

SECTION 5 COMMUNICATION SYSTEM

5.1 INTRODUCTION

This document presents the requirements for the IMCC communication system which implements data flow within the GOSS. Although the system design is intended to satisfy both Gemini rendezvous and Apollo requirements, the numbers and types of circuits described in this document reflect the anticipated requirements for Gemini rendezvous missions. These are, however, considered adequate for Apollo (except for possible wideband data transmission requirements).

5.2 COMMUNICATION REQUIREMENTS

5.2.1 General

The world-wide information flow required for IMCC support and control of manned space flights is accommodated by the GOSS communication network. Depending upon the quantity and type of information required in "near" real time at the IMCC and upon circuit limitations, information will be transmitted via high speed data (2400 bps), low speed data (100 bps), teletype, facsimile, voice and video circuits. The IMCC communication system must terminate and provide the internal distribution system required for these circuits.

5.2.2 Information Requirements

The general information requirements for manned space flight missions are shown in the following list, but not necessarily in their order of importance.

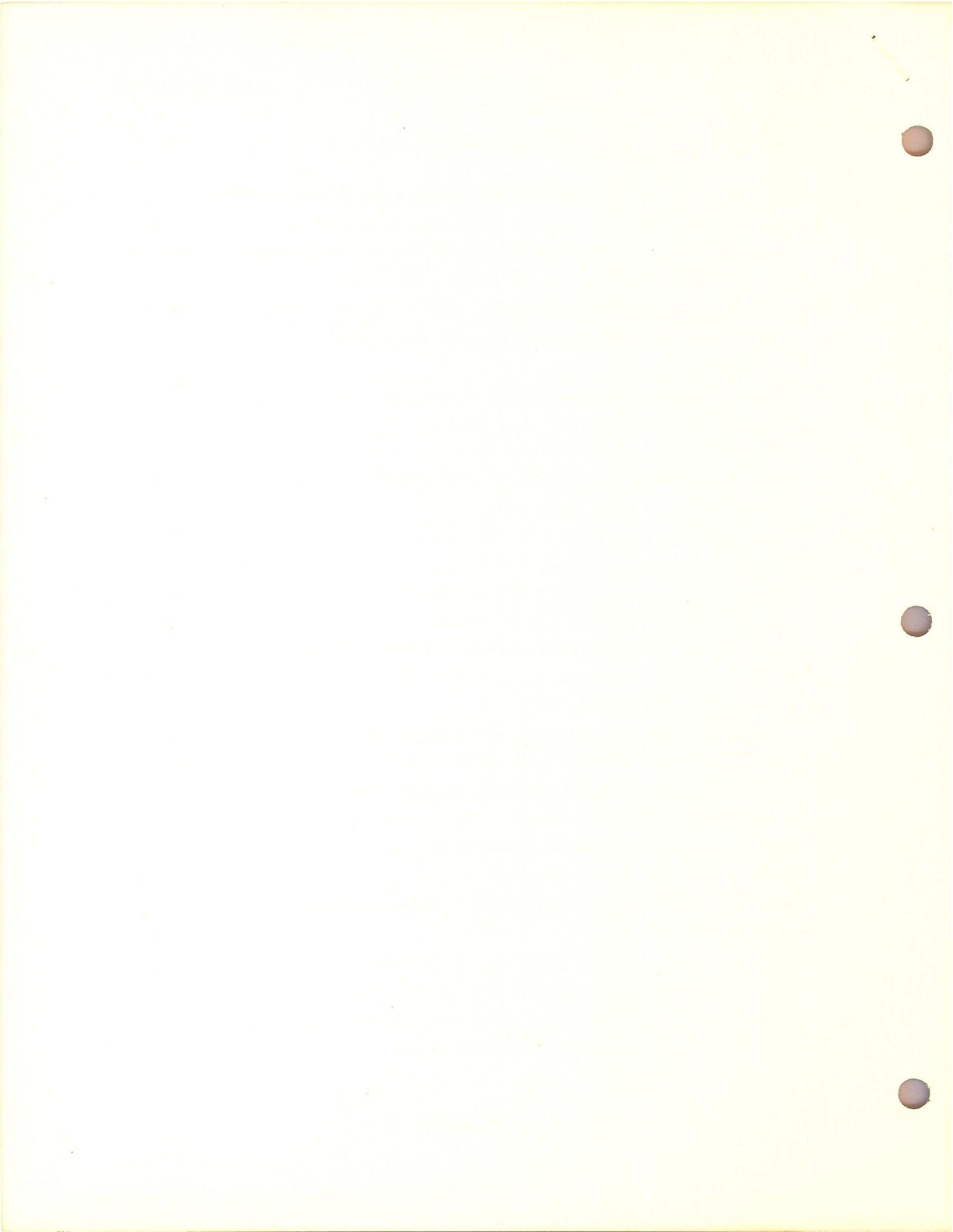
5.2.2.1 Mission Periods

- Provide direct voice contact between the IMCC and the spacecraft
- Provide voice capability between the IMCC and all support sites and other Government agencies
- Receive telemetered biomedical data, environmental data, systems performance data, etc. from the spacecraft and communicate these data for display at the IMCC
- Communicate near real-time tracking data from the remote sites to the operational computers
- Transmit computer-derived data from the IMCC to ground sites
- Transmit near real-time, ground-derived digital information to the spacecraft via remote sites
- Provide remote site status data for display at the IMCC
- Inform remote sites of mission status
- Support simulation and training
- Provide other operational information as required.

5.2.2.2 Non-Mission Periods

- Provide voice capability between the IMCC and all support sites, and other government agencies
- Transmit non-real time command data from the IMCC to remote sites
- Provide intersite communications
- Provide administrative and logistic communication which will satisfy the basic information flow requirements.

The actual amount of information on the data circuits in terms of bits per second will be specified at a later date when results of the concurrent information flow studies are complete. Preliminary information is presented in Philco report WDL-TR-E114-3.



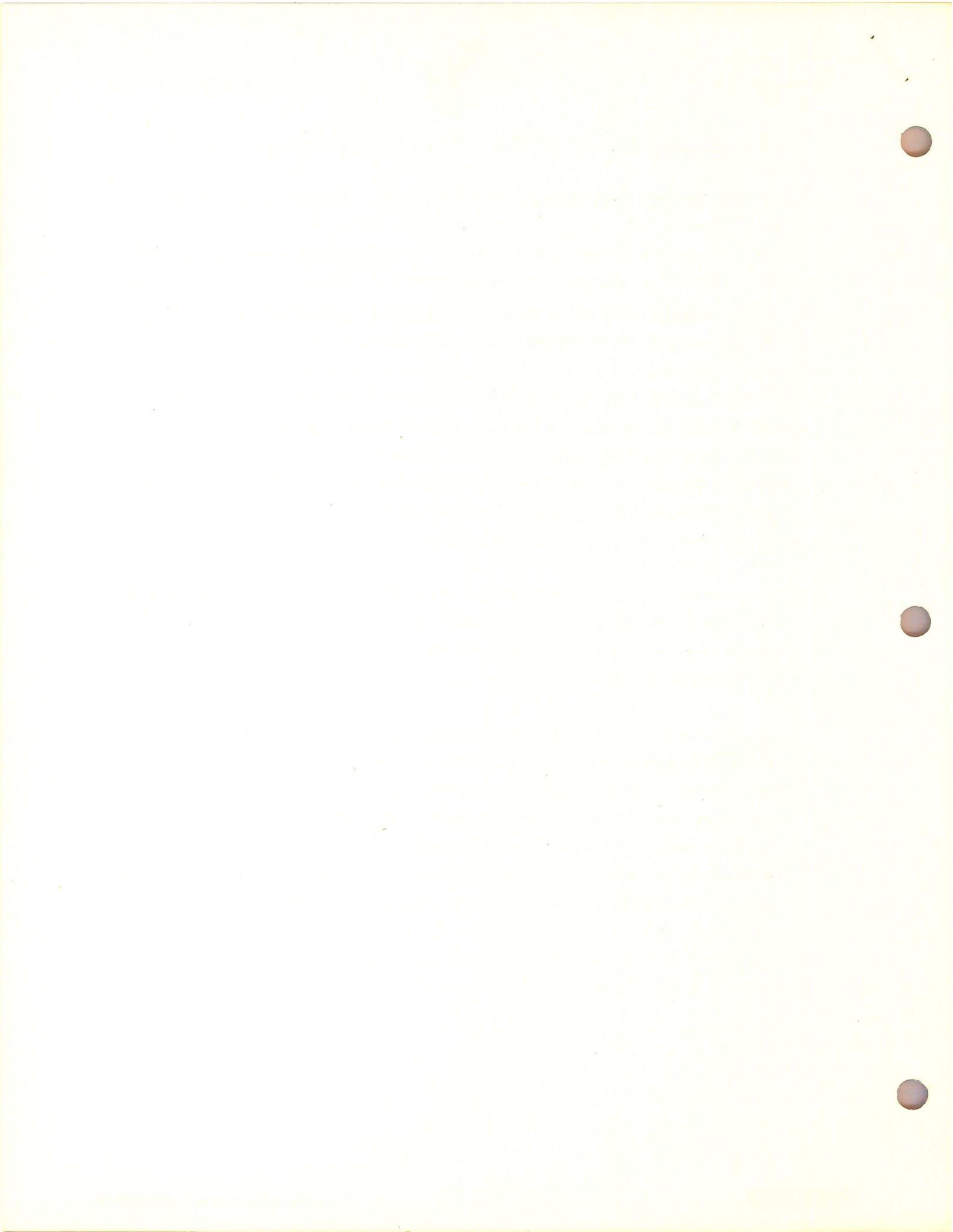
5.2.3 Performance Philosophy

The operational requirements for information flow between the IMCC and the spacecraft, as well as between the IMCC and the remote elements of GOSS, constitute the communication requirements for GOSS. The distribution of this information to the flight control personnel and between flight control and support personnel establishes the internal communication requirements within the IMCC.

The control function of the IMCC during manned space flights requires that the information flow to and from the IMCC, as well as within the IMCC, be as near to real time as is feasible within the constraints imposed by propagation conditions, equipment operating speeds, the response times of the humans involved in the system, and economic considerations.

In addition, the non-mission activities concerned with preparation for missions and the training of personnel must also be considered. Preparation and training during non-mission periods should emphasize efficiency, while mission operation is judged primarily by effectiveness.

The IMCC communication system must be practical, workable, and must be operable by personnel possessing only basic communication skills. Highly specialized manpower requirements and unusual procedures must be avoided. The communication system design must insure continued functioning in the face of the typical problems encountered in any operating communication system; e. g., equipment unreliability, propagation difficulties, operator errors, traffic backlogs, and logistics problems.



5.2.4 Reliability

5.2.4.1 System Reliability

In providing simultaneous voice and data transmissions from the remote sites, it is important that: (1) data transmission in both directions be highly reliable, both in terms of error rate and circuit outage. (this is accomplished through the use of error detection and retransmission techniques with quality control of the circuits to detect degradation of circuits before they actually fail), (2) voice transmission in both directions must be of high quality (to permit direct spacecraft-IMCC connection) and must have high reliability in terms of circuit outage, and (3) while the limited availability of high quality, wideband circuits prohibits some remote sites from transmitting high-speed data, those sites provided with low-speed data circuits must not differ in their mode of operation or capability (except in terms of data rate) and must not have higher error rates (because the data is less redundant) than sites with the higher data rates. The reliability of sites having low-speed data circuits is as important as that of those sites with the high-speed data circuits.

A major function of the IMCC communication Tech Control Facility is monitoring transmission facilities to determine the quality of the transmission and to take appropriate action when the quality on a given line falls below acceptable levels, or when transmission is disrupted. The speed with which these actions are accomplished is a major factor in establishing the reliability of the system. The best place to monitor a transmission facility is at a point where the cumulative effects of the whole transmission path can be determined. Each relay station through which the circuits pass detracts from the reliability of the system. Therefore, there must be a minimum of intermediate switching points.

5.2.4.2 Equipment Reliability

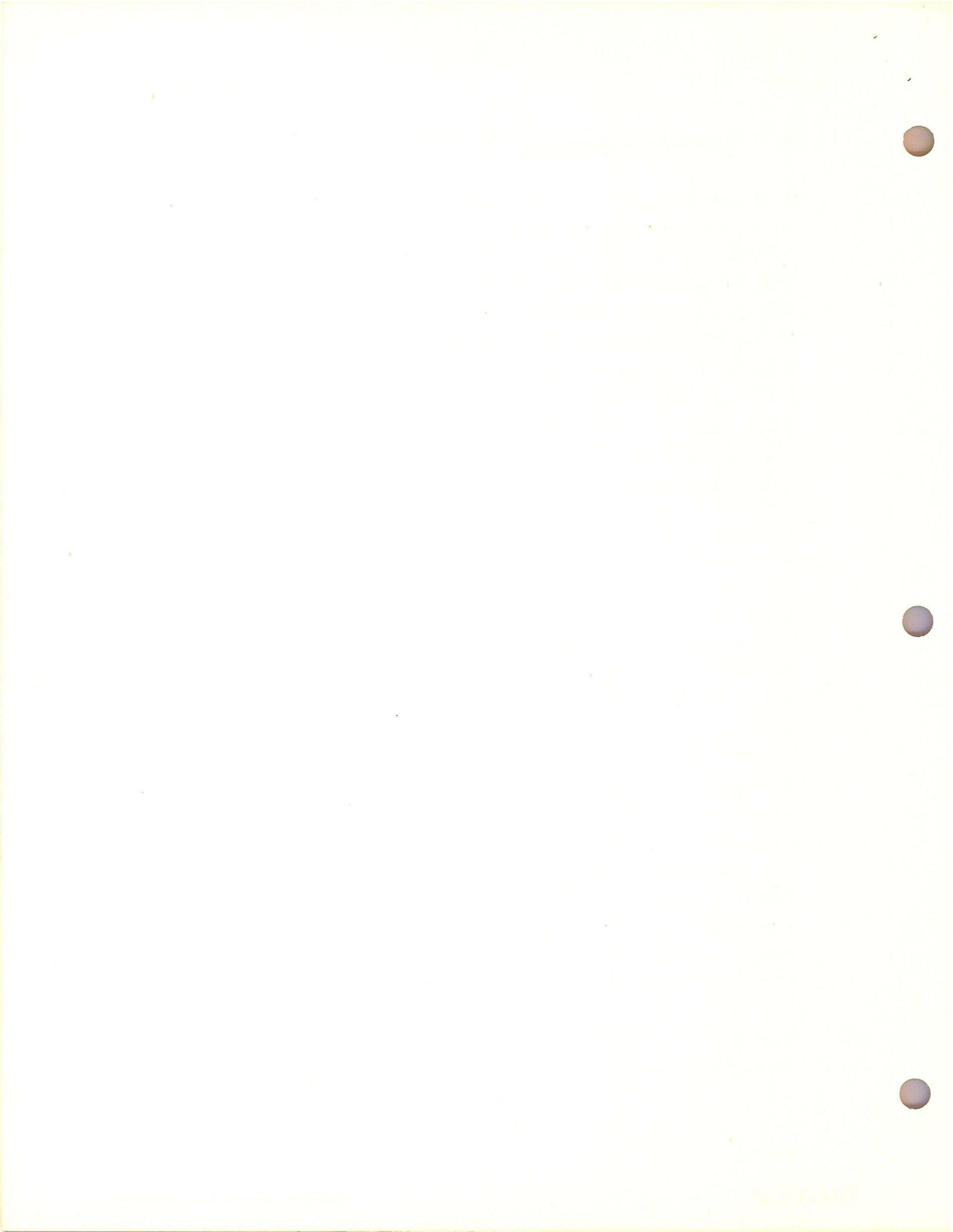
(Information will be supplied when available.)

5.2.4.3 Maintainability

Since the operational availability of the IMCC communication system is a function of the mean-time-to-repair (MTTR), it is essential that a high degree of maintainability be provided to reduce repair time to an acceptable minimum. Typical of the features which should be incorporated into the equipment design to ensure ready maintenance are the following: (1) modular construction, (2) standardized units, modules, etc., (3) ease of access and replacement, (4) efficient fault detection and identification, (5) standardized repair procedures, and (6) effective preventive maintenance methods, such as diagnostic routines.

5.2.5 Capacity for Expansion

Implementation plans for the present system requirements must include consideration of ultimate system capability to minimize equipment obsolescence and provide for orderly system expansion. In the final system, one may anticipate a greater degree of automatic operation. The introduction of automatic solid-state communication processing at the IMCC for handling large volumes of text/data traffic reduces the number of specialized personnel required, and at the same time provides for rapid modular expansion of the system to meet future requirements. Floor space requirements are held to a minimum. Yet, adequate expansion space has been provided. This also applies to the operational intercommunication system and the Technical Control Facility.



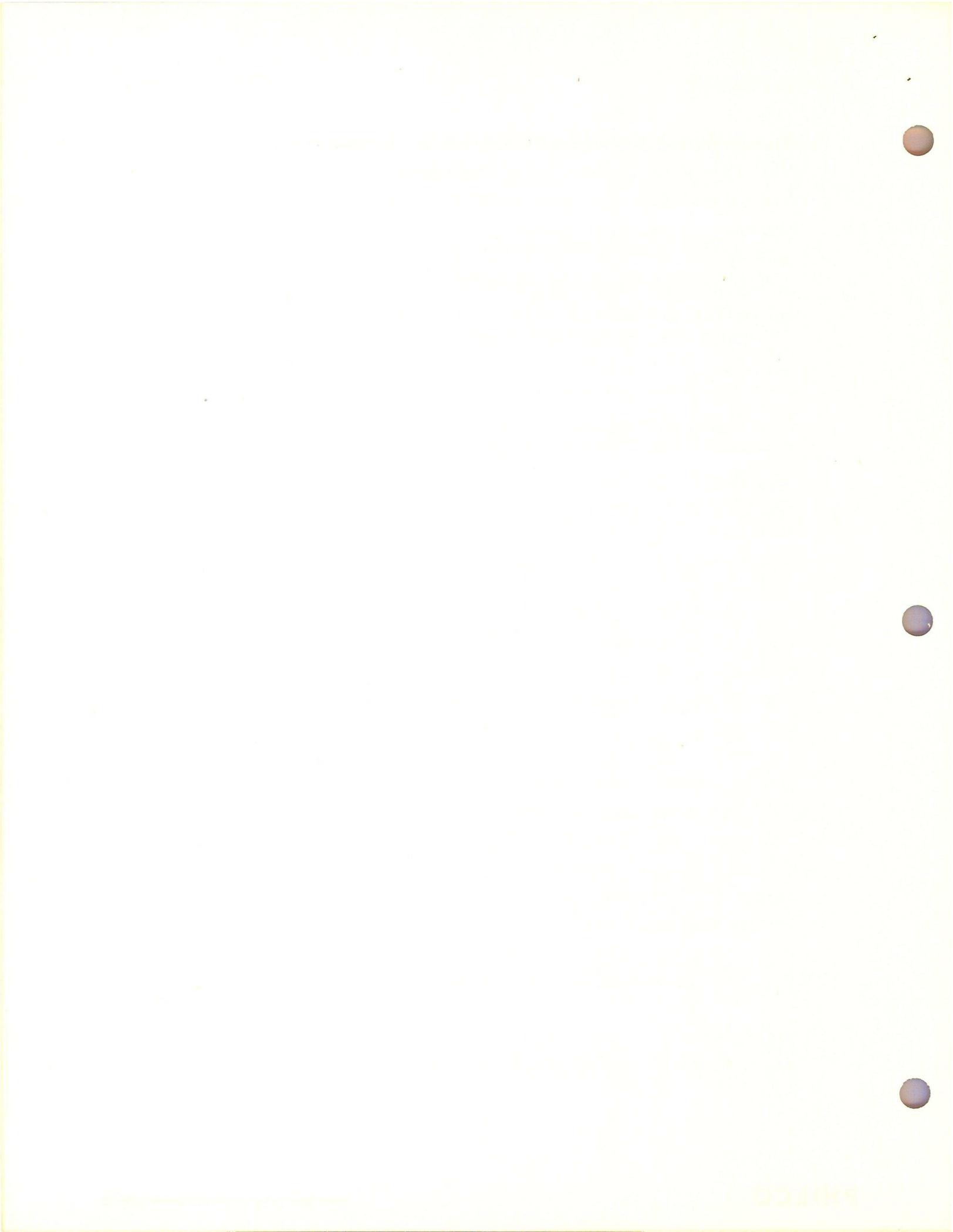
5.3 COMMUNICATION SYSTEM REQUIREMENTS

5.3.1 General

The IMCC communication system should be arranged both operationally and functionally (1) to provide optimum termination and control of the circuits from the remote elements of GOSS, as well as the internal IMCC distribution systems required for these circuits, and (2) to meet the internal IMCC communication requirements. The transmission media for these circuits entering the IMCC consist of normal 3 kc voice lines, 3 kc voice lines specially treated for high-speed data, normal 100 wpm bandwidth teletype, and video channels. These circuits (except for video and facsimile circuits) are all arranged for four wire, full duplex operation, and will arrive at the IMCC via leased commercial facilities. The circuits pass through the communication control room which houses the technical control facilities for monitoring all lines, and terminate at either: (1) the voice control point for local distribution of the voice circuits, (2) the communication processor, the primary control point for routing and switching of data and text messages within the IMCC), or (3) directly at the user's area for specialized circuit requirements. Examples of the latter are video, DOD recovery communication circuits, and meteorological circuits.

During IMCC mission periods, the data circuits, both HSD and LSD, which normally carry serial bit stream traffic, will have associated equipment capable of inserting and extracting text traffic to and from this data stream. This will be accomplished by the communication processor at the IMCC, and a similar requirement will be imposed on the remote site data processing equipment. By means of digital to teletype code conversion, this traffic is put into a format compatible with the teletype terminal equipment in the message center.

During launch, pre-launch, checkout, and simulation periods, high-speed digital data from independent NASA and AMR sources at Cape



Canaveral and downrange AMR tracking stations are utilized at the Launch Control Complex. Portions of this data are selected for retransmission from Cape Canaveral to the IMCC for display, computation and launch monitoring purposes. Voice and teletype circuits will also be required to meet the IMCC communication requirements. These circuits, while under the cognizance of the IMCC Technical Control Facility, will require close coordination with the Cape Canaveral Technical Control Facilities to coordinate their use and operation during the different mission and simulation phases.

5.3.2 Overall Concept

The IMCC communication system consists of three major subsystems. These subsystems and their basic functions are as follows.

5.3.2.1 GOSS Termination Subsystem

- Terminates the HSD, LSD, and teletype circuits which connect the remote elements of GOSS and other outside support agencies to the IMCC.
- Terminates the part-time simplex video circuits between both Cape Canaveral and JPL, and the IMCC.
- Terminates and switches the full-time leased voice circuits from the remote elements of GOSS, and from other outside support agencies.
- Provides technical control facilities, through which all GOSS communication circuits pass so that quality monitoring of the circuits can be performed and control of circuit routing and terminal equipments can be provided. Coordination with the AT&T long-lines test facilities, Goddard personnel, and communicators at other locations will be effected through this facility.
- Provides operational control and supervision over the GOSS network during mission periods and coordination with other agencies for relinquishing this control during non-mission periods.
- Provides the voice recording control and PBX intercept functions, intercommunication interface with the GOSS voice

circuits and the control facilities for the remote control and operation of the remote site A/G voice facilities (if required) in a consolidated voice control and monitor position.

5.3.2.2 Communication Processing and Control Subsystem

- Provides electronic switching and control of traffic from the GOSS network and other circuit terminations for proper routing of alpha-numeric text and digital data messages to the IMCC and MSC destinations during both mission and non-mission periods.
- Provides a communication coordinator's console for overall IMCC Communication System operational supervision and necessary liaison between the Communication Director, the network status monitor console, and the Technical Control Facilities.
- Overall GOSS/IMCC communication network and equipment status information will be supplied to a wall display, associated with the communication coordinator's console.

5.3.2.3 IMCC Internal Communication Subsystem

- Provides internal communication circuits, terminal equipments, and test facilities for the operational voice intercommunication system consisting of separate and distinct intercommunication links for both MOCR's, SCATS and a common interface for rapid rearrangement for mission, simulation, and non-mission operations.
- Provide an operational PBX system as an integral part of the voice intercommunication system to allow dial ringdown calling within the IMCC for both mission and non-mission phases. This will also include an intercept position for unauthorized PBX calls into the MOCR during mission operations.
- Provides local teletype, courier, and written communication circuits and equipment for the local delivery of text traffic from the GOSS communication network, via the IMCC Message Center.
- Provides voice paging and public address facilities.

Figure 5.3-1 is a block diagram of the IMCC Communication System, showing overall information flow within the IMCC. In the following discussion of each of the subsystems, the communication processing and

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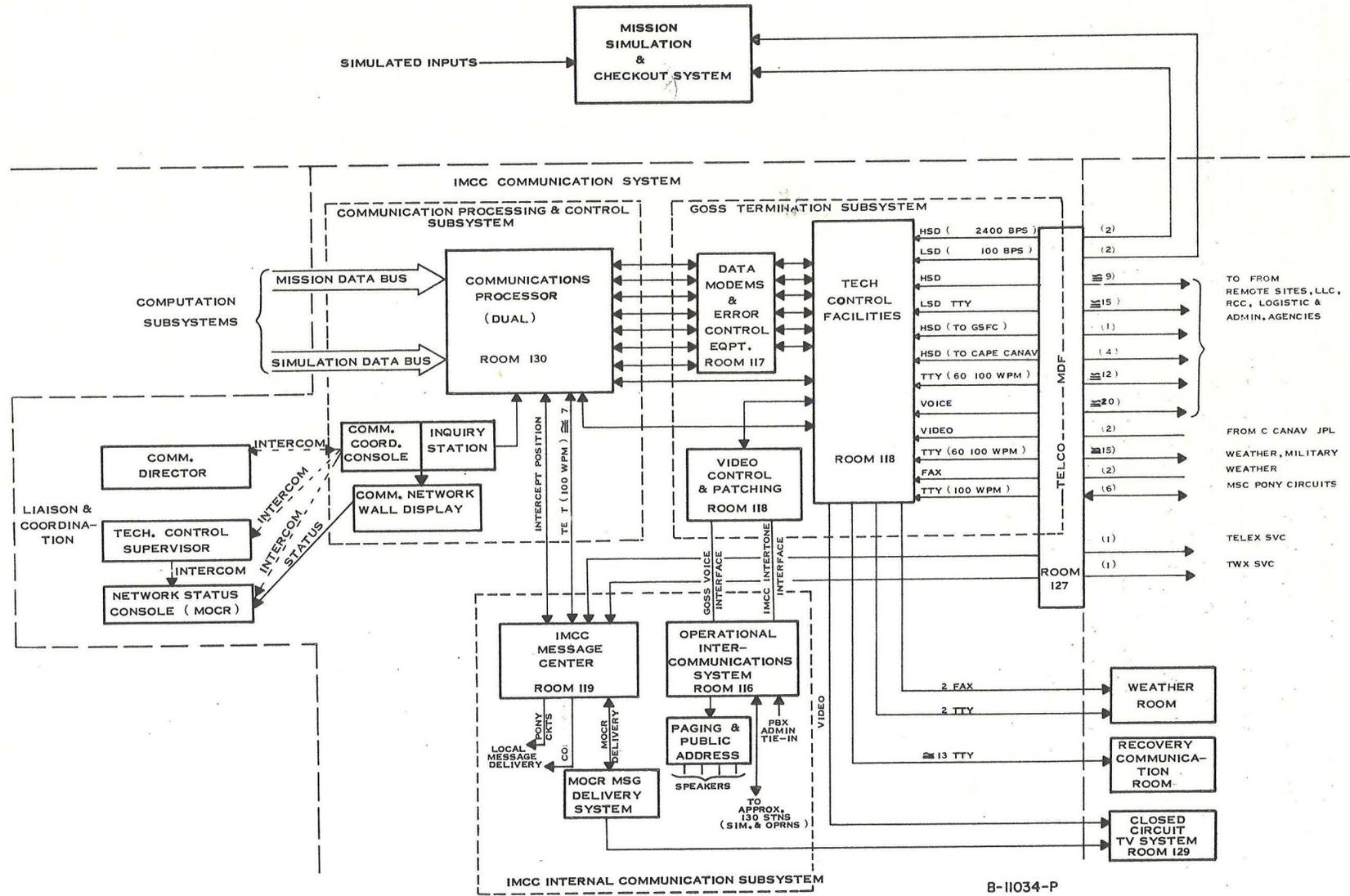


Figure 5.3-1 IMCC Communication System

control, and the internal communication subsystems are emphasized. The technical control, voice control switching, and GOSS supervision facilities within the GOSS termination subsystem will be discussed in detail in this report. However, the terminal equipment utilized on the HSD and LSD circuits will be included as a part of the GOSS Performance Requirements, Philco Report WDL-TR-E122, so that the complete GOSS circuits from terminal to terminal including data modems and error control techniques can be discussed in one report. This will provide continuity of discussion without excessive referencing between the two documents.

5.4 GOSS TERMINATION SUBSYSTEM

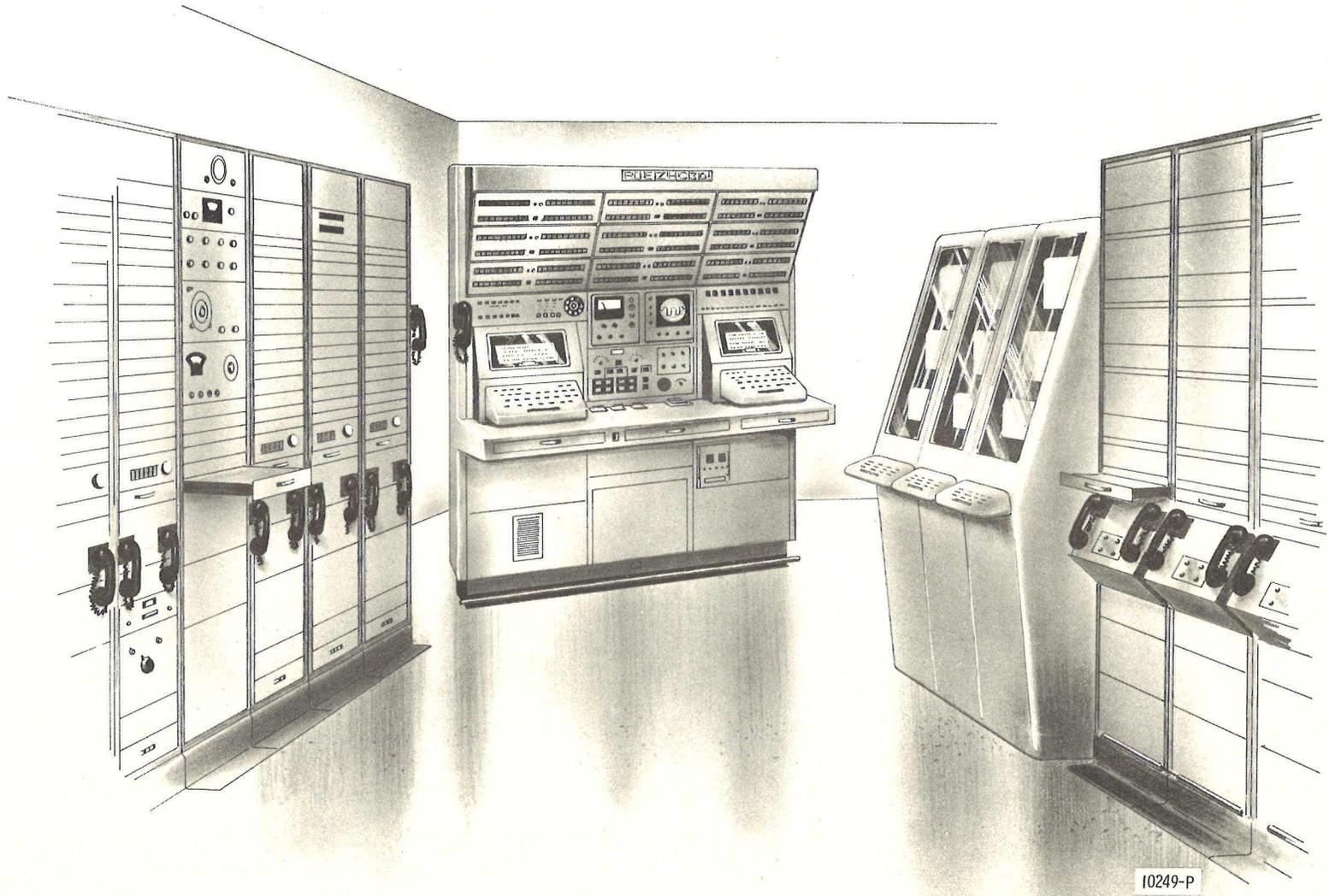
The GOSS termination subsystem comprises the terminal equipment, control and test facilities on all high speed and low speed data circuits, teletype, voice and video circuits which come into the IMCC communication system from the remote elements of the GOSS network. The majority of this equipment is located in the communication control room and the data terminal equipment room.

5.4.1 Technical Control Facilities

All circuits entering or leaving the IMCC will pass through the technical control facilities located in the communications control room. By means of on-line monitoring and test facilities, the operational status and quality of all communication circuits can be continuously monitored to provide preventive and corrective measures related to circuit performance. Through the use of extensive patching facilities, circuits can be rerouted and rearranged to handle varying conditions of traffic loading and circuit or equipment outages.

The operational activities of technical control are divided into three functions: (1) traffic routing and circuit continuity, (2) quality monitoring, and (3) maintenance coordination. The technical control facilities will be grouped according to these functions, and the groups will be arranged to provide optimum operational efficiency. Figure 5.4-1 is an artist's conception of a typical technical control area. Functions to be performed within the Technical Control Facility include the following:

- a. Maintain continuous surveillance of all circuits; respond to alarm indications and monitor all circuits with page printers, distortion test sets, oscilloscopes, meters, and similar equipments to maintain circuit quality
- b. Monitor all circuits into and out of the IMCC with regard to distortion, line quality, etc. in cooperation with the site or agency supplying the transmitting facilities.



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Figure 5.4-1 Artist's Sketch of Typical Technical Control Area

- c. Maintain high quality circuits within the station by diverting a "normal through" send or receive circuit to another path when required
- d. Remote control of circuits by use of cut keys and patch cords
- e. Coordinate with AT&T test facilities (or GSFC) to establish alternate or emergency routes, and to establish cooperative quality circuit testing
- f. Establish special circuits in emergencies and for authorized teletype and voice conferences
- g. Initiate appropriate preventive or corrective action with regard to equipment or circuit failure
- h. Coordinate operational changes of circuits with all other agencies involved (i.e., JPL, GSFC, etc.)
- i. Maintain logs and records to give a comprehensive and accurate picture of circuit conditions at all times.

The Technical Control Facility equipment which provides the means by which these functions are performed should include the following:

- a. Data quality monitor console, including the switching and test equipment for on-line monitoring of all data and teletype circuits by high impedance bridging. Status displays of circuit and equipment condition, excessive error rate alarms, station alarms, etc., are also provided.
- b. Audio Patch Facility
- c. Audio Test Facility
- d. Equipment Patch Facility
- e. Teletype and voice order wire facilities
- f. On-line monitor printers
- g. Station teletype battery equipment (if required)
- h. Voice control and switching console, including automatic voice quality monitor equipment.

From the equipment patching bays, the operator may reroute teletype and digital data traffic to provide on-call system service to circuit users. The electrical design of this bay should be directed to its primary function of providing the facilities required by the operator for monitoring and controlling all traffic between (1) the GOSS network and the communication processor, and (2) the communication processor and the IMCC Message Center. The monitor teletypewriter consoles are associated with this patching facility. These consoles can be provided with space for mounting up to three sound-proof monitor teletype page printers, and can be equipped with shunt monitor applique units which provide the capability for high-impedance, bridged monitoring of an operating teletype circuit with no degradation of the low-impedance teletypewriter loop circuit.

The Quality Monitoring Facility consists of a quality monitor console. This console should contain the necessary equipment to enable operators to monitor, and to perform qualitative analysis, of the teletype and data circuits prior to their entry into the communication processor.

For those channels equipped with on-line monitors, automatic and continuous monitoring of the channel status is provided by the on-line monitor indicators spread across the top portion of the front panel. The console can be simply and efficiently operated by the use of a punched card selection technique to call up a particular circuit for detailed analysis. In addition, the on-line monitors which will permanently monitor each line on a high impedance bridging basis, should provide the following indications to the operator to identify faulty circuits:

- a. Visual and audible indications when the signal quality drops below the level which has been preset on the monitor
- b. Advisory information on the absence of traffic or an open-circuit condition on the monitored circuit
- c. An alarm indication when the number of hits on a line exceeds a preset number in a given three-minute period.

Other functions and equipment at this quality monitoring console should include:

- a. Telephone and teletype order wire equipment
- b. IMCC operational intercommunication keyset
- c. Alarm indicator panel for equipments of interest to the quality monitor operator
- d. Operator's test equipments including digital distortion analyzers, oscilloscopes, level meters, test transmitter-distributor, random word bit generators, etc.
- e. Channel status indicators
- f. Cardmatic switch and switch circuitry designed to automatically preset the test and monitor instruments for the selected channel. Card storage and facilities for making up new or replacement cards should be provided.
- g. Video monitor scope and waveform analyzer.

The equipment included in the console permits rapid diagnosis of channel troubles and provides the operator with ample communication facilities to keep him informed of communication equipment status and maintenance progress.

The Maintenance Patching Facility permits the analysis of dc and audio frequency channels for the purpose of determining which links in the system are not operating properly. Once this determination has been made, a link known to be in proper operating condition may be substituted for a faulty link, thereby allowing the channel to continue to operate with a minimum loss of time while more extensive testing and repairs are being made on faulty equipment.

The Maintenance Patching Facility will consist of three major components;

a. Audio Test Bay

The audio test bay will provide a central location for test instruments used to perform routine testing and evaluation of audio frequency lines and/or intersite channels. It also provides a means for connecting test equipment to operating channels.

b. Audio Patching Bay

The audio patching bay provides facilities required for patching between audio channels and/or audio terminal equipment for control and maintenance purposes. The bay also provides the means for monitoring all incoming and outgoing audio channels and connecting audio test equipment to any audio line or channel.

c. Equipment Patching Bay

This bay provides the means for substituting alternate equipment for the purpose of maintenance and repair.

Figure 5.4-2 is a functional block diagram of a typical Technical Control Facility as it would be integrated into the IMCC communication system.

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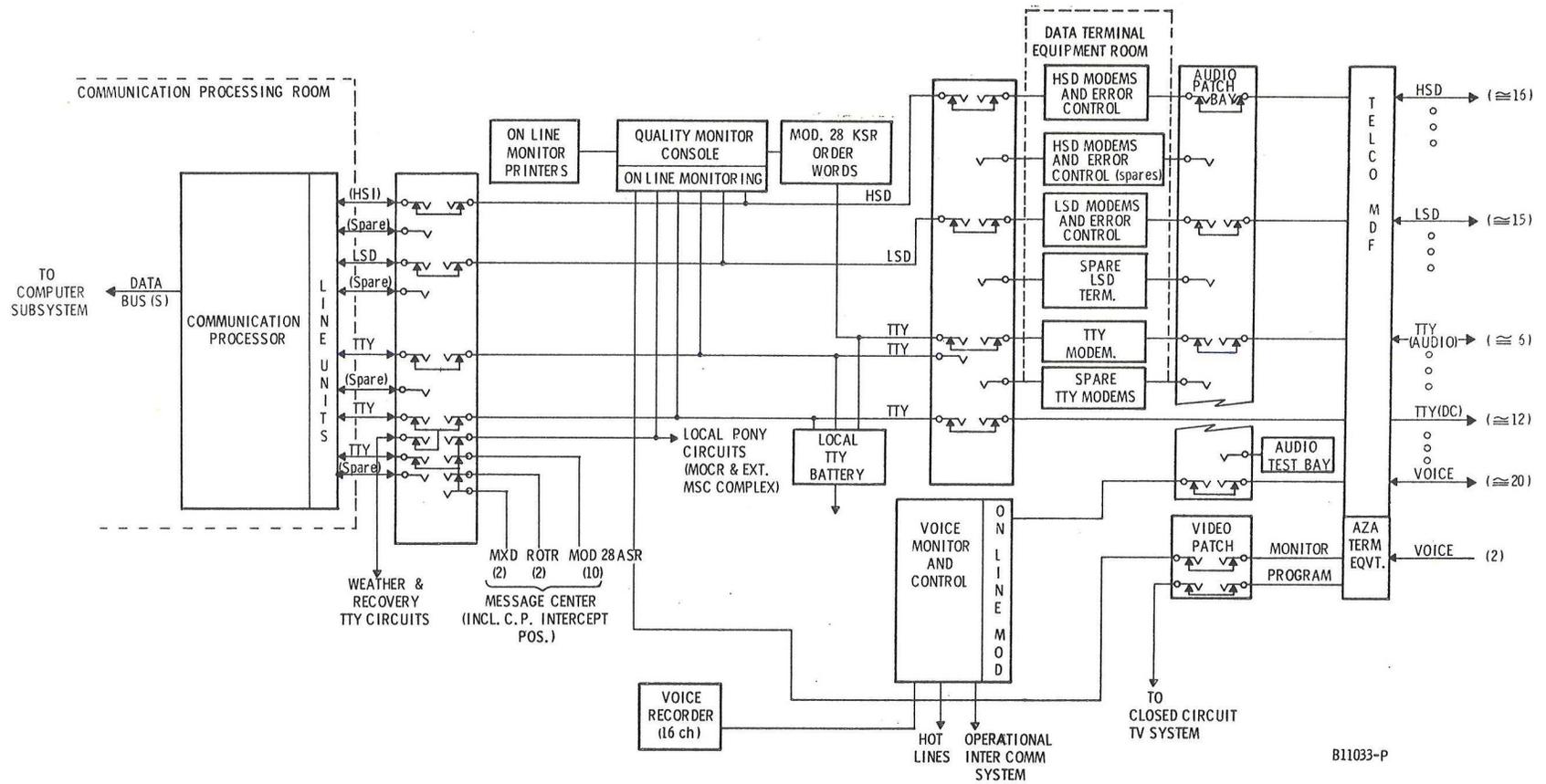


Figure 5.4-2 Functional Block Diagram, GOSS Termination Subsystem

5.4.2 Data Terminations

Located within the Data Transmission Terminal Equipment Room will be the modems and auxiliary test equipment which terminate the high speed data, low speed data, and teletype circuits from the GOSS network.

5.4.2.1 Teletype

Initially, a majority of the present Mercury teletype circuits utilizing Baudot code transmissions may be used from the remote elements of the GOSS network during both mission and non-mission periods. In addition, direct teletype circuits from Goddard, Cape Canaveral and other outside supporting agencies will enter the IMCC communication system. These circuits will operate at both 60 and 100 wpm. The 100 wpm circuits will be used primarily within the continental United States.

The intent is to convert the GOSS network teletype circuits to low speed data circuits during IMCC mission periods, operating over the same teletype bandwidth channel facilities. The primary advantage of this type of operation is the utilization of more efficient coding than the present Baudot code, and the use of more efficient error control techniques to insure the maximum reliability of data. This conversion of teletype to low speed data (at 75-100 bps) will be a gradual transition during the early Gemini rendezvous missions. Because of the flexibility of the communication processor (using electronic switching and code conversion techniques), this phase-over period will not introduce any significant problems or modifications within the IMCC. A more detailed discussion of the GOSS teletype network and terminal requirements, as well as new circuit requirements for the GOSS network will be found in the report on GOSS Performance Requirements (WDL-TR-E122).

In addition to the HSD/LSD circuit requirements, there will exist the need for normal teletype circuits for orderwire backup, and non-mission mode operations. These circuits, which will be frequency

multiplexed together with the LSD circuits to certain of the remote sites, are in addition to the standard leased teletype circuits from the supporting agencies, GSFC and Cape Canaveral, which do not require local NASA-owned channelizing equipment. To accommodate these special teletype circuits, approximately eight channels of teletype multiplexing equipment operating with standard frequency shift-keyed carrier techniques will be required. This equipment may be modularly expanded as required.

Additional teletype circuits from outside agencies and supporting areas will include the following:

- a. Weather network terminations, including facsimile
- b. Military recovery communication network
- c. Liaison military and DOD circuits
- d. Commercial Western Union teletype and Bell System TWX circuits.

These circuits are considered external to the IMCC communication system. Except for the TELEX and TWX circuits, they will pass through the Technical Control Facility for quality monitoring and control, and then terminate directly in the areas of concern.

5.4.2.2 High Speed Data

The remote sites of the GOSS network associated with the Gemini/Apollo missions, connected to the IMCC by hardwire communication facilities over the entire route, will utilize high speed data transmission over nominal 3 kc voice bandwidth circuits as the media for the exchange of data and text type messages.

The serial bit stream data arriving at the IMCC will be quality monitored at the technical control facilities and then the raw data and alphanumeric text messages will be segregated and routed to the IMCC computation system or the IMCC Message Center by the communication processor.

The selection of specific data modem terminal equipment should consider not only technical characteristics, but should also be based on the practical aspects of cost, compatibility with existing transmission media and equipment, and ease of maintenance. The data link terminal equipment should include integral test facilities allowing complete monitoring and test of component modules for maintenance and trouble shooting. In addition, suitable visual and/or aural monitoring and indication should be provided to advise the technical control personnel of equipment status and the condition of the data stream.

5.4.2.3 Low Speed Data

The low-speed data circuits terminating at the IMCC will include, in part, new circuits required to meet the greater mission requirements in addition to those circuits resulting from the transition of Baudot code to digital coding over the present Mercury teletype bandwidth facilities. Data bit rates will be approximately 75 to 100 bps (corresponding to 100 wpm Baudot code transmissions). Actual data rates will be determined at a later date.

These data circuits will carry both compressed raw data formatted for use by the IMCC computation system, and alpha-numeric text messages in digital format which will be code-converted and routed to the IMCC Message Center. The communication processor will perform this function.

The LSD circuits will be implemented with low-speed data transmission modems which will be similar to present teletype carrier modems using pulse keyed tone frequencies. Optimum modulation and detection techniques will be used on an end-to-end basis. The LSD circuits require leasing teletype bandwidth channel facilities from the common carrier companies. These would be standard teletype channels, frequency filtered and group modulated by existing common carrier multiplexer carrier systems but without the actual tone keyed channelizing equipment. Optimum low speed data modems will be provided at the IMCC

at the proper frequencies to be compatible with the common carrier systems. Compatibility with the common carrier system design and equipment operation is essential.

5.4.2.4 Error Control Equipment

Associated with each HSD terminal modem will be the logic circuits to provide an error detection-decision feedback error control system. This system should utilize a cyclic type of polynomial coding and should be a basic part of the data terminal equipment. A similar type of equipment, but less complex due to the reduced data rates, would be associated with each LSD modem. The polynomial coding is relatively simple to implement compared to the more complex Bose-Chaudhuri codes. The coding is designed to combat the type of errors prevalent on communication transmission paths and provides an error rate protection consistent with the requirements of the system.

Additional study and analysis is being performed as part of the GOSS Performance Requirements task to determine the real necessity for and complexity of, the error control requirements. Because of the inherent redundancy of most of the data (due to repeated samplings and/or English text language) the requirement for sophisticated error control techniques may be minimized.

Supervision of error rates, and hence line quality, as indicated by the number of excessive block transmission repeats, should be provided within the Technical Control Facility.

5.4.3 Voice Terminations

Terminal facilities for a number of leased voice circuits will be required at the IMCC. These voice circuits are full period leased 4-wire circuits. Approximately 10 of these lines may be diversely routed to the Goddard Switching, Conferencing and Monitoring Arrangement (SCAMA) voice control facility, where patching and conferencing of circuits from the remote elements of the GOSS network will take place. During mission periods, the GSFC voice switching facility will be under the direct operational control of the Communication Director at the IMCC. During non-mission periods, this voice network is used for non-mission support under the direction of Goddard.

Circuit assignments will vary but will be similar to the existing leased voice circuits used for the Mercury Project. Use of the primary intersite voice circuit will be governed by the location of the orbiting spacecraft, since priority is assigned to the site having the spacecraft in view. All sites may monitor all conversations at the discretion of the Flight Director. This arrangement will retain the circuit cut-off capabilities at GSFC and certain remote locations (if necessary) for cutting out circuits which become noisy due to propagation difficulties common to HF radio circuits. These circuits will terminate at the voice control console in the technical control area. This position will provide conferencing and patching arrangements during mission and non-mission periods and will also provide the interface point at which circuits are integrated into the operational intercommunication subsystem. The technical control facilities will provide voice quality monitoring, remote line cutoff (to reduce noise from circuits routed via HF radio conferenced with other hard line circuits), and liaison with GSFC for maintenance coordination on the voice circuits.

Future consideration will be given to the use of remote push-to-talk operation of the ground to spacecraft voice transmission links over

these voice circuits for the Apollo mission phases. Voice recording assignments and patching on critical circuits will be performed from this position. The following will also be performed from this position:

1. Non-mission assignment of full period lines to hot-line telephone set status at specified location
2. Provide a call-intercept position for the administrative telephone system during mission periods to prevent unauthorized calls in the MOCR and other operational areas
3. Terminate and switch additional directly-routed leased circuits from Cape Canaveral, DOD and other support areas
4. Coordinate with the Goddard SCAMA Voice Control Center.

5.4.4 Video

A television transmission channel may be leased or implemented to transmit video information between the Launch Complex and the IMCC during the prelaunch and launch phases where it would be entered into the television distribution system for viewing at any television display device.

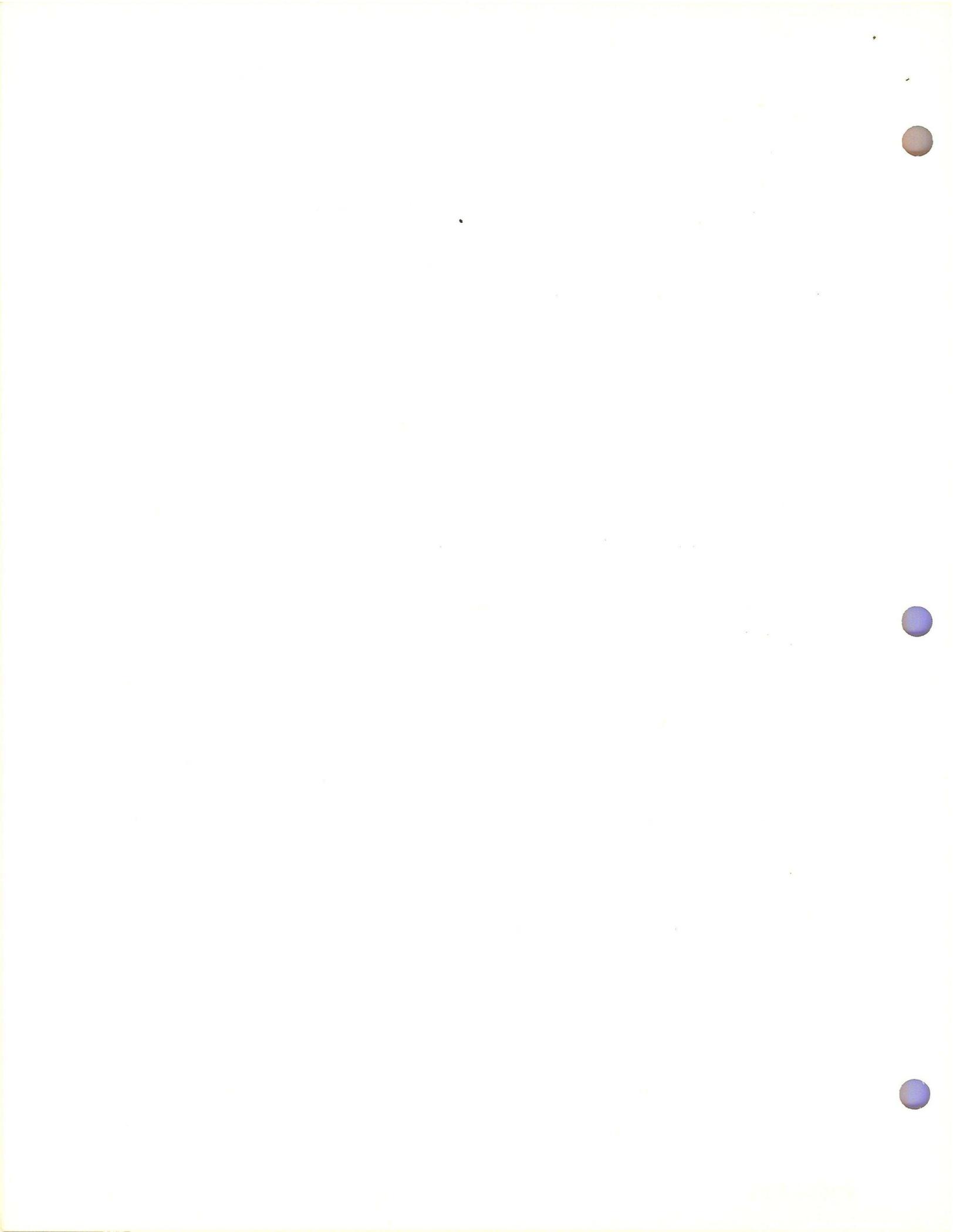
Within the IMCC, the common carrier will terminate this video channel (4.0 to 6.0 Mc bandwidth) with an A2A termination set located in the common carrier equipment room. This termination set is equipped with two 75-ohm coaxial output terminations, a program output and monitor output. The program output will be routed directly to the closed-circuit television termination equipment which will distribute the video information to the appropriate displays. The monitor output jack will feed this same video information to monitor equipment within the technical control facilities where quality monitoring of the circuit can be performed and proper liaison with the Telco liaison representative can be effected.

During the Apollo missions (lunar phases only), an additional simplex video channel will be required from JPL, Pasadena, to the IMCC.

5.4.5 Telemetry Composite

At the present time, economic considerations indicate that decommutation, reduction and processing of the composite telemetry signal at Cape Canaveral and the subsequent retransmission of this data to the IMCC via the 2400 bps high speed data lines is desirable. Alternately, the lease of a wideband "telpac" channel to transfer this data to the IMCC is considerably more expensive, not only imposing on the IMCC the requirement of decommutating and processing this data for use, but subjecting this data to possible degradation due to the transmission channel. Error control equipment to safeguard the data against errors would be quite complex and costly.

When the Operational Instrumentation Facility (OIF) is implemented, the capability will exist at the IMCC to process the composite telemetry signal. Further study will be required to determine the requirements for bringing this raw data to the IMCC-OIF via wideband channels for subsequent processing and use.



5.5 COMMUNICATION PROCESSING AND CONTROL SUBSYSTEM

5.5.1 General

The GOSS/IMCC Communication System involves a multiplicity of external locations (remote sites) communicating with one terminal point, the IMCC. In addition, the system differs from what would be considered a typical communication system in that two types of messages (text and data) may be transmitted, intermixed, over the same communication lines with different formats used on different lines. Each message type, in addition, will be destined for a separate location within the IMCC; text messages being routed to the Message Center and individual subscriber terminals, and data to the computational complex. A similar requirement exists for outgoing IMCC messages, in that both the Message Center and the computational complex will have the capability to communicate with any or all of the remote sites. It is apparent, then, that a message processing and routing control function must be performed within the IMCC.

5.5.1.1 Functional Requirements

The sharing of multiple input lines with multiple output lines is a basic principle of switching in point-to-point communications. For the switching function to be efficient, it must be fast enough to connect the traffic on each incoming line to the desired outgoing line, with little or no delay, except in the outgoing queue necessary for store and forward operation. The burden of moving traffic is transferred to the outgoing line. This means that the switching system must accept and unload all traffic from all the incoming lines connecting to it. Storage of waiting traffic is the primary problem in any switching center.

The use of computer techniques of stored program control to make message switching and processing operations automatic eliminates the cross-office delay and the inflexibility and inefficiency common to the electro-mechanical switching centers in wide use today.

In designing an electronic communication switching and processing system, the communication problem must be approached directly. The selection of the computer which will serve as the communication processor should be functionally directed toward the existing communication problems and requirements. Many existing computers have limitations in data input-output and transfer, and have an arbitrary list of instructions emphasizing arithmetic and logic operations ... not communication functions. Conventional computers are fixed for data processing, whereas they must be flexible for data communication.

To design and specify an efficient communication switching center for the IMCC, it is necessary to take a close look at the requirements and functions which must be accommodated. These are covered in the following sections.

a. Switching Requirements

1. Number of circuits: Present planning indicates there will be a total of approximately 60 input/output lines from the IMCC communications system. These lines will consist of high speed data, low speed data and teletype information. Actual line requirements are not firm at this date. Therefore, it seems reasonable to recommend that the initial system specified for the IMCC be designed for a maximum of 100 lines, and equipped for a total of 65 lines, assigned as follows: 17 high-speed data (HSD), 15 low-speed data (LSD), 25 teletype (TTY) lines plus 8 spare terminations.
2. The communication switching system must switch rapidly enough to accept all incoming messages. In other words, it must be capable of handling the estimated peak traffic loading expected on all internal IMCC and external GOSS communication lines.

3. The communications switching system must be time shared among all incoming and outgoing lines.
4. The communication switching system must sample each incoming line, determine message precedence, perform address recognition, and provide flexible and automatic routing of all messages within the IMCC.
5. The requirement for switching between external lines (i. e., remote site-to-site communication via GOSS) will be limited, but this capability should be provided.
6. Each outgoing line must be sampled to determine its status as defined by the following states.
 - (a) Inoperative
 - (b) In use - transmitting high precedence message
 - (c) In use - transmitting low precedence message
 - (d) Not in use.
7. Outgoing messages must be queued according to precedence, and any message can be interrupted for no delay priority traffic.
8. Multiple address messages, ranging from two addresses to an all stations broadcast, can be accommodated at any time.
9. Data on the HSD/LSD lines must be separated and routed to the computation data busses and/or the message center by recognition of address "tags" in the data stream.
10. Data and digitally coded alphanumeric text messages must be interlaced and transmitted to common addresses via the HSD/LSD lines.

11. Automatic speed conversion between data rates of 75 to 2400 bps must be accomplished.
12. Code conversion must be performed (i. e. , digital to Baudot and vice versa). The system must be capable of accepting, storing, and retransmitting messages of dissimilar form between certain unlike terminal devices.
13. The system must provide automatic diversion of overflow traffic to random access storage files, and timely return for retransmission.
14. Automatic detection of internal errors by generation and checking of parity must be accomplished.

b. Bookkeeping Requirements

To continually monitor the status of all messages handled by the communication switching system and also to monitor the status of the system itself, the processing portion of the switching facility must perform the following bookkeeping functions:

Indicate to the operating personnel the status of each incoming and outgoing line

Indicate the status of all bookkeeping functions

Indicate the presence of exceptions to normal operation (garbled headings, out of sequence messages, etc.)

Provide facilities for program maintenance and control, fault reporting and manual override.

d. Storage Requirements

The outgoing lines are shared by all incoming lines. This may

5.5.1-4

cause queues to form; therefore, outgoing lines must have storage capability. In addition, some storage is required on the incoming lines to accomplish speed and code conversion.

1. Incoming Line Storage

Speed conversion is necessary to match incoming speed with the outgoing line speeds. Since the incoming line speeds are fixed, speed conversion can be accomplished only by an incoming line store in which the slow input line accumulates data until enough is stored for the communication switching system to take the data at its own rate. The amount of storage needed depends on several factors;

- (a) The sampling rate of the system
- (b) The number of lines to be sampled
- (c) The speed of data transfer
- (d) The method of processing the data.

2. Outgoing Line Storage

Implicit in all storage operations is message retrieval. Basically, there are two different methods which can be used. In one method, separate discrete storage for high and low precedence messages is provided on each outgoing line so that the messages have access to this line as the line becomes available. This eliminates the need for further processing during information retrieval, and is the most direct and simple method of handling the switching problem. Because a very large part of the potential storage is in a waiting stage, rather than being used, the storage utilization is very inefficient. Since storage is expensive, a more efficient storage approach is indicated.

It is possible to lessen the amount of storage required by assigning a common storage area to all outgoing lines. This can be done in the following manner.

- Each incoming message is sensed and processed.
- Once processed, the message is removed from the incoming line to make room for subsequent messages.
- The message is put into common storage.
- The message in common store either retains all its routing information while in storage or is reprocessed each time it is taken out of storage.
- The processor continually samples both the status of the outgoing lines and the messages in storage awaiting transmission. Each time a match is made between message store and outgoing line, a message is released for transmission.

This approach uses the storage more efficiently and shares it among all outgoing lines. The switching burden is transferred to the central system which time shares all processing and storage functions with incoming and outgoing lines. Since the processor speed is far in excess of the combined speed of all incoming and outgoing lines, the burden placed on it is well within its capability.

3. Historical Storage

A storage medium will be required for the historical storage of text messages. For this purpose, the use of magnetic tape transports is proposed. Tape storage can provide a

relatively low cost, large capacity, long term storage segmented into days, weeks, etc., by simple reel changes.

5.5.1.2 System Functional Criteria

In fulfilling the above general requirements, and also the more detailed implicit requirements, definite functional criteria must be established and met.

a. Compatibility

The communication processing and control subsystem is to be one element in a large existing and operating worldwide communication complex. It must, therefore, be designed to fit the existing system rather than having the present system conform to specifications established by it. However, designing the IMCC communication center for compatibility with the existing GOSS network should not detract from its primary function.

b. Capability

The communication processing and control subsystem must have the capacity and speed to accomplish the routing, storage, and sequencing for the full complement of communication lines required. It must minimize all queues, other than the outgoing line queues. In addition, it must perform all the book-keeping and other ancillary functions needed to operate an efficient, coordinated communication center.

c. Adaptability

Because of the dynamic nature of the communication field, any system must be designed to adapt to future changes. If this adaptability is not designed into the system, the system will

soon be obsolete. This is one reason that both the software and hardware must be constructed using a building block approach. This will allow modular expansion changes as they are required.

d. Reliability

Two aspects of reliability must be considered, functional reliability and component reliability:

Functional Reliability

The primary function of a switching system is to accept all incoming messages and transfer them to the proper outgoing lines. This must be done without losing any messages.

Component Reliability

All equipment components must be designed to satisfy the highest standards of reliability. Furthermore, redundant equipment for prime circuits will be necessary to provide continuity of operation during scheduled preventive maintenance and, additionally, to forestall catastrophic failure.

e. Human Factors

Though the switching complex will be completely automatic, there will be areas in which operating personnel must interface with functional procedures as well as with operating equipment. The type of interface designed will be a compromise between man's physical and psychological capabilities, and the cost and complexity of procedures and equipment. The individual must not be taxed beyond his capabilities, nor should the equipment cost or complexity become excessive in an effort to oversimplify tasks best performed by man.

f. Practicality

Since the system will be functioning twenty-four hours a day, seven days a week, it must be designed using sound engineering principles for efficient operation and maintainability, and be practical in cost.

5.5.1.3 System Selection

There are several system configurations which will satisfy the functional requirements of communications control. (See Section 5.5.2.) Of these, three related techniques provide the most satisfactory compromise between capability and cost. These are as follows: (1) provide a separate and distinct processing system to handle only communications (2) incorporate the communication functional requirements within one (or more) of the computers and (3) provide an I/O subsystem to the computers which provides for communication control as well as those functions normally assigned an I/O subsystem (editing, formatting, etc.). The distinction between alternatives 1 and 3 is only a matter of degree. The relating factor in the three configurations is the use of a "message switching-electronic processing" approach. (The justification for this selection is given in the Appendix G under the title of "Communications Switching System.") The difference between the three systems is mainly the point at which communications control is applied. In a final comparison of the three techniques (shown in Table G-1 in the Appendix G), made empirically by a functional assessment of equipment capabilities, it was found that the separate and distinct communications processor provided the most satisfactory system concept relating to the functional requirements listed in Section 5.5.2.

5.5.1.4 System Configuration

On the basis of the preceding discussion, the installation of an automatic, high speed, electronic message switching and processing center is

recommended to terminate the teletype and data circuits of the GOSS communication network. This communication processing and control subsystem will serve as the nerve center for the IMCC access to the external communication network. The proposed system differs from the communication switching center for all NASA teletype (and future data) circuits located at the Goddard Space Flight Center in that it is a terminal switching center handling all teletype and data circuits terminating at the IMCC.

Its primary functional requirement is that of accepting traffic from the worldwide GOSS network, either direct during IMCC mission periods or via Goddard during non-mission periods, and separating and routing this traffic (both serial bit stream data and text messages in Baudot or digital coding) to the appropriate destination within the IMCC. A similar requirement exists for assembling and routing of all outward communication from the IMCC. The primary monitoring and control facility for the communication system will be provided by a multiplexed, stored program data processor, henceforth referred to as the communication processor. Peripheral units provide the processor a modular adaptability to both present and future IMCC communication requirements. Peripheral equipment includes such items as input and output line terminal and control units, random access storage to extend the processor's memory for queuing storage of messages, magnetic tape units to provide historical files, traffic analysis and message accounting, a supervisory control console, and a message intercept position for garbled messages.

Figure 5.5-1 shows that the system uses a redundant approach to achieve a high reliability factor. In operation, each processor operates on line to maintain a current memory. The output from the system is selected from one of the processors through the output selection unit which is, in turn, under program control. In the event of a failure of the operational processor, change-over to the second unit is made automatically. Provisions should be included to allow selection of the

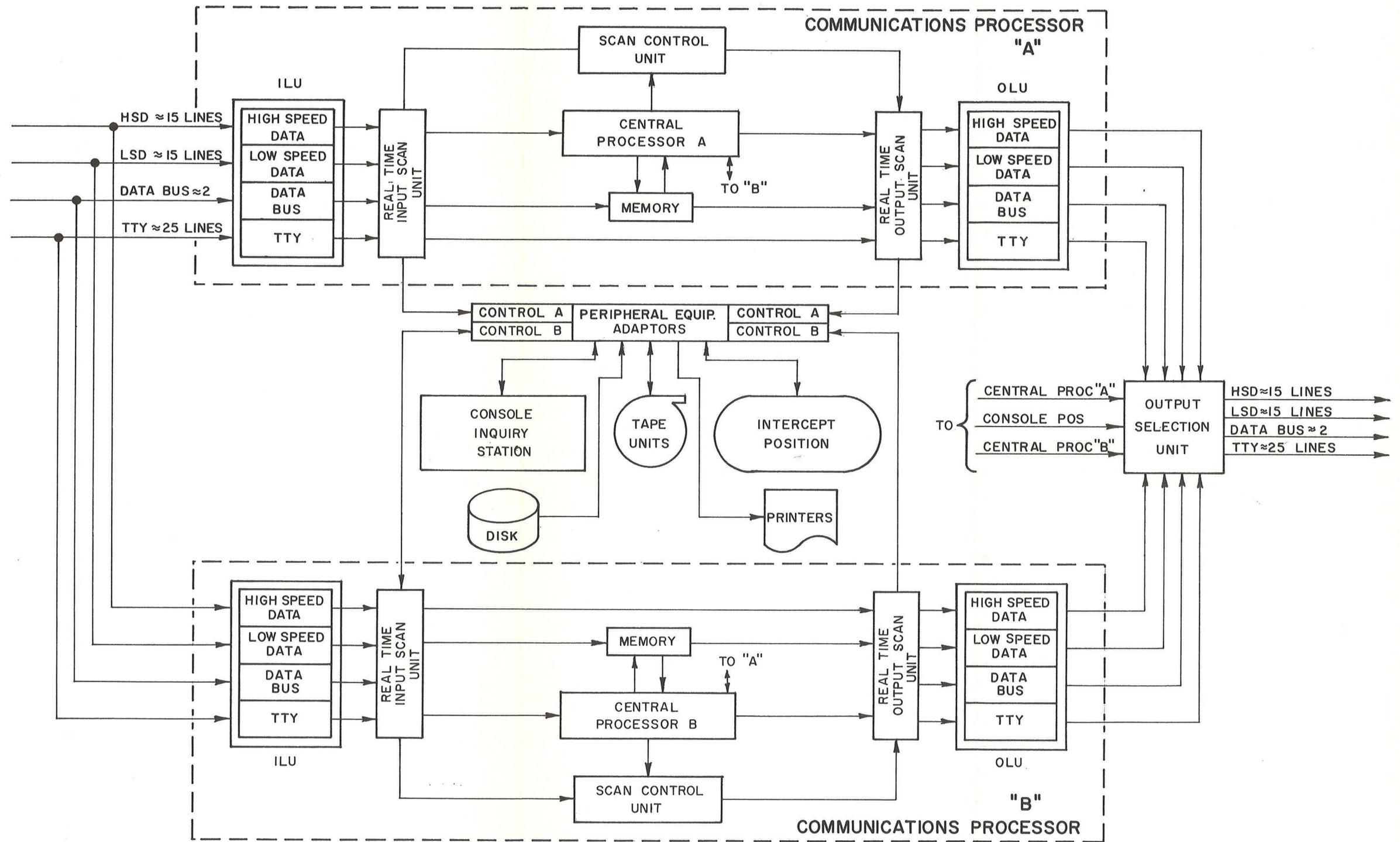


Figure 5.5-1 Dual Communications Processor Installation

processor from the console position. The functions and operations of each portion of the system are discussed in the following paragraphs:

a. Incoming Line Unit (ILU)

The primary function of the ILU is the coupling of the input data lines to the communication processor. The ILU performs impedance matching and level conversion functions to convert the line characteristics to those required by the communication processor. In the case of the TTY inputs, the ILU strips the start-stop codes from the data, retaining only the information bits. Data transfer from the ILU may either be on a "bit-at-a-time" basis with character assembly under program control or character assembly may be done with individual line buffers in the ILU with a parallel character transfer into the processor. In either case, the ILU serves to synchronize the asynchronous external inputs to the communication processor. For serial digital low speed data, the ILU's operate much in the same manner except that the elimination of start-stop codes is not required. For high speed data, the data will normally be assembled in characters in the ILU and data transfer will be on a parallel basis.

b. Outgoing Line Unit (OLU)

The outgoing line units serve as the complement of the ILU's. They serialize data received on a parallel basis from the processor and, in the case of TTY, add the start-stop codes to the information bits. In addition, the OLU's serve as a rate conversion device for the transmission media.

c. Real Time Scan Unit (Input)

The Real Time Scan Unit (RTS) serves to multiplex the multiple

input lines into the main core storage (MCS). To maintain a high degree of flexibility, the RTS will be a programmable unit. In this manner, line changes and rate changes requiring a different scanning procedure can be accommodated through a program change rather than a wiring change. As indicated previously, transfer from the RTS is direct to an assigned cell bank (assigned by line) in the MSC where the message is assembled.

d. Central Processor

The central processor performs all the address recognition, polling, accounting, and control functions required to achieve effective data control. Most processing within the central processor may be accomplished through table look-up procedures, a method which will enhance the capability of the communication processor to cope with changing communication requirements. In route control, the central processor moves messages in data blocks from the incoming MSC location to an outgoing location in the MCS. If the appropriate output line is available, the message is then transmitted immediately. If an output line is not available, the message is moved to a queuing location, either in the MCS or in a random access peripheral storage medium such as a disk or drum unit. Messages are recalled from queuing storage by priority and incident times. A complete ledger accounting system is employed to correlate incoming vs. outgoing messages. Figure 5.5-2 is a simplified diagram indicating the flow of information through the communication processor.

e. Real Time Scan Unit (Output)

The RTS output unit accomplishes the same function for output lines as does RTS input unit for input lines. In operation, the RTS serves to multiplex the output bank of MSC to appropriate

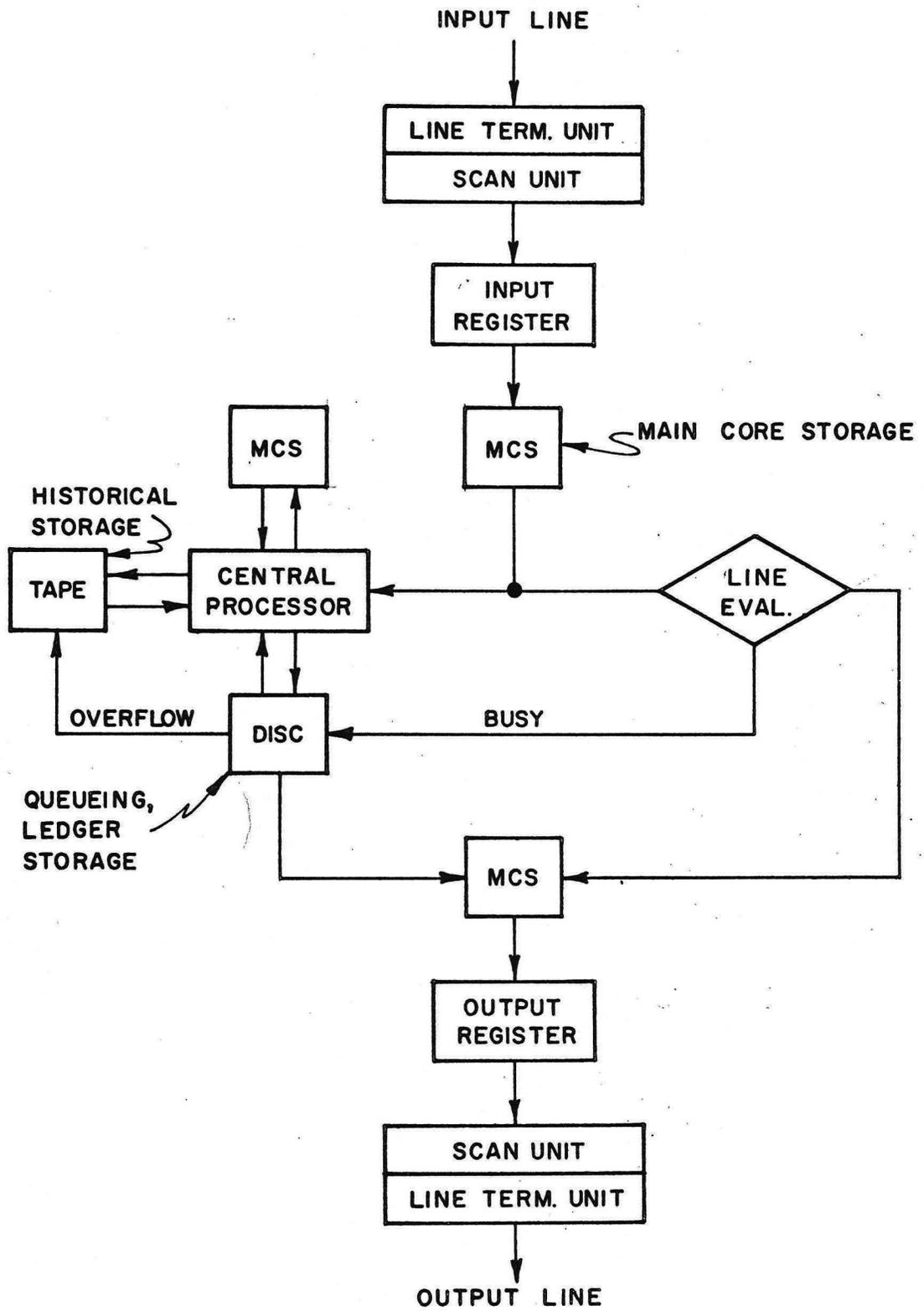


Figure 5.5-2 Communications Processor Information Flow

5.5.1-15

line or peripheral equipment. The RTS also provides the high speed channel connection required between dual units.

f. Peripheral Equipment

All peripheral equipment will be provided with appropriate channel adapters and control units to allow control and communication to and from such units by either processor. A tentative description of the peripheral equipment is as follows:

1. Short Term Storage Media

A disc or drum storage unit, which provides fast, random access storage for the communication processor and acts as an extension of the processor's main memory for storage of "in-transit" messages, will be provided.

2. Long Term Storage Media

Magnetic tape units are provided to maintain a complete record of all traffic entering the system. These units permit complete records to be kept in any code and format for message accounting and traffic analysis. Tape units also provide historical files. Upon receipt of an inquiry from the supervisor, the communication processor can search the long-term file, locate the message and process it as instructed.

3. Intercept Position

The intercept position or console, located in the message center, corrects messages rejected by the communication processor so that they can re-enter the communication system. When a message is sent to the intercept position, it is specifically addressed to this position, just as is done for an outgoing message. The message is received at

the intercept position as a page copy and also punched on a receiving perforator. The intercept operator makes the necessary corrections, and puts the corrected message tape on a transmitting distributor which is connected back through the communication processor by means of an incoming line unit. The number of intercept positions can be increased as needed. If an intercepted message is uncorrectable, proper service messages to the originating station can be initiated from this position.

5.5.1.5 CONCLUSION

Although the system as described herein includes a dual system, consideration is being given to a three-processor system. With such a configuration, one processor would be used for operational data, one for simulation and one for an on-line backup to the operational system. In the event of a failure in one of the operational processors, the simulation exercise could be curtailed and the simulation machine put on line to serve as a backup to the remaining operational processor. Advantages of such a system are increased reliability for operational data and complete separation of simulation data. The reliability factor is perhaps the most important consideration since simulation data can be effectively kept separated within a dual system. The reliability factor will involve a trade-off between economics and the increased reliability gained by adding a third processor. To this end, an effort has been made to determine the availability factor (concerning both the mean time between failures and the mean time to repair) of a typical communication processing system. The results of this effort are given in Appendix I.

5.5.2 Communications Control

5.5.2.1 General

The supervisory control of the GOSS/IMCC communications system has

tentatively been assigned as the responsibility of the Communications Coordinator (CC). In order to effectively exercise this control, it is necessary to provide the CC with a comprehensive, clear, and up-to-date understanding of the system under his responsibility. To this end, it is proposed that both a control console and an associated wall display be provided. The functional assignments of each can be such that all transient displays and operational controls (requiring direct action by the CC) are located in the console while the wall display is utilized as a more static information display. In addition, in order to minimize the complexity of the control system, the console and wall displays should complement each other and information redundancy should be held to a minimum.

5.5.2.2 Wall Display

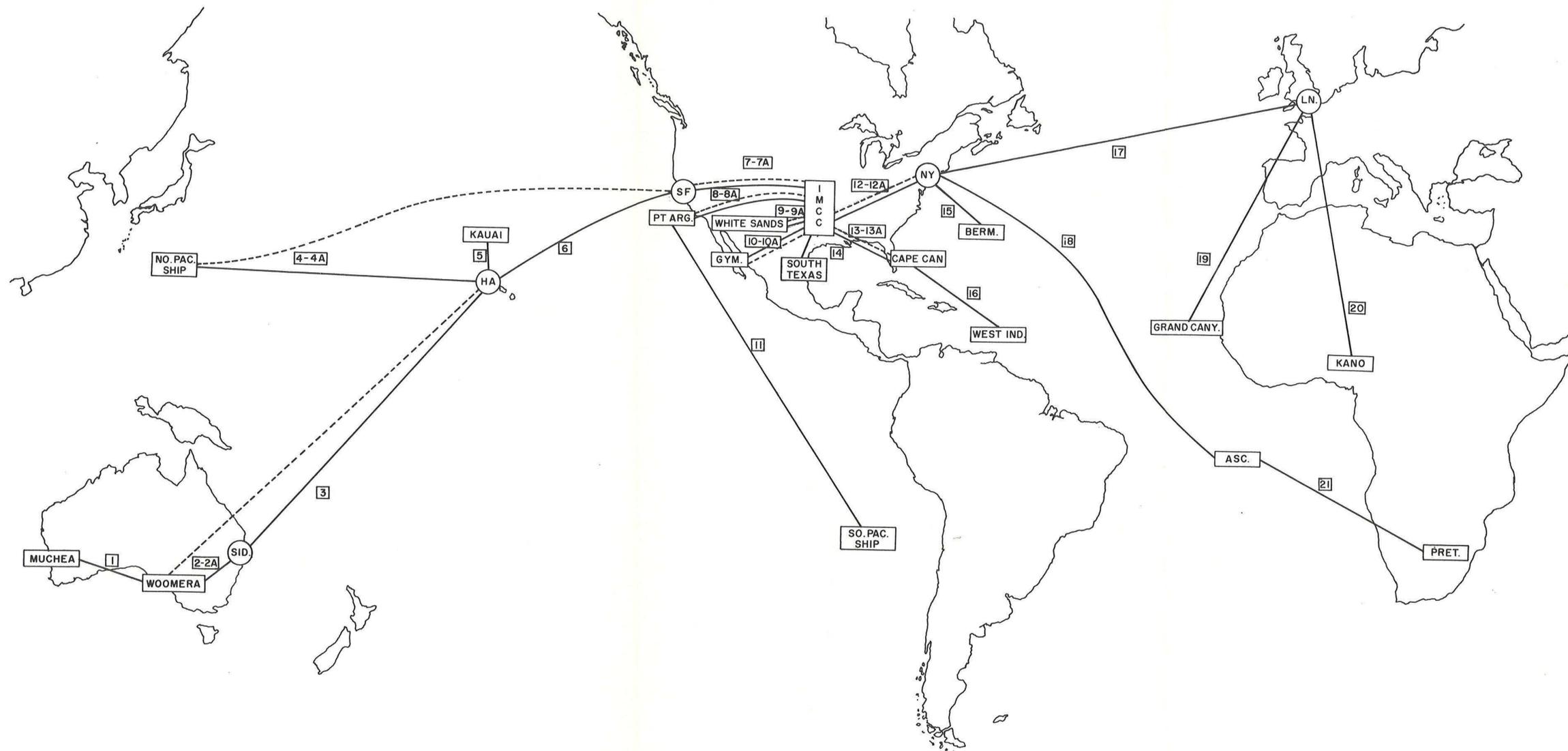
5.5.2.2.1 Functional Assignments

A preliminary listing of the wall display requirements is shown in Table 5-1. The listing includes many functions which, while desirable, may be excluded from a final design because of resultant complexity. Such a decision will involve a trade-off between economics and the display functional capabilities and will be resolved as further data becomes available.

Several possible configurations of wall displays exist which could satisfy most of the functional requirements listed in Table 5-1. Of these, the "light-pipe" type of displays appear to be most effective from a presentation efficiency standpoint. Two such configurations are shown in Figures 5.5.3 and 5.5.4. Figure 5.5.3 utilizes a geographic location approach, while Figure 5.5.4 is only semi-geographic in nature. Each configuration employs multi-colored (either tri or dual) lights to convey the information desired. The table at the bottom of each display indicates the type and number of communications lines contained in each link and (by color) the status of these lines. The individual link conditions are summarized

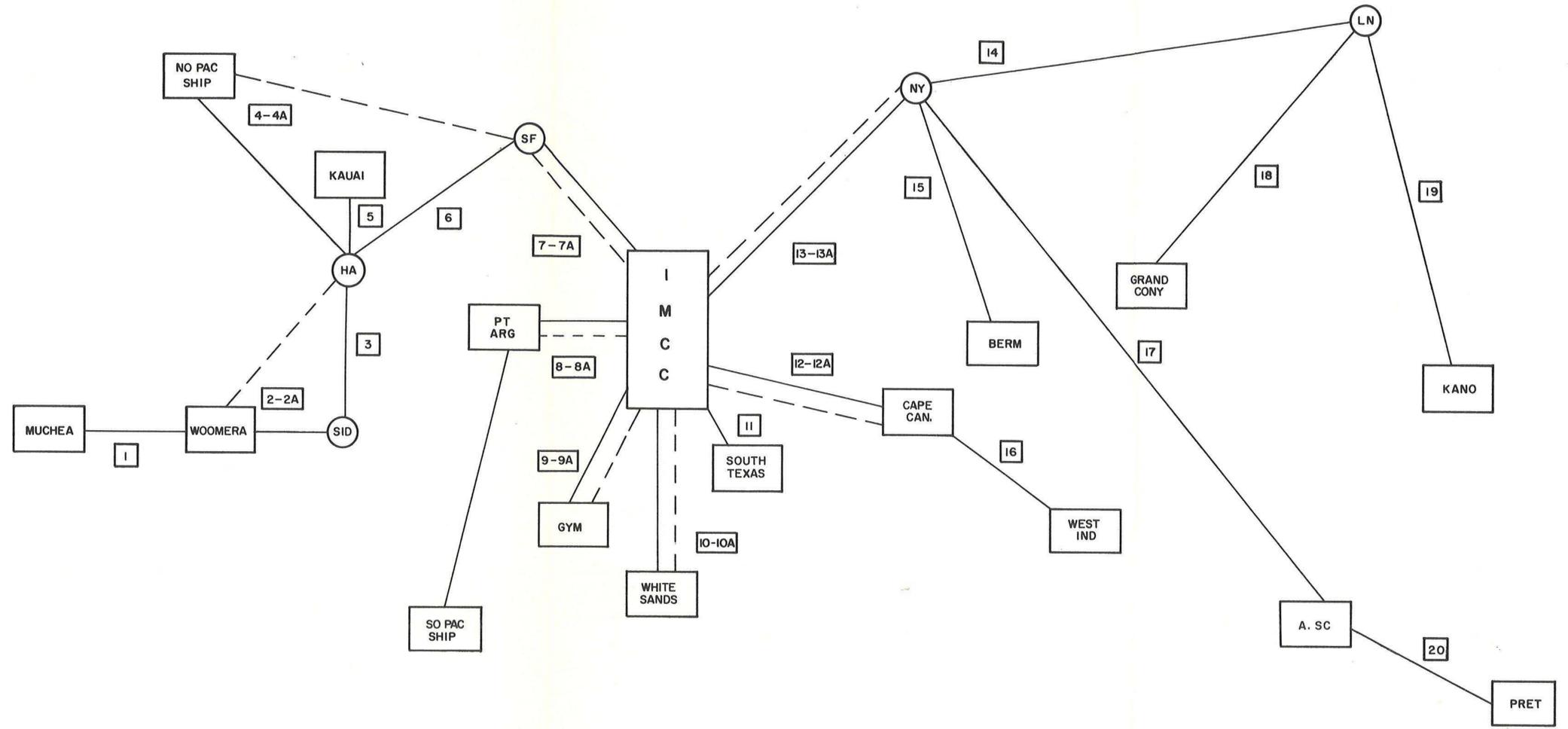
Table 5-1
WALL DISPLAY REQUIREMENTS

Function	Use	Control
(A) Station		
(1) Location	The station descriptive information permits the CC to evaluate the effect of link outages by reference to station.	Static
(2) Status		Manual
(3) Acq. Time		Auto.
(4) Use		Static
(B) Comm. Link	Describes all possible communication routes between the IMCC and Remote Sites.	Static
(1) Use		
(a) Primary	Describes the type and number of communications lines contained in any one link.	Static
(b) Alternate		
(2) Description		
(a) LSD		
(b) HSD		
(c) Voice	Tri-colored status indication for each communication line in any one link.	Manual
(d) TTY		
(e) Video		
(3) Status		Manual
(a) Operable		
(b) Questionable		
(c) Inoperable		
(C) Outage Report	Provides a basis for the CC to analyze seriousness of outages.	Manual
(1) Time of Out.		
(2) Pred. Time in		
(D) Misc. Functions	Complements the CC's knowledge of the communications system and may be useful as diagnostic aids	Static
(1) Relay Points		
(2) Bridged Y Points		
(3) Goddard Link		



LINK	1	2	2A	3	4	4A	5	6	7	7A	8	8A	9	9A	10	10A	11	12	12A	13	13A	14	15	16	17	18	19	20	21
VOICE																													
HSD			X		X	X																							
LSD	X	X					X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TIME OF OUTAGE																													
PREDICTED RESTORE																													

Figure 5.5-3 Alternate Geographical Presentation of Typical Communication Wall Display



LINK	1	2	2 A	3	4	4 A	5	6	7	7 A	8	8 A	9	9 A	10	10 A	11	12	12 A	13	13 A	14	15	16	17	18	19	20	21
VOICE																													
HSD			X		X	X																							
LSD	X	X									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TIME OF OUTAGE																													
PREDICTED RESTORE																													

Figure 5.5-4 Typical Communication Wall Display

by "light-pipe" lines with tri-color capability to indicate operable, partial outage and complete outage. The tables also contain "time-of-outage" and predicted restoral indications which, while desirable, may result in undue implementation complexity. Station status can be implemented by tri-color indicators while the next station to acquire signal may be a light ring or flashing station indicator. While the type of display discussed in the preceding paragraph is felt desirable, several unresolved problems may prohibit the use of such techniques. Among these are: (1) the means of entering data into the display - (most of the information required should be available from other IMCC areas, such as the tech control area and the MOCR), and (2) a means must be provided to insure the Communications Coordinator is aware of all changes on the display. There is also a problem of redundancy, since a good deal of the information required by this display is also required by the status display in the MOCR. The satisfactory resolution of these and other problems will partially dictate the final display configuration and will be presented in future revisions of this report.

5.5.2.3 Communications Coordinator Console

The Communications Coordinator's console functions as an integral part of the communications processing and control system. As such, it (and the wall display) is directly associated with the communications processor and preferably should be located within the same room. The console serves as the monitor and control center for system operation, providing message and circuit supervision, and system control. It consists of teletypewriter units, display lamps for line and equipment status, and alarms. From the console, an operator can perform the following functions: send and receive messages, "busy out" non-operating stations, and initiate inquiries to the processor or retrieve messages from file.

The Communication Coordinator will be provided operational liaison with the Technical Control Facility and the Message Center supervisor, as

well as the Communication Director for administrative scheduling and operational briefing. In addition, all liaison required with GSFC and outside agencies for maintenance and scheduling will be effected through the Communication Coordinator.

5.5.2.3.1 Functional Assignments

The functional assignment of the Communications Coordinator's console should ideally include the following functions:

(A) Processor Functions

1. Pri/Alt status Indication and Control
2. Peripheral Equip. Status & Control
3. Hard Copy Printer & Keyboard
4. Time Indicators
5. Contingency Override & Release

(B) Engineering Position

1. Word Structure Switches (address & test words)
2. Internal Operation Indicators
 - (a) Program Counter
 - (b) Instruction
 - (c) Address
 - (d) Buffer
 - (e) Accumulator
3. Programming Aids
4. Power On/Off Controls
5. Peripheral Equip. Status

(C) Communication Functions

1. Storage Monitor (Normal - Danger - Overflow)
2. Error Indicators (No station response polling)
3. Simulation Traffic Present

4. Simulation Traffic routing error detection alarm
5. Simulation quick disconnect
6. Display status change alarm
 - (a) Audible console alarm
 - (b) Flashing light on display to indicate changeBoth reset by manual button actuated by C. C. - audible alarm turns off and display light resets to steady state indicating new status.

(D) RTCC Functional Indication

1. Status of RTCC computers
2. Functional Assignment of RTCC Computers
 - (a) Operational
 - (b) Operational Backup
 - (c) Simulation
 - (d) Simulation Generation

The listing as shown is tentative and does not preclude the addition or deletion of individual functions. The functional assignment is included in this report only to indicate the major areas of assignment which will be investigated in later revisions of this report.

5.6 IMCC Internal Communication Subsystem

Internal communications will play a major role within the IMCC. Efficient and reliable communications are not only directly related to successful monitoring and completion of manned space flight missions, but also to non-mission operations for normal day-to-day flow of administrative, logistic and support communications required both within the IMCC/MSC complex and between NASA support agencies.

The equipment associated with the IMCC internal communication subsystem is located in two major areas, the Message Center, and the Communication Equipment Room. A detailed discussion of each system requirement is presented in the following pages. Figure 5.6-1 shows an overall block diagram of the internal communication subsystem.

5.6.1 IMCC Message Center

The Message Center is responsible for the acceptance, preparation for transmission, receipt and delivery of messages. It is the termination point for all text type traffic arriving at the IMCC from the GOSS communication network, other direct teletype lines from support services, and the local commercial TWX and TELEX services. This room is also used for equipment terminating the various teletype "pony" circuits used throughout the IMCC/MSC complex. These represent local requirements and may change on a week-to-week basis. Therefore, a satisfactory arrangement for flexible routing and equipment reassignment through local patch panels must be provided.

The major flow of traffic will be between the communication processor and the Message Center. The communication processor accepts and separates text from data on the data lines, performs digital-to-Baudot code conversions, and routes these, as well as all text messages, from the teletype lines to the IMCC Message Center.

5.6.1-2

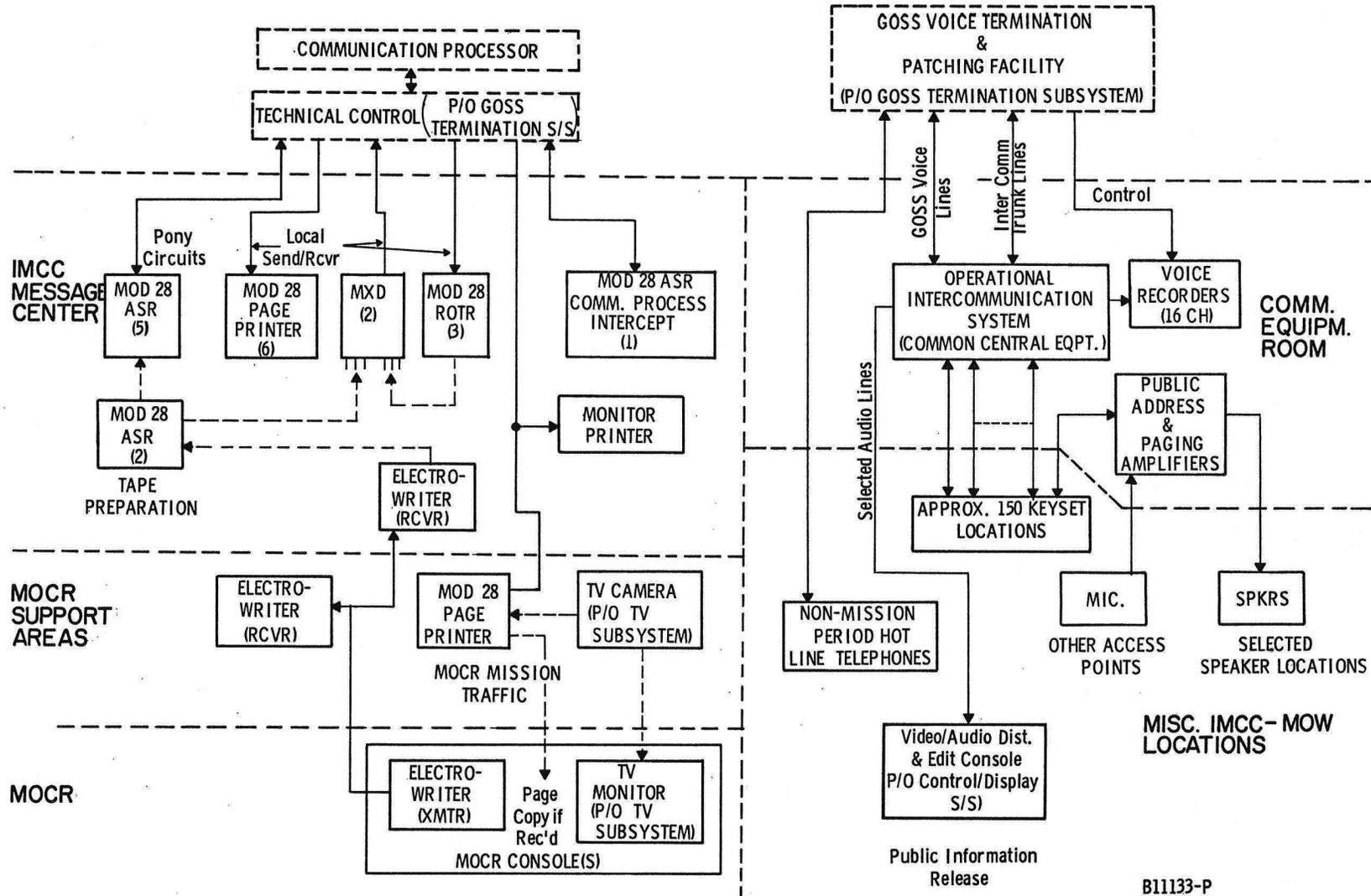


Figure 5.6-1 Overall IMCC Internal Communications Subsystem Block Diagram

5.6.1.1 Terminal Equipment

- a. Within present day message centers these text messages, in Baudot code format, normally terminate on the latest Teletype Corporations' Model 28 teletype equipment. This equipment is operated at either 60 or 100 wpm and arranged for full-duplex, half-duplex or simplex operation depending upon the type of circuit terminated. Overall communication system traffic loading and traffic flow analysis will determine the number of terminal teletypes required to assure that message queuing is held to a minimum in the communication processor. The different types of teletype terminal equipment normally found in a message center are:

1. Model 28 ASR (Automatic-Send-Receive) Teleprinter.

This model is a complete station within a compact console with facilities for the direct interchange of transmitted data with information recorded in printed page form, punching tape as a by-product of transmission and reception, preparing punched tape for subsequent transmission, and automatically transmitting data under the control of perforated tape that utilizes a tape reader unit.

2. Model 28 RO (Receiver-Only) Teleprinter. This model is a message receiving unit (without keyboard) used as a terminal equipment where 2-way communications are not necessary from the same machine. A printed record is produced on page type paper.

3. Model 28 ROTR (Receive Only, Typing-Reperforator).

This model receives incoming electrical signals, punches a 5-level tape and prints data on the tape for easy identification and handling. The Model 28 ROTR may be used as an individual unit or as multiple units, mounted up to six in a cabinet. These models are normally used to record received messages and the perforated tape copy is used for retransmission on other circuits. They are also used as monitor machines to record tape for historical storage of all traffic handled.

4. Model 28-Transmitter-Distributor (TD). The single model, or multi-gate transmitter distributor (MXD), provides transmission facilities for sending 5-level teletype tape messages on a manual or automatic basis. Each MXD unit contains a maximum of three separate automatic Model 28-TD's and can be used to send to three separate circuits. The operation of the 28-TD is the same as the transmitter portion of the 28ASR set.

The Message centers are also provided with additional Model 28 ASR teletypewriters for use as tape cutters. Outgoing messages are cut on tape in advance and the tapes are used for automatic transmission of outgoing traffic by means of the transmitter-distributor units within the Model 28 ASR, or the MXD units. These machines would also serve as standby or spare units for the operational circuits.

- b. Use of Higher Speed Terminal Devices. The majority of text traffic originated externally to the IMCC from the GOSS Network will be delivered to the Message Center via the Communications Processor. The communications processor acts as a buffer and storage device which multiplexes traffic from a large number of lines to a specified number of common lines to the Message Center. Because the communications processor is also capable of performing speed and code conversions, it would be entirely feasible to utilize high speed digital type printers to print page copy of text messages received in the Message Center. This would result in a reduction of the numbers of terminal printers required to terminate text traffic from the GOSS network.

Units similar to the Motorola Model TP-3000, an electrostatic teleprinter system operating at speeds of 750-1500-3000 wpm, could be utilized for this application. One such printer would be capable of replacing an equivalent number of Model 28 teleprinters operating at 100 wpm. This system makes use of a unique electronic printing technique that minimizes the electronic and mechanical complexity normally associated with high speed printer systems. The economic tradeoffs of such a system versus the Mod 28 type equipments are very favorable. The Motorola TP-3000 equipment is presently being utilized for a similar application by JPL in their SFOF facility. The primary disadvantage is that they do not print multiple copies. This disadvantage could be offset by having local reproduction facilities available for duplicating the exact number of copies necessary for distribution to addressee(s) by courier, or by

recalling traffic from the communication processor to be retransmitted to a terminal addressee(s) via local pony circuits.

Very high-speed pageprinters using line-at-a-time printing are also available. This equipment utilizes an impact printing method capable of reproducing multiple copies. However, they are relatively expensive and the economic tradeoffs would not be favorable unless a very large number of Model 28 terminal type printers were under consideration.

- c. Operating Speeds. The use of high speed printers would not eliminate entirely the requirements for Model 28 type printer equipment in the Message Center. A certain number of the 100/60 wpm Model type 28 equipment would be required for the various pony circuits and direct teletype service not utilizing the Communication Processor's capabilities.

Regardless of the types of terminal printing equipment provided within the Message Center, actual message transfer rates between the communication processor and the message center terminal equipments should be as rapid as possible, limited only by the capability of the equipment. Therefore, wherever feasible, this transfer of information should be on a parallel bit basis. The present Model 28 page printing equipment can only be operated on a serial bit basis (at 100 wpm), but the Model 28 line of transmitter-distributors (or MXD's), tape readers, and reperforator equipment can be arranged for parallel operation at 200 wpm. Maximum use of the Teletype Corporations new BRPE tape transmitters and punches operating at 1100 wpm for entry of traffic into and from the communication processor is recommended. The use of parallel bit operation wherever possible means a fast transfer of traffic to and from the Message Center and a corresponding reduction in the numbers of terminal equipment required to handle the projected traffic loads.

5.6.1.2 Message Center Configuration

- a. Installation criteria. The teletypewriter locations should be equipped with Square D-type cabling ducts. These may be wall mounted along the floorboard or mounted on stanchions at equipment height in line with each row of equipment. These ducts are equipped with power and signal cable jacks at each location to facilitate the rearrangement of equipment and circuits with a minimum of rewiring. The cabling from each individual operating teletype equipment is terminated on plugs.

- b. Patch Facilities. A local dc patch panel should be provided within the Message Center for local patching and testing of teletype circuits and equipment. This panel would be a normal dc patching facility containing looping, set, and monitor jacks for local testing and monitoring of teletype line loop currents and patching of spare equipment to the external circuits. However, this is a secondary patch facility and the major patching and rerouting of circuits is normally accomplished at the primary Technical Control patch facilities in the Communication Control room.
- c. Simulation Traffic Area. Within the Message Center, a segregated area should be provided for the SCATS page copy termination of text messages. It is highly desirable to keep this traffic completely isolated from Mission traffic, even to the extent of specially assigned couriers for its delivery during simulation periods. This would eliminate the possibility of this traffic becoming intermixed and substituted for the real-time mission text messages.
- d. Message Pickup Area. Immediately adjacent to the Message Center, a separate message pickup area should be provided. This room would serve as a buffer between the Message Center and the IMCC and would aid considerably in providing a controlled access to the Message Center as well as to eliminate congestion in the hallway adjacent to the Message Center.
- e. Message Center Implementation. Implementation of the Message Center should also include the following considerations:
 1. An adequate storage area should be provided, accessible from within the Message Center for storage of teletype paper, logs, historical tape records and other miscellaneous operating supplies.
 2. Adequate diffused lighting should be installed to eliminate objectionable shadowing at all operating positions and to eliminate glare from the operating equipments and page-printer paper.
 3. This room should be soundproofed as much as possible.
 4. Adequate space should be provided for logging and message servicing areas and for a partitioned office area for the Message Center supervisor.

5. The use of 24-hour clock and time stamps is recommended. Automatic date-time stamping should be provided on the receipt of all messages.
6. The use of non-carbon reproducible paper in all teletype page printers is also recommended. This would contribute towards keeping a clean Message Center, and would minimize the disposal problem.

5.6.1.3 Operational Functions

- a. Intercept Position. The intercept position associated with the communication processor should be located in the Message Center. This position will print out all text traffic which is garbled, or mutilated in such a way that the communication processor does not know what to do with it except to send it out to an intercept position for human intervention. At this intercept position, the operator can correct obvious address or format garbles and return the message to the communication processor for routing or originate service messages on the undeliverable or mutilated traffic.
- b. Historical Storage and Paper Tape Requirements. Historical storage of processed traffic within present day message centers is normally provided in the form of teletype paper tape prepared by typing reperforators on both outgoing and incoming lines. This imposes a large storage problem and causes a considerable amount of time to be spent in traffic lookup in tracing messages. The advent of electronic switching systems enables the message center to utilize the magnetic tape recorders associated with the communications processor for all historical storage. This not only eliminates the necessity for local paper tape storage in the Message Center, but through proper traffic accounting and numbering procedures, minimizes the time required to search the files for back traffic. These historical log tapes may also be analyzed by the communications processor during slack periods to perform various traffic analyses.

Because this magnetic tape is recommended for historical storage at the communications processor, paper tape manufacturing will be held to a minimum in the Message Center. Tape preparation will only be required for outgoing, locally originated traffic, and possibly, for received traffic destined for relay on local pony teletype circuits (using local typing reperforators).

5.6.1.4 Automation of Message Delivery Systems.

Automation of the Message Center teletype terminal equipments and their functions, and delivery of traffic to local addressees will decrease the message handling time periods, reduce the physical workload and manpower requirements and consolidate equipment and operational areas. The teletype facilities within the Message Center should be automated consistent with the present state-of-the-art and the IMCC traffic requirements.

In the future, as both the operational and administrative traffic volume and circuits increase, the flexibility of the communication processor, with proper programming, could provide completely automated local message delivery to the subscriber terminals and eliminate a majority of the present Message Center functions. Of course, this would also require complete revision of the existing message format requirements.

As in any communication system, the major communication delay times occur at the terminal locations and are a result of local message delivery and origination procedures. These problems and recommendations for their solution are presented in the following sections.

5.6.2 IMCC Message Delivery Systems

5.6.2.1 General

The following discussion covers the IMCC Message Center message delivery systems utilizing the pony circuit distribution scheme. The discussion is divided into two parts. Part 1 includes the pony circuit delivery system in general; Part 2 covers the MOCR text communications. To clarify the distinction, the pony circuits are considered to have a terminal point within the MSC complex including the MOCR Support area(s) while the MOCR Communications System involves the transmission of text traffic between the MOCR and the MOCR Support area(s). The need for this distinction arises from aspects of the proposed MOCR Communications System. These aspects, in turn, result from the following general considerations.

- a. It is felt that the delivery of hard copy text messages into the MOCR(s) should be held to a minimum in order to avoid the problems arising from large amounts of text messages which would result from extended missions.
- b. The noise level of the communications medium within the MOCR should be held to a minimum to avoid any undue operator distraction caused by excessive message courier foot traffic.

5.6.2.2 Teletype Pony Circuits

Several methods of mechanizing the pony circuit delivery system have been considered to reduce message delivery delays and, at the same time, facilitate message handling procedures. To this end, it is desirable that the final system include the following features:

- The need for punched paper tape should be minimized
- The number of intermediate steps required for message delivery should be minimized

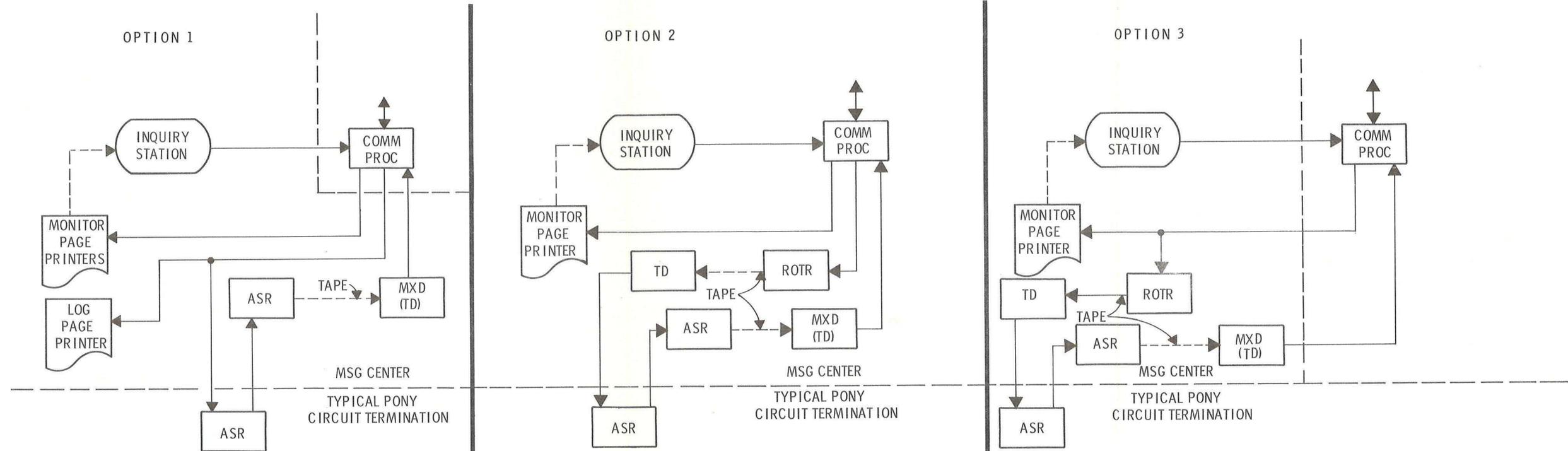
- The system should be flexible to expedite the delivery of both completely and incompletely addressed text messages
- The transmission method and/or rates should be such that undue queuing shall not be required on the terminal lines (by the communications processor)
- The message formatting procedures should be similar to existing procedures (insofar as practical).

Figure 5.6-2 shows a simplified block diagram of three methods of mechanizing the IMCC pony circuit delivery system. As will be noted, each option includes a brief operational description together with a listing of various advantages and disadvantages applicable to the system. Of the three options shown, option #1 provides the most desirable characteristics in that, while adhering to the general functional requirements, the system also utilizes the automatic routing features of the communications processor. The most serious disadvantage of the system is that it would necessitate a change in existing formatting procedures to be completely effective since, although messages can be re-directed from the message center, the system would involve final destination addressing of text messages.

The outgoing (pony circuit to Message Center) message delivery system for each of the three options is identical. In each system, a text message originated at a pony circuit terminal point is transmitted to an ASR unit in the message center. This allows the monitoring of all outgoing messages (by hard-copy print out) by message center personnel. The punched paper tape resulting from the ASR termination can either be manually connected to the MXD unit or can be connected directly from the ASR.

5.6.2.3 MOCR Communications

MOCR Communications are divided into two parts. Part 1 covers the transmission of text messages from the Support Area(s) to the MOCR(s). Part 2 details the transmission of messages from the



OPERATIONAL DESCRIPTION

In operation, the control rests mainly with the communications processor (C.P.). All fully addressed messages are routed directly to final destination. In the event a text message is received which does not include a final address (addressed only to the message center and intended for Pony Circuit distribution) or includes an address which is not recognizable, the CP routes the message to a monitor position in the message center. The message is then manually analyzed and the correct routing indicators are added to the message through the inquiry station. The message is then recalled from a historical storage and transmitted to the proper destination.

ADVANTAGES

- (1) Flexibility - Both complete and incomplete addressed text messages handled by the system.
- (2) Processing Speed - Automatic handling of messages utilizes C.P. processing speeds
- (3) Minimizes intermediate handling points
- (4) Complete final destination log of all traffic
- (5) Use of paper tape is reduced in msg. center

DISADVANTAGES

- (1) CP loading - System adds an additional load on the CP both in number of terminal points and from the effect of handling some msgs. twice.
- (2) Requires changes in existing formatting procedures.

OPERATIONAL DESCRIPTION

In this system, as in the first, all incoming traffic is monitor on page printers. A manual analysis is performed on each message. When a message is detected which is intended for transmission over one of the pony circuits, the message is recalled from Historical Storage and the CP is directed (from the Inquiry station) to route it to an ROTR terminal equipment within the message center. The resulting punched paper tape is then manually inserted in the appropriate TD which transmits the message to the appropriate destination.

ADVANTAGES

- (1) Does not require changes in existing formatting procedures
- (2) Reduces the number of CP terminal points

DISADVANTAGES

- (1) Paper tape involved in the message center receiving equipment
- (2) An intermediate step required to transmit all text messages over pony circuits
- (3) The automatic logging features of the CP would only contain information up to the message center and not the final destination
- (4) All pony circuit messages handled twice by the C.P.

OPERATIONAL DESCRIPTION

In operation, all incoming messages are monitor both on page printers and on ROTR units. When manual analysis of the page printer indicates that a message is to go out on one of the pony circuits, the paper tape is manually inserted in the appropriate TD for transmission to that point. The relative advantages of this system is the same as Option #2 with the following exceptions

ADVANTAGES

- (1) All messages are handled only once by the CP.

DISADVANTAGES

- (1) Large amounts of paper tape are involved since all messages are monitored on ROTR units.

Figure 5.6-2 Three Methods of Mechanizing MCC Pony Circuit Delivery System

MOCR(s) to the Support Area.

5.6.2.3.1 Support Area to MOCR

If it is assumed that the courier method of message delivery can be eliminated because of obvious operational difficulties, there are essentially four methods available for Support Area to MOCR communications. Of these, the teletype system is undesirable from several aspects and, in particular, from the standpoint of obtaining a truly low noise system within the confines of an individual console. The remaining three systems are shown in block diagram form in Figure 5.6-3 with a brief discussion concerning the operational characteristics and relative advantages and disadvantages of each. Of the three systems shown, option #3 provides the most satisfactory operational characteristics and, hence, is the recommended system.

The television system has two detrimental characteristics, however, which may alter the recommendation as more detailed information becomes available. The first is the requirement that hard copy must be hand-carried into the MOCR. If this amount of traffic greatly exceeds that presently envisioned, another system may be justified. The second and more serious requirement is that of time-sharing the console monitors with the operational displays. If it is determined that the console personnel cannot or will not wish to relinquish the console monitor(s) to view text messages in certain situations, then one of the other options may be indicated.

5.6.2.3.2 MOCR to Support Area

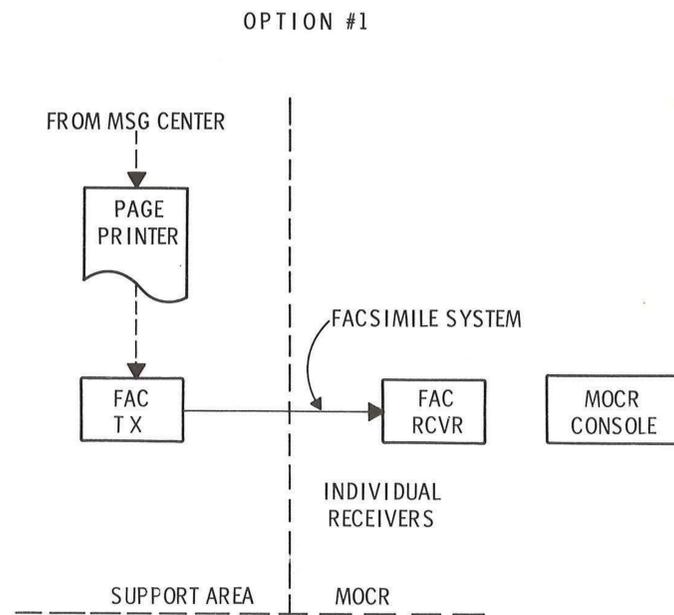
Figure 5.6-3 indicates four alternate ways to communicate text messages from the MOCR to the Support Area or, in the case of option #2, to the Message Center. In each case the system is presented in a simplified block diagram with a representative MOCR console and

the Operations-Procedures Console. Figure 5.6-4 also includes a brief operational description of each system together with relative advantages and disadvantages for each.

Of the four alternates shown, option 4 is the recommended system, for the operational characteristic of this system more nearly satisfy the following general requirements.

- Foot traffic in the MOCR should be held to a minimum
- The message transmission system should exhibit a low noise characteristic within the MOCR
- The number of intermediate steps between the origination of the message at the MOCR console and the arrival at the support area should be minimized
- The message transmission system should be directly accessible to the originator of the message
- The message transmission system should include provisions for authorization of messages by appropriate personnel, when required.

Of the five general requirements listed above, the authorization requirement introduces the most serious complicating factor from an operational standpoint. As will be noted, all options in Figure 5.6-3 include a provision for obtaining a message authorization by the Operations and Procedures Officer, who is located within the MOCR. Such a provision essentially adds an intermediate step to message delivery when authorization is required. With the electrowriter system the time required for the intermediate step is minimized, but an extensive control system may be required to allow multi-MOCR consoles to communicate to the operations procedures console. From a functional standpoint such an arrangement is undesirable since it adds unnecessary complicating factors to the operation of the system. A more sensible arrangement would delegate responsibility for message authorization to the Support Area. In this case each console electrowriter transmitter could terminate directly in a Support Area receiver, a hard copy could then be directly available to responsible personnel when authorization is required. This system,



OPERATION DESCRIPTION

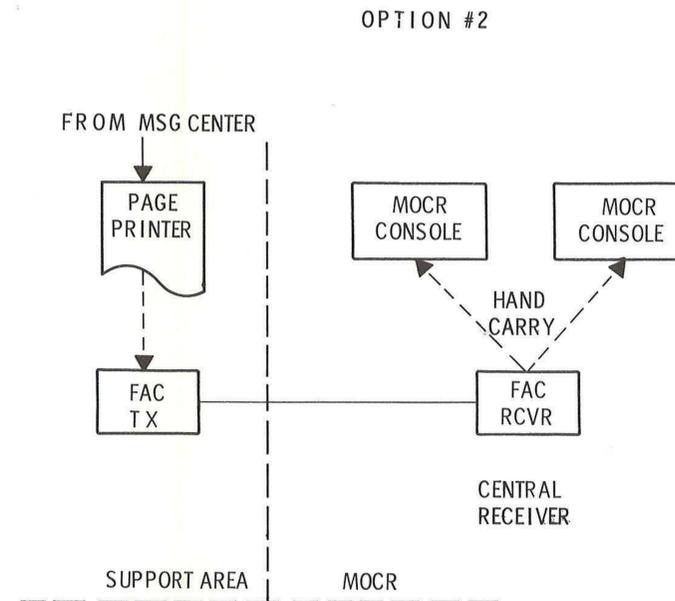
Termination from Msg.Center is a page printing device. Hard copy is removed and placed in a facsimile transmitter which transmits message to a receiving area located in or adjacent to the desired console. Each console utilizes a separate receiver.

ADVANTAGES

- (1) Eliminates foot traffic in MOCR.
- (2) Eliminates additional load on television system.
- (3) Hard copy available in MOCR, multi-hard copy can be generated with multi-receivers operating in parallel.

DISADVANTAGES

- (1) Requires additional space in console (if located in console and not adjacent to).
- (2) All messages delivered in hard copy form.
- (3) Receiving units require special paper which must be supplied at all times.
- (4) Additional system added.
- (5) No positive acknowledgement of Msg required from MOCR Console personnel.



OPERATION DESCRIPTION

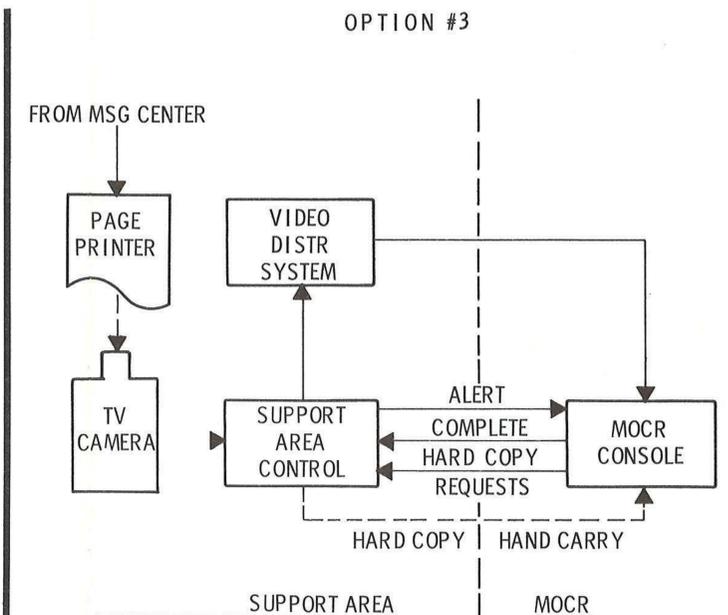
Termination from msg.Center is a page printing device. Support-area personnel remove hard copy and place it in a facsimile transmitter which transmits message to a central receiving area within the MOCR. From this point the messages are distributed by courier to appropriate console.

ADVANTAGES

- (1) Eliminates additional load on television system.
- (2) Hard copy available in MOCR, multi-hard copy can be generated with multi-receiving units operating in parallel.

DISADVANTAGES

- (1) All messages delivered in hard copy form.
- (2) Receiving unit utilizes special paper which must be supplied at all times.
- (3) Foot traffic required for final delivery and adds intermediate step in system.
- (4) Additional system added.
- (5) No positive acknowledgement of Msg required from MOCR console personnel.



OPERATION DESCRIPTION

Termination from Msg.Center is a page printing device. Support area personnel removes hard copy and places it under a Vidicon camera which has an assigned channel in the video distribution system that is accessible by the appropriate console within the MOCR. The support area operator initiates an alert signal to the MOCR console, upon receipt of the alert signal, the MOCR operator selects the designated channel and read the message. Upon completion, the MOCR operator signals such by an appropriate signal and the message is removed from the scanner. If hard copy is desired, the MOCR initiates the request and the hard copy is hand carried in.

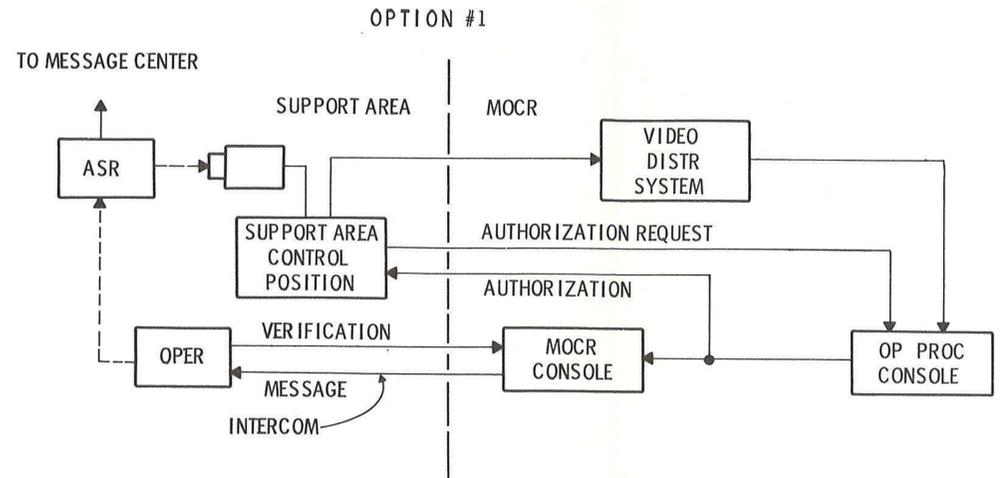
ADVANTAGES

- (1) It reduces the number of hard copy text msgs. in the MOCR.
- (2) Reduces foot traffic in MOCR.
- (3) Silent operation.
- (4) Requires MOCR Operator to give positive acknowledgement of messages.
- (5) Utilizes common display system.

DISADVANTAGES

- (1) Requires time sharing of displays.
- (2) Requires foot traffic to deliver hard copy.
- (3) Requires serial presentation of messages.
- (4) May pose some difficulty when MOCR Operator wants to review prior messages.

Figure 5.6-3 Three Methods of Mechanizing Support Area to MOCR Communications



(1) Operation Description

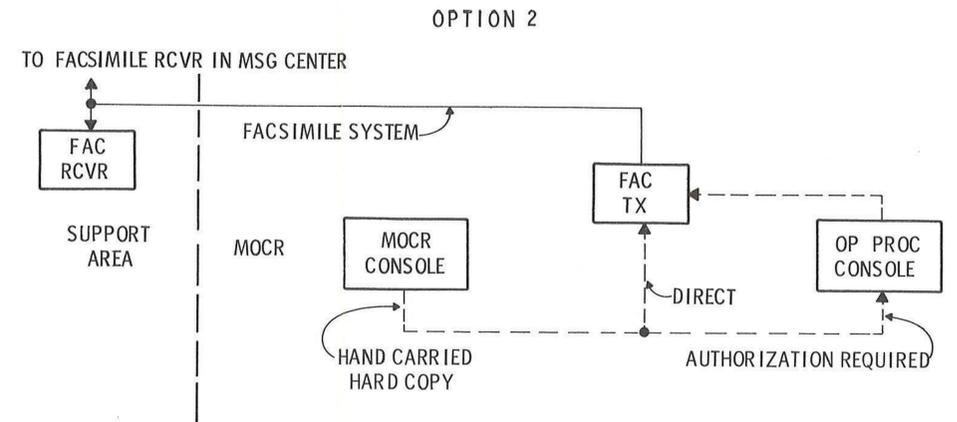
Outgoing text messages are verbally transmitted via an intercomm system to the support area where an operator types the message. The msg. is then verified. If authorization is not required the msg. is sent out by inserting the tape (derived in the original typing) into the TD. If authorization is required the typed copy is inserted under a scanner and transmitted to the Oper. Proc. Console via the video distrib. system.

(2) Advantages

- (A) No foot traffic involved
- (B) Existing system utilized so additional space not required in consoles

(3) Disadvantages

- (A) No copy of msg. available to the MOCR Operator
- (B) Several intermediate steps required to transmit msg.
- (C) Operation may be unwieldy in hurried conditions



(1) Operation Description

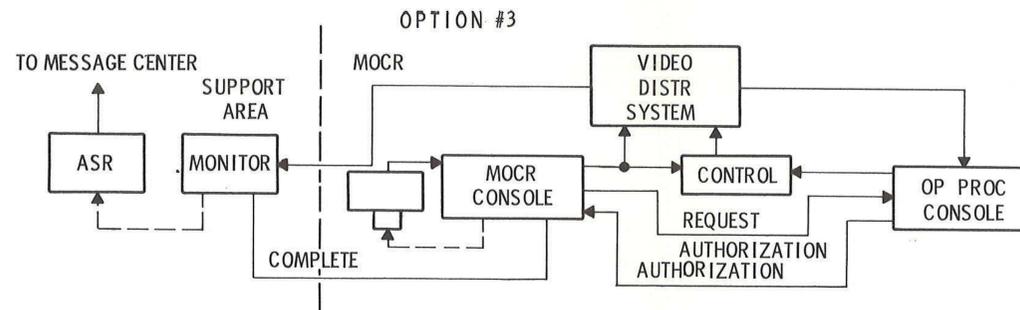
Outgoing messages are hand written by MOCR Operators. The message is then carried by courier either to the FAC transmitter or, if authorization is required, to the OP. Proc. Console and then to the FAC transmitter after authorization is received. The msg. is transmitted direct to the message center and also to the support area for recording purposes.

(2) Advantages

- (A) Simplified operation - control is automatically achieved through use of courier
- (B) Transmits msgs. directly to msg. center

(3) Disadvantages

- (A) Requires extensive foot traffic in MOCR
- (B) Requires special paper in rcvr
- (C) Requires additional system increasing costs



(1) Operation Description

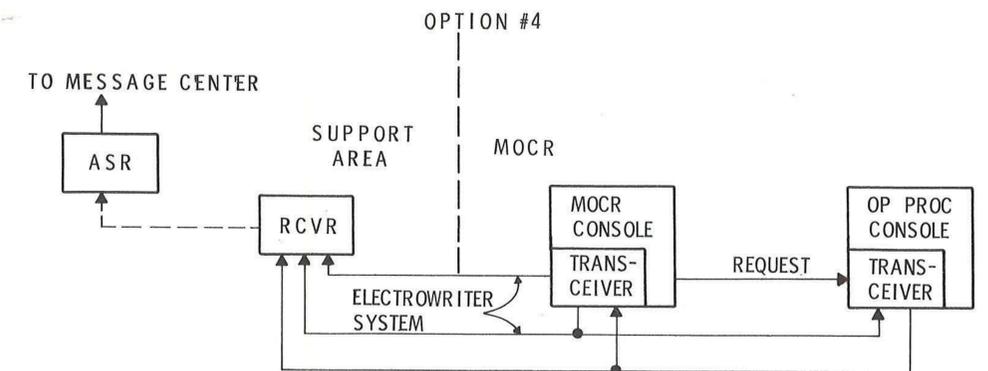
Outgoing messages are routed through video distribution system via a console vidicom scanner. If authorization is required the MOCR routes the message into a controlled channel which terminates at the OP. Proc. Console. The OP. Proc Officer views the message on his console monitor. Upon authorization the message is automatically placed on a video channel terminating in the support area where it is typed from the monitor. Msgs. not requiring authorization are transmitted directly.

(2) Advantages

- (A) No foot traffic required in MOCR
- (B) Silent operation

(3) Disadvantages

- (A) Requires rather large console area
- (B) Additional expense quite high
- (C) Requires intermediate step after writing message to achieve transmission
- (D) Requires control system to allow multistation operation
- (E) Requires time sharing of OP. Proc. Monitor with other types of displays



(1) Operation Description

Outgoing messages are transmitted via an Electrowriter system. Msgs. which do not require authorization are received directly on the support area receiver as the message is written on the console. If authorization is required controls are initiated which transmit the message to both the support area and to the OP. Proc. Console. Approval is obtained by the OP. Proc. Officer signing the message appearing on his transceiver. The signature appears on both the originator's message and on the receiver in the support area. In both cases the message is typed from the written copy and transmitted to the msg. center.

(2) Advantages

- (A) No foot traffic involved
- (B) Minimize intermediate steps required to transmit messages
- (C) Copy available to all personnel concerned
- (D) Silent Operation

(3) Disadvantages

- (A) Requires additional system with control to allow multistations

Figure 5.6-4 Four Methods of Communications - MOCR to Support Area

as compared to internal IMCC authorization procedures, would result in a more efficient operational system and would also result in considerable economic savings. If operationally feasible, it is recommended that this departure be made from Mercury operations.

A further extension of this thinking would delegate this authority to the Message Center and would allow the transmission of messages directly from an MOCR Console to the Message Center via the electrowriter system. A parallel receiver would be terminated in the Support Area to provide hard copy for recording purposes. Such a configuration would eliminate an intermediate step in message preparation and transmission process.

5.6.2.4 Summary

Figure 5.6-5 is a tentative block diagram summarizing the recommended configuration for Pony Circuit message delivery. As will be noted, the block diagram shows the authorization of outgoing MOCR text messages as being performed in the Support Area rather than in the MOCR. This is in keeping with the recommendations of the preceding discussion but differs from existing procedures. The system shown provides the functional capabilities required; however, further study is indicated to determine the operational feasibility of the system. This is due mainly to procedural considerations such as time-sharing of console displays and the Support Area message control feature.

5.6.2-12

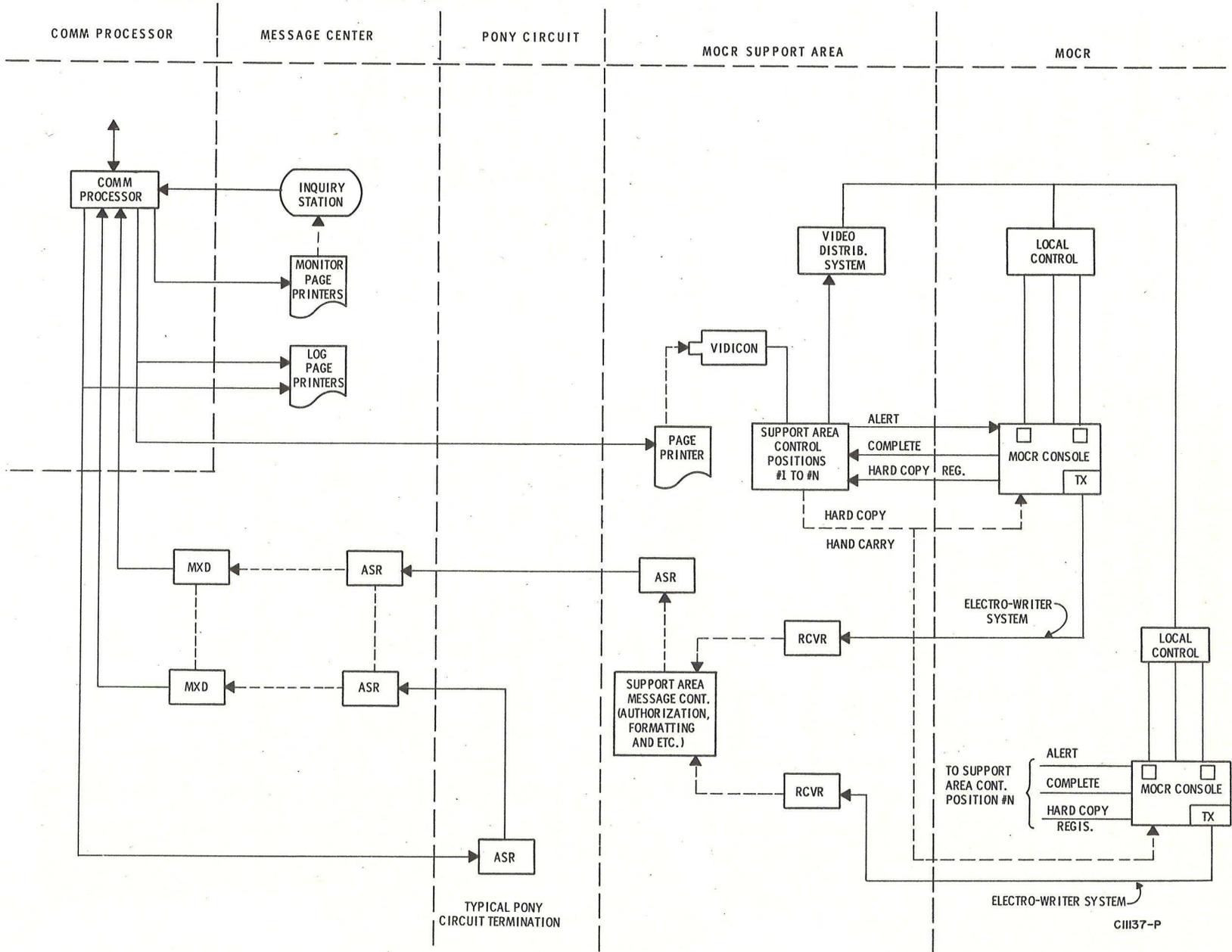


Figure 5.6-5 Recommended Configuration for Pony Circuit Message Delivery

5.6.3 Intercommunication Subsystem

SUBSYSTEM REQUIREMENTS

The primary requirement for the intercommunication subsystem is to integrate the various operating positions within the IMCC and to provide a means of coordinating their operation.

To accommodate this requirement, the intercom subsystem must be capable of providing a variety of Voice Communication services.

The major functions of the subsystem are as follows:

- Provide conferencing capability among the various operating positions within the IMCC Complex
- Provide talking and/or monitoring capability on these conference circuits
- Provide access for certain conference circuits to external communication facilities
- Provide private communication capability among the various locations within the intercommunication complex
- Provide private communication capability from the locations within the intercommunication complex to external facilities
- Provide access of certain positions to a public address system
- Provide access of certain conference circuits to a recording system
- Provide access of certain conference circuits to a simulation system

Since the intercommunication subsystem is required for coordinating the operational activities in various mission and non-mission modes, flexibility in organizing the networks and their assignments is of primary importance.

Emphasis should also be placed on the capabilities of expanding or reducing individual loop capacities, without altering the circuit performance and with minimal circuit rearrangement.

Maintainability of the system requires special attention, since the operational activities of the IMCC relies heavily on the uninterrupted performance of the intercommunication networks. In considering the maintenance aspects of the system, attention must be given, in the system design layout, to allow for maintenance activities to be carried out on any of the circuits without disrupting the operations or degrading the performance anywhere else in the subsystem.

Since the intercommunication subsystem interfaces with existing external communication facilities, it must be designed to fit the entire communication system and conform with the planned external communication specifications.

Operational reliability of the highest standard is of fundamental importance. Component selection must be based on high quality performance and circuit design should include redundancy wherever necessary to ensure continuity of operation during scheduled preventive maintenance.

The quality of performance should be such that the system could lend itself to the application of secure communication techniques, if its application should be required.

The organization of the system should be such that operational control of the networks is centralized at one location. Centralization of control should increase the operational efficiency as well as insure greater privacy and security to the intercom facility.

Intercom System Organization

The major divisions of the intercom system are mainly by location and correspond to the principal operating segments of the IMCC. These groups are:

- a. MOCR 1 and its support areas
- b. MOCR 2 and its support areas
- c. Simulation
- d. Technical Support, (Communication Control)

This particular division of the intercom system was chosen as these areas operate more or less independently of each other. Each MOCR and its support area will operate independently, and they will be exact duplicates. The only interaction between the two would be that necessary for proper activity coordination.

The technical support will have extensive connections to the MOCR's and other groups. This means there must be a method of selecting the desired MOCR. This could be done in two ways. The first is to do the switching in the intercom equipment area. This would mean that a group such as communications personnel would be connected only to one MOCR at any time. The second, and most attractive method is to provide separate loops and their control switches at the intercom station. This would mean, for example, that a communication coordinator would have four keys at his intercom labeled "Communications Administration". One key would be the communication administration-MOCR-1 talk-listen key; one would be the communication administration MOCR-1 monitor only key, and the other two would serve the same purpose for the second MOCR. This second method is recommended for implementing the system.

Position Assignment Considerations

The purpose of an intercom system is to provide rapid communication with a minimum of interference to other people. The number of intercoms for a particular area is governed by the size of the working area, the need to contact outside groups, and the amount of interference that can be tolerated. Each console, or desk in the MOCR is assigned one intercom station. This assumes that one person will sit at or at least be in charge of one console.

In assigning positions in the various MOCR support areas it is desirable to keep the number of phones to a minimum. This minimum number will correspond to the major tasks that the particular area must perform. Assignments in the support areas are to be made on strictly a functional basis. It is assumed that each intercom position would always be attended, and that the attending person (or persons) would be responsible for that function.

Network Assignment Considerations

Construction of the intercom networks requires the following intercom capabilities: (1) key-access to intercom loops, (2) capability to talk and listen on a network, or to monitor only, (3) access to dial system, and (4) any necessary controls for ringing a remotely located phone (outside of intercom subsystem) or any such special feature. Special signaling (audio and visual) circuits within the intercom system could become quite complex and costly. It seems sufficient to rely on operational procedures for signaling. This would mean, for instance, that if two parties had to contact each other during an emergency they should have either a point-to-point link, or they should have authority over a certain loop.

The principal guidelines to be used in assigning intercom loops are:

- a. Each loop should be assigned a principal user. This is to provide network control and to facilitate signaling.

- b. Each loop should be assigned or created to serve a particular function and no more. Although it is not always possible to do this with great certainty, it at least assures that network assignment will proceed in an orderly fashion. By limiting a loop to a single purpose, signaling and operational procedures should be greatly simplified.
- c. The number of people on each loop should be kept to a minimum in the interest of network management and signaling.

Subsystem Configuration

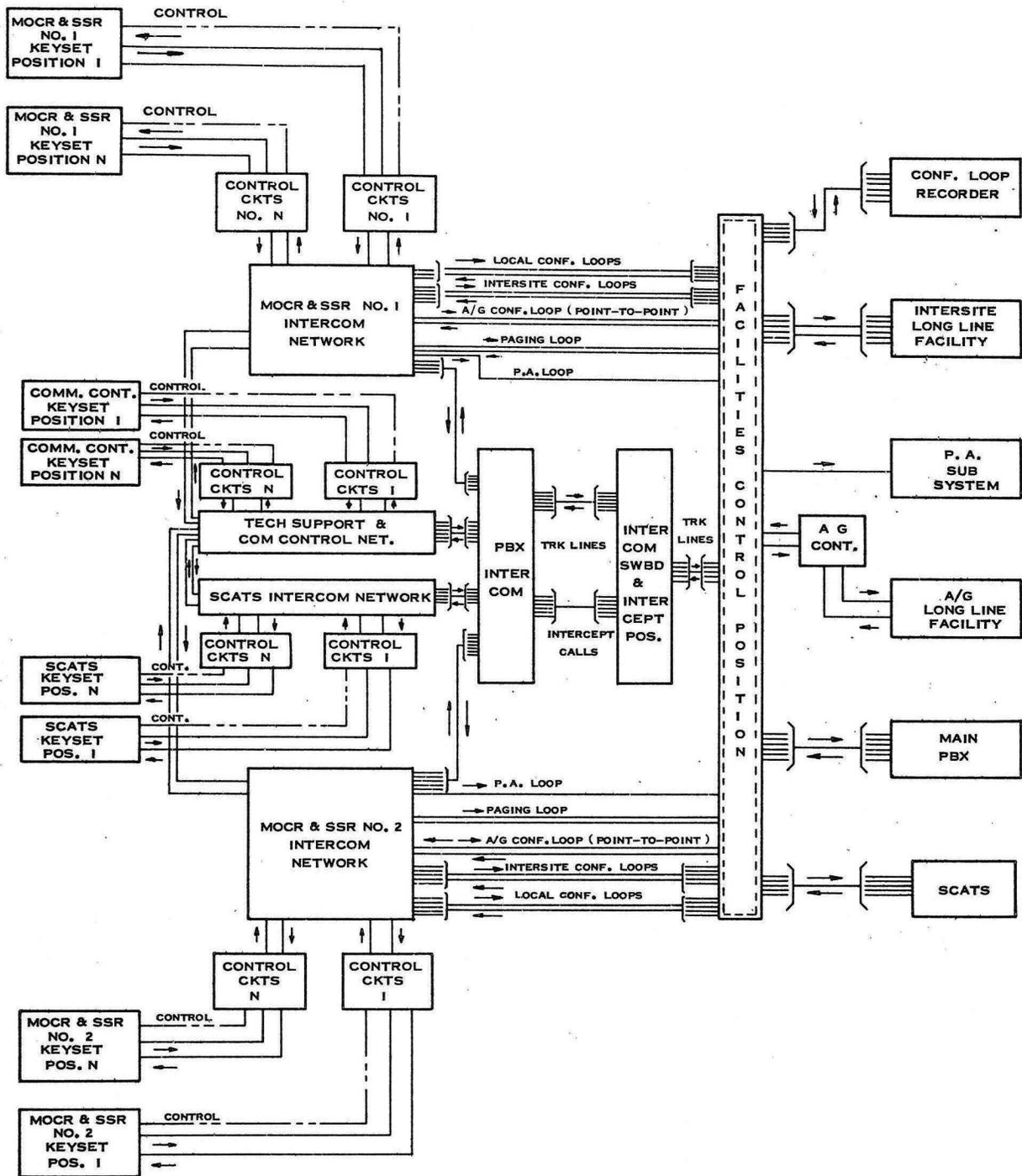
The intercom subsystem configuration is represented by the block diagram shown in Figure 5.6-6.

The subsystem is divided into four major networks each operationally independent of the other. Each network has assigned to it, designated keyset positions. Associated control equipment interfacing the keyset positions and the network, are centrally located. Each network is electronically isolated from the other, with the exception of a minimal interfacing with the communication control network. This interfacing is required for purposes of coordination and maintenance.

Private communication within the intercommunication subsystem as well as with the external facilities is accomplished by means of the intercom PBX.

Control of the internal private communication is by circuit discipline, however, control of communicating with external facilities is by means of the intercom switchboard position which intercepts and controls all communications, incoming or outgoing to external facilities, with the exception of the point-to-point and intersite conference loops.

Control of all the intercommunication conference loops for both MOCR's and their associated support areas is performed at the facilities control position (Voice Control and Monitor Console). It is at this position, that loop assignments are directed to external facilities, such as;



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Figure 5.6-6 IMCC Intercom Block Diagram

5.6.3-6

intersite long line facilities, P. A. system, air-to-ground long line facility; loop recorders, etc. In addition, the facilities control position exercises control over physical assignments of MOCR's and their associated support areas to either the mission mode or simulation mode of operation. Its function is similar in nature to that of the SCAMA at GSFC.

To centralize control of the intercom subsystem, it is proposed to integrate the intercom switchboard position into the facilities control position. With this arrangement all control of the intercom with the external facilities is established at a single point.

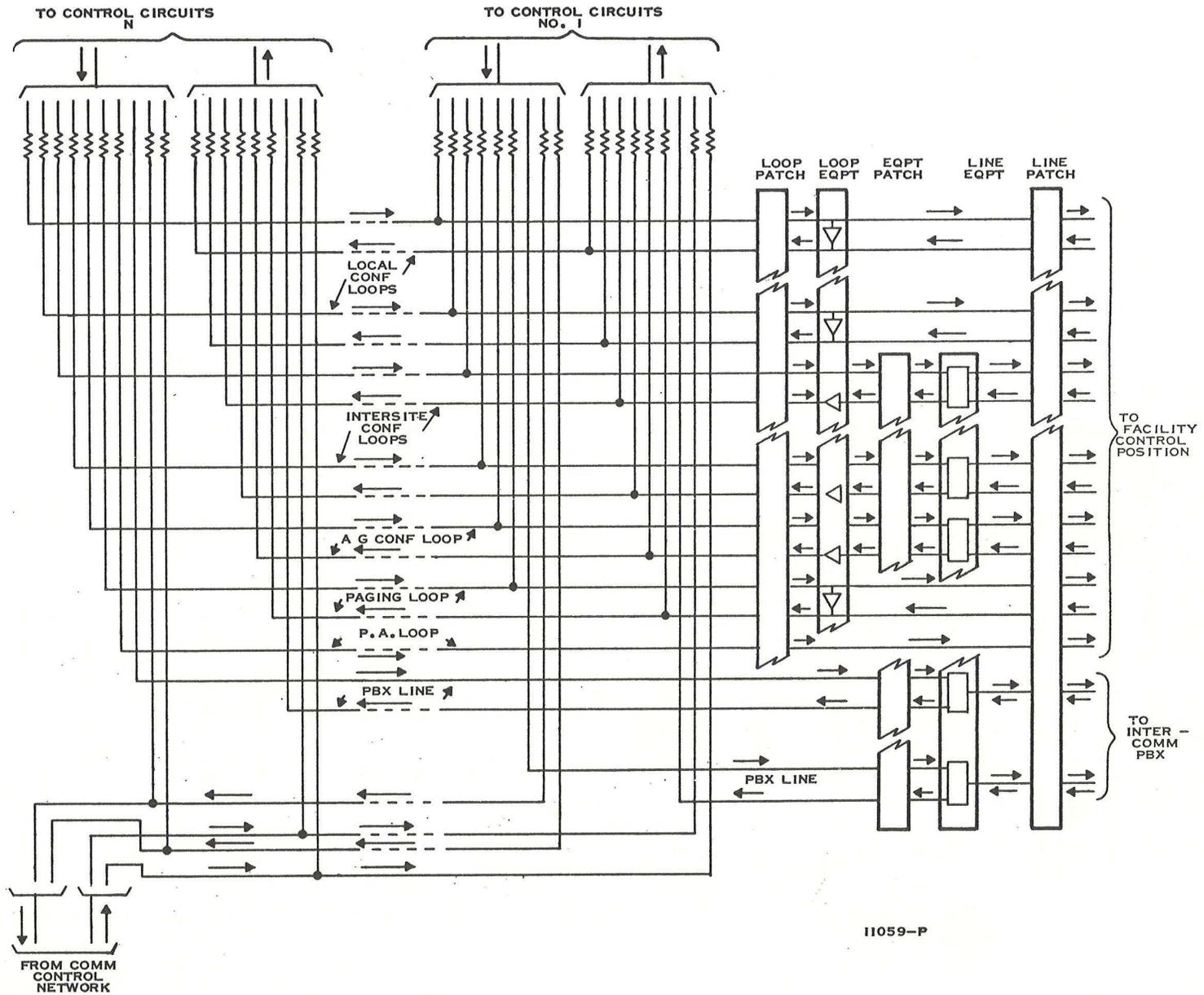
NETWORK REQUIREMENTS

The subsystem must be capable of handling any mixture of communication lines and loop circuits as may be dictated by the requirements of the subsystem. The types of major line and loop circuits that will be incorporated in the intercom subsystem networks are divided into six categories:

- Local Conference Loops
- Intersite Conference Loops
- Public Address Loop
- All Position Paging Loop
- PBX Line
- A/G Conference Loop

Figures 5.6-6A through 5.6-6C are block schematics of the intercom networks of the subsystem. Functional descriptions of the six different line and loop circuits, employed in these networks are as follows:

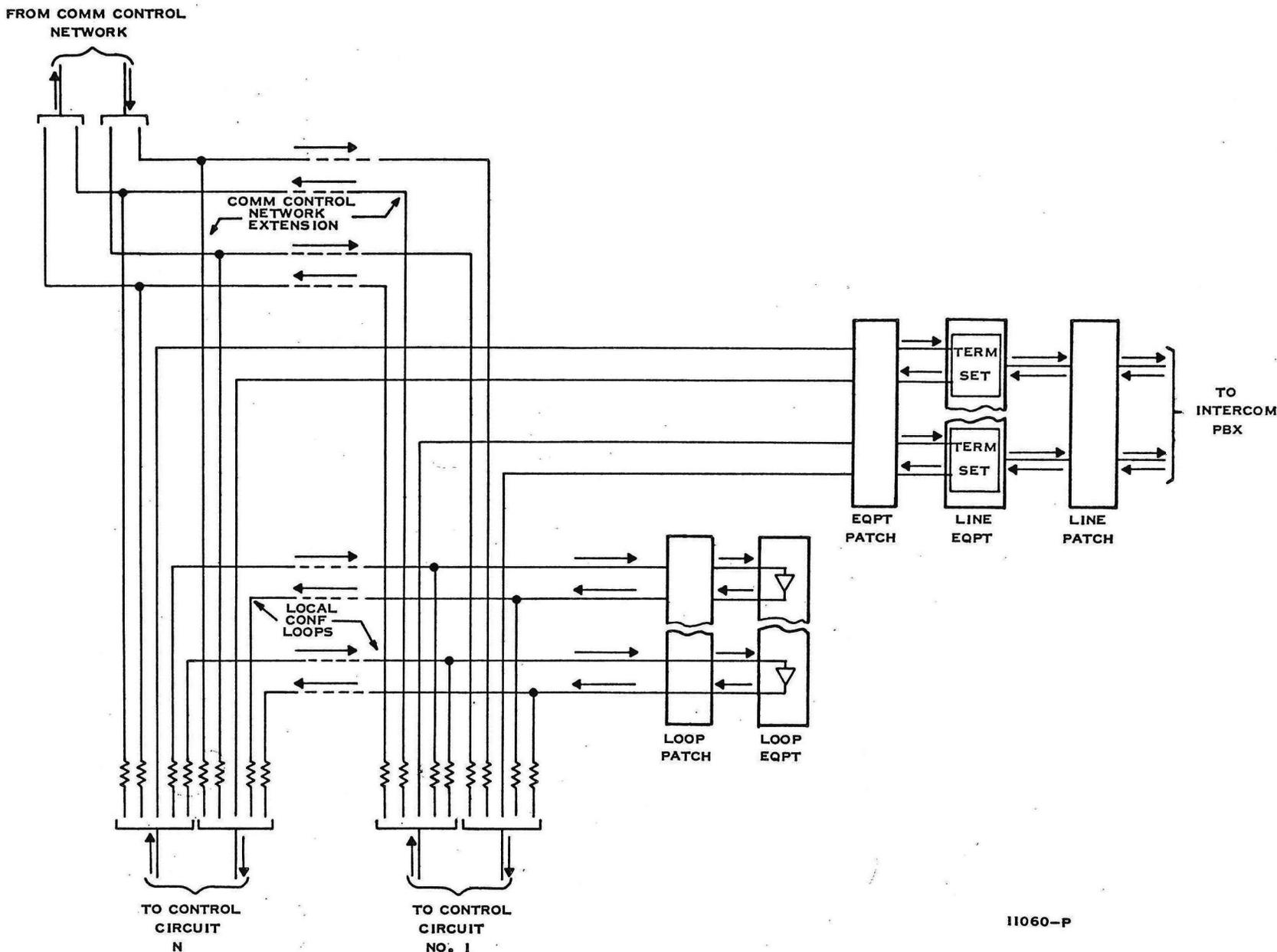
5.6.3-8



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Figure 5.6-6A MOCR and SSR #1 or #2 Intercom Network

5.6.3-9



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Figure 5.6-6B SCATS Intercom Network

5.6.3-10

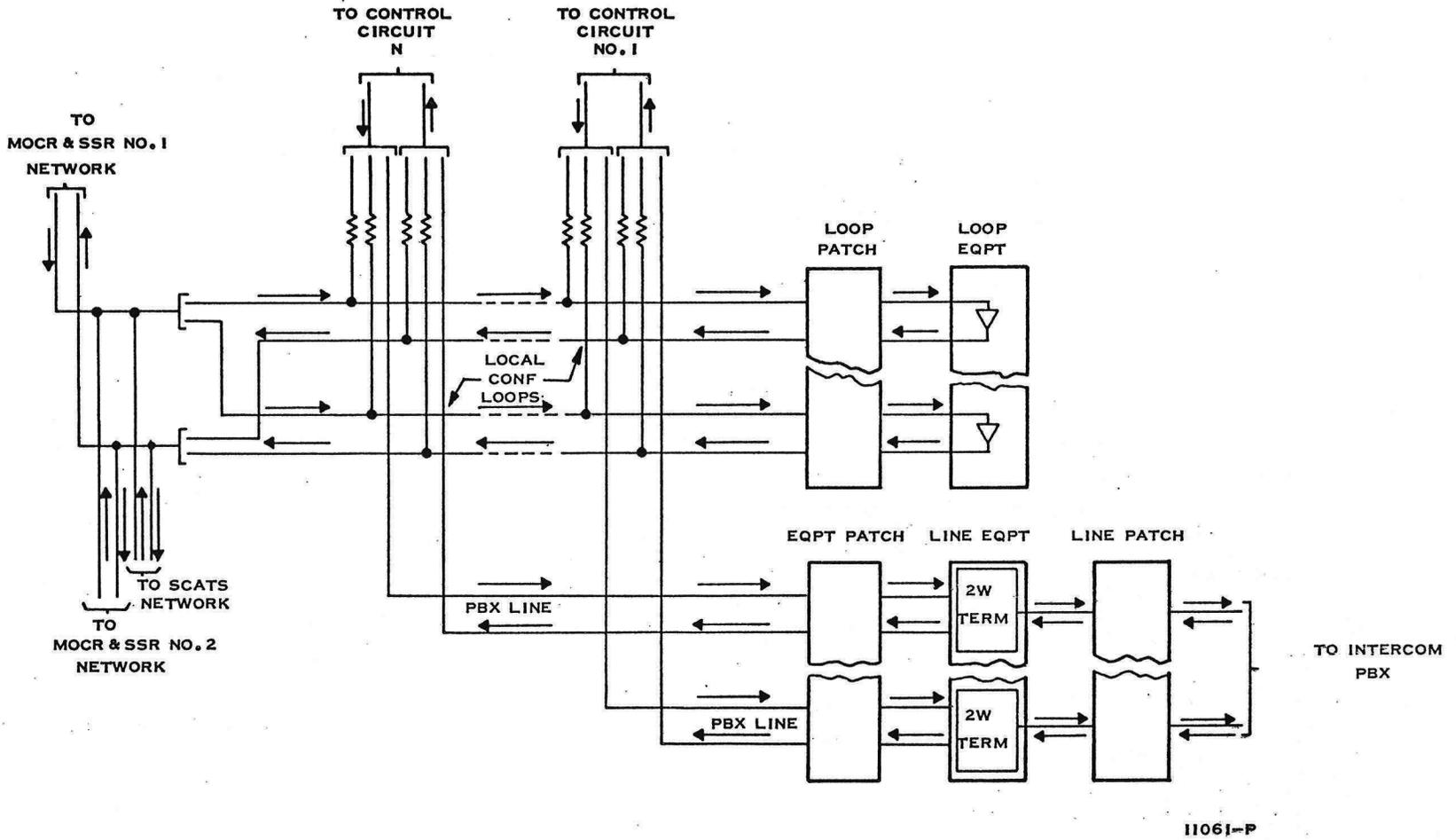


Figure 5.6-6C Technical Support Intercom Network

Local Conference Loop

The local conference loop is a four-wire conference circuit providing two-way communication as well as monitoring capability for all local stations which are included in the loop. The circuit is essentially a closed loop network with no capability of interconnecting with other loops or lines that are associated with the intercom system. Figure 5.6-7 shows a typical block diagram of a local 4-wire conference loop.

The principal components of the four-wire loop are a transmit bus, a receive bus, and a conference amplifier. The receive and transmit circuits of each station in the loop are bridged to the respective receive and transmit buses by means of isolation resistors. Inclusion of the isolation resistors in the bridged circuit eliminates interference to the loop in the event that a short may occur in any of the bridged circuits. The conference amplifier is designed to receive signals with a 20 db variation of input level in the transmit bus and delivering them to the receive bus with less than 2 db of level variation. This constant output level feature is required to compensate for level variations that may be caused by the effects of shorting transmitters in the transmit bus. Selection of the transmitter isolation resistors, shall be such as to provide not more than 8 db of level reduction when a bridged transmitter circuit is shorted. Selection of receiver isolation will be such that virtually no level impairment is provided when one or more receivers are shorted.

Each of the stations in the loop is connected into the conference loop by operation of the proper pickup key on the station key set. Local conference loops will require no signaling. Lamp supervision at each station is provided for the local conference loops as follows: a flutter lamp signal (12 cps) is provided at the local station when the attendant connects into the loop for talking; a steady lamp on condition is provided when the station is connected into the loop in a monitor condition; no lamps on when the station is not connected into the loop.

5.6.3-12

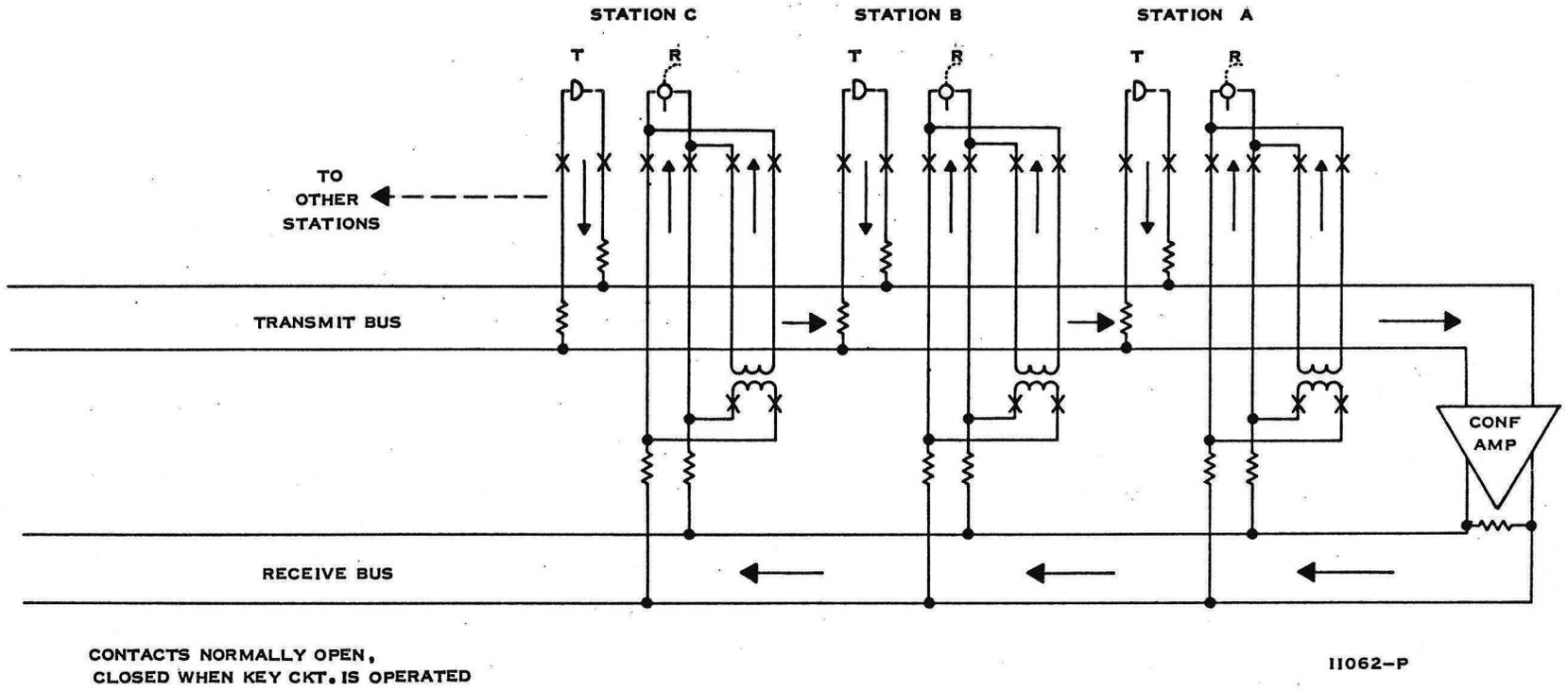


Figure 5.6-7 Typical Local Conference Loop

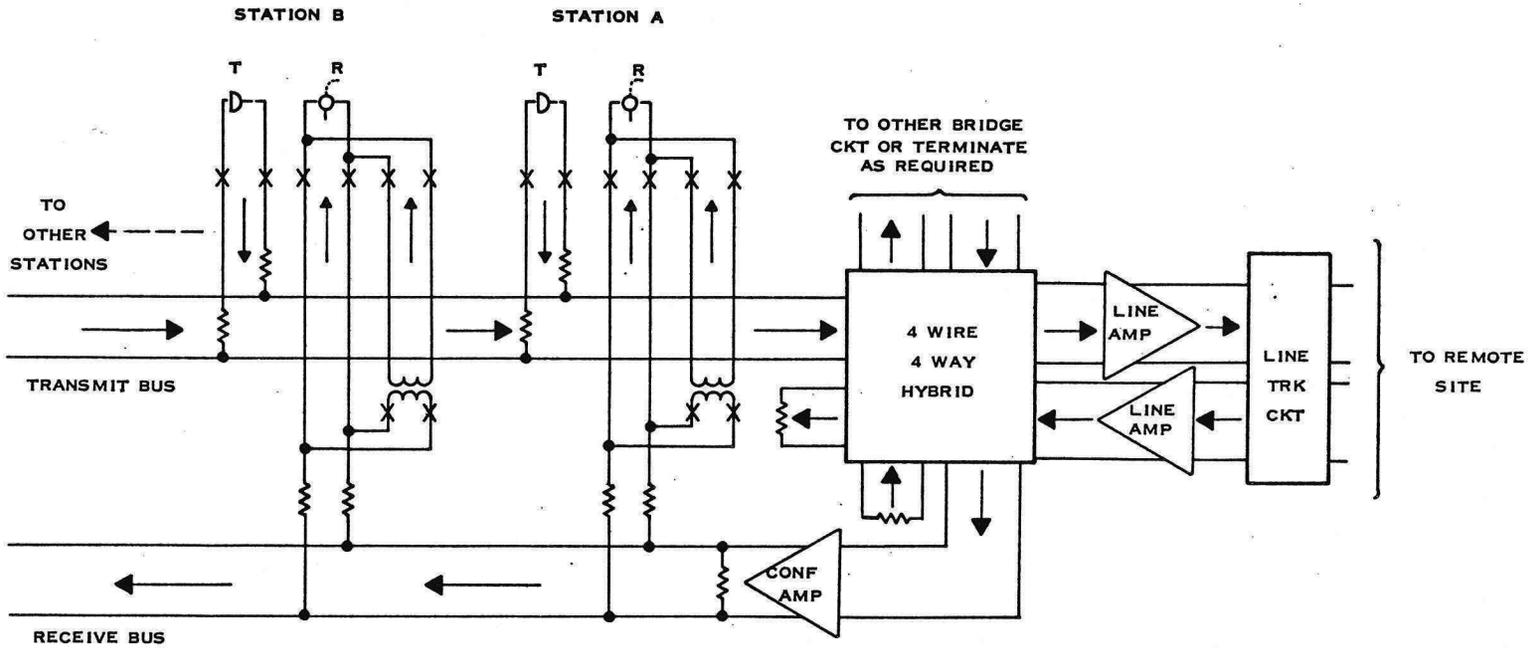
Intersite Conference Loop

The intersite conference loop is similar to the local conference loop, except that the loop is arranged for 20 cycle ringing to a distant, remote end. Basically, the loop circuit is a local conference loop with additional facilities provided to interconnect the loop to a similar loop or single station at a remote location over land line or radio facilities. Figure 5.6-8 shows a typical block diagram of an intersite four-wire conference loop. Bridging of transmitters and receivers on the transmit and receive buses is the same as for the local conference loops. A conference amplifier located in the receive leg of the loop is also identical to the amplifier used in the local conference loop facility. A four-wire, four-way bridging arrangement is provided to interconnect the loop with a distant end (remote site) station via the long line physical line or radio derived voice channel. The four-wire, four-way bridging arrangement consists of a four-wire, four-way resistive hybrid network, resistive elements for terminating the unused legs of the four-way hybrid, and line amplifiers for providing the proper input and output levels to the interconnecting line circuit. (Line amplifiers are similar to those provided for the conference loop.) In addition a ringing circuit is provided on the line side of the hybrid to provide for 20 cycle signaling on the transmitting path between the distant ends.

Public Address Loop

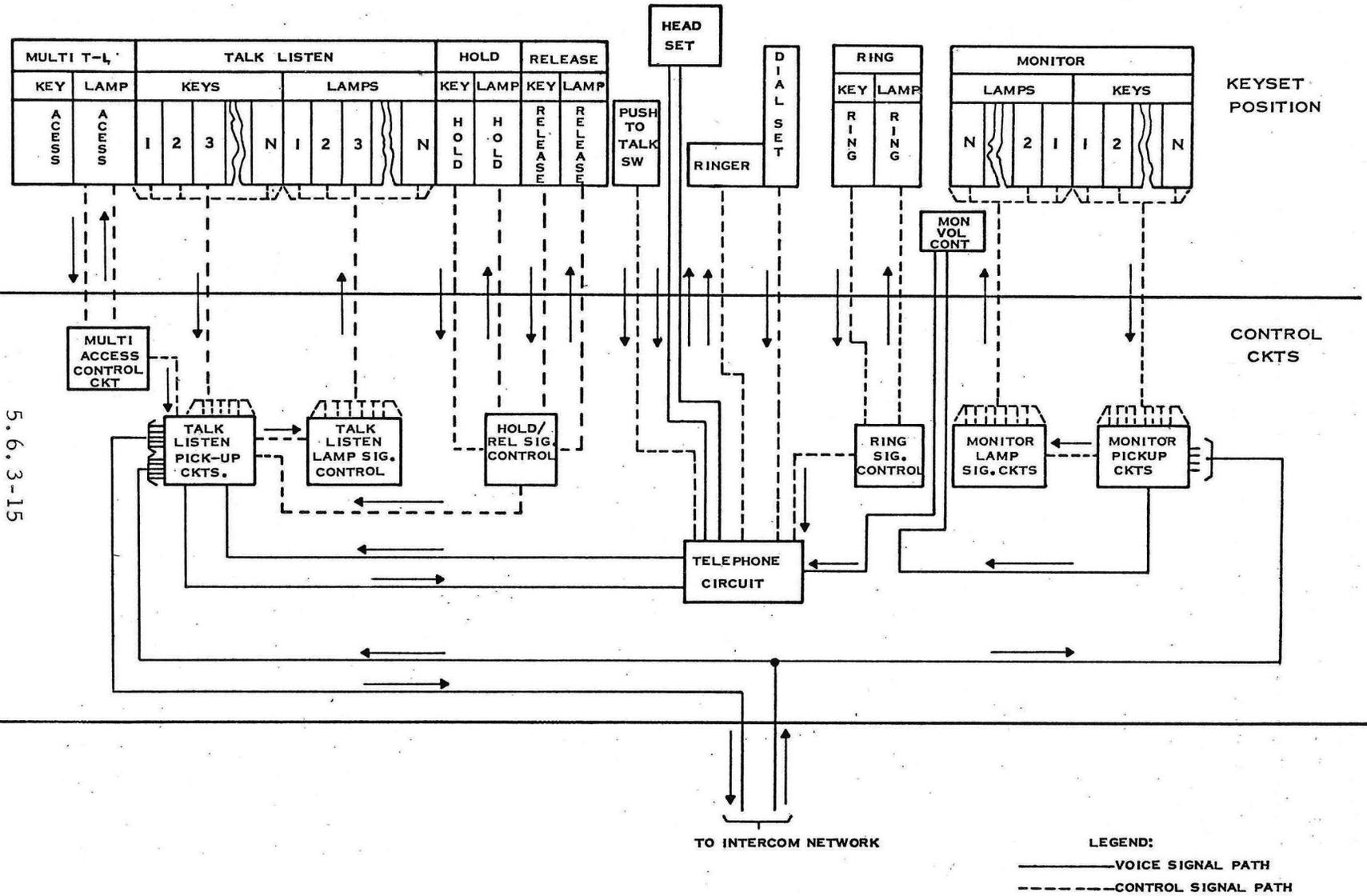
The public address loop is a two-wire transmit only circuit, providing talking access to a public address speaker system. Access to the loop will be possible by means of a key circuit at those stations assigned to the loop. The access will be on a "per station" basis, allowing only one station at a time to access the speaker system. Figure 5.6-9 shows a typical arrangement of the public address loop. The major elements of the loop are a transmit bus, a public address amplifier and public address speaker bridged across a receive bus. The public

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Figure 5.6-8 Typical Intersite Conference Loop



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Figure 5.6-9 Intercom Station Block Schematic

address amplifier is similar to the conference amplifiers. The bridging of transmitters across the transmit bus will also be similar to the conference loop arrangement. Speaker bridging across the receive bus will be such as to have no affect on the system if one or more speakers short out.

PBX Lines

Stations arranged for outside communications, will be furnished with a PBX line circuit, which will provide access to the intercom PBX facility for interconnecting to other PBX lines or trunks. The PBX lines will be arranged for signaling at each of the local stations on incoming calls and ringing from each of the local stations on outgoing calls.

All Position Paging Loop

The all position paging loop is a four-wire conference loop, providing a means of attracting all assigned positions to the conference loop to obtain access to a particular position by audible means. The loop is essentially a local conference loop, arranged by discipline as a paging accommodation.

A/G Conference Loop

The A/G Conference Loop is a point-to-point (intersite) conference loop arrangement used for voice communication with the space vehicle. The loop is identical to the intersite conference loop with the addition of an air-to-ground control circuit. The air-to-ground control system is shown in Figure 5.6-10. The control system provides remote control of selecting the proper radio link to the spacecraft and RF transmitter keying control at the distant end of the A/G loop. The system includes a remote control selector, an encoder, a transmitter, a line selector unit, a receiver, a decoder, and a remote control lamp indicator unit

at the IMCC and complimentary terminal units at the distant end. Operation of control selection is as follows: the remote control selector is a switch type selector which provides the means of originating the desired command. This command signal is routed to the encoding unit. At the same time a control signal is transmitted from the selector to the line selector unit which switches the line facility from the A/G line equipment to the control equipment. The encoder unit translates the command signal into a predetermined code which is used to key the local transmitter. The transmitter sends a tone keyed signal out on the line facility to the remote site. At the remote site the signal is received, decoded and distributed to the proper control. Reception and execution of the command is monitored by the verification circuit and an encoder return signal is transmitted to the originating station which is received, decoded and applied to the lamp indicator unit. The verification signal also resets the line selector.

The control of the RF keying is provided by means of voice monitoring at the distant end of the speech transmitted at the A/G loop at the IMCC. The voice monitor unit is bridged across the input to the RF transmitter. The monitor unit recognizes the introduction of speech on the input line and provides a keying signal to actuate the RF transmitter.

STATION REQUIREMENTS

Each station incorporated into the intercom system must be provided with a key set unit equipped with a head set, a push-to-talk foot switch, a key set for line and/or loop selection, signaling and supervision and a dial set for dialing out on the PBX lines.

Associated signaling, supervisory control, telephone circuitry, power and ringing supplies are to be provided in a centralized equipment room.

Figure 5.6-9 shows a block schematic of a simplified typical circuit arrangement for one station.

Depression of talk-listen key causes (1) the associated pickup control circuit to connect the station telephone circuit to the particular line associated with the key and provide proper 2 w or 4 w configuration for the station telephone circuit; and (2) the visual signal circuit to provide proper lamp signals at the key position.

Depression of a monitor key causes similar action as the talk-listen key circuit, with the exception that the transmission path in the operator's headset circuit is open (not connected) in this mode of operation.

Operation of the push-to-talk switch causes the transmitter circuit in the operator's headset to become energized and readied for transmission of voice.

Station Keyset Unit

The intercom equipment physically located at each station consists of a telephone headset, a dial set, push-to-talk foot switch and a number of flush mounted, illuminated, non-locking, push-button keys to terminate the two-wire and four-wire conference loops and line circuits.

The key equipment is arranged to pick-up, talk, receive, monitor, and release on circuits it terminates. Talking on the intercom circuits is under control of the push-to-talk foot switch.

A volume control is provided to adjust receiver level on the monitored lines.

The number of keys provided at each station depends on the individual station requirements. The functions and color codes assigned are as follows:

<u>Key Function</u>	<u>Color</u>	<u>Number</u>
Line Pickup	White	one per talk circuit
Hold	Blue	one per position
Ring	Green	one per position
Release	Red	one per position
Monitor	Amber	one per monitor circuit
Multi-Access	White	one per position (as required)

Line Pickup Key

- a. Outgoing calls - Depression of a line pickup key provides connection to the associated line or loop and station telephone circuit, causing the associated lamp circuit to flutter (lamp interrupted 12 times/second) until the line is released. All other multiple appearances of the lamp circuit receive a steady illuminated key lamp signal while the line is in use.
- b. Incoming calls - On PBX lines, intersite loops and other private lines or distant end connections, on incoming call to a station is indicated by a flashing lamp (interrupted 60 times/minute with equal time on and off) associated with the line key. Operation of the key connects the station telephone set to the line or loop and changes the lamp signal to a flutter. Other multiple line appearances receive a steady on signal for the duration of the call.

Hold Key

PBX lines, intersite lines and other external loop or line connections are arranged for continuous supervision and arranged for holding. Depression of the hold key performs this function and changes the lamp indicator signal to a winking signal (97 per cent on, 3 per cent off, 60 interruptions/minute).

Ring Key

For establishing an outgoing call requiring manual ringing, the ring key provides the proper 20 cycle ringing signal to the line when the key is depressed.

Release Key

Release of an established call connection is accomplished by depression of the release key. (Release is also accomplished when another line-pickup is depressed.)

Monitor Pickup Key

Initial operation of a monitor pickup key establishes a monitor connection to the operator telephone headset. The connection cannot be released by the operation of the common release key. Normal operation of the talk-listen keys does not affect the monitored lines. Release of the monitor connection is accomplished by depressing the monitor key a second time.

During monitor connection, a steady "lamp on" signal is provided to the associated lamp supervisory circuit. The light is extinguished when the monitor connection is released by depression of the monitor key a second time.

Any number of loops may be monitored simultaneously at a station by merely depressing the proper monitor keys.

Multi Talk-Listen Access Key

For accessing more than one T-L Loop simultaneously (broadcast on all at one time) depression of the multi T-L access key allows the position attendant access to the desired lines by selection of the T-L Key circuits.

Push-To-Talk Foot Switch

Operation of the push-to-talk foot switch provides talking battery to the station transmitter and permits the station operator to transmit over the line circuit. Release of the push-to-talk switch deenergizes the transmitter at the station, thus disrupting voice transmission from the station of the line circuit.

Telephone Head Set

The telephone headset provided is a standard plug-ended operator's telephone headset used in telephone communications. Telephone jacks are provided at the station location to permit inserting the headset into the telephone circuit.

Dial Set

The dial set provided at each station location is a standard telephone dial circuit, providing a normal 10 pulse per second rate of operation with a 61 ± 3 per cent pulse interval during which the contacts remain open.

Monitor Volume Control

The monitor volume control provided at each station position permits level control adjustment of the simultaneous monitored loops appearing at the position. The circuit is a simple variable attenuator allowing the operator at the station position to reduce the monitored inputs to a level which will not interfere with his normal communications over a talk-listen loop or line.

Monitor Unit

Ringer Unit

The ringer provided at each station is a standard 20 cycle ringer used for station ringing on PBX lines and those intersite conference loops which are arranged for ringing at designated positions.

CENTRALIZED CONTROL AND LINE EQUIPMENT REQUIREMENTS

The supervisory and signaling control circuits, line circuits and interconnecting networks for the station keysets is to be located in the centralized equipment room.

The major circuits associated with each station keyset position are (1) a telephone circuit, (2) talk-listen-pickup circuit, (3) monitor pickup circuit, and (4) visual signal circuit. In addition test and patch jack circuits are provided in the equipment room for proper maintenance and operation of the intercom subsystem. DC power supplies and the necessary signaling and ringing supplies adequate for serving the overall intercom subsystem are also located in the centralized equipment room.

Station Telephone Circuit

One station telephone circuit is provided for each intercom position in the subsystem. The major functions of the circuit are as follows:

- Provides connection to all loops or lines assigned to the intercom station
- Provides monitoring for any line or loop arranged for monitoring at the intercom station
- Provides for multiple circuit monitoring while talking to another loop or line
- Provides for push-to-talk on preassigned lines
- Provides for audible signals on incoming calls for circuits so arranged

- Provides for holding on PBX or other outside lines
- Provides for dialing on PBX or other outside lines
- Provides for connection to P. A. address network
- Provides connection to recorder to record conversation on any line so arranged and provides means for starting and stopping the recorder as the line is seized and released.

Talk-Listen Pickup Circuit

One pickup circuit is required for each line or loop arranged for two way communication per position. The pickup circuit provides the means of connecting the telephone circuit to the selected line or loop. The pickup circuit is under control of the associated line key and lamp circuit. All pickup circuits associated with a station position are multiplied to the telephone circuit.

Monitor Pickup Circuit

One monitor pickup circuit is provided at each station position per loop or line requiring monitoring. Any number of loops or lines may be monitored simultaneously. The monitor pickup circuit provides the means of connecting the telephone circuit across the receive bus of a line or loop when the selected monitor key is depressed. All monitor pickup circuits associated with a station position are multiplied to the station telephone circuit via the monitor volume control circuit. The volume control circuit permits the station position operator to adjust the receive level of the combined monitor circuits.

The monitor pickup circuits for two-wire and four-wire conference loops or lines are identical, except that the two-wire monitor circuit is provided with a buffer amplifier, located on the receive bus side of the circuit. The buffer amplifier is a unity gain amplifier with a 38 to 45 db loss in the reverse direction. The amplifier is placed in the

circuit to provide sufficient isolation to the transmit path of the two-wire line or loop, so as to render any interference from the other monitored line of the position ineffective.

Visual Signal Circuit

The visual signal circuit provides the control for the lamp indicators associated with the individual keys at the station position. The circuit provides the following functions: (a) operation of lamp indicators by furnishing battery; (b) control of flutter generating supply; (c) control of flashing supply; (d) control of wink supply; (e) distribution of the flash, flutter and wink signals. The visual signal circuit is comprised of the following circuits:

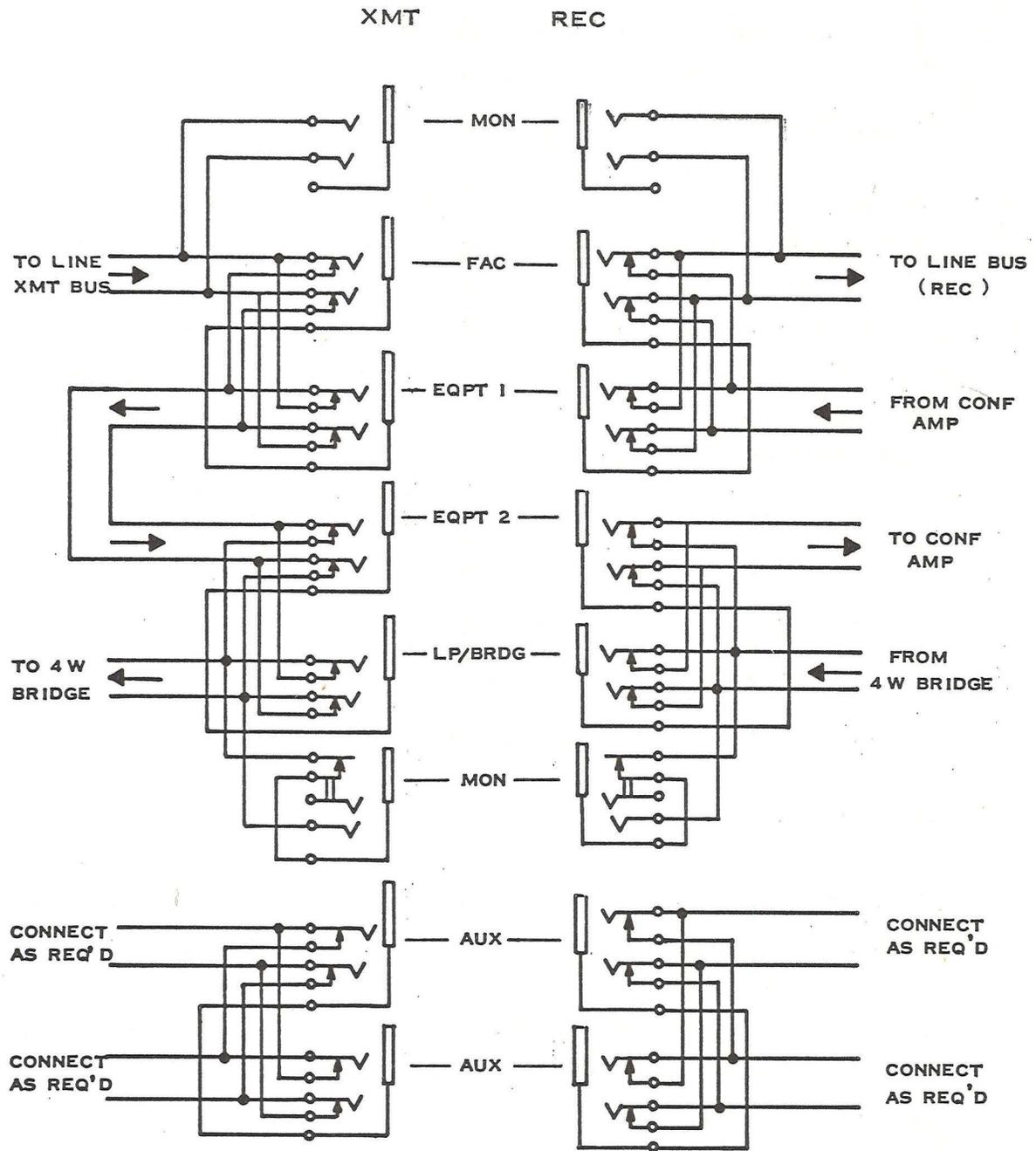
- Lamp battery circuit (one per station position)
- Flutter signal circuit (one per subsystem)
- Flashing signal circuit (one per subsystem)
- Wink signal circuit (one per subsystem)
- Signal control and distribution circuit (as required).

Multi-Access Control Circuit

The multi-access control circuit provides talking access to all of the loops by the operator. Depression of the associated key actuates the control circuit to provide a multiple access of the talk-listen pickup circuits to the telephone circuit. Selection of the loops over which voice is transmitted simultaneously is accomplished by depression of the proper T-L Keys.

Test and Patch Jack Facilities

A universal jack circuit facility is to be furnished to provide for the testing and patching of the intercom circuits and equipment (Figure 5.6-11). A 16 jack-universal circuit is provided for each line or loop circuit. The



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Figure 5.6-11. Typical Universal Jack Circuit

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jacks, each consist of a tip, ring and sleeve conductor. The jacks are arranged so that half of them connect the transmitting path of a four-wire circuit and half connect the receive path. The jacks are provided for insertion between the line equipment, amplifying equipment and bridging equipment. Auxiliary jacks are to be provided where access to other points in the loop circuit is desired.

DC Power and Ringing Supply

A centralized dc power source is required which consists of a full wave rectifier for carrying the load, floating battery and recharging battery; a lead-acid type series connected battery bank; and a counter-cell to permit battery boosting or equalization charging of the battery while connected to the load. In addition, meters, potentiometers and alarms are provided for proper operation and maintenance of the power plant.

A 20 cycle ringing supply is also required in the power plant location for furnishing 20 cycle ringing to lines arranged for signaling to distant ends outside of the site intercommunication complex, and incoming calls from outside facilities.

AUXILIARY FEATURES

In addition to the above major elements of the intercommunication subsystem, additional equipment are needed in limited application for special functions.

Recorders

Recorders are required in certain specified conference loops to record conversations and data that is handled by the loop. The recorder is controlled by the station telephone circuits in the loop and is called into the loop automatically.

Telegraph Keying Circuit

A telegraph key circuit is necessary on certain loops which interconnect with radio intersite lines to provide emergency communications in the event that voice communication becomes unintelligible.

The telegraph key circuit is furnished with a CW oscillator which provides the necessary outgoing signals on the radio transmitter and a transfer key to allow the station position attendant to condition the loop for emergency operation.

PBX FACILITY REQUIREMENTS

A local PBX facility is required to provide automatic dial connections between:

- a. Intercom keyset positions,
- b. Intercom keyset positions and the main PBX for connection to outside commercial lines.

Any of the dial stations can be connected to any other station by dialing the proper station code. The dial equipment is arranged to pickup the calling line indicate when to start dialing (dial tone), connect to the called line; test for busy condition; if busy return an interrupted tone (busy tone); if idle ring called line and return ringing tone to calling line; to stop ringing when called station answers, provide talk battery to both stations; and restore equipment to normal when call is terminated.

All PBX trunk lines are routed through a manual switchboard to allow for the PBX dial stations access to outside facilities with manual assistance provided at the switchboard. In addition, the switchboard operator is capable of establishing a conference loop which includes up to ten stations or trunks.

Intercept facilities are provided for at the switchboard accepting calls directed to non-working stations.

NETWORK LOOP IDENTIFICATION AND STATION ASSIGNMENT

The identification of network loops and the assignments of stations to these loops are shown on Tables 5.6-1 through 5.6-4. These tables have been compiled to agree with the intercom system organization and consist of the 4 major divisions corresponding to the operating segments of the IMCC. These 4 network divisions are (1) MOCR and Support Areas #1 network, (2) MOCR and Support Areas #2 network, (c) Simulation (SCATS) network, (4) Technical Support (control) network.

Loop assignments have been established to correspond with the "principal user" philosophy. Each loop is created to serve one particular function and is controlled by one position (principal user).

MOCR AND SUPPORT AREA #1 NETWORK

The MOCR and Support Area #1 network is comprised of 17 local loops; 1 Public Address Loop; 1 paging loop and 5 intersite loops. Position assignments on these loops have been made in accordance with the functional staffing requirements at the console positions dictated by the mission operational activities.

Each loop is assigned a principal user who has operational control of the loop. Only console positions associated with MOCR #1 and its associated support areas are assigned to this network, allowing for independent operation and isolation of the network from other intercommunication circuits.

A total of 60 positions are included in the network. In addition to the loop assignments, each of the sixty positions is assigned one PBX line for access to the Intercommunication PBX facility.

MOCR AND SUPPORT AREA #2 NETWORK

The MOCR and Support Area #2 network is identical in composition and assignment to the MOCR #1 network configuration. The network is used for voice communications between the MOCR and Support Area #2 console positions and, like the MOCR #1 network, it is isolated from the other intercommunication circuits.

SCATS NETWORK

The SCATS network provides the intercommunication voice circuits between the IMCC Simulation Control Rooms, the Simulation Remote Sites Rooms and the trainer building complex. The network is comprised

of 8 local loops (3 loops associated with MOCR #1, IMCC Simulation Control Room, 3 loops associated with the MOCR #2 IMCC Control Room and 2 loops associated with Simulation Remote Sites Room and the Trainer Building).

A total of 11 positions are included in the network, each provided with a PBX line for access to the Intercom PBX.

The SCATS network does not require any interface with the MOCR networks and is, therefore, isolated from the other intercom circuits and independently operated.

TECHNICAL SUPPORT NETWORK

The Technical Support network provides the Voice Communication Facilities for control, maintenance and interface between the other three intercom networks. The Technical Support network consists of 6 local loops between the common facilities and the MOCR #1 facilities and 6 local loops between the common facilities and the MOCR #2 facilities and 6 local loops between the common facilities and the MOCR #2 facilities. There are twenty positions in the technical support common facilities areas, 3 positions in the MOCR #1 area; and 3 positions in the MOCR #2 area which constitute the Technical Support network (control) stations. These positions are interfaced with 19 established positions in the MOCR #1 complex and 19 established positions in the MOCR #2 complex.

Intercom PBX access is provided for the 31 common facilities positions in the Technical Support network, on a line per station basis.