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MSFN RELIABILITY
A SUMMARY OF THEORY AND RESULTS

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F. Kalil
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MSFN RELIABILITY — A SUMMARY OF THEORY AND RESULTS

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SUMMARY

Reliability — Performance data on AS-502, when combined with data from AS-501 and 204 to provide the largest available statistical basis, indicated a Mean Time Between Failure (MTBF) of 100 hours for the Unified S-Band system during mission status. The 90-percent confidence limits for this MTBF of 100 hours were 54 hours and 192 hours. All reported failures were considered (i.e. hardware, software, and operational) throughout the mission status period, which commences about 2 weeks prior to launch and terminates at the end of mission. The MTBF during flight time was 180 hours, and the availability was 99.5 percent. There was insufficient data during the short flight times (35 hours and 26 minutes total for the three flights) to determine meaningful confidence limits.

MSFN RELIABILITY – A SUMMARY OF THEORY AND RESULTS

I. INTRODUCTION

The purpose of this report is to present in a readily usable and summary form, the results to date of the program for assessing the reliability of the MSFN for supporting an Apollo manned lunar landing mission.

The following introductory discussion is presented to provide the proper perspective regarding this MSFN reliability program and the results presented herein.

The primary purpose of the Manned Space Flight Network (MSFN) is to provide responsive and efficient tracking and data acquisition support to the NASA manned space flight programs including Apollo and Apollo Applications. As a secondary function, the MSFN provides support to other NASA and DOD programs as required and within the network's capability. (See reference 1, which lists in its appendix those unmanned missions which have been supported by the MSFN.)

Furthermore, the MSFN is presently the primary navigation system for project Apollo, the manned lunar landing program.* The Apollo onboard guidance systems are the secondary or back-up navigation systems. As the primary navigation system, the MSFN must continuously determine the position and velocity vectors of the Apollo spacecraft with sufficient accuracy and reliability to ensure the success of the mission. The Apollo on-board guidance systems are periodically updated in accordance with the position and velocity vectors provided by the MSFN. In order to fulfill its role as the primary navigation system, the MSFN must perform the following basic functions:

1. Acquire the spacecraft in order that it might be tracked and communicated with.
2. Measure the range, range-rate, and/or angular position of the spacecraft relative to the ground station which is tracking it.
3. The ground station does some "preprocessing" of this tracking data and then transmits it via NASCOM to the Mission Control Center at Houston (MCC-H) where this data is used to compute the spacecraft position and velocity as a function of time. The position and velocity vector components at a given time is called the state vector.

*Per Apollo Saturn V - PSRD Ground Support Instrumentation - General, May 27, 1968, rev. 5, pg. 2000.0, "However, the current concept now designates the ground network as the primary means for determining the position of the spacecraft (navigation) and in directing the course of the vehicle (guidance)."

4. This state vector is transmitted back to the station via NASCOM, and the station transmits this state vector to the spacecraft on the command up-link in addition to any other commands which may have been received from the Mission Control Center.

5. The spacecraft verifies receipt of these commands which are coded with a message acceptance pulse (MAPS) by telemetering this pulse back to the ground station via the telemetry downlink.

6. In addition, the voice up and downlinks may be used in lieu of these links if necessary, and thus provide a degree of redundancy from the viewpoint of navigating the spacecraft with the MSFN.

In essence then, each of the above functions represents a "link in the chain," and the reliability of the network for fulfilling its role as the primary navigation system (i.e. the navigation reliability) depends on the reliability of each of these links. Other factors which affect the navigation reliability of the network are: (a) the degree of redundant equipment or techniques in each "link of the chain," and (b) the degree of redundant station coverage during the various phases of the lunar mission. For instance, in the case of acquisition, several equipments or techniques may be used to acquire the spacecraft, namely the use of

1. VHF acquisition aids.

2. The wide beamwidth acquisition antenna of the Unified S-Band System.

3. Spacecraft state vector predictions from either the MCC-H or GSFC. These predictions are used by the station in the Antenna Position Programmer for driving the USBS antenna.

4. Scanning techniques wherein the antenna scans the sky until the spacecraft is acquired.

In the case of mission coverage, the spacecraft may be within view of more than one station. For instance, at distances of $\gtrsim$ 10,000 n. mi. the spacecraft will be in view of 1/3 to 1/2 of the stations in the network. This redundant mission support capability is summarized in Figure 1.

The MSFN's basic capability for fulfillment of responsibilities was based on the past Mercury and Gemini networks with augmentations and additions, primarily: (a) the Unified S-Band System (USBS) at 14 land stations plus the network test and training facility; (b) 4 Apollo ships (3 insertion/injection ships, and 1 reentry ship); and (c) 8 Apollo Range Instrumented Aircraft (ARIA). The network is diagrammatically depicted in Figure 2.

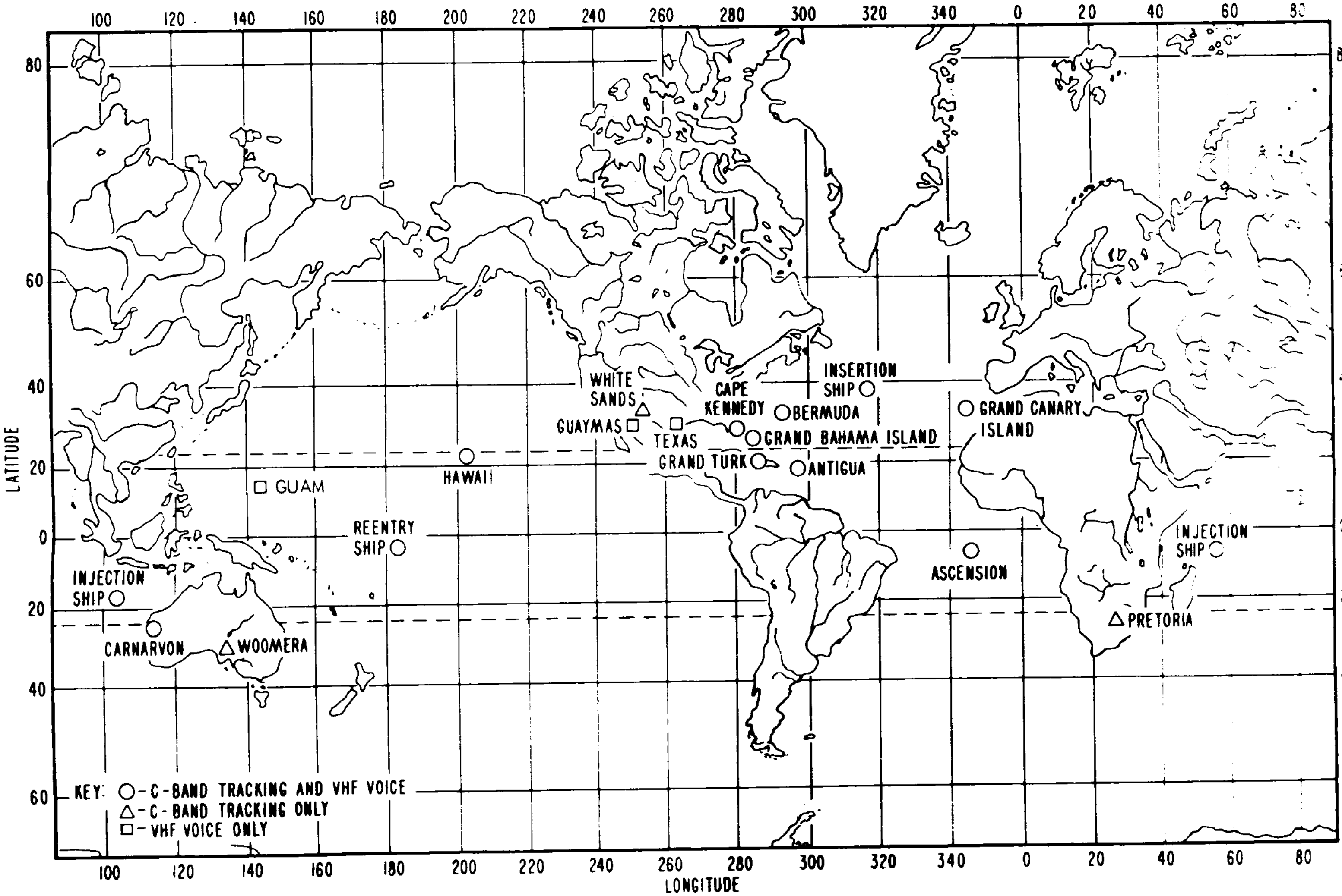
- FIFTEEN UNIFIED S-BAND STATIONS
- FIVE SHIPS AND EIGHT AIRCRAFT
- IMPORTANT CONSIDERATIONS
    - MISSION COVERAGE
        - >100% LAUNCH THROUGH INSERTION
        - 20% DURING EARTH PARKING ORBIT
        - 200 TO 300% ABOVE 10,000 N. MI.
        - 500% AT LUNAR DISTANCES (MULTIPLE 30' BACK-UPS)
    - FUNCTIONAL OVERLAP
        - ACQUISITION EXAMPLE
            - ACQ AIDS
            - S-BAND ACQ ANTENNA
            - ACQ MESSAGES (APP)
            - SCAN
    - HARDWARE REDUNDANCY
        - DUAL USBS MOST MSFN STATIONS (ALL BY FY '69)
        - DUAL BACK-UP WINGS AT DSN 85' SITES
    - CONTINUOUS ACCESS FOR MAINTENANCE

Figure 1—MSFN Mission Coverage Reliability

GSFC initiated reliability analyses of the MSFN during the Gemini Program (see ref. 2, for instance). This activity has been increased for the Apollo Program with particular interest placed upon assessing the reliability of the USB System.

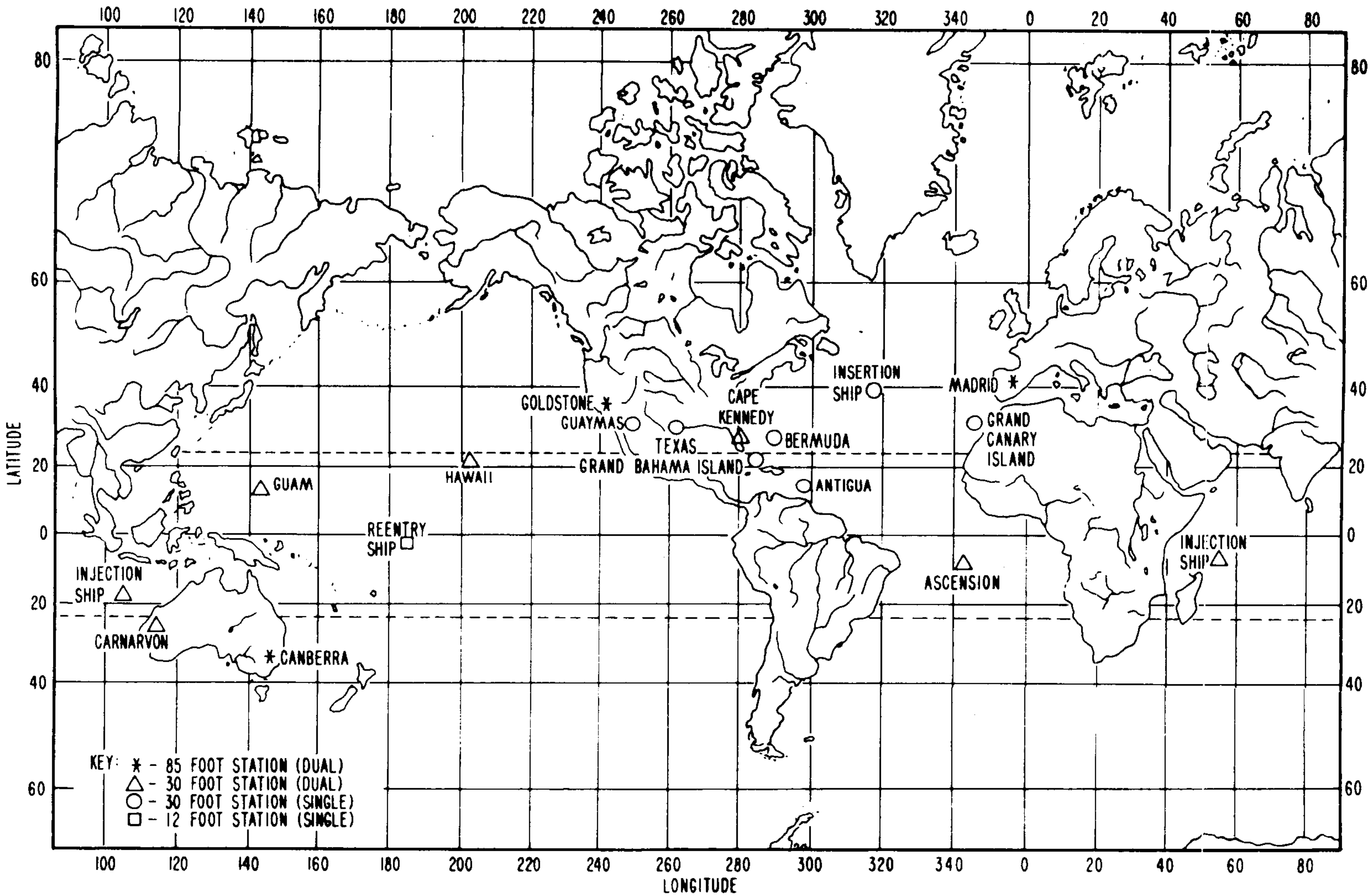
In any reliability assessment, the analytical results are highly dependent upon the accuracy of the data. That is, if a failure occurs which is not accurately reported, or not reported at all as is sometimes believed to be the case, the analytical results are inaccurate. Furthermore, hearsay data or data which is not dutifully documented cannot be used in the reliability analysis because such data cannot be referenced. The results presented herein are based on reported data, and hence they must be viewed accordingly.

Considerable effort is being expended to improve the reporting forms and procedures (see refs. 3, 4) so that it would be easier to relate the reported failures to the network's ability for supporting a particular phase of the mission. Furthermore, procedures are being implemented for obtaining accurate running times for all major subsystems at a station on a year 'round basis (see appendix). This will provide more data, and hence better statistics, for obtaining meaningful values and confidence limits for such factors as "mean time between failure" (MTBF) and availability for a given network support function, system, or station.



MSFN NEAR EARTH VHF/UHF/C-BAND STATION LOCATIONS

Figure 2a–MSFN Near Earth VHF/UHF/C-Band Station Locations



MSFN S-BAND STATION LOCATIONS

Note: Dual Up-Link capability at Bermuda (BDA) and Insertion Ship (Vanguard)

Figure 2b–MSFN S-Band Station Locations

II. METHOD OF ANALYSIS

A. Theory

The purpose of this section is to present a limited explanation of those factors (MTBF, availability, confidence limits, etc.) which are commonly used in reliability analysis to quantitatively evaluate and/or predict the reliability of a system, in particular as these factors are used herein.

Hence, in this section the theory will be brief and simplified as much as possible without sacrificing accuracy, and derivations will be avoided as much as possible, particularly if such derivations exist in the literature and can be readily referred to.

A.1 Mean Time Between Failure (MTBF)

The mean time between failure, usually designated as MTBF or $\hat{\theta}$, is the inverse of the failure rate, usually designated as r (sometimes λ), i.e.

$$\hat{\theta} = \frac{1}{r}, \text{ for a given system} \tag{1}$$

where

$$r = \frac{f}{nT} \tag{2}$$

n = no. of operating units or like systems

f = no. of failures

T = operating time

Strictly speaking, equation 1 should only be used during that part of the unit's life cycle wherein the failure rate is constant. Otherwise, it would not be justifiable to use this MTBF for predicting a systems behavior. A unit or system generally goes through a breaking-in or debugging period during the early part of its life cycle in which case the failure rate is decreasing. The failure rate then levels off and stays nearly constant until age begins to take its toll and the failure rate begins increasing. Hereafter, it will be assumed that the unit is in the flat part of this "bathtub" shaped failure rate curve where the failure rate is constant.

The above equations assume that the number of units (n) all operate for a time T. If the units are all turned on at the same time, and failures occur, and the failed units are down or inoperable for a given time, then this down time must be taken into account. For instance, if we are evaluating the failure rate of the Unified S-Band System (USBS) during the period of active mission support (launch to splash), then

$$\text{Mission support time} = nT, \tag{3}$$

if the down times are small compared to the up time or operational time, where

$$T = t_{splash} - t_{launch} \tag{4}$$

or

$$\text{Mission Support Time} = \sum_{i=1}^{n} T_i, \tag{5}$$

when the down times are significant, where T_i is the up time during mission support for the i^{th} unit.

Thus, it can be seen that the mean time between failure is actually the average or the arithmetic mean time between failure.

A.2 Reliability

The word reliability is used in two contexts in this report. In one context it is used to have the dictionary meaning, "the quality or state of being reliable," with reliable meaning "suitable or fit to be relied upon" (ref. 5). In the other context, it has the definition given by the Radio Electronics and Television Manufacturers Association, (RETMA) now known as Electronics Industries Association (EIA). This definition states: "Reliability is the probability of a device performing its purpose adequately for the period of time intended under the operating conditions encountered." (See ref. 6.) Thus, in this context, reliability is the probability of survival.

It is this latter definition that we now concern ourselves with. According to the exponential failure law which agrees with general experience (see ref. 6, for example), the reliability or probability of survival (P_s) is related to the failure rate as follows

$$P_s = e^{-rt} \tag{6}$$

where

$e = 2.71828$, the base of the natural logarithms

r = failure rate, as before

t = time the unit has been operating without failure.

Thus, in this latter context of time, P_s is the probability that the unit will operate for a time (t) without failure.

If time (t) is defined more generally to be the operational time of a single unit or of a number of n units, then in the context of usage in this report pertaining to the MSFN,

t = mission support time

= operational time (see Eq. 5)

and according to the theory, Poisson distribution for discrete events, which agrees with the real world

$$e^{-rt} = \text{probability of 0 failures in time } t \tag{7}$$

$$rt\, e^{-rt} = \text{probability of 1 failure in time } t \tag{8}$$

$$\frac{(rt)^2\, e^{-rt}}{2!} \quad \text{probability of 2 failures in time } t \tag{9}$$

$$\frac{(rt)^3\, e^{-rt}}{3!} = \text{probability of 3 failures in time } t \tag{10}$$

$$\frac{(rt)^f\, e^{-rt}}{f!} = \text{probability of } f \text{ failures in time } t \tag{11}$$

Considering all the possible combinations of failures, then the sum of all these probabilities, i.e. the cumulative probability, is 100% or 1.

Note the distinction between the expected number of failures in time t which is

$$\text{expected number of failures} = rt \tag{12}$$

while the probability of having a specified number of failures in time t is given by equations 7 through 11.

Also, it is interesting to note that when the number of observed discrete events, namely, independent failures, becomes sizeable enough so that there is a large sample of statistical data for a given type of unit (system), then the Poisson distribution becomes a Gaussian or normal distribution wherein the failures occur randomly. This can be seen in the observed data presented in this report in the "Results" section, where this "random" property of the failures will again be pointed out.

An advantage of the exponential failure law, which as shown above is a special case of the Poisson distribution, is that during the design phase of a system its reliability may be predicted to a fair degree of accuracy depending on how well the failure rates of its components are known. For instance, for the case of "components" in series, the probability of survival of the system or its reliability is, assuming the "component" failures to be independent and their failure rates to be constant,

$$(P_s)_{system} = \prod_{i=1}^{n} P_{s,i} = P_{s,1} \cdot P_{s,2} \cdot P_{s,3} \cdots P_{s,n} \tag{13}$$

$$= \exp\left[\sum_{i=1}^{n} n_i r_i\right] t \tag{14}$$

where

n_i = the number of i^{th} components

r_i = failure rate of i^{th} components.

The summation in equation 14, and hence the system reliability $(P_s)_{system}$ are readily determined.

A.3 Confidence Limits

In this report, the confidence limits of interest are the limits of uncertainty in the observed MTBF. In the Poisson distribution, the times between failures for a given system or unit are random. Thus, if one computes an MTBF based on a relatively small or limited amount of data, then the question is, "How close is this MTBF to the true MTBF?"

We will approach this problem from the viewpoint of the theoretical spread in the observed number of failures during the mission support time, or operational time, t, because the MTBF is the inverse of the failure rate.

According to the Poisson distribution, the probability that the "true" expected number of failures $\hat{f}_{true}$ is greater than or equal to f_u is

$$P(\hat{f}_{true} \geqq f_u) = \sum_{f=f_u}^{f=\infty} e^{-\hat{f}_{obs}} \left[\hat{f}_{obs}\right]^f \Big/ f! \tag{15}$$

where

f = no. of failures, i.e., the variable that is to be observed,

$\hat{f}_{obs}$ = observed no. of failures in time t,

f_u = upper confidence limit in the $\hat{f}_{obs}$

$\hat{f}_{true}$ = "true" expected no. of failures.

Also, the probability that the $\hat{f}_{true}$ is equal to or less than f_L is

$$P(\hat{f}_{true} \leqq f_L) = \sum_{f=0}^{f=f_L} e^{-\hat{f}_{obs}} \left[\hat{f}_{obs}\right]^f \Big/ f! \tag{16}$$

where

f_L = lower confidence limit in the $\hat{f}_{obs}$

If we let

$$P(\hat{f}_{true} \geq f_u) = P(\hat{f}_{true} \leq f_L) = 5\% \text{ probability} \tag{17}$$

then the probability that $\hat{f}_{true}$ lies between f_L and f_u is 90%, or expressed mathematically

$$P(f_L \leq \hat{f}_{true} \leq f_u) = 90\% \tag{18}$$

Since

$$1 - P(\hat{f}_{true} \leq f_L) = P(\hat{f}_{true} \geq f_L) \tag{19}$$

and by using the Table VIII (pg. 263, ref. 7), we obtain Figure 3 where the 90% confidence limits f_L and f_u are plotted versus $\hat{f}_{obs}$. Then

$$MTBF_{obs} = \frac{t}{\hat{f}_{obs}} \tag{20}$$

$$MTBF_u = \frac{t}{f_L} \tag{21}$$

$$MTBF_L = \frac{t}{f_u} \tag{22}$$

Example:

Suppose that there were observed 4 failures in all the 14 USB Systems during a flight time of 28.6 hrs. Then

$\hat{f}_{obs} = 4$

$t = 14 \times 28.6 = 400$ hrs, mission support time

and from Figure 3,

$f_L = 1.4$

$f_u = 9$

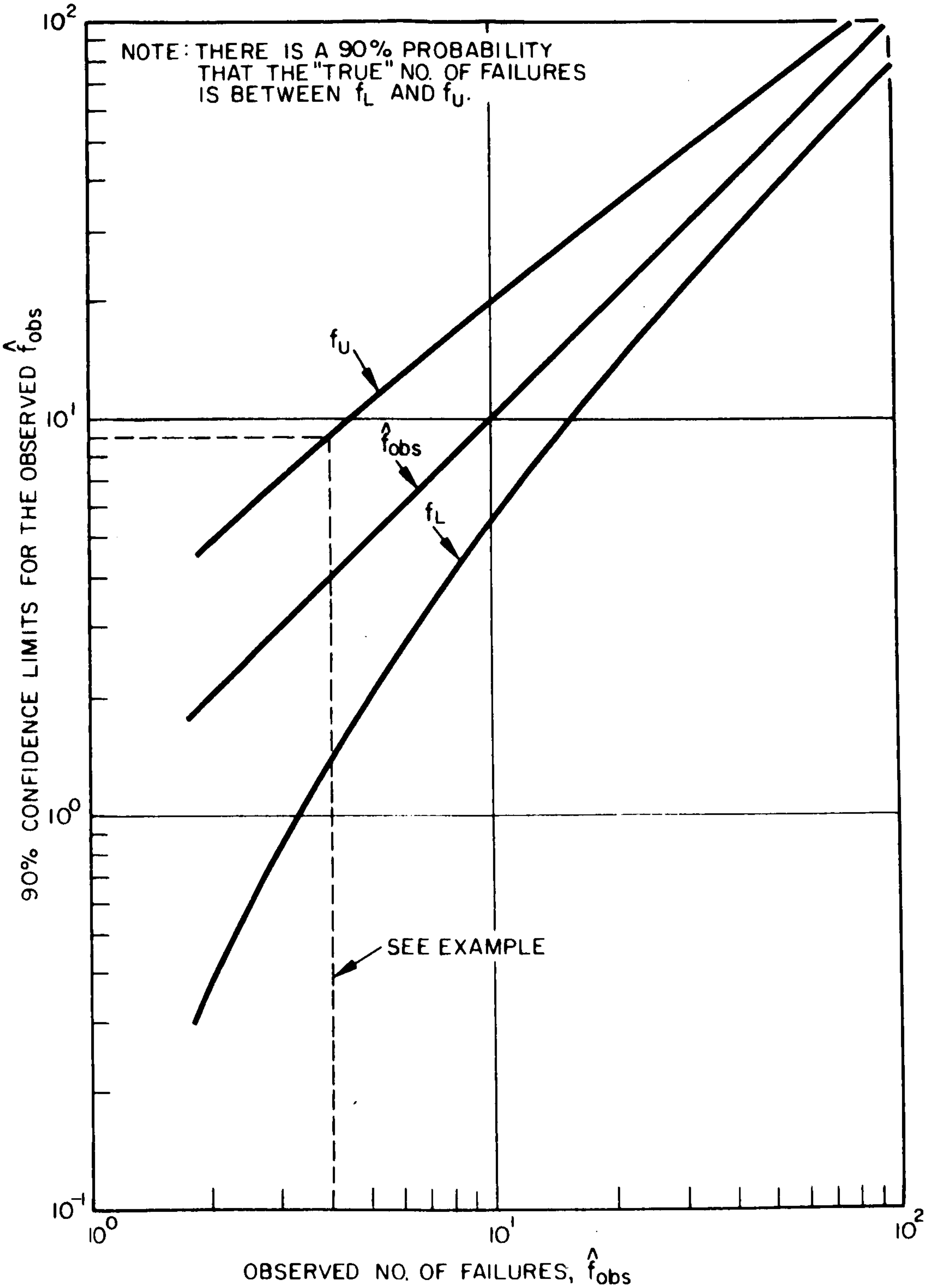


Figure 3–90% Confidence Limits for the Observed No. of Failures

Hence, using equations 20, 21, and 22

$$MTBF_{obs} = 100 \text{ hrs}$$

$$MTBF_u = 286 \text{ hrs}$$

$$MTBF_L = 44.5 \text{ hrs.}$$

The reader might well ask the question, "What is the physical significance of the lower limit of 1.4 failures, i.e. $f_L = 1.4$, since there is no such thing as a fractional part of a failure?" The answer is that this lower limit is a statistical quantity, as is the upper limit. Its physical significance is that if the "experiment" were to be repeated a number of times, each for the same period of time as the original "experiment," then on the average we would not expect to observe fewer failures than 1.4. This number is now a fraction since it is the average for a number of "experiments."

Furthermore, it must be kept in mind that these limits are predictions based on the limited amount of data available from the first "experiment." As the number of "experiments" are increased and more data becomes available, the spread between these limits can be expected to become narrower and the observed failure rate and MTBF to become closer to the "true" value. The "true" value is the average value that would be obtained if the "experiment" were repeated an infinite number of times.

A.4 Availability

The concept of availability as used in this report is the fraction of time that the system is up or operational and can be relied upon for support if needed. Mathematically

$$\text{Availability} = \frac{\text{Mission Support Time-Total Down Time}}{\text{Mission Support Time}}$$

It has been found useful in evaluating network performance to use this availability factor as a measure of the systems' capability to provide active mission support. Availability is distinguished from reliability in that it takes into consideration down time which includes time to diagnose the problem, obtain spare parts (logistics), time to repair, and to check out the system. This then is the time availability, sometimes called the up-time ratio, and gives the probability that the system is operable at time T. It is not to be confused with reliability which is the probability of no failures in time T.

B. Sources of Data

The sources of reliability data used for the results presented herein are:

1. Station Status Reports, see section 32.1 of the Network Operations Directive (NOD), ref. 4.

2. Station Postmission Reports (MMR's), see section 32.3 of the NOD, ref. 4.

3. Network Operations Managers Reports (NOM) (see refs. 8, 9, 10)

4. MSFN Post Mission Reports (see ref. 11, 12, 13)

5. Equipment Failure/Replacement Report, Form GSFC 4-6 (see section 13.2, NOD, ref. 4).

The first two sources are the primary sources of data for mission status ($\sim$ 2 weeks before launch through splash) and flight support (launch through splash) periods; splash meaning termination of the mission.

In the future, the MSFN reliability will be assessed on a year 'round basis using the Equipment Failure/Replacement Reports along with the running times on all major subsystems which will be reported on a monthly basis per instructions given to the sites via TWX which is reproduced in Appendix A for ready reference.

III. RESULTS

This section deals with an assessment of the reliability of: (a) the USB System; (b) an "average" MSFN station complex including all non-USB Systems, and (c) the supporting functions provided by the USB System and/or the non-USB Systems. The results presented here are based on only that data which has been reported by the stations via the station status messages, station post mission reports (MMR's), and Failure report cards (or Equipment Failure/Replacement Reports). Hence the results must be viewed accordingly.

The reporting periods considered were the Apollo AS-501, AS-204/LM, and AS-502 missions, primarily because of interest in evaluating the USB system and these were the first missions requiring a significant amount of active USB System support. All these missions were unmanned. Table 1 gives the times for the start of mission status, launch, and mission termination for each of these missions.

TABLE I

Date Time Groups for Mission Status, Launch, and Mission Termination

Apollo Mission	Date	Time, GMT Hr: Min: Sec	Event
AS-501	Oct. 24, 1967	00:01:00	MSFN placed on Mission Status
	Nov. 9, 1967	12:00:01	Launch
	Nov. 9, 1967	20:18:01	CM reentry
	Nov. 9, 1967	20:18:37	CM splash-down
AS-204/LM	Jan. 4, 1968	00:01:00	MSFN placed on Mission Status
	Jan. 22, 1968	22:48:08	Launch
	Jan. 23, 1968	13:56:00	Termination of MSFN Support
	Jan. 23, 1968	15:18:00	S-IV B reentry (NORAD report)
	Feb. 12, 1968	17:35:00	LM reentry (NORAD report)
AS-502	March 11, 1968	00:01:00	MSFN placed on Mission Status
	April 4, 1968	12:00:01	Launch
	April 4, 1968	21:38:28	CM reentry
	April 4, 1968	21:57:22	CM splash-down
	April 4, 1968	21:20:00	WTN, HAW, ACN, GWM, BDA, and CRO requested to continue tracking S-IV B. All other stations released from support.
	April 5, 1968	17:46:00	Mission officially terminated.

The Apollo AS-501 mission, successfully launched November 9, 1967 at 12:00:01 GMT, was the first launch with a fully configured Saturn V launch vehicle. This mission lasted three orbits. The first two orbits were near earth parking orbits, while the third orbit was an earth-intersecting coast ellipse with a 9,767 n. mi. apogee.

The Apollo AS-204/LM mission, launched January 22, 1968 at 22:48:08, was the first flight test of a fully configured Lunar Module (LM). The primary mission lasted five near-earth orbits, wherein several in-orbit maneuvers were accomplished to test the LM propulsion systems. After completion of the primary mission, the LM stayed in orbit until drag decay caused it to reenter the earth's atmosphere and burn up on February 12, 1968 at approximately 17:35 GMT.

The Apollo AS-502 mission, launched April 4, 1968 at 12:00:01 GMT, was the second launch of a fully configured S-V launch vehicle. The mission lasted three orbits. It was similar to the AS-501 mission. The first two orbits were near-earth parking orbits. The third orbit was an earth-intersecting coast ellipse with an apogee of 12,020 n. mi. The Service Propulsion System was used for injection into this latter coast ellipse, because the S-IV B was "spent" in making up for thrust lost during the launch phase when S-II engines 2 and 3 cut off prematurely.

Table 2 gives the reliability data for the USB System during only flight times of the AS-501, AS-204/LM and AS-502 missions. This data is presented in order to show the reliability during flight support conditions, because preflight activities during mission status, which begins $\sim$ 2 weeks prior to launch, include incorporation of engineering instructions (EI's), brief systems tests, and detailed systems tests wherein the systems are brought up to peak performance. This is not to say that the reliability during mission status is not being analysed, because subsequent tables in this section will do that. Furthermore, future analyses will include data during both non-mission and mission status, as more accurate running times on the subsystems are obtained as discussed earlier (see also Appendix A).

In Table 2, only the single point failures are considered, i.e. only those failures which could not and/or were not by-passed by some alternate hardware or technique. (See also Fig. 4.) Table 3 gives a description of these failures. It should be pointed out that the GDS antenna wheelhouse airconditioner faulted during both the AS-501 and AS-502 missions, but since the wheelhouse was operated in the ventilate mode with no restrictions in both cases, this failure was charged to the USB-System only once. It is believed that this is a conservative approach since operation was not affected in this case.

It is interesting to note that the MTBF of 180 hrs for the USB System during flight support is about a factor of 2 better than the theoretical MTBF of 91.7 hrs and 82.2 hrs predicted by Collins Radio for single and dual USB Systems respectively. However, there is insufficient data to provide meaningful limits to this observed MTBF of 180 hrs because of the relatively short flight times.

Table 4 gives the reliability data for an entire station complex for all non-USB systems, during Flight Support of the AS-501, AS-204/LM, and AS-502 missions. The failures included in Table 4 are only the single point failures which could not and/or were not by-passed by some alternate hardware or technique. Table 5 gives an explanation of all these failures.

TABLE 2
USB System Reliability During Flight Times of AS-501, AS-204/LM, and AS-502 Missions

Station	No. of Reported Failures[1] /Down time				
	AS-501 8 hrs 18 min	AS-204/LM 15 hrs 08 min[3]	AS-502 12 hrs 0 min	Totals 35 hrs 26 min	Availability %
MIL	0	0	0	0	100
GBM	0	0	0	0	100
BDA	0	0	0	0	100
ANG	0	0	0	0	100
CYI	1/0.7[2]	0	0	1/0.7	98
ACN	0	0	0	0	100
MAD	0	Not Up	0	0	100
CRO	0	0	0	0	100
CNB	0	0	0	0	100
GWM	0	0	0	0	100
HAW	0	0	0	0	100
GDS	1/1.0	0	0	1/1.0	98
GYM	0	0	1/1	1/1.0	98
TEX	0	0	0	0	100
VAN	0	Not Up	Not Up	0	100
RED	Not up	0	0	0	100
WTN	Not up	Not Up	0	0	100
Total Failures/ Total Down-time	2/1.7	0/0	1/1	3/2.7	
Total Flight Support Time = Flight Time × No. of Stations = 542 hrs.					
Average USBS Station Reliability (MTBF = 180 hrs)[4]					99.6

(1) Post Mission Reports - Single Point Failures
(2) Key: No. of failures/down time, hrs.
(3) From launch to official termination of mission
(4) The actual MTFB of 180 hrs. compares favorably with the theoretical MTBF of 91.7 hrs. and 82.2 hrs predicted by Collins Radio for single and dual USBS Stations respectively.

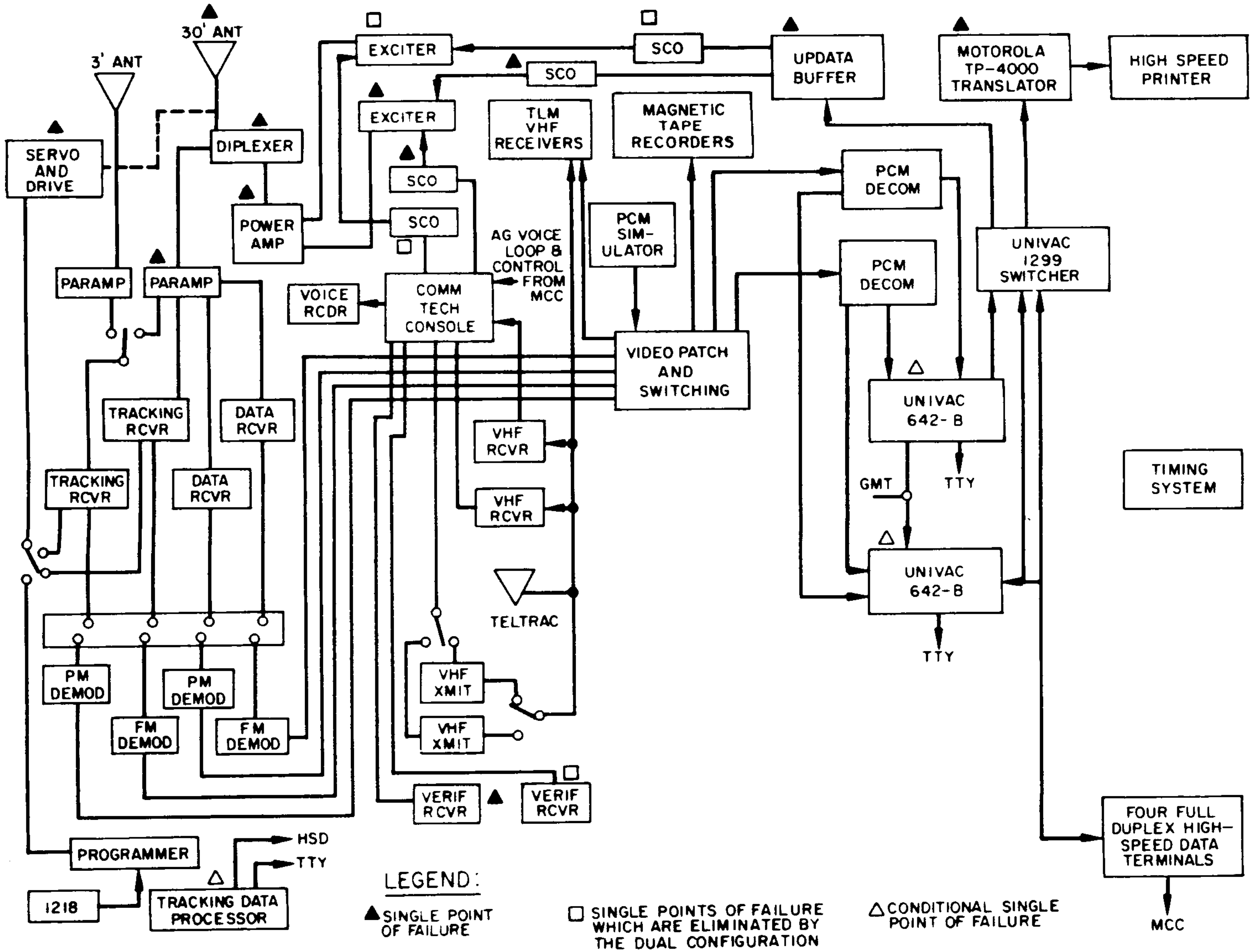


Figure 4–Single Points of Failure for a USB System

TABLE 3
MSFN Failures and Down Times During Flight Time Only

USB Systems Failures		
AS-501 Launched Nov. 9, 1967 12:00:01 GMT	AS-204/LM Launched Jan. 22, 1968 22:48:08 GMT	AS-502 Launched April 4, 1968 12:00:01 GMT
• CYI; Tracking data processor faulted (unknown); down 42 min. • GDS; Antenna wheelhouse airconditioning faulted, operated in ventillate mode with no restrictions; down 1 hr.	• No USB System failures	• GYM, Acquisition paramp failed during Rev. 2, and was bypassed for remainder of mission down 1 hour.

Taking a more pessimistic approach, Table 6 gives the USB System reliability data and results during the entire mission status (~ 2 week prior to launch through mission termination), wherein all hardware, software, and operator failures were considered, even though an alternate or redundant hardware or technique could have been or was used. In this case, the MTBF of 100 hrs for an average USB System compares favorably with the theoretical values of 91.7 hrs and 82.2 hrs predicted by Collins Radio, the prime equipment contractor, for single and dual USB Systems respectively. Also, there was sufficient data to estimate the MTBF 90% confidence limits which were 54 hrs and 192 hrs. The wide variation in the number of failures, MTBF's, and MTBF confidence limits from station to station is due in large part to the statistical nature of the occurence of failures, i.e. failures occur randomly.

This latter more pessimistic approach of considering all hardware, software and operator failures during the entire mission status for AS-501, AS-204/LM, and AS-502 missions was taken in order to get sufficient statistical data. Using this approach, Tables 7 and 8 give the data and results from the viewpoint of reliability of support functions for both USB and non-USB systems. The relative low availability was due to several factors, some of which were: preoccupation with mission simulation and readiness testing; delay in receipt of needed spare

TABLE 4
MSFN Station Reliability (All Non-USB Systems) During Flight Times of AS-501, AS-204/LM, and AS-502 Missions

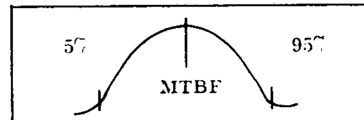
Station	No. of Reported Failures[1] and Down Times[2] AS-501 8 hrs 18 min	AS-204 LM 15 hrs 08 min[3]	AS-502 12 hrs 0 min	Totals 35 hrs 26 min	Availability %
MIL	0	0	0	0	100
PAT AFB	0	0	0	0	100
GBI	1/0.1	0	0	1/0.1	99.7
GTK	0	0	0	0	100
BDA	1/2.8	0	1/4.8	2/7.6	78.6
ANG	0	0	0	0	100
CYI	1/1.0	1/1.3	1/0.4	3/2.7	92.4
ACN	0	0	0	0	100
MAD	0	0	0	0	100
PRE	0	0	0	0	100
TAN	2/4.8	0	0	2/4.8	86.5
CRO	0	0	0	0	100
WOM	1/0.2	0	0	1/0.2	99.5
CNB	0	0	0	0	100
GWM	0	0	1/1.4	1/1.4	96.0
HAW	1/3.8	0	1/0.1	2/3.9	89.0
CAL	0	2/1.5	1/0.1	3/1.6	95.5
GDS	0	0	0	0	100
GYM	1/0.2	0	0	1/0.2	99.5
WHS	0	0	0	0	100
TEX	0	0	0	0	100
VAN	0	Not Up	Not Up	0	100
RED	Not Up	1/10.9	0	1/10.9	70.4
WTN	Not Up	Not Up	0	0	100
RKV	0	0	Not Up	0	100
CSQ	Not Up	0	Not Up	0	100
Total Failures/ Total Down-time	8/12.9	4/13.7	5/6.8	17/33.4	
Total Flight Support Time = Flight Time × No. of Stations = 23 × 35.43 = 820 hrs					
Average Station Reliability (All Non-USB Systems); MTBF = 48.5 hrs					96

(1) Post Mission Reports – Single Point Failures
(2) Key: No of failures/down time, hrs
(3) From launch to official termination of mission

TABLE 5
MSFN Failures and Down-Times During Flight Time Only

Non-USB Systems Failures		
AS-501	AS-204/LM	AS-502
• GBI; TPQ-18 Radar, defective tube in bias power supply; replaced between passes; no data lost; down 8 min. • BDA; computer high-speed printer RED due to fuse in translator unit; down 2 hr. 45 min. • TAN; Capri radar was RED due to AGC problem caused by interference from skin local oscillator; down 1 hr 53 min. • TAN; VR-3600 recorder; defective take-up reel; 2 FR-600 recorders were substituted; down 2 hr. 45 min. • CYI; MPS-26 radar down 1 hr. due to defective card in elevation encoder buffer • WOM; radar transmitter failure; down 11 min. • GYM; 642B command computer (unknown); down 10 min. • HAW; UHF uplink command (problem unknown); down 3 hr. 45 min.	• CYI-C-band Radar, faulty, fine range encoder replaced; down 1 hr. 15 min. • CAL, 1218 computer (inoperative adder); down 1 hr. 22 min. • CAL, site power failure; down 12 min. • RED, 642B telemetry computer faulted (unknown); by-passed with 642B command computer; down 10 hr. 50 min.	• BDA; computer (telemetry); component failure, defective sense AMP Univac P/N 710 4330; down 4.8 hrs. • CYI, VHF Tel., PCM decom faulted at computer telemetry interface; down 0.4 hr. • GWM, component failure in 642B telemetry computer; replaced by command computer with no loss of data; down 1.4 hr. • HAW; computer (unknown); down 0.1 hr. • CAL, C-band radar (TPQ-18) ranging; shut down 0.1 hr. due to emergency generator equipment

TABLE 6
USB System Reliability During AS-501, AS-204/LM and AS-502 Mission Status



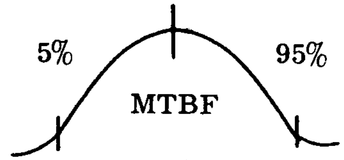
Station	No. of Reported Failures				MTBF [1] (hrs.)	MTBF 90% Confidence Limits	
	AS-501	AS-205/LM	AS-502	Total		Below 5% (hrs.)	Above 95% (hrs.)
MIL	5	9	2	17	60	42	96
GBM	4	1	6	11	95	62	171
BDA	9	5	5	19	55	40	85
ANG	1	3	4	8	130	80	260
CYI	6	5	2	13	80	54	138
ACN	2	1	3	6	174	94	418
MAD	4	Not Up	8	12	59	39	104
CRO	3	9	7	19	55	38	89
CNB	11	10	18	39	27	21	35
GWM	14	6	7	27	38	28	52
HAW	0	2	2	4	260	135	832
GDS	2	1	5	8	130	28	52
GYM	9	1	6	16	65	45	54
TEX	7	3	1	11	95	62	171
VAN	7	Not Up	Not Up	7	57	34	127
RED	0	10	4	14	74	50	121
WTN	Not Up	Not Up	4	4	150	75	480
Total Failures/Mission	84	66	84				
Mission Status Time	480 hrs.	408 hrs.	576 hrs.				
Network Failures/Hr.	0.175	0.160	0.146				
Average USBS Station Reliability (2)					100	54	192

NOTE: (1) All failures considered; include hardware, software, and operator failures. Only a few percent of the failures were serious because the station(s) were generally able to support a degraded level.

(2) The actual MTBF of 100 hrs compares favorable with the theoretical MTFB of 91.7 hrs and 82.2 hrs predicted by Collins Radio for single and dual USBS Stations, respectively.

TABLE 7

Summary of MSFN Reliability Data During Mission Status (i.e. from 2 weeks before launch through splash) for Missions AS-501, AS-204/LM, and AS-502

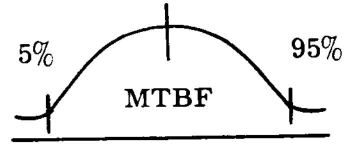


	MTBF[1]	MTBF Limits (90%)		Availability[1,2] %
		Below 5% (hrs.)	Above 95% (hrs.)	
MSFN – USBS Functions				
Acquisition	118	103	142	61
Autotrack	120	103	144	61
Range	106	92	123	63
Range Rate	108	93	124	62
X-Angle	125	107	150	64
Y-Angle	125	107	150	64
Time Standard	778	576	1128	86
Time Tagging of Data	989	712	1483	87
Tracking Data Processor	154	131	185	67
Up-Link Command	84	73	97	53
Down-Link Telemetry	90	79	104	56
Up-Link Voice (Simulated)	190	160	228	66
Down-Link Voice (Simulated)	140	120	168	64
Average USBS Station	100	54	162	70

NOTES: (1) All failures considered; include hardware, software, and operator failures.
(2) Availability with degraded performance was ~100% in practically all cases, because the failures were generally not serious.

TABLE 8

Summary of MSFN Reliability Data During Mission Status (i.e. from 2 weeks before launch through splash) for Missions AS-501, AS-204/LM, and AS-502



MSFN – Functions of Systems Other Than USBS	MTBF(1)	MTBF Limits (90%) Below 5% (hrs.)	MTBF Limits (90%) Above 95% (hrs.)	Availability(1, 2) %
Acquisition	761	578	1063	86
C-Band Autotrack	375	300	487	87
C-Band Range	375	300	487	87
C-Band Azimuth Angle	381	305	495	88
C-Band Elevation Angle	381	305	495	88
Time Standard	3018	1811	5945	99
Time Tagging of Data	1095	657	2190	88
Up-Link Command (UHF)	407	309	570	91
Down-Link Telemetry	420	336	546	86
Up-Link Voice (Simulated)	516	361	826	86
Down-Link Voice (Simulated)	418	293	627	83
On-Site Computer	162	141	194	78
NASCOM TTY	2241	1479	3967	96
NASCOM HSD, Voice, Video	1034	724	1551	87

NOTES: (1) All failures considered; include hardware, software, and operator failures.
(2) Availability with degraded performance was ~100% in practically all cases because the failures were generally not serious.

parts; incorporation of changes according to Engineering Instructions; and the stations' tendency during pre launch to report items which may be suspect even though these items might not affect mission support. Furthermore, the availability with degraded performance was almost 100% in practically all cases, because the failures were generally not serious.

IV. CONCLUSIONS

In evaluating the reliability of the MSFN, with particular attention on the USB System the following observations were of interest:

1. Taking into account during flight support only those failures which were not by-passed by an alternate system or technique, the MTBF of an average USB System was 180 hrs. However, there was insufficient data in this case to provide meaningful confidence limits on this MTBF because of the relatively short flight times. The flight times for the AS-501, AS-204/LM, and AS-502 missions were only 8 hrs. 18 min., 15 hrs. 8 min., and 12 hrs. 0 min., respectively, giving a total of 35 hrs. 26 min. of flight time.

   Under these conditions, the availability of the USB System was over 99%.

2. Taking into account during mission status all hardware, software, and operator failures, even if a redundant or alternate system or technique was available, the MTBF of an average USB System was 100 hrs. with 90% confidence limits of 54 hrs. and 192 hrs. This agrees with the theoretical MTBF of 91.7 hrs. and 82.2 hrs. predicted by Collins Radio for single and dual USB Systems, respectively. Furthermore, the USB System reliability seems to be improving from mission to mission (see Table 6, for instance).

3. Except for brief periods during passes when some telemetry data were lost or commands could not be uplinked, there was no complete failure of the sites to support their functional requirements.

When any function was lost, it was limited to a single pass, such as when the down-link telemetry was lost at Bermuda during the AS-502 launch because of the 642B TLM computer failure. Remedial action, either repair or correction of operator error or activation of standby equipment, was always accomplished before the succeeding pass. Although this is indicative of exemplary dedication and resourcefulness on the part of the station personnel, it should not be assumed that site support problems were minimal. The high level of function support were due largely to considerable equipment redundancy and sufficient inter-pass time to effect repairs.

V. ACKNOWLEDGEMENTS

The authors would like to thank Messrs. J. P. Shaughnessy, W. P. Varson, J. McIntyre, H. Zink, and A. Chandler for their helpful comments and suggestions.

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APPENDIX A

TWX — "OPERATING TIME DATA FOR ALL EQUIPMENT SUBSYSTEMS"

#
CEN002A
RR AADE ACRO AHSK ANBE GACN GANG GBDA GETC GGBM GGDS GGYM GMIL GTEX
LCYI LMAD PGWM PHAW
DE GCEN 002A
25/0601Z
FM CODE 822
TO ALL/STADIR M&O
INFO AADE/GSFC REP 1968 JUL 25 0 15

SECTION ONE OF TWO PAGE ONE OF THREE
A PROGRAM TO EVALUATE THE FUNCTIONAL RELIABILITY OF THE MSFN NETWORK IS BEING SET UP. IN ORDER TO EVALUATE FUNCTIONAL RELIABILITY IT IS NECESSARY TO ACCUMULATE DATA ON OPERATING EQUIPMENT RELIABILITY. IT HAS BEEN DECIDED THAT THE BEST APPROACH FOR ACCUMULATING THE NECESSARY EQUIPMENT RELIABILITY DATA IS TO CONCENTRATE ON SUBSYSTEMS.
THIS MEANS THAT A SUBSYSTEM SUCH AS THE USB RECEIVER/EXCITER WOULD BE EVALUATED ON THE WHOLE RATHER THAN ATTEMPTING A DETAILED BREAKDOWN TO THE SMALLEST MODULE. AN IMPORTANT FACTOR IN THIS SUBSYSTEM EVALUATION IS THE ACTUAL OPERATING TIME FOR EACH SUBSYSTEM.
THIS COMMUNICATION IS TO REQUEST THAT SITES PROVIDE OPERATING TIME DATA FOR ALL EQUIPMENT SUBSYSTEMS AS BROADLY CATEGORIZED FOR THE PURPOSES OF THE RELIABILITY STUDY. THESE SUBSYSTEMS ARE LISTED IN THE FOLLOWING MATERIAL. MUCH OF THE REQUIRED INFORMATION SHOULD BE AVAILABLE FROM LOGS OR OTHER SOURCES CURRENTLY MAINTAINED ON SITE.
ELAPSED TIME METERS ARE THE MOST CONVENIENT SOURCE OF OPERATING TIME DATA, READINGS OF THE METERS SHOULD BE MADE ON THE FIRST WORKING DAY OF EACH MONTH, AND SHOULD BE USED FOR THE FOLLOWING SUBSYSTEMS:

A) USB
   1) UNCOOLED PARAMP
   2) COOLED PARAMP

SECTION ONE OF TWO PAGE TWO OF THREE GCEN 25/0601Z

3) RECEIVER/EXCITER
4) MK-1 RANGING UNIT
5) ANTENNA POSITION PROGRAMMER
6) TRACKING DATA PROCESSOR
7) PRECISION FREQUENCY SOURCE
8) TIME STANDARD A DIGITAL CLOCK
9) TIME STANDARD B DIGITAL CLOCK
10) SERVO BOX FOR X HYDRAULICS
11) SERVO BOX FOR Y HYDRAULICS
12) POWER AMPLIFIER

B) REMOTE SITE DATA PROCESSING (RSDP)
1) 1218 COMPUTERS
2) 642-B COMPUTERS
3) EMU SECTION A
4) EMU SECTION B
5) 1259 TTY ADAPTER
6) 1540 MAG TAPE UNITS

C) UHF COMMAND EQUIPMENT
1) 240 D-2 POWER AMP
2) FRW 2-A TRANSMITTER AND VERIFICATION RECEIVER

D) PCM SIMULATOR

E) TAPE RECORDERS
1) FR-600
2) FR-1100
3) VR-3600
4) M-22
5) M-25

F) TELEMETRY DECOMMUTATORS (ALL PCM'S)

G) C-BAND RADAR
1) TRANSMITTER (P.A., H.V. AND FILAMENT)
2) MODULATOR
3) SERVO CONTROL
4) SERVO POWER DRIVE (E.G. HYDRAULICS)
5) RECEIVER (RANGE AND ANGLE CHANNELS)/RANGE LOOP DIGITAL EQUIPMENT
6) DIGITAL DATA SYSTEM

EQUIPMENT NOT PROVIDED WITH ELAPSED TIME METERS

EQUIPMENT WITHOUT ELAPSED TIME METERS ON SITE WILL BE CONSIDERED "ON" WHEN THE RACK ENCLOSURE OF THE EQUIPMENT IS BEING SUPPLIED WITH AC POWER. THIS WILL REQUIRE A DAILY LOG. COMPILED MONTHLY, TO BE RECORDED

SECTION ONE OF TWO PAGE THREE OF THREE GCEN 25/0601Z
FROM REAL TIME INSTRUMENTS, E.G. WALL CLOCKS, WRIST WATCHES. THE OPERATOR WILL RECORD WHEN AC POWER TO THE RACK IS TURNED "ON" AND WHEN AC POWER TO THE RACK IS TURNED "OFF". THE DEGREE OF ACCURACY SOUGHT IN THIS TYPE OF OPERATING TIME LOG IS IN THE ORDER OF TO THE NEAREST 1/2 HOUR PER WEEK.
THE FOLLOWING CABINETS ARE LISTED INDIVIDUALLY IN OUR REQUEST FOR OPERATING TIME LOGS. IF IN FACT A SERIES OF CABINETS, E.G. 1U36-1U40, ARE TURNED ON BY A SINGLE POWER SWITCH THEN ONLY ONE LOG WILL BE REQUIRED WITH A NOTATION AS TO AN IDENTIFICATION OF THE CABINETS INCLUDED:

A) USB
  1) 1U1
  2) 1U2
  3) 1U3
  4) 1U4
  5) 1U5
  6) 1U6
  7) 1U7
  8) 1U9
  9) 1U10
  10) 1U11
  11) 1U12
  12) SYSTEM MONITOR RACKS (2)

B) PATCH CABLE DATA MULTIPLEX
  1) 1U30
  2) 1U41

C) MICROWAVE LINK DATA MULTIPLEX
  1) 1U35
  2) 1U36
  3) 1U37
  4) 1U38
  5) 1U39
  6) 1U40

COMMUNICATION EQUIPMENT
ALL COMMUNICATIONS, BOTH NETWORK (E.G. TTY EQUIPMENT, MODEMS) AND INTERNAL ON SITE (E.G. INTERCOM, PBX), WILL BE CONSIDERED OPERATING WHENEVER OPERATING PERSONNEL ARE ON STATION. IT IS REQUESTED THAT A WORKING DAY LOG BE RECORDED AND TABULATED ON A MONTHLY BASIS.

25/0611Z JUL GCEN

#
CEN003A
RR AADE ACRO AHSK ANBE GACN GANG GBDA GETC GGBM GGDS GMIL GTEX
LCYI LMAD PGWM PHAW
DE GCEN 003A
25/0601Z
FM CODE 822
TO ALL/STADIR M&O
INFO AADE/GSFC REP

SECTION TWO OF TWO PAGE ONE OF TWO
OTHER SUBSYSTEMS:
OPERATING TIME LOGS FOR THE FOLLOWING CATEGORIES WILL BE DETERMINED BY ON SITE PERSONNEL BASED ON THE BREAKDOWN GIVEN. AN EQUIPMENT UNIT CAN BE MONITORED TO REPRESENT THE CATEGORY IF ITS OPERATION IMPLIES THAT THE MAJORITY OF EQUIPMENT IN THIS CLASSIFICATION IS OPERATING.

A) VHF TLM/ACQ. AID
   1) VHF TLM RCVRS/DIVERSITY COMBINERS/SPECTRUM DISPLAY UNITS
   2) VHF TLM DATA RECORDING EQUIPMENT (E.G. DATA CONVERTER MULTIPLEXERS, DISCRIMINATORS ETC.)
   3) ACQ. BUS/ACQ. BUS CONSOLE
   4) ACQ. AIDS NR 1, NR 2
   5) ANALOG DISPLAYS/MONITORING (E.G. ANALOG RECORDERS, EVENT RECORDERS, OSCILLOGRAPHS).
B) UHF/VHF SPACECRAFT VOICE COMMUNICATION
   1) PREAMPLIFIERS/LINE AMPLIFIERS/DISTRIBUTION UNITS
   2) MODULATORS/TRANSMITTERS
   3) RECEIVERS AND/OR TRANSCEIVER UNITS

SECTION TWO OF TWO PAGE TWO OF TWO GCEN 25/0601Z
IT IS REQUESTED THAT ALL LOGS BE TABULATED ON THE FIRST WORKING DAY OF THE MONTH FOR THE PREVIOUS MONTHS OPERATING TIMES, AND SENT TO:

GODDARD SPACE FLIGHT CENTER
DATA SERVICES SECTION
CODE 824.3
GREENBELT, MARYLAND 20771
ATTN: R.V. CAPO

E MCCARLEY SENDS

25/0615Z JUL GCEN
ACTN: MCCARLEY (822.4)
INFO: SOS 822 822.4 822.3 (R CAPO) XXXXXXX XXXXXXX (WM) 9

MCCARLEY FOR DR KALIL (834-3)

APPENDIX B

USB PROBLEMS DURING AS-501 MISSION STATUS

The following is a list of USB problems that developed while on mission status (AS-501) and a resolution if available: (Per refs. 10, 13)

DTG Red	DTG Green	Station	Problem
Oct. 24/0001	4 Nov.	GWM	The receiver/exciter cooled paramp was Red for a faulty varactor diode. The problem was resolved with the receipt and installation of parts.
24/0001	07/0530	GWM	Acquisition antenna was reported Red due to defective RF cables and a faulty hybrid switch. The station effected temporary repairs by installing substitute cables. Permanent repairs could not be initiated until receipt of replacement cables which were estimated to arrive in January 1968.
24/0001	06/0700	GWM	USB antenna was Red due to deteriorated condition of cables.
24/0001	25/2130	GWM	Antenna feed system was Red due to a defective window. The window was replaced and the system returned to Green.
24/0001	30/2300	GWM	The servo system was Red due to a faulty relay socket. Part was received and installed correcting the problem.

DTG Red	DTG Green	Station	Problem
Oct. 24/0001	06/1110	GWM	USB transmitter was Red due to the power amplifier which had an intermittent sticking relay and an intermittent voltage regulator problem in the KATO motor generator control panel. Support was questionable until a part to make repairs was received. The relay was received on 1 November. A voltage regulator was received on 4 November but was an incorrect replacement.
24/0001	01/0300	CNB	Y-axis was Red due to a defective high pressure fluid filter diaphragm shutoff assembly unit. The unit was replaced and the function became operational.
24/0001	07/1300	CNB	X-axis was Red due to faulty electrical drive motor bearings. The bearings were replaced and the unit was restored to Green.
24/0001	*	CNB	APP "X" encoder shift was faulty causing the TDP X-angle data to be in error. The encoder shift was reset to zero at 02/1400, however, the station had no confidence in the readout accuracy.
24/0001	*	CNB	The 20-volt power supply was reported Red due to a faulty resistor causing incorrect output current to the APP.
24/0001	28/0700	CNB	USB power amplifier of system 1 was Red due to a defective flexible waveguide. The unit was temporarily repaired and could support.

*Item was Red for the duration of the mission but the station was able to support.

DTG Red	DTG Green	Station	Problem
Oct. 24/0001	27/0200	CNB	The USB receiver/exciter system 2 was inoperative due to a defective acquisition potentiometer gear assembly in the exciter. A part was taken from receiver 1 in system 2 and unit restored to operation. Necessary part was received and both systems were operational at 06/0620.
24/0001	29/1000	CNB	The acquisition paramp was Red due to low gain. A new klystron was installed and the paramp was restored to Green status at 29/1000.
24/0001	25/1251	MAD	Receiver/exciter system No. 2 was Red due to a defective UHF buffer amplifier. The station could support the mission by utilization of system No. 1.
24/1330	31/1735	ANG	The receiver/exciter was reported Red due to a faulty spectrum analyzer requiring a K3 relay. The problem affected verifying uplink spectrum for spurious signals and performing ranging threshold tests. Relay was received and the function restored by 31/1735.
24/1330	2 Nov.	ANG	APP was Red due to an inoperative DAC switch and a faulty storage card in the D/A converter. The problem did not affect the station support capability.
24/1055	08/2146	TEX	The USB acquisition antenna polarization switch was Red causing support capability in right hand circular polarization only. Awaiting receipt of replacement part.

DTG Red	DTG Green	Station	Problem
Oct. 24/1055	25/1434	TEX	The USB slow scan TV monitor was Red due to a PC card failure. Awaiting receipt of replacement card. This problem was not reported after 24 Nov.
24/0001	*	GDS	USB transmitters No. 1 and No. 2 were Red due to a damaged wave-guide between the combiner and feed. The waveguide was being redesigned from the combiner to the feed. This problem reported throughout mission status. However, it apparently did not have an adverse effect upon mission support.
24/1045	27/1200	ACN	The USB acquisition antenna was reported Red due to a defective hard-line connector was received 25 October and was installed.
24/1323	07/1200	BDA	The USB system monitor was Red due to a faulty DC amplifier in recorder No. 2. The problem did not affect mission support.
24/1323	26/1200	BDA	Receiver/exciter was Red for a defective frequency shifter. The problem did not affect mission support. The station spare was returned and substituted at 26/1200.
24/1323	*	BDA	The USB acquisition paramp was reported Red due to low gain, bandwidth, and for a defective thermistor in the temperature control circuit. Bright Radio Laboratory varactor diodes and a Metals and Controls

*Item was Red for the duration of the mission but the station was able to support.

DTG Red	DTG Green	Station	Problem
			Incorporated thermistor was on order to effect repairs.
Oct. 24/0947	26/1517	CYI	The power amplifier was defective causing the beam voltage to drop out. Also the motor generator was Red due to defective bearings. The bearings were received 24 October and installed. The unit then had an EI checkout pending. The EI checkout was completed 031630 and the unit was returned to an operational status.
24/0947	*	CYI	The verification receiver was Red due to a faulty tuning unit.
24/0211	*	CRO	The USB transmitter was Red due to a possible main feed polarization wiring error. This problem did not affect the support capability of the site.
24/0211	25/0920	CRO	The Beckman recorders were Red due to a defective channel amplifier. The station was awaiting receipt of a type 476 module.
24/0211	06/0400	CRO	The USB acquisition system was Red due to corrosion on the antenna feed cables. By using substitute cables the station was able to support by 301209 with signal degradation of 0.5 db. New cables were installed and the function was operational at 06/0400.

*Item was Red for the duration of the mission but the station was able to support.

DTG Red	DTG Green	Station	Problem
Oct. 24/0211	25/0920	CRO	The main uncooled paramp was inoperative due to a failure in the temperature control system.
24/0211	25/0920	CRO	USB systems monitor was Red due to a broken pin on the patchboard.
24/0211	27/1230	CRO	Antenna servo system was reported Red due to a defective yoke potentiometer. The problem was corrected and the function restored to an operational status.
24/0211	*	CRO	Receiver/exciter No. 2 was reported Red due to a defective spectrum display unit. The system did support.
24/1335	*	GBM	USB transmitter power amplifier was Red for failure of the input drive switch. Awaiting delivery of replacement part.
24/0001	31/1405	MAD	Verification receiver No. 2 was Red due to an inoperative first intermediate frequency amplifier. The station could support the mission with receiver No. 1.
25/0001	31/2220	GYM	TDP/APP antenna encoders were Red due to a faulty tape adjuster.
25/0404	03/2200	GYM	TDP was Red due to a defective teletype tape perforator. Parts were on order to effect repairs. A temporary resolution was undertaken by substituting a chadless perforator. Parts were received and installed for permanent repair on 3 November.

*Item was Red for the duration of the mission but the station was able to support.

DTG Red	DTG Green	Station	Problem
Oct. 24/0001	09/0215	GYM	Receiver/exciter was Red due to seven defective model 6050 dynamic isolation amplifiers. The station was awaiting receipt of replacement parts. Mission support was not affected.
26/1939	26/2230	GYM	APP was Red for a faulty 27-speed resolver in the APP X-axis servo repeater gear box. The problem was corrected by on-site repair of the unit.
26/1300	06/1305	GBM	APP was Red due to an improper output from the DAC in the Y-channel in units of degrees. The problem was isolated and corrected.
26/0142	02/0500	HAW	S-IVB receiver was reported Red due to a defective Nuvistor in the R/F tuner. The necessary part was received and installed.
26/1125	07/2045	TEX	Acquisition paramp was reported Red due to a defective klystron. Awaiting receipt of a replacement unit.
26/1229	27/1243	GDS	Verification receiver Red due to a defective 30 -kHz disc. Station able to support.
27/1243	28/1303	GDS	System No. 1 Red for a defective klystron pump. Can support by use of the acquisition system.
27/0030	01/0400	GWM	Receiver/exciter was reported Red due to a defective frequency shifter. The parts were received and installation was completed correcting the problem.

DTG Red	DTG Green	Station	Problem
Oct. 30/1900	31/1405	GBM	APP was Red due to an erratic paper tape reader output. The problem was isolated and corrected.
30/0924	02/1200	ACN	USB antenna was reported Red due to defective servo oscillators. Parts were received and system restored to operational status.
30/1010	31/2200	BDA	APP was Red because the X-axis could not be driven correctly with the antenna slaved to the APP. The problem was resolved and the system was restored to operational status.
30/0914	30/1100	CYI	The servo system was Red due to oscillation when in the program mode. The problem was isolated and corrected.
30/0700	08/1600	GYM	The antenna servo system AZ-EL to X-Y coverter was Red due to a defective resolver amplifier module. The station was awaiting receipt of a new module. The problem affected the ability to slave to the acquisition aid.
31/1405	*	MAD	The cassegrain feed assembly was Red due to arcing in the waveguide. The station could support passively for the mission.
31/1304	31/1803	BDA	The receiver/exciter was Red due to a low output from exciter No. 2. The problem was isolated and corrected.

*Item was Red for the duration of the mission but the station was able to support.

DTG Red	DTG Green	Station	Problem
Nov. 01/1922	02/2000	TEX	The S-IVB receiver was Red due to a defective converter. The problem was isolated and corrected.
02/0443	02/0705	GWM	Receiver No. 4 was Red due to a faulty power supply.
02/0443	02/0905	GWM	Receiver/exciter system No. 2 was Red due to ranging interface problems.
02/0441	02/0452	GYM	Receiver No. 2 was Red due to an inoperative paramp. The paramp bias was adjusted and the problem was corrected.
02/1145	*	HAW	Receiver/exciter No. 2 was Red due to a defective function generator. The station was awaiting a replacement function generator. In order to support the mission, a portable function generator was utilized.
02/0419	02/2200	BDA	The APP was reported Red because it did not drive smoothly in the minus quadrant. The problem was reported as intermittent.
02/0725	02/1332	BDA	TDP was Red for a failure of the low-speed data output.
06/1040	08/0926	CRO	Mark I analog-to-digital converter No. 2 was Red due to a faulty PC card.
07/1310	07/1900	GBM	The antenna servo system was Red due to defective hydraulic system interlock switches.

*Item was Red for the duration of the mission but the station was able to support.

DTG Red	DTG Green	Station	Problem
Nov. 07/1058	07/2147	GWM	The receiver/exciter feed system was reported Red for failure of the acquisition paramp. The station utilized a klystron spare to repair the paramp.
07/1323	08/1200	BDA	Antenna servo system AZ-EL to X-Y converter was Red due to a faulty servo amplifier. A servo amplifier was on order to make repairs.
07/1323	07/2100	BDA	TDP was Red due to an intermittent bit 24 of the low-speed range rate word. The problem was isolated and corrected.
07/2310	*	CRO	USB systems monitor was Red due to a defective relay in channel 8 of recorder No. 1. An external switch was substituted for the relay.
08/0817	08/0941	MIL	USB ranging was Red due to a defective RM-35A oscilloscope.
08/0106	08/0415	CNB	TDP was Red due to an erratic printout in the playback mode. Adjustments were made and the unit was returned to Green status.
09/0445	09/0615	GWM	The antenna servo system was Red due to defective tachometers.
09/0930	09/1146	GWM	The APP was Red due to intermittent problems. The problems disappeared shortly before liftoff and no determination of the cause can be made.

*Item was Red for the duration of the mission but the station was able to support.

DTG Red	DTG Green	Station	Problem
Nov. 09/0404	09/0445	CNB	The USB antenna X-axis hydraulics were Red due to the low pressure interlock switch tripping. The interlock switch was adjusted and the unit was returned to Green status.
09/0006	09/0045	TEX	The cable data multiplex system was Red for a failure of transmit channel "B".
09/0806	09/0850	GDS	Receiver/exciter was Red due to binding of the acquisition control gear train assembly of receiver No. 1 system 2. The problem was isolated and corrected.
09/1341	*	GDS	USB antenna was Red due to the wheelhouse air conditioning being inoperative. The system was operated in the ventilate mode with no operational restrictions.
09/1342	09/1424	CYI	Due to a temporary intermittent problem, the TDP was reported Red affecting low-speed tracking data. The problem was unresolved.

*Item was Red for the duration of the mission but the station was able to support.

APPENDIX C

USB SYSTEM OUTAGES DURING AS-204/LM MISSION STATUS

Many problems were reported, but few trends were noticeable. Receiver parametric amplifier failures were numerous; five stations reported problems in this area. These centered mainly on defective klystrons. Problems frequently developed with the cooling of cryogenic systems. A complete listing of all reported problems is contained in the following table (per refs. 9, 12).

In order to understand the date time groups in this table, it should be noted that the MSFN was placed on mission status for the AS-204 LM mission by ISI-1, at 0001Z on 4 January 1968. Network support was terminated at 1356Z on 23 January 1968. This section contains a compilation of equipment outages during the time the Network was on mission status as reported by station status messages. If station equipment was reported faulty prior to the issuance of ISI-1, the data and time of the outage has been arbitrarily denoted as 0001Z 4 January 1968.

USB Equipment Outage

Station	Date/Time Red	Date/Time Green	Description of Outage
Systems Monitor			
GDS	Jan. 04/0001	06/1432	Systems monitor was reported Red pending the installation of EI 2265.
GBM	04/0001	11/0003	Systems monitor was reported Red due to a defective drive amplifier on analog recorder No. 2. Awaiting parts.
ANG	05/1215	07/1200	Systems monitor was reported Red due to DC/M card failures.
MIL	05/1431	12/1451	USB systems monitor was reported Red due to an interlock problem with recorder No. 2.
CRO	17/0940	22/1434	Recorder was reported Red due to a defective amplifier on channel eight. Station was able to support using recorder No. 2, Channel 1.
GYM	19/1722	*	Systems monitor was reported Red due to a defective amplifier in the dynagraph recorder. Station could support by recording the parameters on unused channels of analog recorder No. 3.
Subcarrier Oscillator/Power Amplifier (SCO/PA)			
ANG	04/0001	*	USB power amplifier was reported Red due to a failure of the heat exhanger. Awaiting parts.

*Item was Red for the duration of the mission but the station was able to support.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
SCO/PA (Cont.)			
GDS	Jan. 04/0001	*	SCO/PA was reported Red due to excessive reflected power in both transmitter systems.
GDS	04/0001	17/0822	SCO/PA was reported Red due to an inoperative voltage regulator in transmit system No. 2. Unit was returned to depot for repair.
GWM	04/0001	18/1130	USB R/E power amplifier motor generator control panel was reported Red for an intermittent hunting condition in the voltage regulator.
ANG	19/1225	*	Power amplifier was reported Red due to a faulty waveguide causing high standing wave ratio (SWR).
GDS	10/0808	16/0719	Motor generator transmit system No. 2 was reported Red because it dropped off line intermittently.
GDS	10/0808	*	SCO/PA was reported Red due to a large burn hole in the 6KW combiner dummy load. Station was able to support with a substitute spare water load until a new dummy load was procured.
ANG	20/2045	22/0745	Power amplifier was reported Red due to a shorted diode in the forward output power metering circuit.

*Item was Red for the duration of the mission but the station was able to support.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
		SCO/PA (Cont.)	
TEX	Jan. 22/0941	22/1000	USB transmitter system was reported Red due to a defective nitrogen pressure switch in the power amplifier. Station was able to support with the switch bypassed.
		Receiver/Exciter	
HAW	Jan. 04/0001	11/0718	USB cooled paramp was reported Red due to an inoperative vacuum/ion pump. Unit returned to manufacturer for repair. Also has a coolant hose leak. Coolant hose was received 9 Jan.
CRO	04/0001	11/1300	R/E was reported Red due to a defective power transformer in SDU No. 2. Awaiting parts.
HAW	04/0001	13/0610	R/E No. 2 was reported Red due to an inoperative DC null voltmeter. Awaiting parts.
CYI	04/0001	15/1130	R/E was reported Red due to a defective acquisition paramp for the klystron tube. Awaiting parts.
GWM	04/0001	16/0947	USB R/E acquisition paramp was reported Red cannot support because of a defective klystron. Part was ordered on priority one and installed.
CRO	04/0001	17/0940	USB system 2 ranging was reported Red due to a faulty 946/1000 frequency shifter. Awaiting return of modified module.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
Receiver/Exciter (Cont.)			
HAW	Jan. 04/0001	20/1850	R/E No. 2 was reported Red due to an inoperative 5245L counter. Awaiting parts.
CNB	04/0001	22/0950	R/E was reported Red due to an inoperative acquisition antenna polarization switching. Intermittent 57/221 frequency shifter in system 2. Awaiting parts.
ACN	04/0001	*	USB R/E was reported Red pending the return of the following spares from the module repair depot: (1) 496/1000 frequency shifter 9434000 (2) 20 MHz reference oscillator and X3 multiplier.
ACN	04/0001	*	USB cooled paramp was Red due to a helium gas leak in the compressor coupling.
GWM	04/0001	*	USB R/E was reported Red due to a defective isolation amplifier for receiver No. 4. Part has been ordered priority one. Awaiting parts.
GWM	04/0001	*	R/E cryogenic paramp was reported Red cannot support because of a leaking pressure line intermittent oscillations. Awaiting parts.

*Item was Red for the duration of the mission but the station was able to support.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
Receiver/Exciter (Cont.)			
MIL	Jan. 05/1431	18/0952	USB R/E was reported Red because of a defective auto ranging mode selector. Awaiting parts.
GYM	05/1904	*	USB receiver mounted oscilloscope (RM-503) was reported Red due to a defective high voltage transformer. Station can support with a portable oscilloscope. Awaiting parts.
MIL	09/1320	18/0952	R/E was reported Red cannot support due to a defective VCO module. Unit was returned to depot for repair.
CRO	11/0741	11/1133	R/E was reported Red due to faulty cooled paramp cryogenic. Problem was due to high local temperatures.
TEX	15/1917	19/0100	USB R/E acquisition paramp was reported Red due to a defective klystron. Can support with main paramp.
GWM	16/0947	*	R/E was reported Red due to a defective transformer in the acquisition paramp. Part has been ordered priority one. Station supported with an undersized transformer
GYM	18/0242	*	R/E feed system was reported Red due to a defective waveguide switch. Unit was unable to switch from right hand circular to left

*Item was Red for the duration of the mission but the station was able to support.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
Receiver/Exciter (Cont.)			
			hand circular polarization. System was able to provide full mission support as left hand circular polarization was not required.
CRO	Jan. 20/0524	*	R/E system No. 2 was reported Red pending authorization for 496/1000 frequency shifter through implementation of EI 3126. Station was able to support by substituting a 5100A frequency synthesizer.
CNB	22/0931	22/1039	R/E system No. 2 was reported Red due to a defective tell tale relay causing the ranging receiver to be in lock.
HAW	22/1719	22/1819	USB cannot support due to a defective cryogenic paramp.
GWM	23/0814	23/0900	Receiver No. 2 was reported Red as the manual acquisition voltage control jammed. Station was able to support with receiver No. 1.
Verification Receiver/SDDS			
ANG	Jan. 04/0001	*	SDDS was reported Red due to a 20-volt power supply failure. Unit was sent to depot for repair.
CYI	04/0001	*	USB verification receiver was reported Red due to problems in the tuning unit.

*Item was Red for the duration of the mission but the station was able to support.

Station	Date/Time Red	Date/Time Green	Description of Outage
Verification Receiver/SDDS (Cont.)			
ANG	Jan. 11/2015	20/1135	Verification receiver was reported Red due to a power supply failure. Power supply was replaced with one from dual uplink system which had not been installed. A transistor was required in the original unit.
Servo System			
CRO	Jan. 07/0945	08/1500	Antenna servo system was reported Red due to a noisy hydraulic pump in the X-axis servo. Pump was dismantled and necessary repairs were made.
CNB	04/0001	16/0708	USB antenna was reported Red due to a burst bladder in the X-axis brake accumulator. Awaiting parts.
CYI	04/0001	21/1145	Antenna servo system was reported Red due to all KPTB and TBF type connectors in the "Y" wheel house showed signs of arcing. All connectors were replaced during antenna maintenance.
MIL	05/1431	*	USB servo system was reported Red for defective parts. Awaiting parts.
ANG	11/2015	12/1235	Servo system was reported Red due to the failure of the AZ-EL to X-Y converter.

*Item was Red for the duration of the mission but the station was able to support.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
		Servo System (Cont.)	
MIL	Jan. 04/0001	18/0952	USB servo system was reported Red can support because of an inoperative klaxon horn. Awaiting parts.
		Apollo Timing	
ANG	Jan. 04/0001	*	Apollo timing was reported Red due to the failure of PFS rubidium frequency standard power supply (S/N 104). Awaiting parts.
ANG	04/0001	*	Apollo timing PFS was reported Red as the combiner would not select next preference when the continuity alarm was depressed.
ANG	04/0001	*	Apollo timing was reported Red due to a defective 50 Hz amplifier. Awaiting parts.
TEX	04/0001	*	Apollo crystal oscillator No. 2 was reported Red and returned to BFEC depot for repairs.
GBM	04/0001	*	Rubidium standard No. 2 shipped to depot for repair of defective oven control which caused an unstable output. Station was able to support with redundant units.
BDA	09/2019	10/1301	Apollo timing system was reported Red can support due to an operative Trygon-20-volt 30-amp power supply.

*Item was Red for the duration of the mission but the station was able to support.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
		Apollo Timing (Cont.)	
GYM	Jan. 18/0242	19/1722	Apollo timing was reported Red cannot support pending the installation of EI-1733. Interface cable was missing for implementation. An interim cable was installed with the EI and the station was a able to support.
		TDP/APP/Antenna Encoders	
CNB	Jan. 04/0001	22/0950	APP/TDP was reported Red due to a defective X-encoder shift causing the TDP X-angle data to be in error.
MIL	05/1431	18/0952	USB TDP/APP was reported Red due to defective parts.
CNB	08/0700	10/0633	APP/TDP system 2 was reported Red due to a faulty time interval counter.
TEX	16/0739	17/2100	USB main antenna was reported Red due to a malfunction in the polarization switching control circuit.
CRO	16/0741	16/1300	USB antenna was reported Red cannot support due to a defective Y-axis encoder.
GYM	16/1629	16/1827	APP was reported Red due to an intermittent problem which was corrected by adjusting the optical tape reader. Station was able to support by using alternate acquisition procedures.

USB Equipment Outage (Cont.)

Station	Date/Time Red	Date/Time Green	Description of Outage
TDP/APP/Antenna Encoders (Cont.)			
ANG	Jan. 22/0945	22/1046	USB was reported unable to slave to the acquisition bus in the X-axis.
RF and Optical Collimation Systems			
GBM	Jan. 04/0001	19/0549	RF collimation system was reported Red can support due to the failure of the boresight transmitter modulator.
GBM	18/0430	*	Boresight transmitter modulator was reported Red due to a defective meter relay.
CATV/MUX			
HAW	Jan. 04/0001	11/0718	CATV/MUX channels A and B were reported Red due to the lack of proper test equipment. Model 128A Sierra voltmeter required.

*Note: Item was Red for the duration of the mission but the station was able to support.

APPENDIX D

USB SYSTEM OUTAGES DURING AS-502 MISSION STATUS

The MSFN was placed on Mission Status for the AS-502 mission by ISI No. 1 at 00:01 on March 11, 1968 Greenwich Mean Time (GMT). The mission was officially terminated at 17:56 on April 5, 1968 GMT. The following is a compilation of USB System Outages as reported in the MMR's and included in reference 8.

The equipment most often reported faulty were the cooled and uncooled parametric amplifiers. Engineering is taking action to correct these deficiencies.

NOTE

"N/A" in the "Green" column indicates a system was Red as of mission termination.

System	Time Red GMT	Time Green GMT
1 ACN		
a. USB		
(1) Cooled Paramp. Low gain in No. 1 paramp.	Mar. 11/1300	12/1300
(2) Cooled Paramp. Small helium gas leak.	11/1300	N/A
(3) Apollo Timing. Inoperative VLF monitor chart recorder.	18/1300	20/1330
2 ANG		
a. USB		
(1) Power Amp. Waveguide arcing above 2 KW.	11/1145	N/A
(2) Paramps. Y wheelhouse air conditioning failure.	13/1950	14/1200
(3) Boresight. Inoperative transformer.	15/0610	17/1300
(4) TDP TTY Monitor. Drive gear assembly bearing failure.	15/0750	N/A
(5) Test Transponder. Inoperative	15/1810	01/1430
(6) MK IA Ranging System. Inoperative counter timer.	23/0815	N/A
(7) Receiver No. 2. Manual acquisition control.	April 04/1717	04/1727

3 ARIA

a. ARIA 3

(1) USB TLM. SDDS removed for alignment.	Mar. 25/1400	April 02/1300

b. ARIA 4

(1) USB Track Receiver No. 1. Tuning meter malfunction.	Mar. 25/1400	April 02/1300

c. ARIA 5

(1) USB. SDDS removed for alignment.	Mar. 25/1400	26/1335
(2) USB. Inoperative track antenna.	25/1400	30/1650

4 BDA

a. USB

(1) VLF Receiver. Inoperative.	14/1300	16/1616
(2) UDB. Malfunction in verification loop.	15/0706	15/0934
(3) R/E and MK I Ranging System. Installation of EI-3363.	28/1315	28/2100
(4) Subcarrier Oscillator. Excessive noise on uplink carrier.	27/1755	28/1600
(5) PM Receiver No. 3. Low output from RFI-106A-4 tuner.	April 03/1846	03/2050

5 CAL, No USBS failures reported (ref. 8)

6 CRO

a. USB

(1) Antenna Servo System Y-axis. Hydraulic oil contamination.	Mar. 11/0907	12/1400

	(2) Beckman Recorder. Amplifier on channel 8.	Mar. 12/0753	15/0330
	(3) APP. Incorrect adding in Y register.	15/0657	15/1050
	(4) Apollo Timing System. Atomic PFS No. 2.	18/0948	27/0500
	(5) APP. Defective.	21/1106	21/1205
	(6) Cooled Paramps. Cryogenics problem.	25/0254	25/0550
	(7) Optical and RF Collimation Systems. Wear of refrigerator cross head assembly in cooled paramp.	28/0851	28/1125
	(8) RF System. Cooled paramp pump failure.	29/0341	29/1125
7	CYI		
	a. USB		
	(1) TDP/APP Antenna Encoder. Defective.	11/1015	N/A
	(2) Collimation Tower Transponder. Defective.	15/0255	15/0305
	(3) APP DAC. Inoperable and DAC's.	29/0850	29/1515
8	ETR, No USBS.		
9	GBM		
	a. USB		
	(1) R/E Feed Meter. Defective.	11/1415	28/0030
	(2) Timing System. Rubidium standard No. 2.	11/1415	N/A

(3)	Crystal Standard No. 1. Failure of inner oven control.	Mar. 11/1415	20/0705
(4)	Verification/S-IVB Receivers and SDDS. Red for EI-3154.	13/1300	14/1300
(5)	R/E. Defective klystron.	14/1300	16/0010
(6)	Subcarrier Oscillator/P.A. Defective magnet coolant flow switch.	22/2055	N/A
(7)	Crystal Standard No. 2. Returned to depot for instability.	28/0030	N/A
(8)	UDB. Installation of EI-3178 in S-band CMD.	12/1245	14/1300

10 GDS

a. USB

(1)	Timing. Low output from 5-MHz crystal.	11/1848	26/1600
(2)	SCO/P.A. Inoperative.	11/1848	19/0646
(3)	R/E Feed. Defective.	14/0623	20/0634
(4)	TDP/APP. Installation of EI-3149.	14/0623	20/1330
(5)	Antenna Encoders. Inoperative.	15/0248	15/0345
(6)	Ranging/Timing. Inoperative.	29/2026	03/0745
(7)	Ranging/Timing. Inoperative VLF receiver.	01/1931	01/1945
(8)	Antenna Servo System. Inoperative wheel house chiller.	04/0245	N/A

11 GDSX

a. USB

(1)	System Monitor. Installation of EI-2400.	Mar. 11/1849	12/0025
(2)	Timing. Lack of PFS.	11/1849	16/0610
(3)	RF and Optical Collimation System. Defective.	11/1849	N/A
(4)	Verification Receiver No. 2. Defective power connector.	15/1259	16/0609
(5)	SCO/PA. Transmitter No. 2 inoperative.	16/0610	19/0010
(6)	R/E. Faulty Crosshead in maser No. 1.	19/0010	19/2245
(7)	R/E. Faulty Crosshead in maser No. 2.	20/2400	21/0750
(8)	APP/TDP. Defective.	April 02/0625	03/0200
(9)	P.A. Subcarrier Oscillator load select switch.	02/1843	03/0200
(10)	Subcarrier Oscillator/Power Amp. 24 VDC power supply problem.	02/2310	03/0226
(11)	MK 1 Ranging System. Inoperative readout register.	04/0451	04/0540
(12)	Systems Monitor. Inoperative 100 channel events recorder.	04/1432	N/A

12 GWM

a. USB

(1)	H.P. 5245 Counter Amplifier. Inoperative.	Mar. 11/0455	21/2300

(2)	Cryogenic Paramp. Internal oscillations.	Mar. 11/0455	N/A
(3)	Cryogenic Paramp. Leak in helium line.	11/0455	N/A
(4)	UHF Buffer Amp. Intermittent.	15/1118	21/2300
(5)	Main paramp. Intermittent noise problem.	18/1534	29/0001
(6)	Main Paramp. Passed B.E.T. Lacked feed system checkout parts.	19/1202	21/0720
(7)	TDP/APP. Intermittent error between program angle and real angle.	April 01/1100	03/0500
(8)	Antenna Servo Monitoring Circuit of "Y" Wheelhouse. Grounded.	01/1100	N/A
(9)	Cooled Paramp. Inoperative.	04/0245	N/A

13 GYM

a. USB

(1)	Timing. Defective 106B quartz oscillator.	Mar. 11/1135	N/A
(2)	PA. Defective heat exchanger.	13/0305	15/0100
(3)	UDB. Bad relay.	15/0046	15/0708
(4)	RF Collimation. S-band transponder.	21/0929	28/2000
(5)	Updata SCO. 70 kHz failure.	21/1536	21/1556
(6)	"Y" Wheelhouse Air Conditioning. Inoperative.	30/0019	N/A
(7)	Acq Receiver Paramp. Low gain.	April 02/1957	03/3245
(8)	USB. Acq paramp problem.	04/1535	N/A

14 HAW

a. USB

(1)	Acq Paramp. Defective power transformer.	Mar. 11/1943	April 03/0735
(2)	UDB. Inability to uplink commands.	Mar. 25/1618	25/1710
(3)	USB. Collimation tower transponder.	April 04/0350	N/A

15 <u>HSK</u>

a. <u>USB</u>

(1)	SCO/PA System No. 1. Burned Kato MG Basler static regulator and external transformers T2 and T9.	Mar. 11/0639	16/0713
(2)	Acq Paramp Klystron. Defective.	11/0639	12/0600
(3)	Atomic Timing System No. 2. Inability of crystal oscillator to lock on rubidium optical package.	11/0639	N/A
(4)	Cooled Paramp. Intermittent gain.	11/0639	N/A
(5)	SCO/PA System No. 2. Excessive body current above 12 kw.	11/0639	18/0658
(6)	Antenna Servo. Inoperative axis brakes.	18/0658	18/2300
(7)	R/E System No. 4. Inoperative.	21/1225	24/0717
(8)	RER System No. 1. Intermittent variations.	22/0624	01/0657
(9)	R/E Feed. 7-db deterioration in TLM bit error curve.	27/0646	01/0657
(10)	TDP/APP. PMP on page printer failure.	28/0642	01/0657

(11)	Receiver No. 3. Inoperative.	Mar. 31/0645	01/0657
(12)	APP/TDP. APP arithmetic unit showing intermittent fault.	April 03/0331	03/0900

16 <u>HSKX</u>

a. <u>USB</u>

(1)	PFS. Not on site.	Mar. 11/0639	19/0640
(2)	RF Collimation System Boresight. Transmitter power supply.	11/0639	N/A
(3)	R/E Feed. Lack of four spare modules not returned from modep.	11/0639	N/A
(4)	APP. Arithmetic fault.	12/0656	N/A
(5)	Timing System. Intermittent clock jumps.	20/0722	N/A
(6)	Antenna. Loss of declination on high-speed feedback.	22/0322	24/0717
(7)	TDP Time Internal Counter. Defective 10-MHz card in system 4.	29/1030	N/A
(8)	APP/TDP. BCD to Binary Converter.	April 03/0032	03/2324
(9)	APP/TDP Arithmetic Unit. Intermittent fault.	03/0646	N/A

17 <u>KSC</u>, No USBS.

18 <u>MAD</u>

a. <u>USB</u>

(1)	Cooled Paramp. Defective cryostat temperature controller.	Mar. 11/1245	N/A
(2)	Timing. Defective optical package in atomic standard No. 2.	11/1245	N/A

(3) R/E No. 2. Installation of EI-2514 modification kit.	Mar. 11/1245	12/0850
(4) PA. Defective dummy load.	11/1245	27/1600
(5) Ranging System. CSM range number.	15/0300	15/0305
(6) Test Transponder. High turnaround time.	15/0305	15/0715
(7) Ranging System. Defective.	23/1100	28/1200
(8) P.A. No. 2. Defective reflected power meter.	29/1203	29/1800
(9) Ranging System No. 1. A/D converter failure.	April 04/0425	04/0510
(10) Ranging System No. 2. Removal of A/D converter for installation in system No. 1.	04/0510	04/0600

19 MADX

a. USB

(1) R/E No. 2. Installation and alignment of modules.	Mar. 11/1245	15/2010
(2) Verification Receiver No. 2. Defective multiplexer.	11/1245	N/A
(3) Timing System. Lack of PFS.	11/1245	N/A
(4) Maser No. 2. Maintenance.	18/1200	20/1145
(5) R/E 1 and 2. AGC alignment and curves.	18/1200	N/A
(6) Ranging System. ST-12 performance with both R/E's.	18/1200	N/A
(7) R/E No. 2. Spurious sidebands on exciter uplink.	27/1600	N/A
(8) JPL Maser No. 1. Maintenance.	30/0850	N/A

20 MIL

a. USB

(1)	R/E Paramp. Power Supply ripple problem.	Mar. 15/1259	16/1229
(2)	P.A. Verification receiver No. 1 problem.	15/1259	16/1229

21 RED

a. USB

(1)	Test Translator Power Supply. Defective.	11/1930	13/1300
(2)	Antenna Data. Erratic azimuth optical encoder.	14/0245	03/1325
(3)	Antenna Servo. Inability to switch from utility mode.	27/0245	30/0058
(4)	Antenna. Inoperative in any mode.	27/1400	27/1725

22 TEX

a. USB

(1)	R/E Feed. Intermittent acq power amp.	14/1152	20/1400

23 WTN

a. USB

(1)	System Monitor. Installation of EI-1883.	11/2359	23/0340
(2)	Antenna. Defective potentiometer in spiral scan.	11/2359	N/A
(3)	Receiver No. 2. Sticking AGC meter.	11/2359	N/A

(4)	Exciter. Erratic acq potentiometer.	Mar. 11/2359	N/A
(5)	Spare Harrison Lab. 802B power supply. Parts needed.	11/2359	N/A
(6)	R/E No. 1. Erratic MGC potentiometer.	April 01/1200	N/A