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TITLE- Review of KSC Communications Systems Checkout Needs

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ABSTRACT

The Kennedy Space Center (KSC) has a large complex communications network involving many different types of systems, which include basic audio transmission systems, wideband transmission systems, the Operational Intercommunication System (OIS) and many special purpose applications of the basic cable plant. The types of communications and the methods of monitoring, validating, testing and evaluating the transmission links have been reviewed to determine monitoring and checking methods that are candidates for further investigation.

During the course of this review, the gross nature of the communications problems experienced at KSC was obtained by examining the trouble tickets which were prepared during the CDDT and Launch Counts for Apollo 4, Apollo 5, and Apollo 6. These show that the majority of problems were experienced in the OIS and wideband circuits. In addition, the problems experienced in wideband circuits used by the Apollo Checkout Equipment (ACE) were reviewed using their Unsatisfactory Condition Reports (UCR's).

A number of the communication systems have a limited number of stations and limited transmission facilities. By the nature of their end instruments, and their geographical distribution, they are not candidates for checking other than by scheduled periodic inspection except when difficulty is reported by the user. On the other hand, the OIS system and the data transmission system over wideband facilities appear to be candidates for more augmented testing methods. Both in-service monitoring and additional test equipment and facilities for these communication services should be investigated.

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TECHNICAL MEMORANDUM

1.0 INTRODUCTION

The Kennedy Space Center (KSC) communication systems have been reviewed to suggest appropriate methods for monitoring and checking out these systems. There are a large number of facilities and discrete equipments which share the KSC cable plant. This review presents reasonable systems and methods for monitoring, validating, testing, and evaluating the transmission links.

In general, the various systems, both by application and by experience, can be divided into two types. For many applications, the present manual methods of alignment, operation, and trouble shooting seem to be appropriate. The other systems which appear to merit more test and monitor equipment are (1) the wideband transmission of digital data, and (2) the overall Operational Intercommunication System (OIS).

In the course of this review, the nature of troubles and a measure of the frequency of their occurrence were obtained by a review of the trouble tickets that were written during the CDDT, FRT, and Launch Countdown of Apollo 4, Apollo 5, and Apollo 6. The Apollo Checkout Equipment (ACE) reports (Unsatisfactory Condition Reports (UCR's)) of problems since last summer were also reviewed to determine the user's assessment of the nature of the communication difficulties.

A key element in providing improved communications service is current documentation of the system configuration. This takes precedence over advanced systems monitoring, validation, and testing equipment. In addition, communication facilities for trouble shooting, such as a dedicated order-wire are essential elements.

This report is divided into sections dealing with the facilities reviewed, a discussion of the service experience, a review of normal maintenance practice and its applications at KSC, and then a more detailed discussion of the OIS and wideband data transmission systems.

2.0 KSC TRANSMISSION SYSTEMS

The KSC systems which have been reviewed are:

a. Wideband systems which transmit video signals for standard television and the Operational Television (OTV). The same type of facilities are used for wideband digital transmission for ACE, RCA 110 computers and the Digital Data Acquisition System (DDAS).

b. Operational Intercommunication System (OIS) which includes the various OIS (A) audio facilities and the OIS (RF) system at Launch Complex 39 and the Manned Spacecraft Operations Building (MSOB).

c. Other Audio Transmission Systems which include:

   1. Telephone Company Leased Wire
   2. Point-to-Point Circuits
   3. Mobile Radio Systems
   4. Miscellaneous Administrative Telephone
   5. Timing and Countdown Systems.

d. Other Data Systems:

   1. Leased Teletype and Facsimile Circuits
   2. Digital Data Circuits
   3. Analog Data Circuits
   4. Leased Teletypewriter and Facsimile.

It is recognized that some of these system have been provided to satisfy specific system requirements in a launch complex. The cable plant is used as the hardwire transmission medium between special space vehicle checkout equipment which is located in separated KSC facilities. The engineering of these applications should consider the overall effect of these signals to other services and the possible effects of other services on these specific applications. Thus, although important to the conduct of a test, the routing and application of limited end instruments hardly justifies special test equipment or cable routing. Periodic inspections and tests seem to be the only reasonable maintenance approach. It is our opinion, substantiated by the number and nature of previous difficulties, that such applications as the Digital Transmission System (DTS), the Digital Event Evaluator (DEE), the Digital Secure Range Safety System Closed Loop Checkout, the Booster Emergency Detection System (EDS) and ACE frequency multiplexer use in the 19 AWG cable plant do not merit changes or additions to the present maintenance facilities and operational procedures.

3.0 KSC SERVICE EXPERIENCE

The trouble tickets (TT) from the Apollo 4, Apollo 5 and Apollo 6 missions were reviewed. Trouble tickets are prepared by the Federal Electric Company (FEC), the support contractor for communications operations. Summaries of trouble tickets for the CDDT, FRT and launch periods of these missions can be found in Tables I and II.

Table I is a summary by system and indicates that by far the greatest number of troubles were reported in the OIS system. Of the remaining systems, wideband data topped the list with troubles in the timing system running a relatively close third. From conversations with KSC timing personnel, it appears that most of the timing problems were with the end instruments and not the transmission facility. The "other" category listed last but not with the least number of troubles includes the numerous small systems, their end instruments, and the operational TV (OTV) system (cameras and monitors).

Absolute numbers only are presented here. No attempt is made to rationalize why one system has a greater number of troubles than another. The intent is to determine the number of troubles experienced by a particular system as an indication of future trouble.

Table II is a summary by type of trouble found for the above systems on a mission basis. Equipment problems (combination of columns 3 and 4 in the table), no trouble found (column 5) and wiring or patch problems (column 7) comprised the great majority of troubles reported. Most of the transmission equipment problems were found in the OIS and wideband systems.

3.1 Wideband Circuit Trouble Reports

During visits to KSC information concerning the past history of wideband data-circuit troubles was obtained. A total of twenty-seven Unsatisfactory-Condition Reports (UCR's) on the ACE wideband circuits over a period from July 14, 1967 through March 5, 1968 was made available by the NASA Spacecraft Quality Assessment and Reliability Reporting Staff (LS-QAL-1). In the case of the UCR's, FEC also made available the corresponding trouble tickets that are still retained in the file. Additional information was obtained during formal and informal discussions with FEC and NASA personnel.

It became apparent that one of the major causes of wideband data systems troubles was attributable to personnel. An analysis of the twenty-seven ACE UCR's (5/67-3/68) showed that approximately 56% of the troubles could be classified as caused by personnel (see Table III). One of the principal causes listed was the disconnection of a circuit at one of the numerous patch panels used to configure the wideband circuits. Steps were subsequently taken to reduce the incidence of personnel-caused troubles. All jacks, patch cords and terminals used for ACE wideband circuits were color-coded and rigid procedures instituted controlling access to these dedicated circuits during Apollo 6 checkout. An analysis of the FEC TT survey (11/67-4/68) showed that approximately 37% (see Table I of wideband circuit (ACE, DDAS) were attributed to personnel.

Wideband equipment troubles were found to constitute 44% of the UCR's and 62% of the TT survey. Included in this category was the condition "no trouble found." Those troubles definitely ascribed to equipment constituted 22% of the UCR's and 32% of the TT's surveyed. Of the UCR troubles classified as wideband equipment faults, approximately 67% were characterized as a total lack of signal and 23% as weak-signal. All of the "no trouble found" category were characterized by a lack of signal or the presence of an intermittent signal. (Personnel caused troubles also had 87% characterized by a lack of signal). No detailed breakdown of equipment troubles was available for the TT survey.

It is also recognized that the changes in procedures and the use of dedicated circuits has made a marked improvement in the system performance. The major problems seem to be related to human errors, lack of continuity and few examples related to the technical characteristics of the transmission facility.

The switching of ACE wideband dedicated circuits remotely from the Test and Switching Center is the kind of facility which would reduce the time to restore service. This assumes that provisions will be made to assure that the alternate circuits are good. The basic detection of the existence of trouble can be left to the user.

3.2 Normal Maintenance Practice

In normal telephone practice, circuits are removed from service to perform tests when trouble is detected or suspected. Methods of in-service or in-band testing are not frequently used. Certain users, such as the television networks, do apply special test signals for their own (and the telephone company) evaluations. Where trunks are used by many customers and switching access is available to detect circuit activity and provide test equipment access, measurements between offices may be made. But again, the trunks must be accessible and not in service. There is no direct parallel in the KSC communication system layout.

The usual industry practice for telephone end instruments and teletypewriter equipments often includes periodic inspection and testing. However, the major source of trouble reporting is from the users themselves. When trouble is reported, transmission checks of the loops are needed. Outside of these approches, there are few economical approaches to checking of end instruments. There appears to be no practical method of detecting problems prior to their occurrence. Similar practices are appropriate to the miscellaneous administrative telephone and intercom systems at KSC. They usually do not employ central facilities and should only be subject to periodic performance inspection and testing.

The performance of the mobile radio facilities at KSC cannot easily be measured from central facilities. Detailed unit test and alignment is almost always required. The frequency of testing can best be determined by the past experience and the criticality of the applications. A central monitoring facility could monitor the operational traffic and possible detect problems through service observations but again user complaints are a good indication of trouble and such a central monitoring facility does not appear warranted.

The other audio transmission systems also fall into the category having a limited number of stations which depend on the user for detecting problems. The other special applications have their own critical uses whose performance is best determined by their own end equipment. Thus, the OIS system and the wideband data transmission circuits are the only candidates for more elaborate testing and restoration means.

4.0 OIS AUDIO SYSTEM

The OIS transmission parameters and system configuration are reviewed in this section followed by a discussion of in-service monitoring as compared with overall system checkout. Some possible test methods for noise monitoring and system alignment are presented as possible topics for further study.

4.1 Transmission Parameters

The transmission parameters listed below are generally sufficient to describe the quality of a voice circuit. The values or limits of each parameter are determined primarily by the use of the circuit and its length. Transmission objectives must be established for each segment or link, as well as for the complete circuit, to provide specific test criteria for maintenance personnel.

The transmission parameters of most significance are:

(1) Circuit Net Loss

(2) Loss vs. Frequency

(3) Noise Level

(4) Crosstalk, and

(5) Return Loss

Circuit loss is measured with the circuit out of service and requires access to both ends of the circuit to conduct the measurement. A test tone (usually 1 KHz) at a specified level is applied at one end, and the test tone level is measured at the other end. Each section of the circuit can be measured separately, or an end-to-end measurement can be made.

Loss versus frequency (frequency response) is generally made with the circuit loss measurement since the loss at each frequency is referred to the loss at 1 KHz, and the test configuration is the same.

Noise tests can generally be made at any voice level point in the circuit, and requires only a single piece of test equipment. The measured noise must be referred to a common test point called the zero transmission level point. The test can be made at any time as long as no one is talking on the circuit. However, to determine the noise contribution of the transmission facility, the terminal equipment should be disconnected or isolated.

Return Loss measurements are made at each end of the circuit, with the opposite end terminated, to measure the cumulative effect of all reflection points. A single section of the complete circuit can be measured, but the measurement must be referred to a common transmission level point. Use of a voice bandwidth noise signal is usually preferred for this measurement.

Crosstalk measurements are made on the users loop and requires the application of test signal (tone or voice signal) to all other circuits. A comprehensive test is difficult to establish particularly on long-haul circuits because the interference could occur anywhere in the circuit, and all circuits which could possibly cause the trouble may not be accessible at a single point. Because of the amount of service interruption, this test more likely would be performed as a fault locating procedure, rather than fault detection.

4.2 OIS System Configuration at KSC

All OIS transmission facilities used to interconnect the major KSC facilities are accessible at the Communications Distribution and Switching Center (CDSC). The Launch Complexes and support areas each have their own test area where access to the transmission facilities is possible, and where the terminal equipment can be isolated. Circuits to satellite buildings such as the Automatic Ground Checkout System (AGCS) cannot be tested from the CDSC, but must be tested from their main facility.

At present, the major OIS channels are routed to the CDSC on cable pairs. Present plans call for the use of carrier equipment for some links, but this change would have little effect on any test program since this will be similar to the processing of the OIS RF System.

4.3 In-Service Monitoring and Testing

A noise measurement is the only test which can be easily made on a voice circuit without removing it from service. In this situation, the measured noise will contain contributions from the terminal equipment as well as the transmission facilities. There is no simple way to monitor the voice transmission and arrive at quantitative values for circuit loss, crosstalk or any other parameter. Measurements of these parameters are normally done with the circuit removed from service.

To test automatically during a brief quiescent period requires some method of indicating that a circuit is idle, and a method of disconnecting the terminal equipment to prevent interference with the test and to connect the appropriate test equipment or terminations. The OIS equipment does not provide a busy indication. A voice operated device could be used for this purpose, but it could not determine whether a circuit was idle, or whether there was a pause in a conversation. A noise test made during such a pause could be measuring room noise, assuming that the OIS was not disconnected, while a level measurement would cause the OIS users to be momentarily disconnected.

It is highly improbable that the users would approve of any test arrangements whereby they could be disconnected from the system, no matter how short the time, particularly during critical portions of the launch system checkout and the launch count. This approach would be more applicable to a checkout of the OIS system just prior to CDDT, FRT and the launch count. During these periods, only an in-service monitoring capability appears feasible, and the only test which lends itself to this application is noise measurement.

4.4 System Checkout

As noted in the preceding paragraph, those tests which cause a service interruption lend themselves more to system checkout rather than operational monitoring. Such a checkout would be conducted prior to the start of a major test, or a series of tests, and would supplement or be a part of the circuit validation procedures presently in use.

Prior to a major test, circuits must be configured to support a particular Launch Complex, requiring that many of the circuits be realigned. Unless enough transmission facilities are provided to simultaneously support all possible configurations, this effort cannot be avoided. Therefore, if any automatic checkout equipment were installed, it would only relieve part of the circuit test effort.

Automatic voice circuit checkout is complicated by the condition that both ends must be simultaneously terminated in test equipment. This is accomplished in telephone systems by dialing up a test circuit at the far end of a trunk circuit. This test circuit performs relatively simple functions such as transmitting a test tone. The main control function and test functions are in the test equipment at the near end of the trunk.

In this case, the Central Office switching equipment is used to gain access to both ends of the trunk. Where no switching equipment exists, it must be provided to connect test instrumentation to the circuit under test.

5.0 LIKELY CANDIDATES FOR OIS TESTING

5.1 In-Service Monitoring

When circuits are in use, and cannot be removed from service, the only measurement which appears practical are noise levels. The following methods should be investigated:

(a) Full time use of noise detectors at critical points in the circuit to detect the presence of noise. The threshold of the detectors can be set to any desired level. When this level is exceeded, the detector can cause an alarm lamp to light and an audible alarm to sound.

By connecting the detectors to several points in an OIS circuit such as the input leg of a bridge and other branching points, the source of the noise could be localized without disturbing the circuit. The visual signal from each detector could be brought to the nearest maintenance area, or remoted to a common display area in the CDSC. A clear identification of the circuit points being monitored would be needed for a quick analysis of the noise source.

Western Electric type J1G012YM and YN are examples of noise monitoring devices.

(b) Use of a Noise Measuring Set (NMS) during periods when no conversations are on the channel. The NMS would provide a quantitative measurement of the noise level.

Automatic measurements require a capability to sequentially select a channel, connect the meter to the channel, discriminate between voice and noise, and record the noise measurement.

Manual measurements would be facilitated by a test circuit arrangement in which the circuit test points appeared at a single set of jacks or switches for rapid connection to the NMS. An audible monitoring capability would be required.

5.2 System Checkout

System Checkout is normally done prior to a major test, is generally less constrained by operational requirements, and permits removal of facilities from service. Parameters which are practical to measure are circuit net loss, loss vs. frequency, noise and return loss. The frequency of each type of test can be determined by operational experience.

The following areas should be investigated:

1. Test Equipment - (a) Integrated Test Bays, mobile or fixed, which contain all test equipment needed for a complete checkout. Use of patch cords, test leads etc. should be minimized by provision of a control panel to establish the test configuration with switches.

(b) Test circuits located in remote facilities such as the Launch Complexes, Pads, MSOB and CIF which could be connected to a selected OIS channel under control of the CDSC. The test circuits could be arranged to transmit test tones at discrete frequencies, to measure a received test tone level, and to indicate to the CDSC the value of the received level. This arrangement would require a control unit at the CDSC and a line selecting unit at the remote test area with appropriate tone generators, meters and signaling equipment. The circuit would permit one man to perform end to end tests for system checkout or fault location. It would be particularly suited for locations which are not manned at all times, and which would otherwise require a technician to go to the remote location to assist in a test.

(c) Technical Control facility which would provide access to the critical points of each circuit for test. It should provide the capability to quickly isolate portions of a circuit, to patch or switch out defective equipment, and to patch or switch in spare equipment (amplifiers, cable pairs etc.) for rapid circuit restoral.

2. Test Facilities - (a) Information retrieval system for obtaining circuit layout information at the appropriate test centers or test locations.

(b) An Order Wire for use by maintenance personnel is very desirable and should be separate from the existing trouble reporting OIS channel. The maintenance order wire should terminate at all test locations, equipment bays, distributing frames and other locations where maintenance functions would be carried out.

(c) Simplification of equipment arrangements to reduce the number of bridges in use should be considered as well as the use of a low Z bus for bridge points. This would reduce the number of failure points, and facilitate circuit restoral over spare facilities.

(d) Provision of spare equipment pre-configured and aligned for back-up of critical OIS channels and status indication of spare facilities such as cable pairs and carrier channels should be considered. Test tones and test equipment could be used to continuously monitor the spares.

5.3 OIS-RF System

The monitoring and checkout constraints discussed for the OIS (audio) system, also apply to the OIS(RF). An additional consideration in the OIS(RF) system is that the only points at which audio appears are the end instruments, and at the channel modems where audio lines interface.

Consideration should be given to the use of modified station units for system monitoring and checkout. The units would be modified to simplify connections to test facilities and possible automation of sequential channel selection. The modified stations would be located at the CDSC and other centralized test areas, and would be used in conjunction with test equipment and facilities discussed for the OIS-A system. The existing 4 KHz pilot could be monitored at the CDSC as well as at the Local Communication Areas (LCA).

The wideband portion of the OIS(RF) system that uses the wideband facilities would be checked out in accordance with their procedures.

6.0 DESCRIPTION OF WIDEBAND FACILITIES

The wideband transmission facilities at KSC are used for transmission of information requiring a large bandwidth (up to 4.5 MHz). The wideband transmission system consists of cable pairs (16 gauge, polyethelyene vinyl insulation, shielded). The circuits require the use of amplification and/or equalization units to accomplish the transmission function assigned. Most of the amplification equipment used consists of Western Electric A2A Repeater and General Electric Transistor Cable Amplifier equipment.

The KSC systems requiring the use of wideband transmission facilities with amplification and equalization are as follows:

1. Automatic Checkout Equipment (ACE)
2. Digital Data Acquisition System (DDAS)
3. Saturn Launch Computer Complex (SLCC) (or, RCA-110 Computer System)
4. Operational Television System (OTV)
5. Operational Intercommunications System (OIS)

The planned Test and Switching Center (TSC) installation within the Communication Data and Switching Center (CDSC) at KSC has provisions for positions to control, evaluate performance and coordinate maintenance activities for the wideband transmission facilities.

This discussion covers use of the wideband facilities for television and then data monitoring concluding with a recommended monitor method for further study.

6.1 Operational Television Monitoring

Because of the visual information content and the standard format of the OTV display (525 lines per frame, 60 half-frames per second) it is quite easy to monitor and evaluate a television circuit. In addition, because of the use of a central synchronization generator, it is possible to insert circuit-quality test signals into the television video signal during the vertical retrace interval. These test signals can consist of:

1. A sine-squared signal
2. A multi-burst signal containing short, bursts of different frequencies,
3. A stair-case signal.

These techniques are currently used by commercial television networks to evaluate transmission quality. The network application is quite different than that at KSC because the networks are country-wide and use numerous links of equipment in a series so that the cumulative effects of small variations can become significant.

An anticipated difficulty would be obtaining access to all of the different OTV circuits from one central location in the TSC. Since the KSC application of TV transmission is in general quite limited, the use of special test signals as used by the commercial networks does not appear warranted. Monitoring by the end instruments user would appear to be adequate.

6.2 Wideband Data Circuit Monitoring

In order to provide proper transmission service to wideband data circuit users it is necessary to institute some means of monitoring circuit performance. If possible, this monitoring function should be performed on a non-interference basis. In addition, spare circuits should be maintained at an operating performance level and be continuously available so that they may be used to restore service with the least possible delay. Because of the variety of customer equipments using the wideband data circuits, the signals carried by the circuits vary in data format, data rate and signal waveform. The transmission requirements of this variety of signals are met by the wideband data circuits; however, the nature of some of the signals and the degree of sensitivity of some of the customer equipment to transmission distortion require the operation of some of the wideband facilities in a non-standard configuration. This precludes a ready availability of a "standard" circuit and necessitates the dedication of wideband facilities to the support of specific types of signals.

The wideband data circuit network serves a number of customers in a number of different physical locations. Most of the wideband data circuits pass through the Communications Distribution and Switching Center (CD&SC) where the TSC is located, but a significant number of circuits do not. This latter point serves to complicate the problem of circuit access for monitoring purposes, and may necessitate the use of a remote monitoring system.

There are several types of monitoring methods which could be used, as follows:

1. The "ACE Spacecraft Wideband Transmission System Study," by the Wood-Ivey Systems Corporation, dated November 29, 1967, presents three monitoring concepts as follows:

    a. The first concept consists of passive monitoring of each circuit by means of high-impedance taps. This concept implies the capability of deriving measurements of circuit quality from the customer's signal.

    b. The second concept consists of time-sharing of the circuit with the customer. A test signal is inserted on the circuits at one end and a receiver/analyzer is connected at the other. Circuit quality information is derived from the output of the analyzer.

    c. The third concept is essentially the same as the second except that a calibrated return-circuit is used to return the test signal from the far-end of the circuit, thereby enabling the test signal generator and receiver/analyzer to be co-located.

2. The customer's signal may not occupy the entire bandwidth of the wideband data circuits. This would allow a communications circuit test signal to be inserted in that portion of the band not used by the customer and would permit circuit quality evaluation on a non-interference basis while it was in active use.

3. The customer's end instruments should be examined to determine if some form of communications circuit-test function could be incorporated in them. This test function could be by either hardware or software means; and should be gated by the customer equipment to permit circuit test on a non-interference basis.

4. Normally each of the customer's equipment systems contains some form of error-detection circuitry to test for the proper exchange of information between his terminal equipments. It should be possible to use the error-rate as a measure of the quality of the customer/transmission-system configuration which would serve to alert personnel to the existence of possible communications trouble. Additional steps would have to be taken to isolate the trouble to either the customer equipment or the communications system.

Analysis of the TT's and UCR's has shown that the great majority of wideband data circuit trouble symptoms were a loss of signal, and that the remainder of the trouble symptoms were of a relatively unsophisticated nature. Customer personnel were quick to recognize operation anomalies and were readily able to isolate the probable cause to either the customer equipment or the communications link. Because of the quick reaction on the part of the customer, the implementation of a system to monitor in-use wideband circuits is not recommended. Instead, it is recommended that a sufficient number of trouble-reporting stations be established to permit a customer to reach the communications trouble coordinator position in the TSC quickly. With the advent at KSC of remote switching of wideband circuits and appropriate procedures (with priority order for restoration of service) it is felt that the service needs of the wideband data link customers can be met by providing some operating spares which can be remotely switched into service.

To insure the operational availability of spare circuits it is advised that these circuits be tested periodically for continuity and degradation. A status board for showing the status and availability of spare circuits should be maintained in the TSC. It is not considered to be advisable to remotely monitor or test these spare circuits unless access to the terminal points cannot be achieved during some phases of a mission period.

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Attachments
Tables I-III

SUMMARY OF TROUBLE TICKETS BY SYSTEMS
FOR CDDT, FRT, AND LAUNCH PERIODS
OF APOLLO 4, APOLLO 5, AND APOLLO 6
MISSIONS

	APOLLO MISSION			
SYSTEM	4	5	6	TOTALS
OIS	381	117	219	717
WIDEBAND DATA	49	20	38	107
TIMING	30	17	47	94
SOUTHERN BELL	-	25	36	61
POINT-TO-POINT	-	10	39	49
OTHER	51	6	53	110

* FRT included in OIS.

TABLE I

TROUBLE TICKETS SUMMARIZED

BY TYPE OF TROUBLE FOUND

System	(1) Operator Error APOLLO 4	5	6	(2) Equip. Prob. Caused by User APOLLO 4	5	6	(3) System And/or Equip. Failures APOLLO 4	5	6	(4) Equip. Adjustments APOLLO 4	5	6
OIS	24	18	28	25	2	1	91	18	53	48	7	25
Wideband	12	2	2	1	1	2	17	3	15	13	1	5
Timing	–	–	–	1	–	1	7	5	27	11	8	14
Bell Tel.	–	–	4	–	–	4	–	4	8	–	1	3
Point-to-point	–	2	3	–	–	1	–	–	6	–	1	5
Other	5	1	2	1	–	–	12	–	8	2	2	7

System	(5) No Trouble Found APOLLO 4	5	6	(6) SBT&T And/or Longlines APOLLO 4	5	6	(7) Wire or Patch Problems APOLLO 4	5	6	(8) User Complaint Prior to Install. APOLLO 4	5	6
OIS	113	50	88	–	6	3	65	14	23	9	2	3
Wideband	3	8	3	1	–	1	2	5	12	–	–	1
Timing	5	2	2	–	–	–	6	1	2	–	–	–
Bell Tel.	–	6	16	–	12	–	–	2	4	–	–	–
Point-to-Point	–	2	13	–	–	–	–	5	12	–	–	–
Other	13	–	21	4	2	–	13	1	7	1	–	–

TABLE II

WIDEBAND CIRCUIT EXPERIENCE

SUMMARY OF 27 UNSATISFACTORY CONDITION REPORTS (UCR's) FOR THE PERIOD STARTING JULY 1, 1967 AND ENDING MARCH 5, 1968

SYMPTOM	CAUSE HUMAN ERROR	FAULTY HARDWARE	UNDETERMINED	TOTALS
No Signal	13	4	4	21
Weak Signal	1	2		3
Interference	1			1
Intermittent			2	2
TOTALS	15	6	6	27

TABLE III