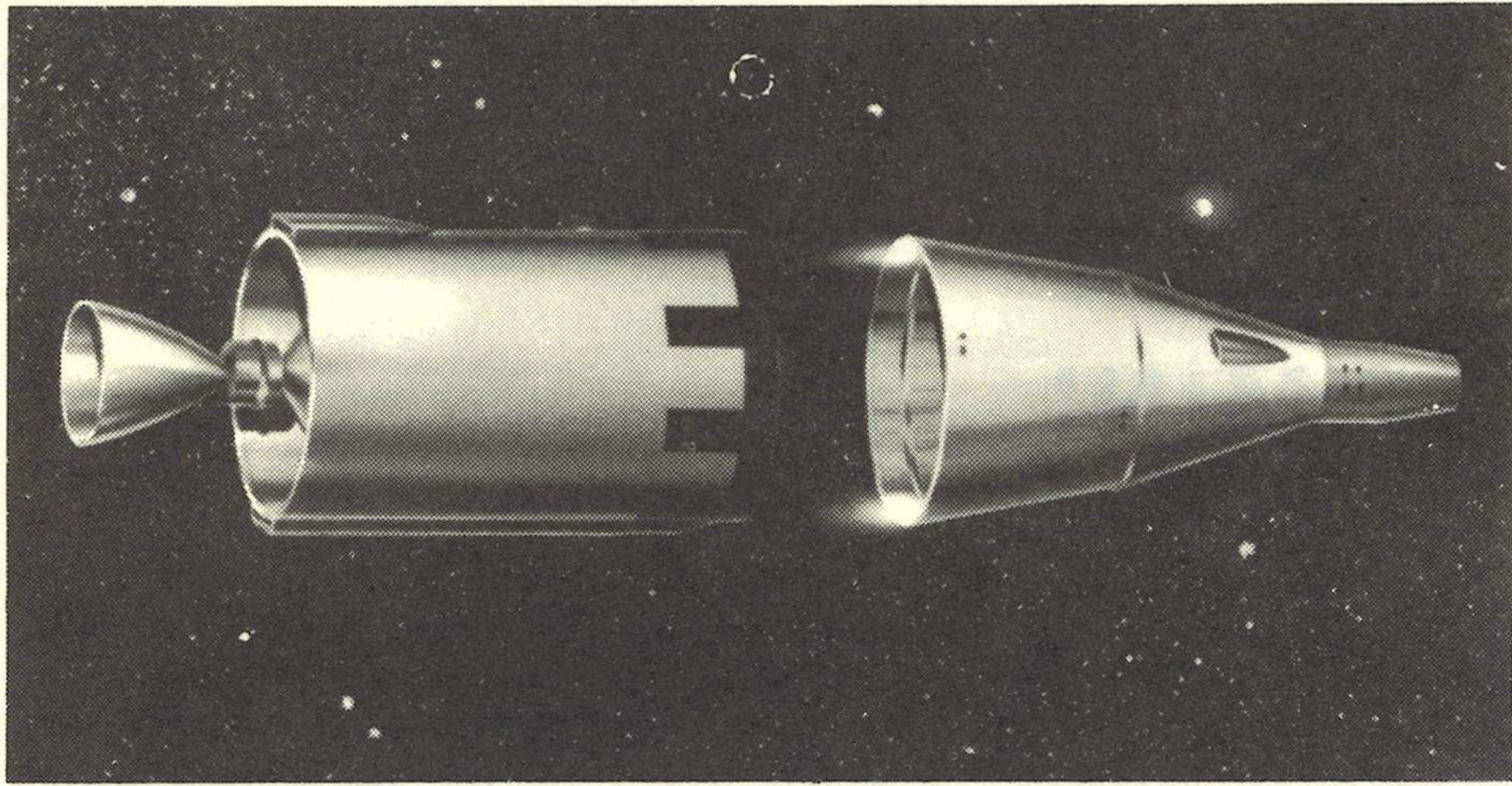
The Agena can wait in orbit for five days. As planned, though, it will go up one day and be followed by the piloted Gemini craft in about 24 hours.

According to the determination of the window, the Gemini vehicle will be launched. Launch-timing and mid-course corrections will be such that the manned spacecraft will be placed in close proximity to the Agena. The Gemini vehicle will be in an 87 to 150 miles altitude orbit. The astronauts will control the Gemini vehicle in an approach manner in accordance with instructions from ground tracking stations and into a terminal docking position with the Agena.

As the Gemini closes to within 250 miles of the Agena in orbit, the manned spacecraft may be guided toward its target automatically by aid of an onboard radar and computer, or the astronaut may use the radar system and control the spacecraft manually. Adjustments for the orbital path will be made from ground control stations as far as the Agena is concerned. The Agena will have a cold gas (nitrogen) system for stability and control thrusts. Similar adjustments will be made for the spacecraft, either manually or by earth control in order to successfully complete the rendezvous.

After using the radar system aboard the Gemini to close within about 20 miles, the astronauts should be able to see the high-intensity, flashing light aboard the Agena for optical tracking.

The two vehicles, though rushing through space at some 18,000 miles per hour, will have a difference in speed of only



one to two miles per hour. The flexibility of this speed is ideal for threading the nose of the Gemini through the docking collar of the Agena. Final docking procedures will probably be accompanied by activating the propulsion units aboard the manned craft for the contact. The spacecraft will use small thrusters of 25 and 100 pounds of thrust with hypergolic propellants—not the hydrogen peroxide as is used for Mercury spacecraft.

There is a possibility that Manned Spacecraft Center engineers will mount a television camera on the Agena or in the spacecraft so that ground controllers in Mission Control Center can monitor the docking procedures. This point in planning is not yet definite.

The astronauts will be able to see the Agena straight ahead of the Gemini through the flat glass of the windows in their hatches. An index bar of the spacecraft will engage the "V" notch or slot in the docking collar on the end of the Agena. The collar area will be fitted with both solid and buffer areas. Upon contact with the cone of the Gemini craft, if the match has not started perfectly, both crafts will turn slightly and conform. If the Agena is bumped away, the astronauts will merely set up for another attempt. Pulse jets will give the Gemini a small kick at a time.

During the latching part of the docking phase, when clamps inside the Agena collar grab the Gemini nosecone and pull it into a latched position, the instrumentation wires will also be connected. The astronaut will then be able to observe the "health" of the Agena—fuel, connection, etc. Facilities aboard the Gemini spacecraft will enable the pilot to start the Agena propulsion system.

Since the Gemini will nose into the front collar end of the Agena, the Agena thrust will be provided from the opposite end. This will cause the astronauts to be propelled backward when using Agena power for maneuvering. The "eyeball out" forces will be less than 2 g's and are not considered a problem of any kind.

Since the Agena engine will have multirestart capability, the Gemini when it arrives in orbit will have another engine waiting there ready to supply power for orbital maneuvering. Here the engine can be used for adjusting the orbit, extending the apogee of the orbit, or for changing to another orbit. All the experiments that will be performed at this phase of the mission have not yet been documented.

Gemini rendezvous experiments are particularly important since lunar orbital rendezvous will be the method employed for carrying out final phases of Project Apollo multimanned, lunar landing and earth return missions.

Since Mercury flights have shown that man can operate satisfactorily in a space environment, and since the second Gemini crew member will provide backup for the first, it is planned that Gemini will have less automatic sequencing of flight modes than did Mercury. Operations with man in the role of mode selector and acting as sensor operator in the rendezvous missions should again provide experience and knowledge that will increase confidence in the role to be played by man in Appolo.

ESCAPE SYSTEM

The ejection seat escape system will be as reliable as the Mercury escape tower system. Either the pilot (spacecraft commander) or the co-pilot (crew) can fire both ejection seats by pulling a "D" ring at his knee. There is no automatic eject device. Normally, the pilot will give the order for ejection; if he is unable, the co-pilot can perform the job.

Unlike the escape tower, the seat system can be used after reentry in the event that trouble develops with the para-glider landing recovery system.

The catapult seat rockets will eject the astronauts at an

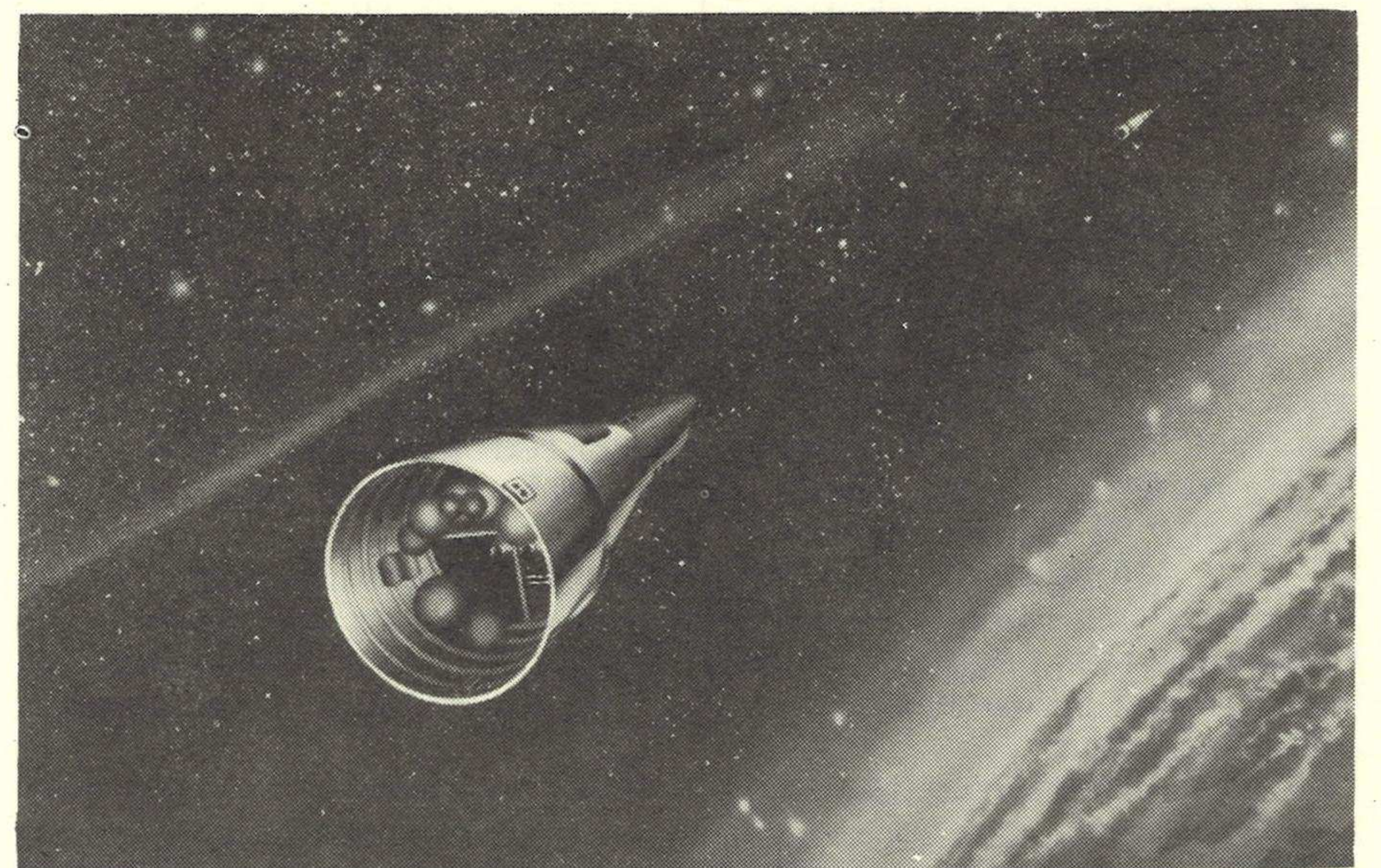
angle of 15 degrees up from horizontal to an altitude of about 500 feet from the ejection level and to a distance of about 1,000 feet out from the vehicle. During ejection, each man will be restrained in his pressure suit and in his restraint couch. A personal oxygen supply will be sufficient for each astronaut until safe altitude is reached in the event of a high altitude abort.

ADAPTER SECTION

The Gemini-Titan adapter section will be carried into orbit with the spacecraft; it will house the fuel cells, the main oxygen supply, the maneuvering control system, the retrorockets, etc. The adapter section itself is 90 inches long, 90 inches in diameter at the top (base of the spacecraft) and 120 inches in diameter at the lower end (top of the launch vehicle).

Fuel cells which combine oxygen and hydrogen to produce electricity and water and which weigh far less than the batteries they replace will be one of the new developments in the Gemini program; these will provide the main source of electricity and part of the water supply during orbital flight.

Water from the fuel cells and perspiration collected during the flight will comprise the water supply. Perspiration will be condensed out of the air and passed through charcoal for purification. Excess water will be discharged into space via a water boiler.



Since the adapter section will be jettisoned prior to reentry the spacecraft will be powered for reentry, landing and post-landing phases of the mission by an array of silver zinc batteries. These batteries also serve as an emergency power source during the orbital phase.

The adapter section will contain the maneuvering control systems to be used in space. Other systems located in the small end of the spacecraft provide the retroattitude and reentry control. The systems are completely dual and give redundancy for this operation. Each system in the small end will be independent and will have eight nozzles; the system in the adapter section will be used during the docking phase and to make small orbital plane changes.

RETROCKET SYSTEM

Just prior to initiation of the reentry process after the Gemini mission, the lower half of the adapted section will be jettisoned to expose the retrorockets housed in the top half of the adapter section.

The retrorocket system will provide the means of slowing the Gemini spacecraft to permit its reentry into the Earth's atmosphere. Solid propellant rockets will fire in ripple fashion upon a signal by the crew or by an automatic device within the spacecraft; this device will be armed by the crew. The retrorocket system may also be used to separate the spacecraft from the launch vehicle in the event of launch abort.

After employment of the retrorockets, this remaining section of the adapter unit will be jettisoned, leaving the heat shield exposed for reentry.

Since few of the Gemini systems will be completely automatic, there will be more dependence upon man than in the Mercury flights. A horizon sensor of the infrared-detecting type, however, will be practically automatic (like an aircraft auto-pilot). This sensor will sense spacecraft roll and pitch attitudes with respect to the Earth's horizon and provide

the basis for attitude reference throughout the mission. Use of this device will conserve fuel and diminish demands on the pilot.

A gyro system for attitude control during reentry will also be automatic to relieve the astronaut of some of the strenuous maneuvers required to control the possibly violent reactions of the craft during reentry.

Some of the life support systems to be studied during the mission include toxicity studies to determine effects of man's living in a closed environment with certain atmospheric mixtures; development of closed systems, self-generating systems, etc.; crew equipment development (pressure suit primarily); waste management and effect on weight and space; crew medical selection and monitoring; biological instrumentation development for man as an integrated part of the system and the development of medical monitoring techniques and keeping the individuals in good muscle tone; and medical data collection analysis.

TRACKING

While the existing Mercury Worldwide Tracking Network will be used for the Gemini program for tracking, telemetry, command, control and communication, final requirements are still being developed. It is foreseen that both the rendezvous requirements and the maneuver experiments will require specialized instrumentation to provide expanded capability.

All the tracking stations now have two-way communications with orbiting Mercury spacecraft; some have both tracking and telemetry receiving capability, while others have only one or the other of tracking and telemetry receiving capability. Some of the stations also have the capability of sending instrument-command communications to the spacecraft.

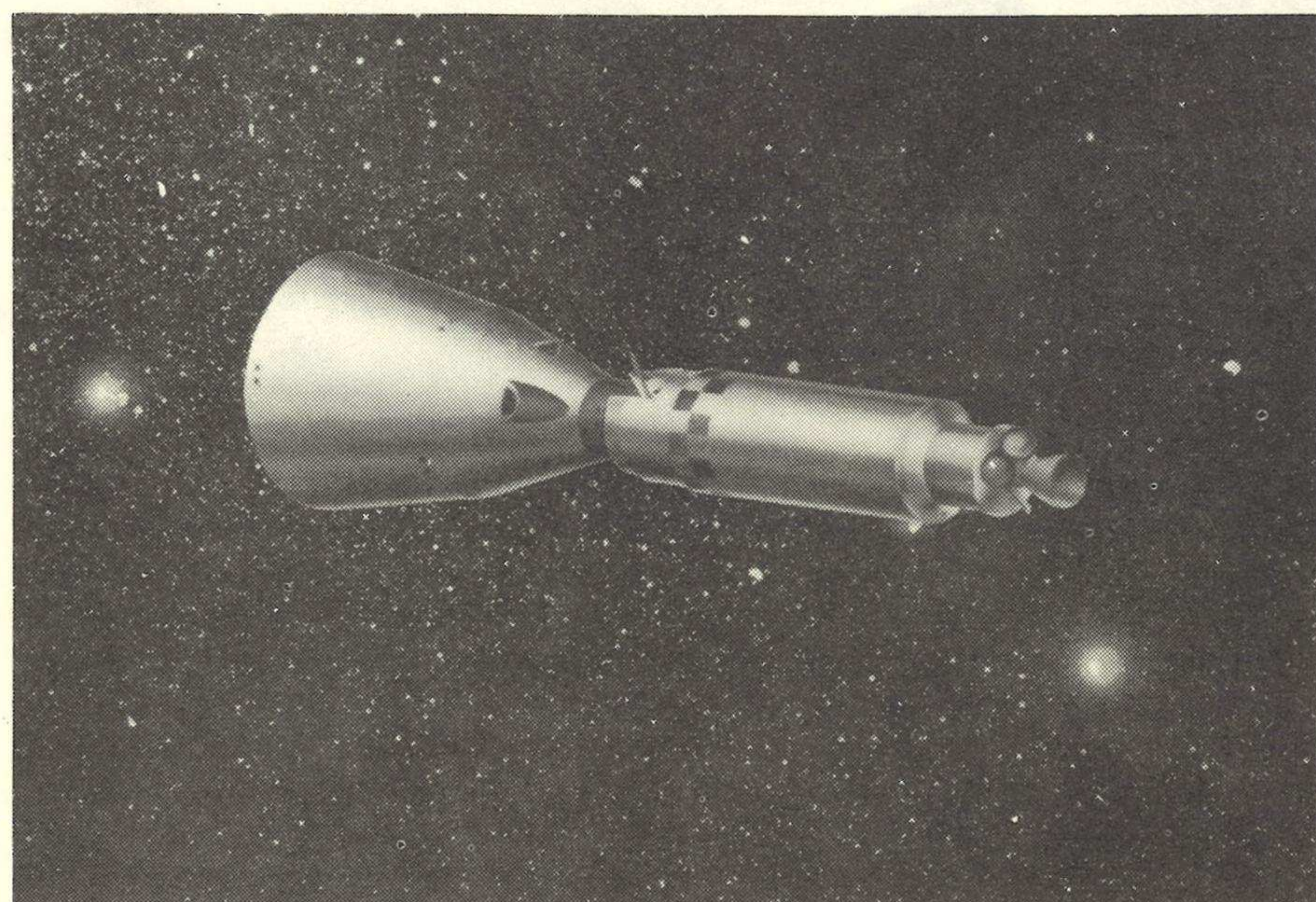
PRESSURE SUIT

A new pressure suit development program is underway in connection with the Gemini program. These suits will have removable arms and legs and a fabric helmet which can be opened and folded aside for astronaut comfort (a "short-sleeve" environment) and exercise. During the Gemini mission, the pilots, one at a time, will unlatch his pressure-tight hatch, open, and climb out of his cockpit into space for up to 15 minutes, protected all the while by the life-supporting atmosphere within his pressurized suit, augmented by an oxygen backpack. What experiments they may attempt while outside the spacecraft have not yet been determined.

COMPUTER

Another innovation in the Gemini spacecraft will be a manual-feed electronic computer, by means of which the astronaut can determine at any time his impact point should he initiate reentry processes. He can also determine what corrections he should make to land at any desired point, and during rendezvous and docking, the amounts and direction of spacecraft thrust to be expended at the proper time to guide the spacecraft toward the target.

After retrofiring, the computer will "sense" each additional aspect and supply landing site information in "real" time. The astronaut will manually feed the variables into the keyboard of the machine to have his desired information returned. Manned Spacecraft Center engineers compare the operation of this instrument with the operation of an adding machine.



RADAR UNIT

The radar unit aboard the Gemini spacecraft will have a range of up to 250 miles. Through the use of this radar unit, the astronauts will receive such information as bearing, range, distance closing rate, and direction. Somewhere between 50 to 20 miles of the Agena, the astronauts should be able to detect the high-intensity flashing light from the beacon aboard the Agena vehicle. Optical tracking will be employed when the range has been closed. From that point, the pilots may use a combination of automatic and manual control or manual control alone for final rendezvous maneuvering. The radar equipment will be jettisoned after reentry but before paraglider deployment.

GUIDANCE PLATFORM

The Gemini craft will have a four-gimballed inertial guidance platform aboard, similar to those aboard many military vehicles. Horizon scanners are provided for occasional corrections. This system can be used to retain attitude reference in event of spacecraft tumbling or to conserve fuel by allowing the spacecraft to tumble, without losing attitude control, and will also serve as an attitude reference and as a means of navigation during rendezvous, reentry and paraglider landing. The space-stabilized platform will operate in conjunction with the general purpose digital computer, and will also backup the launch vehicle guidance during launch.

ASTRONAUT TRAINING

One of the Gemini flight trainers will be located at the Manned Spacecraft Center's new site at Houston, of the new Mission Control Center.

Astronauts will spend isolation periods up to two weeks in test chambers to train for long-duration missions. One of the most important parts of the experimentation will be to determine ability to endure isolation—even with another person or persons—for such long periods.

LANDING

The ability to bring down the Gemini spacecraft safely in a preselected area on land rather than on water must be attained before the terminal phases of space flight can be considered as satisfactorily developed.

The achievement of point-landing capability requires that throughout the reentry phase of flight the pilot must be able to apply controlled lift to the vehicle to change its course and correct navigational errors, winds, etc. The Gemini spacecraft will be built with an offset center of gravity so that it will tend to trim at some definite value of lift. The direction of this lift vector and thus the direction of the course corrections will be controlled by rolling the spacecraft by means of small reaction jets activated by the pilot's hand controller. With such control, the Gemini pilot should be able to reach any landing point within about 100 miles to either side of zero-lift line of flight and several hundred miles up or down range from the zero-lift landing point.

Even with controlled lift during reentry, if a parachute is used for the final stages of letdown, the crew will still face the problems of wind drift in the lower atmosphere, of avoiding local hazards such as rocks, cliffs or trees, and of reducing the final landing shock.

PARAGLIDER

A "Rogallo Wing" or paraglider, a steerable device with inflatable booms covered with a coated synthetic fabric and with a wing-spread of 43 feet and a length of 30 feet, will be used initially for Gemini spacecraft "landings."

Until ready for use in the lower atmosphere, the wing will be carried folded and uninflated. When the spacecraft has completed its entry and has slowed to a subsonic speed of about 60,000 feet, a small drogue chute will be deployed. The paraglider will be deployed at about 50,000 feet in a collapsed shape. It will then be released into flight shape, fully inflated, and will be operational at about 42,000 feet. The pilot will then have the ability to glide to a preselected landing strip, counteract rather high winds that would blow a parachute off course, avoid local hazards, and finally flare out to reduce the speed of his vertical descent, and to land at a speed of about 45 knots.

The Gemini landing gear will consist of a nose skid and two out-rigger skids for stability and support. The nose skid will be extended during paraglider deployment, but the pilot will extend the rear skids. The landing, although at a low speed, will resemble that of the X-15 aircraft.

The paraglider is controlled in pitch and roll modes; the astronaut's movement of the hand-controller, which actuates gas-operated cable reels, will move the spacecraft relative to the paraglider; this will shift the center of gravity of the assemble forward, aft, or sideways to permit the paraglider to dive, climb, or bank. No rudder control is necessary.

The alternate or backup system is a large parachute. If this chute is used over land, the astronauts will eject themselves prior to the landing of the spacecraft. Impact forces will be too great for the astronauts but low enough to let the vehicle down without serious damage.

FLIGHT SCHEDULE

Under present plans, two-man flights should begin during

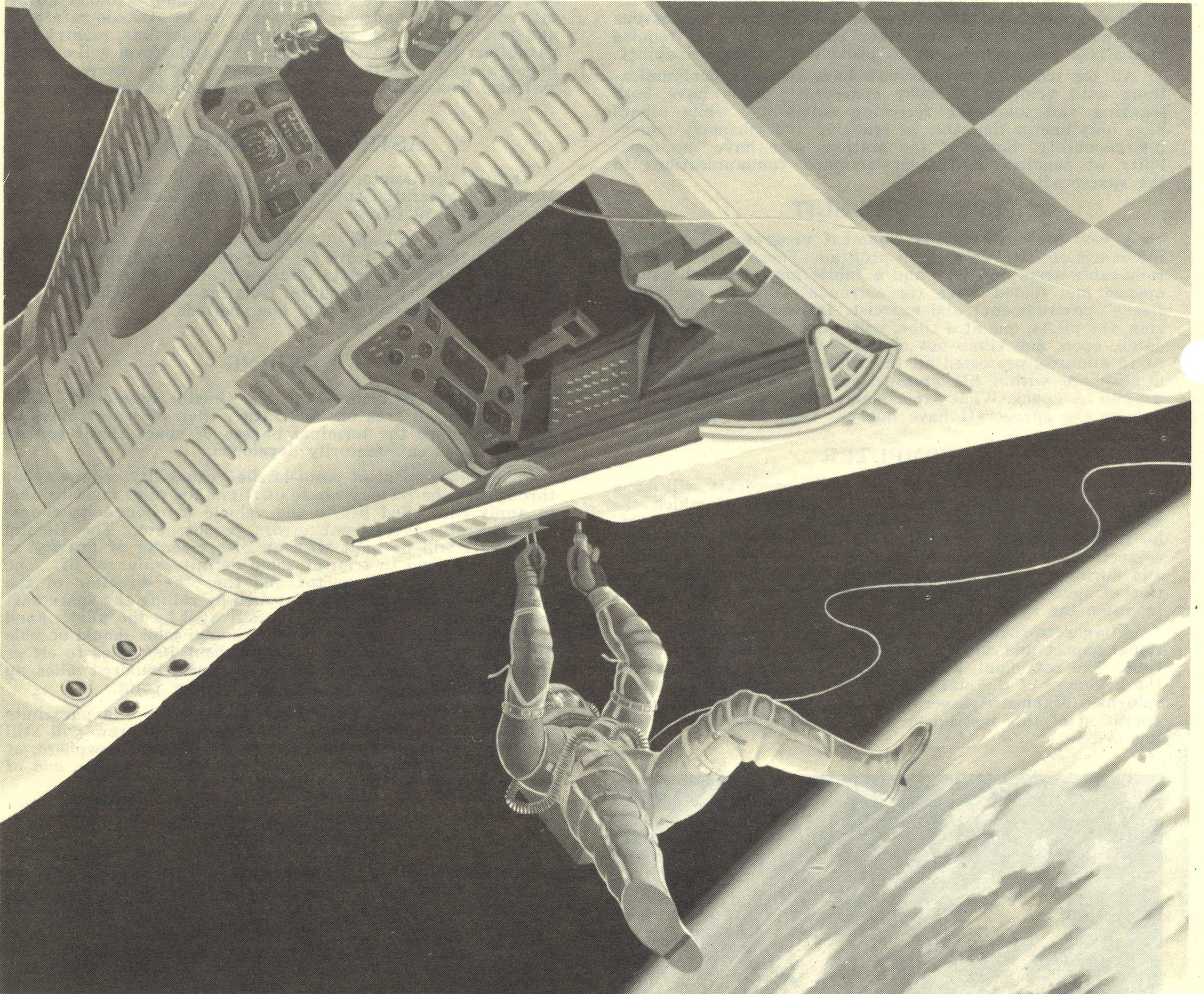
the 1963-64 period, starting with an unmanned, parachute-recovery flight from Cape Canaveral for tests of overall launch vehicle-spacecraft compatibility and systems engineering. The second, third, and fourth Gemini flights will be manned for long-duration missions.

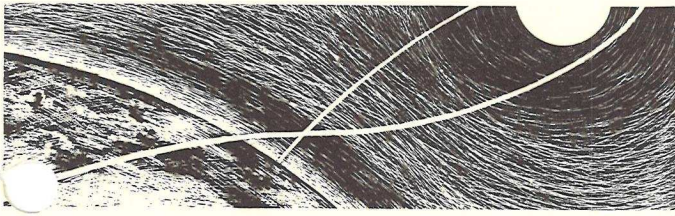
The first manned Gemini-Titan flight will be an 18-orbit mission, while the second will be a two-week trip.

Rendezvous and docking missions will begin with the fifth Gemini flight. The fifth mission will not be a long-duration flight; after rendezvous, docking and preplanned maneuvering and experiments, the crew will prepare for reentry.

ADDITIONAL ASTRONAUTS

The Manned Spacecraft Center's original astronauts team are slated to serve as senior pilots for the Gemini Missions. New members of the MSC astronauts team may serve as crew members (co-pilots) for these missions.





MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT APOLLO

After intensive evaluation of its Apollo Manned Lunar Exploration Program, the National Aeronautics and Space Administration decided to:

1. Base the next phase of its planning, research and development, procurement and space flight program on the use of the advanced Saturn to accomplish the initial manned lunar landing and recovery, using the lunar orbit rendezvous as the prime mission mode.

2. Employ a lunar landing vehicle spacecraft to be launched on the same launch vehicle with the Apollo mother craft and capable of landing two men on the lunar surface and returning them to a mother craft in lunar orbit before the return to Earth. The plan is for a third crewman to remain at all times in the Apollo mother craft.

3. Employ a 2-stage Saturn (configuration C-1B) using the present 8-engine Saturn first stage and the high energy S-IVB stage already under development for early flights to test the lunar orbit configuration of Apollo. These flight tests will be utilized to perfect module maneuvers in earth orbit with minimal spacecraft fuel loads in the mid 60's. Saturn C-1B will develop sufficient thrust to put 16 tons into earth orbit.

4. Begin an immediate in-depth study of an unmanned lunar logistic vehicle to determine how such a vehicle could be used to support the lunar exploration program.

5. Continue studies of the feasibility of the Earth orbit rendezvous mode using the advanced Saturn with a spacecraft somewhat smaller than the 3-man Apollo under contract and employing a 2-man command module. Possibilities of utilizing such a spacecraft for a direct flight to the moon, using the advanced Saturn will also be considered.

6. Conduct active and continuing studies of a Nova vehicle with development deferred at least two years, the objective of these studies would be a Nova with a weight-lifting capability at least two to three times that of Saturn which could be used for possible missions beyond Apollo. (Saturn can launch 45 tons to escape velocity; 120 tons to earth orbit.)

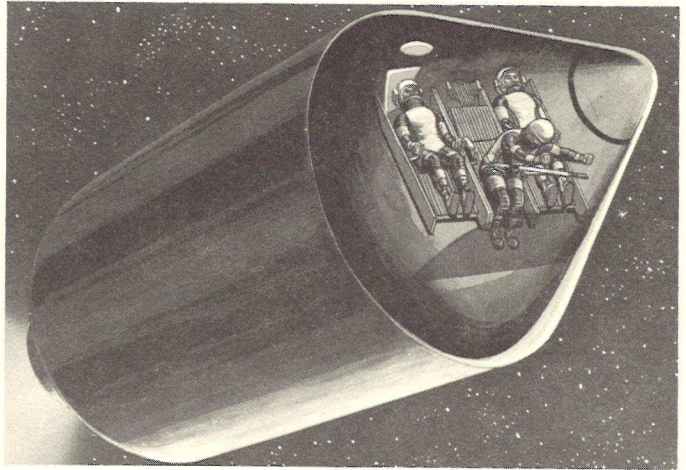
The LOR, (Lunar Orbit Rendezvous) mission mode was adopted because it:

1. Provides a higher probability of mission success with essentially equal mission safety.

2. Promises mission success some months earlier than other modes. (National goal is to accomplish the mission by 1970.)

3. Will cost 10 to 15 percent less than the other modes.

4. Requires the least amount of technical development



beyond existing commitments while advancing significantly the national technology.

As presently envisioned, lunar orbit rendezvous would require a single launch of a Saturn boosting a 13-foot-diameter, 3-module spacecraft. The spacecraft would include a 5-ton, 12-foot-tall lunar excursion module. The three modules would proceed to the vicinity of the moon and would be placed in lunar orbit as a unit. Two astronauts would then transfer to the lunar excursion vehicle and descend to the moon while the Apollo spacecraft and service modules remain in lunar orbit.

After a period of exploration extending up to four days, the two men would use the lunar excursion vehicle to ascend from the moon to a rendezvous with the Apollo spacecraft in lunar orbit. After crew transfer, the lunar landing vehicle would be jettisoned, and the command craft carrying the 3-man team would be boosted back toward Earth by the service module with an engine generating 20,000 pounds thrust. Just before entering the Earth's atmosphere, the service module would be jettisoned and the command module oriented for reentry.

The Apollo LOR configuration and its Saturn booster would stand about 325 feet tall and weigh 6 million pounds at launch. The first stage of the launch vehicle will be powered by five engines generating 7.5 million pounds of thrust; the second stage powered by five hydrogen-oxygen engines with each generating 200,000 pounds thrust; the third stage powered by a single engine. All elements of the launch vehicle are currently under contract.

Using command service modules now under development, Earth orbital rendezvous would require the additional development of two propulsion modules weighing about 50 tons—a lunar braking module and a lunar touchdown module—in order to decelerate the 28-ton command and service modules to a soft landing on the lunar surface.

As presently viewed, Earth orbit rendezvous, using the 3-man Apollo, would require for each mission Earth launchings of two or more advanced Saturns. One vehicle would launch into orbit a 60-foot-tall liquid oxygen tanker weighing some 110 tons. It would rendezvous with the separately launched modular spacecraft attached to a fueled but unloxed third stage of a Saturn. The lox would be transferred and the third stage would then power the spacecraft to the moon. A 3-man direct flight would have the same requirements as Earth orbital rendezvous for the command and service modules and the lunar braking and touchdown stages. In addition, this mode would require the immediate development of the Nova vehicle with a 12 million-pound thrust first stage and upper stages employing the 1.2 million-pound thrust hydrogen-oxygen engines.

