22p

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report No. 32-881

Mariner Mars 1964 Project Report: Mission Operations

GPO PRICE $ ____________

CFSTI PRICE(S) $ ____________

Hard copy (HC) 3.75

Microfiche (MF) 1.25

ff 653 July 65

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

June 15, 1966

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Report No. 32-881

Mariner Mars 1964 Project Report: Mission Operations

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

June 15, 1966

Prepared Under Contract No. NAS 7-100
National Aeronautics & Space Administration

PREFACE

On November 28, 1964, *Mariner IV* was successfully launched on a trajectory that would take it within 150,000 miles of Mars. On December 5, 1964, the spacecraft performed a successful midcourse maneuver, altering its flight path so that it would pass within 6118 miles of the planet. The flight took approximately 7½ months, during which time a great deal of scientific information was gathered concerning the environment of both near-Earth and interplanetary space. And then, on July 14, 1965, *Mariner IV* photographed the surface of Mars, and telemetered to Earth the most advanced scientific and technical data regarding the planet yet recorded.

An earlier volume of the series reports on *Mariner III*. This volume, which deals with *Mariner IV*, only, describes various operations of the Project during the flight from the time of midcourse maneuver to the end of the mission on October 1, 1965. It includes an account of the trajectory and orbit determination analyses, a description of the Space Flight Operations System, a summary of the post-launch testing results, and a brief account of the final configuration and disposition of the MC-4 and PTM spacecraft at the end of the mission. (Since the generation of material for this report, the additional *Mariner IV* and *Mariner* Venus 67 Projects were authorized by NASA, and these two spacecraft are being used in the follow-on projects.)

The *Mariner* Mars 1964 mission required the use of a great many new techniques in designing, building, and operating unmanned spacecraft. The success of *Mariner IV* has made these techniques significant, particularly in the light of future space programs. It is hoped that the operations and results documented in this volume will be useful reference to those who are planning future space missions.

W. H. Pickering, Director
Jet Propulsion Laboratory

J. N. James, Acting Assistant Laboratory Director for Lunar and Planetary Projects

D. Schneiderman, Project Manager
Mariner Mars 1964

ELEMENTS OF THE *MARINER* MARS 1964 PROJECT REPORT

The *Mariner* Mars 1964 Project Report consists of the following volumes:

Mariner Mars 1964 Project Report, Mission and Spacecraft Development, Volume I: From Project Inception Through Midcourse Maneuver (TR 32-740, Vol. I)

Mariner Mars 1964 Project Report, Mission and Spacecraft Development, Volume II: Appendixes (TR 32-740, Vol. II)

Mariner Mars 1964 Project Report, Mission Operations (TR 32-881)

Mariner Mars 1964 Project Report, Spacecraft Performance and Analysis (TR 32-882)

Mariner Mars 1964 Project Report, Scientific Experiments (TR 32-883)

Mariner Mars 1964 Project Report, Television Experiment, Part I: Investigators' Report (TR 32-884, Part I)

Mariner Mars 1964 Project Report, Television Experiment, Part II: Picture Element Matrices (TR 32-884, Part II)

Tracking and Data Acquisition Support for *Mariner* Mars 1964, Volume II: Cruise to Post-Encounter Phase (TM 33-239, Vol. II)

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

TABLES

FIGURES

FIGURES (Cont'd)

JET PROPULSION LABORATORY

INTEROFFICE MEMO

19 June 1963

TO: All Concerned

FROM: J. N. James

SUBJECT: Significance of 19 June 1963

Today, the 19th of June, the USSR spacecraft, Mars I, made its encounter with Mars - dead as a doornail. You are receiving an issue of the memorandum because you are one of the individuals who by your daily actions and efforts can make Mariner C the first spacecraft to take measurements on the planet Mars.

It's as tough a job as we could pick. The Soviets have made at least seven launches to Venus and Mars, none of which have succeeded. You have tried twice - to Venus - and succeeded with Mariner II. On the basis of those statistics you are better than they are.

But there is another set of statistics we should look at. An analysis* made for ARPA by Arinc Research, Inc. shows that of sixteen satellites that had been injected, they demonstrated a 95% probability of living only 2000 hours. Mariner II ceased to operate after 129 days - a little over 3000 hours. The Mars I, if we can believe the Soviet news releases, was launched 1 November and failed 21 March, giving it a life of about 3400 hours. We must launch two Mariner C spacecraft in 1964 which will live at least 6000 hours. To accomplish this depends on each of you as an individual - your initiative - your craftsmanship - your ingenuity - your precision - your making each decision in the direction of success - your conscientious attitude towards the system as a whole and not just your part of the system alone - your meeting of schedules on time to permit us to face and resolve the unknowns quickly.

I believe we have a first rate design in the Mariner C. We have plenty of talent assigned to all Project areas, and the schedule isn't too bad. So it is pretty much up to each of us to make every day count.

The Soviets will launch again for Mars in 1964 but they will have some company. Thus you have another opportunity to demonstrate to the world that you excel in this type of venture by encountering Mars with two spacecraft in perfect operating condition.

J. James

J. N. James
Mariner Project Manager

JNJ:pk

*See Aviation Week, May 28, 1962

I. PROJECT ORGANIZATION AND MANAGEMENT

A. Structure

Responsibilities for key divisions of mission activities for the flight and encounter phases of *Mariner IV* were essentially the same as those discussed at length in the *Mission and Spacecraft Development* volume for the pre-trajectory correction maneuver phase. Figure 1, which defines the specific, applicable, organizational structure for the period reported in this volume, reflects the greater emphasis on flight analysis and support activities and the lesser emphasis on the design and development work—except as it pertained to unusual equipment performance or non-standard telemetry results. One function not shown on the chart was the necessary one of public information, which drew a considerable amount of Project personnel's attention; this requirement grew in proportion to the success of the mission.

The management structure provided the base for various administrative checks and controls of the project; these took such forms as master planning and scheduling and follow-up, reviews, reports, and appropriate meetings and workshop sessions. In addition, the Project P List was continued throughout the mission to highlight major problems that could seriously affect the success of the mission. The post-launch P List is presented in Appendix A.

B. Schedules

The absolute irrevocability of flight events imposed even more stringent demands on the precision and thoroughness of scheduling than did the pre-liftoff events. For example, the encounter sequence necessitated more exact time-table adherence than did countdown—obviously, encounter could not slip one day, as did launch.

That the schedule was not only designed but executed within proper tolerances is evidenced by the success of the mission. Details of steps and objectives, and a record of the manner in which they were met, are shown graphically in the schedule package in Appendix B. These charts present original schedules, completion dates, and rescheduling information. Many of the highlights of flight support are contained in these charts. Here again, as in the case of the organization chart for the Project,

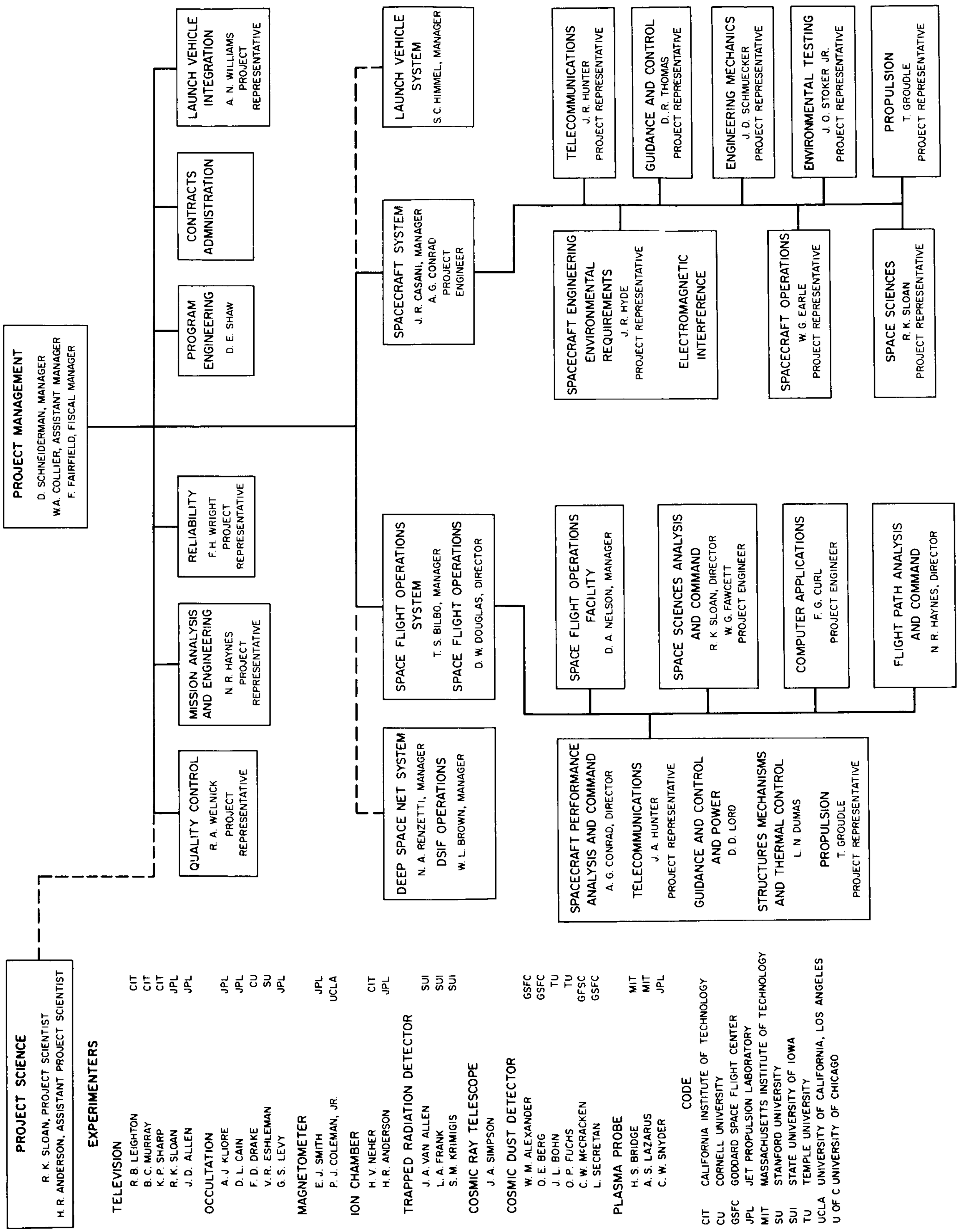


Fig. 1. *Mariner Project organization chart*

there is a strong resemblance between this group of charts and that included in the volume covering the earlier period of mission activity.

C. Reviews

One of the most effective techniques used in assuring that problems were receiving appropriate attention was in the use of continuing reviews—regular Quarterly Reviews of the Project by NASA Headquarters, and self review of selected areas of concern by the Project, itself. These latter were more frequent as time for encounter neared. Table 1 lists some of the major sessions.

Table 1. Major review sessions

Date, 1965	Subject	Location
23 February	Quarterly review	NASA HQ
3 May	Encounter planning	JPL
17 May	Occultation planning	JPL
25 May	Quarterly review	JPL
30 June	Encounter preparation status	JPL
23 July	Encounter review	JPL
2 August	Quarterly review	JPL
28 October	Quarterly review	NASA HQ

Encounter-readiness test critiques continued up to the day before fly-by. Finally, a post-encounter briefing was held to disseminate data to assure all Project participants' receiving the important information.

D. Problem/Failure Reports

During the subject period of the mission, problem/failure reports (PFRs) continued to be made on flight performance anomalies and on misoperation observed during the extended testing of the spare, MC-4 spacecraft, and of the proof test model (PTM), MC-1. Similar reports were prepared by the operations team against the Space Flight Operations Facility (SFOF); and when occasioned, malfunction reports were generated because of difficulties of the Deep Space Network (DSN).

In response to these notices, the cognizant organization was required, as in the development phase, (1) to undertake a thorough and responsible diagnosis of the problem, (2) to establish corrective and preventive measures, (3) to assure by supervisor signoffs that the best remedial steps had been taken, and (4) to follow up all problem areas by reviews.

A summary of PFRs appears as an appendix in Volume I of this *Mariner* Mars report.

E. Meetings

Unless superseded by other more important meetings, there were weekly meetings of Project Representatives. In addition, daily flight operations briefings were held. From these latter sessions, in which were discussed unusual spacecraft or science activities, were originated the daily technical bulletins and TWX s to Headquarters.

Shortly after the trajectory correction maneuver, the Space Flight Operation Director's team instituted a series of regular meetings devoted to encounter planning. Every facet of the encounter was probed and an optimum encounter plan was evolved.

Other groups meeting to solve particularly difficult tasks were those concerned with occultation and data processing operations.

F. Workshops

In the design, development, and testing of the *Mariner IV* spacecraft, use was made of certain technologies that reached new limits. Since, in some cases, requirements could not be met by use of existing methods, new techniques were evolved to meet the unique engineering demands of the mission.

Steps were taken to disseminate information of these advanced technologies to aerospace affiliated personnel and to others who might benefit from its application. Project members were encouraged to contribute to, and participate in, professional conferences and symposiums and to submit papers for professional journal publication. Three areas of serious concern to the *Mariner* Project were the subjects of technical workshops hosted by the Jet Propulsion Laboratory, with attendance ranging from 50 to 150. The Magnetics Workshop (Ref. 1) was held 30 March to 1 April 1965; the Thermal Workshop met 23–24 June; and the High Voltage Workshop (Ref. 2) convened 18–20 August 1965.

In addition to the above cited proceedings, a list of available documents pertaining to many aspects of *Mariner IV* history are listed in Appendix C.

II. TRAJECTORY AND ORBIT DETERMINATION

A. *Trajectory*

1. Launch Phase

The *Mariner IV* spacecraft was launched from Launch Complex 12 at the Air Force Eastern Test Range (AFETR), Cape Kennedy, Florida, on Saturday, 28 November 1964, using an *Atlas D/Agena D* launch vehicle. Launch occurred at 14:22:01.309 GMT, with an inertial launch azimuth of 90.5 deg east of north. After liftoff, the booster rolled to an azimuth of 91.4 deg and performed a programmed pitch maneuver until booster cutoff. During the sustainer and vernier stages, adjustments in vehicle attitude and engine cutoff times were commanded, as required, by the ground guidance computer, to adjust the altitude and velocity at *Atlas* vernier cutoff. After *Atlas/Agena* separation, there was a short coast period prior to the first ignition of the *Agena* engine. At a preset value of sensed velocity increase, the *Agena* engine was cut off. At this time, both the *Agena* and the attached spacecraft were coasting in a nearly circular parking orbit in a southeasterly direction at an altitude of 188 km and traveling at an inertial speed of 7.80 km/sec.

After a parking orbit coast time of 32.25 min, determined by the ground guidance computer and transmitted to the *Agena* during the *Atlas* vernier stage, a second ignition of the *Agena* occurred. Ninety-six seconds later, the *Agena* was cut off with the *Agena*-spacecraft combination in a nominal Earth–Mars transfer orbit.

The launch phase ascent trajectory profile is illustrated in Fig. 2, and a sequence of events, from launch to Canopus acquisition, is shown in Fig. 3.

2. Near-Earth Phase

Injection (second *Agena* cutoff) occurred at 15:04:27.7 GMT over the Indian Ocean at a geocentric latitude and longitude of −26.25 and 68.82 deg, respectively. At that time the *Agena*-spacecraft combination was at an altitude of 197.2 km and traveling at an inertial speed of 11.443 km/sec. The geocentric characteristics of the *Agena-Mariner IV* trajectory are listed in Table 2.

At 1 min 23 sec after injection, the *Agena* combination entered the Earth's shadow. The *Agena* separated from the spacecraft 1 min, 18 sec later. At 15:17:34.8 GMT, *Mariner IV* left the shadow after a total shadow duration of 11 min, 44 sec. Within an hour after injection, the spacecraft was receding from the Earth in almost a

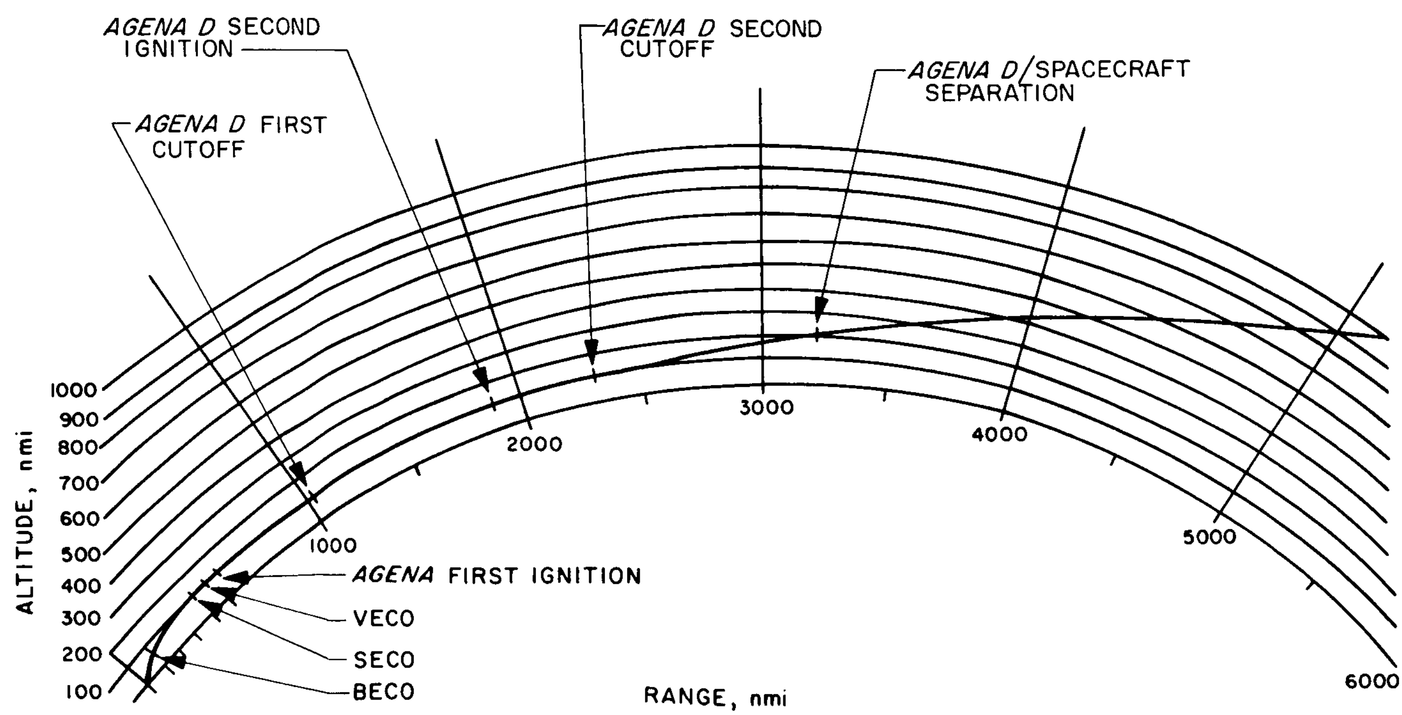


Fig. 2. Ascent trajectory profile

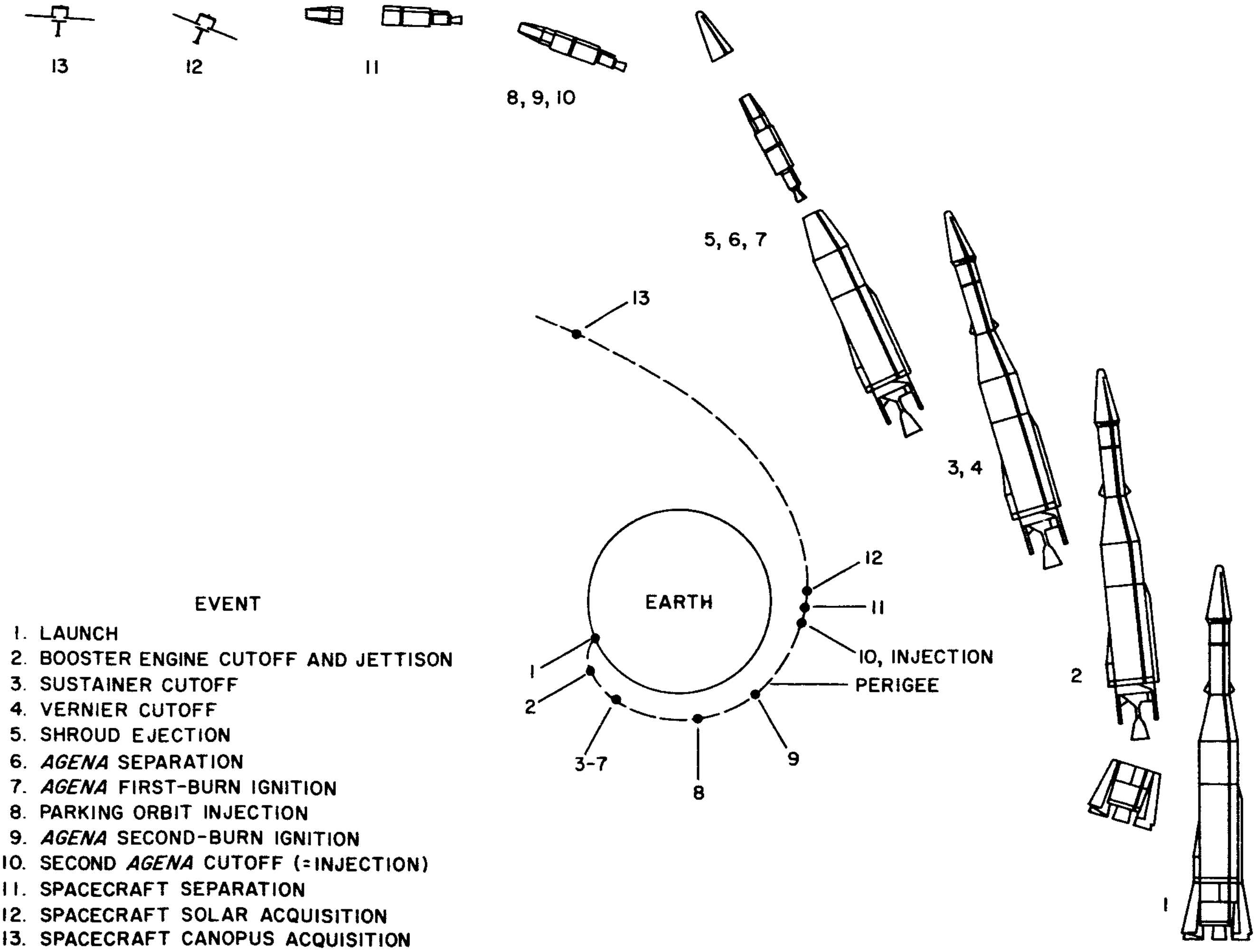


Fig. 3. Sequence of events to Canopus acquisition

Table 2. Geocentric characteristics of *Mariner IV* trajectory

Characteristic	Pre-encounter (injection)	Pre-encounter (post-midcourse)	Post-encounter
Parameter			
Radius R, km	6872.9574	2,022,402	228,218,340
Inertial speed V, km/sec	11.206585	3.1515691	30.785551
Earth-fixed speed v, km/sec	10.775777	142.00596	16,550.953
Geocentric latitude ϕ, deg	−28.130141	15.678090	−5.1082557
Longitude θ, deg	86.212637	186.01606	289.33886
Right ascension Θ, deg	20.742333	142.85406	192.49794
Path angle of inertial velocity Γ, deg	12.650441	89.557318	30.007818
Azimuth of inertial velocity Σ, deg	90.421969	47.958569	110.91233
Path angle of Earth-fixed velocity γ, deg	13.165104	1.2716438	0.05330023
Azimuth of Earth-fixed velocity σ, deg	90.439744	270.00658	269.96705
Time of event T, GMT	15:07:57 (28 Nov 1964)	16:09:25 (5 Dec 1964)	21:27:02 (23 July 1965)
Hyperbolic orbital element			
Semimajor axis a, km	−41,535.874		
Eccentricity e	1.1580740		
Inclination to Earth's equator i, deg	28.133045		
Longitude of ascending node Ω, deg	111.63727		
Argument of perigee ω, deg	245.65952		
Perigee distance p, km	6565.7425		
Time of perigee passage T, GMT	15:03:53.852 (28 Nov 1964)		

radial direction with decreasing speed; this reduced the geocentric angular rate of the spacecraft (in inertial coordinates) until the angular rate of the Earth's rotation exceeded that of the spacecraft. The phenomenon is illustrated (Fig. 4) on a map showing the Earth-track of the spacecraft reversing its direction from increasing to decreasing longitude. Also shown is the tracking station coverage and location of the various boost vehicle and spacecraft events.

After several days of continuous tracking, it was estimated that, without a midcourse correction, the spacecraft would pass the upper leading edge of Mars at a closest approach distance of 253,800 km. Closest approach would have occurred at 01:27:00 GMT on 17 July 1965. Comparison of these results with the desired Mars trailing edge pass indicated that the launch-vehicle's injection guidance system had performed within 3σ (three times the standard deviation) of the nominal values.

3. Midcourse Maneuver Phase

To alter the trajectory so as to pass through a selected aiming region located at approximately 10,000 km from the center of Mars, a midcourse maneuver, utilizing a 16.70 m/sec velocity increment (87 m/sec capability), was required. In addition to altering the miss distance at Mars, this correction was selected to change the arrival time to 01:46:00 GMT on 15 July 1965, thus allowing the spacecraft's CC&S to activate various subsystems at the correct times near encounter. To properly align the thrust direction of the midcourse motor for the burn, a −39.16 deg pitch turn and 156.06 deg roll turn were required. The midcourse motor was ignited at 16:09:25 GMT on 5 December 1964, at which time the spacecraft was at a geocentric distance of 2,022,400 km and moving at an inertial speed of 3.139 km/sec relative to Earth. Analog data received at the Goldstone Tracking Station and relayed to the JPL Space Flight Operations Facility gave positive indication that the midcourse

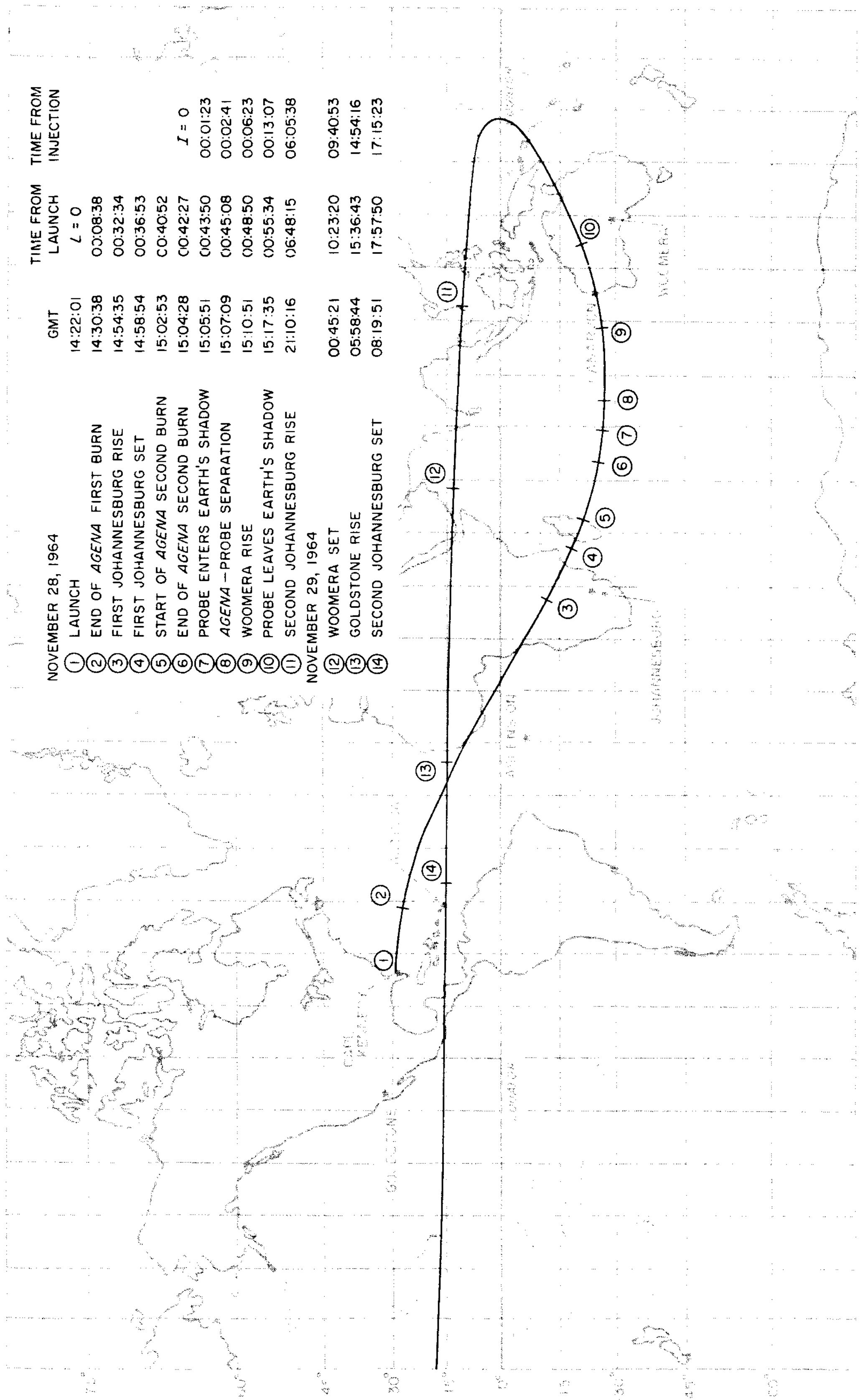


Fig. 4. Earth track of *Mariner IV* trajectory

maneuver and motor burn had been executed precisely. This was further verified by the observed doppler data, which were essentially the same as those predicted for the maneuver.

4. Cruise Phase

Following the midcourse maneuver, the spacecraft reacquired the Sun and Canopus, thus returning to the cruise mode. At this time the spacecraft was moving primarily under the gravitational influence of the Sun in an ellipse with the Sun at the focus. During the early portion of the cruise phase, the spacecraft's heliocentric velocity was greater than the Earth's, causing the spacecraft to lead the Earth around the Sun. This phenomenon is illustrated in Fig. 5, which contains a heliocentric plan view of the orbits of Earth and *Mariner IV* during the first 35 days of flight. Slowly, however,

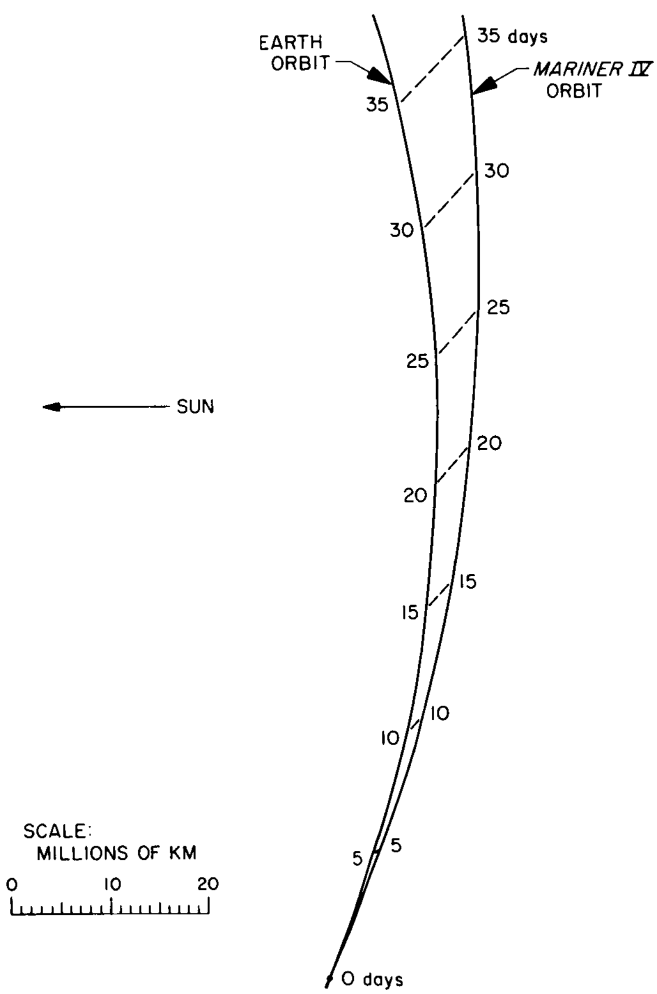


Fig. 5. Heliocentric plan view of *Mariner IV* trajectory during first 35 days of flight

Mariner began to move out toward the orbit of Mars with decreasing heliocentric speed. On 28 February 1965 (61 days after launch), the Earth finally passed the spacecraft in its orbital motion around the Sun. At this time, the spacecraft was at a distance of 18.9-million km behind the Earth and 320,000 km above the ecliptic plane. Throughout the rest of the flight, the Earth increased its lead in orbital rotation about the Sun (Fig. 6).

Figures 7 to 13 present curves of geocentric radius, geocentric speed, heliocentric radius, heliocentric speed, areocentric radius, Earth cone angle, and Earth clock angle as functions of flight time from launch to Mars encounter. Note in Fig. 12 that the minimum Earth cone angle (Earth-Spacecraft-Sun angle) was approximately 1 deg, rather than 0 deg, when the Earth passed the spacecraft in its orbital revolution around the Sun. (If the inclination of the heliocentric transfer orbital plane to the ecliptic plane had been 0 deg, the minimum Earth cone angle would have equaled 0 deg.) The heliocentric characteristics of the *Mariner IV* trajectory are shown in Table 3.

Table 3. Heliocentric orbital elements of *Mariner IV* trajectory

Elliptical orbital element	Pre-encounter orbit	Post-encounter orbit
Semimajor axis a, km	190,929,830	200,588,100
Eccentricity e	0.22750296	0.17322007
Inclination to the ecliptic i, deg	0.12569963	2.5437401
Longitude of ascending node Ω, deg	68.665534	226.75545
Argument of perihelion ω, deg	352.56527	200.64908
Perihelion distance p, km	147,492,730	165,842,220
Time of perihelion passage T, GMT	23:11:28 (23 Nov 1964)	07:25:19 (16 Nov 1964)
Period P, days	526.64530	567.11321

During the interplanetary phase of the flight, several orbital computations were made covering the period from the midcourse maneuver on 5 December 1964 to 10 July 1965 when the mass of Mars caused the first detectable perturbation in the *Mariner IV* trajectory. On the basis of these computations, it was determined that the closest approach to the surface of the planet would be 12,322 km occurring at 01:04:49.5 GMT, 15 July 1965. The areocentric characteristics of the *Mariner IV* trajectory as predicted during the interplanetary portion of the flight are listed in Table 4.

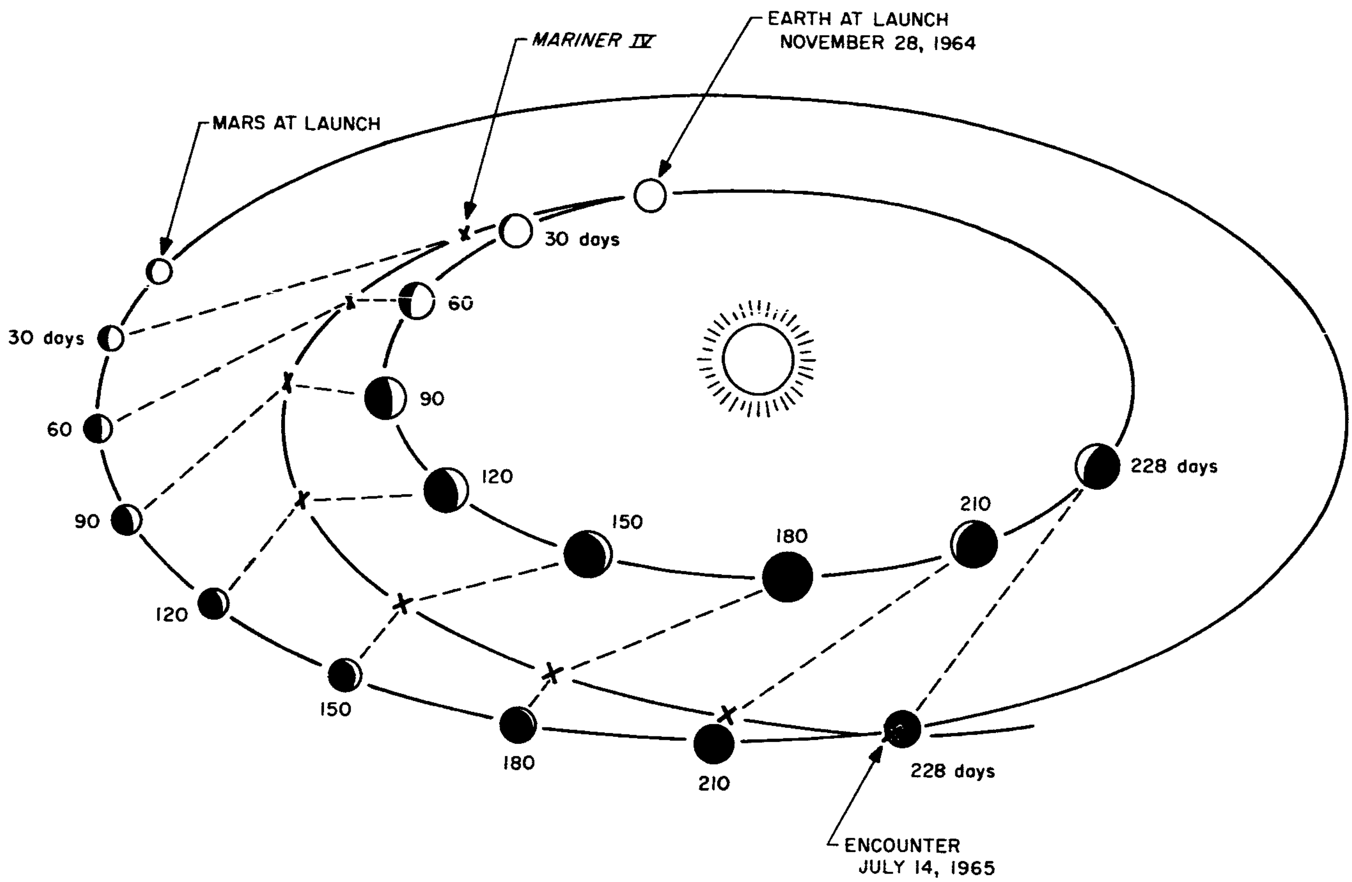


Fig. 6. General relationship of Earth, Mars, and *Mariner IV* during cruise to encounter

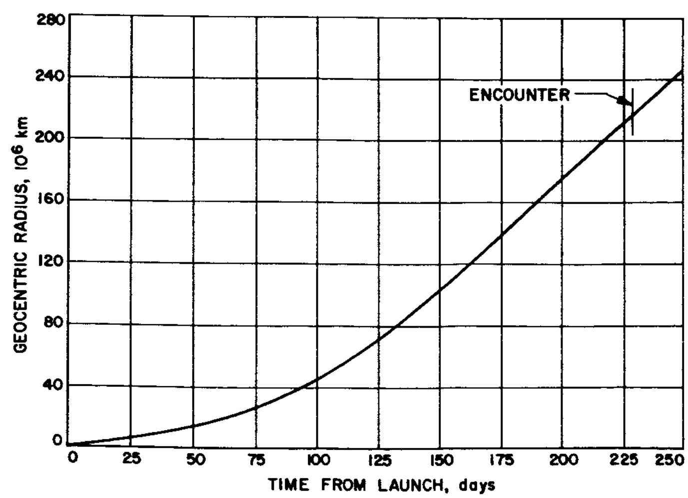


Fig. 7. Geocentric radius vs time from launch

Table 4. Areocentric orbital elements of *Mariner IV* trajectory

Hyperbolic orbital element	Pre-encounter prediction	Actual Mars-encounter orbit
Semimajor axis a, km	−22,046	−22,092
Eccentricity e	0.65894	0.69753
Inclination to the ecliptic i, deg	60.458	58.186
Longitude of ascending node Ω, deg	188.009	187.499
Argument of periapsis ω, deg	289.546	289.321
Periapsis distance p, km	12,322	13,201
Time of periapsis passage T, GMT	01:04:49.5 (15 July 1965)	01:00:58.1 (15 July 1965)

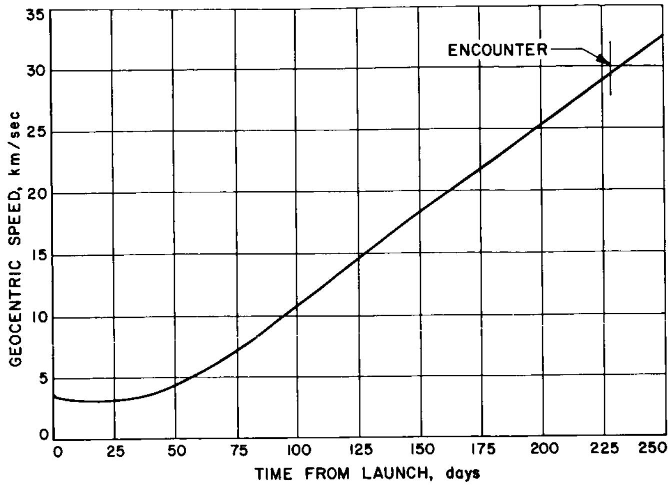


Fig. 8. Geocentric speed vs time from launch

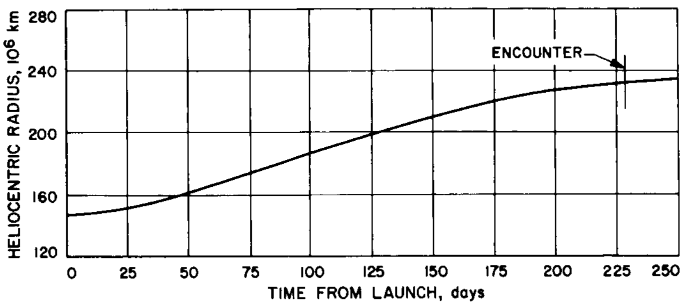


Fig. 9. Heliocentric radius vs time from launch

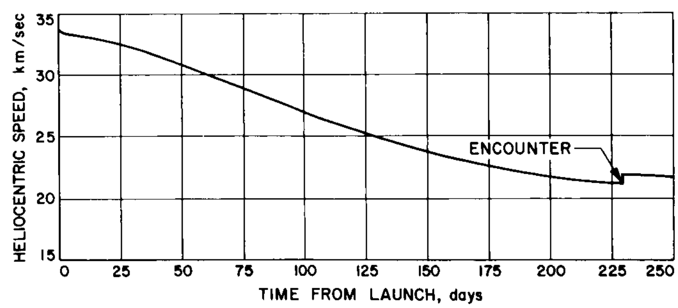


Fig. 10. Heliocentric speed vs time from launch

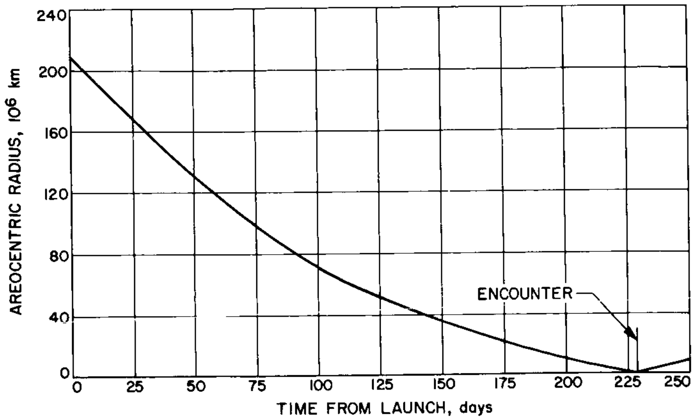


Fig. 11. Areocentric radius vs time from launch

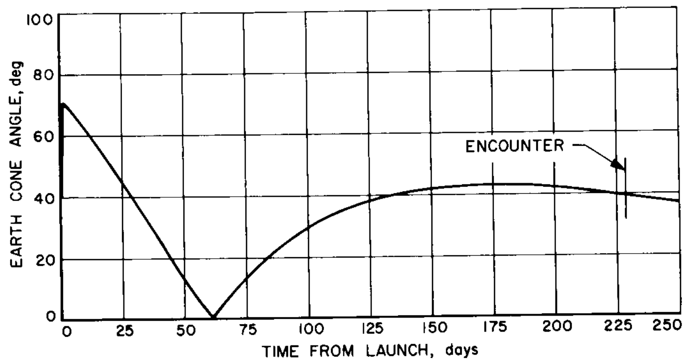


Fig. 12. Earth cone angle vs time from launch

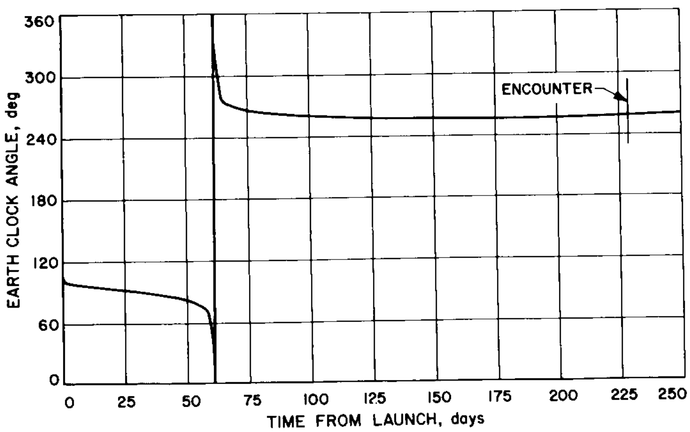


Fig. 13. Earth clock angle vs time from launch

5. Encounter Phase

Mariner IV approached Mars along the trailing edge and from inside the planet's orbit (Fig. 14). Figure 15 illustrates the areocentric geometry of the flight past Mars. At about 43.5 min before closest approach, or at a distance of about 18,000 km from the planet's center, the Narrow-Angle Mars Gate sensed the planet, causing the tape recorder to start recording TV data 1 min 12 sec later. At a distance of about 13,196 km from the planet's center, after a 25 min 12 sec picture taking sequence, the scan platform moved permanently off the planet because of the angular movement of the spacecraft in its hyperbolic orbit about Mars. At 02:19:11 GMT, the spacecraft

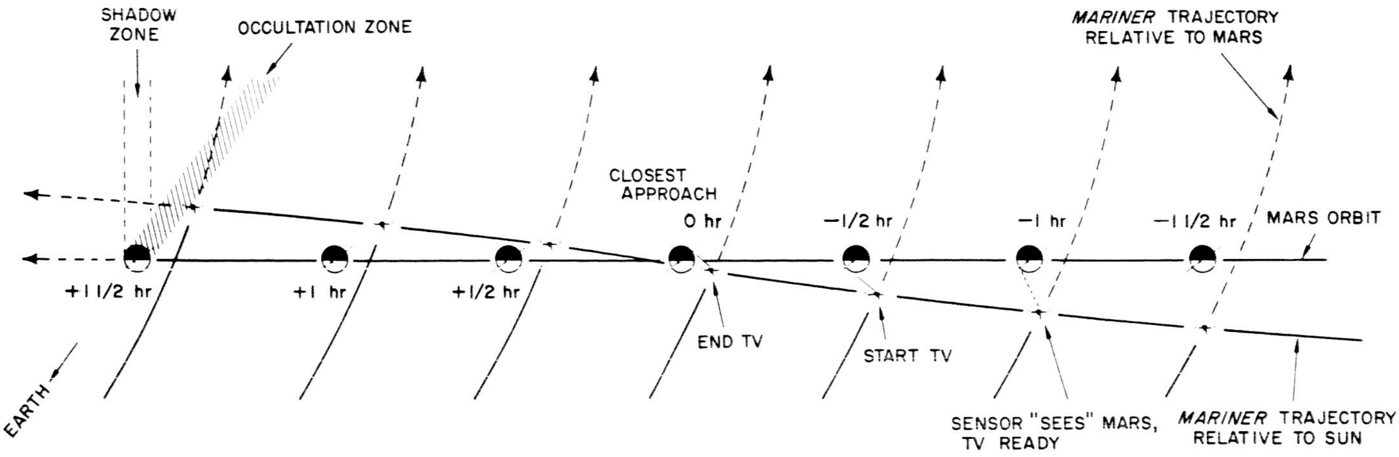


Fig. 14. ***Mariner IV*** **and Mars orbits near encounter**

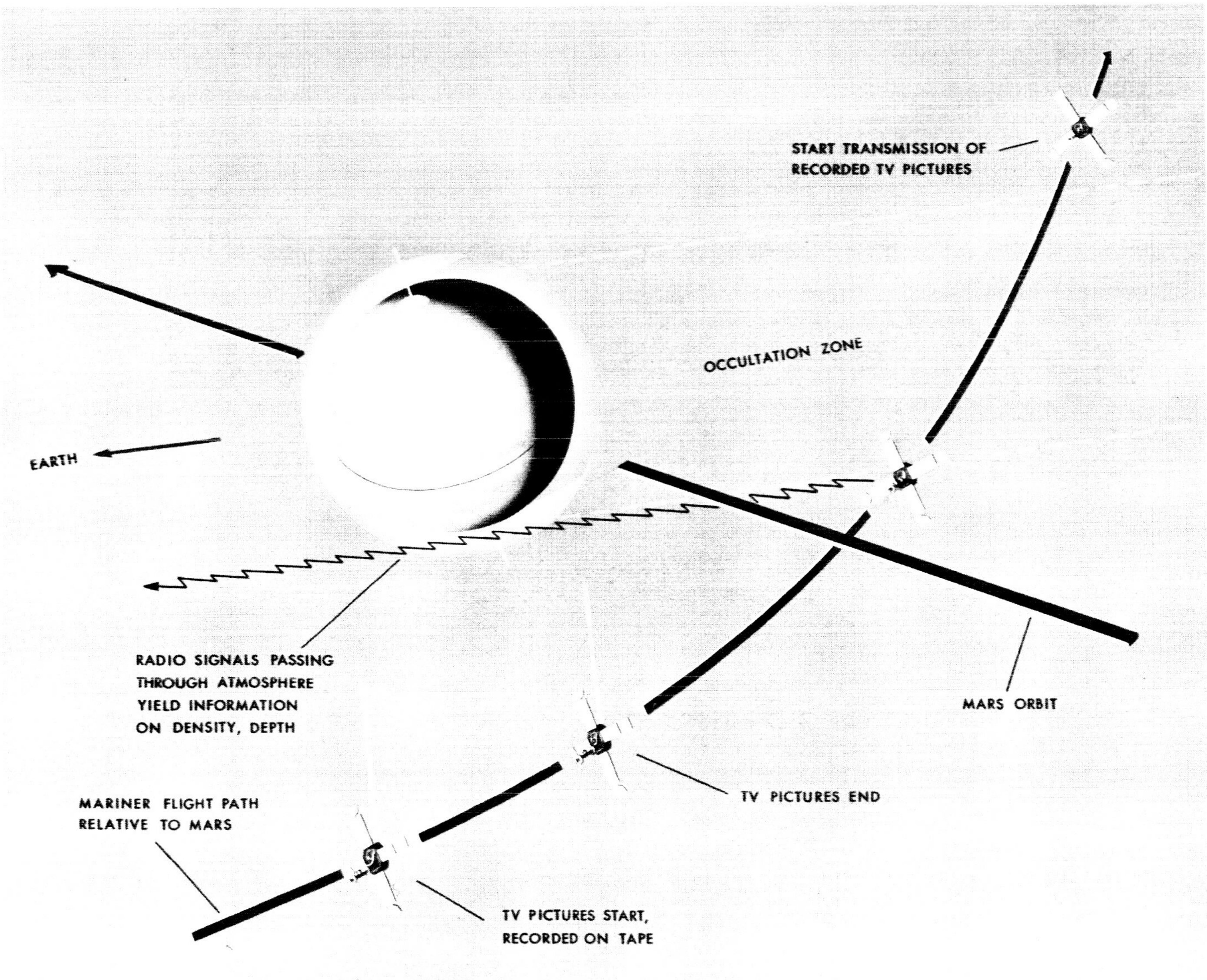


Fig. 15. ***Mariner IV*** **encounter of Mars as seen from inside Mars orbit**

passed behind Mars as seen from Earth (enter occultation). The spacecraft emerged from occultation at 03:13:04 GMT after remaining behind the planet for 53 min 53 sec.

Tracking data gathered and analyzed during the encounter sequence indicated that the Mars encounter trajectory as predicted during the cruise portion of the flight was slightly in error. Orbit computations made as early as 1 hr before encounter revealed that the actual closest approach distance would be 13,201 km (instead of 12,322 km) occurring at 01:00:58 GMT. The principal causes of this discrepancy were an error in the operational value of the astronomical unit (AU) and errors caused by small forces originating in the attitude control system. The areocentric characteristics of the *Mariner IV* trajectory as determined from encounter data are shown in Table 4.

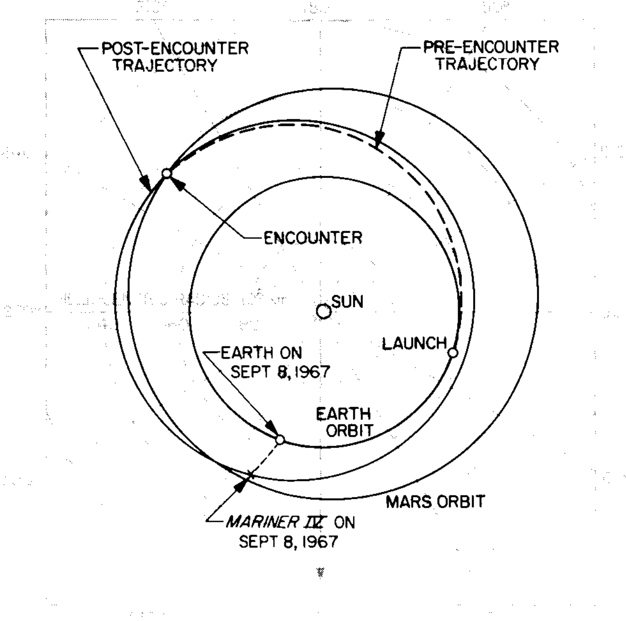


Fig. 16. Heliocentric plan view of *Mariner IV* pre- and post-encounter orbits

6. Post-Encounter Phase

As it left the vicinity of Mars, the planet's gravitational pull altered the spacecraft's heliocentric orbit to such an extent that the perihelion distance changed from 147,493,000 to 165,842,000 km (Fig. 16). Because the spacecraft passed underneath the planet, a heliocentric-orbit-plane change of 2.67 deg occurred between the pre- and post-encounter orbits. To illustrate this effect, a plot of spacecraft celestial latitude as a function of calendar date is given in Fig. 17. By reference, again, to Fig. 16, it may be noted that the *Mariner IV* post-encounter orbit does not intersect the Earth's orbit. The minimum distance between these orbits, which represents the smallest possible closest approach distance between the Earth and spacecraft, equals 16,244,000 km. Figure 18, which contains a plot of geocentric radius as a function of calendar date, reveals that the spacecraft will attain a close encounter with the Earth in 1967.

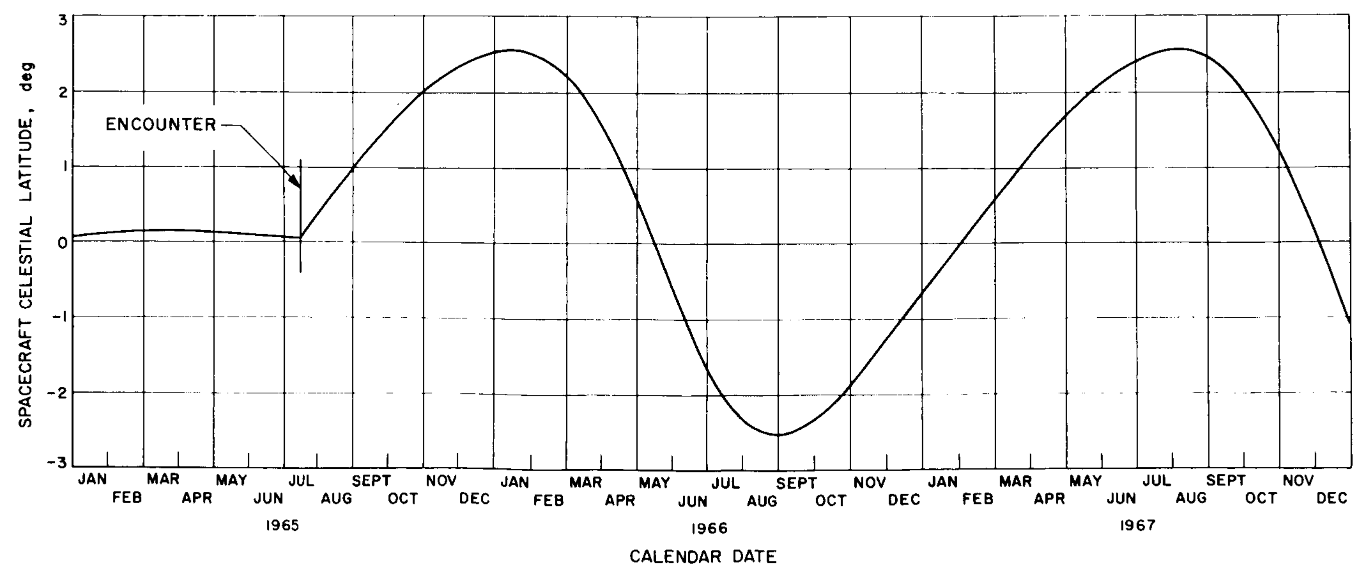


Fig. 17. Spacecraft celestial latitude vs calendar date

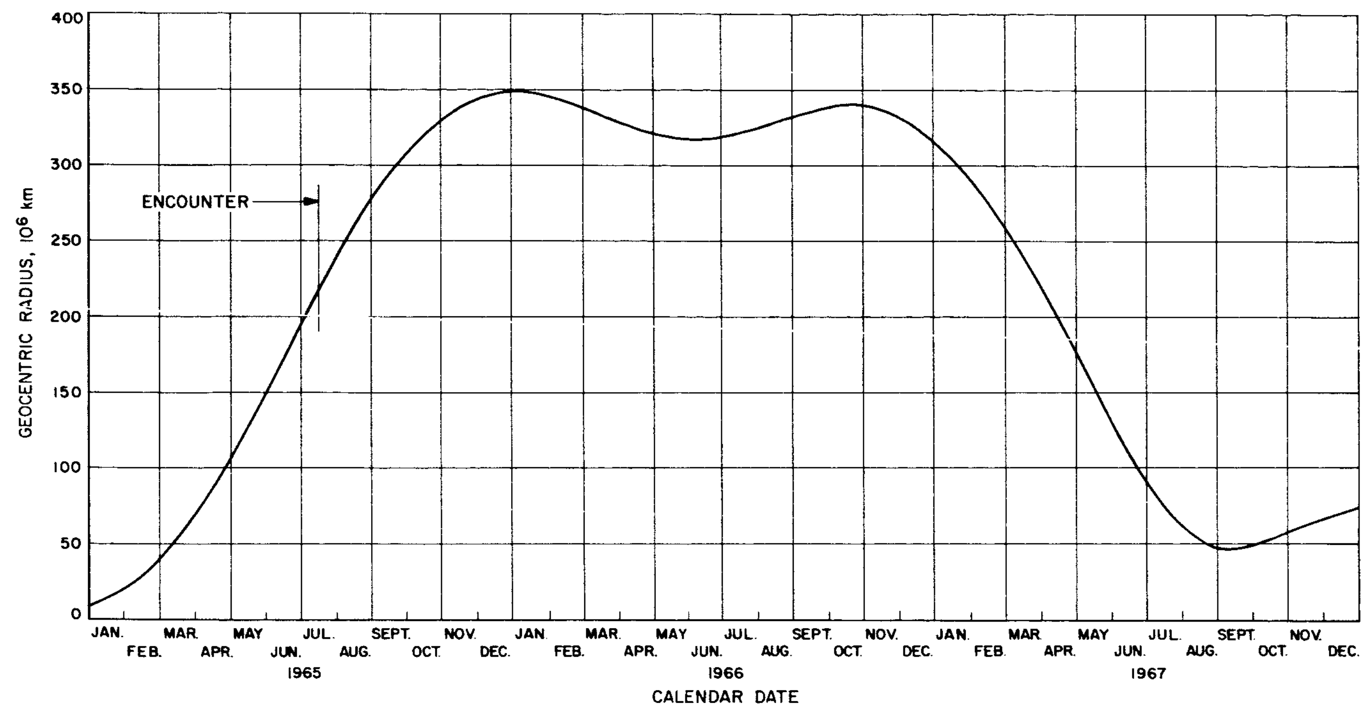


Fig. 18. Geocentric radius vs calendar date

This pass, to occur on September 8, will yield a closest approach distance of about 47-million km. Curves of various heliocentric trajectory parameters for the post-encounter orbit are given as a function of calendar date in Figs. 19 to 22. The heliocentric characteristics of the *Mariner IV* post-encounter trajectory are shown in Table 3.

B. Orbit Determination

This section of the report presents a summary of the orbit results obtained from the *Mariner Mars* Mission. It will be divided into six categories.

1. *Tracking Data Validity and Usage,* containing a discussion of the high-frequency noise seen on the

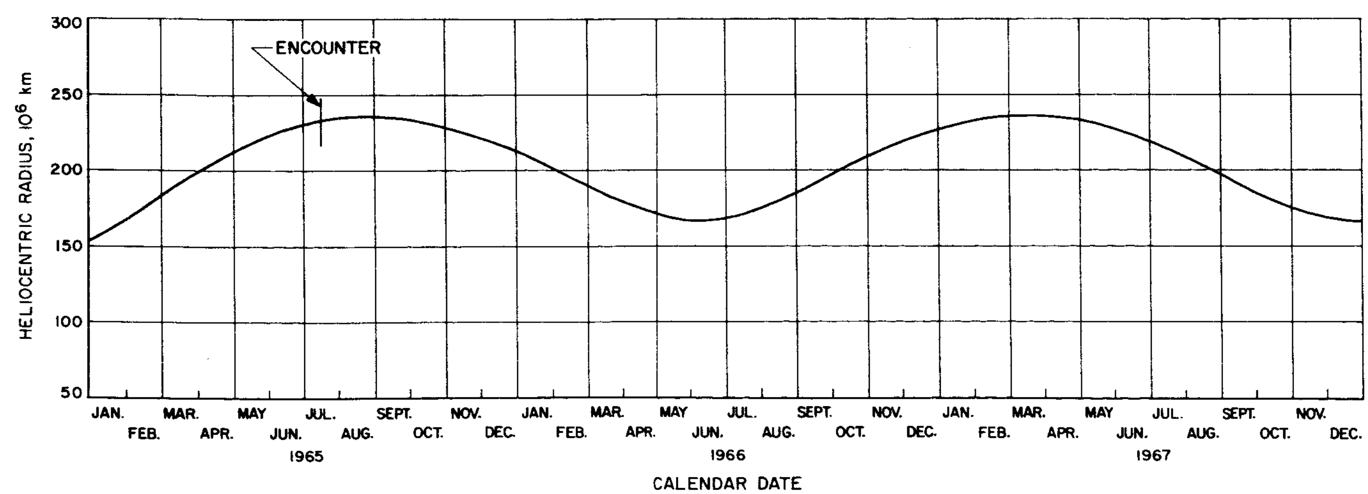


Fig. 19. Heliocentric radius vs calendar date

doppler tracking data, the actual data weights used for *Mariner IV*, and the rationale for using that weighting scheme

2. *The Mariner IV Encounter Orbit Tracking from Encounter (E) − 5 Days to E + 5 Days*, presenting a very accurate encounter orbit and giving both statistical and non-statistical evidence for its validity (this orbit referred to as the *true* encounter orbit)

3. *Evaluation of Combined Pre-Midcourse Orbit and Maneuver Errors*, evaluating the combined error, based on the actual target point and the achieved target point (a preliminary effort to show how much of the total errors might have been due to orbit determination error)

4. *Cruise Orbit Determination Errors*, including discussion and plots of errors (predicted target point

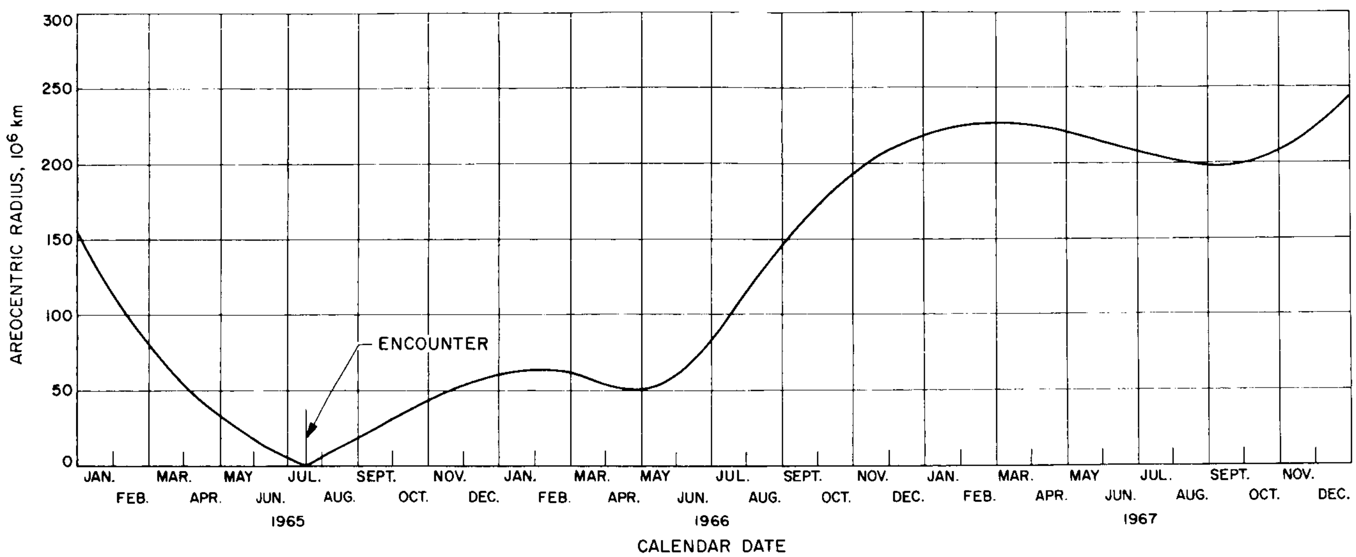


Fig. 20. Areocentric radius vs calendar date

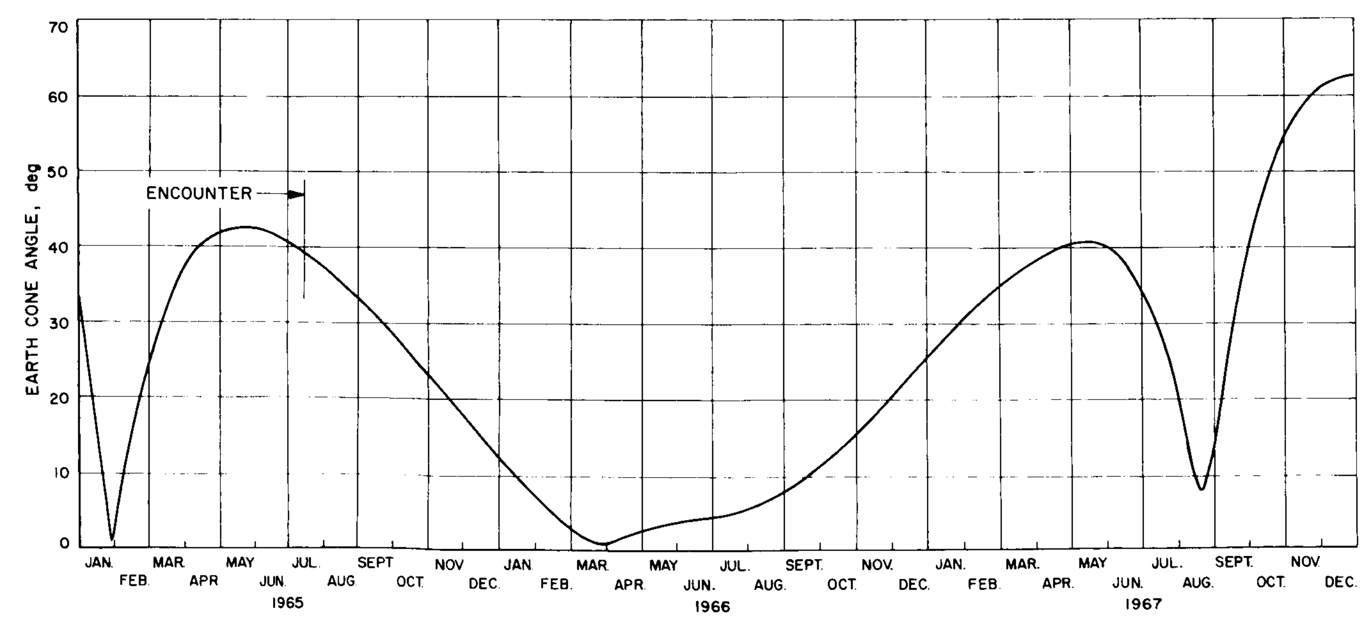


Fig. 21. Earth cone angle vs calendar date

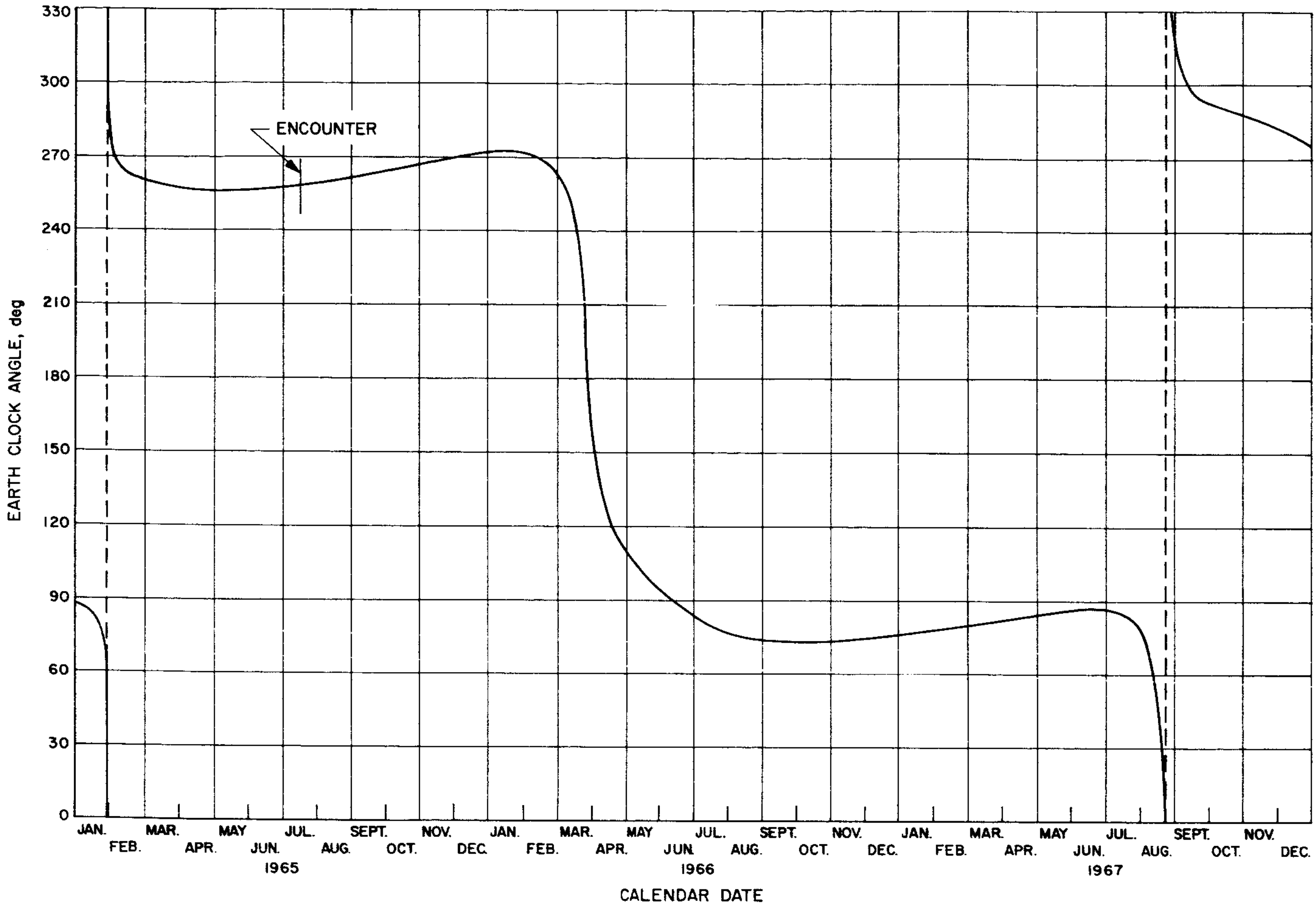


Fig. 22. Earth clock angle vs calendar date

minus actual achieved target point) as a function of time from midcourse until 10 July 1965 (E − 5 days)

5. *Near-Encounter Orbit Errors*, presenting the real-time orbit errors from E − 10 hr to E + 5 hr

6. *Conclusions*, discussing the known error sources and giving a brief discussion of future investigations

1. Tracking Data: Validity and Usage

Two-way DSIF doppler data comprised the only data type used in the orbits described here. Data were taken continuously during such critical phases of the mission as pre-midcourse maneuver and closest approach to Mars; data taken during other phases averaged 24 hr/5 day (these figures refer to 2-way doppler, only). Data acquisition was from Goldstone, California; Johannesburg, South Africa; Woomera and Canberra, Australia; and Madrid, Spain. The data time span considered here is from launch (28 November 1964) until 1 October 1965 (E + 2½ mo). There is a reasonably good chance of obtaining more tracking data when *Mariner IV* passes by the Earth in late 1967. These data were coherent without involving any use of microwave links to achieve coherency. No observable biases due to equipment were observed in the data, and the bias due to lack of knowledge of the refraction correction was minimized by allowing only data above 17 deg elevation in the orbit fits. High-frequency noise on the data was less than 0.02 cps for doppler counted over 60 sec. At the S-band frequency of 2295 Mc, this accuracy is equivalent to 0.12 cm/sec error in the range rate of the probe relative to the tracking station. It was possible to increase this resolution either by counting over larger counting intervals (accomplished by data processing of the original 60 sec sampled data) or by multiplying the doppler frequency to be counted by a factor (for *Mariner IV* a factor of 8) before the counting was performed. Thus, the data noise was generally $<$ 0.003 cps S-band (0.02 cm/sec) as seen in the orbit residuals. The 0.003 cps represents the limiting accuracy of the existing single precision orbit determination program (ODP) to compute tracking data. The principal advantage to *Mariner IV* of such small data noise is in being able to see biases in the orbit residuals more clearly. Unfortunately, the physical model of the universe in the ODP is not exact, and this fact prohibits making the best use of the data. Since the ODP takes into account only those error sources formally implemented in a deterministic solution model and since the accuracy claimed by the ODP for its answers is directly proportional to the accuracy the user claims for his data (assuming that no a priori information is used), the ODP for planetary cases would give grossly optimistic accuracy estimates if the input data accuracy estimate (data weight) were the same as the high-frequency noise on the data. This has been confirmed by actual experience with *Mariner II* and *Mariner IV*. Furthermore, if the no a priori answers obtained from tracking data are combined with a priori constants which have reasonable associated statistics (such as the AU, station locations, and the solar pressure coefficients) as is actually done for most orbits, the a priori constant values will be outweighed by the no a priori values. Thus, an error in the actual orbit itself can be induced by data weights that are too small. To avoid this as much as possible and to produce ODP statistics (tracking plus a priori data) that are reasonable, a semi-arbitrary range rate weight of $\sigma_{\dot{r}} = 3$ cm/sec was chosen for 60-sec sampled data. Note that this is approximately 30 × larger than the noise seen on 60-sec counted S-band doppler and more than 150 × the noise on the 600-sec S-band data typically used in orbits. When 600-sec counted data are used (data points 600 sec apart) the $\sqrt{N}$ rule is used; this produces a weight of $\sigma_{\dot{r}} = 3/\sqrt{10} \cong 1$ cm/sec. Essentially, this weighting scheme assumes that low-frequency biases due to program insufficiencies and physical model errors are the dominating error source and that data noise is so small as to be a negligible error source.

It is obvious that using large data weights to compensate for orbit errors is not an optimum procedure. Unfortunately, it is the only one currently available and, therefore, was used for both *Mariner II* and *Mariner IV*. The error sources for *Mariner IV* and the planned remedies for them are discussed under headings 4 and 5 of this section. In the absence of valid statistical descriptions of the orbit solutions, the labeling of solution parameters with statistical error estimates becomes a matter of engineering judgement. In making those judgements, particular attention is paid to three factors:

1. The stability of a parameter being solved for when the conditions of the problem are varied (For example: (a) other important parameters can be frozen at various values and the effect on the parameter under test noted, or (b) solutions may be made using data from a single tracking station. By comparing several solutions of this type, a definite test can be made for the presence of bad tracking data.)
2. The ability of the ODP to predict future measurable events such as Mars occultation times and future doppler observables
3. The ability of the ODP to predict future events which are not directly observable but which are felt to be well determined after the conclusion of the mission (The near Mars orbit is believed to be such an observable.)

2. *Mariner IV* Post-Flight-Encounter Orbit Tracking from E − 5 Days to E + 5 Days

This section presents a representative orbit computed after the flight on 30 October 1965. The epoch to which the initial position and velocity were referenced was on 10 July 1965 (E − 5 days).

a. A priori 1σ statistics input to the ODP.

1. Geocentric position and velocity of the probe,
   $\sigma_{pos} = 10{,}000$ km spherical uncertainty
   $\sigma_{vel} = 10$ m/sec spherical uncertainty
   a priori values taken from cruise tracking
2. Mass ratio of Mars to the Sun
   $\sigma_{m_M/m_S} = 2\%$
   a priori value $0.32280422 \times 10^{-6}$
3. Solar pressure coefficient
   $\sigma_{1+G} = 5\% \cong 5\%$ of the total solar pressure force of 2 dynes
   a priori value for $1 + G = 1.2067$
4. Astronomical unit
   $\sigma_{AU} = 2{,}000$ km
   a priori value = 149,598,500 km
5. Station locations
   $\sigma_{pos} = 50$ m spherical
   a priori values from surveys, *Ranger* results and pre-*Mariner IV* encounter solutions

b. Best available encounter orbit. When the solution was made, the geocentric position changed by slightly less than 1000 km, the geocentric velocity by approximately 1 m/sec, the solar pressure by 0.005%, and the station locations by less than 10 m. The solutions for the AU and mass of Mars with their associated ODP 1σ statistics follow:

AU = 149,597, 470 $\pm$240.
and $m_M/m_S = (.322728 \pm 0.000015) \times 10^{-6}$

The encounter orbit parameters follow:

E = Time of closest approach = TCA = 15 July 1965 $01^h\ 0^m\ 58^s180$ (GMT)

B = 15,251.5 km $\pm$15

$\mathbf{B \cdot T}_c$ = 8,141.6 km $\pm$20

$\mathbf{B \cdot R}_c$ = 12,896.6 km $\pm$20

Tracking data used in the fit was 600-sec counted doppler data, except that 60-sec counted doppler data were used from $E - 4$ hr to $E + 4$ hr. The important points are discussed in the following paragraphs.

First, in a variety of other encounter orbits, the solutions for the encounter orbit (**B**, TCA, etc.) and the mass of Mars remained very stable. The range of values for the $\mathbf{B \cdot T}_c$ and $\mathbf{B \cdot R}_c$ components from the values quoted above was less than 5 km in all cases, the range of values about TCA was less than 2 sec; and finally, the range of values for m_M/m_S from the quoted value was less than 0.01%.

Second, for reasons probably connected with the stability of the single precision computer program, a solution which included the AU always resulted in larger residuals between computed and observed data than a solution that did not include the AU. However, the numerical value of the AU solution fell within a range of 200 km of the quoted value. It was shown that even if AU were frozen at a value of 149,598,500 km, which is 1000 km higher than the quoted solution, the target orbit and m_M/m_S remained within the ranges given above. This would indicate, since AU is an ephemeris parameter, that ephemeris error does not affect the quoted solution significantly. Monte Carlo simulation studies, changing the look-up argument between Universal Time and Ephemeris Time by 20 sec, showed similar results.

Third, even for orbits fitting data from midcourse through E + 5 days, the range of values about **B** was less than 50 km, the range of m_M/m_S less than 0.1%, and the range of AU less than 1000 km. This is surprising because, in most of these runs, no provision was made to solve for the Earth–Mars ephemeris errors and because the single precision ODP is not adequate for making such orbits.

Fourth, the uncertainty in the radius of Mars obtained by astronomical measurements was approximately 50 km. The observed enter occultation time of the radio signal compared very favorably with that predicted by the encounter orbit and an average value of R_{Mars} (3378 km), thus indicating the orbit was valid to within 50 km.

Fifth, it is concluded from the preceding four points, that the encounter orbit has been well determined and the following 1σ uncertainties might reasonably be attached:

$\sigma_{\mathbf{B \cdot T}_c} = \mathbf{B \cdot R}_c = 20$ km

$\sigma_B = 10$ km

$\sigma_{TCA} = 10$ sec

$\sigma_{m_M/m_S} = 0.02\%$ of m_M/m_S

$\sigma_{AU} = 500$ km

3. Evaluation of Combined Pre-Midcourse Orbit and Maneuver Errors

The aiming point for the midcourse maneuver made 5 December 1964 was:

B = 12011 km

$\mathbf{B \cdot T}_c$ = 6007 km

$\mathbf{B \cdot R}_c$ = 10401 km

TCA = $01^h\ 47^m$

The actual achieved target point from computation under the previous heading was:

B = 15251 km

$\mathbf{B \cdot T}_c$ = 8142 km

$\mathbf{B \cdot R}_c$ = 12897 km

TCA = $01^h\ 01^m$

Therefore, the errors were (actual minus desired)

ΔB = +3240 km

$\Delta \mathbf{B \cdot T}_c$ = +2135 km

$\Delta \mathbf{B \cdot R}_c$ = +2496 km

ΔTCA = −46 min

The actual error was approximately three-fourths of the specified 1σ requirement set by the *Mariner IV*

Project. The 1σ requirement on pre-midcourse orbit determination accuracy is given as 2250 km. This error is hard to assess since the estimated error is a strong function of AU and solar pressure. However, preliminary results have shown that an error of +1,000 to 1,500 km in $\mathbf{B \cdot T}_c$ and an error of +300 km in $\mathbf{B \cdot R}_c$ to be the most likely pre-midcourse orbit error. Much work remains if more definite numbers are required.

4. Cruise Orbit Determination Errors

Orbits were performed at an average of one per two weeks during the cruise phase (midcourse to E − 5 days) of the mission. During the first few months of the flight, the data were not strong enough to solve for AU so that, essentially, the AU was frozen at the JPL Venus radar bounce value of 149,598,500 (±500 km 1σ). Later it was possible to loosen the a priori on AU somewhat, allowing the data to participate more fully in determining AU. Since the solution for AU tended to change somewhat from week to week, there was a corresponding jumpiness in the target parameters, which was intensified when, approximately one month before encounter, the mass of Mars was added to the solution set. Thus, there was no set of runs done in real time during cruise that used the same a priori assumptions.

The plots (Figs. 23 to 25) of real-time orbit errors show trends consistent with the above procedures in that the orbits are stable for the first few months and then tend to jump around late in the mission. Two other curves are also shown in each of these figures. These curves represent systematic sets of runs done after the end of the mission in which all a priori conditions were held constant and data were added in 1-mo blocks. For one set of runs, AU was frozen at the JPL Venus bounce AU value of 149,598,500, and the other set AU was frozen at the value obtained from the *Mariner IV* encounter fit (149,597,500). All available features of the program were used in these latest runs, including improved timing equations, an improved estimate of the solar pressure from telemetry, and the use of solar pressure forces in two components normal to the Sun-probe line. These K/r_S^2 type forces were needed to approximate the forces induced by moving solar vanes on the ends of the solar panels. Since the telemetry measurements of these vane positions gave better knowledge of the normal solar forces than was possible by solving for these forces with tracking data, the corresponding constants were included in the trajectory but not the parameter solution list.

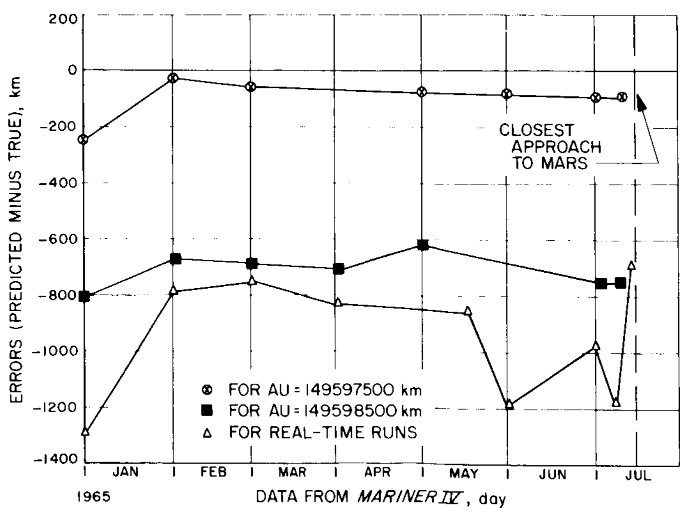


Fig. 23. *Mariner IV* errors in predicting $\mathbf{B \cdot T}_C$

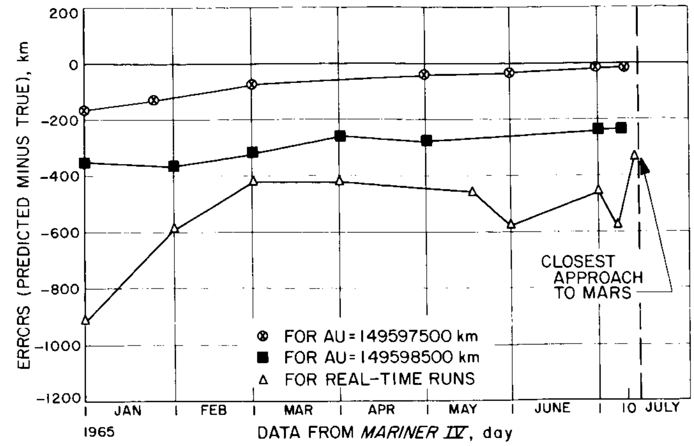


Fig. 24. *Mariner IV* errors in predicting $\mathbf{B \cdot R}_C$

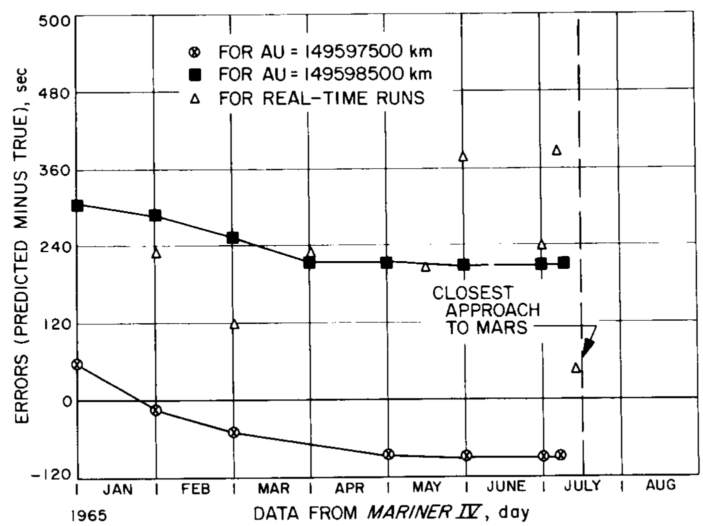


Fig. 25. *Mariner IV* errors in predicting time of closest approach

When AU = 149,597,500 km is used, the remarkable reduction of target prediction error enhances the validity of the otherwise suspect encounter AU solution. Other recent results from Venus radar bounce observations give a result of AU = 149,598,000 km. Therefore, since $\partial B/\partial AU = 0.6$, it is likely that the real-time AU value of 149,598,500 km produced a target error of from 300 to 600 km.

As for the real-time runs, it is seen that there are errors of from 500 to 1000 km throughout cruise, even though the consistency of the orbits is high for certain portions of the flight.

5. Near-Encounter Orbit Errors (Epoch 0^h 10 July 1965; Tracking Data from 0^h 10 July)

This section presents the errors in the orbits performed starting at closest approach, minus 10 hr. Note that the errors at that time are roughly those existing at the end of the cruise plots (Figs. 23 to 25). A priori sigmas were possibly somewhat tighter on position and velocity than would seem wise in the light of post-flight analysis. However, during the mission, there had been no evidence of an error of the size that actually existed. During the last 5 hr before encounter, two computers were operating. One computer was using $\tilde{\sigma}_{pos}$ = 500 km and $\tilde{\sigma}_v$ = 0.1 m/sec, while the other used $\tilde{\sigma}_{pos}$ = 200 km and $\tilde{\sigma}_v$ = 0.1 m/sec. Later, at approximately E − 1 hr, both computers used the looser a priori. The errors in several representative orbits are shown in Fig. 53. Considerably more work will be done in making systematic runs similar to the two cruise sets of runs described in the preceding section.

Operationally, the orbit errors during the period from E − 10 hr through E + 5 hr did not result in any degradation of the scientific results from *Mariner IV* including the television pictures and the Mars occultation data.

6. Conclusions

a. Adherence to specification. Operationally, the orbit determination error met the error specifications set by the *Mariner IV* project and did not degrade the performance of the mission significantly.

b. Deviation from predicted errors. The orbit errors during the cruise and near-encounter portion of the mission were 3- or 4-times larger than had been expected.

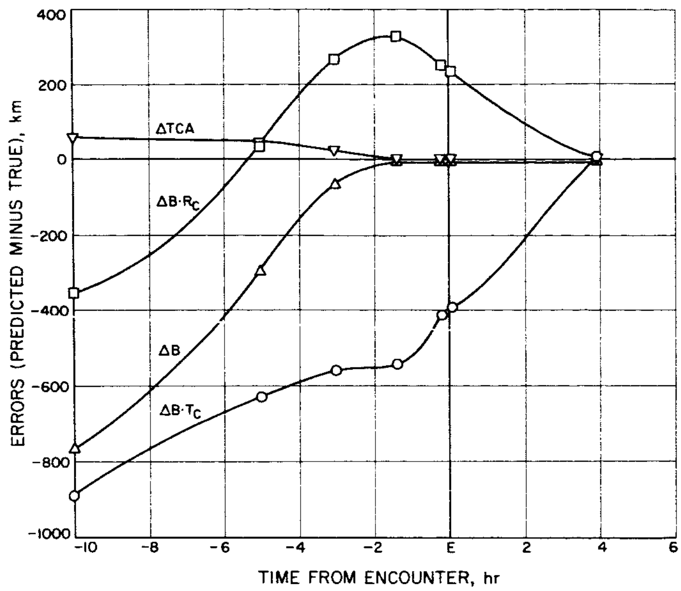


Fig. 26. Errors in predicting encounter quantities vs time, *Mariner IV*

Some of the possible causes, or multiple causes, are the following:

1. ODP computations are done mainly in single-precision (8-digit) arithmetic. This causes some instability in the cruise orbits but is not a major error source.

2. Solar pressure forces caused by solar vane positions were not implemented in ODP until after encounter. These forces cause a 200-km error.

3. Telemetry data indicated random forces of 0.5% of the solar-pressure force (or larger) due to valve leakage from the attitude control system. The leak rate was found to vary occasionally when a valve was actuated. From the limit cycle telemetry, it is possible to verify frequent changes in the leak rate of 0.5% of the solar-pressure force. The solar-pressure force averaged 4 dynes on the 260 kg *Mariner IV* spacecraft. The time-averaged translational force due to the total leak rate is greater than this but very probably no greater than 3% of the solar-pressure force. Pre-flight measurements of leak rate on the *Mariner IV* valves typically showed leak rates in the range of 0.5 to 2% of the solar pressure force. One percent of the solar pressure force maps into a B-plane error of 200 km.

4. Planetary ephemeris error is a possible error source, although the ephemerides are believed to be accurate to 400 km (3σ).

*c. **Difficulty in fitting data.*** In the light of the above mentioned error sources, it is understandable that the cruise data were difficult to fit and that the residuals should show long-term trends with maximum amplitude of 0.05 cps S-band (0.3 cm/sec range rate). Taking this disturbance into account, it is also plausible that the stability of the cruise orbit results might deteriorate when two highly correlated effects such as solar pressure and the AU are solved for simultaneously.

*d. **Program for complete analysis.*** A definitive analysis of the *Mariner IV* orbit errors cannot be completed until proper computer programs are available to analyze the data. Such analysis will require the new double precision orbit data program (DPODP), which is scheduled for completion in early 1967. In the meantime the investigation will be carried out with improved versions of the current ODP. There is considerable doubt as to the extent to which the attitude control forces can ever be represented in the solution, even with the DPODP, because of their non-deterministic character.

*e. **Solutions for mass of Mars and AU.*** The mass of Mars and AU solutions are reasonably consistent with earlier experimenters. In Figs. 27 and 28, bar graph plots show the various values (by the dark lines) and the probable errors (by the length of the bar away from the value line). All solutions except that for *Mariner IV* use Venus radar bounce data taken near the Earth–Venus conjunctions. No value is given for the *Mariner II* 1962 Venus flight; the definitive *Mariner II* AU solution will probably be published in the next year. For *Mariner II,* the encounter AU solution was a factor of 25 weaker than the *Mariner IV* encounter solution; thus, to obtain a stronger *Mariner II* AU solution, the cruise and encounter data must be combined in one orbit. The delay in achieving a high-accuracy *Mariner II* AU solution has been caused by difficulties in making the combined solutions. The *Mariner IV* combined solutions will also be released within one year. The JPL Venus bounce value, which is marked "provisional" (not yet published), is quoted with the permission of Dr. D. Muhleman of JPL. This solution is considered to be more accurate than the 1961 JPL value since it uses a double-precision computer program, solves for the Venus ephemeris as well as the AU, and has data from three conjunctions. The 1961 solution was in single precision and did not solve for ephemeris corrections. All values are for a value of the speed of light of $c = 299792.5$ km/sec. The speed of light is considered to be a defined constant in orbit and planetary bounce work, so that lengths are really determined in light seconds and are then translated to meters for more convenient use.

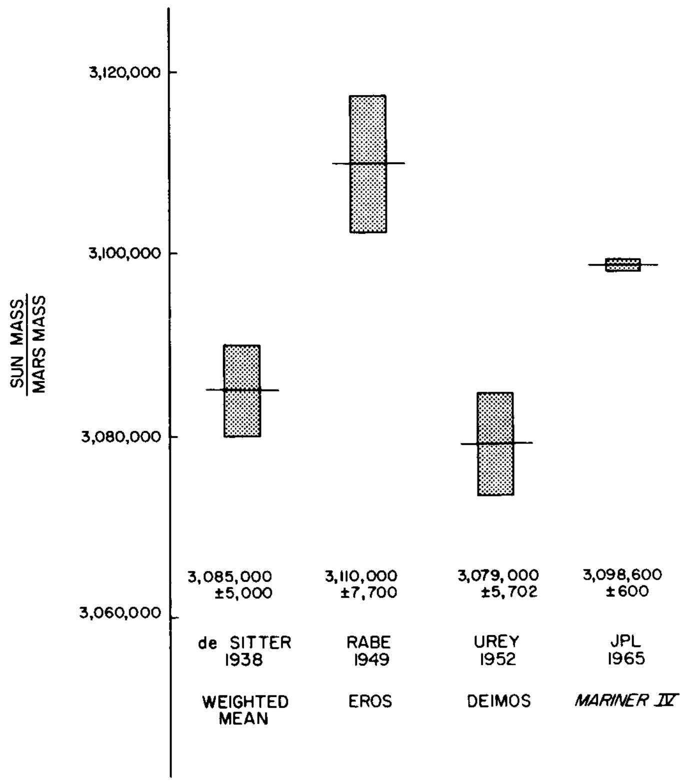


Fig. 27. Mass of Mars solutions

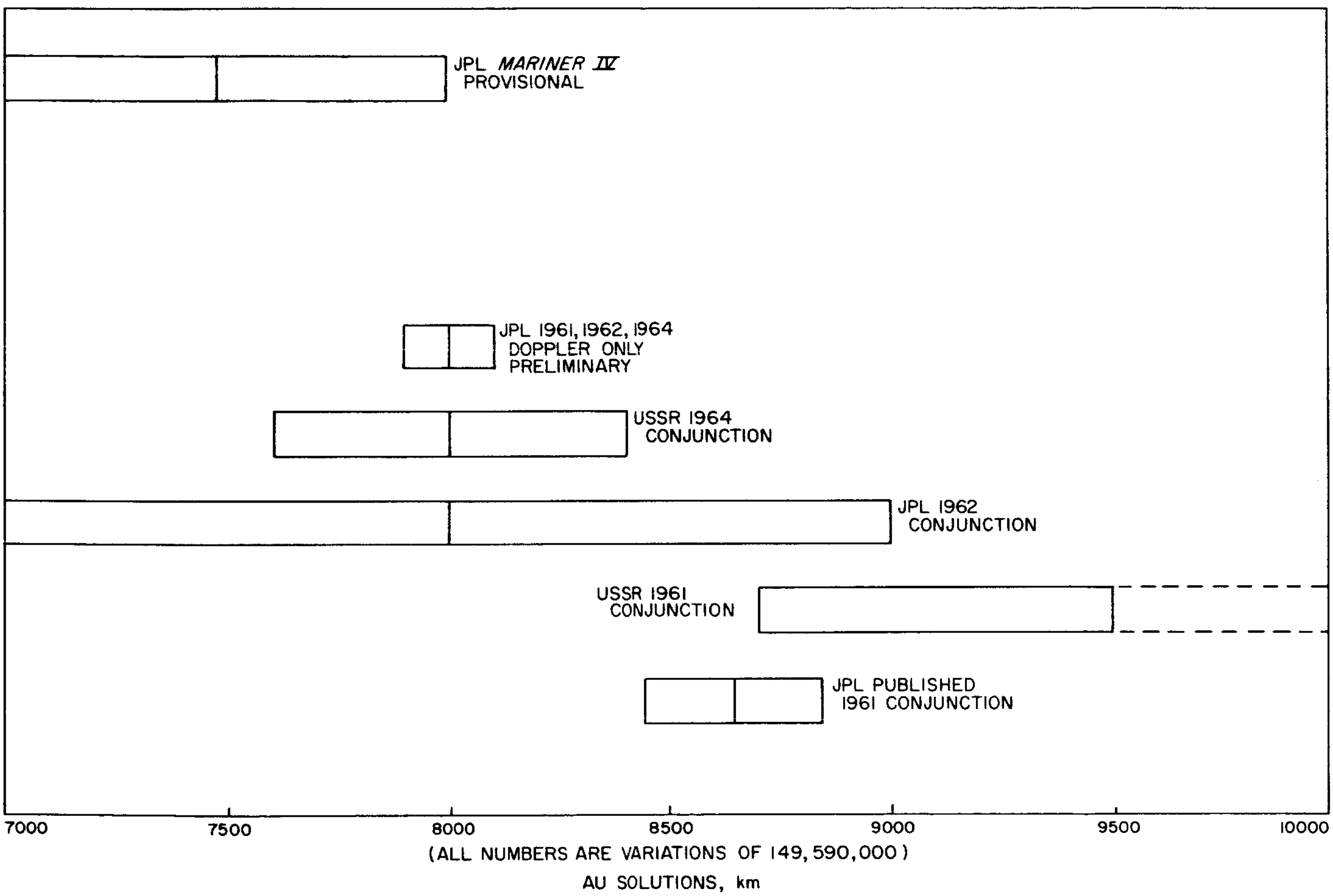


Fig. 28. AU solutions from Venus bounce and *Mariner IV* data

III. SPACE FLIGHT OPERATIONS

A. Data Recovery and Processing

The data recovered from *Mariner IV* was, basically, of two types—tracking and telemetry—which may be related, primarily, to two phases: (1) the high-activity times of launch, midcourse maneuver, and encounter; and (2) the cruise phase. Other periods of high interest will, also, be discussed.

It was expected that hardware and software problems would be encountered in this thorough operation of the SFOF Data Processing System used throughout the *Mariner IV* mission; however, the majority of these were resolved. Certain system anomalies were uncovered and changes are being incorporated into the design.

1. Science and Engineering Data

From liftoff to antenna changeover, the *Mariner* spacecraft transmitted approximately 3×10^8 bits of data back to the earth. Of these, 10^7 bits were television data, 97×10^6 bits were engineering data, and 193×10^6 bits were science data.

Approximately 98% of the data transmitted to the SFOF in real time was processed and logged by the IBM 7040 computers. The IBM 7094 post-processing recovered approximately 90% of the available data. The 2% lost in real-time processing was due to communication outages and computer outages. The 10% lost by the 7094 post processing was caused, primarily, by the inadequate assignment of time with data and by the inability of the edit program to identify preambles.

The Master Data Library (MDL) effort recovered from 99.5 to 100% of the data recorded at the DSIF stations. Of the *total* data transmitted from the spacecraft, about 85% was actually presented as the MDL; this percentage includes data missed during the two periods that Station 51 was not tracking the spacecraft, as well as all that lost as a result of individual station outages.

2. Tracking Data

The number of tracking points taken during the *Mariner IV* mission may be estimated from the following tracking coverage summary:

1. Elapsed time was 307 days between 29 November 1964 and 1 October 1965.
2. Total tracking coverage was approximately 9500 hr, averaging 10 hr/day per station for three stations.
3. The tracking pattern from launch to encounter comprised 1-sec, 10-sec, and 60-sec data. (a) A total of 20 min of data were acquired during the following periods of each pass: from horizon (rise) to horizon + 20 min; at maximum elevation + 10 min; and at horizon − 20 min to horizon (set). (b) The 60-sec data were taken at other times during each pass.
4. Two passes per week of horizon-to-horizon 2-way data were taken each week per station.

The 60-sec points totaled approximately 550,000; the 10-sec points approximately 320,000; and the 1-sec points approximately 3,200,000. The 60- and 10-sec points were sent in real time to the SFOF. It is estimated that close to 1,000,000 points were transmitted to the SFOF in real time, of which approximately 300,000 were precision two-way points. The 1-sec points were shipped in non-real time for Master Data Library post-processing.

3. Coverage

a. High Activity Phases. During the high activity phases of the mission, redundant systems were utilized wherever possible. At the SFOF all operational computers were up and on line. Both the 7040 and 7094 computer strings were operated in computer Mode II.[1] During the critical phases, the 7094 data processors were divided between the two computer strings. One 7094 was used primarily for flight path programs; the second was used for engineering and science programs. All programs were loaded into both strings so that an immediate backup was available for any given program.

Continuous orbit updating was performed from launch to launch + 20-hr. After that time, orbit updates were performed approximately every 6 hr up to midcourse maneuver; then, tracking data monitoring was done on a nearly continuous basis.

Because of the unreliable performance of the Data Processing System (DPS) in handling tracking data, it was decided to back up the DPS by punching cards with tracking data information. These cards could be read

[1]Computer Mode II consists of a 7044 (input/output processor) linked to a 7094 (detailed analysis machine) by a data storage disk.

directly into the 7094 Tracking Data Processor (TDP), and merged with data coming into the 7094 via the 7040. This backup procedure retrieved much valuable data that, otherwise, would have been lost in the early hours of the mission from various malfunctions in the DPS; during the first 30 days of the mission, only about 10 or 15% of the data were processed through normal channels (7288 data channel multiplexer with the 7040 and 7094 computers). When the card information was added, this figure increased to about 85 to 90% of the usable tracking data. Corrections made to the mission-independent editor in the 7094 increased the data recovery to about 85 to 90% through the DPS; it remained at this figure, or better, throughout the remainder of the mission.

b. Cruise Phase. During the cruise phase, only the 7040 computer was used in real time. The real-time computer output consisted of: (1) Quick-look formats for science and engineering, (2) high-speed teleprinter formats of selected engineering measurements, and (3) 30 × 30-in. plots of selected science and engineering measurements. During this time, the 7040 computer also generated a log tape consisting of all the incoming raw data. No real-time processing of tracking data was done in this mode.

The 7094 user programs were run on a production type operation. The 7040 log tape was removed at 6:00 a.m. each day and edited by the 7094. Science and engineering programs were then run on the edited data. The computer printout was duplicated by document control and then delivered to the user areas. User program output for a 24-hr period was delivered to the user areas by noon the day following its acquisition.

During the cruise phase, tracking data monitor runs were made to validate the tracking data quality approximately every two or three days. At these times, the tracking data file was updated with the new data. Orbit updates were performed every two weeks during the cruise phase.

4. Ground Telemetry Subsystem Performance

The Ground Telemetry Subsystem for *Mariner* consisted of the demodulator, the decommutator, and the TTY encoder. The system performed satisfactorily throughout the *Mariner* mission. The output of the demodulator was occasionally data bar (compliment of data), however, the problem was easily corrected by resynchronizing the demodulator. The data bar condition was most prevalent during station acquisition.

The TTY encoders performed well throughout the mission. However, two anomalies were observed at the SFOF: (1) When the station paper tapes were processed by the Telemetry Processing Station (TPS) at the SFOF, excessive skew was evident. The skew was generated by the punches in the TTY encoders at the stations. Mechanical readers were not affected by this skew; however, TPS used an optical reader for increased speed of reading. (2) During TV picture playback, the TTY encoder would occasionally insert two carriage returns into the data stream instead of one. This caused a problem for the data processing system at the SFOF and it was necessary to modify the mission-independent editor to accommodate the situation.

No problems affecting data recovery were encountered with the decommutator during the mission.

5. Picture Data

During the encounter and the beginning of picture playback, full data processing capabilities were used. Both computer strings were exercised, one for flight path and the other for science and engineering. After the playback of picture 1, the computer coverage was reduced to two 7040s making redundant recording tapes, and 7094 video processing was performed each morning at 6:00 a.m.

The 7094 processing of the picture data produced two outputs. One was a computer printout, and the other was a magnetic tape.

The 7094 computer printout consisted of a number of formats that displayed picture data, as well as summary data, concerning the picture. The picture data were displayed in a 200 × 200 decimal element matrix and, also, in a printout of the binary serial bit stream.

The magnetic tape was written in a manner which was compatible with the link film recorder.

The above processing constituted the SFO commitment to the Project; however, an extensive enhancement effort was conducted by Space Science personnel.

6. Occultation Phase

As Mars encounter approached, the orbit determination effort was increased. Daily orbits were completed during the two weeks prior to encounter. Continuous orbit runs were made on one string, and periodic orbit runs were made on the backup string from closest approach − 12 hr to exit occultation. During the occultation period (enter occultation − 30-min to exit occultation), residual data generated by differencing the incoming data and predicted data were transmitted to the SFOF from the Goldstone Echo Site and plotted in near real-time on the FPAC 30 × 30 plotter. Unexpectedly large residuals, from difficulties with the orbital calculations at encounter, caused part of the plotting effort to be of limited value; however, it was possible to verify the existence of the Martian atmosphere and make some preliminary estimates of its character in near real-time from observation of the plot. The delay in locking up the closed loop at Goldstone at exit occultation made it impossible to plot residuals at that time.

7. *Mariner* Master Data Library

Since August 1964, an active program was underway to design, develop, and implement a system to produce a master library of all data received and recorded during the *Mariner* Mars 1964 mission. This Master Data Library (MDL) would provide the best source of telemetry and tracking data received and recorded by the DSIF during the *Mariner* mission, as well as discrete DSIF instrumentation performance parameters. The primary purpose of the MDL was to produce a history of the *Mariner* mission from which post-flight analysis could be accomplished on the spacecraft's subsystems, the scientific payload, the spacecraft's trajectory, and the performance of the DSIF.

To afford a more flexible and expedient access to data comprising the MDL, the system was categorized into the three data tables—telemetry data, tracking data, and comment data.

a. Telemetry Data. The MDL telemetry data table comprised two types of digital-recorded magnetic tapes generated by IBM 7094 computer programs: Station Master Merge Tapes and Composite Master Merge Tapes.

Station Master Merge Tapes. The Station Master Merge Tapes were generated by the Merge Program for each Deep Space Station (DSS) and contained the *best* telemetry data and ground instrumentation performance parameters recorded during each station's pass. The best telemetry data available was derived from the three data sources processed, i.e., the demodulator input, the demodulator output, and the teletype encoder output. The selection of the data source was made by the Merge Program based on the data quality and continuity of each of the data streams within a recorded source.

Composite Master Merge Tapes. The Composite Master Merge Tapes, which were also generated by the Merge Program, contained a continuous and sequential stream of the best telemetry data derived from the composite of DSIF stations receiving and recording telemetry data (Station Master Merge Tapes) during each day of the *Mariner IV* mission. The overlap of telemetry data between DSIF stations was eliminated by data source selection based upon data quality and continuity of each recorded source. The ground instrumentation performance parameters were not contained on these tapes.

b. Tracking Data. The MDL tracking data table was developed from both real time and non-real time data. Real-time data (data sampled at low rates, only) were received from the DSIF stations via TTY communications into the SFOF and were processed through the DPS in real time. Non-real-time data (data sampled at both low and high rates) were received from the DSIF stations and were, also, processed through the 7094 portion of the DPS. Both real-time and non-real-time tracking data were maintained on digital recorded magnetic tapes in formats compatible with the TDP Program and Orbit Data Generator (ODG) Program, which were in themselves user programs. The raw tracking data, as recorded on TTY paper tapes, were maintained as part of the MDL.

c. Comment Data. To explain peculiarities and/or anomalies that occurred in both the telemetry and tracking data tables, the supporting flight operations logs and MDL processing logs were maintained in the comment data table which was recorded on microfilm. The flight operations logs consisted of the SFO log and the DSIF Operations log from each DSS. The history of the MDL processing was contained in the MDL data processing logs and the actual telemetry and tracking data which were printed in tabular outputs. Each type of operations log, MDL data processing log, and tabulated output was maintained on separate positive-microfilm records providing convenient reproduction and access by users.

B. Space Flight Operations Performance

During the launch phase of *Mariner IV*, the DPS, which was configured for two Mode II systems, encountered no problems. Approximately one-half of the period from launch to maneuver was devoted to Mode II processing and the other half to Mode III[2] processing. The only significant failure during this period was that the 7040 occasionally had problems processing high-speed time words, which caused a loss of data synchronization.

[2]In computer Mode III, the 7044 operates alone.

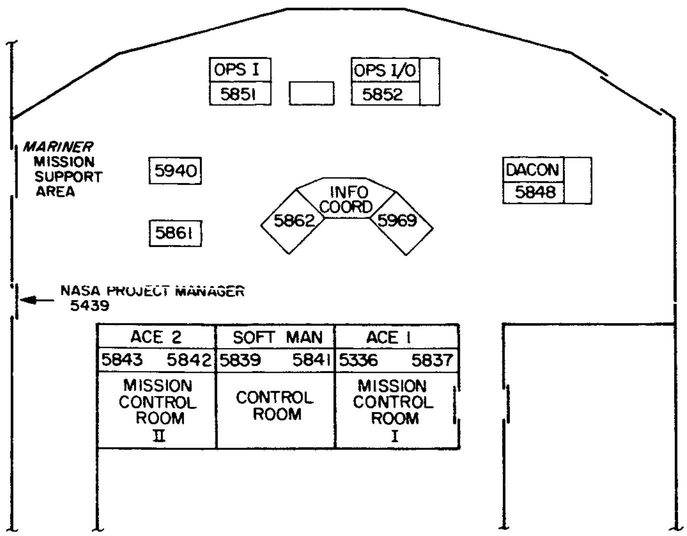


Fig. 29. Operations area

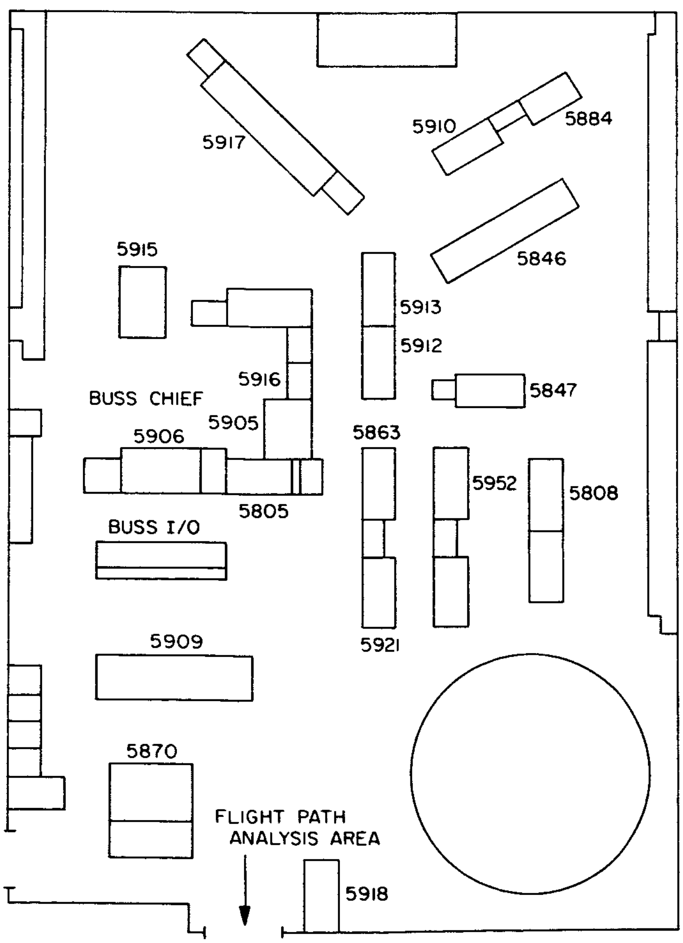


Fig. 30. Spacecraft performance analysis area

Two Mode III computer systems were maintained throughout the maneuver operation with no significant problems or failures.

Figures 29 through 32 show the configuration of the analysis areas provided in support of *Mariner IV* from launch through maneuver.

Figures 33 and 34 show the areas provided for support of *Mariner* throughout the cruise phase and until mission termination on 1 October 1965.

Four Operations Controllers maintained 24-hr/day alarm monitoring of the *Mariner IV* spacecraft during the cruise portion of the mission. Some of the duties performed by the Operations Controllers were the following:

1. Alarm monitor the incoming real-time data.
2. Notify cognizant personnel should a spacecraft alarm condition exist.
3. Monitor data condition.
4. When incoming data is not good, determine the cause, communication line, or computer, and take corrective action.

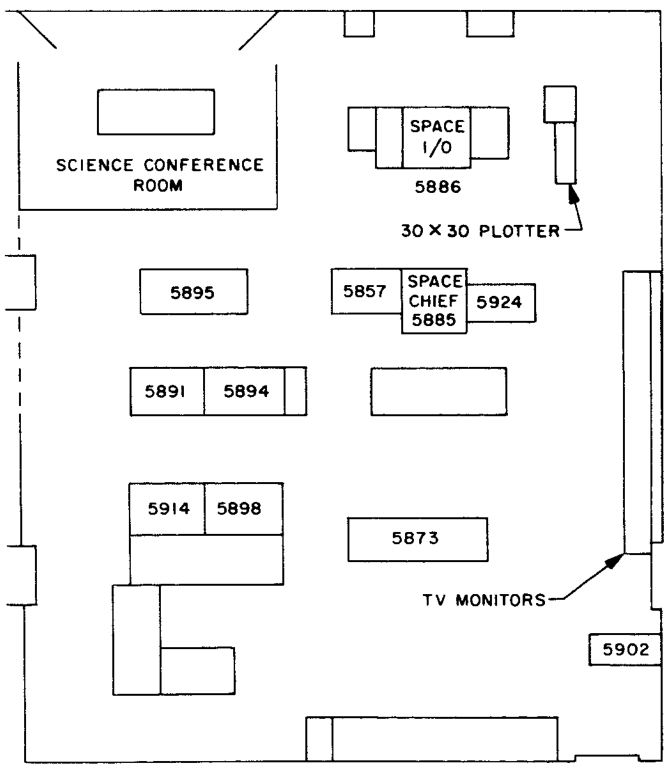


Fig. 31. Space Science Analysis area, first floor

5. See that data distribution by the Technical Assistants is accomplished daily.

6. Update status board daily.

7. Update status phone daily.

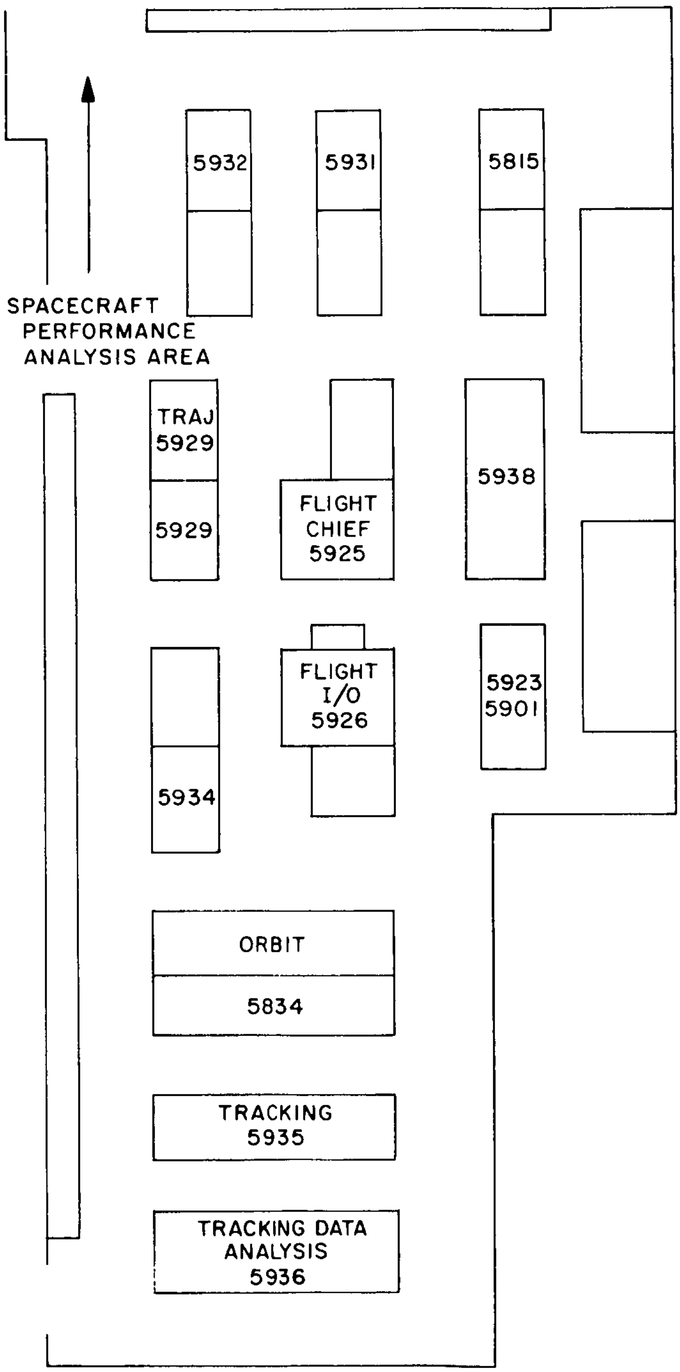


Fig. 32. Flight Path Analysis area, first floor

An Engineering Planner was assigned to support the project throughout the entire mission. The functions performed in support of the *Mariner IV* mission were:

1. Produce *Mariner* Mars 1964 Technical Bulletins.
2. Schedule facilities and computers.
3. Maintain flight history chart.
4. Provide inputs to documentation.
5. Provide prelaunch test scheduling and distribution of test notices.
6. Maintain master file of *Mariner* documentation.
7. Write *Mariner* failure reports.
8. Publish daily status meeting minutes.

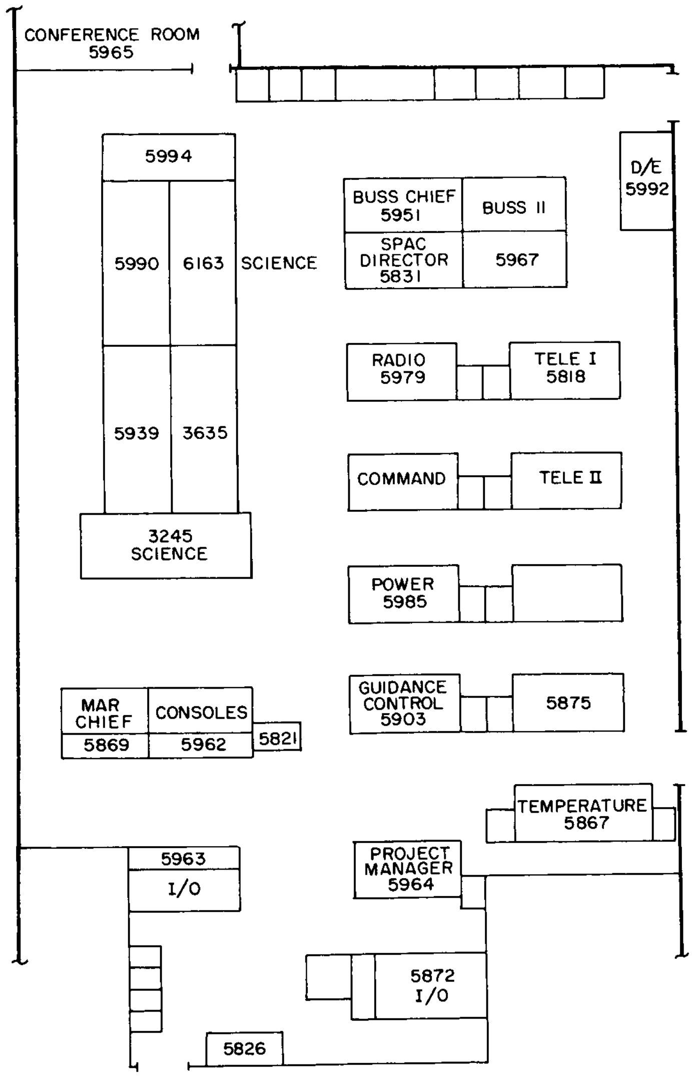


Fig. 33. *Mariner* Mission Support area

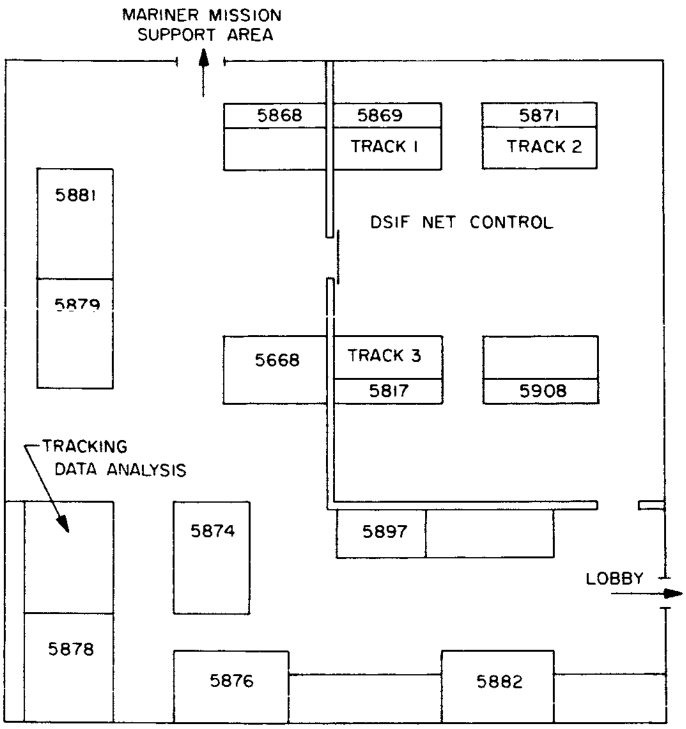


Fig. 34. Track area

9. Act as standby Operations Controller.
10. Assist in maintaining SFO Flight Log.

During the cruise phase, the data processing system underwent a series of changes designed to increase the capacity and flexibility of the system. The basic moves made in this period were the installation of a 7044 in place of the 7040 in the X string, the modification of the 7094 in the Y string to be a Model II, and the move of the Data Processing Control Area to the south end of the Computer Area of the SFOF.

The completion of these moves took place on schedule and with little or no complication in the performance of the work. The installation of this equipment was followed by a period of trial during which many problems were found in the remainder of the system.

1. Investigation and Correction of Problems

Although some of these problems were still being investigated and solved, the majority of them were corrected prior to encounter. The week of testing prior to *Mariner* encounter revealed many of the problems and resulted in a concentrated effort to get them cleared up in time for the encounter; therefore, the week of encounter produced an exceptionally clean period of operation. There were a few minor problems but nothing of operational importance. At the end of the period, however, one of the old installation problems recurred. A summary of the problems encountered during the period of this report follows.

a. Memory errors. A memory driver failure was isolated and repaired in one day. Memory parity errors appeared frequently on both 7044s. These errors were apparently cured after a team from the IBM factory in New York spent a week prior to *Mariner* encounter working on both 7044s. During this time, they ran digital and analog diagnostics and did considerable adjustment of the memory circuits which affected the more critical timing of the high-speed memories. At the end of this period, there seemed to be no more memory parity errors. The computer system performed very well through encounter, but on 15 July there was another memory parity error on the 7044X. This was followed during the week of 21–28 July by a series of memory parity errors on the 7044Y. These parity errors were found to be due to two bad electronic circuit cards in the memory parity register. Card replacements corrected the major portion, if not all, of the memory parity error problems.

Most direct data channel failures were corrected after a short period of observation and trouble shooting. One remaining problem was found during the week of 5 July in an encounter testing period and was corrected after about 5 hr of down-time during the test.

b. Wiring problem. During the investigation of the memory parity problem, it was discovered that the computers had not been wired properly to the power lines. The main source of the problem was the substitution of the neutral wire of the three-phase power system for a green ground wire. This caused the computer equipment frame ground to be noisy, reflecting the voltage drops caused by the current-carrying neutral wire. The problem was corrected.

c. Connector wear. A continuing problem had been the inability of the connectors on the 7242 M-box to withstand the constant reconfiguration of the input/output (I/O) devices. This constant reconnection caused the pin that retains the shoulders in the connector block to become worn, causing pushed pins and loss of signal continuity to the device.

d. Other problems. Although there was the usual amount of routine problems, in addition to those outlined above, they were of little individual significance. They consisted, principally, of such items as data processing card reader failures which were easily diagnosed, or such others as tape drive failures; these were corrected easily and in a routine manner.

A failure of the under-floor insulation of an M-box ground wire caused the M-box to become nonoperational and prevent function of the input/output of the 7044s. This problem, massive in its symptom but subtle in its analysis, was corrected in about 2 hr.

2. Three-Shift Coverage, 6 July to 6 August 1965

Support of the computer subsystem starting the week of July 6 included third shift coverage as well as the usual two shifts. This coverage continued until 6 August.

A third SC-3070 was installed in the *Mariner* control center and a 30 × 30 plotter in the Operations Area for encounter.

No severe problems were met in the I/O equipment in the User Areas. The I/O operators were scheduled for continuous 12-hr shifts from 6–9 July (the pre-encounter test week) and from 12–16 July. The I/O maintenance personnel were on continuous 12-hr shifts from 6–10 July and 13–16 July. This coverage, and the spotting of stand-by equipment in the Operations Area, enabled equipment changes on almost a minute-by-minute basis, which in several instances allowed User Areas to remain on-line with virtually no interruption of service.

On 1 July 1965, a short-duration power failure in the Edison commercial power line caused an automatic shutdown of all computers. After a short period of waiting to ensure that the power transient would not be repeated, the computers were brought back up, diagnostics run, and the operating programs reloaded. This procedure took about 1 hr and 20 min.

All communication subsystems within the SFOF supported the *Mariner* Mission.

3. Support Services Rendered

The SFOF Operations Support System and the Display System provided the following assistance to the *Mariner IV* mission:

1. Maintenance of electrical and air-conditioning systems
2. Handling of space flight data for distribution and storage in SFOF document control
3. Logging
4. Scheduling
5. *Mariner* Mission Support Area technical assistance
6. Information display
7. Access control
8. Special services
9. Documentation

Power supply and air-conditioning were maintained. In order to provide for any emergency situation due to loss of power, a standard operating procedure (SOP) was written and authorized. Instructions for handling power failure in order to minimize a possible loss of data were given in this SOP to all personnel participating in mission endeavors.

a. SFOF Document Control. The SFOF Document Control group provided the following support for the *Mariner IV* Mission:

1. Data Accumulation
    - Magnetic tapes
        - Station tapes
        - Master data library (MDL) tapes
            - Time sequence tape of best data
            - Station overlap tape of best data
    - Teletype tapes
2. Microfilm Rolls Processed
    - 16 mm
        - All computer program printouts
    - 35 mm
        - Communication center page printout
        - Oscillograms
        - 3070 printout
        - SFOF Operations Logs
    - SC 4020
3. Binder formatted printouts of computer programs for analysis groups
4. SFOF Operations Log
5. Station logs
6. Sequence of events for both tests and operations

In addition, Document Control handled data distribution to all the areas of the operation, which were further distributed by the Technical Assistants. Document Control provided service for recalling data for any portion of the *Mariner* flight upon request.

The system used by the SFOF Document Control in support of the mission performed smoothly and effectively.

The typing of SFOF Operations Logs for *Mariner* was performed throughout the mission. These logs, which provided a continuous record of SFOF operations, were microfilmed for inclusion in the Master Data Library.

Technical Assistants were provided to Operations throughout the mission. Among many other things, they provided computer printout distribution as shown in Table 5.

The real-time AGC display on the Sanborn Recorder in the MMSA displayed data from all prime DSIF stations supporting *Mariner*.

b. Access Control. The Support Group was supplied with *Mariner*-dependent access lists, and communication, DSIF, and data processing lists of personnel to be given access to closed areas of the SFOF. The lists were computer-generated. Badges were issued to 650 people.

Control was maintained during testing and actual operations. Security was enforced at the access desk and by six guards.

Table 5. Computer printout distribution

MSA bulk data distribution	Buss Chief Div 29	Science Div 32	Communications Div 33	Radio Div 33	Data encoding Div 33	Guid & control Div 34	Attitude control Div 34	CC&S Div 34	Power Div 34	Temperature Div 35	Propulsion Div 38	Data processing advisor
EAPM, PAP Power analysis	1					1			1			
CCAP Central computer & sequencer	1					1		1				
ACAM, ACAP Attitude control analysis	1					1	1					
CPPM Communications predictions	1		1									
Plots	a		1a									
AGCM Automatic gain control			1									
Plots			1									
ATRM Attitude reference	1					1	1					
Plots	a					1a	a					
ENGR Engineering data display	a	a	a	a		a	a		a	a	a	a
SSDM System suppressed data	1a	a	1a	a		1a	1a		a	1a	a	a
EPLM Plots (separated)	a,b	1	1	a		1						
SIPM Star data, magnetometer antenna data	1					2	1					
Plots	a					1a	a					
VIPM Variable parameter input	a											

[a]Reproduced copy (8½ × 11) within 2 to 4 hr.
[b]Unseparated.

The SFOF Operations Support Group arranged for special services for the *Mariner* mission including the following items:

1. The handling of a special sequence of events (Appendix D) for encounter.

2. A form for DSN communications coverage.

3. A special telephone directory (300 copies) of *Mariner* Mars 1964 mission-dependent personnel. This directory listed personnel, their titles, SFOF extensions, and Laboratory extensions.

The SFOF Documentation Group prepared and published the documents listed in Table 6 in support of *Mariner IV*.

Table 6. SFOF *Mariner* documents

a. Standard Operating Procedures

SFOF/SOP No.	Title	Date
M20-300A	DSIF Predicts Transmission	10/30/64
M20-302	Punching Tracking Prediction Tape	1/21/65
M20-306	*Mariner* Tracking Predicts for Non-DSN Tracking Stations	4/2/65
M31-105	Special Instructions for Teletype Patching *Mariner* Midcourse Maneuver	9/24/64
M31-320	Availability of SFOF Conference Nets Outside SFOF Operations Areas	10/16/64
M40-100	Computer Operations Power On/Off	4/6/65
M45-100	Computer Operations: 7040 Computer Operations	10/9/64
M45-101	Computer Operations: 7094 Computer Operations	10/9/64
M45-102	Computer Operations: M-Box Setup and Channel Override Switch Setup	10/9/64
M45-103	Computer Operations: Responsibilities of Personnel	10/9/64
M45-110	Computer Initialization: 7040 Initialization Deck Parameters	10/9/64
M45-111	Computer Initialization: 7094 Initialization Deck Parameters	10/9/64
M45-120	Editor Operating Procedures	10/9/64
M45-130	Operation of the DPCC: General Responsibilities	10/9/64
M45-131	Operation of the DPCC: Hardware Preparation	10/9/64
M45-132	Operation of the DPCC: Software Preparation	10/9/64
M45-133	Operation of the DPCC: Data Stream Status	10/9/64
M45-134	Operation of the DPCC: System Start Up	10/9/64
M45-135	Operation of the DPCC: Data Stream Selection and Data Identification	10/9/64
M45-136	Operation of the DPCC: Special DPCC Functions	10/9/64
M45-137	Operation of the DPCC: System Performance Monitoring	10/9/64

a. (Cont'd)

SFOF/SOP No.	Title	Date
M45-138	Switching Trap Procedure	6/25/65
M45-140	Computer Operations: 1401 SFOF Output Program	10/12/64
M45-200	TPS High-Speed Modem Setup	10/12/64
M45-201	Setup for *Mariner* High-Speed Telemetry Simulator (PDP-4)	10/12/64
M45-202	Simulation of High-Speed Telemetry Data	10/12/64
M45-203	Setup of the Tracking Data Simulator (PDP-4)	10/12/64
M45-204	Setup for the TTY Encoder	10/12/64
M45-300	Direction and Coordination During a Mission-Data Control (DACON)	10/12/64
M45-350	AFETR Data: Computer Processing	10/28/64
M70-115A	Support Group Duties for *Mariner* Cruise Phase	7/12/65
M72-105	Bulk Data Handling and Distribution	10/12/64

b. Engineering Project Documents

No.	Title	Date
EPD-122, Addendum I	Space Flight Operations Plan, *Mariner* Mars 1964	7/5/65
EPD-122, Revision 2	Space Flight Operations Plan, *Mariner* Mars 1964	10/28/64
EPD-122, Revision 1	Space Flight Operations Plan, *Mariner* Mars 1964	8/17/64
EPD-122	Space Flight Operations Plan, *Mariner* C: Missions P-70 and P-71	7/15/63
EPD-173, Revision 1	Space Flight Operations Test Plan, *Mariner* C	5/11/64
EPD-173	Space Flight Operations Test Plan, *Mariner* C	8/1/63
EPD-203	Space Flight Operations Facility Capabilities Document for *Mariner* C	3/2/64

Table 6. (Cont'd)

c. Manuals

Title	Date
Mariner Data Processing Manual, Revision 1	4/15/65
Mariner Data Processing Manual	10/13/64
Mariner IV Progress Report No. 4 (Launch + 155 Days to Launch + 185 Days)	7/5/65
Mariner IV Progress Report No. 3 (Launch + 109 Days to Launch + 154 Days)	6/7/65
Mariner IV Progress Report No. 2 (Launch + 79 Days to Launch + 108 Days)	4/15/65
Mariner IV Progress Report No. 1 (Launch to Launch + 80 Days)	3/29/65
Mariner Mars 1964 Quarterly Report for the DSN/SFOF	5/17/65
Mariner Mars 1964 Quarterly Report for the DSN (SFOF)	2/15/65
Space Flight Operations System Design Specifications, *Mariner* C	Original 3/12/64
Mariner (III) Mars 1964 Technical Bulletin No. 1	11/9/64
Mariner (IV) Mars 1964 Technical Bulletin Nos. 1 through 307	11/30/64 through 10/4/65

To consolidate the planning and preparation for the mission following maneuver, Encounter Planning Groups were organized and defined. Regular sessions were held and priorities of effort were established in these meetings.

From the encounter planning activities, test requirements were established, using the SAF/PTM/SFO facilities. During the operational readiness tests there was a SAF/PTM/SFO/DSIF participation.

The appointment of a specific Communications Project Engineer for *Mariner* greatly improved the interface between SFO and Communications. This improved interface accomplished the encounter ground communication requirement of Fig. 35 with very few problems.

An SFOF Project Engineer supported the *Mariner IV* mission from prelaunch through mission termination. Provisions supported by this function were: (1) continuous facility hardware status, and (2) implementation of hardware for both flight operations and test activities.

C. Encounter Readiness Tests

In preparation for encounter, a number of tests were scheduled involving nominal encounter operations and possible encounter operations in a failure mode condition (Table 7). These tests exercised the analysis and operations personnel in the performance of their duties and met the objective of developing and maintaining the proficiency required to participate properly during the planetary encounter portion of the mission.

Table 7. Encounter readiness tests

Date	Description
4/13/65	DC-18 Test
4/15/65	DC-18 Test
4/20/65	Nominal SPAC encounter
5/4/65	Roll position simulation
5/4/65	Data Mode 4/1 transmission from DSIF 51
5/27/65	Encounter backup mode
6/3–4/65	Preliminary operational readiness
6/23–24/65	Command and occultation
6/24–25/65	Command and occultation
6/24/65	Encounter alternate plan
6/25/65	Encounter alternate plan
6/28–30/65	Operational readiness
7/6–7/65	Operational readiness
7/8–9/65	Operational readiness
7/12/65	Operational readiness

1. Roll Increment Tests

The first test in preparation for encounter involved the use of DC-18 (gyros on inertial control: positive roll increment). The test was performed on 13 April 1965 and was conducted from the Mission Support Area (MSA) using the PTM as the data source. The objectives of the test were:

1. To familiarize personnel with an encounter procedure that uses DC-18 as a backup to observe degradation in spacecraft parameters
2. To familiarize the Spacecraft Performance Analysis and Command (SPAC) and Space Sciences Analysis and Command (SSAC) personnel with the spacecraft while operating in a simulated radiation field of Mars
3. To familiarize personnel with the communications time at encounter, and to perform operations with this constraint

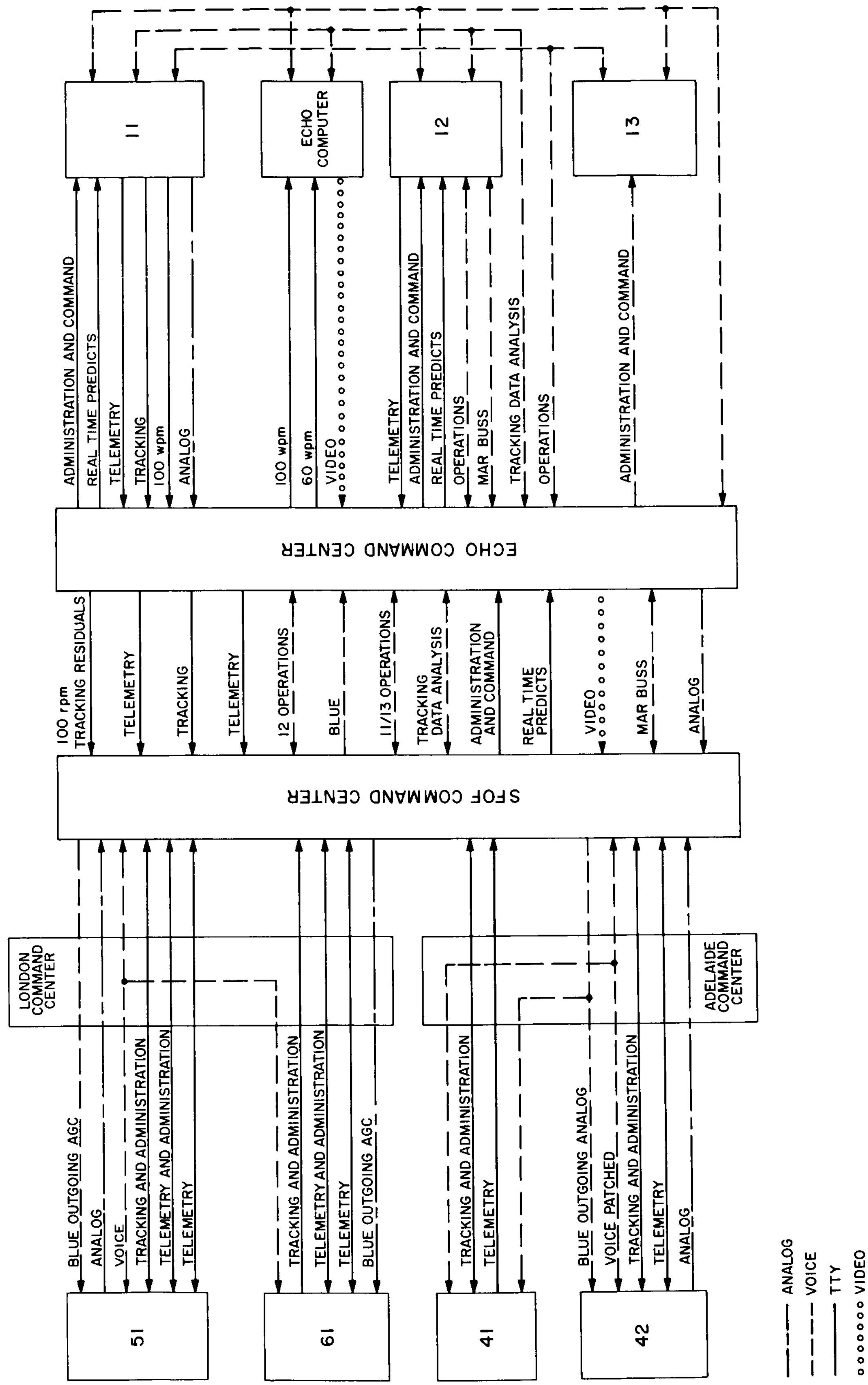


Fig. 35. *Mariner* Encounter Ground Communications

4. General DC-18 familiarization with roll position determination from the down link signal
5. To familiarize personnel with the procedure to be followed in going from a DC-18 mode to the DC-15 mode of operation

A second DC-18 test was conducted from the MSA on 15 April 1965 using the PTM as the data source. This test differed from the first DC-18 test in that the DC-18 was used as the primary mode of operation.

A roll position simulation test was performed using DSIF 11 and the SFOF on 4 May 1965 between 2210 GMT and 0830 GMT. The test was conducted to determine the effect of spacecraft roll on the ground received signal.

2. Scan Platform Positioning

In addition to positioning the scan platform during all the tests involving an encounter sequence, several individual scan positioning tests were conducted. All platform positioning tests involved the PTM with the exception of one which used simulated data transmitted from DSIF 51. These tests were proficiency tests for the science operations personnel involved in positioning the scan platform via ground command.

3. Procedure Verification Tests

A preliminary operational readiness test was conducted on 3 and 4 June 1965. Simulation and *Mariner* PTM data were used for this test. The objective was to verify the adequacy of encounter procedures and to verify the smooth operation of all of the interfaces between the various components of the DSN.

A nominal SPAC encounter test was performed on 20 April 1965 using the *Mariner* PTM as the data source for telemetry and simulating DSIF data and functions. The test objectives were (1) to determine the feasibility of the nominal encounter sequence in terms of command response, timing, and opportunity for thorough evaluation of data; and (2) to offer *Mariner* operations personnel, SPAC, and SSAC an opportunity to familiarize themselves with the proposed encounter sequence.

A tape containing Mode 4/1 data was sent to DSIF Station 51, and on 4 May 1965 it was transmitted to the SFOF. The data transmission occurred during those hours that the actual encounter data would be transmitted from Johannesburg. The purpose of this test was to simulate transmission conditions that were closely related to those occurring during the actual picture playback from Station 51.

4. Backup Mode Test

An encounter backup mode test was conducted, using the *Mariner* PTM as data source on 27 May 1965 from 1500 to 0000 GMT. The backup mode test measured the capability of the SPAC and SSAC operations personnel to respond adequately to failures and/or anomalies occurring during the encounter phase of the *Mariner* mission. The SAF/PTM Test Team, at their discretion, induced failures and anomalies for which it was SPAC's responsibility to determine the nature of the problem and make recommendations for corrective action.

5. Tests from Flight Path Analysis Area

Two command and occultation tests were run from the Flight Path Analysis Area (FPAA) at times shown in Table 8.

Table 8. Command and occultation tests

Date	Start	End	Time (GMT)
23 June 1965	X		2000
24 June 1965		X	0445
24 June 1965	X		2000
25 June 1965		X	0445

There were four principal objectives of the occultation test:

1. Checkout the ability of the orbit determination program (ODP) to provide predictions with the required accuracy in Mode 2 and to test the plotting capabilities of the SFOF Data System
2. To verify the ability of the data processing system of Goldstone to provide computations of occultation data and open-loop receiver synthesizer settings
3. To train the station personnel in the operation of the open-loop receiver and tape recorder system, as well as in the special handling of occultation doppler data
4. To establish procedures for rapid reacquisition of two-way communications in emergency conditions, using the 100kw Station 13 transmitter

Two encounter alternate plan tests were conducted on the following dates:

Date (GMT)	Time
24 June 1965	1500–2300
25 June 1965	1500–2300

The encounter alternate plan tests were basically logic-diagram checkout tests used to establish and verify a set of telemetry criteria that determined the logical state of the spacecraft; they also served as a basis for decision concerning nonstandard ground command action and deviations from the nominal encounter sequence plan.

6. Operational Readiness Tests

The first operational readiness test was conducted from 0700, 28 June 1965 GMT to 0400, 30 June 1965 GMT. The objective of the operational readiness test was to provide verification of the operational readiness of the combined DSN prior to the *Mariner IV* planetary encounter. The test also verified the adequacy of encounter procedures and the smooth operation of all the interfaces between the various components of the DSN.

The final operational readiness test was conducted from 0700, 6 July 1965 GMT to 2230, 7 July 1965 GMT. The objective of this test was to verify the operational status of all equipments, procedures, techniques, and programs required during the *Mariner IV* encounter.

An additional operational readiness test was conducted from 0100, 8 July 1965 GMT to 1300, 9 July 1965 GMT. The objective of this test was to verify that the Analysis Areas and the DSN were fully prepared to commit to support the *Mariner IV* encounter.

On 12 July 1965 a final operational readiness was conducted. Previous tests had simulated many anomalous conditions, and the purpose of this test was to perform an encounter sequence with no anomalous events.

7. Command-Loop Lockup

A number of command-loop lockup exercises were conducted, starting in April, 1965 with Station 13. These exercises were conducted to maintain a high degree of proficiency at all stations involved in the planetary encounter of *Mariner IV*. Table 9 provides tabular information of the command-loop lockup exercises.

Table 9. Command-loop lockup exercises

Date	Station	Number of times	Remarks
8 April	11/13	1	Station 13 (100kw) transmitter
28 April	51	1	
28 April	11	1	
30 April	42	2	
12 May	11/13	1	Station 13 (100kw) transmitter, Station 11 receiver
1 June	11/13	1	Station 13 (100kw) transmitter
3 June	13	1	
16 June	11	1	Station 13 (100kw) transmitter
28 June	51	1	
28 June	11	1	
30 June	51	1	
1 July	11	1	Station 13 (100kw) transmitter
6 July	51	2	Once with each RWV
6 July	11	1	Using 10kw transmitter
7 July	13	1	

IV. POST-LAUNCH TESTING

A. Life Test Program

A life test on the subsystem level was a *Mariner C* Project requirement. In carrying out this directive, lists of equipment that should be subjected to life testing were compiled, and members of the Environmental Requirements group worked with the various cognizant personnel to delineate test philosophy and establish general rules for testing the equipment.

Cognizant personnel outlined minimum test plans for each unit—for the operating modes, measurements to be made, instructions for test performance, acceptable performance, and a format for a monthly status report. Individual test plans were completed prior to 30 November 1964.

Monthly status and progress reports were submitted to the Environmental Requirements group—where they were integrated and, between February and July 1965, the status of life testing was published each month. Abnormal results were reported on detection.

On 3 June, the Spacecraft System Manager's Office announced the decision to terminate all life testing by 30 July 1965, and final reports on the individual life tests were called for by 16 August. Subsequently, a decision was made, jointly with the *Voyager* Project Office, to continue testing on the radio and on the Canopus tracker.

A summary of life tests is given in Table 10.

Table 10. Summary of life test status

Test item	Ref.	Serial No.	Life test span		Regular reporting, date of start	Test environment				Observed effects	
						Vac.	Temperature				
			Start	End			Low	High	Cycling	Failures	Degradation
Cosmic Dust Detector	24A1	TA	2/25/65	9/15/65	2/28/65	—	—	—	x	—	—
Ionization Chamber	26A1	111	10/16/64	7/30/65	2/25/65	x	—	—	—	x	—
(Cosmic Ray Telescope, not tested)	21A1	TA									
Trapped Radiation Detector	25A1	TA	6/18/65	7/30/65	2/25/65	—	—	—	x	—	—
Magnetometer, operated at ~ flight temperatures	33A1 33A2 33A3	2 2 0	10/12/64	7/30/65	2/26/65	x	—	—	—	—	x
Solar Plasma Probe	32A1 32A2 32A3 32A4	MC-0 MC-0 MC-0 MC-0	12/22/64	(Final report not received)	2/23/65	x	—	x	—	x	No data
Data automation system	20A1 20A2 20A3 20A4 20A5	2 MC-7 TAW MC-7 3	12/23/64 2/12/65 1/23/64 2/12/65 12/23/64	7/30/65	2/24/65	—	—	—	—	—	—
Planetary scan	31A1 31A2 31A3	TA TA TA	8/24/64	7/4/65	2/25/65	x	—	—	—	—	—
Television	C36	MC-TAM	8/4/64	7/30/65	2/22/65	—	—	—	—	—	x
Data encoder	6A1-13	3	7/10/64	4/26/65		—	—	x	—	—	—
Command	3A1-7	2	7/9/64	7/31/65	3/29/65	—	—	x	—	—	x

Table 10. (Cont'd)

Test item	Ref.	Serial No.	Life test span		Regular reporting, date of start	Test environment				Observed effects	
			Start	End		Vac.	Temperature: Low	Temperature: High	Temperature: Cycling	Failures	Degradation
Radio	2	MC-0	1/27/65	7/30/65	2/28/65	x	—	x	—	x	x
Tape machine	16A1-5	2	8/4/64	2/23/65		x	—	x	—	(some set observed from long storage)	
Power	4A	02	8/17/64	7/16/65	2/16/65	x	—	—	x	x	—
Battery[a]	4A14	6	2/11/64	11/2/64	2/16/65	x	x	—	—	—	x
		7	2/11/64	4/27/64		—	—	x	—	x	x
		8	8/19/64	5/3/65		x	—	x	—	—	x
		9	5/1/64	12/18/64		x	—	x	—	x	x
		18	11/28/64	7/28/65		x	—	x	—	—	x
Attitude control electronics	7A1	002	6/15/64	8/30/65	3/3/65	—	—	x	—	—	—
Sun sensors	7PS6	2	6/15/64	5/3/65	1/4/65	—	—	—	—	—	—
Earth detector	7ED6	2	5/12/64	6/18/65	2/2/65	—	—	—	—	—	—
Canopus sensor	7CS8	004	12/18/64	7/31/65		x	—	—	—	—	—
Narrow-Angle Mars Gate	7MG1	011	5/12/64	4/19/65	2/1/65	—	—	—	—	—	—
Solar pressure control assy.	7PC	8	10/5/64	8/30/65	3/1/65	—	—	x	—	—	—
Jet vane actuators	7JV	2,4,7,32	8/24/64	8/30/65	3/1/65	—	—	x	—	—	—
Attitude control gyros	7A2	012	4/1/64	8/6/65	3/1/65	x	—	x	—	—	x
Central computer and sequencer	5A	MC-TA	4/1/64	8/15/65	2/17/65	—	—	—	x	x	—
Scan actuator	31A4	C111	11/9/64	5/5/65	2/11/65	x	—	x	—	—	—
Dampers, retarder and timer	8M1	C126									
		C104									
		C132									
Science cover latch actuator	31M2	C4									
		C-Proto									
Pyro control	8A1	1003	8/31/64	7/30/65	1/29/65	x	—	x	—	—	—
	8A2	1004									
Post-injection propulsion system		003	2/10/64	12/30/65		—	—	x	—	—	x

[a] Degradation was normal aging process.

1. Significant Findings

Some units survived during the test period with no apparent degradation; others showed degradation and/or failure. The varying degree to which units were affected is summarized here.

a. Units showing neither degradation nor failure.

Unit tested	*Accumulated operation time, hr*
Cosmic Dust Detector	5,514
Trapped Radiation Detector	7,033
Data automation system (DAS)	4,800
Planetary scan	3,194
Data encoder	9,000
Attitude control (A/C) electronics	11,000
Earth detector	9,268
Solar vane actuator	5,846
Thrust vector control	7,828
Pyro control	8,256

b. Units showing degradation. There were six units that exhibited some form of degradation during life test. The reduced performance and probable causes are described.

Magnetometer. Degradation in the sensor was detected early in the life test; it was probably due to a defective lamp and cell that were installed prior to life test and were not flight acceptance (FA) or type approval (TA) tested. Implications of this degradation are not clear.

Vacuum operation of the unit disclosed a leak in the hermetic seal of the infrared detector, which is part of the sensor; this fact supports the argument for performing the life test in vacuum.

Television. Slight degradation in picture quality was detected; this could be the result of overexposure caused by shutter failure on several occasions. The shutters are known to be limited life items and were not part of this life test. (A longer life test might have been helpful in evaluating the causes of this degradation.)

Command subsystem. No failures were detected in 8000 hr of life test; the total accumulated time on the life test unit, including other tests, was 10,800 hr. Only the voltage controlled oscillator (VCO) frequency exhibited some drift. The drift was consistent and would indicate that eventually the parameter would drift out of spec. It is difficult to estimate precisely the time when this amount of drift would occur—the cause of which has not been investigated; a longer life test might have been helpful in evaluating the cause.

Video storage. On 3 February 1965, after 6 mo of nonoperation, power was applied to the video unit. A record sequence was initiated, and the *run-up* and *run-down* times of the motor were measured. The run-up times decreased from 2.15 sec on the first picture to 1.95 sec on the seventh and succeeding pictures. The run-down time increased from 4.65 sec to 5 sec after seven pictures. The conclusion is that the unit did take a *set* during the period of vacuum storage; since it was hermetically sealed and did not leak during test, the degradation must have been caused by age, not vacuum. How serious a set would exist after longer periods of storage could not be evaluated on the basis of this life test because of the test interruption to facilitate a decision on the *Mariner IV* cover drop exercise.

Narrow-angle Mars gate. Some degradation in sensitivity was observed during the first 20 hr of life test; however, the unit stabilized and operated without failure or further degradation for the remainder of the life test (total operating time, 8210 hr).

Attitude control gyros. Gyro motor bearing wearout was observed after about 5000 to 5500 hr. As expected, the high operating temperatures encountered during the 1000 hr vacuum run seem to have accelerated this wearout. Lubrication breakdown and subsequent bearing wear is always accelerated by high operating temperatures. It is suspected that the bearing preload was too high on these *Mariner C* gyros; meeting the requirement on the anisoelastic coefficient may have been the cause of the sacrifice of some bearing life. The lifetime of the gyros was demonstrated by this test to more than exceed the mission requirements, although in general, the life test gyros' performance was somewhat poorer than was expected. The additional handling involved with this unit may account for some of this degraded performance during the life test.

c. Units showing degradation and failure. The following units exhibited either sudden failure or degradation leading to failure.

Radio. The life test, begun on 30 January 1965, is continuing on this unit. Some degradation is being observed in the oscillator circuit but, since the test is continuing, further analysis is being postponed. The redundant exciter failed after 262 hr on life test; however, this is not considered life-test failure, since this unit's performance had degraded considerably prior to life test.

Battery. One failure, resulting from a manufacturing defect, was detected early enough in the project to result in a modified FA test procedure. Some qualitative information was obtained on the battery's degradation rate as a function of temperature. Cell voltage was found to be an adequate parameter for the detection of battery failures. Degradation was detected on all five batteries life tested. One other failure was observed during the life test, but this was considered a normal end-of-life for a battery operating at an elevated temperature.

The battery is the only case observed during the life test when degradation in unit's operation parameters led to a complete failure. The degradation observed on the gyros may have been another example, but this test was interrupted before the failure became catastrophic.

d. Units experiencing failure. Four units experienced sudden failures during the life test without earlier detection of degradation.

Ionization Chamber. The same failure mode experienced by the flight unit was duplicated in the life-test unit by stimulating it to the high counting rates experienced in flight. Although this was actually beyond the scope of the test, it illustrates the use of life-test hardware to support the mission. No failure and/or degradation was detected that was not the result of the induced failure.

Plasma Probe. On 24 December 1964, after a total of about 1163 hr, the R-342 resistor failed. This type of failure is identical to the one that occurred in the *Mariner IV* instrument during flight. A life test performed early enough, under operating conditions similar to those encountered in flight, would have revealed the design deficiency that caused this failure.

Power Unit. The life test was terminated after 8300 hr because the 3-phase inverter drew excessive power from the maneuver booster regulator. The input filter capacitor of the 3-phase unit was short-circuited as a result of electrolyte leakage through the terminal seals of the capacitor. This failure mode might have been obscured if the life test were conducted at ambient laboratory conditions (the unit was tested in vacuum). When the unit was removed from life test, another failure was detected. This was a non-catastrophic failure and was not detected during the life test. The cause of failure could not be discovered but some mishandling (during manufacture) of the failed part (2N1016D transistor) is suspect.

Central computer and sequencer (CC&S). All life test failures observed appear to be mechanical in nature and may be the result of TA testing. Briefly, these failures consisted of two corroded jumper wires, two corroded component leads, one cracked diode, one broken unit of prepackaged magnetic wires. Outside of these, the unit performed without any failure or degradation for 10,000 hr.

It should be pointed out that the temperature cycling during the life test may have been responsible for such failures as those detected in the prepackaged magnetic wires, as well as the cracked diode. However, since the unit was subjected to a severe TA test which may have contributed to these failures also, the actual cause cannot be determined.

e. Ground Support Equipment Problems.

Canopus sensor. Sole failure reported against the life test sensor resulted from damage caused as a result of ground support equipment (GSE) failure. Unit accumulated 5831 hr of operation.

Sun sensors. No failures and/or degradation was detected after 7765 hr of operation. The test equipment was less accurate and stable than the sensors, causing faulty parameter drift information.

Mechanical devices. No problems with the actual hardware were encountered during the test. Some problems with the GSE were experienced. The science cover solenoid and the scan actuator operated without any detectable failure or degradation. The long term oil leakage test performed on the dampers was not very successful because of the problems with the GSE. However, the measured weight losses indicated that the outgassing was in such small amounts that any effect on spacecraft performance would be negligible.

2. Summary of Significant Interruptions

a. Building power failures. The following subsystems reported several interruptions to the life tests resulting from building power failures:

- Data encoder
- Command subsystem
- Radio
- Power subsystem
- Attitude control electronics
- Sun sensors
- Earth detector
- Canopus sensor
- Narrow-angle Mars gate
- Attitude control gyros and gyro electronics

b. Thermal/vacuum system problems. The life tests of the following units were interrupted as a result of a thermal/vacuum system problem:

Magnetometer. On 27 and 28 January 1965, repairs were performed on the vacuum chamber, resulting in a 36-hr interruption to the life test. (This was not a very severe interruption since, at the beginning of each week, the unit was removed from the vacuum chamber to check the lamp and cell ignition voltage of the magnetometer sensor.)

Plasma Probe. Test was interrupted on 1 January 1965 because of vacuum problems. Life test was not resumed until 20 February 1965.

Radio. The pump system in the vacuum chamber failed on 25 February 1965. Test was interrupted until 1 March 1965.

Power subsystem. On 5 June 1965, the temperature control system of the vacuum chamber failed, causing the temperature of the unit to reach 250°F at one temperature monitoring point (see P/FR 7825 for details).

Scan actuator and support; dampers, retarder and timer; science cover latch actuator. One of the major objectives of this particular life test was the detection of slow oil leaks from the hydraulic devices. To accomplish this, small condensing mirrors were placed in strategic points throughout the chamber. These condensing mirrors could be used to detect traces of oil by measuring the changes in their optical properties. However, the master valve controlling the flow of liquid nitrogen to the entire Environmental Test Laboratory, where the life test on this unit was performed, was accidentally closed, resulting in backstreaming of the condensible material from the cold trap into the chamber and contaminating the mirrors.

c. Life test operations support equipment (OSE) problems.

Sun sensors. Several days of life tests were lost due to abnormalities in solar simulator operation and building power shutoffs.

Canopus sensor. On 12 April 1965, problems with OSE power supply caused a transformer in the tracker to burn out.

Narrow-Angle Mars Gate. Planet simulator power supply failed and had to be replaced.

d. Test interruptions for mission support activities.

Ionization Chamber. Special tests were performed to investigate the flight failure.

A/C electronics. At one point in the life test, the unit was withdrawn for use in the investigation of a flight spacecraft problem.

Tape machine. The life test of the tape machine, which consisted of storage in a controlled thermal/vacuum environment, was terminated prematurely to investigate possible problem areas which may have been encountered by the *Mariner IV* unit.

e. Interruption for radiation tests. Life tests on the planetary scan, the television, and the Narrow-Angle Mars Gate units were interrupted to allow special radiation tests to be performed.

f. Interruptions from various causes.

DAS. The DAS was initially placed on life test 23 December 1964 using two MC-1 real-time (RT) trays (20A2 and 20A4). After 990 hr of life test, the MC-1 RT failed and was removed for evaluation. The MC-7 (TA) RT was installed in place of the failed unit and the test was resumed on 14 February 1965.

Television. From 4 September 1964 to 8 September 1964, there was a shutter failure. From 12 September 1964 to 21 September 1964, a shortage of personnel to conduct life test caused interruption of testing.

Battery. All life tests prior to August 1964 were conducted at atmospheric pressures because of the unavailability of vacuum facilities. From 16 August 1964 through 19 August 1964, life tests on batteries 6 and 9 were interrupted to place units in vacuum chambers.

A/C gyros and gyro electronics. The A/C gyros and associated electronics underwent a series of tests which were considered as phases of the life test. Going from one phase to the other resulted in some short interruptions.

g. Life tests reporting no interruptions.

Cosmic Dust Detector

Cosmic Ray Telescope

Trapped Radiation Detector

Solar pressure control assembly

Jet vane actuator

CC&S

Pyrotechnic control subsystem

Post-injection propulsion system (PIPS)

3. Recommendations for Future Programs

a. Central test facility. An examination of the summary of significant interruptions to the various life tests reveals that most of these were the result of either building power shutdown or test facility failure. Indeed, the objectives of one life test (mechanical devices) were not fully realized because of a facility failure. These facts would suggest that future life tests be performed under more controlled test conditions with stringent safety controls and constant, transient-free, power sources.

An efficient solution to this problem would be to provide a central test facility for all life tests, which would give the following advantages:

1. Only one constant-power, transient-free source would have to be provided.

2. Economy, with respect to the number of trained test personnel necessary to operate the facility, would result.

3. Supervision and rigid control of the necessary safety provisions would be provided.

4. A central location for test equipment having long mean time between failures, as well as the specialized facilities necessary for their maintenance, would be provided.

5. Interference of life tests with other test activities that might be going on at the same time would be prevented.

Almost mandatory to an efficient operation of such a facility would be the provision of automatic test checkout equipment for the hardware on test. This not only would minimize the test personnel necessary to staff the central test facility but, also, would minimize the danger from mishandling and operator error during the equipment checkout procedures.

Continuous monitoring of the hardware on test, either by technician or automatic equipment, is always desirable in detecting and analyzing intermittent and/or periodic failures. Automated checkout equipment is the more efficient and, in most cases, the more economical.

b. Central data storage and analysis. A central data storage and analysis area would contain all test histories for an entire test program and would provide easy access to all needing such data. Such a library would facilitate the comparison of related effects and the analysis of these effects.

c. Selection of life test units. To provide data on the flight units, the life test units should resemble the flight units as closely as possible. Any incidents in the history of life test units that would not normally be experienced by the flight units, and the effects of which on the life test units cannot be fully evaluated, should be avoided. The use of TA units, which have undergone a wide range of tests more severe than the FA tests, is not ideal because the effect of the TA environment on the life expectancy of the test items cannot be fully evaluated. For example, the observed cracked diode in the CC&S may have been the result of the temperature cycling during life test or may have been the result of TA testing.

The use of more than one unit for the life tests would be a great aid in the analysis of the effects observed during life tests and would, also, provide a better sample from a statistical viewpoint. Effects peculiar to a specific unit, but not typical of the hardware design, can be eliminated more easily. On the other hand, time-dependent effects that are typical of the flight equipment will become easily recognizable when exhibited by more than one test unit.

d. Use of thermal/vacuum facilities. The desirability of using thermal/vacuum facilities has been demonstrated during the *Mariner C* life tests by the significant number of failures and degradation which would not have been detected if the life tests were performed at ambient laboratory conditions. Good examples of these failures and/or degradation are the ones occurring on the Magnetometer, the power subsystem, battery, and the A/C gyros.

e. Desirability of performing life tests in space simulated environments. In general, it is desirable to minimize the number of unknown effects contributing to the unit's degradation and/or failure. Since it is important to evaluate the hardware's ability to perform its mission, and since insufficient data were obtained to validate acceleration techniques, it is most desirable to duplicate, as much as possible, the mission environment.

Accelerated testing may be a valuable tool if enough is known about the acceleration process. If the acceleration process is not properly understood, more may be obscured by an accelerated life test than revealed by it. However, when only short periods of time, relative to mission duration, are available for life testing, the use of accelerated techniques may be unavoidable; but the life test in such a circumstance becomes simply a tool for the generation of hardware failures in the hope that significant design deficiencies would thus be revealed.

f. Radiation environment. The experience with the ion chamber suggests that it may be possible and desirable to simulate a radiation environment which will be experienced during the mission and to subject test units to it. Life test may be the proper place in which to evaluate the effects on hardware of prolonged exposure to radiation.

g. Digital electronics. To aid in the detection of degradation and the analysis of failures, some provisions should be made on digital electronics to perform 'parameter' measurements on vital test points throughout the unit.

h. Life test scheduling. Life tests should be performed early enough so that results may be implemented in the final hardware design.

4. Conclusions

Reporting on failures of life test units has been confined here to those failures resulting from inherent equipment weaknesses that, in turn, were caused either by improper manufacturing procedures or by the use of defective components.

Overall test objectives of the life test program were achieved: that is, (1) the analysis of such performance effects as degradation as a function of time, (2) the identification of critical failure modes and influences of space environments, (3) the support of inflight problem diagnosis, and (4) the provision of test information indicating the nature and extent of flight hardware deterioration. In addition, there has been an accumulation of experience and useful data that will aid in conducting future tests.

B. Electron Radiation Tests

The effects of possible radiation hazards to be encountered by *Mariner IV* at the time of encounter with the planet were investigated.

Tests[3] were conducted on several *Mariner C* electronic subsystems with a Dynamitron accelerator at fluxes in the range 1×10^7 to 2×10^{11} electrons/cm^2-sec, and energy levels of 0.5 to 2.7 Mev electron energy.

Aluminum or copper foils were placed in the beam path upstream from the test item to scatter the beam uniformly ($\pm 20\%$) over the bombarded subsystem surface. Each subsystem exhibited a repeatable circuitry failure threshold. The failure thresholds were rather insensitive to either the electron energy or integrated flux, but they were very dependent on the flux rate. Failure thresholds for the subsystems tested ranged from 8×10^8 to 6×10^9 electrons/cm^2-sec. One subsystem was found to operate satisfactorily in a flux as high as 5×10^{10} electrons/cm^2-sec.

JPL became concerned with the effects of electron radiation on *Mariner IV* subsystems when R. Davies, a radio astronomer from Jodrell Bank, England, reported that his observations of radio noise at 21 cm showed that Mars had a brightness temperature of 1140°K. Since the infrared (IR) temperature of Mars is 250°K, this suggested that Mars had radiation belts several times as strong as those of the Earth.

[3]Tests were conducted at General Dynamics Convair, San Diego.

Consequently, an electron testing program was begun on those *Mariner IV* subsystems that were judged to be most susceptible to radiation, that were critical to the mission, and that might be ground controlled in such a manner as to avert disaster if their radiation sensitivities were known. The systems chosen for testing were: (1) the Canopus star sensor, which is a sensitive electro-optical instrument containing a special photomultiplier tube; (2) the data encoder, a complex electronic switchyard that prepares the scientific and engineering data in proper format and sequence for telemetry; (3) the planetary scan platform, a wide-angle optical sensor whose purpose is to point the narrow-angle television camera lens at Mars; (4) the television system; (5) the narrow-angle Mars gate (NAMG), a narrow-angle Mars detector used as a back-up start for the television camera; and (6) the gyro and attitude control system.

1. Environmental Estimates

a. Earth's Van Allen belts. The electron flux in the outer Van Allen belt at approximately four Earth radii was measured by *Explorer XIV* during the 5 mo from October 1962 through February 1963 (Ref. 3). Typical omnidirectional fluxes in the heart of this zone were:

$$Jo\,(E > 40\text{ kev}) = 3 \times 10^7 \text{ electrons/cm}^2\text{-sec}$$

$$Jo\,(E > 230\text{ kev}) = 3 \times 10^6 \text{ electrons/cm}^2\text{-sec}$$

$$Jo\,(E > 1.6\text{ Mev}) = 3 \times 10^5 \text{ electrons/cm}^2\text{-sec}$$

Temporal variations were observed to raise and lower the above values by as much as a factor of 10.

b. Estimated radiation belts at Mars. With the assumptions that Mars had a magnetic field and that the electron flux on Earth and Mars was equal at points of the same field strength, rough estimates of the radiation belts of Mars were made based on assumptions of strength of the Mars magnetic dipole moment. Since at the beginning of the investigation the moment of Mars was not known, early estimates of the Mars radiation belts were highly conjectural. If the Martian magnetic moment were less than that of the Earth, then it was expected that the spacecraft would encounter fluxes less than 3×10^7 electron/cm²-sec at Mars. H. R. Anderson made an estimate based on various assumed Martian magnetic moments; the containment power of the magnetic field gives extreme upper limits of electron fluxes through which *Mariner IV* would fly, as follows:

Condition	*Max. omnidirectional flux* ($E_e > 2$ *Mev*)
$M_M = 0.1\, M_E$	1.2×10^9 electrons/cm²-sec
$M_M = 1.0\, M_E$	1.2×10^{11} electrons/cm²-sec

Since Mars was expected to have a magnetic moment $< 10\%$ of Earth's ($M_M < 0.1\, M_E$), it was considered highly unlikely that the spacecraft would encounter

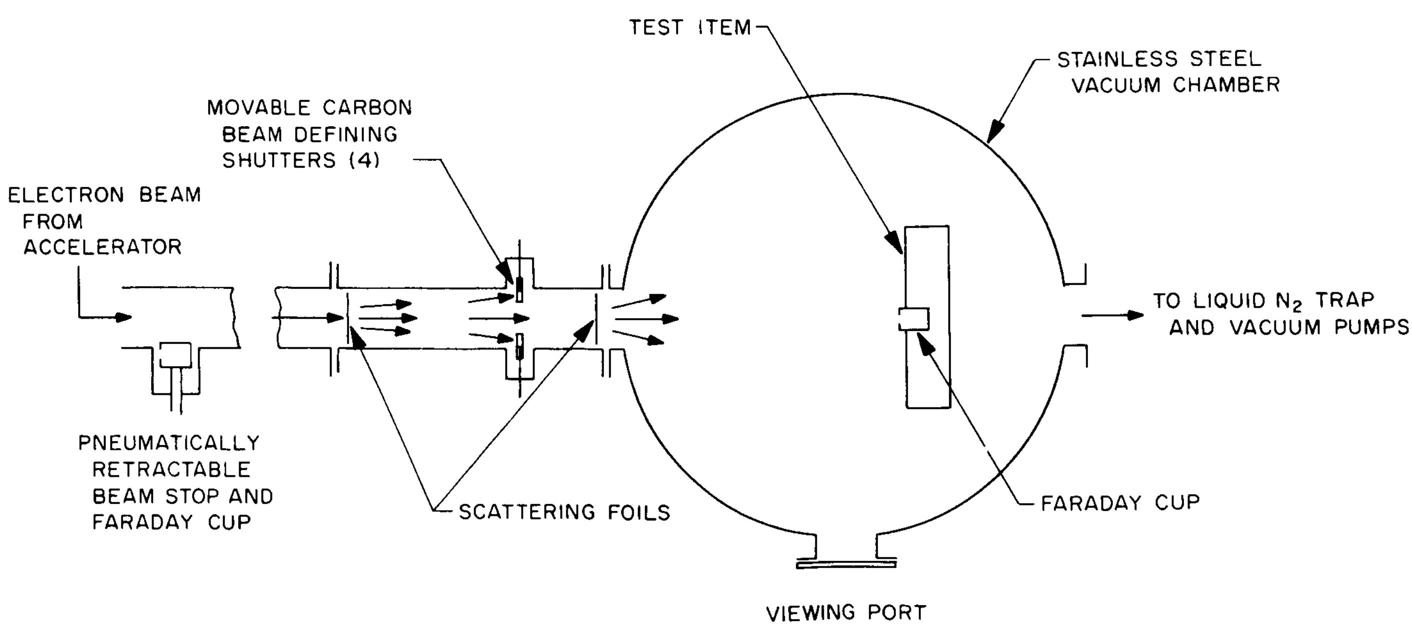


Fig. 36. Electron radiation test setup

electron fluxes as large as 1.2×10^9 electrons/cm²-sec; rather, they were expected to be $< 3 \times 10^7$ electrons/cm²-sec.

2. Test Activity

a. Apparatus. Figure 36 shows the geometry of the test setup. The electron beam from the accelerator may be stopped by the pneumatically operated Faraday cup, allowing the beam current to be preset to the required test value. The scattering foils are 24 in. apart; their function is to broaden the beam spatially to cover the test item with a uniform electron flux. The four carbon shutters could be moved into, or out of, the beam to achieve a rough control over the beam intensity at the test surfaces. During the test, vacuum in the chamber was maintained at 10^{-5} torr or below.

The shape of the beam after scattering was determined by driving a Faraday cup across the vacuum chamber with a screw mechanism and monitoring the collected current with an electrometer driving a strip chart recorder. Several flux maps obtained in this way are shown in Fig. 37, together with roughly fit Gaussian curves. The flux distribution was shown to be symmetrical about the beam centerline by traverses below center, horizontally, and at 45 deg from vertical. The curves were taken with one foil only in a traverse across the center of the vacuum chamber 26 in. from the foil. Similar curves were obtained by using two foils as shown in Fig. 36. It was found that changing the position of the carbon shutters did not change the curve shape, within experimental accuracy.

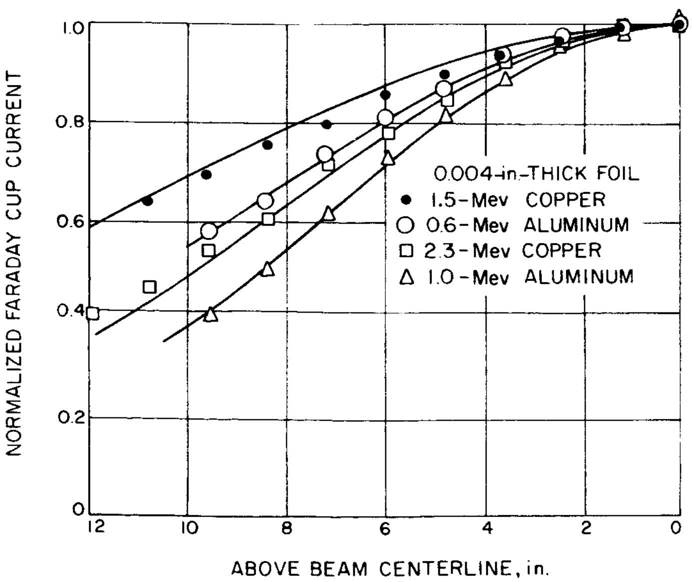


Fig. 37. Electron flux distribution in the area of the test flux

It is apparent that the single aluminum ($Z = 13$) foils are useful electron scatterers for this test only below 1 Mev. Accordingly, two copper foils ($Z = 29$) were used for the higher energies. The lower Z foils were used whenever possible because the bremsstrahlung or X-ray production, as well as the scattering ability, rises as Z^2 (Ref. 4).

With the test geometry described above, directly measurable beam fluxes at the subsystem surfaces varied from 10^7 electrons/cm²-sec to a maximum of 2×10^{11} electrons/cm²-sec. The low fluxes were attainable only at lower electron energies where corona discharge inside the accelerator beam tube was not excessive. The upper flux limit is determined by accelerator stability at low energies and by the beam current that will burn a hole through the foils at higher energies. Electron energies from 0.5 to 2.6 Mev were used in the test. Flux monitoring was achieved by using a Faraday cup mounted adjacent to or, if possible, on the front surface of the test item. The flux measurements are estimated to be accurate to within ±20%. Electron energies quoted in the test results are corrected for energy loss due to foil traversal. Taking into account the energy spread due to foil-induced straggling and the accuracy of the measured accelerator voltage, the electron energies are accurate to roughly 10%.

The subsystems were mounted in their magnesium flight cases with the beam incident on the flight case. At the thinnest portions of the case, the electrons had to penetrate about 0.6 g/cm² of magnesium, with loss of about 0.8 Mev. Note that the Canopus sensor, planetary scan preamplifier and motor, television preamplifier and optics, and the NAMG are not protected by a flight case. A nominal 0.2-Mev electron energy loss occurs in penetrating the respective aluminum shields.

The test items were mounted inside the vacuum chamber on an adjustable aluminum pedestal and platform. With the exception of the planetary scan, television, and NAMG subsystems, the test items were located 39 in. from the last scattering foil. The above noted exceptions were mounted in the chamber center 26 in. from the foil, so as to utilize external optical stimuli. The subsystems were connected by 35-ft cables to the OSE located outside the accelerator target area.

b. Test procedure. Following exploratory test runs on the Canopus sensor to determine general areas of malfunction, the procedure was to initially irradiate the subsystem at 0.56 Mev for 20 min at a flux of 10^8 electrons/cm^2-sec. This was chosen as a flux/energy combination yielding a conservative simulation of radiation levels that the spacecraft might experience during the encounter sequence. The program was then to increase fluxes by approximately half-order-of-magnitude steps (pausing at each level for subsystem checkout by the cognizant engineer), until a malfunction ensued or maximum accelerator flux was reached. The electron energy was then increased and the flux values again stepped through. Whenever a malfunction occurred, the beam flux was adjusted downward in small steps in order to ascertain a threshold flux level for malfunction. The subsystem was also monitored after each malfunction to determine if permanent damage had occurred. Monitoring was done by moving the retractable beam stop in to intercept the beam. Subsystem recovery was then evidence that RF fields, power-line loading or other phenomena associated with operating the accelerator were not responsible for the observed behavior.

3. Results

Figure 38 is a plot of the malfunction thresholds observed for the various subsystems. The various modes of malfunction are presented in Table 11.

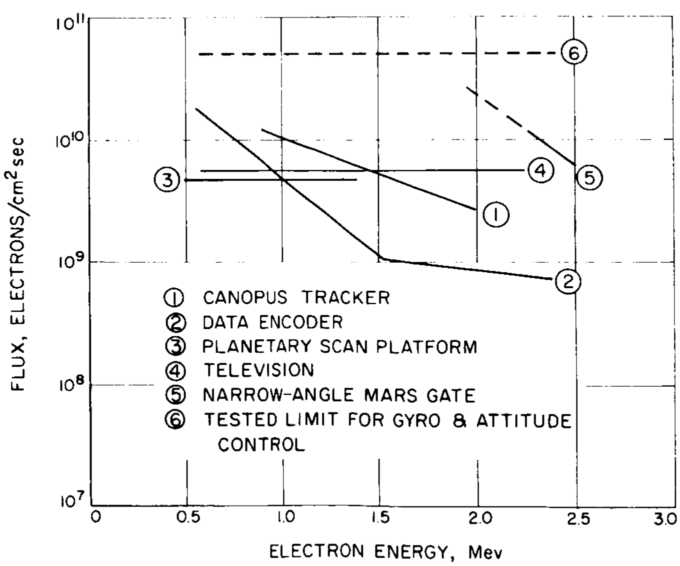


Fig. 38. Radiation thresholds of malfunction for various subsystems in test

Table 11. Subsystem failure modes

Subsystem	Radiation-induced failure mode	Damage recovery
Canopus sensor	Decrease in roll error saturation voltage below ±2.0 v Null voltage offset Apparent star intensity increase with no star in view	Star tracking ability regained immediately following beam cut off (Front lens element was darkened, degrading transmission by 35% after an inferred total dose of 3000 r.)
Data encoder	Commutator sync loss predominant at energies below 1 Mev Demodulation lock loss above 1 Mev Event counter change of state Switch from Mode 1 to Mode 4 at flux of 5×10^{10}	Immediate recovery following beam cutoff
Planetary scan	Unprogrammed scan direction reversals Failure to generate planet in view signal Failure to carry out programmed search mode	Recovery achieved after about 20 min for medium flux levels (up to 12 hr for flux levels of 10^{10})
Television	White spots on the picture associated with transients on the video line Switch to fast exposure speed Increased noise level causing grayish background Decrease in picture resolution	Recovery following high flux bombardments achieved after about 20 to 30 min
Narrow-Angle Mars Gate	False planet acquisition only at high energies and fluxes	Immediate recovery following beam cutoff
Gyros and attitude control	No anomalous behavior found	

The Canopus sensor was the only assembly tested capable of giving an analog performance output correlated to the electron flux. The other subsystems exhibited a *go/no-go* type of behavior. During irradiation of the sensor, a simulated Canopus star was swept back and forth across the sensor's field of view. The position of the star was indicated by the potentiometer signal, which was used to drive the X-axis of an X-Y-Y recorder. Intensity and roll error voltages were simultaneously plotted vs the roll position of the star. The roll error voltage is a signal proportional to an angular displacement (-1 deg $\leq \theta \leq 1$ deg) of the star from a plane going through the optical axis of the sensor and roll axis of the spacecraft. Displacements between ± 1 to 3 deg give saturated roll error outputs, while displacements $> \pm 3$ deg are out of the field of view. A plot of the saturated or maximum roll error signal as a function of electron flux is shown in Fig. 39 for an irradiation at 2.25 Mev. The maximum roll error voltage varies between $+10$ and -12 v. Loss of roll attitude control occurs when the maximum roll error signal falls below 2 v. Figure 39 shows that this point is reached for 2.25 Mev electrons at an electron flux of 4×10^9 electrons/cm²-sec. In addition, we note a sizable offset in the star null position voltage at fluxes greater than 10^9. The polarity of the null offset was a function of the direction of the incident radiation with respect to the sensor. Consequently, null offset voltages were expected to be less of a problem in an omnidirectional flux field.

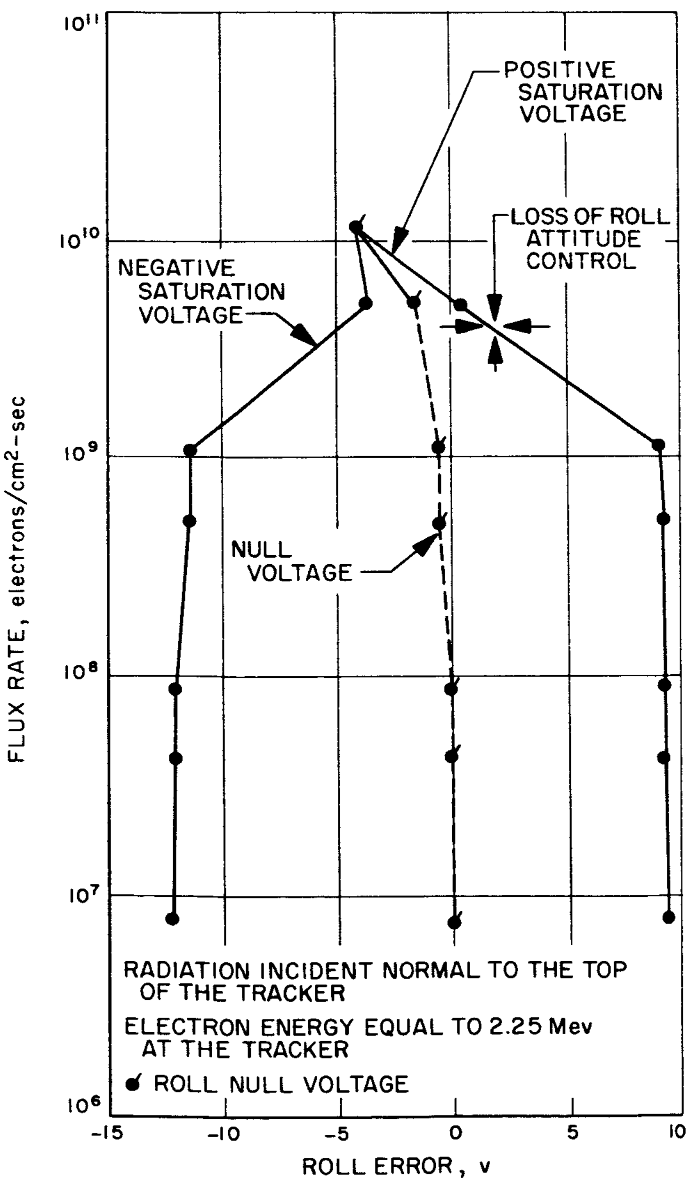


Fig. 39. Performance of the roll error signal under radiation with electronics at 2.25 Mev

The star intensity signal was also monitored. It was found that when there was no star in the field of view, an apparent star intensity signal was produced whenever electrons were incident on the sensor. Furthermore, it was found that when this apparent star-intensity signal reached six times Canopus brightness, the roll-error signal peak had dropped to the 2-v control loss level. Plots of the apparent star intensity for no star input vs radiation flux rate are shown in Fig. 40 for three electron energies. In this case, the electrons are incident 32 deg from the normal to the top of the sensor. This direction, which permits the electrons to reach the photocathode while traversing the minimum absorber thickness, was predicted to be the most sensitive direction to cause a radiation-induced failure. In the final analysis, however, there was no preferred direction of incidence. The energies shown on Fig. 40 are electron energies upstream from the 4-mil copper scatterer. About ⅛ Mev should be subtracted from the quoted energy values to give the electron energy at the sensor surface.

The Canopus sensor exhibited the only permanent damage degradation of all subsystems tested. The front

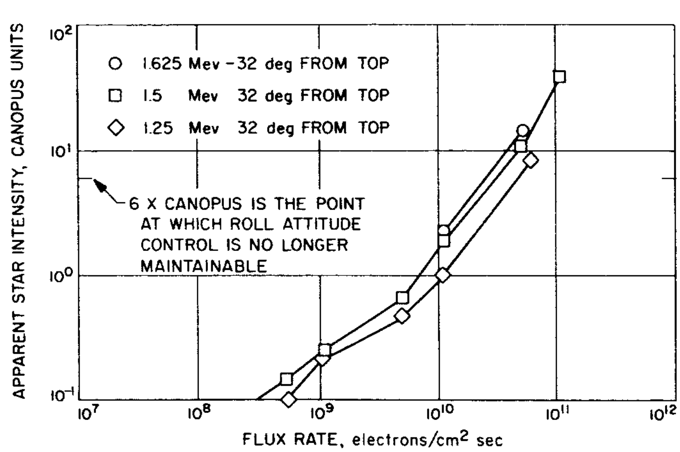


Fig. 40. Apparent star intensity for no star input vs radiation flux rate

lens element was darkened, degrading transmission by 35%. The darkened element was made of flint glass and the integrated dose was estimated to be 3000 rad.

Note that the data encoder malfunctioned at electron energies which could not penetrate the flight case, indicating that bremsstrahlung produced by the electron deceleration in the scattering foils and the flight case contributes significantly to the system's radiative degradation. Such bremsstrahlung produced in the scattering foils acts to make this test more conservative.

The planetary scan subsystem was checked for its ability to search for, and lock onto, a simulated planet located outside the vacuum chamber, and to generate a planet-in-view signal. In this case, the planetary scan sensor generated an error signal when the planet was off the sensor axis. The error signal applied to a servo loop resulted in driving an electric motor in the direction required to keep the planet centered in the field of view. As Table 11 shows, failures occurred in all the operational modes monitored. A phenomenon peculiar to the planetary scan and television subsystem was the long recovery time after each failure induced by the radiation. This was found to be due to a slowly decaying radiation-induced noise level in the *p-n* junction sensor. Radiation sensitivity to electrons was energy independent.

The television camera was focused onto a test pattern outside the vacuum chamber during irradiation. A decrease in picture resolution, grayish backgrounds caused by increased noise level in the preamplifier, and large transient pulses on the video signal line were seen. The large pulses caused white spots to appear on the television picture and were, also, responsible for switching the camera to a fast exposure speed. The threshold failure level was 5×10^9 electrons/cm^2-sec, independent of the electron energy.

The narrow-angle Mars gate was found to malfunction only in relatively high flux fields at energies above 2.5 Mev. The sensor is a cadmium sulfide photoconductive cell that simply changes resistance with incident light level. A two-transistor trigger circuit comprises the remainder of the circuitry. The failure modes were the appearance of a false planet-in-view signal at the flux levels shown in Fig. 38 or, at lower fluxes, the inability of the gate to drop out after the Mars simulator was switched first on, then off.

The gyro and attitude control circuitry was the only subsystem that was totally unaffected by the electron irradiation as far as we could detect by overall system performance checks. It is felt that this is mainly due to the fact that all the amplifiers used a very high degree of feedback.

Except for the darkening of the Canopus sensor optics, there were no effects that could be attributed to a cumulative radiation dose.

4. Summary

The extent of the bremsstrahlung produced by the electron beam in the scattering foils and its effect on the electronic subsystems is, at present, an unknown factor. However, the bremsstrahlung does act to make the test conclusions conservative. Rough bremsstrahlung measurements have subsequently been made, under contract,[4] in a somewhat similar irradiation geometry. The dose and flux measurements were also made in a plane 26 in. from a 4-mil copper scattering foil. It was found that for electron energies lower than 1.7 Mev, the dose rate due to foil bremsstrahlung was $< 1\%$ of the dose rate due to the electrons, alone. However, the ratio was seen to increase rapidly to a value of 14% at 1.95 Mev, which is the high energy limit of the contracted facility; so the region above 2 Mev was not explored.

The accumulated radiation dose given to the items in this test is higher by several orders of magnitude than the accumulated dose intercepted by *Mariner IV* in traversing the Van Allen belt, the solar wind, and cosmic radiation. The tests indicated that the *Mariner IV* spacecraft should be capable of operating reliably and continuously for at least 1 hr in electron flux fields of 10^9 electrons/cm^2-sec at electron energies between 0.5 and 2.7 Mev. Since this flux was much higher than the practical predictions of Martian trapped radiation fluxes, the project decided not to modify the nominal encounter sequence. The wisdom of this decision was borne out by the charged particle and magnetic field measurements made by *Mariner* during fly-by. The *Mariner* measurements detected no trapped radiation belts, and the Martian magnetic moment was shown to be $< 3 \times 10^{-4}$ times that of the Earth's.

C. *Electromagnetic Interference Test Activities*

Three tests were performed in the electromagnetic interference (EMI) area during this post-launch period. One of these tests, the RF signature test, had been

[4]At the Statitron facility of Atomics International, Division of North American Aviation, Inc., Canoga Park, California.

waived during the test operations because of limited time available; the results were expected to benefit future spacecraft programs, but were not considered mandatory for a successful *Mariner* mission. The second of these tests was performed to verify that peak power RF levels expected to be encountered on the launch pad and during the launch phase would not deteriorate the spacecraft pyrotechnics. The third test investigated the noise that had been observed in space chamber PTM tests when the attitude control gas jets were energized. It had been feared that if the noise appeared during the encounter sequence, some commands or information would be lost.

Two tests that were suggested to the Project Office for further investigation of possible problem areas were not performed. These two tests were: (1) a complete umbilical and separation connector transient test and (2) high-voltage tests that would simulate breakdowns of accumulated voltages on the spacecraft/shroud configuration. The tests were not performed because it was felt that the information gained would not be directly applicable to future spacecraft programs.

The test of RF noise at the transmitter frequency was not performed because it could not be carried out without disturbing the flight configuration. Its performance would not yield valid results if the flight configuration were changed, and no other test method was devised. The problem was one of making a noise measurement in the presence of the transmitted high-level RF signal.

1. Spectrum Signature Test of PTM

No major problems were encountered during the PTM spectrum signature test. A frequency range from 30 Hz to 10 GHz was surveyed while the PTM was operated in the cruise mode. The cruise mode was chosen for this test because a majority of the spacecraft functions would be active at this time. The encounter mode, in which the science systems would be in operation, would have been preferred, but that mode could not be kept on for the total test time. Results of this test will be useful in planning test requirements for future spacecraft programs.

Measurement was made of the RF environment to which the spacecraft was subjected on the system test complex; this measurement may be valuable in determining *Voyager* program RF environmental test levels.

The RF contribution by the spacecraft was also measured. The exact level generated by the spacecraft could be of importance—for example, in the event an electromagnetic measurement experiment were included. Such a measurement could be severely restricted by the ambient RF level; in such a case, the measurements must be made with the spacecraft in a shielded enclosure that has a low ambient RF level. Since adequate facilities were not available at the time, a complete measurement of the spacecraft RF levels was not made.

A spectrum signature measurement, a *Mariner* program requirement, was made on the PTM between 21 and 30 April 1965. The findings will be directly applicable to the *Voyager* program. The results will be used to prepare allowable limits for electromagnetic radiation output from future spacecraft, and the measurement of radiation present on the spacecraft may aid in the design of radiation-measurement experiments to be carried on the spacecraft.

A block diagram of the test configuration is shown in Fig. 41. The antennas were positioned 10 ft away because a closer distance would not allow some of the more directive horn antennas to view the complete spacecraft.

The spacecraft was first conditioned according to the following list, though not necessarily in the order shown.

1. Spacecraft power on
2. Simulated solar power, Mars mode
3. Data encoder Mode 2 (8⅓ bits/sec)
4. Radio: traveling wave tube, TWT (power amplifier A), exciter A, transmitter high-gain, receiver low-gain antenna, RF power up (DC-8)
5. DC-1, cruise on, encounter with scan inhibited, DC-24

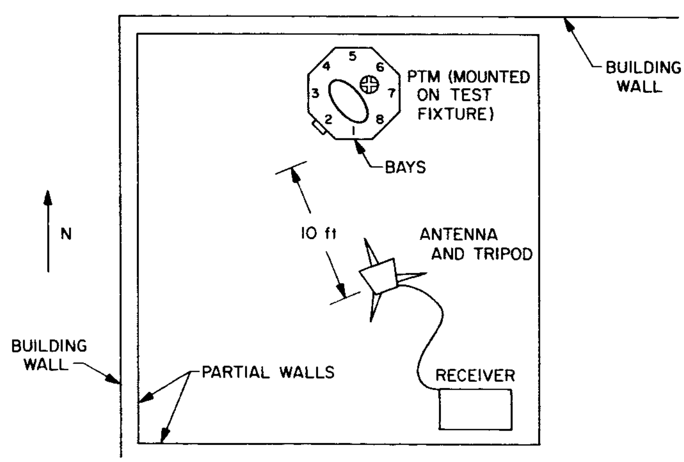


Fig. 41. Block diagram of test configuration

6. CC&S: L-2, L-3, set for attitude control; MT-7 set to turn encounter science on
7. Attitude control: Sun gate, dc power; DC-15 and DC-18 in effect
8. Video storage: 2.4-kc power on (not recording)

After the spacecraft was conditioned, it remained in this mode of operation while measurements of the radiated electromagnetic fields were made. The noise and field intensity meters and associated equipment were operated in a normal manner to make the measurements. The measured voltages at the receiver input were later converted to field strength.

The greatest problem was identifying the source of radiation. Because of space limitations in the shielded room, it was not possible to perform the test there. As a consequence, the test was performed in a location that has a certain ambient electromagnetic field not contributed by the spacecraft. Signals from local stations and some other sources can be identified by monitoring the received signals with earphones. These signals were not recorded. The remainder, however, may not necessarily be assumed to be due to the spacecraft. When the measurement of a frequency band or set of bands on the receiver was completed, the spacecraft was turned off, OSE was left on, and the ambient field was measured. In some cases, the reading had increased by a few db for this measurement. This is typical in a normal unshielded environment because of variation in man-made and natural radiation, so it caused no concern. However, any spacecraft fields lower than the ambient cannot be measured.

Because of various other commitments of the spacecraft and test team, the spacecraft configuration was not exactly the same during each day's testing. However, deviations were not considered to be serious.

The results are presented in Figs. 42 to 45. With each graph of RF noise measured with the spacecraft on, there is a corresponding graph of RF noise measured with the spacecraft off, but with as much OSE on as possible. In some cases, it can be seen that the spacecraft contributed little or nothing in excess of the ambient noise level. In other cases, it appears that the spacecraft reduced the ambient noise level; in fact, the variation of the ambient could be on the order of ±5 db, which makes interpretation of signals near the ambient very difficult. In the frequency region of 1 to 10 GHz, the ambient noise level was low and was not measured.

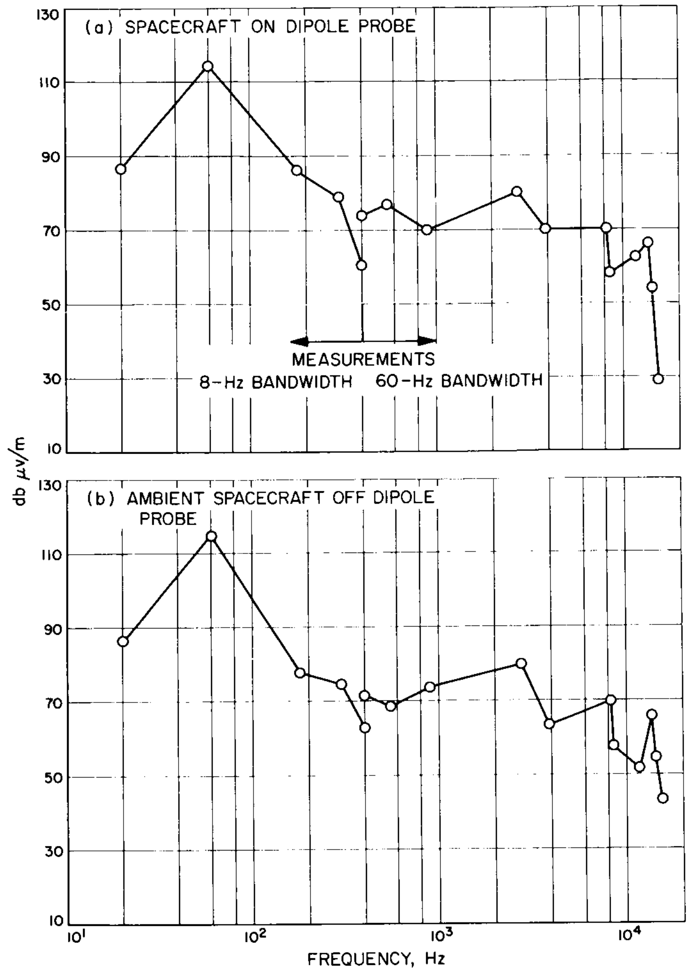


Fig. 42. Spectrum signature, dipole probe

In the frequency region 50 kHz to 1 MHz and near 10 MHz, the spacecraft apparently emitted broadband RF noise above the ambient noise level. In the frequency region of 50 to 300 MHz, much more broadband noise was recorded with the spacecraft on than with the spacecraft off; more continuous wave (CW) signals were also generated. In the frequency region 1 to 10 GHz, four signals were obviously the first harmonic (fundamental), second, third, and fourth harmonics of the spacecraft transmitter (2295 GHz). Near these harmonics were apparent sidebands, spaced primarily at intervals of approximately ±150 MHz on either side of the harmonics.

The noise amplitudes shown in the figures are in db above 1 μv/m (CW) or db above 1 μv/Mc/m (broadband) because they are the standard units used in electromagnetic compatibility (EMC) and in standard EMC specifications.

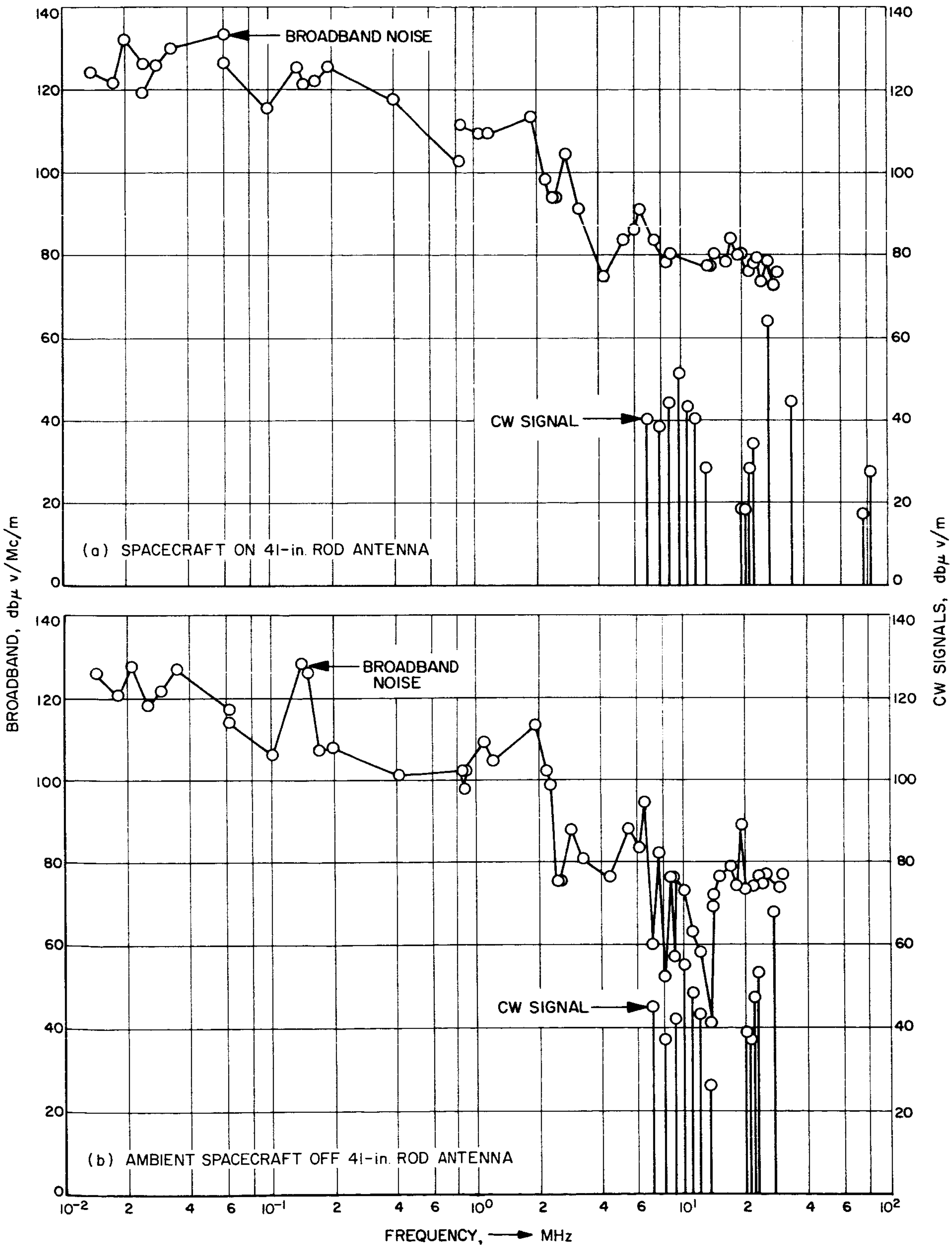


Fig. 43. Spectrum signature, rod antenna

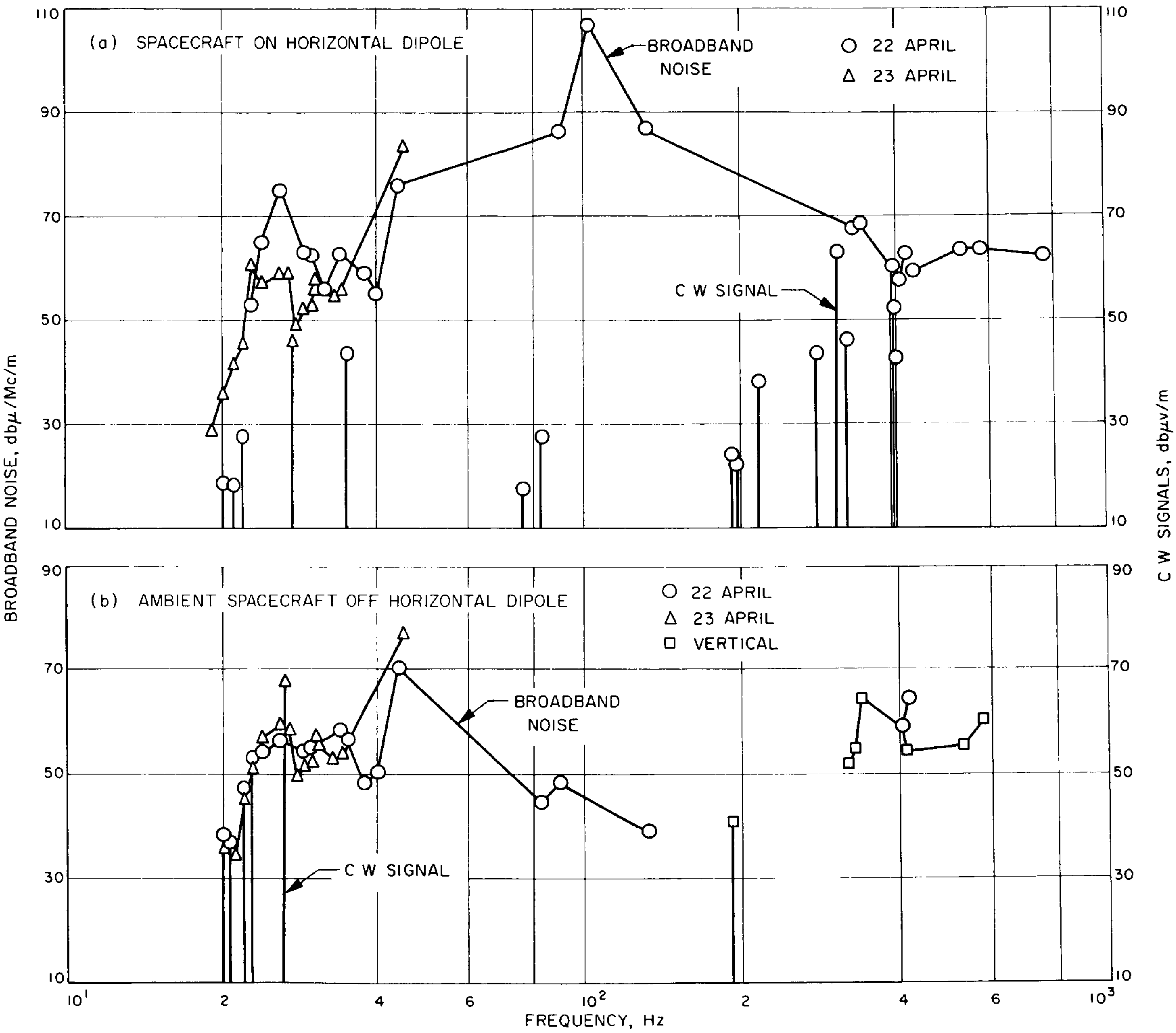


Fig. 44. Spectrum signature, horizontal dipole

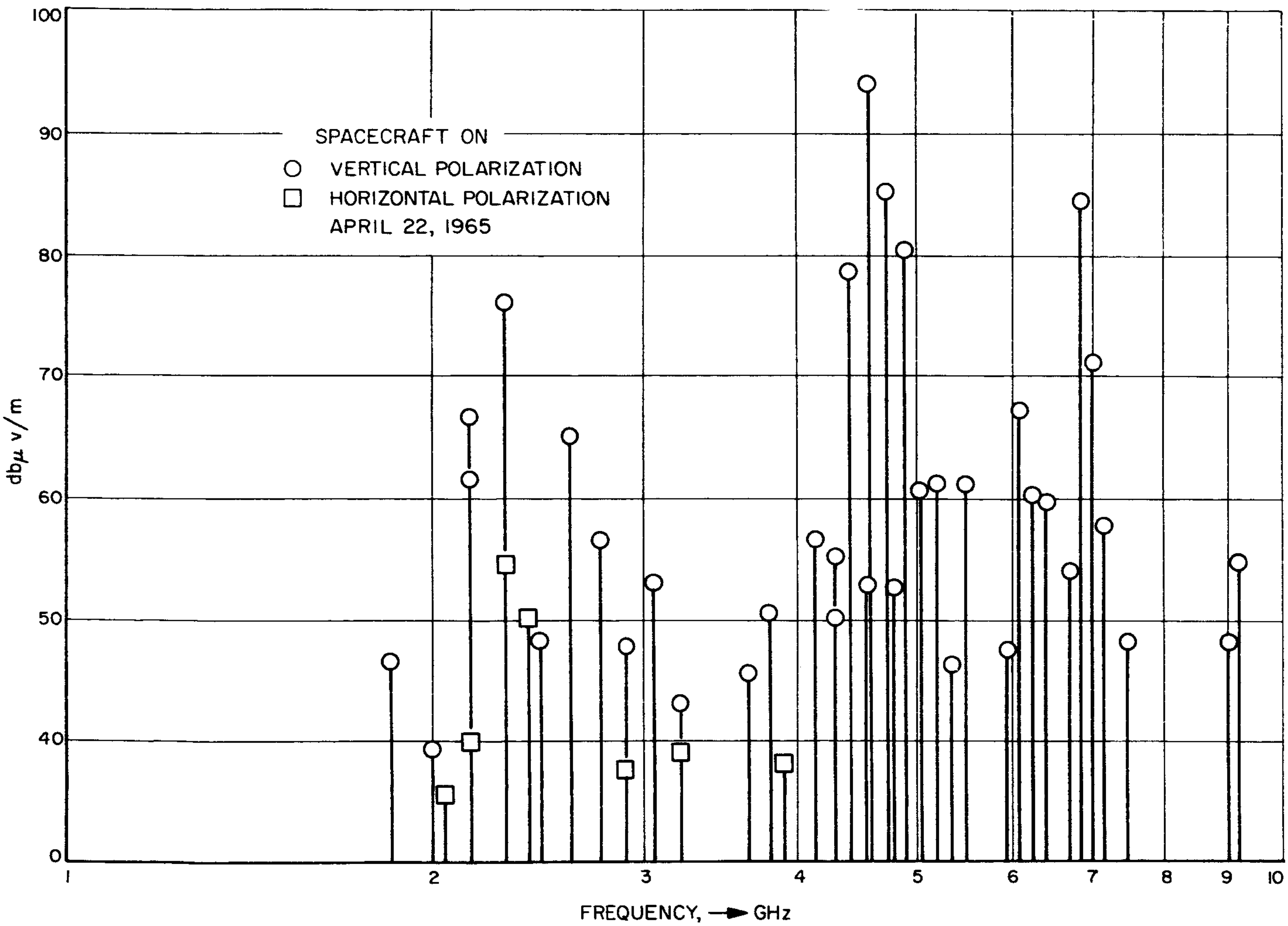


Fig. 45. Spectrum signature test results, spacecraft on vertical and horizontal polarization

2. RF Simulation Test With Peak RF Power Densities

The purpose of this test was to determine the effects of peak RF simulation levels on the spacecraft pyrotechnics. Some of the RF levels had not been used during previous testing because average power levels had been employed. One other test with live pyrotechnics and RF simulation had been performed on the PTM spacecraft on 4 and 5 May 1964. That test employed an S-band RF generator that provided a radiation of 100 w from the spacecraft omni-antenna. The shroud was both on and off for that test. No pyrotechnics had been detonated or showed any degradation. Reservations had been expressed, though, on the validity of the test because two of the RF sources simulated were simulated with an average CW level instead of the peak level. To increase the confidence on the test safety margin, the test was performed again on 16 April 1965 using peak power density levels.

Continued revisions of the RF simulation levels using information obtained after the first PTM test determined that some of the RF levels would now be lower in magnitude and that two of them, Atlas pulse and rate beacons, would be greater. Decision was made that the higher level in all cases should be used. Therefore, the test levels used were those used previously, with the exception of the levels for the Atlas rate and pulse beacons. The simulation levels, antenna distances, etc., are shown in Table 12, and the simulation equipment setup is shown in Figs. 46 and 47.

No pyrotechnic devices were activated by the simulation sources during the test. The pyrotechnics were examined and no degradation was observed in either the pinpuller or midcourse motor valve squibs.

3. S-band RF Noise Measurements on PTM in Spacecraft Assembly Facility

The objective of this test was to determine whether noise at the spacecraft receiver frequency observed during space chamber tests on the PTM was still present when the attitude control gas valves and other functions were actuated. If noise had been observed, methods were to have been investigated that would determine how to

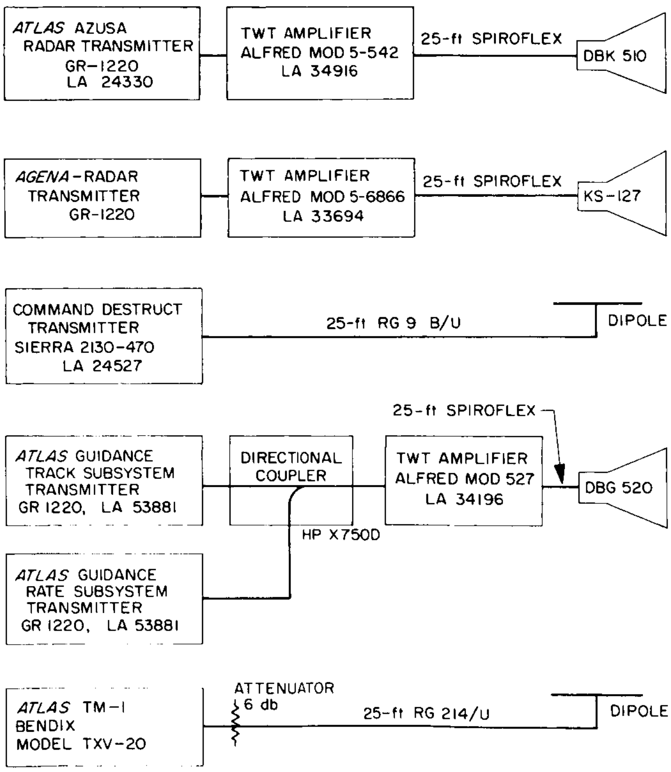


Fig. 46. Simulation equipment

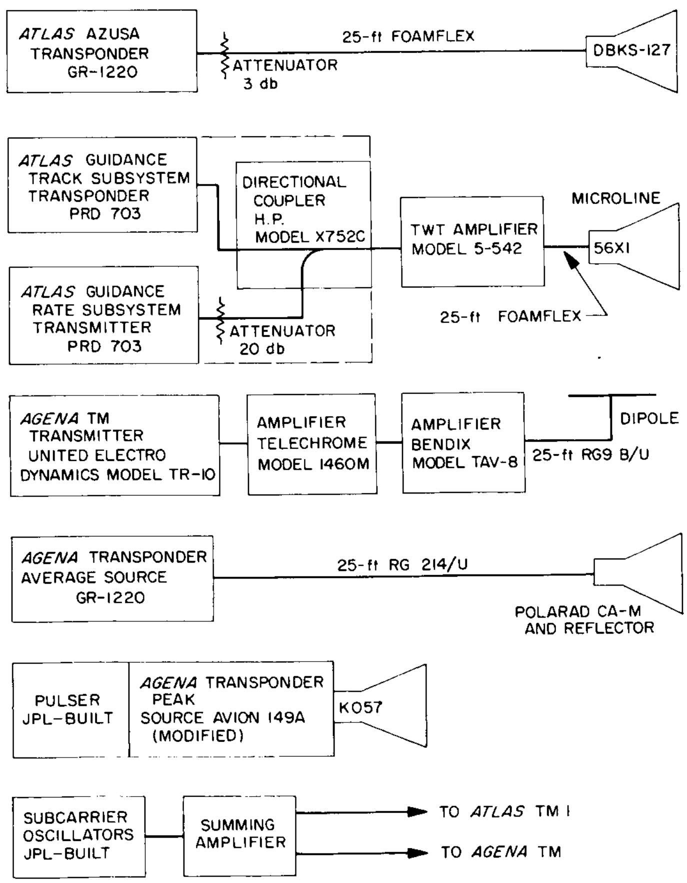


Fig. 47. Modulation source for *Atlas* TM-1 and *Agena* TM sources

Table 12. RF simulation test parameters

Electromagnetic interference source	Frequency, Gc	Antenna power, mw	Antenna and gain	Antenna to spacecraft distance		Antenna azimuth	Power density required, mw/m²	Power density (actual) based on calculations using actual power antenna & distance, mw/m²
				Required meters	Actual measured meters			
Agena radar transmitter (FPS-16)	5.690	159.0	Horn[a] 15 db	2	2	[b]	100.0	100.0
Atlas Azusa radar transmitter	5.060	2000.0	Horn 10 db	1.414	1.414		795.0	795.0
Atlas guidance track subsystem transmitter	Classified	252.0	Horn 15 db	1	1		640.0	640.0
Atlas guidance rate subsystem transmitter	Classified	25.2	Horn 15 db	1	1		64.0	64.0
Command destruct transmitter	Classified	173.0	Half-wave dipole 2.14 db	3	3		2.52	2.52
Atlas telemetry No. 1	0.2299	87.2	Half-wave dipole 2.14 db	3	1.5m		1.26	1.26[c]
Atlas Azusa transponder	5.000	35.8	Horn 15 db	1.5	1.5		40.0	40.0
Atlas guidance track subsystem transponder	Classified	200	Horn[a] 17 db	1	1		795.00	795.0
Atlas guidance rate subsystem transponder	Classified	0.06	Horn[a] 17 db	1	1		0.25	0.25
Agena telemetry	0.2443	26700.0	YAG1 Y103-N 12 db	2.9	2.9		4000	4000
Agena transponder average source	5.765	6.28	Reflector & Horn feed 24 db	2	2		32.0	32.0
Agena transponder peak source, 500 pps	5.765	540 W 259 MW 600 pps 0.8 μsec	Horn 10 db	1.85	1.85	[b]	126,000	126,000

[a]One antenna for two sources.

[b]Per JPL Procedure CM 409.00, p. 14.

[c]It was not possible to set the antenna for this source at the required 3-m distance. A 1.5-m distance was used and a 6-db pad was used to decrease the antenna power accordingly.

minimize any injurious effects during the encounter. The test was performed in the spacecraft assembly facility (SAF) because of the requirement that the PTM be available for backup tests during the flight of *Mariner IV*.

The frequency translation system of the S-band receiver was used in conjunction with a magnetic tape recorder, and a frequency band of 120 kHz centered about 175 kHz was recorded during the test. The tape recording was subsequently analyzed; apparently some change had been made to the spacecraft, or a change in the test configuration had occurred, since no noise was observed during the test or in the subsequent analysis of the tape recordings.

During the PTM space simulator mission tests, the omni-antenna output was monitored for the presence of noise in the spacecraft receiver frequency to comply with the test and operation plan requirements. Low-loss foamflex coaxial cables and a duplexer were used to connect the omni-antenna output to the EMI receiver console. At various times during the 10-day period of the test, measurements were made and some predetection magnetic tape recordings (in a bandwidth from 25 to 300 kc) were made of the omnidirectional antenna output. It was determined that when the valves were operated, noise bursts were observed with the test receiver. The noise was recorded, and later analysis of one of the longest bursts indicated that the level exceeded the allowable maximum noise level by approximately 20 db during the 50 msec of its occurrence.

It was requested that tests with the PTM spacecraft in the space chamber be performed to determine more fully the noise characteristics and effects on the spacecraft receiver at encounter. Some objectives of this test were: to determine the mode of noise generation, to determine the magnitude of the noise at the spacecraft receiver input, and to arrive at a method of living with the noise bursts if they occurred during encounter. Certain radio tests during gas jet firing were suggested to determine adverse effects. Because the noise bursts were not observed with a horn antenna, even at a close proximity, the radio tests were not performed.

Because of the requirement that the PTM spacecraft be maintained in a ready condition for *Mariner IV* backup exercises and investigations prior to encounter, the PTM was not placed in the space simulator for the noise measurement test. An analysis had shown that a test performed in the SAF would yield a more sensitive noise receiver system sensitivity than the test configuration at the space simulator. Therefore, the requirement that the PTM remain in SAF did not adversely affect the noise test—except for the possibility that the simulated space conditions would be a factor in the creation of the noise.

a. Receiver system. The S-band noise measurements were made with a sensitive receiver. The noise receiver configuration is shown in Fig. 48. The noise receiver is a double conversion device with stable oven controlled local oscillators. A parametric amplifier with a low-noise figure is used for the spacecraft receiver frequency. Two preselectors are used, one for the center frequency and one for the spacecraft receiver image. The second IF frequency (at 9.56 Mc) is inserted into the receiver. The receiver final IF magnitude at 455 kc is measured with a vacuum tube voltmeter.

The system noise temperature for a test configuration in SAF is lower than for a configuration in the space simulator (Appendix B). The system temperature in the SAF configuration is calculated as 945°K, and it is calculated as 3188°K for the space simulator. Although the space simulator walls are cooled by liquid nitrogen, the long coaxial cable length with several db of loss causes that configuration to yield a higher system temperature. The differences in receiver system temperatures yield a sensitivity margin of 5.3 db, and since it is more difficult to conduct a test in the space simulator, the SAF configuration was preferred.

b. EMI noise receiver calibration. During the survey period, the noise receiver was calibrated with the S-band calibrator unit. This unit included a crystal oscillator encased in an oven-controlled stable temperature chassis. The basic crystal frequency was multiplied up to the spacecraft receiver frequency, and the calibrator power output was monitored with a thermistor and a microwave power meter. Part of the power was diverted through a directional coupler and attenuated by precision variable and fixed value attenuators. The output calibration RF level was a stable, known value, since the signal path had previously been carefully calibrated. The power supply and power monitor leads were well filtered, and the calibrator case was an integral casting with a tight fitting RF gasketed cover. The variable attenuator dial had been calibrated in position vs attenuation, and a chart listing dial position vs output power was used in the calibration.

The calibration technique was to determine the 3-db sensitivity level of the noise receiver and to observe that the frequency read on the noise receiver was correct.

Before the tests were started on each day, the gain of the S-band noise receiver was adjusted and the noise figure was measured. This process was repeated halfway through the test and, also, at its conclusion. The receiver remained stable throughout its operation with a noise figure of essentially 3 db.

c. Predetection recording. The frequency translator system placed the S-band receiver frequency for the PTM at 175 kHz. The bandwith of interest was 120 kHz centered about 175 kHz. The tape recordings were taken to the Data Analysis Laboratory for analysis. The analysis immediately available was one using a wave analyzer

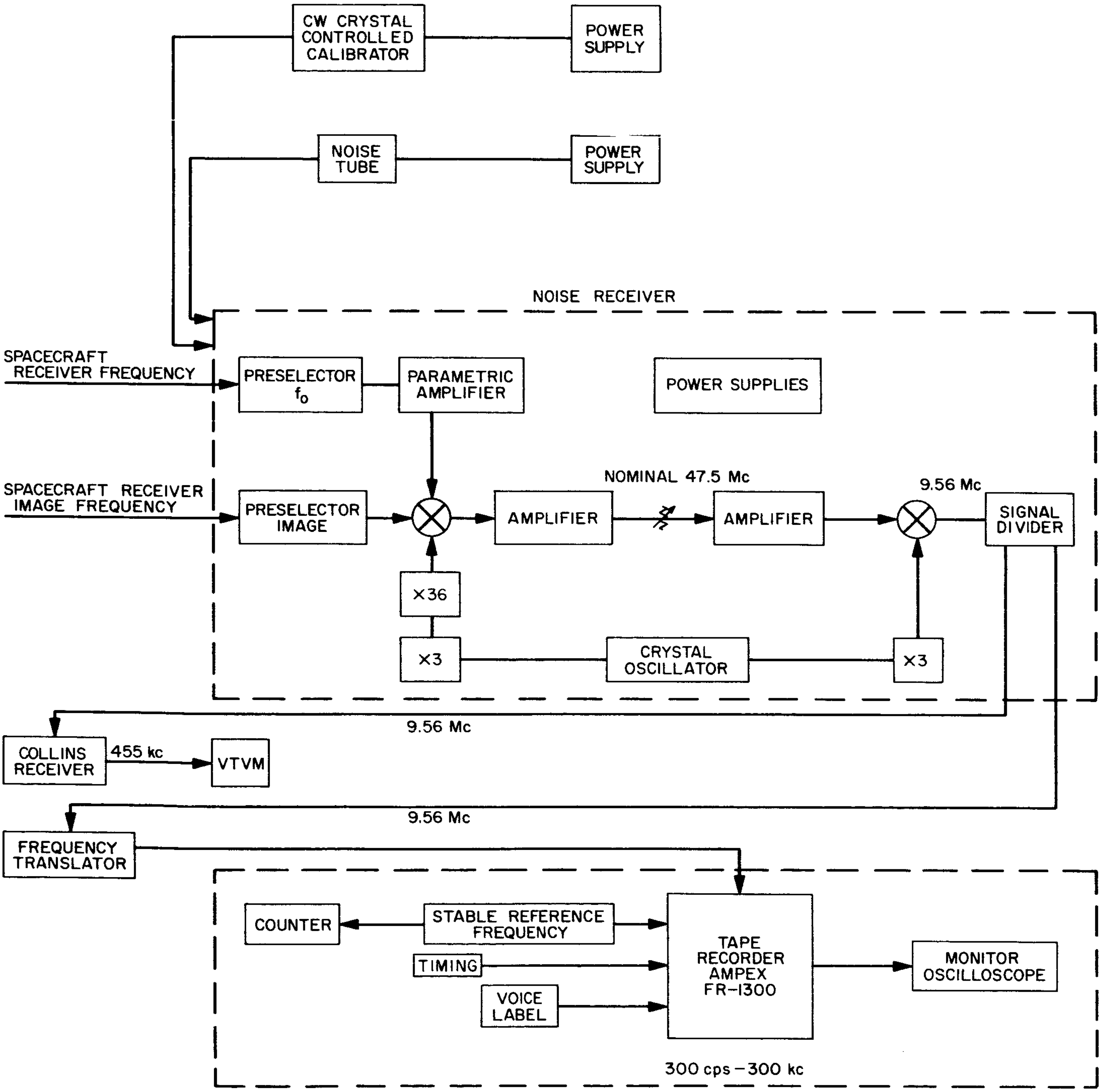


Fig. 48. Noise receiver configuration for S-band noise measurements

that required a tape slowdown by a factor of eight. With a 20-Hz bandwidth filter, a resolution of 160 Hz at the original frequency was possible. There existed a limitation with the wave analyzer; the cutoff frequency was 25 kHz and this would correspond to an original frequency of 200 kHz. The data were then analyzed in a bandwidth of 175 (+25, −60) kHz. Since this data reduction was to be merely a preliminary analysis, the cutoff would be acceptable. It was hoped that an analysis could later be made of the entire band.

The magnetic tape recordings made during a series of valve actuations, Sun gate initiate commands, etc., were analyzed and calibrations were placed on the tape recordings; these included discrete S-band CW calibrator RF levels, an ambient 50 Ω termination, and a gas tube noise source.

d. Measurements in SAF. The measurements were performed using the spacecraft omnidirectional antenna and a portable S-band horn antenna. For tests with each antenna, the following attitude control functions were actuated:

1. Yaw and pitch valve firings clockwise (cw) and counterclockwise (ccw)
2. Roll ccw
3. Initiate Sun gate
4. Canopus sensor on

No noise was observed when the spacecraft omnidirectional antenna was used (this would be the noise introduced into the spacecraft receiver). After a period of testing, a horn antenna (with 15.9-db gain at 2113 Mc) was set up on a tripod approximately 4 ft from the spacecraft. Again, the several functions were actuated. Only one possible noise burst was observed, but it could not be repeated. Since it was not repeatable, its origin was attributed to some other cause not found. A light-weight horn antenna (with similar gain) was then used to probe about the spacecraft as individual elements were energized: the several valves, the Sun sensor, the Canopus sensor, and Case VII. No noise bursts were seen. The horn antenna, connecting cable, and receiver were verified to be working when the background noise level varied with antenna orientation.

Although no noise bursts were observed visually on an oscilloscope at the EMI S-band receiver output, a tape recording was made during the series of valve actuations, Sun gate initiate commands, etc.

The results of the analysis for six separate spacecraft events were available a few days before encounter, and an examination of the results seemed to indicate no apparent discrete noise components. The analysis of the magnetic tape was performed at discrete occurrences of the noise test, but it was difficult to determine the exact time of each spacecraft occurrence. This experience indicates that if future tests of this type are performed, instrumentation will be required that will place an event marker on one of the tape recorder data channels at the time of its execution.

e. Conclusions. Since no noise bursts were observed in these tests and some had been observed with the PTM in the space simulator, the following reasons may account for it.

1. The vacuum environment is required for the noise to be generated.
2. Any noise, however small, when in the space simulator, is reflected efficiently into the omnidirectional antenna. This is not the condition for a spacecraft in free space, of course.
3. Some change in spacecraft hardware or configuration between the two tests eliminated the noise generation.

D. Magnetic Stability and Demagnetization Tests

While the *Mariner* solar panels were successfully demagnetized for the flight spacecraft, their magnetic stability remained an uncertainty. Because of this lack of information, limited magnetic tests were scheduled subsequent to the *Mariner IV* midcourse maneuver on TA solar panels and on the complete PTM bus.

In the first tests conducted in February and March 1965, two TA solar panels were subjected to vibration tests and storage for periods of four weeks in controlled environments in both the magnetized and demagnetized conditions. The tests on the PTM bus were conducted during a week in May followed by a second week in August 1965. In the earlier tests, attempts were made to demagnetize the spacecraft in the presence of the Earth's field, while in the latter tests, the ambient field was reduced by more than an order of magnitude using a special coil system.

1. Solar Panel Magnetic Stability Tests

The solar panel stability study, which had as its primary purpose a determination of the stability of the flight solar panels during launch operations and interplanetary cruise, was conducted in four phases:

1. Determination of the effects of vibration in the presence of an ambient magnetic field
2. Storage of a demagnetized panel in the Earth's field
3. Storage of a demagnetized panel in a low-field environment
4. Storage of a magnetized panel in a low-field environment

The vibration tests were conducted to indicate what the effects of launch might be on the solar panels due to vibration in the Earth's field as enhanced by the presence of the launch vehicle and umbilical tower. Unfortunately, the degree of similitude is not good. The vibration levels in these tests are higher, and the ambient field is believed to be more than an order-of-magnitude higher and very divergent. Vibration fields as high as 10 gauss were measured near the solar panel when it was mounted on the vibration exciter. The field of the launch vehicle and umbilical tower is not so well known. Limited measurements indicated that the magnetic field at launch is only slightly more than the Earth's field, alone.

The vibration tests disclosed that magnetization of the solar panels was entirely independent of the frequency of vibration over the range of testing (40 to 2000 cps). A magnetized panel appeared less stable than a demagnetized panel when shaken on the vibration exciters. The residual magnetization acquired by the demagnetized panels was consistently the same, whereas the magnetized panel, when shaken, ended with a residual magnetization that appeared to bear no relation to either the initial magnetization or the shaker field. It appears that the resultant, residual field of a demagnetized panel following vibration is entirely a function of the ambient field from the vibration exciter and the orientation of the panel in the ambient field. The solar panels, with their Kovar strips and wires principally parallel to the long axis of the panel, became magnetized to a considerably higher value with the field in this axis. It was found that the solar panel residual magnetization followed a typical magnetization curve, with saturation occurring at about 20 gauss (which is the expected value for Kovar). In the region of the Earth's field magnitude, the field at the magnetometer would be about 2 γ.

The storage tests indicated that a demagnetized solar panel is relatively stable when stored either in a low ($< 100\ \gamma$) field or in the Earth's field. A magnetized (permed) solar panel, on the other hand, definitely loses its magnetization with time when stored in a low-field environment. Earlier measurements made on solar panels transported between Pasadena and Cape Kennedy also showed negligible change in field over a period of several months. For these low-field tests, the panel was stored both in a magnetic shield room and in a single-axis spherical coil system; because of the size of the solar panels, the ends of the panels were exposed to somewhat higher fields; however, changes in the residual magnetization of the solar panels was negligible in all cases except the stored magnetized panel.

From the above study, it can be concluded that the magnetic field due to a demagnetized solar panel should not change during interplanetary cruise, but could change a limited amount on launch. It is estimated that the change of field of each solar panel on launch would be less than 2 γ, even under worst-case conditions.

2. Proof Test Model Bus Demagnetization Study

Time did not permit a demagnetization of the *Mariner III* or *Mariner IV* bus structures before launch. With the successful demagnetization of the solar panels, there was renewed interest in the possibilities of demagnetizing the remainder of the spacecraft; so a study was scheduled on the PTM spacecraft. A 1/20 cps alternating, decreasing field was used for the spacecraft demagnetizing to avoid inducing damaging voltages in the spacecraft circuitry.

The first week of the study consisted of attempts to demagnetize the spacecraft in the Earth's field. Demagnetization was attempted in successively increasing initial field steps of 5, 10, 20, 40, and 80 gauss in each of three orthogonal axes. The Z axis component of the spacecraft field, which is the predominant one, was decreased in steps from 30½ down to 17 γ. At each initial field level, the spacecraft was demagnetized in two perpendicular axes in the X-Y plane, followed by mapping, and in the Z axis with the order alternated at successive levels. Even though the initial field was doubled at successive levels, the change in remanent field was less in the instances where successive demagnetizations were in the same axes, than when the initial field was the same and the orientation of the demagnetizing field changed. This indicates that it will probably be necessary to demagnetize a spacecraft in more than one axis, except where the demagnetizing field can be aligned with the residual magnetization of the spacecraft.

Following this partial demagnetization, it was concluded that the saturation level of some spacecraft material, such as the hard magnets, had not been reached and that, in order to further demagnetize the spacecraft, it would be necessary to reduce the ambient Earth's field. This latter course of action was followed in August 1965. Available 10-ft-diam Helmholtz coils were adapted to encompass the spacecraft demagnetizing fixture. For demagnetizing in the X-Y plane, the demagnetizing coil axis was oriented in the magnetic north–south direction and two pairs of Helmholtz coils were arranged to buck out the vertical and north–south components of the Earth's field (Fig. 49). With this arrangement, the ambient field over the volume to be occupied by the spacecraft bus structure was reduced to $< 4000\ \gamma$, or almost an order of magnitude.

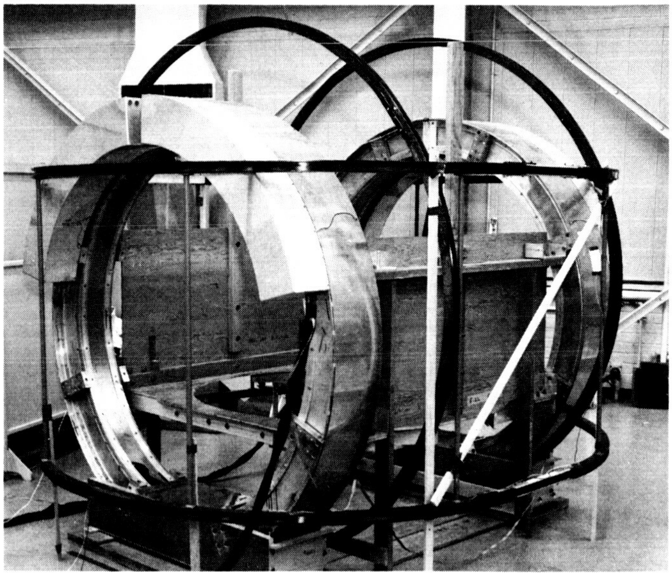


Fig. 49. *Mariner* X-Y plane demagnetization facility with Earth's field bucking Helmholtz coils

In demagnetizing in the Z axis, a single pair of Helmholtz coils were inclined so as to oppose the total Earth's field (Fig. 50). Over the large volume of the spacecraft, this arrangement reduced the ambient field to $< 3000\ \gamma$. In these latter tests, demagnetization was only attempted at initial field values of 40 and 80 gauss. The improvement in field reduction at 80 gauss was very slight. For optimum demagnetization, it was necessary to demagnetize in three axes. By this means, the PTM spacecraft bus was demagnetized so that the remanent field at the magnetometer location was reduced to $H_X = -4$, $H_Y = 0$, $H_Z = 4\frac{1}{4}\ \gamma$. In the course of these tests, the spacecraft was magnetized by exposure to fields of 25 and 50 gauss. The spacecraft acquired a much higher residual magnetization when magnetized in the Z-axis direction. Following this magnetization, the residual magnetization could be reduced to its minimum

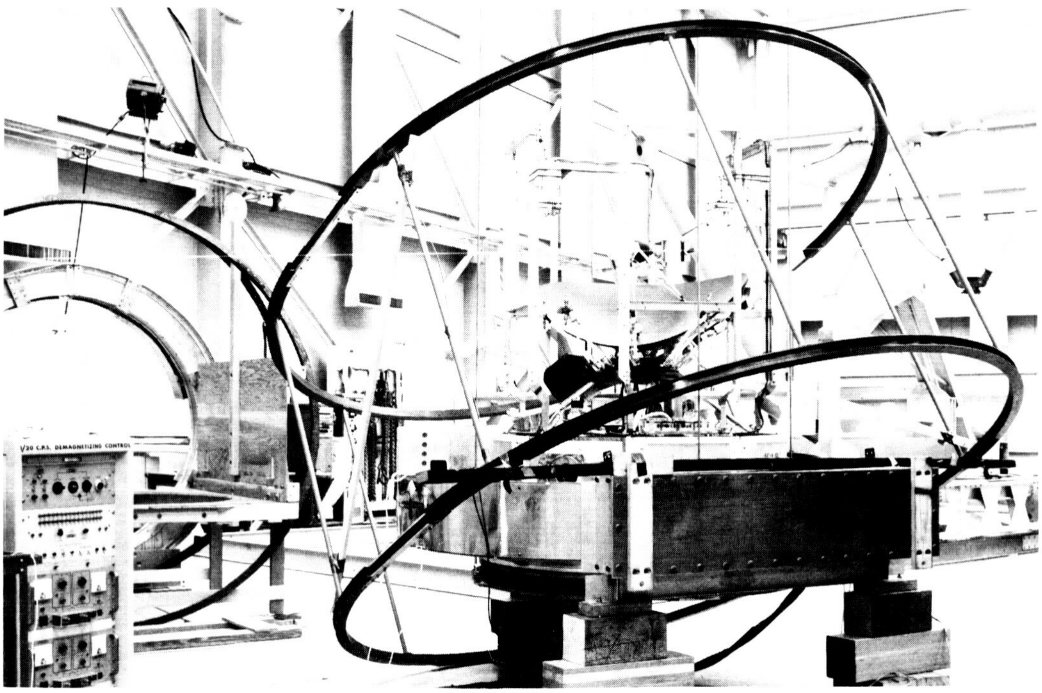


Fig. 50. Demagnetization of PTM spacecraft in Z axis with Earth's field bucking Helmholtz coils

value by a single demagnetization in the same direction as the earlier magnetizing field. Table 13 summarizes the results obtained with the *Mariner* PTM spacecraft. In the magnetized case, the sign is dependent on the direction of the magnetizing field.

Table 13. *Mariner C* PTM residual field at Magnetometer

Condition of PTM spacecraft	H_X	H_Y	H_Z
Before demagnetization	+2½	+3½	+30½
After 40Γ demagnetization in Earth's field	−4½	0	+19
After 80Γ demagnetization in Earth's field	−4¾	−½	+17
After 40Γ demagnetization in low ambient	−5¾	0	+4
After 80Γ demagnetization in low ambient	−4	0	+4¼
After 25Γ magnetization X-Y plane	−41	−32	+12
After 50Γ magnetization X-Y plane	+72	−68	+29
After 25Γ magnetization Z axis	+2	+27	+132
After 50Γ magnetization Z axis	−10	−51	−205

E. Proof Test Model, Usage and Disposition

1. From 1 to 8 December 1964

PTM spacecraft operations during the period 1 through 8 December 1964 were devoted to support of *Mariner IV* midcourse maneuver preparations and problem analysis resulting from the loss of Canopus acquisition, when the DC-27 command was transmitted at the start of the first midcourse maneuver attempt. Specifically, the tests were:

1. An SFOF midcourse maneuver practice test
2. An SFOF midcourse maneuver using command tapes prepared for the proposed maneuver to verify accuracy of the tapes
3. A series of tests designed to aid analysis of the Canopus loss that occurred at the start of the first midcourse maneuver attempt
4. An investigation of Canopus sensor susceptibility to power system transients

a. SFOF midcourse maneuver tests. A simulated midcourse maneuver test was conducted on 1 December 1964 to provide practice and procedure verification for the operations team. Spacecraft operating time was 2.9 hr. As a simulated problem, a shorted squib was inserted in each half of the pyro harness. Spacecraft operations were completely normal.

The second SFOF midcourse maneuver test was conducted on 3 December 1964 to provide practice for the operations team and to verify the accuracy of command tapes prepared for the MC-3 maneuver. Spacecraft operating time was 2.7 hr.

The midcourse maneuver was performed by the PTM spacecraft with commands supplied by the SFOF midcourse tapes. All maneuver and burn durations and polarities were verified by measuring the responses of the PTM. No simulated problems were introduced and spacecraft operation was normal.

b. Maneuver abort problem investigation. An investigation of maneuver command sequence responses was conducted on 4 December 1964. Spacecraft operating time was 6.5 hr.

Objectives of the investigation were to examine possible explanations for the loss of Canopus acquisition at the instant that the midcourse maneuver counter was started by a DC-27 command and to develop procedures for circumventing another maneuver abort if acquisition loss was found to be inevitable.

Three maneuver sequences were completed with Canopus intensity adjusted to the lower limit. Three attempts failed to cause loss of acquisition. But it was likely that sufficient torque was produced to cause loss of Canopus acquisition if the flight spacecraft roll were at a limit of the roll cycle. The sequence was repeated with positive and negative roll errors introduced and again with occasional gas valve operation. Canopus acquisition was not disturbed on the PTM spacecraft.

To establish corrective procedures to recover acquisition, if lost at the time of the DC-27 command, six variations of the proposed roll command sequence were tried to determine the effect on the spacecraft. Repetitive roll increment commands were issued at short intervals without inducing unusual response from the spacecraft. Acquisition was accomplished immediately after roll increment commands. All of the procedures attempted were successfully completed with no apparent spacecraft problems induced in the PTM.

c. Canopus sensor noise susceptibility test. A Canopus sensor noise susceptibility test was conducted on 8 December 1964. Spacecraft operating time was 1.1 hr. The objective of this test was to determine the sensitivity of the Canopus sensor to power system transients generated by attitude control gas valve operation. This test was conducted in support of analysis of Canopus acquisition loss during cruise conditions on 7 December 1964. Transient conditions were induced with the Canopus sensor adjusted for various roll error and intensity adjustments.

Results of the tests were entirely negative. Canopus acquisition was not disturbed by power noise transients produced by any combination of gas valve operation or gyro on commands.

2. From 9 December 1964 to 11 February 1965

The period from 9 December 1964 through 11 February 1965 was primarily devoted to preparations for the early encounter exercise performed by *Mariner IV* on 10 February 1965. A series of tests was conducted to investigate anomalies observed in the functioning of *Mariner IV* and to support SFOF early encounter investigations prior to the actual performance (see Fig. 51).

The test sequence follows:

1. A science investigation of the *Mariner IV* Plasma Probe failure mechanism
2. A television encounter
3. An attitude control investigation of gyro turnoff delay reduction, as a function of Canopus acquisition loss interval
4. A science cosmic dust investigation
5. A radio investigation of suspected *Mariner IV* carrier suppression change, caused by the flight data rate switch from 33⅓ bits/sec to 8⅓ bits/sec
6. A system verification test
7. A science subsystem to OSE computer and 83.3 kc interface verification
8. A computer data system data reduction demonstration for *Surveyor* personnel
9. A series of three SFOF science command sequence verification tests
10. Five SFOF scan platform positioning tests

a. Plasma Probe noise test. To determine the effects of an arc in the high voltage circuit, a science Plasma Probe noise test was performed on 11 December 1964.

The purpose of this test was to determine if the suspected failure of the high voltage bleeder resistor in the *Mariner IV* Plasma Probe could adversely affect encounter experiments.

High voltage arc simulation was achieved by connecting a spark gap across the Plasma Probe cup, to ensure arcing when the voltage stepped to the highest levels.

b. Television encounter. A television encounter was performed and encounter data were examined for evidence of interference due to arcing. The noise bursts caused the data automation system to issue an erroneous motor stop–start command to video storage and also produced interference in the form of a television picture line displacement. Data automation system synchronization was disrupted occasionally and the data encoder skipped a 200-deck position when Data Mode 2 operation was attempted. Spacecraft operating time was 3.4 hr.

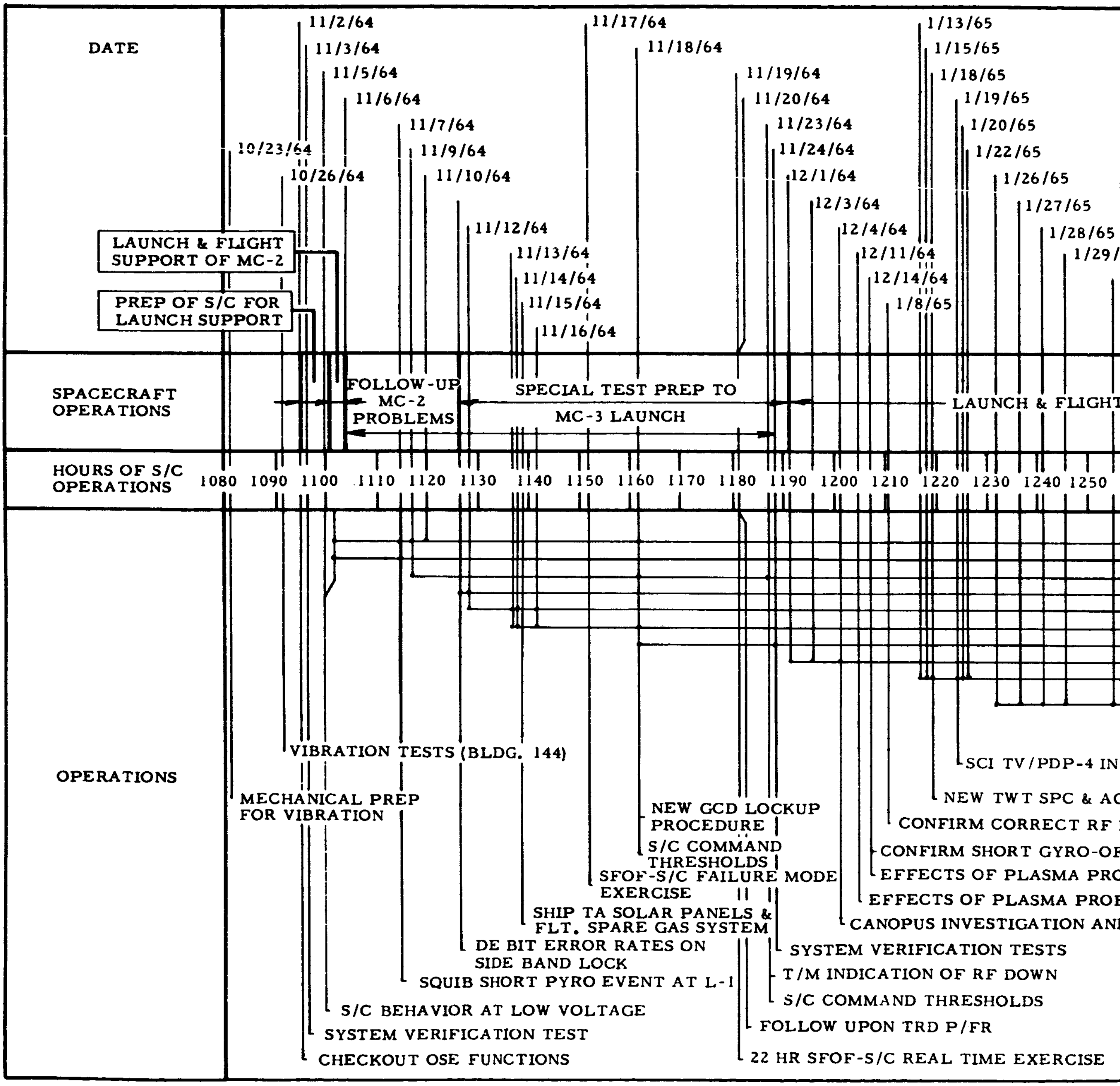
c. Attitude control. Attitude control examined the gyro turnoff time delay following Canopus acquisition as a function of the duration of the loss of acquisition. The purpose of this test was to improve the explanation of results noted on *Mariner IV* flight data following brief losses of Canopus acquisition.

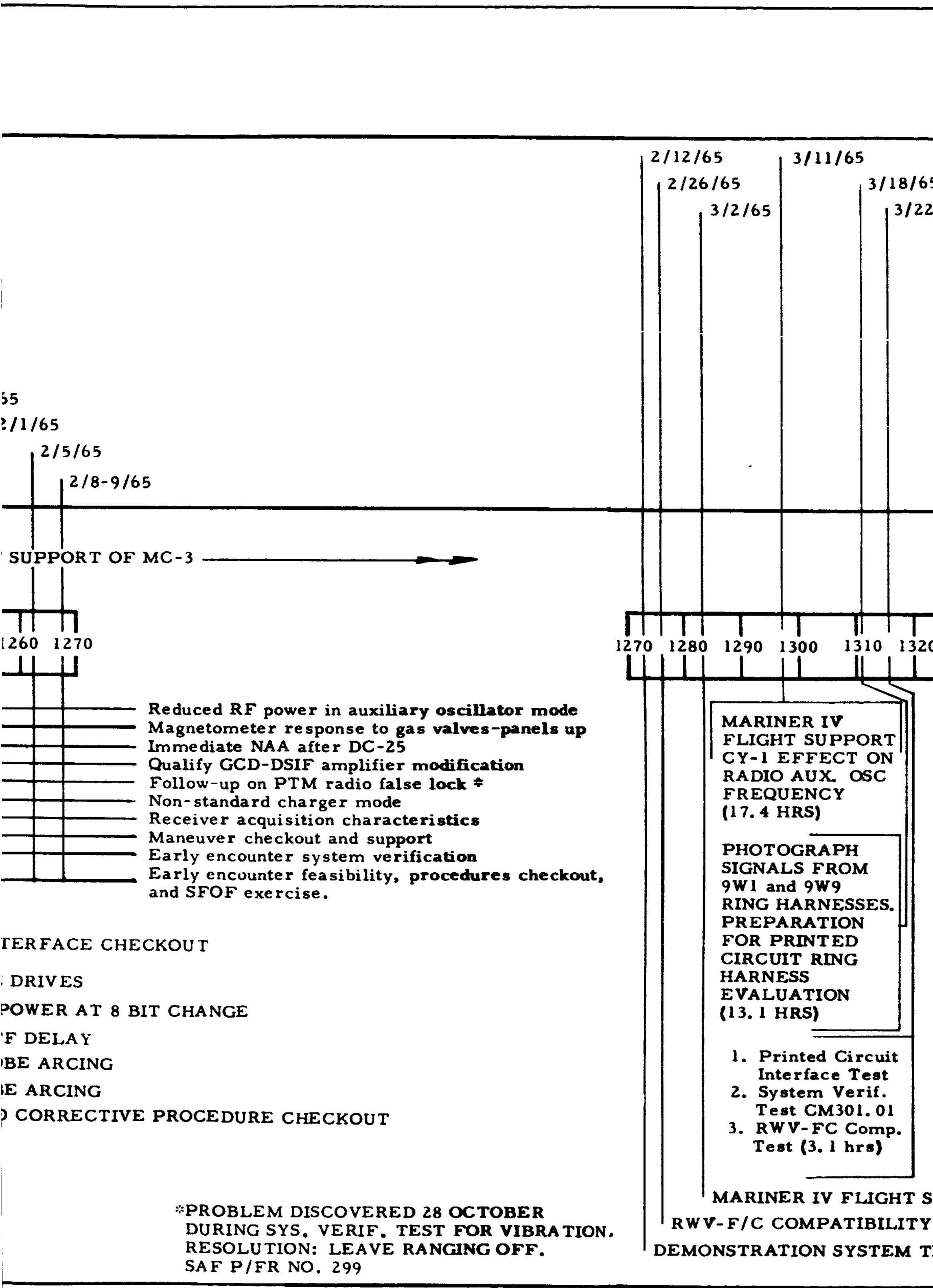
Results of the test demonstrated that a brief loss of acquisition will result in a turnoff time delay of less than 3-min duration and that a very short acquisition loss interval did not turn on gyros.

d. Cosmic Dust Detector. Science conducted a Cosmic Dust Detector calibration test during 5–6 January 1965. Mechanical preparations were completed during the period 28 December 1964 to 4 January 1965 to put the spacecraft in complete flight configuration, except that dummy solar panels were installed.

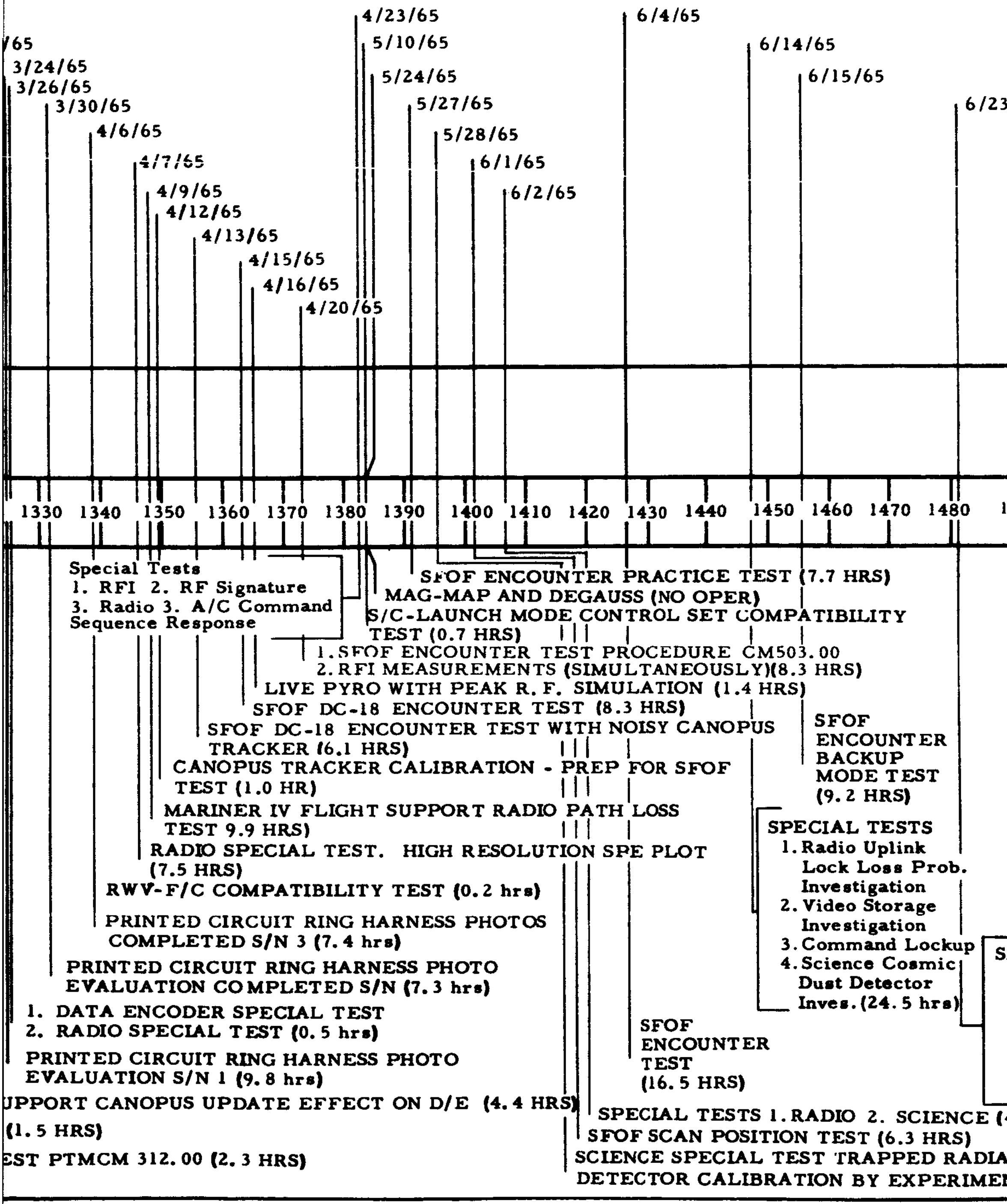
The test consisted of dropping shot on the spacecraft bus, Case IV, and on the dummy solar panels, while observing the output of the Cosmic Dust Detector. Objective of the test was to verify sensitivity and calibration of the Cosmic Dust Detector as related to particles striking spacecraft surfaces. During the test the Cosmic Dust Detector was operated from an external source; no other spacecraft systems were turned on.

MARINER PTM TEST AND OPERATIONS SUMMARY

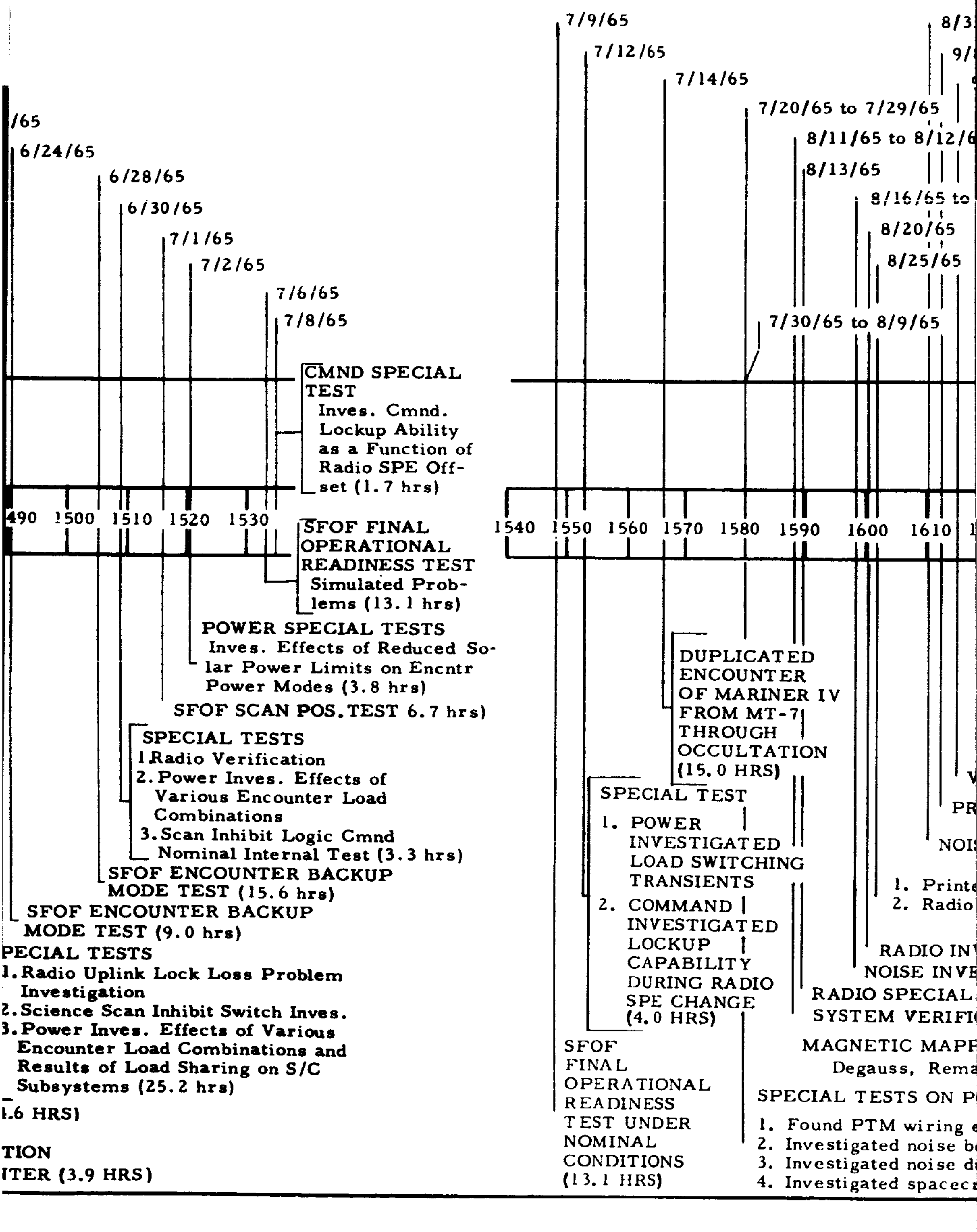




2/12/65
3/11/65
2/26/65
3/18/6
3/2/65
3/22
55
?/1/65
2/5/65
2/8-9/65
SUPPORT OF MC-3
1260 1270
1270 1280 1290 1300 1310 1320
Reduced RF power in auxiliary oscillator mode
Magnetometer response to gas valves-panels up
Immediate NAA after DC-25
Qualify GCD-DSIF amplifier modification
Follow-up on PTM radio false lock *
Non-standard charger mode
Receiver acquisition characteristics
Maneuver checkout and support
Early encounter system verification
Early encounter feasibility, procedures checkout, and SFOF exercise.
TERFACE CHECKOUT
DRIVES
POWER AT 8 BIT CHANGE
F DELAY
BE ARCING
E ARCING
CORRECTIVE PROCEDURE CHECKOUT
MARINER IV FLIGHT SUPPORT CY-1 EFFECT ON RADIO AUX. OSC FREQUENCY (17.4 HRS)
PHOTOGRAPH SIGNALS FROM 9W1 and 9W9 RING HARNESSES. PREPARATION FOR PRINTED CIRCUIT RING HARNESS EVALUATION (13.1 HRS)
1. Printed Circuit Interface Test
2. System Verif. Test CM301.01
3. RWV-FC Comp. Test (3.1 hrs)
MARINER IV FLIGHT S
RWV-F/C COMPATIBILITY
DEMONSTRATION SYSTEM T
*PROBLEM DISCOVERED 28 OCTOBER DURING SYS. VERIF. TEST FOR VIBRATION. RESOLUTION: LEAVE RANGING OFF. SAF P/FR NO. 299



/65
3/24/65
3/26/65
3/30/65
4/6/65
4/7/65
4/9/65
4/12/65
4/13/65
4/15/65
4/16/65
4/20/65
4/23/65
5/10/65
5/24/65
5/27/65
5/28/65
6/1/65
6/2/65
6/4/65
6/14/65
6/15/65
6/23
1330 1340 1350 1360 1370 1380 1390 1400 1410 1420 1430 1440 1450 1460 1470 1480
Special Tests
1. RFI 2. RF Signature
3. Radio 3. A/C Command
Sequence Response
SFOF ENCOUNTER PRACTICE TEST (7.7 HRS)
MAG-MAP AND DEGAUSS (NO OPER)
S/C-LAUNCH MODE CONTROL SET COMPATIBILITY
TEST (0.7 HRS)
1. SFOF ENCOUNTER TEST PROCEDURE CM503.00
2. RFI MEASUREMENTS (SIMULTANEOUSLY)(8.3 HRS)
LIVE PYRO WITH PEAK R. F. SIMULATION (1.4 HRS)
SFOF DC-18 ENCOUNTER TEST (8.3 HRS)
SFOF DC-18 ENCOUNTER TEST WITH NOISY CANOPUS
TRACKER (6.1 HRS)
SFOF
ENCOUNTER
BACKUP
MODE TEST
(9.2 HRS)
CANOPUS TRACKER CALIBRATION - PREP FOR SFOF
TEST (1.0 HR)
MARINER IV FLIGHT SUPPORT RADIO PATH LOSS
TEST 9.9 HRS)
SPECIAL TESTS
1. Radio Uplink
Lock Loss Prob.
Investigation
2. Video Storage
Investigation
3. Command Lockup
4. Science Cosmic
Dust Detector
Inves. (24.5 hrs)
S
RADIO SPECIAL TEST. HIGH RESOLUTION SPE PLOT
(7.5 HRS)
RWV-F/C COMPATIBILITY TEST (0.2 hrs)
PRINTED CIRCUIT RING HARNESS PHOTOS
COMPLETED S/N 3 (7.4 hrs)
PRINTED CIRCUIT RING HARNESS PHOTO
EVALUATION COMPLETED S/N (7.3 hrs)
1. DATA ENCODER SPECIAL TEST
2. RADIO SPECIAL TEST (0.5 hrs)
PRINTED CIRCUIT RING HARNESS PHOTO
EVALUATION S/N 1 (9.8 hrs)
SFOF
ENCOUNTER
TEST
(16.5 HRS)
UPPORT CANOPUS UPDATE EFFECT ON D/E (4.4 HRS)
(1.5 HRS)
EST PTMCM 312.00 (2.3 HRS)
SPECIAL TESTS 1. RADIO 2. SCIENCE (
SFOF SCAN POSITION TEST (6.3 HRS)
SCIENCE SPECIAL TEST TRAPPED RADIA
DETECTOR CALIBRATION BY EXPERIME



/65
6/24/65
6/28/65
6/30/65
7/1/65
7/2/65
7/6/65
7/8/65
7/9/65
7/12/65
7/14/65
7/20/65 to 7/29/65
8/11/65 to
8/13/65
8/20/65
8/25/65
7/30/65 to 8/9/65
CMND SPECIAL TEST
Inves. Cmnd. Lockup Ability as a Function of Radio SPE Off-set (1.7 hrs)
1500
1510
1520
1530
1540
1550
1560
1570
1580
1590
1600
1610
SFOF FINAL OPERATIONAL READINESS TEST
Simulated Prob-lems (13.1 hrs)
POWER SPECIAL TESTS
Inves. Effects of Reduced So-lar Power Limits on Encntr Power Modes (3.8 hrs)
SFOF SCAN POS.TEST 6.7 hrs)
SPECIAL TESTS
1 Radio Verification
2. Power Inves. Effects of Various Encounter Load Combinations
3. Scan Inhibit Logic Cmnd Nominal Internal Test (3.3 hrs)
SFOF ENCOUNTER BACKUP MODE TEST (15.6 hrs)
SFOF ENCOUNTER BACKUP MODE TEST (9.0 hrs)
Investigation
Subsystems (25.2 hrs)
DUPLICATED ENCOUNTER OF MARINER IV FROM MT-7 THROUGH OCCULTATION (15.0 HRS)
SPECIAL TEST
1. POWER INVESTIGATED LOAD SWITCHING TRANSIENTS
2. COMMAND INVESTIGATED LOCKUP CAPABILITY DURING RADIO SPE CHANGE (4.0 HRS)
SFOF FINAL OPERATIONAL READINESS TEST UNDER NOMINAL CONDITIONS (13.1 HRS)
SPECIAL TESTS ON
1. Found PTM wiring
2. Investigated noise
3. Investigated noise
4. Investigated
Degauss,

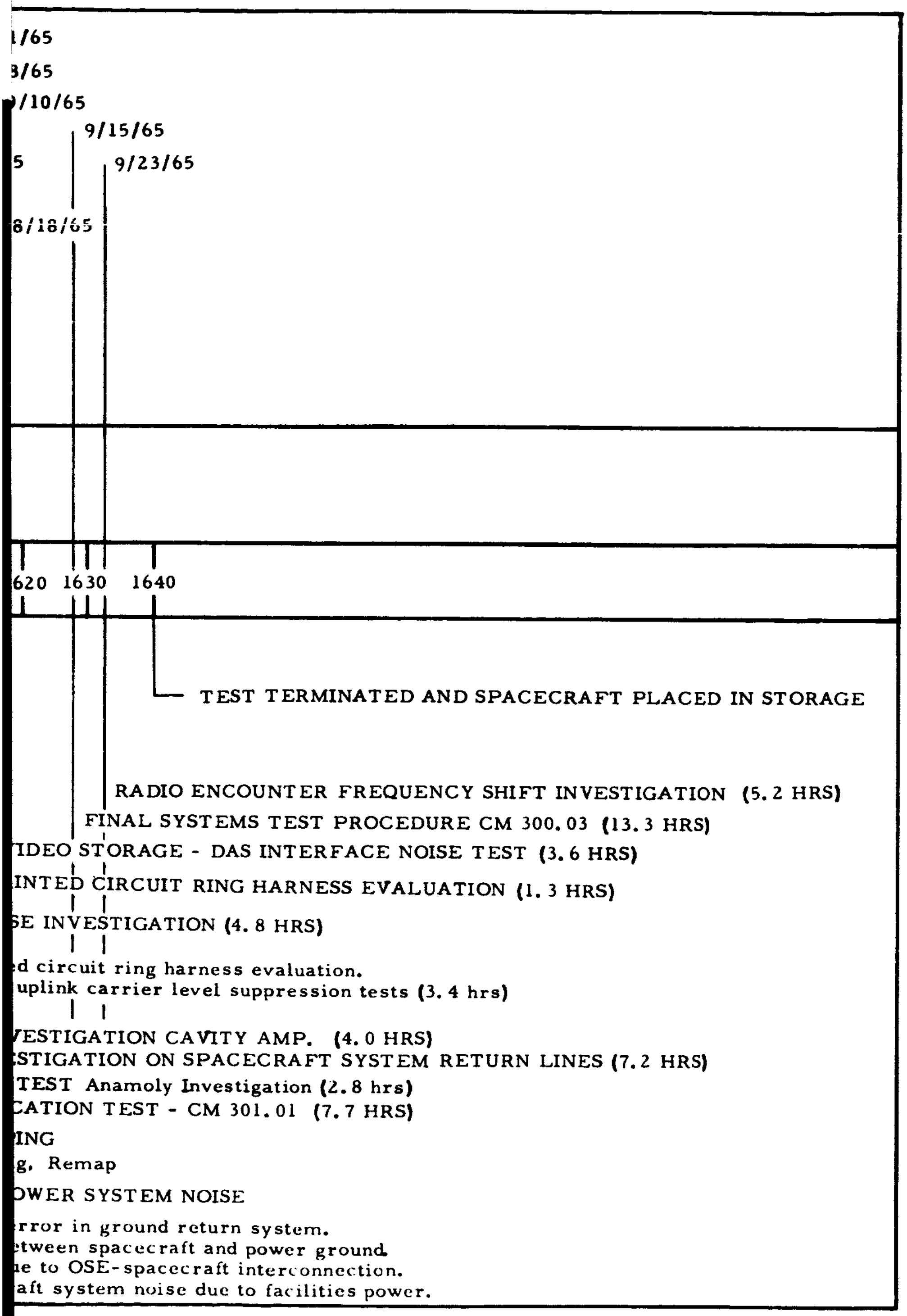


Fig. 51. ***Mariner*** **PTM test and operations summary**

e. Radio carrier suppression test. A special radio test was conducted on 8 January 1965 to determine if the change of data encoder data rate from 33⅓ bits/sec to 8⅓ bits/sec could be detected by a ground station as a change in radio carrier power level suppression. The reason for this test was to confirm or refute reports of a change in carrier level suppression on the *Mariner IV* signal coincident with the MT-6 event. As a result of these tests, the apparent change of *Mariner IV* signal level was attributed to the L- to S-band converters at Woomera and Johannesburg. Spacecraft operating time was 1.6 hr.

f. System verification test. A system verification test was conducted during the period 13 January to 19 January 1965. Spacecraft operating time was 13.9 hr. The objective of the verification test was assurance that all spacecraft subsystems were in flight condition, following the mechanical rework necessitated by the cosmic dust test, and as preparation for the early encounter exercises anticipated for support of the *Mariner IV* flight sequence.

Although several significant events occurred during the test, none were caused by spacecraft malfunctions. An external power system surge resulted from an error in shutdown procedure and caused the radio TWT amplifier power supply to fail. Procedure changes and operator instruction were instituted to preclude power transfer surges during future operations.

During the playback portion of the test, video storage measured the noise generated by the foil section at end-of-tape to determine if the PTM tape had deteriorated from excessive operation. No detrimental noise was present.

Following installation and checkout of a new TWT amplifier and power supply, the verification test was completed without incident.

g. Science encounter test. A science encounter test was conducted on 20 January 1965. Spacecraft operating time was 2 hr. Objective of this test was to verify the 83.3-kc interface between the television subsystem and the PDP 4 recording equipment in preparation for the early encounter exercises.

h. Spacecraft-computer data system interface demonstration. A spacecraft-computer data system interface demonstration test was conducted on 22 January 1965. Spacecraft operating time was 1 hr. The purpose of this test was to demonstrate the application of the computer data system (CDS) to spacecraft telemetry and direct access measurement evaluation, to enable the *Surveyor* personnel to determine the usefulness of CDS on their program.

i. SFOF early encounter command sequence verification tests. Three early encounter command sequence tests were conducted from 27 to 29 January 1965. Spacecraft operating time for all three tests was 14.6 hr. The objective of these tests was to enable SFOF personnel to test every sequence of commands that might be employed during the early encounter exercise and to determine if any combination commands could produce a deleterious effect on the spacecraft. All command combinations were found to be acceptable and usable without restriction.

j. Space Flight Operations Facility tests. Five scan platform positioning tests were conducted during January and February 1965. Total spacecraft operating time was 30.2 hr.

3. From 12 February to 14 July 1965

The pre-encounter phase of PTM operations was primarily devoted to support of *Mariner IV* flight encounter preparations. In addition, several series of tests were conducted to analyze nonflight problems and to evaluate printed circuit ring harnesses substituted for the 9W1 and 9W9 ring harnesses. Flight support tests consisted of twelve SFOF practice encounter tests and fifteen flight simulation tests that were conducted to verify or analyze *Mariner IV* data.

Twelve special tests were completed to investigate spacecraft problems that were not directly associated with *Mariner IV* flight conditions but that needed solutions for satisfactory spacecraft flight support and future design verification. The test sequence for this period is shown in Table 14.

a. Demonstration system test. A demonstration system test was performed on 12 February 1965. Spacecraft operating time for this test was 2.3 hr. The objective of the test was to demonstrate *Mariner* system test facilities and computer data reduction methods to the *Surveyor* program personnel to assist them to adapt the *Mariner* techniques to their needs. Spacecraft operation was normal and the demonstration was concluded satisfactorily.

Table 14. Test sequence, 12 February to 14 July 1965

No.	Date	Test
1	2/1/65	Demonstration system test Procedure PTM CM 312.00
2	2/26/65	Ground command/flight command compatibility
3	3/2/65	Canopus tracker update/data encoder deck skip investigation
4	3/4/65	Investigation of downlink signal dropout on flight spacecraft coincident with CY-1 command
		Canopus sensor update/data encoder deck skip investigation continued
5	3/8/65	Investigation of effect of CY-1 on transfer command voltage; continuation of test No. 4
6	3/9/65	Continuation of test No. 4
7	3/10/65	Continuation of test No. 4
8	3/11/65	Radio calibration of auxiliary oscillator frequency vs transfer command voltage
9	3/15/65	Ring harness interface test; investigation start for printed circuit ring harness evaluation, continuing through 4/6/65
10	3/22/65	System verification test following installation of printed circuit ring harness
11	3/26/65	Radio plot; no signal static phase error (SPE)
12	4/7/65	Radio SPE fine calibration
13	4/9/65	Radio investigated path loss through open circulator switch, part of interferometer effect investigation
14	4/12/65	Modified Canopus sensor calibration; preparation for SFOF test
15	4/13/65	SFOF DC-18 encounter test
16	4/15/65	SFOF DC-18 encounter test
17	4/16/65	Live pyro-peak RF simulation
18	4/20/65	SFOF test and RFI measurements
19	4/21/65	RFI, RF Signature, attitude control command sequence investigation, radio investigation of PTM uplink lock loss anomaly
20	4/22/65	RF signature
21	4/23/65	RF signature
22	5/10/65	Launch mode control set compatibility
23	5/12/65	Magnetic mapping and degauss investigation, continuing through 5/26/65
24	5/27/65	SFOF encounter test
25	5/28/65	Science Trapped Radiation Detector test
26	6/1/65	SFOF scan position test
27	6/2/65	Radio uplink lock anomaly investigation, science television voltage investigation
28	6/3/65	SFOF encounter test, continuing through 6/4/65
29	6/7/65	Radio uplink lock anomaly investigation
30	6/8/65	Radio uplink lock anomaly investigation, science DAS investigation
31	6/9/65	Flight command lockup investigation
32	6/10/65	Radio uplink lock anomaly investigation
33	6/11/65	Video storage count-two circuit transient response investigation
34	6/14/65	Science Cosmic Dust Detector noise investigation, flight command lockup investigation
35	6/15/65	SFOF encounter backup test
36	6/17/65	Radio uplink lock anomaly investigation, scan platform inhibit investigation
37	6/18/65	Radio uplink lock anomaly investigation
38	6/21/65	Power investigation of low primary power voltage operation, continuing through 6/22/65
39	6/23/65	Power investigation of encounter load share conditions
40	6/24/65	SFOF backup mode test
41	6/25/65	Calibration of special instrumentation installed for SFOF tests
42	6/28/65	SFOF backup mode test
43	6/30/65	Radio subsystem verification, power investigation of encounter load share conditions, scan platform inhibit logic investigation
44	7/1/65	SFOF scan position test
45	7/2/65	Power modes test for encounter loads
46	7/6/65	SFOF operational readiness test
47	7/8/65	Flight command lockup capability investigation
48	7/9/65	SFOF final operational readiness test
49	7/12/65	Power transient investigation, flight command lockup investigation
50	7/14/65	Flight encounter simulation

b. Mariner IV flight support tests. A series of tests in direct support of the *Mariner IV* flight data analysis effort was conducted during this phase of test operations. Spacecraft operating time for the series was 74.3 hr.

The first test was an attempt, on 2 March 1965, to duplicate telemetry indications of a failed suppressor diode on a relay operated by the MT-1 command from CC&S. Although a data encoder deck skip apparently occurred at the flight spacecraft when the Canopus sensor cone angle was updated, no similar effect could be produced on the PTM. Commands to the PTM were issued with the relay driver circuit in normal configuration, as well as with the suppressor diode disconnected, but no deleterious effects resulted.

Five radio tests were completed between 4 and 11 March 1965 to investigate a frequency shift of the flight transmitter signal coincident with the issuance of CY-1 commands. The results of these tests proved that the radio transfer command voltage experiences a level change concurrent with the first CY-1 command issued following radio loss of lock between the ground transmitter and airborne receiver. Each transponder exciter auxiliary oscillator frequency shifts a different amount determined by its individual characteristics and alignment conditions. It was concluded that the effect noted on the flight radio frequency is inherent in the transponder design.

A special radio test was conducted on 9 April 1965 to verify an interferometer effect noted at the spacecraft receiver as a result of dual signal paths from the high-gain and low-gain antennas when the RF circulators were switched to receive on the low-gain antenna. Results of the test indicate that the circulator loss through the nonoperating path is approximately equal to the gain of the high-gain antenna.

Flight command tests were conducted on 9 and 14 June 1965 to verify the ability of the command detector in the flight command subsystem to lock up and remain in lock with various amounts of radio receiver static phase error (SPE) and with the command detector voltage-controlled oscillator (VCO) offset various amounts. In addition, the command detector was monitored for command bit errors resulting from adjustment of radio static phase error while command was in lock. No undesirable effects were detected as a result of the test conditions while displacements and tuning rates were held within reasonable magnitudes.

An additional test was conducted on 12 July 1965 that demonstrated the ability of the flight command detector VCO to lockup to the ground command VCO while radio was adjusting the receiver SPE at the rate normally employed by the Deep Space Instrumentation Facility (DSIF) stations.

Video storage count-two logic circuit tests were conducted on 11 June 1965 to determine the effect of power subsystem transients. Transients were generated by issuing commands that were applicable to the encounter portion of the flight and by inducing main booster regulator failures and turning gyros on and off with the spacecraft battery disconnected. None of the test conditions were able to disturb the count-two circuits.

A series of six power subsystem tests was conducted between 21 June and 12 July 1965 to determine the effects of all possible encounter load switching sequences when the spacecraft was powered by solar power at Mars levels and without a spacecraft battery to absorb current transients. The results of this series of tests indicated that encounter equipment turn-on transients could be supported by the solar panels alone and that the current surges could be reduced to still lower levels by following a procedure that reduced power requirements during encounter initiation commands.

The final flight support test was conducted on 14 July 1965; it consisted of an encounter conducted on the PTM in step with the flight encounter performed by *Mariner IV*. The objective of this test was to provide a test specimen preconditioned to the flight mode throughout the encounter period to facilitate investigation of any nonstandard conditions that might be observed in the flight data. No questionable conditions were noted and the PTM was turned off following exit from occultation by the flight spacecraft.

c. SFOF encounter preparation tests. Thirteen encounter tests were conducted for the SFOF between 12 April and 9 July 1965 to enable evaluation of various encounter command sequences and to provide operations personnel with experience in the spacecraft reactions to encounter conditions as preparation for the actual event. Since several of the tests were intended to furnish practice in interpreting the telemetered data from the spacecraft, special instrumentation was attached to the PTM during those tests to enable the system test personnel to produce variations in temperature and signal information to telemetry and to simulate various failure modes in the encounter instruments as well as the spacecraft systems that were essential to the encounter sequence. Spacecraft operating time during this series of tests was 122.6 hr.

Tests on 13, 15, and 20 April 1965 were devoted to evaluation of various command sequences that were proposed to prevent loss of Canopus acquisition during the encounter period. The commands were intended to place the spacecraft on inertial control and correct for drift with incremental commands. The procedure was successful but was subsequently ruled out as unnecessary.

The objective of these tests was to enable SFOF personnel to determine the optimum procedure for opening the science cover and prepositioning the scan platform, and to practice the selected procedure and timing sequence.

Several modes of operations were employed during the tests to enhance the responses to be investigated. Since transmission time is an important factor in the timing of spacecraft commands, both uplink and downlink radio transmission times were simulated during several of the tests.

For each test, the spacecraft was conditioned to a pre-encounter cruise mode by the system test personnel, who then reacted to SFOF requests for commands through a procedure simulating the DSIF command links. Spacecraft telemetry signals were processed to a teletype format and transmitted to SFOF.

The tests demonstrated the feasibility of an early encounter to open the science cover and position the platform as well as providing the necessary practice for the SFOF personnel to develop their technique.

SFOF encounter practice and backup mode tests were conducted on 27 May and 3, 4, 15, 24, and 28 June 1965. Simulated failures and nonstandard operating conditions were introduced into the telemetry signals during each of these tests to provide the operations personnel with practice in the analysis and corrective action to be used for each anomalous condition.

SFOF scan position tests were conducted on 1 June and 1 July 1965. Although these two tests were conducted specifically to investigate the timing of the scan platform positioning commands, the technique was practiced during several of the other SFOF encounter practice tests. No operational problems were introduced during these tests.

SFOF operational readiness tests were conducted on 6 and 9 July 1965. Spacecraft operational problems were simulated during the first test, but the second was completed with nominal operating conditions.

d. Printed circuit ring harness evaluation tests. Printed circuit ring harness evaluation tests were conducted on the spacecraft from 15 March until 6 April. These tests consisted of detailed investigation of all signal and power circuits in the 9W1 and 9W9 ring harnesses while the spacecraft subsystems were connected to the original wired harnesses and while they were connected to the printed circuit ring harnesses. Two versions of the printed circuit ring harnesses were employed and, in addition, a combination of the original 9W9 wired harness for power circuits and the printed circuit harness for the signals normally routed through the 9W1 was examined. The method of investigation was to photograph all signals on the original wired harness by means of an oscilloscope camera, then repeat each of the photographs under identical conditions except with the printed circuit harness substituted for the wired harness. Subsequent tests on the second printed circuit harness consisted of comparison of the oscilloscope patterns with the original photographs and repeating photographs of the ones that indicated a change. An analysis of the results of these tests appears in Ref. 5.

e. Magnetic mapping and degaussing investigation. Magnetic mapping and degaussing tests were conducted from 18 to 24 May 1965 with investigations extending from 12 to 26 May 1965. The objective of these tests was to determine the stability of the spacecraft magnetic fields. The spacecraft was not operated during the magnetic tests.

f. Miscellaneous tests. Miscellaneous tests were conducted on the radio, science, and pyrotechnic subsystems and on the read, write, verify (RWV) and launch mode control set OSE equipments from 26 February to 18 June 1965. These tests were performed to investigate subsystem problems and obtain information about spacecraft and support equipment that, while not directly related to the *Mariner IV* flight, was necessary for evaluation of the program. All miscellaneous tests were conducted on a noninterference basis with the flight support tests. Total spacecraft operating time for this series of tests was 50.3 hr.

Ten tests were conducted on the radio subsystem to recheck calibrations and to investigate a temperature sensitive anomaly that caused a momentary loss of uplink lock approximately 1 hr after power turn on. This problem was peculiar to the PTM radio subsystem and was the result of transponder instability confined to a narrow temperature range. The subsystem was removed from the spacecraft and returned to the laboratory for more complete testing.

Science subsystem tests were conducted on the Trapped Radiation Detector, to investigate the effects of high level radiation sources; on the television camera, to verify that apparent voltage variations are introduced by the telemetry sampling system and are not reflected back to the television circuits; and on the data automation system, to investigate noise introduced into the Cosmic Dust Detector readout.

A pyrotechnic test was conducted on 16 April 1965 using RF sources to illuminate the spacecraft and to simulate launch environment with live squibs installed in all pyrotechnic positions. No problems occurred during the test.

One test was conducted to determine compatibility of the spacecraft with the launch mode control set assembled to operate the PTM spacecraft during vibration tests. Operation from the test set was normal.

The electromagnetic interference group conducted tests to identify the RF signature of the PTM spacecraft and to investigate noise generated by the on board radio equipment and the attitude control gas valve operation.

Several tests were conducted to verify ground command equipment compatibility with the operating spacecraft prior to shipment to the various DSIF stations.

Since many of the listed tests involved individual subsystems, several were performed simultaneously when they were noninterfering.

4. From 16 July to 23 September 1965

The post-encounter phase of PTM spacecraft operations was devoted primarily to completion of tests having value as sources of information for future spacecraft design. Two tests were performed to assist with interpretation of *Mariner IV* flight data, and two were performed to investigate anomalies in the PTM radio subsystem.

Tests were run to obtain information on spacecraft noise-reduction techniques; there were examinations of power return and spacecraft grounds, as well as of signal return lines for noise, while various grounding techniques were tried. Additional photographs were taken of signals from modified printed circuit harnesses; and a final magnetic mapping was completed.

Flight support tests were conducted to develop a technique to control ground transmitter carrier level for spacecraft automatic gain control (AGC) calibration, analyze the effects of encounter commands on the radio transmitter frequency, and attempt to determine the cause of false end-of-tape signals observed in *Mariner IV* data during encounter.

Radio subsystem tests were conducted to investigate an uplink lock anomaly and cavity amplifier power instability; both problems were peculiar to PTM equipment.

One system verification test and a final systems test were performed during the period. Tests performed during this period are listed in Table 15.

Table 15. Test sequence, 15 July to 23 September 1965

No.	Date	Test
1	7/20/65	Power investigation of noise on spacecraft ground, continuing through 7/28/65
2	7/29/65	OSE power ground noise investigation
3	7/30/65	Magnetic mapping and degaussing, continuing through 8/9/65
4	8/11/65	System verification test, completed 8/12/65
5	8/13/65	Radio uplink lock anomaly investigation
6	8/16/65	Spacecraft return system noise investigation, continuing through 8/18/65
7	8/19/65	Radio investigation of periodic amplitude variations of cavity amplifier output power, completed 8/20/65
8	8/24/65	Printed circuit ring harness investigation, completed 8/25/65
9	8/25/65	Radio investigation of ground transmitter power suppression techniques
10	8/26/65	Coupled noise investigation, continuing through 8/31/65
11	9/8/65	Printed circuit ring harness investigation
12	9/9/65	Video storage—data automation system interface noise investigation, completed 9/10/65
13	9/13/65	Final system test, continuing through 9/15/65
14	9/21/65	Radio encounter investigation, completed 9/23/65

a. Power subsystem noise investigation. Power subsystem noise investigations were carried out during 20–29 July, 16–18 August, and 26–31 August 1965. Total spacecraft operating time for these tests was 25.1 hr.

Both spacecraft and OSE power and signal returns were examined for excess noise and circulating currents. The possibility of reducing noise induced into the signal lines to data encoder by making a hard ground connection between the spacecraft power return and spacecraft was tested by connecting a fuse between the two points in question. The first attempts to connect the fuse resulted in abnormal spacecraft operation and high noise levels in all signal circuits, but the problem was resolved as a wiring error resulting from an engineering change instruction that was not worked on the PTM power distribution subassembly module. The problem had not been noticed previously due to the isolation between primary power and the spacecraft bus. After completion of the applicable engineering change instruction (ECI), no problems were noted when the spacecraft power return and spacecraft frame connected. An attempt was also made to compare the susceptibility of the spacecraft subsystems to power transients with the power return floating as in the normal configuration and with it connected to the spacecraft frame. No change in response to power transients was noted.

OSE power distribution return lines were examined for circulating currents that could cause induced noises and the result was the location of a faulty transformer in the science data format converter. The faulty transformer was disconnected from the system and both return currents and noise were reduced within normal levels.

Tests were also conducted to determine the effects of various shield connections and ground schemes, but no definite improvements were achieved. It was determined that noise from signals on one line can be induced into another line by a common conducting cover or shorted loop encircling them.

b. Magnetic mapping. Magnetic mapping of the spacecraft was conducted during the period 30 July through 9 August 1965 to determine what effects were produced in the spacecraft magnetic field by the electrical tests conducted since the mapping tests completed 26 May 1965. The following changes were observed in the permanent magnetic field (P):

P_X from $-3\frac{3}{4}$ to $-4\frac{1}{4}\ \gamma$

P_Y from 0 to $\frac{1}{2}\ \gamma$

P_Z from $4\frac{1}{4}$ to $5\frac{3}{4}\ \gamma$

The spacecraft was not operated during the magnetic tests.

c. System verification test. A system verification test was conducted on 11 and 12 August to verify that spacecraft operation was normal following the mechanical work necessitated by the magnetic mapping procedure. Spacecraft operating time for this test was 7.7 hr. All spacecraft operation was normal.

d. Radio special tests. Radio investigation of an anomaly in the uplink lock circuitry was conducted on 13 August 1965 to determine if removal and reinstallation of the radio subsystem had caused a change in previously noted conditions. The anomaly was still present and unchanged. Spacecraft operating time for this test was 2.8 hr.

Radio investigation of power variation from the cavity amplifier was conducted on 19 and 20 August 1965. The power variation was found to be of small amplitude and to have a period of approximately 35 min. It was attributed to the temperature compensating features of the cavity amplifier and was not of importance. Spacecraft operating time for this investigation was 4.0 hr.

e. Printed circuit ring harness investigations. Printed circuit harness tests were conducted 24 and 25 August and 8 September 1965. Objective of these tests was to determine if noise coupled between circuits could be reduced by grouping noise producing lines away from low level signal circuits and to determine the effects of removing transpositions from the power lines. Very little change in noise levels was observed. Spacecraft operating time during these tests was 4.7 hr.

f. Mariner IV flight support tests. Three tests were conducted in direct support of the *Mariner IV* flight data analysis effort. Spacecraft operating time for these tests was 8.8 hr in addition to the radio carrier level suppression tests which were conducted concurrently with the printed circuit ring harness tests.

Radio tests were conducted on 24 and 25 August 1965 to develop and verify a method to control uplink carrier level suppression by means of a 10-kc modulating signal applied to the ground transmitter. The objective of this method is to enable precise control of the uplink signal level transmitted from the DSIF stations in order to calibrate the *Mariner IV* receiver AGC voltage during flight. The technique was successful and achieved carrier level suppression of 20 db. Since the modulating frequency was 10 kc the sidebands that it generated were outside the spacecraft receiver passband.

Video storage/DAS interface noise tests were conducted on 9 and 10 September 1965. The test objective was to determine if false video storage end-of-tape signals can be issued to DAS by noise spikes produced by tape start–stop commands. Start–stop commands were issued to video storage first from the OSE through the direct access lines and then from DAS by conducting an encounter. Both methods produced noise spikes of approximately equal amplitude on the video storage/DAS end-of-tape line, but DAS only issued false end-of-tape signals to data encoder when the start–stop commands were issued from the OSE. Since a much greater number of start–stop commands were issued by the OSE method than by encounter conditions, it is possible that a greater number of encounter start–stop commands may have resulted in a false end-of-tape signal from DAS to data encoder.

Radio encounter tests were conducted on 21 and 23 September 1965 to determine if the encounter sequence produces a change in the transponder transfer command voltage. The object of this test was to look for an explanation for a slight frequency shift noted in the *Mariner IV* downlink signal following the planet encounter and the dark encounter. The results of the test indicated that the transfer command voltage does change if the encounter is controlled by radio commands, but does not change if the encounter sequence is initiated and terminated by CC&S commands without radio using two-way lock. The tests were not able to determine if the effect is the result of transferring from auxiliary oscillator to the VCO and back to auxiliary oscillator or the result of the command source.

*g. **Final system test.*** A system test was conducted from 13 through 15 September 1965 to assure spacecraft integrity prior to storage. Spacecraft operating time was 13.3 hr. All spacecraft subsystems functioned normally and the test was considered satisfactory.

5. Spacecraft Configuration for Storage

The PTM spacecraft has been prepared for storage and testing has been terminated. Table 16 describes the detailed configuration of the PTM spacecraft at the time of its commitment to storage. Also included is such spacecraft-related information as planetary instrument alignment angles, spacecraft behavior idiosyncrasies, transmitter frequencies, and nominal spacecraft power demands in various power modes.

Table 16. PTM configuration and nominal characteristics at time of storage

a. Nominal spacecraft power demands

Mode	Spacecraft configuration	Power demand,[a] w
Prelaunch science checks	Cruise science on, encounter science off, RF power down (cavity), OSE relay hold on, gyros on, external power	171[b]
Prelaunch	All science off, RF power down (cavity), OSE relay hold on, gyros on, external power	149.5[b]
Launch	All science off, RF power down (cavity), spacecraft relay hold on, gyros, on, internal power. VSS *not* in launch mode	155[b]
Separation	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, internal power	189[b]
Sun acquired (Earth cruise with gyros on)	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, solar power Earth mode	195[b]
Earth cruise (Canopus acquired)	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Earth mode	140[b]
Midcourse	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, internal power	198[b]
100-day cruise	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power 100-day	140[b]
Mars cruise	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Mars mode	142[b]
Mars cruise with gyros on	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, solar power Mars mode	196[b]
Encounter	Cruise science on, encounter science on, RF power up (cavity), relay hold off, gyros off, solar power Mars mode	173[b]
Playback	Cruise science off, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Mars mode, video storage 2.4-kc power on	123[c]

[a]The demand of the battery charger is variable and must be added to the figures shown above to obtain total spacecraft demand. The demand of the battery charger is 27w when charging at the maximum rate of 300 ma with 44-v input to the charger.
The power demands shown are based on the averages of system tests 3, 4, and AFETR 1 and 2 and the space simulator test.

[b]The TWT uses 27w more than the value shown with the cavity on.

[c]Measurement was made with TWT on, then 27w subtracted to provide nominal figure for cavity.

Table 16a. (Cont'd)

Mode	Spacecraft configuration	Power demand,[a] w
Playback with cruise science	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Mars mode, video storage 2.4-kc power on.	144[c]
Failed booster with gyros on	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, solar power 100-day mode.	189[b]
Failed booster with gyros off	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power 100-day mode.	142[b]

[a]The demand of the battery charger is variable and must be added to the figures shown above to obtain total spacecraft demand. The demand of the battery charger is 27w when charging at the maximum rate of 300 ma with 44-v input to the charger.
The power demands shown are based on the averages of system tests 3, 4, and AFETR 1 and 2 and the space simulator test.

[b]The TWT uses 27w more than the value shown with the cavity on.

[c]Measurement was made with TWT on, then 27w subtracted to provide nominal figure for cavity.

b. Nominal planetary instrument alignment

Instrument	Measurement, deg	
Fields of view		
Television	1.1 × 1.1	
Scan sensor	48.5, cone	
Narrow-Angle Mars Gate	1.5 × 2.5	
Look angles	Clock angle	Cone angle
Television (reference)	0.00	120.00
Scan sensor	1.00	119.70
Narrow-Angle Mars Gate	0.10	120.10

c. Nominal planetary scan platform alignment

Parameter	Measurement
Clock angle (pinned)	238 deg 02 min arc
Backlash	21.47 min arc
Voltage indication in stowed (pinned) position	162 ±1.9022 v

d. Nominal Canopus sensor alignment

Parameter	Measurement
Clock angle	259 deg cw from Bay II centerline

Table 16. (Cont'd)

e. Radio frequencies

Classification	Frequency, Mc
Nominal 25°C uplink frequency for VCO at zero SPE	2115.698747
Nominal 25°C downlink frequency for VCO at zero SPE	2297.591400
Nominal 25°C frequency for one-way transmission	
Exciter A	2297.586552
Exciter B	2297.592936

f. Nominal radio power output

Classification	Power, dbm
RF power up	
Power amplifier A	40.0
Power amplifier B	38.0
RF power down	
Power amplifier B	28.0

g. Permanent magnetic output[a]

Magnetometer axis	Measurement, γ
X	−4.25
Y	+0.5
Z	+5.75

[a]Spacecraft perm without solar panels.

h. Video storage record time

Period	Time, sec
During encounter	1512 ±1.0

i. Spacecraft idiosyncrasies

Subsystem	Idiosyncrasy
Radio	Possible loss of lock on command DC-9 at weak signal level
Command	Loss of lock on command DC-9
Data encoder	Power transients occasionally causing medium deck skips

F. MC-4 Spacecraft Operations and Disposition

1. From 30 September 1964 to 9 April 1965 (at AFETR)

Mariner spacecraft MC-4 arrived at AFETR on 29 September 1964. Unloading and assembly operations were completed on 2 October 1964. System level tests were performed as necessary to assure that the spacecraft was in flight-worthy condition to support the launches of MC-2 and MC-3 as spares or as a replacement. Following the launch of MC-2, two updated TA solar panels were added to bring the spacecraft to launch configuration as standby for MC-3. On 1 December 1964 the spacecraft was placed in temporary storage at AFETR until 9 April 1965.

The tests conducted at AFETR are listed in Table 17.

Table 17. Operations and tests of MC-4 at AFETR

Operation or test	Date
Assembly	10/2/64
System verification test	10/2/64
System test AFETR No. 1	10/2/64 to 10/6/64
Autopilot test	10/6/64
Final inspection, disassembly and assembly	10/8/64 to 10/15/64
System verification test	10/16/64
Attitude control leak check	10/28/64 to 11/2/64
System verification test	11/10/64
Science subsystem alignment (SPINAL) check	11/10/64
Science calibration checks	11/12/64
System test AFETR No. 2	11/13/64 11/17/64
Current loop magnetic mapping test	11/17/64 to 11/18/64
Magnetic mapping	11/18/64
Attitude control nozzle flow rate test	11/18/64
Final mechanical preparation	11/19/64 to 11/24/64

a. Spacecraft arrival. The spacecraft arrived at AFETR on 29 September 1964. Unloading and mechanical assembly were started on 30 September and completed 2 October 1964. All units were flight qualified except the science Cosmic Dust and Trapped Radiation Detectors, which were PTM modules. The flight units for those experiments did not arrive at AFETR prior to spacecraft assembly. A science DAS unit scheduled for use in MC-3 was installed in MC-4 to undergo the system test.

b. System verification test. Spacecraft testing started on 20 October 1964 with the system verification test. Spacecraft operating time was 8.2 hr. No significant problems were encountered but the pitch gyro output was noisy; it was evaluated during succeeding tests.

c. System test AFETR No. 1. System test AFETR No. 1 was started 2 October and completed 6 October 1964. Spacecraft operating time for the entire test was 40.6 hr. To assist with scheduling, the test was conducted in segments during a 5-day period. Several significant problems occurred and were corrected:

1. The Canopus sensor shutter solenoid failed to operate because the wires were not properly connected or soldered. During an investigation into the solenoid problem, the wires were shorted, causing the main booster regulator to drop out. Subsystem laboratory tests determined that no damage had resulted from the short circuit. All wiring was reconnected and soldered properly.

2. The pitch gyro channel again produced excessive noise and the entire gyro package was changed to correct the problem.

3. No track change was obtained on the video storage tape recorder at end of tape or by OSE commands. The track change relay had been hung up by an OSE operator error prior to test start. The relay was released in the laboratory and normal operation restored.

d. Attitude control autopilot test. An attitude control subsystem autopilot test was conducted on 6 October 1964. Spacecraft operating time was 1.8 hr. No significant problems were encountered.

e. Final inspection. Spacecraft disassembly for final inspection was started on 8 October 1964. Final inspection and reassembly were completed on 15 October 1964. Final inspection of each spacecraft is normally performed at JPL, Pasadena, prior to shipment to AFETR, but in the case of MC-4, the inspection was delayed until the spacecraft had been delivered to AFETR to demonstrate feasibility of performing the inspection at that facility.

f. System verification test. A system verification test was conducted on 16 October 1964. Spacecraft operating time was 10.4 hr. The purpose of this test was to verify that the spacecraft system functioned within specifications following the final inspection and reassembly. Two problems were recorded:

1. Scan platform unlatch failed to give a data encoder event.
2. The science Ionization Chamber and Cosmic Ray Telescope did not calibrate properly and were removed for test and calibration.

g. Attitude control gas leak check. An attitude control gas leak test was started on 28 October and completed 2 November 1964. The system was within specifications. Following the leak test, the spacecraft was assembled in complete flight configuration and placed on standby to support the launch of MC-2.

h. System test AFETR No. 2. System Test AFETR No. 2 was started and completed through half of the first encounter on 10 November 1964 as a verification of spacecraft performance and as the first section of the final spacecraft system test. Spacecraft operating time was 6.7 hr. Significant problems were Cosmic Ray Telescope noise and failure of the scan platform pin release to give a data encoder register event.

i. Science subsystem alignment check. Science subsystem alignment (SPINAL) checks were conducted on 10 November 1964. Spacecraft operating time was 2.5 hr.

j. Science calibration checks. Science subsystem calibration was started on 11 November and completed on 12 November 1964. Spacecraft operating time was 16.6 hr. No significant problems were encountered; however, one previously observed problem recurred when the removal of the science scan platform pin failed to produce a data encoder event.

k. System test AFETR No. 2 (Concluded). All remaining portions of the final system test started on 10 November were conducted during the period 13 to 17 November 1964 to verify that the spacecraft was ready for launch if needed as a replacement for MC-3. Spacecraft operating time for the test was 34.8 hr.

Two significant problems were observed and corrected during the test.

1. The Cosmic Ray Telescope noise problem was attenuated by the addition of an extra cover screw to tighten the cover and complete the shielding continuity.
2. A circuit board in the scan platform unlatch event circuit was replaced to correct the intermittent event readout.

l. Magnetic mapping current loop test. A magnetic mapping current loop test ran from 14–15 November. Spacecraft operating time was 4.4 hr. Results of the test were normal as compared with the information obtained during tests of MC-2 and MC-3.

m. Magnetic mapping. Magnetic mapping of the spacecraft was conducted on 18 November 1964. The spacecraft was not turned on during this test.

n. Attitude control nozzle flow rate test. An attitude control nozzle flow rate test was conducted on 18 November 1964 under the direction of the attitude control cognizant engineer.

o. Final mechanical preparation. Final mechanical preparation of the spacecraft for launch was started 19 November and completed 24 November 1964. Four flight solar panels were installed including two that had been updated from type-approval to flight configuration.

The spacecraft was placed on standby as a launch replacement for MC-3 on 29 and 30 November 1964. On 1 December 1964 the spacecraft was placed in storage under a continuous nitrogen purge in Building AO at AFETR, where it remained until 9 April 1965. The spacecraft test history from 25 November 1964 to 24 May 1965 is recorded in Fig. 52.

2. From 9 April to 15 June 1965 (at JPL)

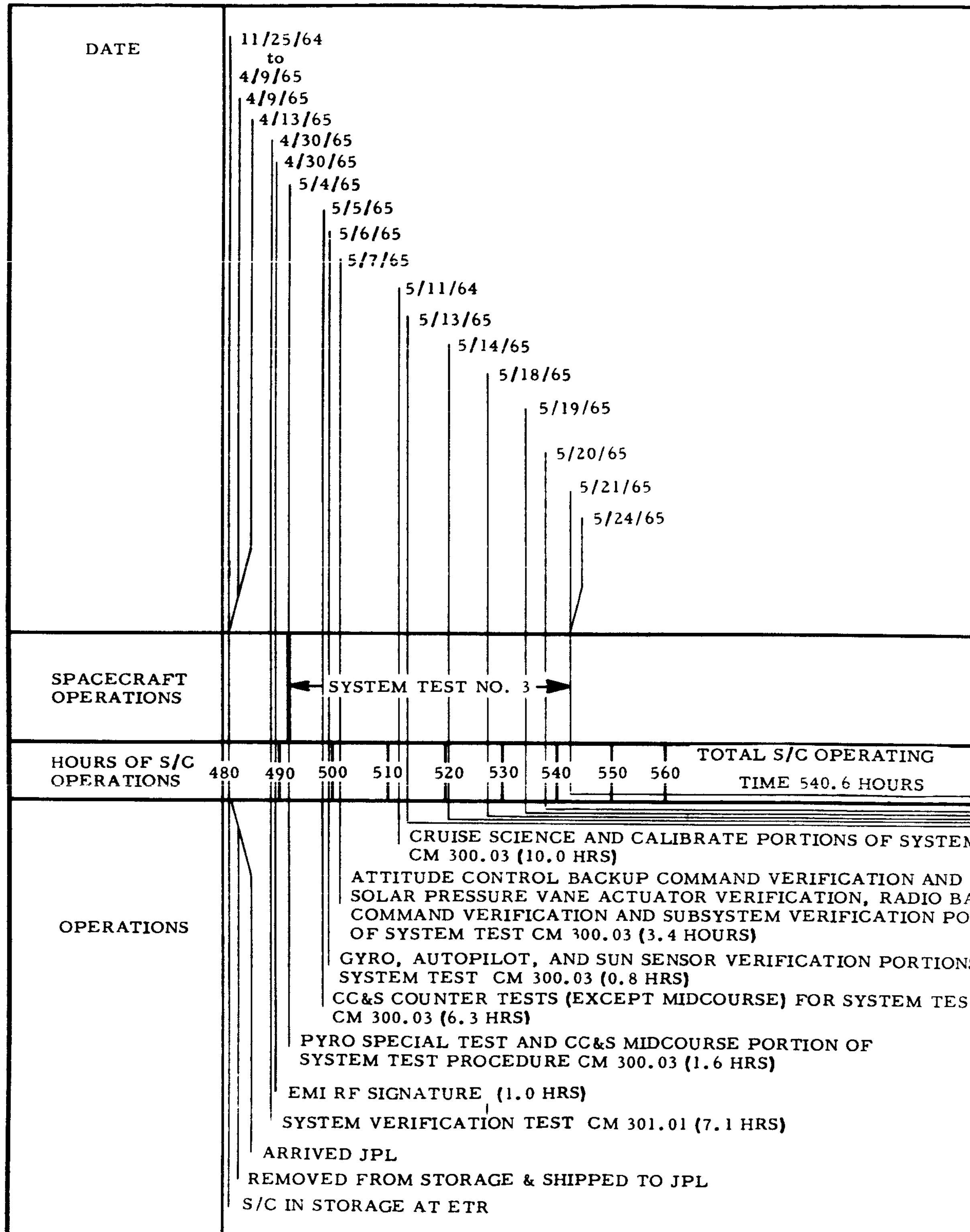
On 9 April 1965 the spacecraft was removed from storage at AFETR, shipped to JPL, Pasadena, subjected to verification and system tests, operated in support of Space Flight Operations Facility encounter practice tests, then finally, placed in temporary storage in the SAF on 15 June 1965. All test results were within specified values.

The tests conducted at JPL prior to storage of the spacecraft are listed in Table 18.

a. Return to JPL. The spacecraft was removed from storage at AFETR and shipped to JPL, Pasadena, on 9 April 1965.

Following arrival on 14 April, mechanical inspection and preparation of the spacecraft for system test was completed. It was connected to the system test complex on 28 April 1965.

MARINER C-4 TEST AND OPERATIONS SUMMARY



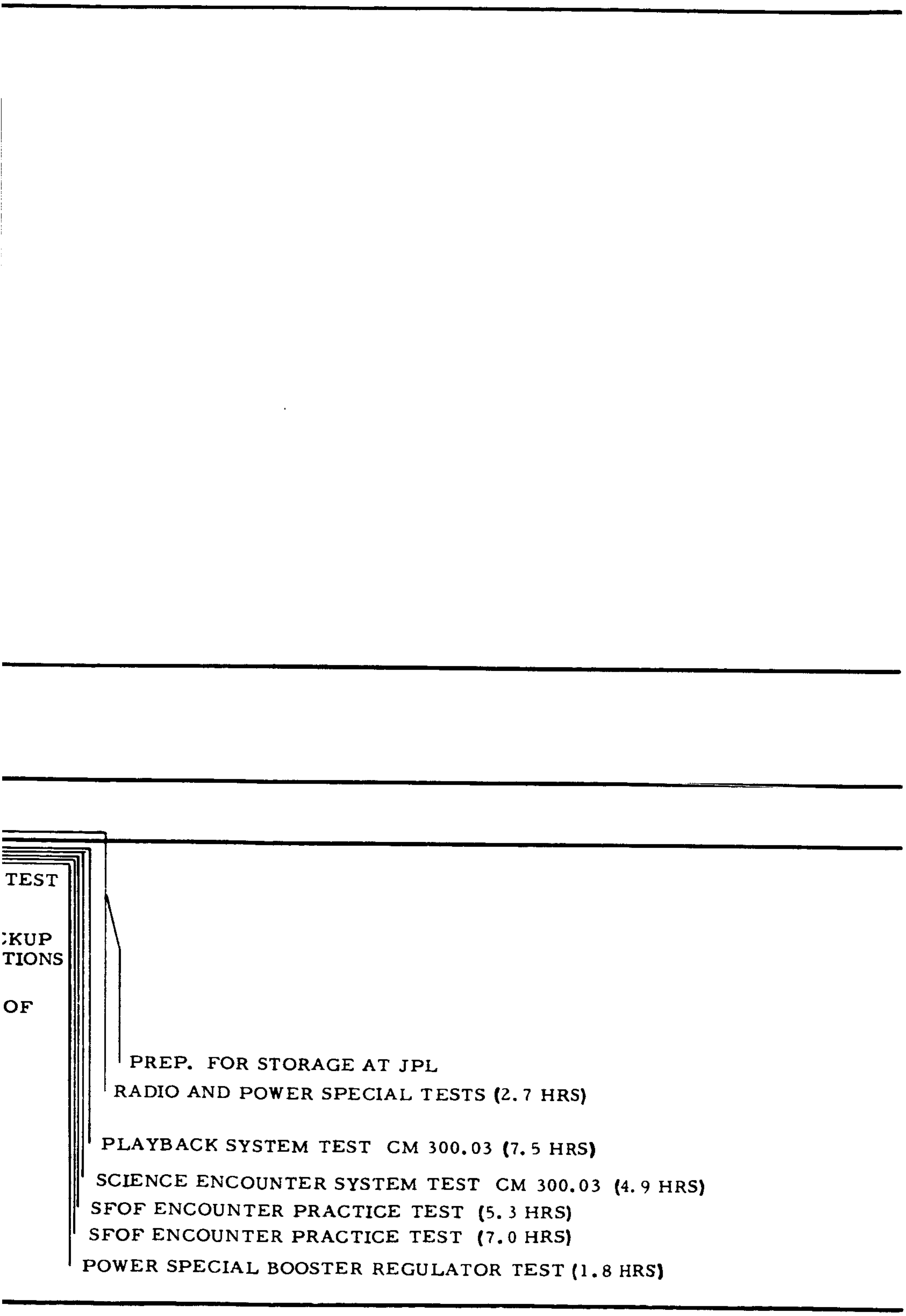


Fig. 52. MC-4 test history, 25 November 1964 to 24 May 1965

Table 18. Tests at JPL prior to storage

Title	Date
System verification test	4/29/65 to 4/30/65
Radio frequency signature	4/30/65
System test	5/4/65 to 5/20/65
Power booster regulator investigation	5/13/65
SFOF encounter practice test	5/14/65
SFOF encounter sequence logic flow diagram checkout	5/18/65
Special cleanup tests	5/21/65

b. System Verification Test and RF Signature Investigation. A system verification test was started on 29 April and completed 30 April 1965. Spacecraft operating time was 8.1 hr. The purpose of this test was to verify that the spacecraft had not sustained damage or deterioration during storage and shipment and that it was still compatible with the PTM system test complex. All spacecraft systems functioned normally and all apparent discrepancies were resolved as being external to the spacecraft.

Concurrently with the system verification test, an RF signature investigation was conducted by the EMI group. This investigation provided a knowledge of spacecraft radiation characteristics in the HF, VHF, and UHF portions of the RF spectrum, and was a continuation of a similar test conducted on the PTM.

Since the spacecraft was to be operated for several weeks to support the flight of *Mariner IV*, the television optics were replaced with the units from the PTM to avoid wear on the shutter in the flight qualified unit.

c. System Test. A complete system test was performed from 4 to 20 May 1965. Since continuous operation was not practical, the test procedure was divided into convenient segments that were conducted on separate days when they best fitted the schedule of tests required to support the *Mariner IV* flight. The spacecraft was operated a total of 34.5 hr for the entire system test.

Objective of the system test was to provide a complete system operational checkout prior to spacecraft storage, to guarantee operational readiness of a requirement for spacecraft operation if generated in the future. The system test resulted in the conclusion that all subsystems and the entire spacecraft system were operational.

During the test, several apparent anomalies were observed, but all were resolved as the result of non-standard conditions or support equipment problems. One incident of particular interest was the result of performing a main booster regulator failure exercise while the spacecraft was operating from external power, rather than simulated solar power. The transfer resulted in a cruise science turnoff. Normally the failure procedure is performed under flight conditions with the spacecraft battery connected in the circuit to supply the current demand and no exceptional transients are noted. The test was repeated with the spacecraft operating from simulated solar power; all results were according to procedure.

d. Power subsystem special booster regulator test. A special power subsystem main booster regulator failure test was conducted on 13 May 1965, with the spacecraft operating from the various power sources available in the system test configuration. Spacecraft operating time was 1.8 hr. The purpose of the test was to verify the effects observed during system test when the main booster regulator test was performed with the spacecraft operating from external power.

Simulated main booster regulator failures were induced while the spacecraft was operating on external power with results identical to those observed during the system test. The test was repeated with the spacecraft operating from simulated solar power and the results were the same as those normally observed during the standard system test procedure.

Since the external power source is current-limited and no spacecraft battery is connected in the circuit during the external power mode of operation, no firm power source is available to supply the switching transient developed by the changeover from main to maneuver booster regulator. Operation from the simulated solar power sources is normally performed with the spacecraft battery connected in flight configuration, to provide a high current source to supply the switching transient, so very little disturbance is noticed in the spacecraft subsystems at the time of changeover from main to maneuver booster regulator. Spacecraft operation was considered normal for the test configuration involved.

e. SFOF encounter practice tests. Two SFOF encounter practice tests were conducted to support the flight spacecraft (*Mariner IV*) during the interval that the PTM was committed to magnetic mapping and degaussing.

The first test was conducted on 14 May 1965 resulting in 7 hr of spacecraft operating time. Since the test objective was to furnish SFOF with spacecraft telemetry signals similar to those expected from *Mariner IV* during encounter, the test spacecraft was conditioned as closely as possible to the flight mode of operation without making changes to MC-4. This procedure generated some attitude control and science indications similar to the flight telemetry but did not provide flight temperature readings.

Several minor problems were introduced into the telemetry data to simulate possible flight problems to make the exercise more meaningful. All of the indications were produced without resorting to special equipment or changes in the MC-4 spacecraft.

The test resulted in one P/FR[5] written against the radio subsystem because the telemetry indication of transmitter power output varied continually throughout the test. No corresponding variations were detectable in direct access measurements however, and later tests on 21 May 1965 resolved the problem as an incorrect ground on the recorder in attitude control OSE.

[5] P/FRs initiated at SAF are listed in Table 19.

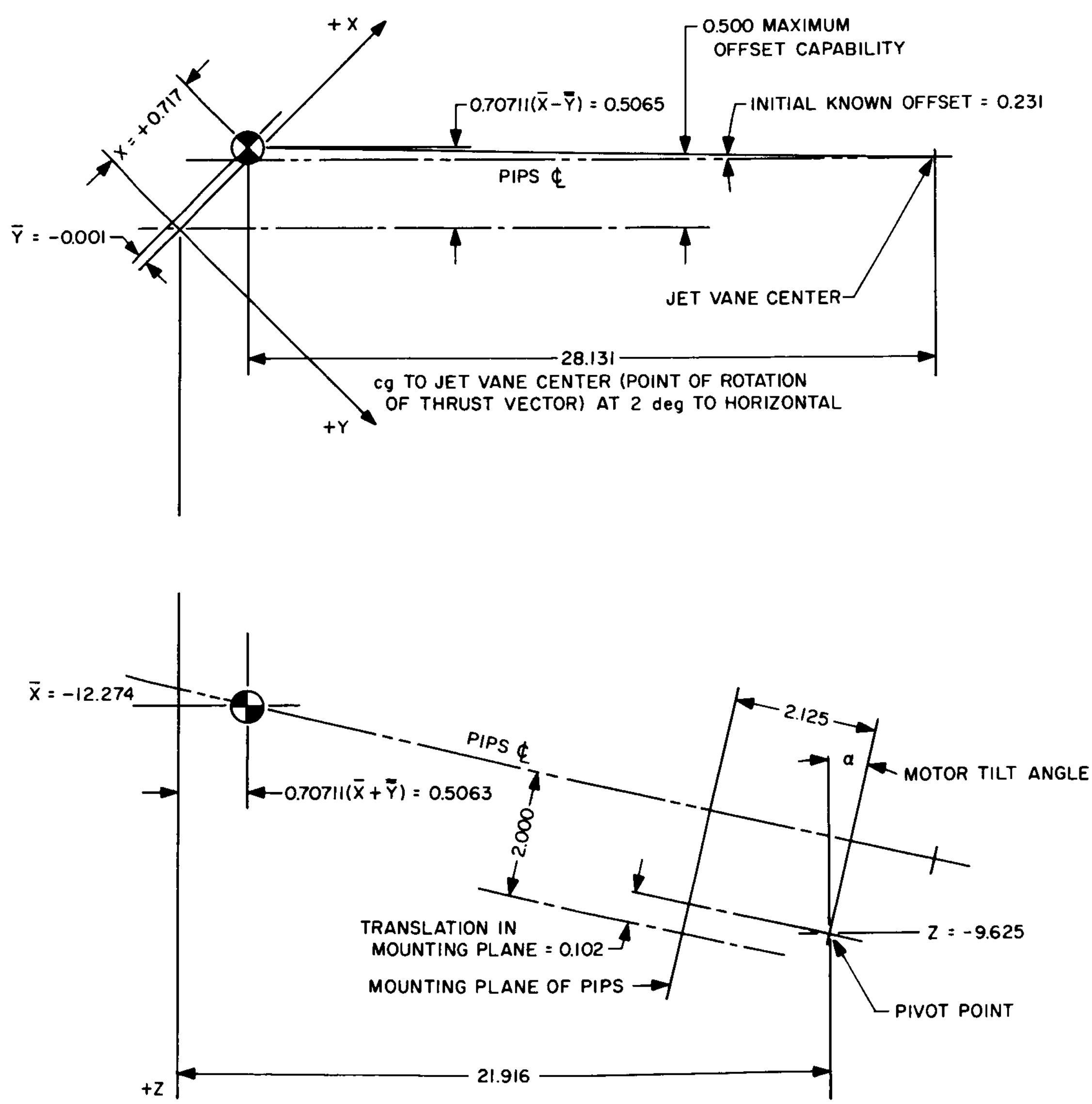


Fig. 53. MC-4 PIPS positioning

Table 19. SAF initiated P/FRs against MC-4 spacecraft

Subsystem	Ref desig.	SAF P/FR No.	Problem	Date open	Date resolved	Date closed	Resolution
Structure	4101303	2	Leg C thread bad in insert	7/8/64	7/21/64	7/28/64	Press-nut replaced
	4101303	4	Two screws frozen in insert, Legs B and F	7/15/64	8/14/64	8/21/64	Reworked, correct HiTi screws used
	E-A1	5	Loose insert	7/21/64	8/3/64	8/6/64	Insert removed, new insert installed
	E-A7	78	Insert missing	4/29/64	4/29/64	7/21/65	Replaced
Radio	02	18	Malfunction in system	8/7/64	8/20/64	8/20/64	Replaced cable corrected problem
	02	22	Malfunction in releasing boost inhibit	8/12/64	8/20/64	8/20/64	Reworked per ECR 7636, 7702
	02	25	Malfunction, lost lock	8/13/64	9/12/64	9/19/64	Not applicable
	02	26	Malfunction, in mixer preamplifier	8/13/64	9/1/64	10/1/64	Replaced
	02	57	Noise in receiver	9/3/64	10/1/64	10/8/64	Not applicable
	02	80	Data not varied −105 −109	5/14/64	6/8/65	9/7/65	Panel updated
Power	4A13	16	Data encoder lost lock	8/5/64	8/25/64	8/31/64	Telemetry calibration procedure changed
	4A11	19	Bad insert, screw binds	8/7/64	8/12/64	8/18/64	Insert replaced
	4A3	33	TA panel seemed to chatter, Leg D, Bay III	8/23/64	9/11/64	9/22/64	Use restricted to non-flight
	04/OSE	37	Noise malfunction	8/26/64	9/29/64	10/1/64	None (OSE or cabling)
	04	81	Malfunction in system	5/13/65			Still open
CC&S	5A	48	Power supply in central timer burned up power transformer (CC&S)	9/11/64	9/21/64	10/1/64	Power supply replaced
Data Encoder	6A	20	Data encoder trouble staying in sync while homing	8/7/64	8/14/64	8/25/64	None

The second SFOF test was conducted on 18 May 1965, resulting in 5.3 hr of spacecraft operation. The objective of this test was to support SFOF checkout of their proposed encounter sequence logic flow diagram. As in the previous test, the spacecraft was conditioned to the pre-encounter cruise configuration; commands were then executed as directed by SFOF.

All spacecraft operations were normal.

*f. **Special cleanup tests.*** Three special tests were conducted on 21 May 1965. Spacecraft operating time was 2.7 hr. The objective of the tests was to ensure that all problems were correctly explained prior to spacecraft storage.

First, a special test was conducted on the video storage subsystem to verify an explanation by the operator of the circumstances that resulted in loss of part of the recorded video during system test. The test established that the video was inadvertently erased by the video storage operator when he advanced the tape prior to the encounter science turn-off command. Since this is an OSE function, it cannot happen to the flight spacecraft.

The second test was an investigation of the radio subsystem to determine the apparent variation of transmitted power as indicated by telemetry during the SFOF test. An abnormal ground in the attitude control OSE rack was the result of a jumper that had been used to connect the attitude control strip chart recorder to the OSE cabinet. The jumper closed a ground loop involving spacecraft ground with the OSE ground system and introducing noise in the spacecraft data encoder input. The noise amplitude was sufficient to disturb the 100 mv telemetry channels from radio. Examination of the previous test data revealed corresponding variations in all of the radio 100 mv channels. Again the cause of the problem was the result of support equipment and is not a flight problem.

The third test was a repeat of the power main booster regulator failure test performed on 13 May 1965. Its purpose was to provide photographic documentation of the transients observed during the earlier test. All results were the same as obtained previously.

As a result of the test sequence, the spacecraft was considered to be in flight condition and to have suffered no deleterious effects from storage at AFETR or shipment to JPL.

g. Spacecraft Preparation For Storage. Preparations for storage were completed during the period 25 May to 15 June 1965. All components requiring special service prior to storage were properly prepared and all items requiring separate storage containers were removed. The spacecraft was placed in its storage container under

Table 20. MC-4 configuration and nominal characteristics at time of storage

a. Nominal spacecraft power demands

Mode	Spacecraft configuration	Power demand, w[a]	Mode	Spacecraft configuration	Power demand, w[a]
Prelaunch science checks	Cruise science on, encounter science off, RF power down (cavity), OSE relay hold on, gyros on, external power	168[b]	100-day cruise	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power 100-day mode	142[b]
Prelaunch	All science off, RF power down (cavity), OSE relay hold on, gyros on, external power	149[b]	Mars cruise	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Mars mode	142[b]
Launch	All science off, RF power down (cavity), spacecraft relay hold on, gyros on, internal power	153[b]	Mars cruise with gyros on	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, solar power Mars mode	196[b]
Separation	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on internal power	185[b]	Encounter	Cruise science on, encounter science on, RF power up (cavity), relay hold off, gyros off, solar power Mars mode	174[b]
Sun acquired (Earth cruise with gyros on)	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, solar power Earth mode	195[b]	Playback	Cruise science off, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Mars mode, video storage 2.4-kc power on	129[c]
Earth cruise (Canopus acquired)	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Earth mode	142[b]	Playback with cruise science on	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power Mars mode, video storage 2.4-kc power on	147[c]
Earth cruise (minimum demand)	All science off, RF power up (cavity), relay hold off, gyros off, solar power Earth mode	117[b]	Failed booster with gyros on	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, solar power 100-day mode	186[b]
Midcourse	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros on, internal power	196[b]	Failed booster with gyros off	Cruise science on, encounter science off, RF power up (cavity), relay hold off, gyros off, solar power 100-day mode	144[b]

[a]The demand of the battery charger is variable and must be added to the figures shown above to obtain total spacecraft demand. The demand of the battery charger is 27w when charging at the maximum rate of 300 ma with 44-v input to the charger.

The power demands shown are based on the averages of system tests 2, 3, 4 and 5, and the space simulator test.

[b]The TWT uses 27w more than the value shown with the cavity on.

[c]Measurement was made with TWT on, then 27w subtracted to provide nominal figure for cavity.

continuous nitrogen purge in a temporary storage area at the JPL Spacecraft Assembly Facility.

Table 20 describes the detailed configuration of the MC-4 spacecraft at the time of its commitment to storage. Contained here is such spacecraft-related information as nominal planetary instrument alignment angles, spacecraft behavior idiosyncrasies, nominal transmitter frequencies, and nominal spacecraft power demand in various power modes.

Table 20. (Cont'd)

b. Nominal planetary instrument alignment

Instrument	Measurement, deg	
Fields of view		
Television	1.1 × 1.1	
Scan sensor	50 cone	
Narrow-Angle Mars Gate	1.5 × 2.5	
Look angles	Clock angle	Cone angle
Television (reference)	0.00	120.00
Scan sensor	+0.95	120.30
Narrow-Angle Mars Gate	−0.10	120.05

c. Nominal planetary scan platform alignment

Parameter	Measurement
Planetary scan platform clock angle (pinned)	239 deg 32 min arc
Backlash	16.9 min arc
Voltage indication in stowed (pinned) position	
Driving ccw	1.8995 v
Driving cw	1.8886 v

d. Nominal Canopus sensor alignment

Parameter	Measurement
Clock angle	259 deg cw from Bay II centerline

e. Radio frequencies

Factor	Frequency, Mc
Nominal 25°C uplink frequency for VCO at zero SPE	2116.724077
Nominal 25°C downlink frequency for VCO at zero SPE	2298.704880
Nominal 25°C frequency for one-way transmission	
Exciter A	2298.680770
Exciter B	2298.719602

f. Nominal radio power output

Classification	Measurements, dbm
RF power up	
Exciter A, power amplifier A	39.3
Exciter B, power amplifier A	39.7
Exciter A, power amplifier B	38.0
Exciter B, power amplifier B	38.4
RF power down	
Exciter A, power amplifier B	27.7
Exciter B, power amplifier B	28.0

g. Permanent magnetic field

Magnetometer axis	Measurement, γ
X	+21.0
Y	+ 6.0
Z	+32.0

h. Video storage record time

Period	Time, sec
Total recording time during encounter	1512 ±1.0

i. Spacecraft idiosyncrasies

Item	Effect
Telecommunications	
Flight command subsystem	Has momentary loss of lock with DC-9 (ranging on).
Data encoder	Has tendency either to reset a deck or to skip a deck position with any of the commands that cause power transients (such as DC-7, DC-25, DC-26, and DC-28). The lower decks are most susceptible, but high deck may be affected.
Telemetry channel 302 (exciter No. 2 voltage)	Change in spacecraft mode between two-way lock (VCO mode) and one-way lock (auxiliary oscillator mode) necessitates change in telemetry calibration curves.

Table 20. (Cont'd)

i. (Cont'd)

Item	Effect
Telemetry channel 210	Receiver local-oscillator drive will increase with decreasing temperatures, and vice versa.
Guidance and control	
Telemetry channel 303 (Canopus cone angle)	When DC-13 or L-2 (but not L-3) is in effect and Canopus sensor power is off, data number changes can be expected.

j. Autopilot (nominal)

Item	Performance
Jet vane position null offsets	$\leq$ 5 deg
Jet vane actuator friction	Within tolerance
Gains determined by autopilot mix resistors	Within tolerance
Pitch and yaw channels	Some extra b-axis gain in both channels; resulting pitch/yaw cross-coupling coefficient $<$ 15%

k. Weight, center of gravity, and post-injection propulsion system (PIPS) positioning

Factor	Measurement
Spacecraft weight with PIPS motor	575.61 lb
Center of gravity[a]	
X	+0.717 in.
Y	−0.001 in.
Z	−12.274 in.
Jet vane center of lift[b] (with motors as shown in Fig. 18)	
X_{JV}	20.591 in.
Y_{JV}	19.884 in.
Z_{JV}	−11.292 in.
Motor tilt angle	2°0′00″ from horiz

[a]MC-4 did not have four solar panels assigned to it; two flight spare panels, serial numbers 14 and 15 (substrate numbers 32 and 33) and two TA panels, serial numbers 3 and 4 (substrate numbers 18 and 14) were installed. The measured properties shown are for the motor position as in Fig. 19.

[b]As in the case of MC-2 and MC-3, the undeflected thrust vector misses the cg because the horizontal cg offset in the plane of Bay II is greater than the adjustment capability.

V. END-OF-MISSION PLANNING

A. Proposal for 1967 Reacquisition

1. Introduction

The Project goals specified in the Project Development Plan dated 14 February 1964 have been met. This part of the mission, which was terminated on 1 October 1965, has been designated as Phase I. Phase II of the mission will consist of periodic contact with the *Mariner IV* spacecraft by the research and development facilities of the Deep Space Network at Goldstone, using advanced communications techniques. During this period, commands restricted to updating the Canopus cone angle (Table 21) may be sent to the spacecraft if, and when, the system capability is available. It is not expected that telemetry reception capability will be available. As the opportunity presents itself, two-way experiments will also be attempted, using the 100 kw transmitter at the 85-foot antenna site (Venus DSIF 13), in which some doppler radar information may be extracted. The project will be informed if the DSN has been able to establish whether or not the *Mariner* spacecraft is transmitting. Furthermore, during this phase additional trajectory data may be provided that will yield further information on the inherent accuracy of the DSN, and which may possibly improve some astrodynamical constants. Finally, the *Mariner* spacecraft will act as a far-field calibration device for the DSN.

Phase II began on 1 October 1965. The termination of Phase II is defined as that time when the *Mariner IV* telemetry can again be received by the standard configuration of the DSN. It is expected that this will occur during the first half of calendar year 1967. The exact date depends on the operational mode chosen (omnidirectional vs high-gain antenna mode) and on the DSN performance capabilities available at that date.

Table 21. Canopus sensor position and command sequence for 1966 and 1967

Date	Position	Command
1966		
26 JAN – 9 MAR	OPT-2(MT-4)	1 DC-17
1 MAR–28 MAR	MT-3	5 DC-17
23 MAR–16 APR	MT-2	7 DC-17
11 APR – 7 MAY	MT-1	7 DC-17
3 MAY–29 MAY	PRESET	7 DC-17
25 SEP – 4 NOV	MT-1	1 DC-17
25 OCT – 5 DEC	MT-2	1 DC-17
25 NOV– 5 JAN	MT-3	1 DC-17
1967		
27 DEC –10 FEB	MT-4	1 DC-17
30 JAN – 1 APR	OPT-1	1 DC-17
15 AUG–28 SEP	OPT-2	1 DC-17
16 SEP –17 OCT	MT-3	5 DC-17
13 OCT – 8 NOV	MT-2	7 DC-17
3 NOV–30 NOV	MT-1	7 DC-17
17 NOV–20 DEC	PRESET	7 DC-17

During Phase II it is hoped that significant measurements can be made with the RF emissions from the spacecraft as it passes behind the solar corona during conjunction. This event is due to occur in April 1966.

Needless to say, sudden and continuous silence of the spacecraft during Phase II would obviate the need to proceed with Phase III.

Phase III is defined as that period when normal telemetry reception (and processing) is again possible during the reacquisition period. Phase III must, of course, include those tasks or functions necessary to prepare for the actual operational period.

Any version of Phase III holds the promise of an even more remarkable feat than Phase II. Starting about February 1, 1967, the trajectory of *Mariner IV* is such that telemetry should again be available through the use of the spacecraft high-gain antenna. At this time, however, Canopus will not be in a favorable locale, and the orientation of the high-gain antenna toward Earth will have to be maintained through the use of inertial roll control. This would require an operational plan discouragingly more complex than those for Phases I and II.

2. Objectives

But the basic opportunity is unique in that it presents the possibility of also going to a locale in space that has not yet been explored. The plans offer the possibility of coordinating results with the *Pioneer* missions. In addition, some very valuable information as to the longevity in space of our present technology can be obtained.

a. Performance degradation measurement. With the relatively few measurements available in the *Mariner IV* system, the effects of performance degradation on flight equipment from extended exposure to space environments are difficult to interpret, and the ability to pinpoint a failed element is tenuous, at best. Nonetheless, *some* new information regarding longevity characteristics can be extracted from a continuing flight, and this information should be valuable to spacecraft engineering technology. A spacecraft that is found to be still operating in 1967 could well affect our basic approach to system design philosophy. A notion of failure modes and mechanisms can also be obtained—again, to a restricted level—by discrete exercise of the various redundant provisions inherent in the design. In this connection, telemetry readings will provide invaluable diagnostic assistance. Redundancy exists for many of the critical elements required to make the 1967 tracking opportunity a success. Except for the DC-15 condition, the redundant provisions of the spacecraft have not been utilized. The redundant elements assumed to be available are:

1. Cavity amplifier
2. Exciter B
3. Power frequency sources
4. Booster regulator
5. Analog-to-digital converter and pseudonoise generator
6. Gyro inertial roll control

Limited determinations will also be possible regarding the following factors:

1. Solar cell performance trends
2. Clock accuracy
3. Deterioration of surfaces and finishes
4. Communication margin changes
5. Stability of stored picture data

Based on flight performance, there has been no reason for doubting that the spacecraft can continue operating for an extended period of time and, indeed, through 1967. Attitude control gas supply depletion is not anticipated until late 1968; the low rate of gas consumption experienced so far should permit three-axis control of the spacecraft in 1967. And in order to receive telemetry data in 1967, it is not necessary to have command capability.

b. Sampling of Interplanetary Conditions. Inherently, the greatest advantage lies in the basic scientific importance of continued sampling of the interplanetary conditions for an extended period during a time of relatively high solar activity. Figures 54 and 55 show that the expected sampling will provide unique coverage across solar distances and activity greater than has been experienced on any mission so far. Besides the intrinsic value of these measurements, results describing the interplanetary environment in these intervals could bear heavily on spacecraft design and experiment selection for other Mars missions.

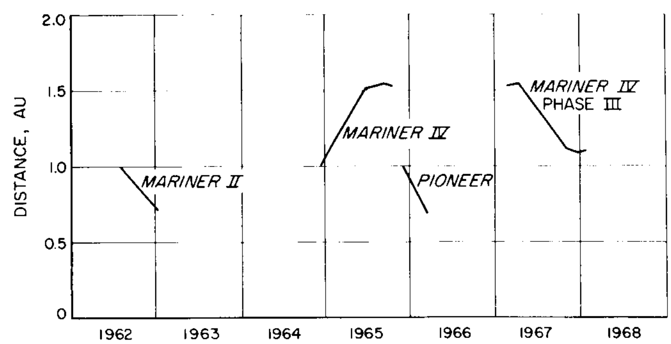


Fig. 54. Interplanetary missions coverage

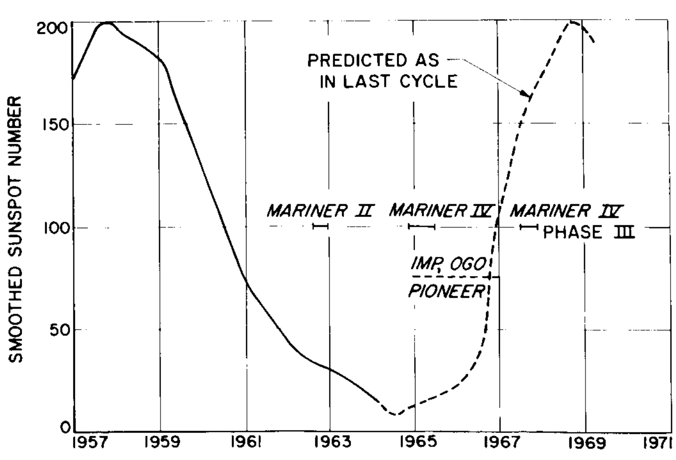


Fig. 55. Solar activity and launch date

During the time that *Mariner IV* telemetry can be received and decommutated in 1967, the spacecraft will approach the Sun from 1.5 to about 1.1 AU, as shown in Fig. 54. In 1967, solar activity (Fig. 55) will have risen somewhat more than halfway from the minimum of 1964–65 to the predicted maximum in 1968—if the cycle is like the last one.

The object of measuring fields and particles in interplanetary space is to construct a quantitative, theoretical description of the interaction between the solar wind and the magnetic field carried by it and, also of the action of the magnetic field upon energetic particles. Corollary objectives are (1) to describe the connection between the interplanetary phenomena and activity in the outer parts of the Sun and (2) to explain in detail the action of the interplanetary medium upon the planets and their magnetospheres.

The basic data needed are the composition and energy spectrum of the solar wind, the direction and intensity of the magnetic field, and the composition, direction, and energy spectrum of the energetic particle flux observed simultaneously over a period of time that encompasses different levels of solar activity. It is known that there must be a semi-static variation of field intensity and energetic particle flux. This gradient does not exceed 10 or 20% AU according to data from *Pioneer V*, *Mariner II*, and preliminary results from *Mariner IV*. Simultaneous measurements at points separated by distance of more than 0.3 AU from the Sun are required to observe this gradient. The solar plasma flux varies more rapidly, approximately as (heliocentric distance)$^{-2}$.

The transient phenomena—such as streams of high velocity plasma, blast waves, associated modulation of energetic particle intensity, and the large fluxes of energetic solar particles—occupy volumes several AU in diameter and extend on the order of 45 deg in heliocentric longitude. It is of interest to determine the spatial dependence and the velocity of propagation of the transient phenomena. This requires simultaneous observations at two or more points widely separated in radial distance from the Sun and/or heliocentric longitude.

On a theoretical basis, it is more difficult to predict the distribution of cosmic dust in the solar system. A priori, the flux is expected to increase as the asteroid belt is approached, although the sweeping action of Mars and Earth may modify the flux near their orbits. The *Mariner IV* measurements suggest a relative maximum in flux between the Earth's and Mars' orbits in consonance with the sweeping theory.

Charged particles and fields will be observed in 1967 during a period of increasing solar activity, with the identical instruments used at solar minimum. It is expected that the flux of low-energy galactic cosmic rays will be lower in 1967 than in 1965 and that the flux of low energy particles (probably solar) detected by the Trapped Radiation Detector will have increased. The average velocity of the solar wind may become higher as solar activity increases. This will move the peak current up into those energy channels in which the instruments operates best in its present condition. The magnetic field may be more disturbed than it has been in 1965 if the plasma velocity is really greater.

In addition to the above changes, solar flares will occur more frequently in 1967, and some of these will produce energetic particles and other phenomena that the spacecraft can observe.

The flux of cosmic dust particles probably does not vary with solar activity. However, its variation with heliocentric distance can be measured again in 1967. It is important to repeat this observation because the flux is so low that the statistical accuracy of the *Mariner IV* data is not very high.

Any spacecraft which measures fields and particles in interplanetary space near Earth or inside its orbit can provide data needed for the simultaneous observations at two locations.

Pioneer goes farthest inside Earth's orbit (to about 0.75 AU), thus providing the greatest separation in heliocentric distance from *Mariner IV*. Operation of the two spacecraft should overlap by at least 100 days (4 solar rotations). Several of the *Mariner* experimenters have similar apparatus on *Pioneer* that would facilitate correlation of results.

Ideally, *Mariner IV* data reception should be received 24 hr/day during the 1967 operation. However, continuous reception for 8 hr/day would be entirely adequate to measure quiet conditions in interplanetary space. If only partial coverage is given, then provision should be made to go to full coverage if solar disturbances are reported by Agiwarn, or if unusual events are observed in the *Mariner* data or the *Pioneer* data—assuming the two were operating simultaneously.

It would be important to receive *Pioneer* and *Mariner IV* data simultaneously, not just on the same days. It would also be very desirable to go to full coverage for one or two days at regular intervals, even if no special effects are observed.

*c. **Conclusions.*** The goals for the Phase III 1967 reacquisition opportunity may thus be stated as:

1. The recovery of interplanetary science data
2. An increase in engineering knowledge about the consequences of extended exposure of complex electronic equipment in the interplanetary space environment

3. Alternate Plans

Three of the most promising alternatives in Phase III are:

IIIA Inertial mode, starting February 1967

IIIB Inertial mode, starting June 1967

IIIC Passive mode, starting June 1967

*a. **Phase IIIA.*** This phase considers tracking the spacecraft early in 1967 by utilizing the inertial mode of the spacecraft via the command system, providing reception of spacecraft data 24 hr/day. This would require as full an effort as was mounted in 1965 for the planetary encounter. All elements of spacecraft engineering analysis, scientific analysis, and flight path analysis would be required to support this operation in order to make coordinated decisions on sending commands, analyzing longevity performance, interpreting data, and presenting coordinated results. In such a case, the operation would need to be coordinated through a Project Management structure similar to that of Phase I.

During the early part of 1967, coverage for 24 hr/day would be available through the use of the inertial mode. However, the battery on board *Mariner IV*, to all indications, may have gone bad. It is almost certain that the battery will be unavailable in 1967. The situation is complicated by the potential solar panel degradation. Thus, the transient load of the gyros may not be supported, and the mission could be aborted when the gyros are turned on.

In addition, many of the people who are best qualified to exercise this mode will undoubtedly be committed to higher priority missions. It is not considered advisable to place this complicated spacecraft in the hands of any except a team trained at least to the competence level of the group used during encounter. For these reasons, Phase IIIA has not been recommended.

b. Phase IIIB. Phase IIIB would start in mid-June 1967. The predicted solar panel power is sufficient to support the gyro turn-on. The spacecraft will be near enough to the Earth so that telemetry would be available through the low-gain antenna, and an analysis could be made as to the spacecraft condition prior to sending any command. In addition, the commands would not have to be sent in the blind as they would early in Phase IIIA.

Phase IIIB allows the option of exercising the inertial mode for 24-hr coverage if the engineering analysis indicates a spacecraft capability and if the scientific value is enhanced. Such an opportunity might arise during a solar flare, where total coverage would be most important.

In order to exercise this alternative, the analytical capability must be available; the effort would have to be coordinated by a suitable Project staff, with analysis personnel in support. However, the availability of trained personnel would again be a problem, as in Phase IIIA.

The age of the spacecraft at this time would raise doubts as to its ability to respond to commands. The same cautious care applied in 1965 would need to be magnified many times. Consequently, Phase IIIB has not been recommended.

c. Phase IIIC. Phase IIIC would be initiated in mid-June 1967, and differs from Phase IIIB in that the activity would be passive. Telemetry would be obtained through the omnidirectional antenna; no commands would be transmitted, since no analytical support is planned.

The operations plan for this phase has five characteristics.

First, *Mariner IV* 1967 reacquisition will be conducted as a passive, listen only, omnidirectional antenna operation, with command action only if absolutely necessary to attain mission objectives. This implies that only single station coverage (210-ft antenna) over most of the period from June through December 1967 will be possible, resulting in about 10 hr/day of telemetry data when, and if, this station is available.

Second, real time monitoring of data will be performed in the SFOF, using those data processing facilities as required.

Third, a Master Data Library will be prepared in non-real time, using best data inputs from the tracking stations. Extract tapes will be available to transmit to the science experimenters and to the appropriate JPL technical divisions (for subsystem performance) within 30 days after real-time occurrence. This will be the only data transmitted to the experimenters unless specific arrangements are made. The real-time monitoring will be available to the experimenters or their representatives for real-time perusal of their data.

Fourth, the DSN will perform all necessary operations for tracking and data acquisition and will make the necessary computations to enable predictions to be generated for all stations.

Fifth, no requirement will exist for support of either the PTM or MC-4 spacecraft for this phase.

The spacecraft is on its way around the Sun, having already made its mark on history. The reacquisition possibilities described here are still only possibilities, and further studies will have to be performed before a final committment is made. When, and if, the 1967 reacquisition occurs, it is expected that a full report of the operation will be written and published.[6]

B. Spacecraft Final Conditioning

In order to carry out the proposed plans to track the spacecraft in its orbit around the Sun and to attempt to reacquire it in 1967, it was necessary to condition the spacecraft so that it would be in an optimum configuration for these actions.

After the encounter with Mars, the spacecraft was still receiving via the high-gain antenna. There was, of course, no guarantee that the high-gain antenna would be pointing at the Earth in 1967, even assuming that the spacecraft were still locked on Canopus. The spacecraft would have to receive via the low-gain antenna in order to provide the maximum reacquisition possibility.

As a result of a possible internal failure, the spacecraft could conceivably perform a midcourse maneuver, which would alter the heliocentric orbit. To prevent such an occurrence, it would be necessary to send an *inhibit maneuver* command. As an additional safeguard, quantitative commands could be stored in the CC&S to produce minimum roll and pitch turns and a minimum motor burn time.

[6]Description of the disposition of the PTM and MC-4 spacecraft is as of 1 October 1965, and does not represent the final disposition. Subsequently, *Mariner IV* and *Mariner* Venus 67 Projects were activated, and these spacecraft were removed from storage to be used with these projects.

As a result of these considerations, a DC-13 maneuver inhibit command was transmitted to the spacecraft on 26 August 1965. At the same time, the appropriate quantitative commands were also transmitted. The termination of the Phase I portion of the mission occurred on 1 October 1965. At that time, a DC-12 command was transmitted to the spacecraft, transferring spacecraft reception from the high-gain to the low-gain antenna.

REFERENCES

1. Baston, J. G., editor, *Proceedings of the Magnetics Workshop, March 30 to April 1, 1965, Jet Propulsion Laboratory,* September 15, 1965.
2. *Workshop Proceedings on Voltage Breakdown in Electronic Equipment at Low Air Pressures,* Technical Memorandum No. 33-280, Jet Propulsion Laboratory, Pasadena, California (to be published 1966).
3. Frank, L. A., Van Allen, J. A., and Hills, H. K., "A Study of Charged Particles in the Earth's Outer Radiation Zone, with Explorer XIV," *Journal of Geophysical Research,* Vol. 69, 2171 (1964).
4. Rossi, Bruno, *High Energy Particles,* Prentice-Hall, Inc., New York, 1952.
5. "Performance Test Data on an Electrical Prototype, Printed Circuit Upper Ring Harness for *Mariner* C Involving Intersubsystem Power Distribution and Signal Interfacing," *Space Programs Summary No. 37-33, Volume IV,* Jet Propulsion Laboratory, Pasadena, California, June 30, 1965, pp. 84–90.

APPENDIX A

P List

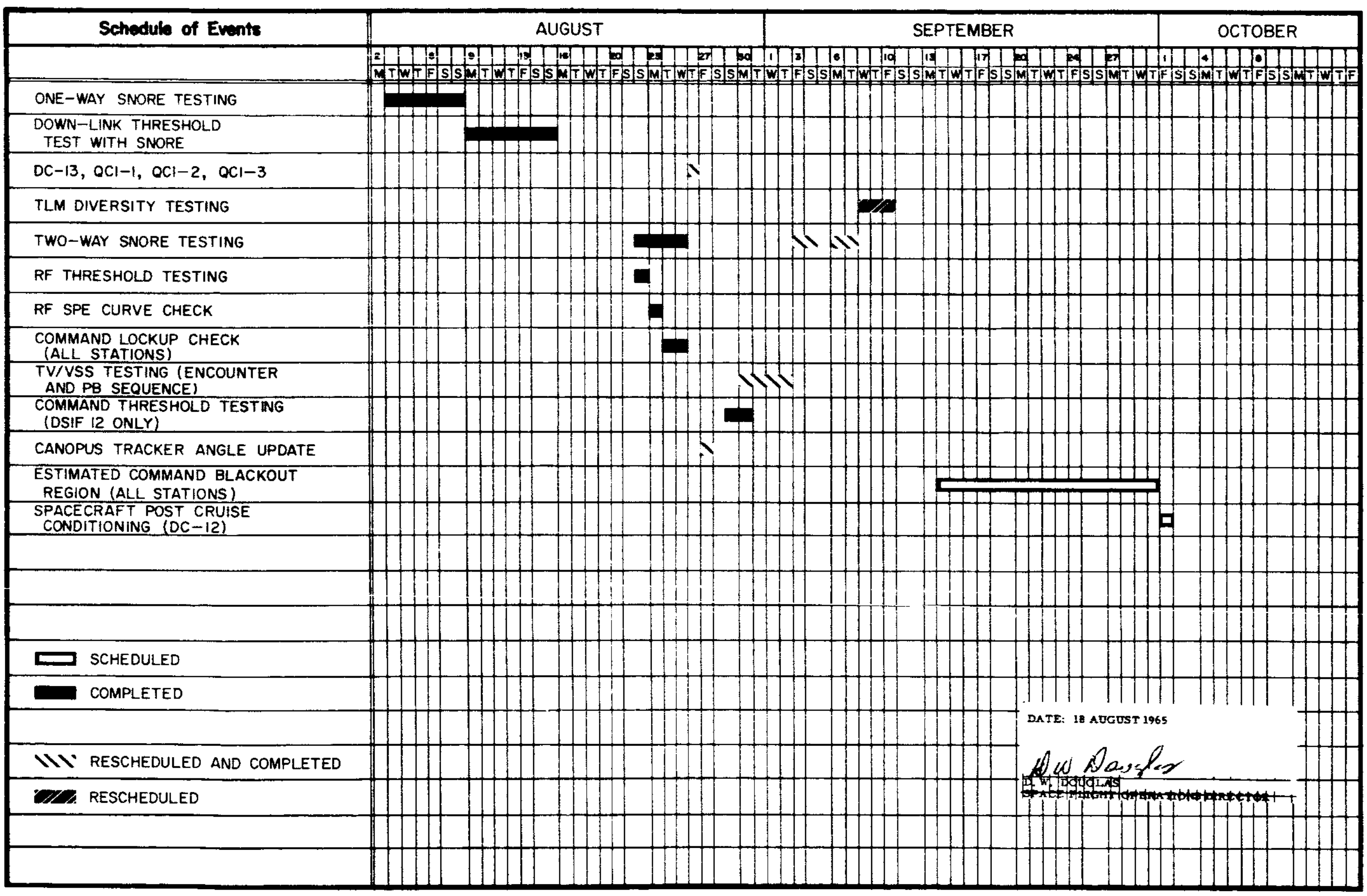
MARINER C "P" LIST

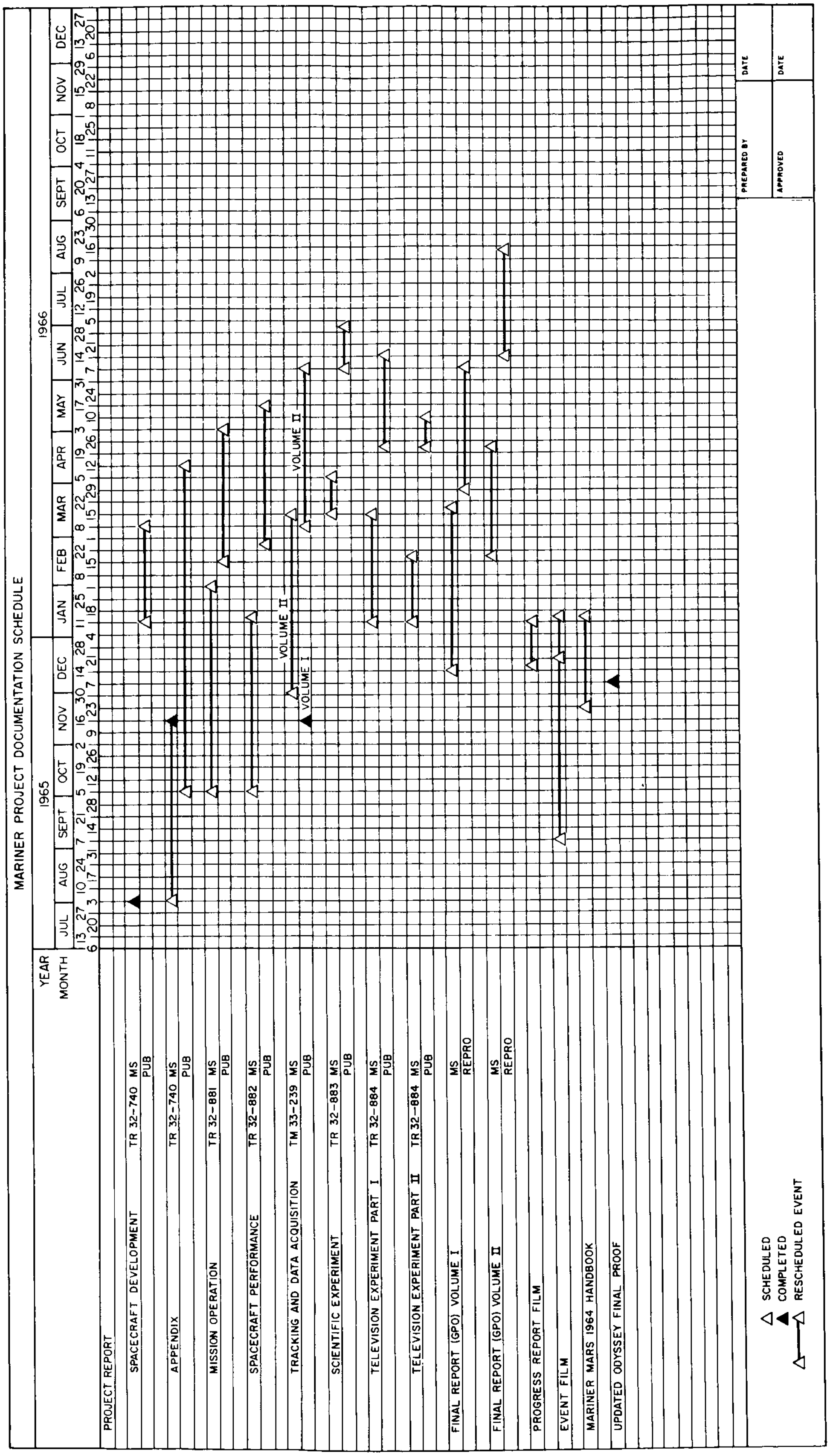
A List of Problems considered to be jeopardizing the mission

P-No	Sys	Problem Description	Primary Responsibility for Resolving Problem Assigned To	Design Assistants	Date Assigned	Date Resolved
P-101	SC/ DSIF	Predicts for 2-way lockup of s/c receiver. Unable to accurately provide predict frequencies to the DSIF stations to acquire 2-way lock in the minimum time after start of ground r.f. transmission. A new quickest lock bias figure of about 7 cps below the VCO frequency value measured prelaunch now appears to be optimum. This new number must be tested in s/c lockup procedure before a definite conclusion can be drawn. This item will remain on the "P" List until then. Tests have been satisfactorily run and this item can now be closed. See IOM Hunter to Schneiderman "Mariner C P-101" 29 March 1965	J. Hunter (33)		3/15	3/29
P-102	DSN	TIM (EPD-167) It is reported there are as many as 19 changes to the TIM since publication. This leads to uncertainty as to whether any particular copy is up-to-date. Issuance of Rev. I (dated 6/4/65) to Vol. I "Mission Schedules and System Operation" closes this item.	W. Brown (33)		3/30	6/21
P-103	SFO	Encounter Programs The late delivery date (6/21) of the DAS/SCAN Computer Program seriously compromises the encounter operational testing and practice of the scan position lockup mode. This program appeared to work satisfactorily during the final Operational Readiness Test on 7/9; however, due to its late completion can only be considered as a backup for the actual positioning. This item now closed.	D. Douglas (31)	F. Curl (31)	4/14	7/9

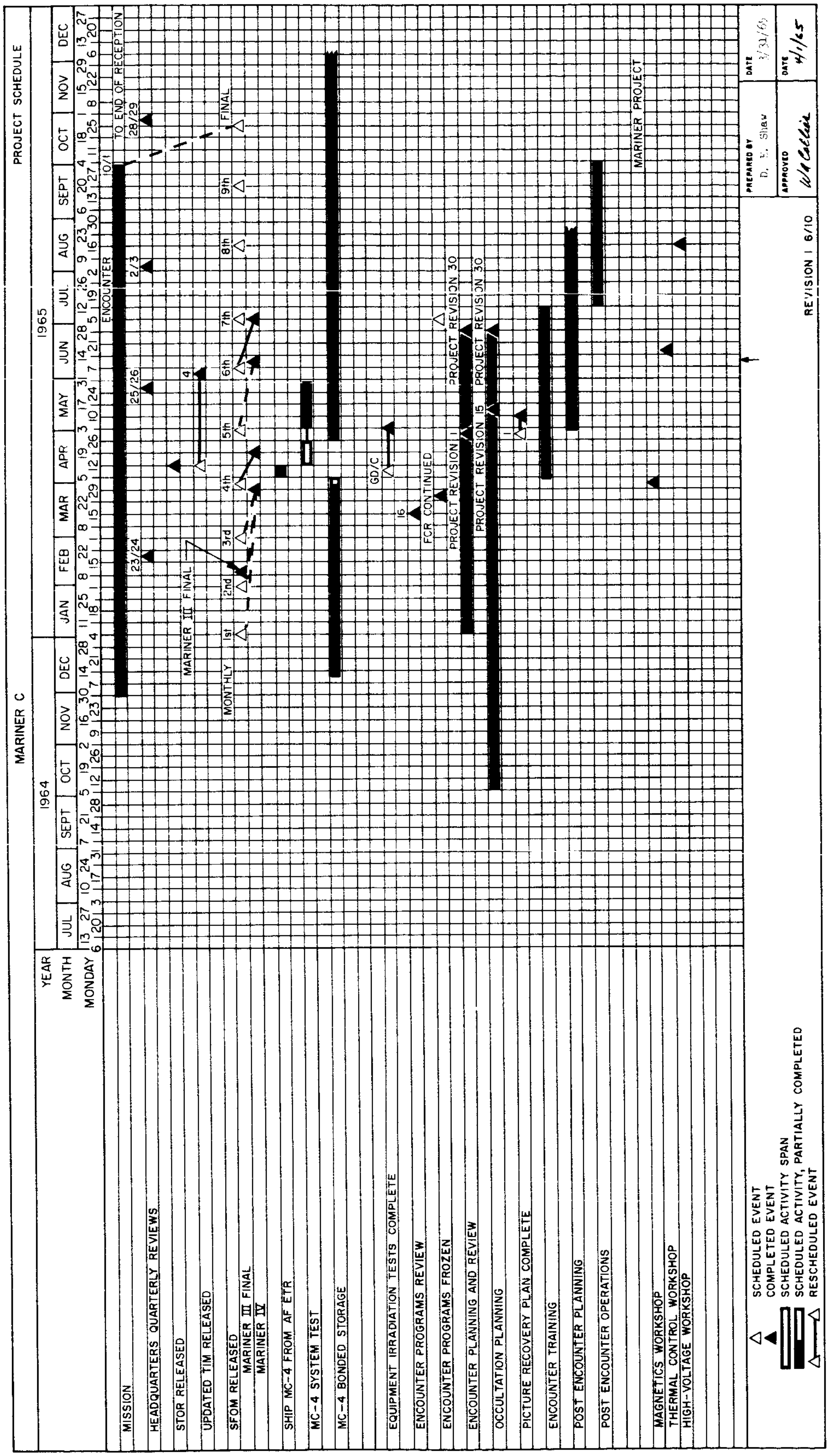
APPENDIX B

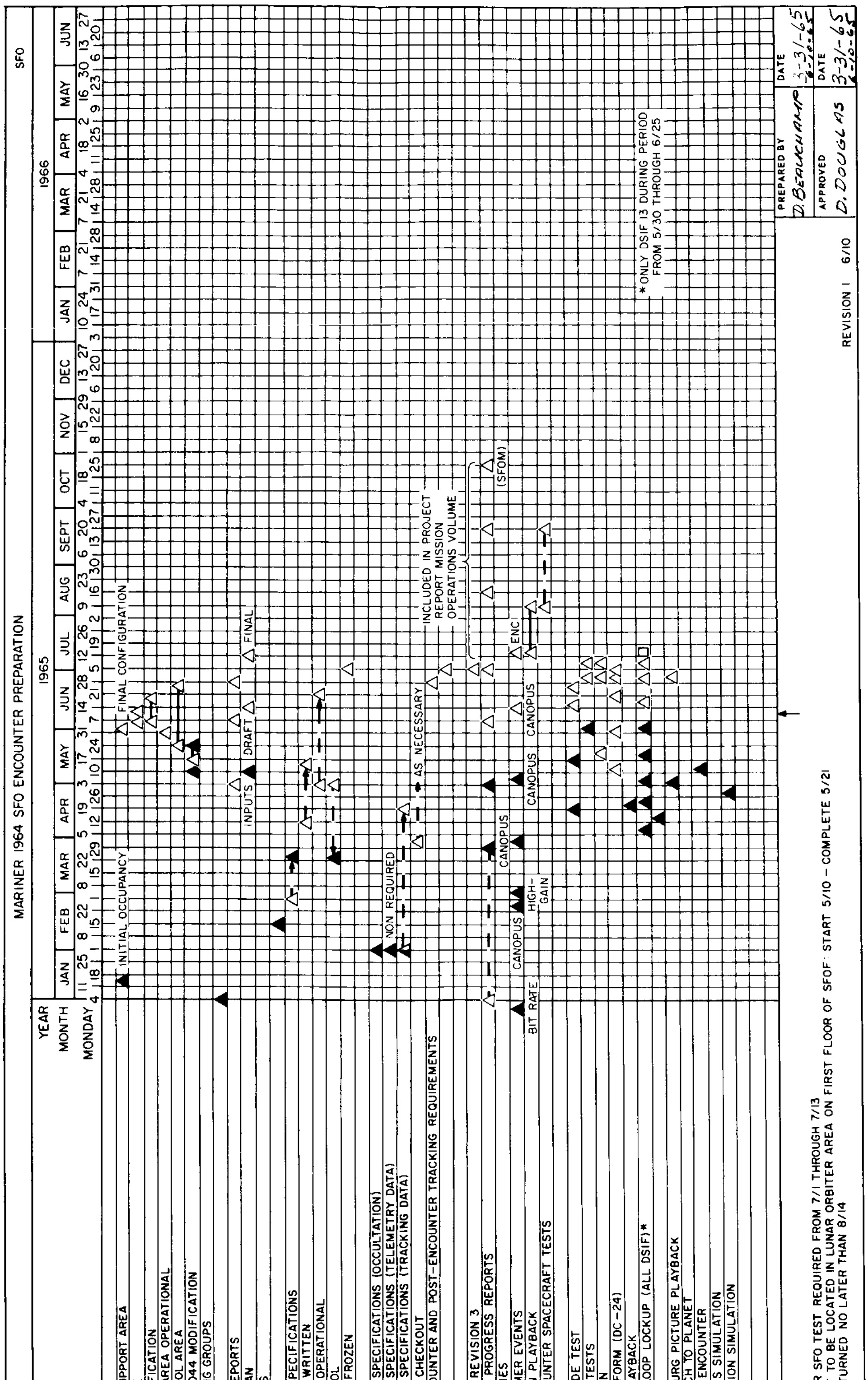
Schedule Package

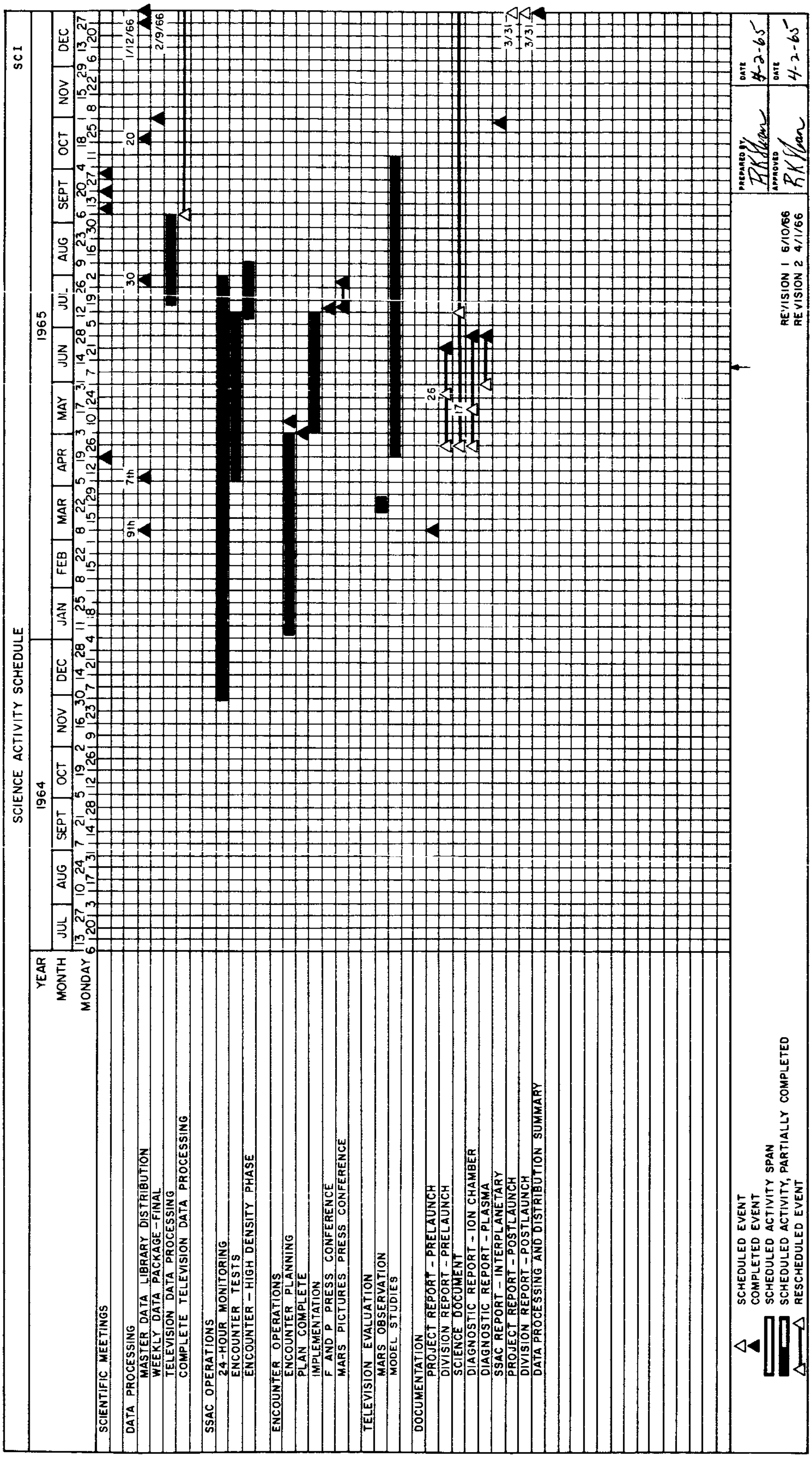

Schedule of Events
AUGUST
SEPTEMBER
OCTOBER
ONE-WAY SNORE TESTING
DOWN-LINK THRESHOLD TEST WITH SNORE
DC-13, QCI-1, QCI-2, QCI-3
TLM DIVERSITY TESTING
TWO-WAY SNORE TESTING
RF THRESHOLD TESTING
RF SPE CURVE CHECK
COMMAND LOCKUP CHECK (ALL STATIONS)
TV/VSS TESTING (ENCOUNTER AND PB SEQUENCE)
COMMAND THRESHOLD TESTING (DSIF 12 ONLY)
CANOPUS TRACKER ANGLE UPDATE
ESTIMATED COMMAND BLACKOUT REGION (ALL STATIONS)
SPACECRAFT POST CRUISE CONDITIONING (DC-12)
SCHEDULED
COMPLETED
RESCHEDULED AND COMPLETED
RESCHEDULED
DATE: 18 AUGUST 1965
D. W. DOUGLAS

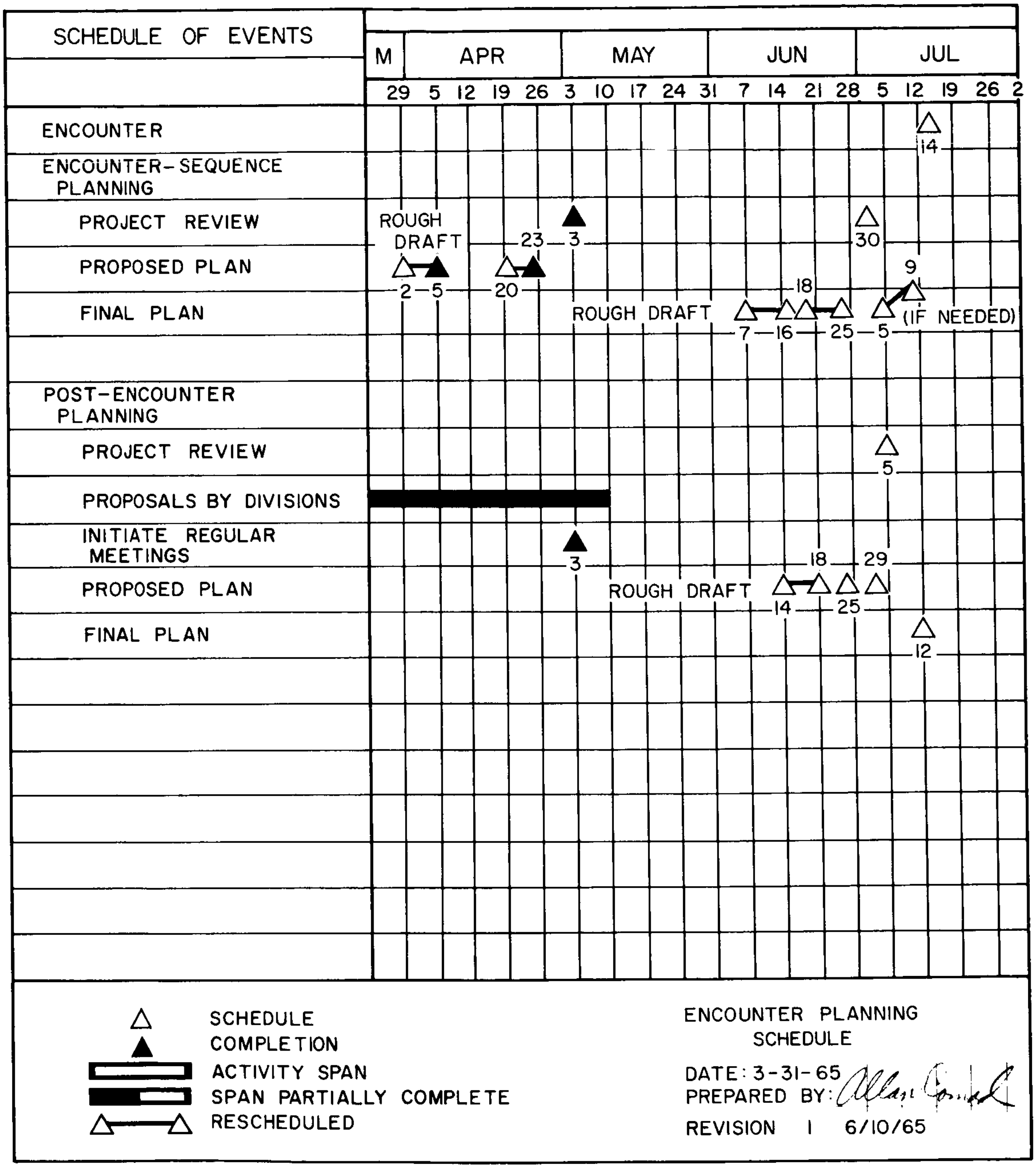


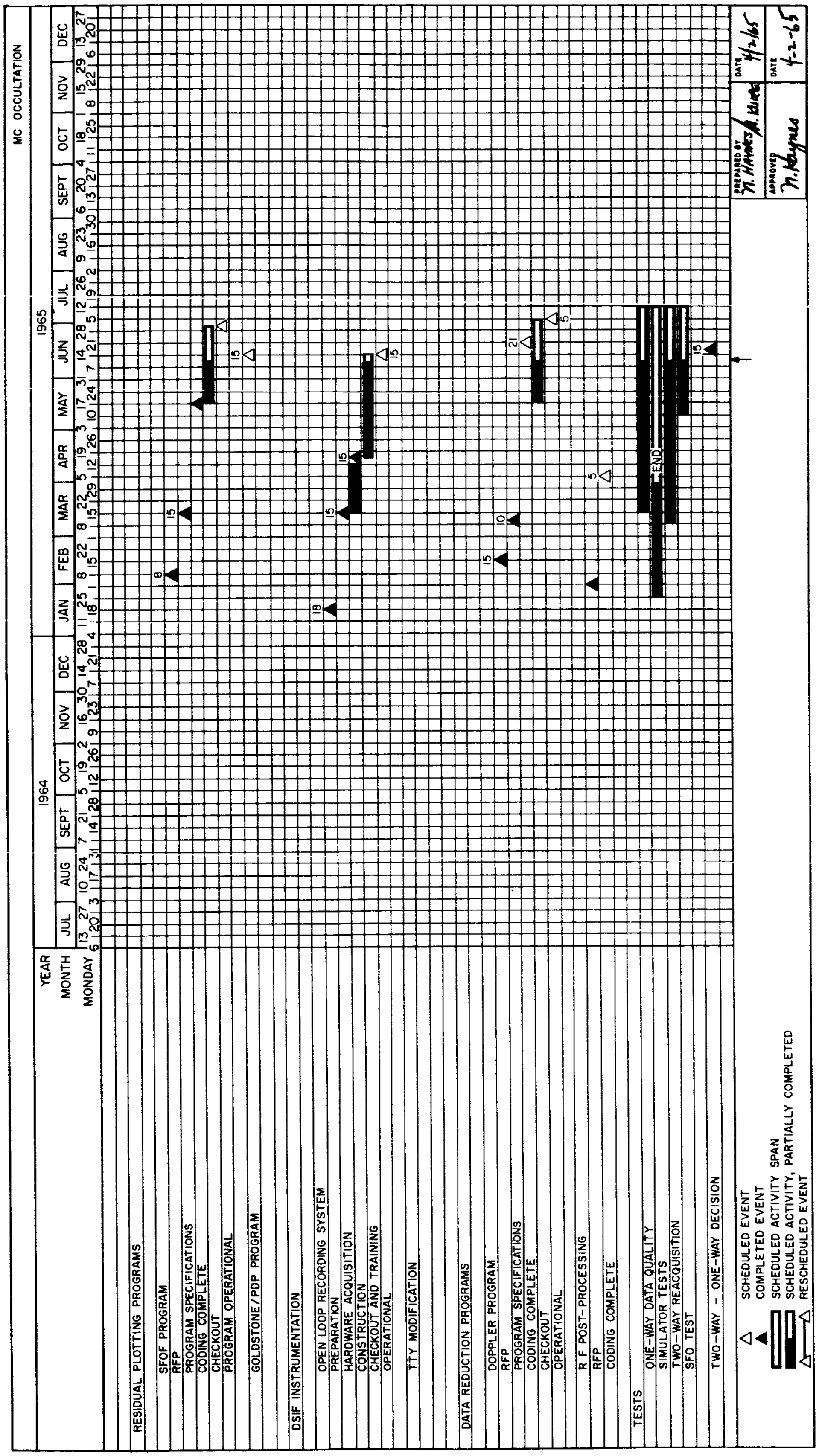
MARINER PROJECT DOCUMENTATION SCHEDULE
YEAR
MONTH
1965
1966
JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC
PROJECT REPORT
SPACECRAFT DEVELOPMENT TR 32-740 MS PUB
APPENDIX TR 32-740 MS PUB
MISSION OPERATION TR 32-881 MS PUB
SPACECRAFT PERFORMANCE TR 32-882 MS PUB
TRACKING AND DATA ACQUISITION TM 33-239 MS PUB
SCIENTIFIC EXPERIMENT TR 32-883 MS PUB
TELEVISION EXPERIMENT PART I TR 32-884 MS PUB
TELEVISION EXPERIMENT PART II TR 32-884 MS PUB
FINAL REPORT (GPO) VOLUME I MS REPRO
FINAL REPORT (GPO) VOLUME II MS REPRO
PROGRESS REPORT FILM
EVENT FILM
MARINER MARS 1964 HANDBOOK
UPDATED ODYSSEY FINAL PROOF
VOLUME I
VOLUME II
SCHEDULED
COMPLETED
RESCHEDULED EVENT
PREPARED BY
DATE
APPROVED
DATE

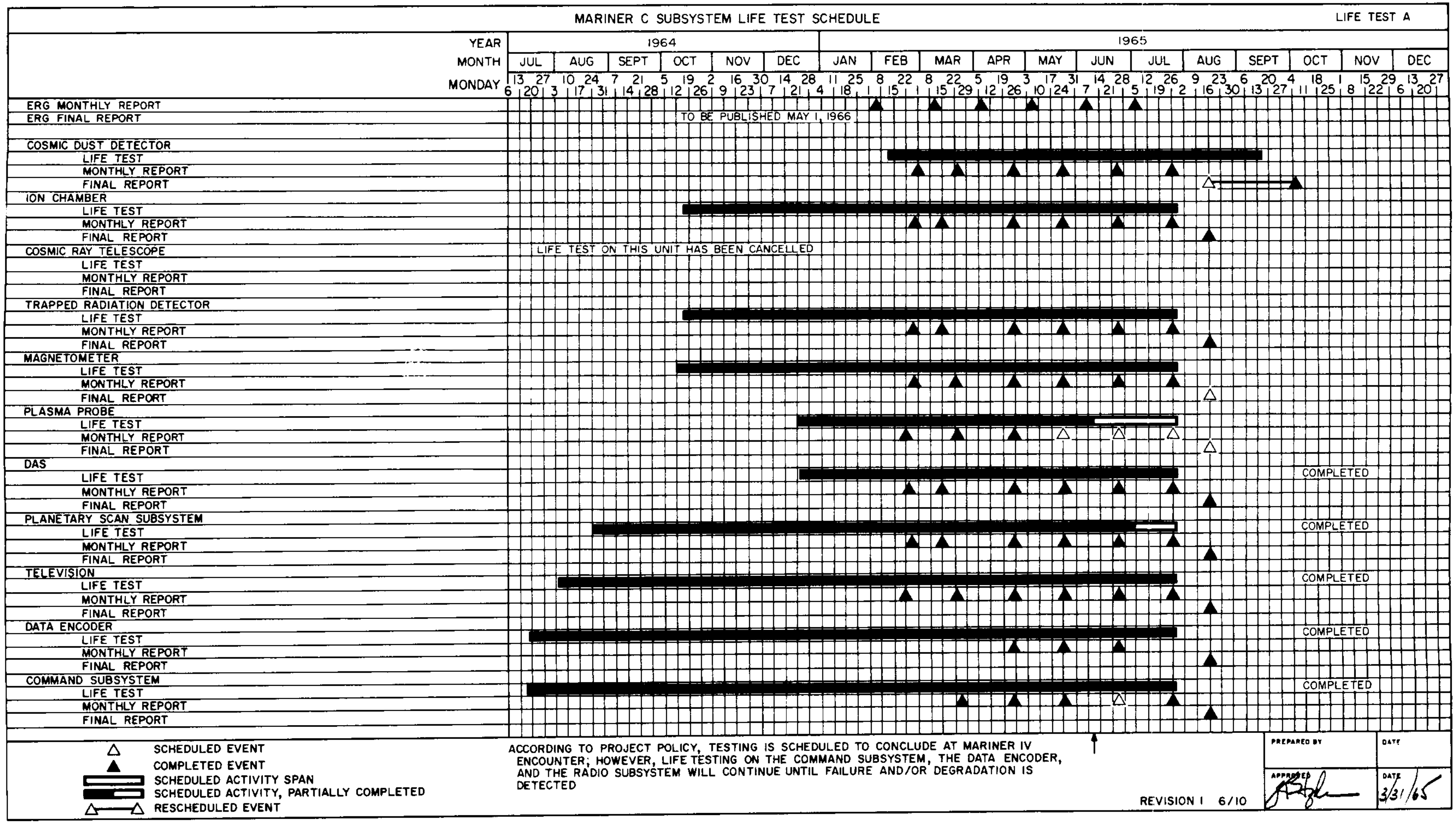

MARINER C
PROJECT SCHEDULE
YEAR
MONTH
MONDAY
1964
1965
JUL
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
MISSION
HEADQUARTERS QUARTERLY REVIEWS
STOR RELEASED
UPDATED TIM RELEASED
SFOM RELEASED
MARINER III FINAL
MARINER IV
SHIP MC-4 FROM AF ETR
MC-4 SYSTEM TEST
MC-4 BONDED STORAGE
EQUIPMENT IRRADIATION TESTS COMPLETE
ENCOUNTER PROGRAMS REVIEW
ENCOUNTER PROGRAMS FROZEN
ENCOUNTER PLANNING AND REVIEW
OCCULTATION PLANNING
PICTURE RECOVERY PLAN COMPLETE
ENCOUNTER TRAINING
POST ENCOUNTER PLANNING
POST ENCOUNTER OPERATIONS
MAGNETICS WORKSHOP
THERMAL CONTROL WORKSHOP
HIGH-VOLTAGE WORKSHOP
ENCOUNTER
10/1
TO END OF RECEPTION
23/24
25/26
2/3
28/29
MARINER III FINAL
MONTHLY
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
FINAL
GD/C
16
FCR CONTINUED
PROJECT REVISION I
PROJECT REVISION 30
PROJECT REVISION 15
MARINER PROJECT
SCHEDULED EVENT
COMPLETED EVENT
SCHEDULED ACTIVITY SPAN
SCHEDULED ACTIVITY, PARTIALLY COMPLETED
RESCHEDULED EVENT
REVISION I 6/10
PREPARED BY
D. E. Shaw
APPROVED
DATE
4/1/65

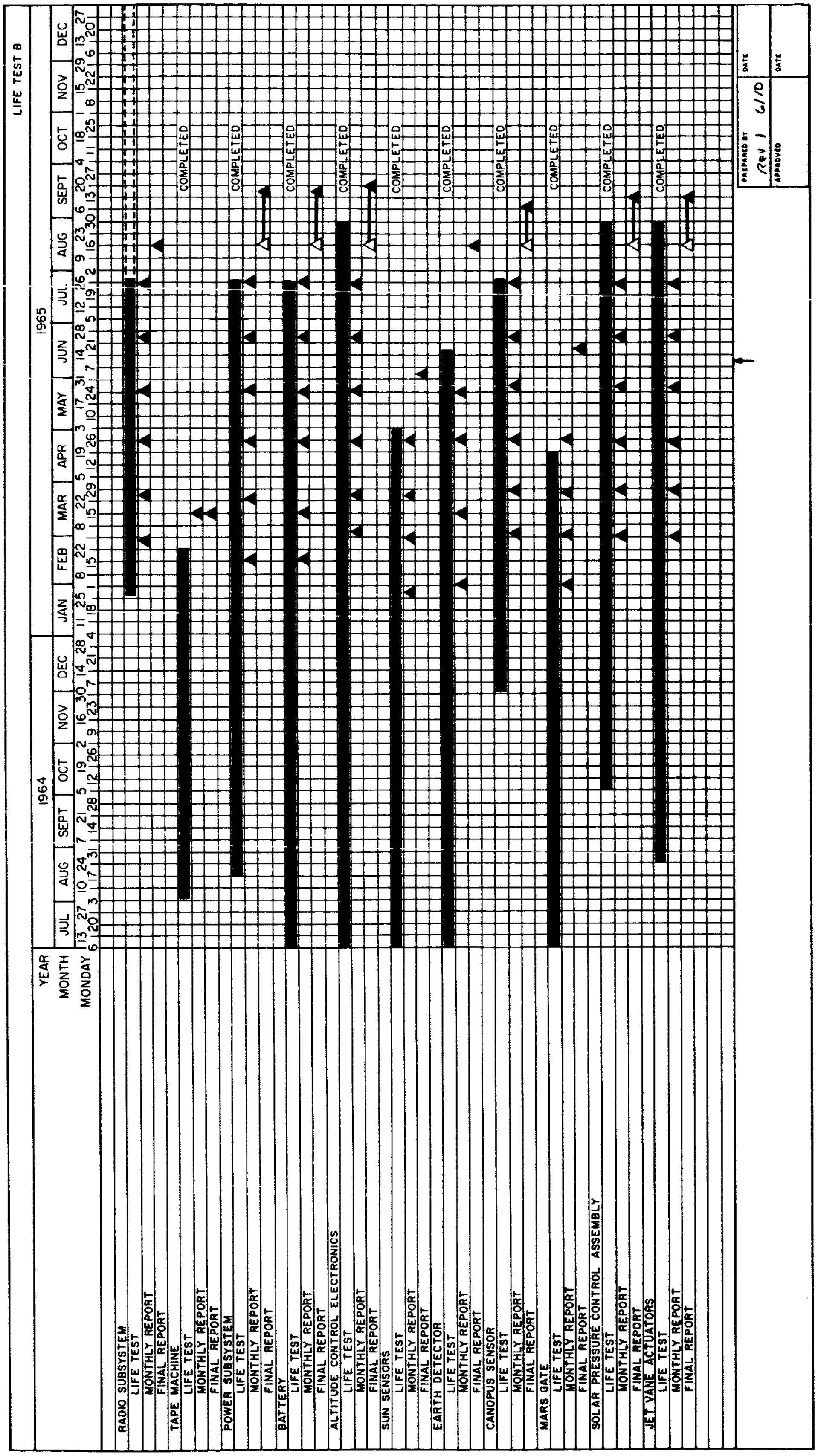

MARINER 1964 SFO ENCOUNTER PREPARATION
SFO
YEAR
MONTH
MONDAY
1965
1966
JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC
JAN FEB MAR APR MAY JUN
SFOF ACTIVITIES
MISSION SUPPORT AREA
DPCC MOVE
FPAC MODIFICATION
NEW DSIF AREA OPERATIONAL
DSN CONTROL AREA
7040 TO 7044 MODIFICATION
ENCOUNTER PLANNING GROUPS
FORMED
PROJECT REPORTS
POST ENCOUNTER PLAN
COMPUTER PROGRAMS
RFP
PROGRAM SPECIFICATIONS
PROGRAMS WRITTEN
PROGRAMS OPERATIONAL
ECR CONTROL
PROGRAMS FROZEN
DSIF REQUIREMENTS
HARDWARE SPECIFICATIONS (OCCULTATION)
HARDWARE SPECIFICATIONS (TELEMETRY DATA)
HARDWARE SPECIFICATIONS (TRACKING DATA)
HARDWARE CHECKOUT
FINAL ENCOUNTER AND POST-ENCOUNTER TRACKING REQUIREMENTS
FINAL SFO FREEZE
DOCUMENTATION
SFO PLAN-REVISION 3
TECHNICAL PROGRESS REPORTS
SPACECRAFT ACTIVITIES
MASTER TIMER EVENTS
TELEVISION PLAYBACK
POST-ENCOUNTER SPACECRAFT TESTS
ENCOUNTER TESTS
BACKUP MODE TEST
READINESS TESTS
OCCULTATION
SCAN PLATFORM (DC-24)
PICTURE PLAYBACK
COMMAND LOOP LOCKUP (ALL DSIF)*
DC-18
JOHANNESBURG PICTURE PLAYBACK
SCAN SEARCH TO PLANET
ALTERNATE ENCOUNTER
SCAN Y-AXIS SIMULATION
ROLL POSITION SIMULATION
INITIAL OCCUPANCY
FINAL CONFIGURATION
INPUTS
DRAFT
FINAL
NON REQUIRED
AS NECESSARY
INCLUDED IN PROJECT REPORT MISSION OPERATIONS VOLUME
(SFOM)
CANOPUS
HIGH-GAIN
BIT RATE
ENC
*ONLY DSIF 13 DURING PERIOD FROM 5/30 THROUGH 6/25
REVISION 1 6/10
PREPARED BY
DATE
APPROVED
DATE
NOTE:
1) PTM SUPPORT FOR SFO TEST REQUIRED FROM 7/1 THROUGH 7/13
2) G-CAT AND T-CAT TO BE LOCATED IN LUNAR ORBITER AREA ON FIRST FLOOR OF SFOF: START 5/10 – COMPLETE 5/21
AREA TO BE RETURNED NO LATER THAN 8/14

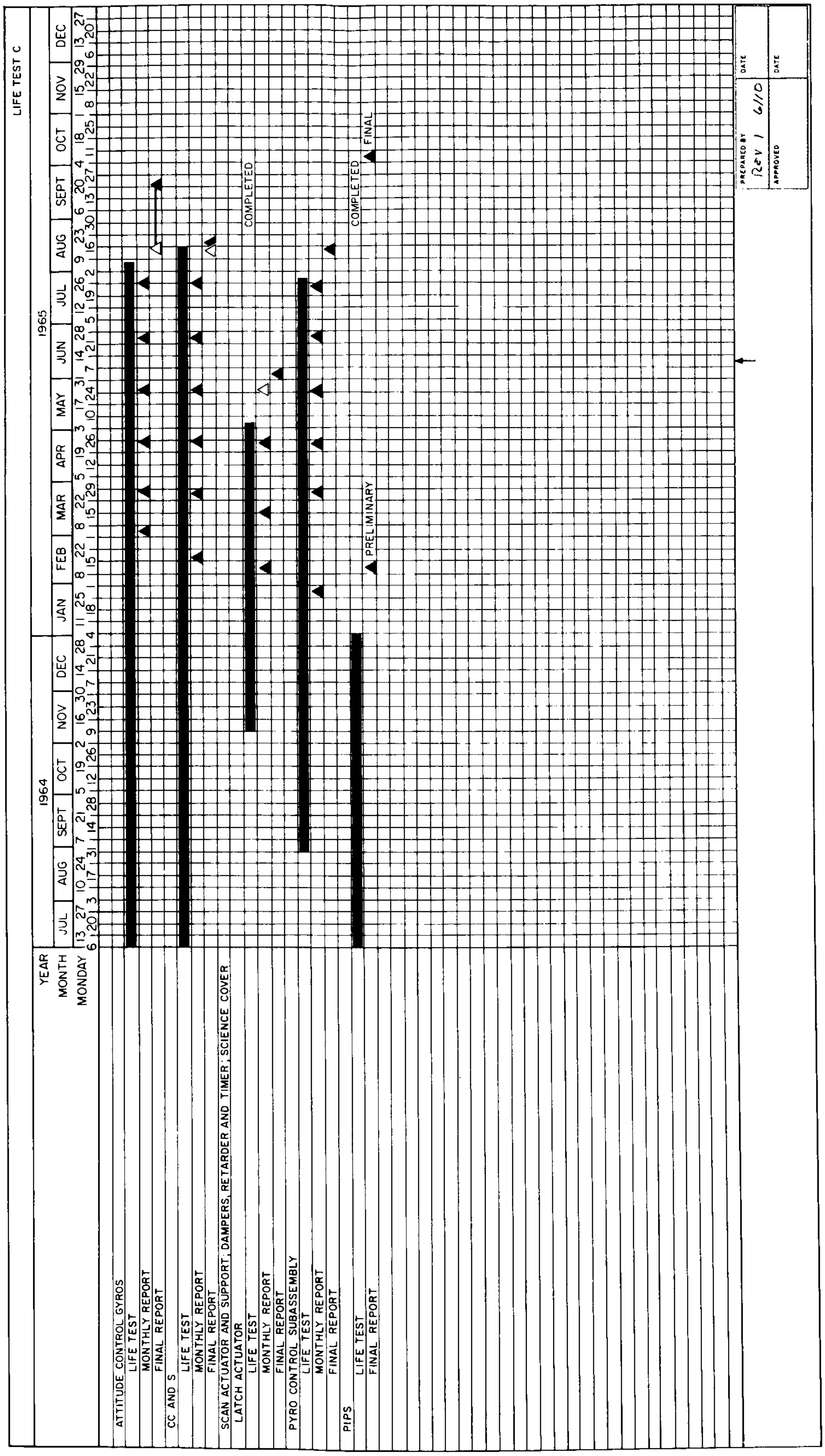

SCIENCE ACTIVITY SCHEDULE
SCI
YEAR
MONTH
MONDAY
1964
1965
SCIENTIFIC MEETINGS
DATA PROCESSING
MASTER DATA LIBRARY DISTRIBUTION
WEEKLY DATA PACKAGE – FINAL
TELEVISION DATA PROCESSING
COMPLETE TELEVISION DATA PROCESSING
SSAC OPERATIONS
24-HOUR MONITORING
ENCOUNTER TESTS
ENCOUNTER – HIGH DENSITY PHASE
ENCOUNTER OPERATIONS
ENCOUNTER PLANNING
PLAN COMPLETE
IMPLEMENTATION
F AND P PRESS CONFERENCE
MARS PICTURES PRESS CONFERENCE
TELEVISION EVALUATION
MARS OBSERVATION
MODEL STUDIES
DOCUMENTATION
PROJECT REPORT – PRELAUNCH
DIVISION REPORT – PRELAUNCH
SCIENCE DOCUMENT
DIAGNOSTIC REPORT – ION CHAMBER
DIAGNOSTIC REPORT – PLASMA
SSAC REPORT – INTERPLANETARY
PROJECT REPORT – POSTLAUNCH
DIVISION REPORT – POSTLAUNCH
DATA PROCESSING AND DISTRIBUTION SUMMARY
SCHEDULED EVENT
COMPLETED EVENT
SCHEDULED ACTIVITY SPAN
SCHEDULED ACTIVITY, PARTIALLY COMPLETED
RESCHEDULED EVENT
REVISION 1 6/10/66
REVISION 2 4/1/66
PREPARED BY
APPROVED
DATE

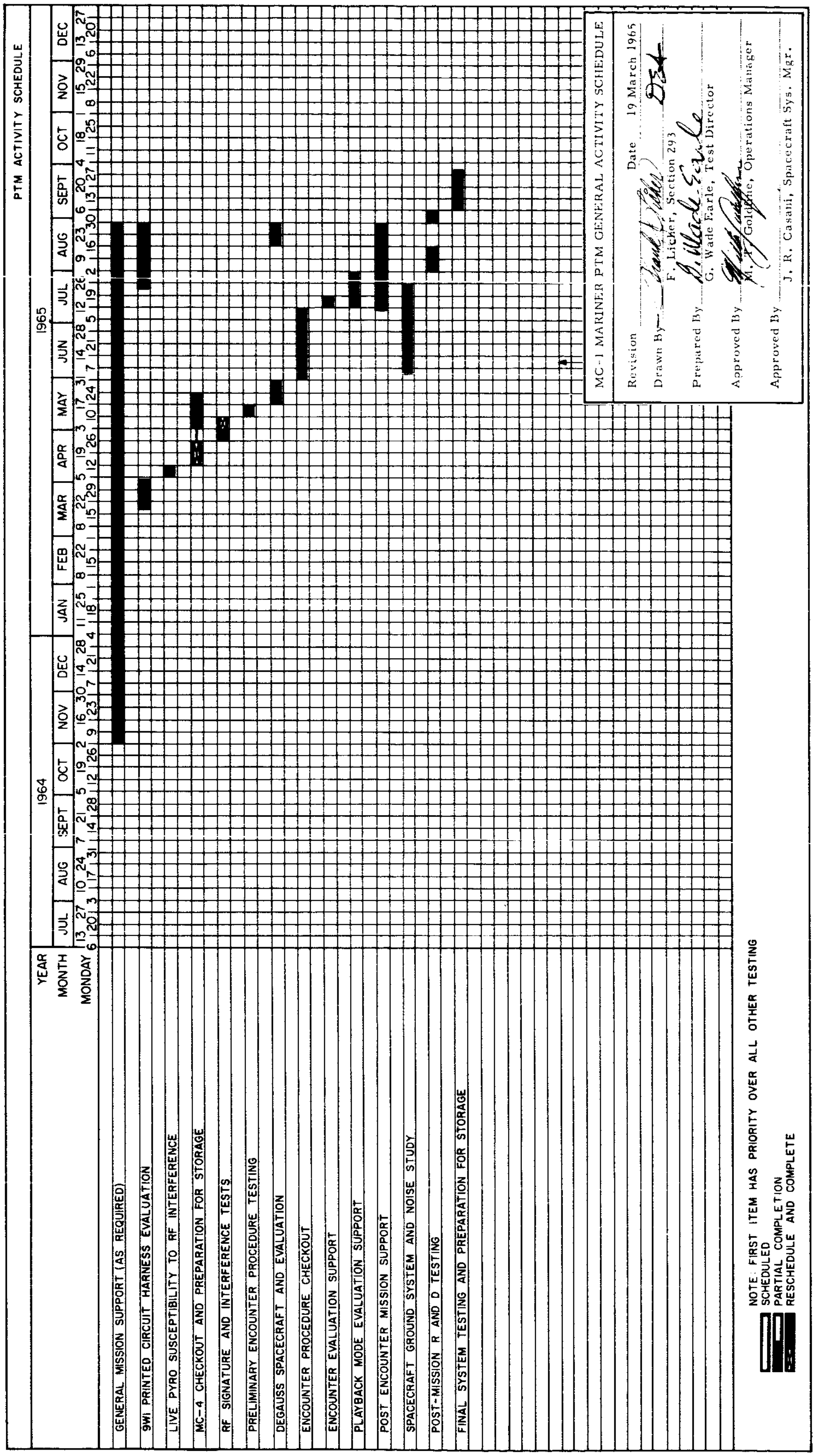

SCHEDULE OF EVENTS
M
APR
MAY
JUN
JUL
29 5 12 19 26 3 10 17 24 31 7 14 21 28 5 12 19 26 2
ENCOUNTER
14
ENCOUNTER-SEQUENCE PLANNING
PROJECT REVIEW
3
30
PROPOSED PLAN
ROUGH DRAFT
23
2 5
20
FINAL PLAN
ROUGH DRAFT
18
9
(IF NEEDED)
7 16 25 5
POST-ENCOUNTER PLANNING
PROJECT REVIEW
5
PROPOSALS BY DIVISIONS
INITIATE REGULAR MEETINGS
3
PROPOSED PLAN
ROUGH DRAFT
18
29
14
25
FINAL PLAN
12
SCHEDULE
COMPLETION
ACTIVITY SPAN
SPAN PARTIALLY COMPLETE
RESCHEDULED
ENCOUNTER PLANNING SCHEDULE
DATE: 3-31-65
PREPARED BY:
REVISION I 6/10/65


MC OCCULTATION
YEAR
MONTH
MONDAY
1964
1965
JUL
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
RESIDUAL PLOTTING PROGRAMS
SFOF PROGRAM
RFP
PROGRAM SPECIFICATIONS
CODING COMPLETE
CHECKOUT
PROGRAM OPERATIONAL
GOLDSTONE/PDP PROGRAM
DSIF INSTRUMENTATION
OPEN LOOP RECORDING SYSTEM
PREPARATION
HARDWARE ACQUISITION
CONSTRUCTION
CHECKOUT AND TRAINING
OPERATIONAL
TTY MODIFICATION
DATA REDUCTION PROGRAMS
DOPPLER PROGRAM
RFP
PROGRAM SPECIFICATIONS
CODING COMPLETE
CHECKOUT
OPERATIONAL
R F POST-PROCESSING
RFP
CODING COMPLETE
TESTS
ONE-WAY DATA QUALITY
SIMULATOR TESTS
TWO-WAY REACQUISITION
SFO TEST
TWO-WAY - ONE-WAY DECISION
END
SCHEDULED EVENT
COMPLETED EVENT
SCHEDULED ACTIVITY SPAN
SCHEDULED ACTIVITY, PARTIALLY COMPLETED
RESCHEDULED EVENT
PREPARED BY
DATE
APPROVED
DATE


MARINER C SUBSYSTEM LIFE TEST SCHEDULE
LIFE TEST A
YEAR
1964
1965
MONTH
JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC
MONDAY
ERG MONTHLY REPORT
ERG FINAL REPORT
TO BE PUBLISHED MAY 1, 1966
COSMIC DUST DETECTOR
LIFE TEST
MONTHLY REPORT
FINAL REPORT
ION CHAMBER
LIFE TEST
MONTHLY REPORT
FINAL REPORT
COSMIC RAY TELESCOPE
LIFE TEST ON THIS UNIT HAS BEEN CANCELLED
LIFE TEST
MONTHLY REPORT
FINAL REPORT
TRAPPED RADIATION DETECTOR
LIFE TEST
MONTHLY REPORT
FINAL REPORT
MAGNETOMETER
LIFE TEST
MONTHLY REPORT
FINAL REPORT
PLASMA PROBE
LIFE TEST
MONTHLY REPORT
FINAL REPORT
DAS
LIFE TEST
MONTHLY REPORT
FINAL REPORT
COMPLETED
PLANETARY SCAN SUBSYSTEM
LIFE TEST
MONTHLY REPORT
FINAL REPORT
COMPLETED
TELEVISION
LIFE TEST
MONTHLY REPORT
FINAL REPORT
COMPLETED
DATA ENCODER
LIFE TEST
MONTHLY REPORT
FINAL REPORT
COMPLETED
COMMAND SUBSYSTEM
LIFE TEST
MONTHLY REPORT
FINAL REPORT
COMPLETED
SCHEDULED EVENT
COMPLETED EVENT
SCHEDULED ACTIVITY SPAN
SCHEDULED ACTIVITY, PARTIALLY COMPLETED
RESCHEDULED EVENT
ACCORDING TO PROJECT POLICY, TESTING IS SCHEDULED TO CONCLUDE AT MARINER IV ENCOUNTER; HOWEVER, LIFE TESTING ON THE COMMAND SUBSYSTEM, THE DATA ENCODER, AND THE RADIO SUBSYSTEM WILL CONTINUE UNTIL FAILURE AND/OR DEGRADATION IS DETECTED
REVISION I 6/10
PREPARED BY
DATE
APPROVED
DATE
3/31/65


LIFE TEST B
YEAR
MONTH
MONDAY
1964
1965
JUL
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
RADIO SUBSYSTEM
LIFE TEST
MONTHLY REPORT
FINAL REPORT
TAPE MACHINE
LIFE TEST
MONTHLY REPORT
FINAL REPORT
POWER SUBSYSTEM
LIFE TEST
MONTHLY REPORT
FINAL REPORT
BATTERY
LIFE TEST
MONTHLY REPORT
FINAL REPORT
ALTITUDE CONTROL ELECTRONICS
LIFE TEST
MONTHLY REPORT
FINAL REPORT
SUN SENSORS
LIFE TEST
MONTHLY REPORT
FINAL REPORT
EARTH DETECTOR
LIFE TEST
MONTHLY REPORT
FINAL REPORT
CANOPUS SENSOR
LIFE TEST
MONTHLY REPORT
FINAL REPORT
MARS GATE
LIFE TEST
MONTHLY REPORT
FINAL REPORT
SOLAR PRESSURE CONTROL ASSEMBLY
LIFE TEST
MONTHLY REPORT
FINAL REPORT
JET VANE ACTUATORS
LIFE TEST
MONTHLY REPORT
FINAL REPORT
COMPLETED
PREPARED BY
DATE
APPROVED
DATE


LIFE TEST C
YEAR
MONTH
MONDAY
1964
1965
JUL AUG SEPT OCT NOV DEC
JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC
ATTITUDE CONTROL GYROS
LIFE TEST
MONTHLY REPORT
FINAL REPORT
CC AND S
LIFE TEST
MONTHLY REPORT
FINAL REPORT
SCAN ACTUATOR AND SUPPORT, DAMPERS, RETARDER AND TIMER, SCIENCE COVER
LATCH ACTUATOR
LIFE TEST
MONTHLY REPORT
FINAL REPORT
PYRO CONTROL SUBASSEMBLY
LIFE TEST
MONTHLY REPORT
FINAL REPORT
PIPS
LIFE TEST
FINAL REPORT
COMPLETED
COMPLETED
FINAL
PRELIMINARY
PREPARED BY
Rev 1 6/10
DATE
APPROVED
DATE


PTM ACTIVITY SCHEDULE
YEAR
MONTH
MONDAY
1964
1965
JUL AUG SEPT OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC
GENERAL MISSION SUPPORT (AS REQUIRED)
9WI PRINTED CIRCUIT HARNESS EVALUATION
LIVE PYRO SUSCEPTIBILITY TO RF INTERFERENCE
MC-4 CHECKOUT AND PREPARATION FOR STORAGE
RF SIGNATURE AND INTERFERENCE TESTS
PRELIMINARY ENCOUNTER PROCEDURE TESTING
DEGAUSS SPACECRAFT AND EVALUATION
ENCOUNTER PROCEDURE CHECKOUT
ENCOUNTER EVALUATION SUPPORT
PLAYBACK MODE EVALUATION SUPPORT
POST ENCOUNTER MISSION SUPPORT
SPACECRAFT GROUND SYSTEM AND NOISE STUDY
POST-MISSION R AND D TESTING
FINAL SYSTEM TESTING AND PREPARATION FOR STORAGE
NOTE: FIRST ITEM HAS PRIORITY OVER ALL OTHER TESTING
SCHEDULED
PARTIAL COMPLETION
RESCHEDULE AND COMPLETE
MC-1 MARINER PTM GENERAL ACTIVITY SCHEDULE
Revision
Date 19 March 1965
Drawn By
F. Licker, Section 293
Prepared By
G. Wade Earle, Test Director
Approved By
Operations Manager
Approved By
J. R. Casani, Spacecraft Sys. Mgr.

APPENDIX C

Summary of Reference Documents

(Facsimile of a portion of an internal JPL document)

JPL Project Document No. 67

NASA DOCUMENTS

Reports

Title	No.	Date
Booster Requirements Document, Revision 1 (Lewis Research Center)	BRD-4900 Rev 1	July 1964
Mariner Mars 1964 Final Report, Volume I (U.S. Government Printing Office, Washington, D.C.)		In prep
Mariner Mars 1964 Final Report, Volume II (U.S. Government Printing Office, Washington, D.C.)		In prep
Mariner IV (Government Printing Office, Washington, D.C.)	NASA Facts Vol II No. 9	1965
Report from Mars	EP 39	In prep

News Releases

Title	No.	Date
NASA to Begin Unmanned Mars Exploration This Year	64-205	21 Aug 1964
Mariner Mars 1964 Missions Scheduled for Early November	64-266	29 Oct 1964
Magnetometer Experiment	65-117-B	19 Apr 1965
Mariner IV Interim Science Findings, News Conference	N65-21853	21 Apr 1965
Solar Plasma Experiment	65-117A	19 Apr 1965
Trapped Radiation Experiment	65-117C	19 Apr 1965
Faint Radio Signals Provide Firm Lock on Mariner Mission	65-198 CSCL 17B	16 Jun 1965
Mariner IV Pre-Encounter Press Conference, Jet Propulsion Laboratory	N65-27472	22 Jun 1965
Mariner IV Press Conference	N65-30565 CSCL 22A	15 Jul 1965

NASA News Releases available from NASA Scientific & Technical Information Div., Washington, D. C.

- 2 -

JPL Project Document No. 67

News Releases (Cont'd)

Title	No.	Date
News Conference on Initial Scientific Interpretation of Mariner IV Photography	N65-29786 CSCL 22A	29 Jul 1965

AFETR DOCUMENTS

Air Force Systems Command

Title	No.	Date
Mariner-Mars 1964: Data Transmission Test	OD-4340	18 Sep 1964
Mariner-Mars 1964 Spacecraft: RF Systems Test	OD-4341	16 Sep 1964
Program Requirements Document Revision 3	PRD-4300 Rev 3	15 Sep 1965
Range Scheduling Handbook	AFM TCP 80-1	15 Jan 1963
General Range Safety Plan Volume I	AFM TCP 80-2 Volume I	5 Mar 1963
General Range Safety Plan Volume II	AFM TCP 80-2 Volume II	29 Oct 1962

Contact Section 293 for information about these documents.

JPL Project Document No. 67

JPL TECHNICAL REPORTS

Author	Title	No.	Date
Becker, R. A.	Analysis of Solar Panel Effect on Louver Performance	TR 32-687	1 Jun 1965
Becker, R. A.	Design and Test Performance of Mariner IV Television Optical System	TR 32-773	1 Jul 1965
Clarke, V. C., Jr., et al.	Design Parameters for Ballistics Interplanetary Trajectories, Part 1: One Way Transfers to Mars and Venus	TR 32-77	16 Jan 1963
Clarke, V. C., Jr.	Trajectory Design for Ranger Missions	TR 32-471	1 Mar 1965
Coyle, G.	Mariner IV Science Platform Structure and Actuator Design, Development and Flight Performance	TR 32-832	15 Nov 1965
Dawson, K. M., et al.	Reliability Considerations in the Design, Assembly, and Testing of the Mariner IV Power System	TR 32-729	1 Jul 1965
Dallas, S. S.	High Energy Earth to Mars and Return Trajectories	TR 32-803	In prep
Easterling, M. F.	A Long Range Precision Ranging System	TR 32-80	10 Jul 1961
Easterling, M. Goldstein, R.	The Effect of the Interplanetary Medium on S-Band Telecommunications	TR 32-825	1 Sep 1965
Groudle, T. Schmitz, D.	Development of the Mariner C Post-Injection Propulsion System	TR 32-830	In prep
Hunter, J. H.	Mariner Mars 1964 Telecommunication System	TR 32-836	1 Dec 1965
James, J. N., et al.	Mariner IV Mission to Mars, Part I	TR 32-782	15 Sep 1965

- 5 -

JPL Project Document No. 67

JPL TECHNICAL REPORTS (Cont'd)

Author	Title	No.	Date
Kliore, A., et al.	Determination of Some Physical Properties of the Atmosphere of Mars from the Changes in Doppler Signal of a Spacecraft on an Earth Occultation Trajectory	TR 32-674	16 Oct 1964
Mathison, R. P.	Mariner Mars 1964 Telemetry and Command System	TR 32-684	1 Jun 1965
Pickering, W. H., et al.	The Mariner IV Mission to Mars	TR 32-782 Part II	15 Dec 1965
Schiffer, R. A.	Correlation of Launch Vehicle Wind Tunnel Aerodynamic Noise with Flight Vibration Data, Revision 1	TR 32-619 Rev 1	15 Sep 1964
Schutz, F. L., et al.	The Mariner Mars Science Subsystem	TR 32-813	15 Feb 1966
Thostesen, T. O. Lewis, D. W.	The Mariner Mars 1964 Absorptivity Standard	TR 32-734	1 Mar 1966
Wong, R. Y.	A Fiber Optical System for Space Application	TR 32-646	31 Aug 1964
Project Team	Mariner Mars 1964 Project Report, Mission and Spacecraft Development; Volume I: Basic Report	TR 32-740 Vol I	In prep
Project Team	Mariner Mars 1964 Project Report, Mission and Spacecraft Development; Volume II: Appendixes	TR 32-740 Vol II	In prep
Project Team	Mariner Mars 1964 Project Report, Mission Operations	TR 32-881	In prep
Project Team	Mariner Mars 1964 Project Report, Spacecraft Performance and Analysis	TR 32-882	In prep

- 6 -

JPL Project Document No. 67

JPL TECHNICAL REPORTS (Cont' d)

Author	Title	No.	Date
Project Team	Mariner Mars 1964 Project Report, Scientific Experiments	TR 32-883	In prep
	Mariner Mars 1964 Project Report, Television Experiment, Part I: Investigators' Report	TR 32-884 Part I	In prep
	Mariner Mars 1964 Project Report, Television Experiment, Part II: Picture Element Matrices	TR 32-884 Part II	In prep

JPL Project Document No. 67

JPL TECHNICAL MEMORANDA

Author	Title	No.	Date
Batchilder, R. R. Wada, B. K.	Stiffness Matrix Structural Analysis	TM 33-75	12 Feb 1962
Haynes, N. R. Gordon, H. J.	A Study of the Probability of Depositing Viable Organisms on Mars During the Mariner '64 Mission	TM 33-194	23 Oct 1964
Bastow, J. G., Jr., et al.	Proceedings of the Magnetic Workshop, March 30 to April 1, 1965, CIT, Pasadena	TM 33-216	15 Sep 1965
Johnson, N. E.	Investigation of Fiberglass Shroud Materials	TM 33-214	1 Apr 1965
Pedersen, E. S.	Heat-Sterilizable Power Source Study for Advanced Mariner Missions	TM 33-180	1 Jul 1964
Pefley, R. K.	Temperature Control, A Case History of the Mariner Space-craft	TM 33-189	1 Mar 1965
Wilson, J. H.	The Odyssey of Mariner IV	TM 33-229	Jul 1965
Renzetti, N. A.	Tracking and Data Acquisition Support for Mariner Mars 1964 Volume I. Near Earth Trajectory Phase	TM 33-239 Vol I	1 Jan 1965
Renzetti, N. A.	Tracking and Data Acquisition Support for Mariner Mars 1964, Volume II. Cruise to Post-Encounter Phase	TM 33-239 Vol II	In prep

- 8 -

JPL Project Document No. 67

OTHER JPL FORMAL REPORTS IN PREPARATION

Antenna Structure, Design and Development

Basic Structure, Design and Development

Design and Manufacturing of Mariner C Solar Panels

Design, Mechanization, and Flight Analysis of the Mariner C Power System

Design of Mariner Power Operational Support Equipment

Design of the Mariner C Power Conversion Equipment

Development Spacecraft Utilization

Effects of Dust Particles on the Canopus Tracker

Electronic Cabling

Electronic Packaging

Filtering Techniques for Noise Suppression in Quasi-Balanced Circuits

Manufacturing and Quality Assurance of the Mariner C Conversion Equipment

Mariner C Battery, Final Report

Mariner C Environmental Facilities and Test Program Summary

Mariner C Post-Injection Propulsion System Regulator Development

Mariner C Post-Injection Propulsion System Squib Development

Mariner C Post-Injection Propulsion System Squib/Valve Development

MC-4 Timing and Sequencing Subsystem

Mariner IV Flight Path and Its Determination from Tracking Data

Mariner Mars Temperature Control Subsystem

Mechanical Configuration

Performance Evaluation of Mariner C Solar Panels

Propulsion System Components

Solar Panel: Structure, Boost Restraint, and Deployment

Spacecraft Inertial Property Determination

- 9 -

OTHER JPL FORMAL REPORTS IN PREPARATION (Cont'd)

Temperature Control Design, Testing, and Flight Results

Temperature Control Hardware Design and Development

Total Propulsion System Configuration

JPL Project Document No. 67

SPACE PROGRAMS SUMMARY, VOLUMES III

The Deep Space Network

No.	Page	Title	Date
37-25	18-19	Mariner C 100-kw Transmitter	31 Jan 1964
37-26	22	Mariner C 100-kw Transmitter	31 Mar 1964
37-27	37-38	SFOF Operations	31 May 1964
37-27	52	Mariner C Transmitter Development	31 May 1964
37-28	43-45	Mariner C Transmitter Development	31 Jul 1964
37-29	38	Ground Instrumentation for Mariner C Occultation Measurements	30 Sep 1964
37-29	38-39	Mariner C Transmitter Development	30 Sep 1964
37-30	34-35	Ground Instrumentation for Mariner C	30 Nov 1964
37-30	36	Mariner C 100-kw Transmitter	30 Nov 1964
37-31	32	Ground Instrumentation for Mariner C Occultation Experiment	31 Jan 1965
37-31	33-34	Mariner C 100-kw Transmitter	31 Jan 1965
37-32	9-10	Ground Instrumentation for Mariner IV Occultation Experiment	31 Mar 1965
37-33	32-38	Ground Instrumentation for Mariner IV Occultation Experiment	31 May 1965
37-33	56-58	Venus Station Mariner IV Support	31 May 1965
37-33	58-62	Venus Station Mariner IV Encounter Receiver	31 May 1965
37-34	41-44	Ground Instrumentation for Mariner C Occultation Experiment	31 Jul 1965
37-34	3-4	Mariner IV Operations	31 Jul 1965
37-35	34-37	Mariner Master Data Library	30 Sep 1965
37-35	39-42	Ground Instrumentation for Mariner IV Occultation Experiment	30 Sep 1965
37-35	42-45	Venus Station Mariner IV Encounter Receiver and X-Band Lunar Radar	30 Sep 1965

- 11 -

JPL Project Document No. 67

SPACE PROGRAMS SUMMARY, VOLUMES IV
Supporting Research and Advanced Development

No.	Page	Title	Date
37-25	49	Mariner Configuration Study	29 Feb 1964
37-26	74-75	Welded Electronic Packaging	30 Apr 1964
37-27	92-97	Carrier Collection and Spectral Response of Radiation Detectors	30 Jun 1964
37-28	101-108	Planet Acquisition-Range Prediction of a Planetary Scan System	31 Aug 1964
37-30	131	High- and Low-Field Characteristics of the Helium Magnetometer	31 Dec 1964
37-33	84-90	Printed Conductor Assembly Substitution for Mariner C Upper Ring Harness	30 Jun 1965

SPACE PROGRAMS SUMMARY, VOLUMES VI
Space Exploration Programs and Space Sciences

37-17	29-31	Mariner Command Subsystem	31 Oct 1962
37-18	70-72	Planetary Scan Systems	31 Dec 1962
37-19	43-46	Mariner Mars 1964 Design	28 Feb 1963
37-19	81-82	Mariner Mars 1964 Logically Controlled Shutter-and-Filter Wheel	28 Feb 1963
37-20	27-34	Mariner Mars 1964 Design	30 Apr 1963
37-20	104-108	Mariner Mars 1964 Photographic Subsystem	30 Apr 1963
37-20	112-113	Mariner Mars 1964 Television Subsystem Optical Subassembly	30 Apr 1963
37-21	32	Launch and Arrival Date Considerations	30 Jun 1963
37-21	32-42	Spacecraft Design	30 Jun 1963
37-21	75-78	Planetary Scan Subsystem for Mariner Mars 1964	30 Jun 1963
37-22	17-18	Spacecraft Mission Simulation	31 Aug 1963

- 12 -

JPL Project Document No. 67

SPACE PROGRAMS SUMMARY, VOLUMES VI (Cont'd)

No.	Page	Title	Date
37-22	18	Mariner Mars 1964 Systems Test Plans	31 Aug 1963
37-22	19-24	Mariner Mars 1964 Spacecraft Design	31 Aug 1963
37-22	53-56	TV Camera Shutter	31 Aug 1963
37-23	17-18	Mariner Mars 1964 TV System Test	31 Oct 1963
37-23	18-26	Mariner Mars 1964 Spacecraft Design	31 Oct 1963
37-23	42-49	Operational Support Equipment	31 Oct 1963
37-24	14-22	Spacecraft Design and Development	31 Dec 1963
37-24	71-87	Mariner C Scientific Instrumentation	31 Dec 1963
37-25	12-13	Systems Testing	31 Jan 1964
37-25	13-14	Atlantic Missile Range Launch Complex Facility Design	31 Jan 1964
37-25	14-18	Spacecraft Design and Development	31 Jan 1964
37-25	41-43	Mariner Television Subsystem Optical Subassembly	31 Jan 1964
37-25	43-46	Mariner C TV Development Support Equipment	31 Jan 1964
37-25	53-56	Mechanization of the Nonreal Time Data Automation System	31 Jan 1964
37-25	56-58	Planetary Simulation for Mariner C Planetary Scan Subsystem	31 Jan 1964
37-26	20	Flight Analysis Program	31 Mar 1964
37-26	20-21	Systems Testing	31 Mar 1964
37-26	21-23	Spacecraft Development and Testing	31 Mar 1964
37-26	55-69	Mariner C Magnetometer	31 Mar 1964
37-26	70-72	Improved Slow-Scan Vidicon Camera Tubes (Mariner C)	31 Mar 1964
37-26	72-28	Effects of Bit Errors on Pulse Code Modulated (PCM) Television Picture Data (Mariner C)	31 Mar 1964

- 13 -

JPL Project Document No. 67

SPACE PROGRAMS SUMMARY, VOLUMES VI (Cont'd)

No.	Page	Title	Date
37-27	10-11	System Testing	31 May 1964
37-27	11-15	Spacecraft Design and Development	31 May 1964
37-27	15-17	Three-Axis Spacecraft Simulator	31 May 1964
37-27	41-44	Planetary Scan Subsystem (Mariner C)	31 May 1964
37-28	18-21	Spacecraft Systems Testing	31 Jul 1964
37-28	21-29	Design and Development	31 Jul 1964
37-28	43-48	Mariner TV Subsystem Science and Engineering Calibration	31 Jul 1964
37-28	48-51	The Mariner Vidicon as a Ruggedized Space Component	31 Jul 1964
37-29	34-37	Spacecraft Systems Testing	30 Sep 1964
37-29	37-44	Design and Development	30 Sep 1964
37-29	59-63	Mariner C TV Subsystem Camera-Shutter Electronics	30 Sep 1964
37-30	18-20	Spacecraft Systems Testing	30 Nov 1964
37-30	20	Spacecraft Thermal Testing	30 Nov 1964
37-30	20-21	Design and Development	30 Nov 1964
37-31	16-18	Mission Operations	31 Jan 1965
37-31	18-19	Power Subsystem Operation During the Mariner Mission	31 Jan 1965
37-31	19-21	Developmental and Testing Activities	31 Jan 1965
37-31	54-55	Magnetic Shields to Support Mariner C Magnetometer Testing	31 Jan 1965
37-32	14	Mariner IV Mission Operations	31 Mar 1965
37-32	14	Mariner IV Power Subsystem Performance	31 Mar 1965
37-32	15-16	Life Testing Activities	31 Mar 1965

- 14 -

JPL Project Document No. 67

SPACE PROGRAMS SUMMARY, VOLUMES VI (Cont'd)

No.	Page	Title	Date
37-32	37-41	Mariner C TV Field Support Operations	31 Mar 1965
37-32	41-43	Mariner C Magnetometer: Development of Modified Helium Lamps and Cells	31 Mar 1965
37-32	44-48	Methods of Determining the Characteristics and Performance of Radiation Detectors Used in the Mariner C Planetary Scan Subsystem	31 Mar 1965
37-32	49-55	Advanced Mariner Data Automation System Development	31 Mar 1965
37-33	18	Mariner IV Space Flight Operations	31 May 1965
37-33	18-22	Mariner IV Attitude Control Subsystem Performance	31 May 1965
37-33	22	Development of a Star Identification Procedure	31 May 1965
37-34	20-21	Mariner IV Space Flight Operations	31 Jul 1965
37-34	21-22	Mariner IV Radio Subsystem Performance	31 Jul 1965
37-34	27-39	Mariner IV Ionization Chamber Failure Analysis	31 Jul 1965
37-34	39-41	Mariner IV Plasma Probe Failure Analysis	31 Jul 1965
37-34	41-44	Mariner IV TV Interpretation Studies	31 Jul 1965
37-34	44-47	Spurious TV Image Phenomena	31 Jul 1965
37-34	48-49	Space Sciences Encounter Planning Activities	31 Jul 1965
37-35	10	Mariner IV Space Flight Operations	30 Sep 1965
37-35	10-12	Mariner IV Spacecraft Performance During The Mission	30 Sep 1965
37-35	12	Future Operations for Mariner IV	30 Sep 1965
37-35	22	Mariner Master Data Library	30 Sep 1965
37-35	35-37	Total Radiation Dose Experienced by the Mariner IV Spacecraft as Measured by the Ion Chamber Experiment	30 Sep 1965

- 15 -

JPL Project Document No. 67

SPACE PROGRAMS SUMMARY, VOLUMES VI (Cont'd)

No.	Page	Title	Date
37-35	37-44	Mariner IV Magnetic Measurements Inside the Earth's Magnetosphere, Magnetic Tail, and Magnetosheath	30 Sep 1965

- 16 -

JPL Project Document No. 67

OPEN LITERATURE

Author	Title	Publication	Date
Alexander, W. M., et al.	Zodiacal Dust: Measurements by Mariner IV	Science 149:1240-1241	10 Sep 1965
Anderson, H. R.	Spacecraft Description and Encounter Sequence	Science 149:1226-1228	10 Sep 1965
Billingsley, F. C.	Digital Video Processing at JPL (10th Annual Symposium, San Francisco, Calif., 16-20 August 1965)	Conference Proceedings	To be pub
Bouvier, H. K.	The Mariner IV Attitude Control System	Space Res & Eng (France) I:7-8:41	1965
Casani, J. R., et al.	Mariner IV: A Point of Departure	Astronaut & Aeronaut 3:8:16-24	3 Aug 1965
Christensen, E.	Ranger and Mariner Temperature Control Experiences (AIAA Thermophysics Specialists Conference Sponsored by NBS and AF Materials Lab, Monterey, California, 13-15 Sep 1965)	Conference Proceedings	To be pub
Coughey, T. K.	Classical Normal Modes in Ramped Linear Dynamic Systems	J Appl Mech 269-271	Jun 1960
Dawson, K. M., et al.	Design and Reliability Considerations for the Mariner Mars 1964 Spacecraft Power System (AIAA Unmanned Spacecraft Meeting, Los Angeles, 1-4 March, 1965)	AIAA Pub CP-12, 323-332	1965
Drummond, A. J. Laue, E. G.	The Extraterrestrial Solar Spectrum and its Simulation in Space Environmental Test System (IES Solar Simulation Symposium, Los Angeles, January 1964	Conference Proceedings	Oct 1964

- 18 -

JPL Project Document No. 67

OPEN LITERATURE (Cont'd)

Author	Title	Publication	Date
Ewing, A.	Canals May Be Craters	Sci. NL 88:103	14 Aug 1965
Fawcett, W. G., et al.	Scientific Exploration with Mariner IV	Astronaut & Aeronaut 3:10:22-28	Oct 1965
Fink, D. E.	Mars Vehicle Becomes Major Scientific Program	Aviation W. 82:116-18+	15 Mar 1965
Forney, R.G., et al.	Mariner IV Maneuver and Control	Astronaut & Aeronaut 3:10:36	Oct 1965
Foss, K. A.	Coordinates which Uncouple the Equations of Motion of Damped Linear Dynamic Systems	J Appl Mech 361-364	Sep 1958
Gianopulos, G. N.	Use of the Computer in Ranger and Mariner Projects (IBM Symposium on Computer Aid Experimentation, Poughkeepsie, New York, 11-13 October 1965)	Conference Proceedings	To be pub by IBM
Goldstein, R. M.	JPL Radar Observations of Mars	Science 150:3704:1715-1717	24 Dec 1965
Haynes, N. R., et al.	Mariner IV Flight Path to Mars	Astronaut & Aeronaut 3:28-33	Jun 1965
Heller, G. B.	A First for Thermo Physics (Review)	Astronaut & Aeronaut p 42	Jan 1966
Herman, N. H. Lingon, U. S.	Mariner IV Timing and Sequencing	Astronaut & Aeronaut 3:10:40	Oct 1965
Highstrete, B. A.	Ceramic Traveling Wave-tubes for Space Vehicles	Microwave J 7:49-57	Jan 1964
Hyde, J. R.	Mariner Mars 1964 Acoustically Induced Vibration Environment (35th Symposium on Shock Vibration, Shock and Vibration Information Center, New Orleans, 25-28 Oct 1965)	Conference Proceedings	To be pub

JPL Project Document No. 67

OPEN LITERATURE (Cont'd)

Author	Title	Publication	Date
Hyde, J. R.	Systems Testing (1965 Educational Seminar, Ames Research Center, Dec 1965)	J Environ Sci	To be pub
James, J. N.	Managing the Mariner Mars Project	Astronaut & Aeronaut 3:8:34-41	Aug 1965
Kliore, A., et al.	Mariner IV Occultation Experiment	Astronaut & Aeronaut 3:72-80	Jul 1965
Kliore, A., et al.	Occultation Experiment: Results of the First Direct Measurement of Mars Atmosphere and Ionosphere	Science 149:1243-1248	10 Sep 1965
Kliore, A. J.	Preliminary Results of the Mariner IV Occultation Measurement of theAtmosphere of Mars (CIT/JPL Lunar and Planetary Conference, 13-18 Sep 1965)	Conference Proceedings	1965
Lear, J.	Mariner IV's Expense Account: Increase Due to Extreme Tenuity of Martian Atmosphere	Sat R 48:35	7 Aug 1965
Leighton, R. B., et al.	Mariner IV Photography of Mars: Initial Results	Science 149:627-30	6 Aug 1965
Lewis, Donald W.	Maintaining Thermal Control in Mariner IV	Astronaut & Aeronaut 3:10:30	Oct 1965
Lindsey, R.	Mars Atmosphere Probe Proposed	Miss & Roc	8 Feb 1965
Malling, L. R.	Slow Scan Vidicon as an Interplanetary Imaging Device	Advances in Electronics and Electron Physics (Academic Press)	To be pub
Malling, L. R.	Space Astronomy and the Slow Scan Vidicon	J SMPT	Nov 1963

- 20 -

JPL Project Document No. 67

OPEN LITERATURE (Cont'd)

Author	Title	Publication	Date
Mathison, R. P.	Mariner Mars 1964 Telemetry and Command System	IEEE Spectrum 2:76-84	Jul 1965
Meisenholder, G. W.	The Mariner IV Canopus Tracker (XVI International Astronautical Congress, Athens, Greece, 13-18 September 1965)	Conference Proceedings	To be pub (Poland) 1966
Miller, B.	JPL Facing Mariner C Avionics Problems	Aviation W 80:16-17	29 Jun 1965
Normyle, W. J.	Planetary Exploration Hopes Buoyed by Mariner Flight	Aviation W 83:86-7	9 Aug 1965
O'Gallagher, et al.	Search for Trapped Electrons and a Magnetic Moment at Mars by Mariner IV	Science 149:1233-1239	10 Sep 1965
Pay, R.	VAD Group Processed Mariner Photos	Miss & Roc 17:28+	9 Aug 1965
Pickering, W.H.	Mariner IV's Flight to Mars	Astronaut Aeronaut 3:10:20	Oct 1965
Schutz, F. L.	Integration of Scientific Instruments into Mariner IV (XVI Int'l Astronautical Congress, Athens, Greece, 13-18 September 1965)	Conference Proceedings	To be pub (Poland) 1966
Schmuecker, J. D. Wilson, J. N.	Structural and Mechanical Design of Mariner Mars	Astronaut & Aeronaut 3:8:26-33	Aug 1965
Schneiderman, D., et al.	Recent Mariner Spacecraft Missions (AIAA Unmanned Spacecraft Meeting Los Angeles, 1-4 March 1965)	AIAA Pub CP-12, 385-394 Astronaut Acta II	1965
Shipley, W.S. Maclay, J. E.	Mariner IV Environmental Testing	Astronaut & Aeronaut 3:8:42-48	Aug 1965

JPL Project Document No. 67

OPEN LITERATURE (Cont'd)

Author	Title	Publication	Date
Scull, J. R.	Guidance and Control of the Mariner Planetary Spacecraft (IFAC Symposium on Peaceful Uses of Automatic Controls in Space, Stavanger, Norway, 2-24 June 1964)	Conference Proceedings	To be pub
Sjogren, W. J. Trask, D. W.	Astrodynamical Results From the Radio Tracking of the Mariner Venus and Ranger Lunar Missions	J Spacecraft Rockets 2:689-697	Sep-Oct 1965
Sloan, R. K., et al.	Mariner IV Flight Path to Mars	Astronaut & Aeronaut	Jun 1965
Smith, E. J., et al.	Magnetic Field Measurements Near Mars	Science 149:1241-1242	10 Sep 1965
Smith, E. J.	A Review of Lunar and Planetary Magnetic Field Measurements Using Space Probes (NATO Advanced Study Institute Meeting on Planetary and Stellar Magnetism	Magnetism and the Cosmos, Conference Proceedings (Oliver & Boyd, Edinburgh, Scotland)	To be pub
Smith, E. J.	Measurement of Magnetic Fields in the Vicinity of Magnetosphere and in Interplanetary Space Prelim. Results from Mariner IV (Sixth COSPAR Meeting)	Space Research VI	To be pub 1966
Soffen, G. A.	Mars Biological Mission: Possibilities and Constraints (AAS Symposium on Unmanned Exploration of Space, Denver, Colo., 8-10 February 1965)	Bioscience	To be pub
Stone, L.	Mariner Data May Limit Voyager Payload	Aviation W 83:55+	2 Aug 1965
Stone, L.	Mariner Design Modified by Mars Flyby	Aviation W 78:50-1+	6 May 1965

- 22 -

JPL Project Document No. 67

OPEN LITERATURE (Cont'd)

Author	Title	Publication	Date
Taylor, H.	Webb Says Mariner Winning Mars Race: Zond a Month Behind	Miss & Roc 16:15	15 Feb 1965
Thomas, G.M. Menard, W.A.	Experimental Measurements of Nonequilibrium and Equilibrium Radiation from Planetary Atmospheres (AIAA Entry Technology Conference, Williamsburg and Hampton, Va., 12-14 October 1964)	AIAA CP-9	1965
Van Allen, J.A., et al.	Absence of Martian Radiation Belts and Implications Thereof	Science 149:1228-1233	10 Sep 1965
Wainwright, L.	Our Encounter with Mars: Successful Combination of Men and Machines	Life 59:14	6 Aug 1965
Watkins, H.D.	JPL Debating Alternate Methods for Contacting Mariner IV in 1967	Aviation W 83:32	2 Aug 1965
Watts, R.N., Jr.	Mariner Flight Continues	Sky & Tel 29:95-6	Feb 1965
Watts, R.N., Jr.	Mariner IV Completes Mars Mission	Sky & Tel 30:136-8	Sep 1965
Watts, R.N., Jr.	Mars Observations Wanted: Mariner IV Probe	Sky & Tel 29:150	Mar 1965
Watts, R.N., Jr.	Results from Mariner	Sky & Tel 26:195+	Oct 1963
Way, John, Sr.	Analog-Digital Conversion of TV Data on Mariner IV	Space/Aeron 44:83-88	Aug 1965
Welnick, R.A. Wright, F.H.	Assuring Quality and Reliability for Mariner IV	Astronaut & Aeronaut 3:8:50	Aug 1965
Wilson, J.H.	Space Probes	Encyc Sci & Technology 1966 Yearbook (McGraw-Hill)	1966

JPL Project Document No. 67

OPEN LITERATURE (Cont'd)

Author	Title	Publication	Date
Younkin, R. L.	A Search for Limonite Near Infrared Spectral Features on Mars	Astrophys J	May 1966
	Craters Found on Mars	Sci NL 88:82	7 Aug 1965
	Journey to July: Mariner IV	Newsweek 64:67	7 Dec 1965
	Mariner Photos to Be Studied with Eye to Voyager	Miss & Roc 17:16-17	9 Aug 1965
	Mariner IV Measurements Near Mars: Initial Results	Science 149:1179, 1226-48	10 Sep 1965
	Mariner IV Photographs of Mars	Sky & Tel 30:155-61	Sep 1965
	Mariner IV Sensors Relay Excellent Data	Aviation W 81:26-7	7 Dec 1964
	Mars in Focus: Mariner IV Probe	Sr Schol 87:19-20	16 Sep 1965
	Martian Surface Shows Moon-Like Quality	Aviation W 83:30-1	2 Aug 1965
	Moonfaced Mars	Newsweek 66:58	9 Aug 1965
	Moon-faced Mars: Concerning Pictures Taken by Spaceship Mariner IV	Time 86:58	6 Aug 1965
	Notes and Comment: News from Mariner IV	New Yorker 41:17	7 Aug 1965
	Rendezvous with Mars	Sci Digest 57:24-7	Jan 1965
	Section of Planetary Sciences, Symposium on Mariner IV Interplanetary Results	Am Geophys Union Trans 46:113	Mar 1965
	Symposium on Mariner IV Results	Am Geophys Union Trans 46:532	Sep 1965

- 24 -

JPL Project Document No. 67

OPEN LITERATURE (Cont'd)

Author	Title	Publication	Date
	Terrain of Neighbor Mars: Pictures Taken 135 Million Miles Away	Life 59:62A-62C	6 Aug 1965
	What Scientists Hope to Learn from Mars Shot: Mariner IV	U. S. News 57:18-19	14 Dec 1964
	With an Eye on Canopus: U. S. Mariner IV	Newsweek 64:58	14 Dec 1964

JPL Project Document No. 67

CONFERENCE PAPERS

Author	Title	Occasion
Anderson, H. R.	Interplanetary Radiation Measured by Mariner II and IV	Seminar, Rice University
Anderson, H. R.	Preliminary Results of Mariner IV Ion Chamber Experiment	Cosmic Ray Conference January 1965
Anderson, H. R.	Results from the Mariner IV Ion Chamber Experiment	Intl. Conf. on Cosmic Rays, London, England 6-17 Sep 1965
Anderson, H. R.	The Space Environment Measured by Mariner IV (Summary of Material presented at AGU Meeting, 19-20 April 1965	AIAA
Bell, D. E.	Mariner IV TV Camera and Mission Results	International Symposium on Space Electronics, Miami Beach, Florida, 2-5 Nov 1965
Billingsley, F. C.	Mariner Mars 1964 Television	Data Reduction & Computer Working Group, of Inter-Range Instrumentation, Los Angeles, 20 Oct 1965
Cherry, W. R. Zoutendyke, J. A.	The State of the Art in Solar Cell Arrays for Space Electrical Power	AIAA 64-738, Sep 1964
Conrad, A. G.	Design and Flight Operation of Mariner IV	AIAA 2nd Annual Meeting San Francisco, 26-29 July 1965
Dow, P. C., Jr.	Exploration of Interplanetary Space by Unmanned Vehicles	Fifth European Space Flight Symposium, Munich, West Germany 19-22 July 1965
Eckman, P. K., et al.	Some Possible Means of Acquiring Increased Information Return from Mars	Symposium on Unmanned Exploration of the Solar System 8 Feb 1965

- 26 -

JPL Project Document No. 67

CONFERENCE PAPERS (Cont'd)

Author	Title	Occasion
Gabron, F., et al.	Thermal Scale Modeling of a Modified Prototype of the Mariner Mars 1964 Spacecraft	Paper 65-386 AIAA 2nd Annual Meeting, San Francisco, 26-29 Jul 1965
Goble, M. E. Earle, W. G.	System Test Program for the Mariner to Mars Spacecraft	AIAA-AAS Conference: Stepping Stones to Mars, Baltimore, Maryland, 28 Mar 1966
Gordon, H. J. Michel, J. R.	Midcourse Guidance for Mariner Mars 1964	Paper 65-402 AIAA 2nd Annual Meeting, San Francisco, 26-29 Jul 1965
Happe, R. A.	Materials Engineering for Interplanetary Probes	1965 Metals/Materials Congress, Detroit, 22 Oct 1965
Herriman, A. LaBaw, C. C.	The Mariner IV Photographic Mission	98th Conference of Motion Picture and TV Engineers, Montreal, Canada, 1 Nov 1965
Hyde, J. R.	Managing the Mariner Mars Spacecraft Test Program	Richards-Gebaur AFB Management Group, Kansas City, 27 Jan 1966
Hyde, J. R.	Mariner IV Mission to Mars	Armed Forces Communications Electronics Assn, Kansas City, 27 Jan 1966
Hyde, J. R.	The Mariner IV Mission to Mars	18th Annual Mid-America Electronics Conference, Kansas City, Mo., 18 Nov 1965
Jodele, J.	Packaging Techniques for Mariner IV Spacecraft Components	Intl. Conf. on Components & Materials Used in Electronics Engineering, London, 17-25 May 1965
Lewis, D. W. Thostesen, T. O.	Mariner-Mars Absorptance Experiment	Paper 65-650 AIAA Conference on Thermal Physics, Monterey, Calif., 13-15 Sep 1965

JPL Project Document No. 67

CONFERENCE PAPERS (Cont'd)

Author	Title	Occasion
Maclay, J. E., et al.	Vacuum Capability Requirements for the Mariner Testing Program	ASTM 5th Pacific Nat Meeting, 3 Nov 1965
Malling, L. R.	Data Compression for Planetary Photography	Paper 97-8 SMPTE Conference, Los Angeles, 29 Mar - 2 Apr 1965
Malling, L. R.	Time Bandwidth Compression for Planetary Pictures	SPIE Technical Symposium, San Francisco, 28 Aug 1964
Meghreblian, R. V., et al.	Science Payloads from Mariner II to Mariner IV	NASA-AFCRL Conference on Space Science and Technology, Roanoke, Va., 23-27 Aug 1965
Meisenholder, G.W.	Stabilization of Ranger and Mariner Reconnaissance Systems	SPSE Conference, Cleveland, Ohio 17 May 1965
Porter, R. W.	Space Research in the United States, 1964	COSPAR Plenary Meeting, Buenos Aires, Argentina, 11-12 and 19-21 May 1965
Olbeter, A., et al.	A Sensitive S-Band Noise Meter Developed for the Mariner Mars '64 Spacecraft Program	IEEE 7th Annual Symposium on Electromagnetic Compatability, New York City, 28-30 June 1965
Schiffer, R. A. Hyde, J. R.	The Mariner Mars 1964 Spacecraft Acoustically Induced Vibration Environment	5th International Congress on Acoustics, Liege, Belgium, 7-14 Sep 1965
Schneiderman, D.	Mariner IV - The Design, Application and Results	6th Intl. Symposium on Space Technology Science, Tokyo, Japan, 29 Nov - 7 Dec 1965
Schneiderman, D.	Review of Mariner 1962 and 1964 Spacecraft Design and Operational Planning	Conference on Mars and Venus, Virginia Polytechnic Institute, Sep 1965
Sloan, R. K.	The Interplanetary Mission of Mariner IV	AGU Meeting, 19 April 1965, Washington, D. C.

JPL Project Document No. 67

CONFERENCE PAPERS (Cont'd)

Author	Title	Occasion
Snyder, C. W.	Some Aspects of the Mariner IV Solar-Plasma Observations	AGU Meeting, 19 April 1965, Washington, D. C.
Soffen, G. A.	Life Detection Experiments	Lecture in UCLA course of study (four campuses): Horizons in Space Sciences, Spring 1964 (Series of lectures to be pub by UC, Berkeley)
South, J. F.	Space-Simulated Testing of Mariner Spacecraft Autopilot Systems With Rocket Motor Firing	Paper 63-343 AIAA Guidance and Control Conference, MIT, Cambridge, Mass., 12-14 Aug 1963
Thomas, G. M.	Ultraviolet Radiation Program at JPL	NASA Research Div, Office of Advanced Research & Technology, Fluid Physics Contractors Conference on Ultraviolet Radiation and Heat Transfer, 31 Aug 1965
Tito, D. A.	Trajectory Design for the Mariner 1964 Mission	Paper 65-516 AIAA 2nd Annual Meeting, San Francisco, 26-29 July 1965
Wiggins, C. P.	High Power Microwave Transmitters for Deep Space Communication with Unmanned Spacecraft	1966 National Telemetering Conference, Boston, Mass., 10-12 May 1966 (Proceedings to be published)
Younkin, R. L.	Spectral Energy Distribution and Reflectivities of Martian Maria and Continents in the Visible and Near Infrared	AAS Meeting, Ann Arbor, Mich., Aug 1965 (Abstract in Astronom J Nov 1965)

APPENDIX D

Encounter Sequence of Events

MARINER ENCOUNTER SEQUENCE OF EVENTS

July 11, 1965

The following is a list of those stations in this Sequence of Events which might require additional identification.

STATION	IDENTIFICATION	STATION	IDENTIFICATION
FOG	Flight Operations Group	DISPLAY	SFOF Display Areas
GSFC	Goddard Space Flight Center	FLITE CH	FPAC Director (or Rep.)
SUP	Support	TRACK	DSIF Talker
COMM	Communications	BUSS CH	SPAC Director (or Rep.)
ODC	Operations Document Control	11	DSIF 11, Pioneer, Goldstone, California
MBOX	Marriage Box	12	DSIF 12, Echo, Goldstone, California
DACON	Data Control	13	DSIF 13, Venus,Goldstone, California
DPS	Data Processing System	41	DSIF 41, Woomera, Australia
OPS 1	SPAA Operations Console	42	DSIF 42,Tidbinbilla,(Canberra)Australia
DATA CHIEF	Data Control Directors Console	51	DSIF 51, Johannesburg, South Africa
SPACE CH	SSAA Director (or Rep.)	61	DSIF 61, Madrid,Spain
SPACE 1	SSAA Director Console		

E - "X" Days Referenced to July 15, 0000 GMT

E - "Y" Hours Referenced to July 15, 0105 GMT

E - "Z" Minutes Referenced to July 15, 0105 GMT

(Time or Time/E = Earth Time)

(Time/S = Spacecraft Time)

Mariner Encounter Sequence of Events
Rev II 11 July 1965

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
1	01/0000Z	42			1. RISE 0210, SET 1311	01
	E-337H05M	41			2. RISE 0220, SET 1416	02
		51			3. RISE 1003, SET 2118	03
		11			4. RISE 1953, SET 0700	04
		12			5. RISE 1916, SET 0711	05
		SUP			1. TECHNICAL AREA ASSISTANTS CHECK	06
					SUPPLIES ON HAND TO DETERMINE	07
					ITEMS AND QUANTITIES TO BE ORDERED	08
					PER SFOF/SOP #70-501.	09
		COMM			1. ORDER PAPER, TAPE, RIBBON, FAX SUPPLIES + AUDIO	10
					RECORDING TAPE.	11
					2. NOTIFY PT+T, JPL PBX + WESTERN UNION MICROWAVE REGARDING	12
					PERSONAL SUPPORT FOR ENCOUNTER COVERAGE.	13
					3. CHECK SPARES OF ALL SYSTEMS (COMPONENTS + CARDS)	14
2	02/0000Z	42			1. RISE 0208, SET 1309	01

7/14/65 MA-64 SEQUENCE PAGE 58

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
3	E-313H05M				2. RISE 0217, SET 1415	01
		51			3. RISE 1000, SET 2116	02
		11			4. RISE 1951, SET 0658	03
		12			5. RISE 1915, SET 0708	04
		SUP			1. PUBLISH IOM TO TRANSPORTATION SPEC-	05
					IFYING DATES AND TIMES OF EMERGENCY	06
					GENERATOR COVERAGE AND REQUESTING	07
					THAT DEISELS BE CHECKED AND FUEL	08
					TANKS FILLED.	09
					2. PUBLISH IOM TO PLANT MAINTENANCE	10
					SPECIFYING DATES AND TIMES OF	11
					STANDBY ELECTRICIAN AND AIR CON-	12
					DITION COVERAGE.	13
					3. PUBLISH IOM TO SECURITY REQUESTING	14
					GUARDS FOR ACCESS CONTROL IN THE	15
					SFOF.	16
					4. PUBLISH IOM TO EMPLOYEE SERVICES	17
					DEFINING CAFETERIA SUPPORT REQUIRED	18
					PER SFOF/SOP =70-107.	19
					5. ARRANGE FOR SPECIAL TRANSPORTATION	20
					PER SFOF/SOP =70-103.	21
					6. PUBLISH FAC-SUP. PERSONNEL WORK SCHEDULES.	22
		COMM			1. CIRCUITS ORDERED + COVERAGE REQUIRED.	23
	03/0000Z	42			1. RISE 0205, SET 1307	01
	E-289H05M	41			2. RISE 0215, SET 1413	02
		51			3. RISE 0958, SET 2114	03
		11			4. RISE 1950, SET 0656	04
		12			5. RISE 1914, SET 0706	05
	04/0000Z	42			1. RISE 0203, SET 1305	01
	E-265H05M	41			2. RISE 0212, SET 1412	02
		51			3. RISE 0956, SET 2112	03
		11			4. RISE 1945, SET 0654	04
		12			5. RISE 1914, SET 0655	05

7/14/65 MA-64 SEQUENCE PAGE 59

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
6	05/0000Z	42			1. RISE 0200, SET 1304	01
	E-241H05M	41			2. RISE 0212, SET 1411	02
		51			3. RISE 0953, SET 2111	03
		61			4. RISE 1150, SET 2310	04
		11			5. RISE 1947, SET 0652	05
		12,13			6. RISE 1913, SET 0652	06
7	05/1505Z	COMM			1. ORDER TELETYPE, VOICE AND DATA CIRCUITS FROM NNSG.	01
	E-226HRS				2. ORDER SPECIAL/CIRCUIT COVERAGE FROM NNSG.	02
					3. ORDER PROP FORECASTS FROM NETREV.	03
					4. PREPARE FOR PLANT CHECKOUT.	04
					5. VERIFY ACCESS CONTROL LISTS.	05
8	5/1913Z	12			1. S/C ON DSIF 12 HORIZON, ACQUIRE 1 WAY.	01
	E-221H52M					02
9	5/1947Z	11			1. S/C ON DSIF 11 HORIZON, ACQUIRE 2 WAY.	01
	E-221H18M				2. DSIF 12 AND 51 ACQUIRE 3 WAY	02
10	5/2000Z	SFO			1. BEGINNING OF ENCOUNTER PERIOD. CONTINUOUS TWO WAY TRACKING BEGINS.	01
	E-221HR55M				COVERAGE BY BACKUP DSIF STATION BEGINS.	02
11	5/2111Z	51			1. END OF TRACK, DSIF 51	01
	E-219H54M					02
12	5/2311Z				1. END OF TRACK, DSIF 61	01
	E-217H54M					02
13	06/0000Z	42			1. RISE 0156, SET 1303	01
	E-217H05M	41			2. RISE 0210, SET 1409	02
		51			3. RISE 0951, SET 2109	03
		61			4. RISE 1150, SET 2310	04
		11			5. RISE 1946, SET 0649	05
		12,13			6. RISE 1911, SET 0650	06

7/14/65 MA-64 SEQUENCE PAGE 60

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
14	06/1500Z	COMM			1. BEGIN PLANT CHECKOUT.	01
	E-202H5M				A. CCTV	02
					B. OVCS	03
					C. PA AND RECORDER	04
					D. TTY EQUIPMENT	05
					E. TSS TO INCLUDE COMM CONTROL CONSOLES	06
15	06/1900Z	COMM			F. REQUEST PT+T TO OPERATIONALLY VERIFY LEASED TTY EQUIPMENT	01
	E-198H5M					02
16	07/0000Z	42			1. RISE 0155, SET 1302	01
	E-193H05M	41			2. RISE 0208, SET 1407	02
		51			3. RISE 0949, SET 2107	03
		61			4. RISE 0950, SET 2310	04
		11			5. RISE 1944, SET 0647	05
		12,13			6. RISE 1910, SET 0647	06
		SUP			1. CHECK COFFEE SUPPLIES ON HAND TO	07
					DETERMINE QUANTITIES AND ITEMS	08
					TO BE ORDERED.	09
					2. REPORT STATUS TO SFOF OPS. MGR.	10
					3. OPERATIONS TEAM WILL SUBMIT ACCESS	11
					LISTS OF ALL M.D. PERSONNEL TO	12
					SFOF OPS. MGR. PER SFOF/SOP	13
					870-101.	14
					4. PROJECT OFFICE WILL SUBMIT LISTS	15
					OF PERSONNEL ALLOWED ACCESS IN	16
					GALLERY PER SFOF/SOP 70-110	17
17	7/0353 07.6Z	BUSS			1. CYCLIC 80 OBSERVED IN DATA (NOMINAL)	01
	E-189H11M					02

7/14/65 MA-64 SEQUENCE PAGE 61

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
18	08/0000Z	42		1. RISE 0152, SET 1300	01
	E-169H05M	41		2. RISE 0206, SET 1405	02
		51		3. RISE 0947, SET 2105	03
		61		4. RISE 0945, SET 2305	04
		11		5. RISE 1944, SET 0644	05
		12,13		6. RISE 1909, SET 0645	06
		COMM		1. NNSG CONFIRMS COMMUNICATION CIRCUITS AND SPECIAL/CIRCUIT COVERAGE TO	07
				NNSG REP.	08
				2. NNSG REP DSN SCHEDULE DSN CIRCUITS.	09
19	08/0700Z	COMM		1. REQUEST PT+T TO VERIFY LEASED TTY EQUIPMENT.	01
	E-162H5M			2. COMPLETE PA, OVCS+RECORDER PLANT CHECKOUT.	02
				3. CONFIRM M/W AND PT+T SPECIAL COVERAGE	03
20	08/1200Z	FOG		1. PERSONNEL REQUIREMENTS.	01
	E-157H5M			A. AREA DIRECTORS AND CHIEFS.	02
				B. PROGRAMMER SUPPORT.	03
				C. COMPUTER OPERATIONS.	04
				D. SYSTEM SUPPORT.	05
				E. MAINTENANCE SUPPORT.	06
21	08/1500Z	FOG		1. PREPARE SFOF ENCOUNTER PERSONNEL SCHEDULE.	01
	E-154H5M	COMM		1. COMPLETE TTY USER MACHINE CHECKOUT.	02
				2. BEGIN CHECKOUT OF MESSAGE CENTER TTY MACNINES.	03
22	08/1900Z	COMM		1. COMPLETE CCTV PLANT CHECKOUT.	01
	E-150H5M			2. COMPLETE TSS PLANT CHECKOUT.	02
				3. PT+T REPORTS STATUS OF LEASED TTY EQUIPMENT.	03
				4. COMPLETE CHECKOUT OF MESSAGE CENTER TTY MACHINES.	04
				5. POST PERSONNEL 7 DAY SCHEDULE.	05
		GSFC		1. CONFIRM ALL COMMUNICATIONS CIRCUIT COMMITMENTS TO COMM CHIEF.	06
		DISPLAY		1. CHECK MSB FOR CORRECT INFORMATION.	07
				2. MAKE UP PLATENS FOR MISSION EVENTS	08
				PROJECTOR.	09
				3. REPORT READINESS STATUS TO SFOF	10
				OPS. MGR.	11

7/14/65 MA-64 SEQUENCE PAGE 62

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
23	09/0000Z	42			1. RISE 0150, SET 1258	01
	E-145H05M	41			2. RISE 0204, SET 1403	02
		51			3. RISE 0944, SET 2103	03
		61			4. RISE 0945, SET 2305	04
		11			5. RISE 1942, SET 0641	05
		12,13			6. RISE 1908, SET 0642	06
		COMM			1. PLANT CHECKOUT COMPLETED	07
24	09/0100Z	SUP			1. UPDATE STATUS RECORDING	01
	E-144H5M				=354-3967-8-9	02
25	09/1400Z	FOG			1. REPRODUCE SFO ENCOUNTER PLAN.	01
	E-131H5M	CDC			A. INTEROFFICE MEMO.	02
		CDC			B. PERSONNEL SCHEDULE.	03
		CDC			C. SEQUENCE OF EVENTS AS EXTRACTED FROM SECTION 316.	04
26	09/1500Z	COMM			1. BEGIN SYSTEM TEST GTS MICRO WAVE	01
	E-130H5M					02
27	09/1700Z	FOG			1. MAIL SFO TEST PLAN AS PER DISTRIBUTION LIST NO. 2.	01
	E-128H5M				A. HAND DELIVER AS MARKED, MAIL OTHERS.	02
					2.FINAL COEFFICIENTS FOR 7040 DELIVERED TO DPS.	03
					3.PROGRAMMERS DELIVER SOURCE DECKS.	04
28	9/2233 23.1Z	BUSS			1. CYCLIC 81 OBSERVED IN DATA (NOMINAL)	01
	E-122H31M					02
29	09/2300Z	COMM			1. COMPLETE SYSTEM TEST GTS MICRO WAVE	01
	E-122H5M					02
30	10/0000Z	42			1. RISE 0148, SET 1257	01
	E-121H05M	41			2. RISE 0202, SET 1401	02
		51			3. RISE 0942, SET 2101	03
		61			4. RISE 1140, SET 2300	04
		11			5. RISE 1940, SET 0639	05
		12,13			6. RISE 1906, SET 0640	06
		COMM			1. PLANT FREEZE	07
					(NO MODIFICATIONS, NO WORK PERFORMED ON ANY COMM SYSTEM OR SUBSYSTEM	08
					WITHOUT WRITTEN APPROVAL OF SFOD)	09

7/14/65 MA-64 SEQUENCE PAGE 63

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
31	10/0100Z	SUP			1. UPDATE STATUS RECORDING	01
	E-120H5M					02
32	11/0000Z	42			1. RISE 0145, SET 1255	01
	E-97H05M	41			2. RISE 0200, SET 1359	02
		51			3. RISE 0940, SET 2059	03
		61			4. RISE 1140, SET 2300	04
		11			5. RISE 1939, SET 0637	05
		12,13			6. RISE 1906, SET 0637	06
33	11/0105Z	COMM			1. POST PERSONNEL STAFFING SCHEDULES.	01
	E-4 DAYS	SUP			1. UPDATE STATUS RECORDING	02
					2. CHECK FURNITURE CONFIGURATION ON FIRST FLOOR.	03
34	12/0000Z	42			1. RISE 0142, SET 1253	01
	E-73H05M	41			2. RISE 0158, SET 1357	02
		51			3. RISE 0937, SET 2057	03
		61			4. RISE 1135, SET 2255	04
		11			5. RISE 1937, SET 0631	05
		12,13			6. RISE 1906, SET 0635	06
		COMM			1. BEGIN GO NO GO TESTS ALL EQUIPMENT.	07
35	12/0700Z	IBM			1. X-STRING PREVENTIVE MAINTENANCE.	01
	E-66H5M					02
36	12/1100Z	FOG			1. UNLOCK FLIGHT PROGRAM FILES.	01
	E-62H5M				2. START CHECK OUT OF LOCKUP COMPUTER FLIGHT PROGRAMS.	02
					A. CHECK PROGRAMS IN LOCKUP FILE AGAINST A CURRENT LIST OF SFOF	03
					OPERATIONAL PROGRAM TAPES AND DECKS.	04
					3. CHECK START AND FINISH DATES FOR MOST CURRENT TAPES AND DECKS.	05
					4. LOCK FLIGHT PROGRAM FILES.	06
		IBM			1. Y-STRING PREVENTIVE MAINTENANCE.	07
		7094X			1. TEST 100 MAGNETIC TAPES FOR SOFOF TESTS. (SEC. 316)	08
37	12/1500Z	7094X			1. 7094X COMPUTER PREVENTIVE MAINTENANCE. (SEC. 316)	01
	E-58H5M	7044X			A. CLEAN ALL TAPE UNITS.	02
		FOG			1. UNLOCK FLIGHT PROGRAM FILES.	03

7/14/66 MA-64 SEQUENCE PAGE 64

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
38	12/1530Z	7094X		1. 94-INITIALIZATION.	01
	E-57H35M			A. MOUNT MAGNETIC TAPES.	02
				1) (A-2 P-194 OR P-195 (USE P-NO. WITH NO FINISH DATE).	03
				2) (A-3 TAB OUTPUT TAPE).	04
				3) (A-7 EDITOR SCRATCH).	05
				4) (B-1, B-2, B-3, B-4 SCRATCH).	06
				5) (B-9, PLOT TAPE).	07
				B. SENSE SWITCHES.	08
				C. 7094 INITIALIZATION DECK.	09
				1) (P-190 OR P-193 (USE P-NO. WITH NO FINISH DATE ONLY).	10
				D. PUSH LOAD TAPE BUTTON.	11
39	12/1655Z			1. SWITCHING COMPUTER SYSTEM STRING.	01
	E-56H10M	MBOX		A. SLAVE E. S. C.	02
		7044-7094		B. SELECT PROPER SWITCHES.	03
		7094-7909 94-DIS		C. SELECT PROPER SWITCHES.	04
		7094X		D. 556-200 BPI.	05
		7044X		2. 44-INITIALIZATION.	06
				A. MOUNT MAGNETIC TAPES.	07
				1) D-1.	08
				2) D-2 SIMULATION TAPE P-	09
				3) D-3 RAW DATA INPUT NO. 1.	10
				4) D-4 ALTERNATE RAW DATA INPUT NO. 2.	11
				5) D-5 MODE-3 TAPE.	12
				6) D-6 P-171 OR P-172 (P NO. TAPES MUST NOT HAVE A FINISH	13
				DATE).	14
				7) D-8 SCRATCH.	15
40	12/1620Z	DATA	CHIEF	1. SET CORRECT HARDWARE CONFIGURATION IN SWITCHING CONSOLE.	01
	E-56H45M			2. INITIATE PANIC SWITCH FOR COLD START.	02
				3. SWITCH USER AREAS TO APPROPRIATE COMPUTER.	03
		7094X-STRING		4. ---- MODE 2 ----	04
41	12/1625Z	OPS1		1. UPON APPROVAL OF DACON, TURN ON PSIX -AUTO	01
	E-56H40M			FOR THE SC3070 PRINTER, OPTION SWITCHES 30-35 ON.	02
				2. PUT PSIX TAPE ON COMPUTER.	03
		FPAA.		1.USERS CHECK SOURCE DECK LOADING.	04

7/14/65 MA-64 SEQUENCE PAGE 65

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
42	12/1713 38.6Z	BUSS			1. CYCLIC 82 OBSERVED IN DATA (NOMINAL)	01
	E-55H51M					02
43	12/1800Z	7094X			1. MOUNT TAPE A-0 + A-3	01
	E-55H5M					02
44	12/1815Z	FPAA			1. START USER PROGRAMS AS FOLLOWS.	01
	E-54H50M				A. TDPX.	02
					B. CDGX	03
					C. CDPX	04
					D. TRJX.	05
45	12/2035Z	7094X			1. REMOVE A-0 AND A-3 OUTPUT TAPE.	01
	E-52H30M	1401			1. PROCESS A-3 OUTPUT TAPE ON 1401 WITH SFOF PROGRAM.	02
		CDC			1. CDC DELIVER 1401 LISTING TO DACON AS SOON AS	03
					POSSIBLE.	04
		DACON			1. INSPECT LISTINGS.	05
46	12/2037Z	7094X			1. MOUNT SCRATCH TAPE ON A-3.	01
	E-52H28M	SPAA			1. START FOLLOWING PROGRAMS.	02
					A. CPPM.	03
					B. AGCM	04
					O. SSDM	05
					C. EDPLOT	06
47	12/2150Z	7094X			1. REMOVE A-3 OUTPUT TAPE.	01
	E-51H15M	1401			1. PROCESS A-3 OUTPUT TAPE WITH SFOF PROGRAM.	02
		CDC			1. CDC DELIVER 1401 LISTING TO DACON AS SOON AS	03
					POSSIBLE.	04
		DACON			1. INSPECT LISTINGS.	05

7/14/65 MA-64 SEQUENCE PAGE 66

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
48	12/2152Z	7094X		1. MOUNT SCRATCH TAPE ON A-0 AND A-3.	01
	E-51H13M	SSAA		1. START FOLLOWING PROGRAMS.	02
				A. MAGM.	03
				B. CRTM.	04
				C. DSTM.	05
				D. RADM	06
				E.	07
				1) DAS 1	08
				2) DAS 2	09
				3) DAS 3	10
49	12/2215Z	7094X		1. REMOVE A-0 AND A-3 OUTPUT TAPE.	01
	E-50H50M	1401		1. PROCESS A-3 OUTPUT TAPE WITH 1401 SFOF PROGRAM.	02
		CDC		1. CDC DELIVER 1401 LISTING TO DACON AS SOON AS	03
				POSSIBLE.	04
		DACON		1. INSPECT LISTINGS.	05
		FOG		2. LOCK X FLIGHT PROGRAM FILE.	06
		BLDG. 125		1. PROCESS A-0 ON PASS PROGRAM.	07
50	12/2216Z	Y-STRING		1. 44Y, 94Y COMPUTER PREVENTIVE MAINTENANCE.	01
	E-50H49M			A. CLEAN ALL TAPE UNITS. (SEC. 316)	02
51	12/2245Z	7094Y		1. 94-INITIALIZATION.	01
	E-50H20M			A. MOUNT MAGNETIC TAPES.	02
				1) (A-2 P- OR P-) (USE P-NO. WITH NO FINISH DATE).	03
				2) (A-3 TAB OUTPUT TAPE).	04
				3) (A-7 EDITOR SCRATCH).	05
				4) (B-1, B-2, B-3, B-4 SCRATCH).	06
				5) (B-9, PLOT TAPE).	07
				B. SENSE SWITCHES.	08
				C. 94-INITIALIZATION DECK.	09
				1) (P-206 OR P-207) (USE P NO. WITH NO FINISH DATE ONLY).	10

7/14/65 MA-64 SEQUENCE PAGE 67

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
52	12/2300Z			1. SWITCHING COMPUTER SYSTEM STRING.	01
	E-50H5M	MBOX		A. SLAVE E.S.C.	02
		7044-7094Y		B. SELECT PROPER SWITCHES.	03
		7094-7909 94-DIS		C. SELECT PROPER SWITCHES.	04
		7094Y		D. 556-200 BPI.	05
		7044Y		2. 44-INITIALIZATION.	06
				A. MOUNT MAGNETIC TAPES.	07
				1) D-1.	08
				2) D-2 SIMULATION TAPE P-	09
				3) D-3 RAW DATA INPUT NO. 1.	10
				4) D-4 ALTERNATE RAW DATA INPUT NO. 2.	11
				5) D-5 MODE-3 TAPE.	12
				6) D-6 P-210 OR P-211 (P N3. TAPES MUST HAVE NO FINISH DATE).	13
				7) D-8 SCRATCH.	14
53	12/2301Z	DATA CHIEF		1. SET CORRECT HARDWARE CONFIGURATION IN SWITCHING CONSOLE.	01
	E-49H55M			2. INITIATE PANIC SWITCH FOR COLD START. FOR SYSTEM SWITCH, USE NORMAL	02
				SWITCH ROUTINE.	03
				3. SWITCH USER AREAS TO APPROPRIATE COMPUTER.	04
		7094Y-STRING		4. ---- MODE 2 ----	05
54	12/2315Z	OPS1		1. UPON APPROVAL OF DACON, TURN ON PS1X -AUTO	01
	E-49H50M			FOR THE SC 3070 PRINTER.	02
				2. SEE ITEM 40.	03
55	13/0000Z	42		1. RISE 0139, SET 1252	01
	E-49H05M	41		2. RISE 0156, SET 1355	02
		51		3. RISE 0935, SET 2055	03
		61		4. RISE 1135, SET 2255	04
		11		5. RISE 1936, SET 0627	05
		12,13		6. RISE 1904, SET 0632	06
		COMM		1. UP 1 TTY WITH EACH STATION.	07
				(11,41,42,51,61)	08
				(CONTINUOUS 24 HOUR PER DAY REQUIREMENT UNTIL RELEASED BY SFOD)	09
				2. COMPLETE GO NO GO TESTS.	10

7/14/65 MA-64 SEQUENCE PAGE 68

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
56	13/0045Z	FPAA			1. START PROGRAMS AS FOLLOWS.	01
	E-48H20M				A. TDPX	02
					B. ODGX	03
					C. ODPX.	04
					D. TRJX.	05
57	13/0315Z	7094Y			1. REMOVE A-3 OUTPUT TAPE.	01
	E-45H50M	1401			1. PROCESS A-3 OUTPUT TAPE ON 1401 WITH SFOF PROGRAM.	02
					2. ODC DELIVER 1401 LISTING TO AREA 5 AS SOON AS	03
					POSSIBLE.	04
		DACON			1. INSPECT LISTINGS.	05
		7094Y			1. MOUNT SCRATCH TAPE ON A-3.	06
		OPS1			1. START FOLLOWING PROGRAMS.	07
					A. CPPM.	08
					B. AGCM.	09
					D. SSDM	10
					C. EDPLOT	11
58	13/0430Z	7094Y			1. REMOVE A-3 OUTPUT TAPE.	01
	E-44H35M	1401			1. PROCESS A-3 OUTPUT TAPE WITH SFOF PROGRAM.	02
		ODC			1. ODC DELIVER 1401 LISTING TO AREA 6 AS SOON AS	03
					POSSIBLE.	04
		DACON			1. INSPECT LISTINGS	05
59	13/0432	7094Y			1. MOUNT SCRATCH TAPE ON A-3.	01
	E-44H33M	OPS1			1. START FOLLOWING PROGRAMS.	02
					A. MAGM.	03
					B. CRTM.	04
					C. DSTM.	05
					D. RADM	06
					E.	07
					1) DAS 1	08
					2) DAS 2	09
					3) DAS 3	10

7/14/65 MA-64 SEQUENCE PAGE 69

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
60	13/0415	7094Y			1. REMOVE A-0 AND A-3 OUTPUT TAPE.	01
	E-44H50M	1401			1. PROCESS A-3 OUTPUT TAPE WITH 1401 SFOF PROGRAM.	02
					2. ODC DELIVER 1401 LISTING TO AREA 4 AS SOON AS	03
					POSSIBLE.	04
		DACON			1. INSPECT LISTINGS	05
		AS REQUIRED			1. Y PROGRAM RERUNS IF NEEDED.	06
		FOG			2. LOCK Y FLIGHT PROGRAM FILE.	07
61	13/0600Z	DPS			1. CHECKOUT OF THE DATA PROCESSING SYSTEM (SEC. 318 CONTROL)	01
	E-43H5M					02
62	13/0800Z	DATA	CHIEF		1. DATA PROCESSING SYSTEM HARDWARE - FINAL CHECKOUT	01
	E-41H5M				A. START IBM-CE UNIT CHECKOUT OF X-STRING.	02
63	13/1000Z	DATA	CHIEF		B. COMPLETE IBM-CE UNIT CHECKOUT OF X-STRING.	01
	E-39H5M				C. START IBM-CE CHECKOUT OF DIRECT DATA AND SWITCHING USING	02
					ALL COMPUTERS.	03
64	13/1100Z	DATA	CHIEF		D. COMPLETE IBM-CE CHECKOUT OF DIRECT DATA AND SWITCHING.	01
	E-38H5M				E. START IBM-CE UNIT CHECKOUT OF Y-STRING.	02
65	13/1200Z	DATA	CHIEF		F. START UNIT CHECKOUT OF USER AREA DEVICES AND TPS USING 7040X.	01
	E-37H5M					02
66	13/1300Z	DATA	CHIEF		G. COMPLETE IBM-CE UNIT CHECKOUT OF Y-STRING.	01
	E-36H5M				H. COMPLETE UNIT CHECKOUT OF USER AREA DEVICES AND TPS.	02
					I. START 2HR IDLE FOR REQUIRED MAINTENANCE.	03
		COMM			1. VERIFY COMM READINESS.	04
67	13/1400Z	SUP			1. UPDATE STATUS RECORDING	01
	E-35H5M					02
68	13/1450Z	SUP			1. ADVISE ALL PERSONNEL THAT ACCESS CONTROL WILL GO INTO EFFECT	01
	E-34H15M				IN TEN MINUTES. (PAGE)	02
69	13/1500Z	DATA	CHIEF		1. START DPS COMBINED SYSTEMS CHECKOUT.	01
	E-34H5M					02
		COMM			1. ADVISE ALL PERSONNEL THAT ACCESS CONTROL IS NOW IN EFFECT. (PAGE)	03

7/14/65 MA-64 SEQUENCE PAGE 70

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
70	13/1600Z	DATA CHIEF		1. COMPLETE DPS COMBINED SYSTEMS CHECKOUT.	01
	E-33H5M				02
		SUP		1. UPDATE STATUS RECORDING	03
71	13/1700Z	DATA CHIEF		1. DATA PROCESSING SYSTEM HARDWARE GO.	01
	E-32H5M				02
72	13/1715Z	X-STRING		1. SPACE FLIGHT PROGRAM VERIFICATION OF PREVENTIVE MAINTENANCE FOR	01
	E-31H50M			7094-7044X DATA PROCESSING SYSTEM AS FOLLOWS...	02
73	13/1720Z	FOG		1. UNLOCK X FLIGHT PROGRAM FILE.	01
	E-31H45M	X-STRING		1. 94-INITIALIZATION.	02
				A. MOUNT MAGNETIC TAPES.	03
				1) A-2 P- OR P- . (USE P-NO. WITH NO FINISH DATE).	04
				2) A-3 TAB OUTPUT TAPE.	05
				3) A-7 EDITOR SCRATCH.	06
				4) B-1, B-2, B-3, B-4 SCRATCH.	07
				5) B-9, PLOT TAPE.	08
				B SENSE SWITCHES.	09
				C. 94-INITIALIZATION DECK.	10
				1) P-190 OR P-193. (USE P NO. WITH NO FINISH DATE ONLY).	11
74	13/1725Z			1. SWITCHING COMPUTER SYSTEM STRING.	01
	E-31H40M	MBOX		A. SLAVE E.S.C.	02
		7044-7094X		B. SELECT PROPER SWITCHES.	03
		7094-7909, 94-DI		C. SELECT PROPER SWITCHES.	04
		7094X		D. 556-200 BPI.	05
		7044X		2. 44-INITIALIZATION.	06
				A. MOUNT MAGNETIC TAPES.	07
				1) D-3 RAW DATA INPUT NO. 1.	08
				2) D-4 ALTERNATE RAW DATA INPUT NO. 2.	09
				3) D-5 MODE-3 TAPE.	10
				4) D-6 P-171 OR P-172 (P-NO. TAPES MUST NOT HAVE A FINISH	11
				DATE).	12
				7) D-8 SCRATCH.	13

7/14/65 MA-64 SEQUENCE PAGE 71

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
75	13/1735Z	DATA CHIEF			1. SET CORRECT HARDWARE CONFIGURATION IN SWITCHING CONSOLE.	01
	E-31H30M				2. INITIATE PANIC SWITCH FOR COLD START.	02
					3. SWITCH USER AREAS TO APPROPRIATE COMPUTER.	03
		7094X-STRING			4. ---- MODE 2 ----	04
76	13/1740Z	OPS1			1. UPON APPROVAL OF DACON, TURN ON PS1X -AUTO	01
	E-31H25M				FOR THE SC 3070 PRINTER.	02
					2. SEE ITEM 40.	03
77	13/1755Z	FPAA			1. START PROGRAMS AS FOLLOWS...	01
	E-31H10M				A. TDPX.	02
					B. CDGX	03
					C. CDPX.	04
78	13/1800Z	SUP			1. UPDATE STATUS RECORDING	01
	E-31H5M				2. RECEIVE STANDBY ELECTRICIAN NAMES	02
					AND WORK SCHEDULES FROM PLANT	03
					MAINTENANCE.	04
					3. TRANSPORTATION VERIFIES THAT	05
					DIESELS HAVE BEEN CHECKED AND	06
					FUEL TANKS FILLED.	07
					4. DORMATORIES CHECKED FOR READINESS,	08
					PER SFOF/SOP =70-104.	09
					5. REPORT READINESS TO SFOF OPS. MGR.	10
		DISPLAY			1. CHECK ALL FIRST FLOOR DISPLAYS	11
					INCORPORATING DDU"S FOR CORRECT	12
					OPERATION.	13
					2. CHECK FOR CORRECT OPERATION OF'	14
					A) EIDOPHOR PROJECTOR	15
					B) MISSION EVENTS PROJECTOR	16
					C) TELEPROMPTER PROJECTOR	17
					3. CHECK MSB AND REMOTE TIMERS	18
					FOR SYNCRONIZATION.	19
					4. REPORT READINESS TO SFOF OPS. MGR.	20
79	13/1835Z	7094X			1. REMOVE A-3 OUTPUT TAPE.	01
	E-30H30M	1401			1. PROCESS A-3 OUTPUT TAPE WITH SFOF PROGRAM.	02
		CDC			1. CDC DELIVERS 1401 LISTING TO DACON AS SOON AS	03
					POSSIBLE.	04

7/14/65 MA-64 SEQUENCE PAGE 72

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
80	13/1855Z	DACON			1. INSPECT LISTINGS.	01
	E-30H10M					02
81	13/1900Z	FPAC			1.RUN ODP ON 7094X.	01
	E-30H5M					02
82	13/1915Z	Y-STRING			1. SPACE FLIGHT PROGRAM VERIFICATION OF PREVENTIVE MAINTENANCE FOR 7094	01
	E-29H50M				-7044Y DATA PROCESSING SYSTEM AS FOLLOWS...	02
83	13/1920Z	FOG			1. UNLOCK FLIGHT PROGRAM FILES.	01
	E-29H45M	Y-STRING			1. 94-INITIALIZATION.	02
					A. MOUNT MAGNETIC TAPES.	03
					1) A-2 P- OR P- . (USE P-NO. WITH NO FINISH DATE.	04
					2) A-3 TAB OUTPUT TAPE.	05
					3) A-7 EDITOR SCRATCH.	06
					4) B-1, B-2, B-3, B-4 SCRATCH.	07
					5) B-9, PLOT TAPE.	08
					B. SENSE SWITCHES.	09
					C. 94-INITIALIZATION DECK.	10
					1) P-206 OR P-207 (USE P-NO. WITH NO FINISH DATE ONLY).	11
84	13/1925Z				1. SWITCHING COMPUTER SYSTEM STRING.	01
	E-29H40M	MBOX			A. SLAVE E.S.C.	02
		7044-7094Y			B. SELECT PROPER SWITCHES.	03
		7094-7909, 94Y			C. SELECT PROPER SWITCHES.	04
		7094Y			D. 556-200 BPI.	05
		7044Y			2. 44-INITIALIZATION.	06
					A. MOUNT MAGNETIC TAPES.	07
					1) D-1.	08
					2) D-2 SIMULATION TAPE P-	09
					3) D-3 RAW DATA INPUT NO. 1.	10
					4) D-4 ALTERNATE RAW DATA INPUT NO. 2.	11
					5) D-5 MODE-3 TAPE.	12
					6) D-6 P-210 OR P-211 (P-NO., TAPES MUST NOT HAVE A FINISH	13
					DATE).	14
					7) D-8 SCRATCH.	15

7/14/65 MA-64 SEQUENCE PAGE 73

ITEM	TIME	STATION	REPORTED BY		EVENT	LINE NO.
85	13/1935Z E-29H30M	DATA	CHIEF		1. SET CORRECT HARDWARE CONFIGURATION IN SWITCHING CONSOLE.	01
					2. INITIATE PANIC SWITCH FOR COLD START.	02
					3. SWITCH USER AREAS TO APPROPRIATE COMPUTER.	03
		7094 Y	-STRING		4. ---- MODE 2 ----	04
86	13/1940Z E-29H25M	OPS1			1. UPON APPROVAL OF DACON, TURN ON PS1X -AUTO O	01
					FOR THE SC 3070 PRINTER.	02
					2. SEE ITEM 40.	03
		FPAA			1. CHECK SOURCE DECK	04
87	13/1955Z E-29H10M	FPAA			1. START PROGRAMS AS FOLLOWS...	01
					A. TDPX.	02
					B. CDGX	03
					C. CDPX.	04
		SUP			1. UPDATE STATUS RECORDING	05
88	13/2045Z E-28H20M	7094 Y			1. REMOVE A-3 OUTPUT TAPE.	01
		1401			1. PROCESS A-3 OUTPUT TAPE WITH SFOF PROGRAM.	02
		CDC			1. CDC DELIVERS 1401 LISTING TO DACON AS SOON AS	03
					POSSIBLE.	04
89	13/2055Z E-28H10M	DACON			1. INSPECT LISTINGS.	01
						02
90	13/2110Z E-27H55M	SUP			1. UPDATE STATUS RECORDING.	01
						02

7/14/65 MA-64 SEQUENCE PAGE 74

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
91	13/2115Z E-27H50M	DPS			1. FINAL CHECKOUT OF THE DATA PROCESSING SYSTEM. (SECTION 318)	01
						02
					I I	03
					I X,Y-STRINGS MODE II I	04
					I BE CAREFUL SYSTEM READY FOR I	05
					I ENCOUNTER PROGRAMS GREEN I	06
					I I	07
					A. IBM-CE.	08
					B. USER DEVICE.	09
		SUP			1. 1ST SHIFT OF TECHNICAL AREA ASSTS.	10
					REPORT FOR DUTY.	11
					2. BEGIN COFFEE PREPARATION	12
					3. UPDATE STATUS RECORDING	13
					4. REPORT STATUS TO SFOF OPS. MGR.	14
92	14/0000Z E-25H05M	42			1. RISE 0137, SET 1250	01
		41			2. RISE 0155, SET 1354	02
		51			3. RISE 0933, SET 2053	03
		61			4. RISE 1135, SET 2255	04
		11			5. RISE 1934, SET 0624	05
		12,13			6. RISE 1903, SET 0630	06
93	14/0030Z E-24H35M	COMM			1. UP 1 TTY, VOICE, ANALOG WITH 42	01
					(BRIDGE 41/42 VOICE AT AADE)	02
					(RELEASE PER SCHEDULE AND TRACK CHIEF CONCURRENCE)	03
94	14/0105Z E-1440MIN	COMM			1. UP 1 TTY WITH 41 AND 42.	01
					(NOTE. 4 TTY-2 TTY 41, 2 TTY 42)	02
					(RELEASE PER SCHEDULE AND TRACK CHIEF CONCURRENCE)	03
		DISPLAY			1. CHANGE MISSION CLOCK TO READ E-1440 MIN(UPDATE E TIME WITH FLIGHT	04
					PREDICTS).	05

7/14/65 MA-64 SEQUENCE PAGE 75

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
95	14/0700Z E-1085MIN	SUP			1. NOTIFY ALL STATIONS THAT FACILITY WILL BE SWITCHED TO GENERATOR POWER IN TEN MINUTES.(PAGE)	01 02
		MAR I/O			1. INITIALIZE SCIENCE ENCOUNTER FORMATS. A. MSA 1. SPACE CHIEF 3070 SCIENCE QUICK LOOK 2. DAS 3070-F-35 3. 30X30 PLOTTER F-17,180 SC/INCH B. SSAA 1. 3070 SCIENCE QUICK LOOK 2. 30X30 PLOTTER F-18,180 SEC/INCH	03 04 05 06 07 08 09 10
96	14/0710 E-1075MIN	SUP			1. SWITCH FACILITY TO GENERATOR POWER. 2. CHECK WITH DATA CHIEF. 3. ADVISE SFOF OPS. MANAGER.	01 02 03
97	14/0800Z E-1025MIN	COMM			1. UP 1 TTY WITH 51 (RELEASE PER SCHEDULE)	01 02
98	14/0830Z E-995MIN	COMM			1. UP ONE TTY VOICE AND ANALOG WITH 51(RELEASE PER SCHEDULE)	01 02
99	14/0912Z E-953MIN	OPS.1			1. RUN AGCM	01 02
100	14/0932Z E-933MIN	51			1. THREE-WAY ACQUISITION OF S/C BY DSIF 51. START SENDING R/T TRACKING AND T/M DATA TO SFOF BY TTY.	01 02
101	14/0935Z E-930MIN	TRACK			1. REPORT ACQUISITION BY DSIF 51 (3-WAY).(RED)	01 02
102	14/0945Z E-925MIN	TRACK			1. TRANSFER 2-WAY LOCK FROM DSIF 42 TO DSIF 51.	01 02
103	14/1000Z E-905MIN	COMM			1. UP 1 TTY WITH 61 (RELEASE PER SCHEDULE)	01 02
104	14/1010Z E-895MIN	TRACK			1. REPORT DSIF-51 IN 2-WAY LOCK WITH THE S/C.	01 02

7/14/65 MA-64 SEQUENCE PAGE 76

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
105	14/1030Z E-875MIN	COMM			1. UP 1 TTY, VOICE, ANALOG WITH 61 (RELEASE PER SCHEDULE)	01 02
106	14/1150Z E-795MIN	FPAC			1. RUN TDP/ODG/ODP	01 02
107	14/1215Z E-770MIN	TRACK			1. INSTRUCT DSIF 51 TO TUNE TO NEW XA FOR TIME 1600Z(51).	01 02
108	14/1230Z E-755MIN	SPACE			1. INPUTS OF EXPECTED SCAN PERFORMANCE TO FPAC (MAR OPS)	01 02
109	14/1235Z E-750MIN	51			1. REPORT XA CHANGE COMPLETE.	01 02
110	14/1250Z E-735MIN	FPAC			1. TRAJX (RED)	01 02
111	14/1251Z E-734MIN	42			1. END OF TRACK DSIF42	01 02
112	14/1253Z E-732MIN	ALL			1. ALL PERSONNEL ON STATION IN SFOF FOR ENCOUNTER.	01 02
113	14/1255Z E-730MIN	TRACK			1. REPORT DSIF 42 END OF TRACK (RED)	01 02
114	14/1300Z E-725MIN	FPAC			1. RUN FLY BY FINE PRINT (NO PROGRAMMER). (RED)	01 02
		TRACK			1. BEGIN NORMAL PRE-COMMAND MODULATION TURN-ON PROCEDURE WITH DSIF 51.	03

7/14/65 MA-64 SEQUENCE PAGE 77

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
115	14/1300Z-1400Z	COMM		1. MAKE PIO PATCHES ,CCTV AS REQUESTED.	01
	E-725MIN TO			2. START RECORDING MAR NET, MAR OPS., RED NET, 11, 42, 51, TIME.	02
	E-665MIN			(CONTINUE UNTIL RELEASED BY SFOD) (ACTIVE STATIONS ONLY)	03
				3. PATCH S/C AGC SIGNAL TO VON KARMAN(PIO).	04
				4. PATCH MAR NET TO PROJECT REP. BLDG. 186/PATCH PIONEER NET TO	05
				VON KARMAN(186).	06
				5. CONFIGURE MAR BUS , MAR OPS. , MAR SPACE, ACCORDING TO IOM 316-1138.	07
				6. MAKE AUDIO PATCH BLUE NET LISTEN ONLY TO GSFC FOR	08
				A. HANGER AO	09
				B. LERC	10
				C. WOODSHOLE	11
				D. NASA HDQ.	12
				E. GSFC	13
				7. PATCH BLUE NET TO PIO LISTEN ONLY	14
				8. PATCH BLUE NET TO DSIF 41/42 LISTEN ONLY ON GDA58186	15
				9. PATCH BLUE NET TO DSIF 51/61 LISTEN ONLY ON GDA58160	16
				10. PATCH BLUE NET TO GOLDSTONE LISTEN ONLY	17
116	14/1320Z	ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION	01
	E-705MIN			IF NO-GO GIVE REASON. (MAR OPS)	02
		TRACK		1. WITH APPROVAL OF SFOD AND MAR CHIEF , REQUEST DSIF 51 TO TURN	03
				ON COMMAND MODULATION .	04
		BUSS		1. GIVE COMMAND MODULATION TURN-ON STATUS, RECOMMEND 8FS LAST TWO	05
				DIGITS. (MAR OPS)	06
		FLIGHT CHIEF		1. REPORT BEST TIME FOR DC-25 TO HAVE SCAN INTERCEPT PLANET PROPERLY.	07
				(MAR OPS)	08
		OPS.		1. PERFORM AD AND USER PROGRAM PROCESSING FOR SCIENCE DATA RECEIVED UP	09
				TO THIS DATE(CRTM,MAGM,RADM,DSTM,AD). (RED)	10
				DISTRIBUTE BY 1600Z.	11
117	14/1345Z	BUSS		1. VERIFY COMMAND MODULATION ON. (COMMAND 8FS IS NOT NORMALIZED)	01
	E-680MIN			(MAR OPS.)	02
118	14/1355	BUSS		1. REPORT COMMAND LOOP LOCK. (MAR OPS.)	01
	E-670MIN				02

7/14/65 MA-64 SEQUENCE PAGE 78

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
119	14/1400Z E-665MIN	SPACE			1. REPORT DC-25 TIME AS ___ H ___ M ___ S. (MAR OPS) 2. REQUEST MAR CHIEF TO HAVE DC-25 TRANSMITTED AT ___ H ___ M ___ S. (MAR OPS)	01 02 03 04
		BUSS			1. INFORM MAR CHIEF OF THE COMMAND STATUS. (MAR OPS.)	05
120	14/1410Z E-655MIN	SFOD			1. REQUEST TRACK CHIEF TO TRANSMIT DC-25 AT ___ H ___ M ___ S. (MAR NET)	01 02
121	14/1415Z E-650MIN	TRACK			1. REQUEST DSIF 51 TO TRANSMIT DC-25 AT ___ H ___ M ___ S.(51)	01 02
122		TRACK			1. REPORT INITIATE TIME OF DC-25 BY DSIF 51 AT ___ H ___ M ___ S.	01
123	14/1421Z E-644MIN	DSIF			1. DC-25 TRANSMITTED (+,- 6 MIN)	01 02
124	14/1433Z E-632M	S/C			1. DC-25 RECEIVED (+,- 6 MIN)	01 02
125	14/1445Z E-620M	BUSS			1. DC-25 SEEN IN DATA (+,- 6 MIN)	01 02
126	14/1450Z E-615MIN	7094X			1. RUN DAS-SCAN EACH 15 MIN FROM 1450Z ON.	01 02
127	14/1500Z E-605MIN	ALL			1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS.)	01 02
		MAR I/O			1. DISABLE ALL SCIENCE ALARMS	03
128	14/1515Z E-590MIN	SFOD			1. REPORT GENERAL STATUS TO PROJECT MANAGER. (MAR NET)	01 02
129	14/1530Z E-575MIN	TRACK			1. REQUEST DSIF-51 AND DSIF-61 TO SWITCH GTS PRINTER FROM PROGRAMMED TO ALL. (51,61)	01 02
130	14/1541Z E-564MIN	S/C			1. MT-7	01 02

7/14/65 MA-64 SEQUENCE PAGE 79

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
131	14/1553Z E-551MIN			1. MT-7 SEEN IN DATA (15'53'47)	01 02
132	14/155349Z E-551MIN 49SEC	51		1. MT-7. REPORT EVENT TO TRACK WHEN OBSERVED AT STATION AND GIVE TIME. (51)	01 02
		TRACK	CHIEF	1. ANNOUNCE TIME DSIF OBSERVED THE EVENT. (MAR OPS., MAR NET, RED)	03
133		BUSS,	SPACE	1. REPORT EVENT TO MAR CHIEF (MAR OPS) A. COUNTER 1 AND 2 EVENTS	01 02
134 EC	14/1553 49.5Z E-551MIN 10.5S	BUSS		1. MT-7 OBSERVED IN DATA (NOMINAL)	01 02
135	14/1555Z E-550MIN	SFOD		1. REPORT STATUS OF DC-25 TO PROJECT MANAGER. (MAR NET)	01 02
136	14/1557Z E-548MIN	BUSS		1. REPORT COMMAND STATUS TO MAR CHIEF (MAR OPS)	01 02
137	14/1600Z E-545MIN	FPAC		1. RUN TDP/ODG/ODP (94Y) (RED)	01 02
138	14/1610Z E-535MIN	OPS1		1. RUN DAS-SCAN (94X) (RED)	01 02
139	14/1615Z E-530MIN	ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS,RED)	01 02
140	14/1640Z E-505MIN	OPS.1		1. RUN DAS-SCAN (94X) (RED)	01 02
141	14/1655Z E-490MIN	OPS.1		1. RUN DAS-SCAN (94X) (RED)	01 02
142	14/1700Z E-485MIN	ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS,RED)	01 02
143	14/1710Z E-475MIN	OPS.1 FPAC		1. RUN DAS-SCAN (94X) (RED) 1. RUN TRAJX (94Y) (RED)	01 02

7/14/65 MA-64 SEQUENCE PAGE 80

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
144	14/1720Z	SPACE			1. REPORT RESULTS OF DAS-SCAN TO MAR CHIEF. (MAR OPS)	01
	E-465MIN					02
145	14/1725Z	OPS.			1. RUN DAS-SCAN (94X) (RED)	01
	E-460MIN					02
146	14/1730Z	FPAC			1. RUN FLY BY FINE PRINT (94Y) FOR USE IN FLY BY FINE RUN. (RED)	01
	E-455MIN					02
147	14/1740Z	OPS.			1. RUN DAS-SCAN (94X) (RED)	01
	E-445MIN	FLIGHT,COMM,OPS,			1. TRANSMIT SAMPLE PREDICTS TO GTS/DIS.	02
		TRACK				03
		SPACE			1. REPORT TIME FOR TRANSMISSION OF DC-24 (MAR OPS)	04
		SFOD			1. REPORT TO PROJECT MANAGER ON STATUS OF DC-24 (MAR NET)	05
148	14/1748Z	BUSS	CHIEF		1. REQUEST SFOD TO HAVE DC-24 TRANSMITTED AT ___ H ___ M ___ S	01
	E-437MIN				(MAR NET)	02
149	14/1749Z	BUSS			1. REPORT COMMAND STATUS. (MAR OPS)	01
	E-436MIN	SFOD			1. REQUEST TRACK CHIEF TO HAVE DSIF-51 TRANSMIT DC-24 AT	02
					___ H ___ M ___ S. (MAR NET)	03
150	14/1750Z	TRACK	CHIEF		1. REQUEST DSIF-51 TO TRANSMIT DC-24 AT ___ H ___ M ___ S (51)	01
	E-435MIN				NOTE. IF FOR ANY REASON DSIF-51 IS UNABLE TO TRANSMIT DC-24 AT THE TIME	02
					SPECIFIED DO NOT TRANSMIT. WAIT FOR ANOTHER TRANSMISSION TIME.	03
					THIS COMMAND MESSAGE WILL BE TRANSMITTED BY VOICE AND FOLLOWED	04
					BY TTY MESSAGE.	05
		FLIGHT			1. REPORT EXPECTED TIME OF CLOSEST APPROACH, WAA, AND NAA BASED ON	06
					LATEST ORBIT. ALSO REPORT UNCERTAINTIES IN TIME FOR WAA AND NAA.	07
					(MAR OPS)	08
151	14/1753Z				1. DC-24 - LATEST TIME TO TRANSMIT	01
	E-432MIN					02
152	14/1754Z	TRACK	CHIEF		1. REPORT DC-24 INITIATE TIME GIVEN BY DSIF-51. (MAR OPS,MARNET,RED)	01
	E-431MIN	OPS.			1. RUN DAS-SCAN (94X) (RED)	02

7/14/65 MA-64 SEQUENCE PAGE 81

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
153	14/1800Z	FPAC		1. RUN TDP/ODG/ODP (RED)	01
	E-425MIN	COMM		1. UP TTY WITH 11/12 AS REQUIRED	02
				(CAPTURE BACKUP FACILITIES , GP7206,7207-GDA7214,7215)	03
				2. UP VOICE, ANALOG WITH 11/12 AS REQUIRED	04
		ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION.	05
				IF NO-GO GIVE REASON. (MAR OPS,RED)	06
		GTS/DIS		1. RUN OPEN LOOP RECEIVER PREDICTION PROGRAM USING SAMPLE PREDICTS.	07
154	14/1815Z	GTS/DIS		1. RUN PSUEDO RESIDUAL PROGRAM USING SAMPLE PREDICTS AND XMIT RESIDUALS	01
	E-410MIN			TO SFOF.	02
155	DC-24+25MIN	BUSS		1. REPORT COUNTER 4 EVENT AND SCAN POWER STATUS TO MAR CHIEF WHEN	01
				OBSERVED IN DATA. (MAR OPS)	02
		SPACE		1. REPORT SCAN MOTION STATUS TO MAR CHIEF. IF STOPPED REPORT THE POSIT-	03
				ION AND THE VALUE OF THE POSITION RELATIVE TO TV DATA. (MAR OPS)	04
				1. OPTIONS.	05
				A. IF DC-24 IS UNSUCCESSFUL IN STOPPING THE PLATFORM THE SYSTEM	06
				WILL AWAIT THE FUNCTIONING OF WIDE ANGLE ACQUISITION (WAA).	07
				B. IF DC-24 IS SUCCESSFUL IN STOPPING THE PLATFORM BUT AT A	08
				DISASTROUS ANGLE, A RECYCLE PROCEDURE WILL BE EXECUTED USING	09
				DC-26 AND DC-25. NO ADDITIONAL DC-24"S WILL BE SENT AND THE	10
				SYSTEM WILL AWAIT WAA.	11
156	14/1820Z	SFOD		1. REPORT STATUS OF DC-24 ACTION TO THE PROJECT MANAGER. (MAR NET)	01
	E-405MIN				02
157	14/1850Z	FLITE,COMM,DPS,		1. PREDICTS FOR STATION 11,12,13,AND 42 TO BE TRANSMITTED.	01
	E-375MIN	TRACK			02
158	14/1900Z	ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION.	01
	E-365MIN			IF NO-GO GIVE REASON. (MAR OPS,RED)	02
159	14/1903Z	12		1. GOLDSTONE - ECHO RISE	01
	E-362MIN				02
160	14/1910Z	FPAC		1. RUN TRAJ PROGRAM (94Y) (RED)	01
	E-355MIN				02

7/14/65 MA-64 SEQUENCE PAGE 82

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
161	14/1914Z E-351MIN	OPS.		1. RUN AGCM PROGRAM (94X) (RED)	01 02
162	14/1920Z E-345MIN	SPACE		1. REPORT RESULTS OF DAS-SCAN TO MAR CHIEF. (MAR OPS)	01
		BUSS, SPACE, SFOD		1. DISCUSS POSSIBLE COMMAND CONDITIONS. (MAR NET)	02
		SFOD		1. IF NO COMMAND CONDITIONS EXIST, INSTRUCT TRACK CHIEF TO BEGIN PREPARATION OF S/C TRANSFER TO DSIF 11.	03 04
		TRACK CHIEF		1. INSTRUCT DSIF 51 TO TURN OFF COMMAND MODULATION, AND TUNE TO NEW XA FOR TIME OF 2010Z. 2. REPORT DSIF 51 COMMAND MODULATION TURN OFF TIME. (MAR OPS.)	05 06 07
163	14/1930Z E-335MIN	FPAC		1. TURN ON FLY BY FINE PRINT.	01 02
164	14/1934Z E-331MIN	11		1. GOLDSTONE - PIONEER RISE	01 02
165	14/1935Z E-330MIN	11		1. THREE-WAY ACQUISITION OF S/C BY DSIF 11. START SENDING TRACKING AND T/M TO SFOF VIA TTY.	01 02
166	14/1936Z E-329MIN	TRACK CHIEF		1. REPORT S/C ACQUISITION TIME OF DSIF 11(3-WAY). (MAR NET, MAR OPS.)	01 02
167	14/1940Z E-325MIN	GTS/DIS		1. RUN FSUEDO RESIDUAL PROGRAM USING REGULAR PREDICTS AND XMIT RESIDUALS TO SFOF.	01 02
168	14/1950Z E-315MIN	FLIGHT		1. REPORT RESULTS OF LATEST ORBIT AND THE EXPECTED TIME OF CLOSEST APPROACH (CA), WIDE ANGLE ACQUISITION "WAA), AND NARROW ANGLE SENSOR (NAS) WITH TOLERENCES (MAR OPS)	01 02 03
169	14/2010Z E-295MIN	TRACK		1. TRANSFER TWO-WAY LOCK FROM DSIF 51 TO DSIF 11. (11,51)	01 02
170	14/2015Z E-290MIN	TRACK		1. INSTRUCT DSIF 11 TO BEGIN BLIND XA CHANGE FOR TIME 0000Z. (11,51)	01 02
171	14/2030Z E-275MIN	11		1. REPORT XA CHANGE COMPLETE. (11,51)	01 02

7/14/65 MA-64 SEQUENCE PAGE 83

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
172	14/2035Z	TRACK	CHIEF	1. REPORT VERIFICATION OF 2 WAY BY DSIF-11. (MAR OPS)	01
	E-270MIN	TRACK		1. BEGIN PRE-COMMAND MODULATION TURN-ON PROCEDURES WITH DSIF-11.	02
				XA SHOULD BE AT 62.5 DN. (11)	03
173	14/2053Z	51		1. END OF TRACK (51)	01
	E-252MIN	TRACK		1. REPORT DSIF 51 END OF TRACK. (MAR OPS RED)	02
		SFOD		1. VERIFY S/C IS IN CONDITION FOR TURN-ON OF COMMAND MODULATION.	03
				REPORT PROPER 8FS FOR COMMAND MODULATION. (MAR OPS)	04
174	14/2055Z	SFOD		1. REQUEST TRACK TO HAVE DSIF 11 TURN ON COMMAND MODULATION. (MAR NET)	01
	E-250MIN				02
175	14/2100Z	TRACK		1. REQUEST DSIF-11 TO TURN ON COMMAND MODULATION. (11)	01
	E-245MIN	OPS.1	, FPAC	1. RUN TDP/ODG/ODP (RED)	02
176	14/2105Z	S/C		1. S/C WOULD NOMINALLY PENETRATE MAGNETOSPHERE THE SIZE OF EARTH"S	01
	E-240MIN			IF SUCH EXISTS AT MARS.	02
177	14/2110Z	TRACK	CHIEF	1. REPORT TIME DSIF-11 TURNED ON COMMAND MODULATION. (MAR NET,MAR OPS)	01
	E-235MIN				02
		ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION.	03
				IF NO-GO GIVE REASON. (MAR OPS,RED)	04
178	14/2120Z	SPACE	1	1. EVIDENCE IN T/M DATA FOR MAGNETOSPHER AS LARGE AS EARTH"S. IF NO	01
	E-225MIN			EVIDENCE, RADIATION HAZARD UNLIKELY. REPORT TO SPACE. (MAR SPACE)	02
179	14/2125Z	BUSS		1. VERIFY COMMAND MODULATION ON .(MAR OPS.)	01
	E-220M				02
180	14/2135Z	BUSS		1. REPORT COMMAND LOOP LOCK.(MAR OPS.)	01
	E-210MIN				02
181	14/2150Z	FLIGHT,COMM,DPA,		1. PREDICTS SENT TO DSIF-11,12,13 AND 42.	01
	E-195MIN	TRACK			02
182	14/2200Z	OPS. 1,FLIGHT		1. RUN TRAJX. SCIENCE REPORT TO FPAC THE LASTEST SCAN PARA METERS TO	01
	E-185MIN			USE. (RED)	02
		BUSS		1. REPORT TO SFOD TRANSMISSION TIME OF DC-3 ______ H ______ M ______ S	03
				(MAR NET)	04

7/14/65 MA-64 SEQUENCE PAGE 64

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
183	14/2205Z E-180MIN	SFOD		1. REQUEST TRACK CHIEF TO HAVE DSIF-11 TRANSMIT DC-3 AT (NAA-2HOURS) ______ H ______ M ______ S (MAR NET)	01 02
184	14/2210Z E-175MIN	TRACK CHIEF		1. REQUEST DSIF-11 TO TRANSMIT DC-3 AT ______ H ______ M ______ S (11)	01 02
		DSIF		1. DC-3 TRANSMITTED (+ 30 SEC),(- 30 SEC)	03
185	14/2220Z	TRACK CHIEF		1. REPORT DSIF 11 TRANSMISSION OF DC-3. (MAR NET,MAR OPS RED) __ H __ M __ S	01 02
	E-165MIN	OPS.1, FPAC		1. RUN FLY BY FINE PRINT. (RED)	03
186	14/2222Z E-163MIN	S/C		1. DC-3 RECEIVED	01 02
187	14/2230Z E-155MIN	ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS,RED)	01 02
		FPAC		1. TURN ON FLY BY FINE PRINT.	03
188	14/2234Z E-151MIN	S/C		1. SWITCH TO DATA MODE 3	01 02
189	14/2239Z E-146MIN	MARS		1. MARS BEGINS TO ENTER SCAN FIELD OF VIEW FOR 180 PRE-POSITIONED PLATFORM (E-0124)	01 02
190	14/2245Z E-140MIN	SPACE MAR I/O		1. CONFIRM MODE 3 DATA (MAR OPS) 1. INSTRUCT DATA CHIEF TO PROCESS MODE 3 DATA (RED)	01 02
191	14/2300Z E-125	FPAC		1. REPORT RESULTS OF LATEST ORBIT AND EXPECTED TIME OF CA, WAA, NAA AND THE TOLERANCES. (MAR OPS)	01 02
192	14/2312Z E-113MIN	SPACE 1		1. IF NO EVIDENCE OF MAGNETOSPHERE BY NOW, THERE IS NO RADIATION HAZARD. REPORT TO SPACE. (MAR SPACE)	01 02
193	14/2330Z E-95MIN	ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS,RED)	01 02
194	14/2349Z E-76M	S/C		1. WAA (0.7 PROBABILITY)	01 02

7/14/65 MA-64 SEQUENCE PAGE 85

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
195	14/2350Z	S/C			1. WAA OCCURRED AT THE SPACECRAFT.	01
	E-75MIN					02
196	15/0000Z	42			1. RISE 0135, SET 1248	01
	E-65MIN	41			2. RISE 0153, SET 1352	02
		51			3. RISE 0930, SET 2051	03
		61			4. RISE 1130, SET 2250	04
		11			5. RISE 1932, SET 0621	05
		12,13			6. RISE 1902, SET 0627	06
		FPAC			1. RUN TDP/ODG/ODP	07
197	15/0005Z	COMM			1. UP 1 TTY WITH 42	01
	E-60MIN				(NOTE' 2 TTY 41, 2 TTY 42)	02
					2. UP 1 TTY WITH 41	03
198	15/0001Z	BUSS			1. WAA OBSERVED (0.7 PROBABILITY)	01
	E-64MIN					02
199	15/0002Z	SFOD			1. REPORT STATUS OF WAA TO PROJECT MANAGER. (MAR NET)	01
	E-63MIN					02
200	15/0008Z	BUSS			1. INFORM SFOD OF DC-16 XMIT TIME. __ H __ M __ S	01
	E-57MIN	SFOD			1. REQUEST TRACK CHIEF TO TRANSMIT DC-16 AT ___ H ___ M ___ S	02
					(MAR NET)	03
		TRACK			1. REQUEST DSIF-11 TO TRANSMIT DC-16 AT ___ H ___ M ___ S	04
					(11)	05
201	15/0014Z	TRACK			1. REPORT INITIATE TIME OF DC-16 BY DSIF-11 (MAR NET,MAR OPS RED)	01
	E-51MIN					02
202	15/0015Z	OPS.			1. RUN DAS1 (RED)	01
	E-50MIN					02
203	15/0017Z	DSIF			1. DC-16 TRANSMITTED	01
	E-48MIN					02

7/14/65 MA-64 SEQUENCE PAGE 86

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
204	15/0020Z E-45MIN	S/C SFOD			1. NAA AT S/C (NOMINAL) 1. REQUEST TRACK TO HAVE DSIF-11 TRANSMIT DC-26 AT ___ H ___ M ___ S OR BEFORE, FOLLOWED BY DC-2 AT ___ H ___ M ___ S WITH THE DC-2"S TO CONTINUE ON ___ MINUTE CENTERS UNTIL NOTIFIED TO STOP. (MAR NET)	01 02 03 04 05
205	15/0021Z E-41MIN	S/C			1. NAS (E-0042) NOMINAL	01 02
206	15/0022Z E-43MIN	TRACK	CHIEF		1. REQUEST DSIF-11 TO TRANSMIT DC-26 AT ___ H ___ M ___ S WITH DC-2 TO FOLLOW AT ___ H ___ M ___ S AND DC-2"S TO CONTINUE ON ___ MINUTE CENTERS UNTIL NOTIFIED TO STOP. THESE SOMMANDS TO BE TRANSMITTED IN THE MANUAL INITIATE MODE.	01 02 03 04
207	15/0023Z E-42MIN	S/C			1. NAA (NAS +60 TO 132 SEC)	01 02
208	15/0024Z E-41MIN	S/C			1. START TV RECORD (NAA +60 TO 72 SEC)	01 02
209	15/0025Z E-40MIN	S/C			1. DC-16 ARRIVES AT S/C	01 02
210	15/0029Z E-36MIN	S/C			1. DC-16 RECEIVED	01 02
211	15/0030Z E-35MIN	COMM			1. UP VOICE, ANALOG WITH 42 (BRIDGE 41/42 VOICE AT AADE)	01 02
212	15/0032Z E-33MIN	SPACE SPACE SFOD			1. NAA SEEN IN DATA (MAR OPS) 1. NEW TIME FOR DC-26 IS ___ H ___ M ___ S (MAR NET) 1. REQUEST TRACK CHIEF TO XMIT DC-26 IMMEADIATELY. (MAR NET)	01 02 03 04
213	15/0033Z E-32MIN	BUSS			1. NAS OBSERVED	01 02
214	15/0035Z E-30MIN	BUSS			1. NAA OBSERVED	01 02

7/14/65 MA-64 SEQUENCE PAGE 87

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
215	15/0037Z E-28MIN	BUSS		1. VERIFY DC-16 (COUNTER EVENT) (MAR OPS)	01 02
		TRACK CHIEF		1. REQUEST DSIF 11 TO XMIT IMMEADIATELY. (11)	03
216	DC-16=0	11		1. TRANSMIT DC-26 (LATEST TIME FOR XMIT)	01
217	DC-16+1M	11		1. TRANSMIT DC-2 AND CONTINUE TO TRANSMIT DC-2"S ON ___ MINUTE CENTERS UNTIL NOTIFIED TO STOP.	01 02
		TRACK CHIEF		1. REPORT TO SFOD THAT DC-26 AND DC-2 HAVE BEEN TRANSMITTED (MAR NET, MAR OPS, RED)	03 04
218	NAA+25M	S/C		1. TV RECORDING SEQUENCE COMPLETE AT S/C.	01
219	DC-16+12M	S/C		1. ALL SCIENCE AND 400 CPS INVERTER OFF AT S/C	01
220	DC-16+13M	S/C		1. CRUISE SCIENCE ON AT S/C	01
221	NAA+49M	MAR I/O		1. MODE 2 SEEN IN DATA. REQUEST DATA CHIEF TO PROCESS MODE 2 DATA. (RED)	01 02
222	15/0038Z E-27MIN	DSIF		1. DC-26 TRANSMITTED (NAA +1 MIN 44 SEC)	01 02
223	15/0039Z E-26MIN	DSIF		1. DC-2 TRANSMITTED	01 02
224	15/0049Z E-16MIN	S/C		1. TV RECORD SEQUENCE COMPLETE SWITCH TO DATA MODE 2 (TV START +24 MIN 48 SEC)	01 02
225	15/0050Z E-15MIN	S/C		1. DC-26 RECEIVED	01 02
226	15/0051Z E-14MIN	S/C		1. DC-2 RECEIVED	01 02
227	15/0101Z E-4MIN	S/C		1. SWITCH TO DATA MODE 2	01 02

7/14/65 MA-64 SEQUENCE PAGE 88

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
228	15/0102Z E-3MIN	BUSS		1. DC-26 OBSERVED	01 02
229	15/0103Z E-2MIN	BUSS		1. DC-2 OBSERVED	01 02
230	15/0105Z E=0MIN	S/C		1. TCA AT S/C	01 02
		BUSS		1. VERIFY SCIENCE ON. REQUEST DSIF STOP TRANSMITTING DC-2. (MAR OPS)	03
		MAR OPS.		1. INITIALIZE 30X30 PLOTTERS IN MSA AND SSAA FOR CRUISE MODE. F-16(1800 SEC/INCH).	04 05
		DISPLAY		1. UPDATE ENCOUNTER CLOCK. 2. START OCCULTATION CLOCK AT OCC-67 MIN (UPDATE CLOCK USING FLIGHT PREDICTS.)	06 07 08
231	15/0115Z E+10MIN	OPS 1		1. RUN AGCM AND DAS1 (RED)	01 02
232	15/0120Z E+15MIN	OPS 1		1. RUN TRAJX TO PREDICT OCCULTATION TIMES FROM LATEST ORBIT. (RED) 1. TRANSMIT PREDICTS TO DSIF 11,12.	01 02
		FPAC/COMM/DPA/TR		1. SEND PREDICTS TO STATIONS 11,12,13.	03
233	15/0130Z E+25MIN	FPAC		1. RUN TRJX.	01 02
234	15/0135Z E+30MIN	42		1. TID BIN BILLA RISE	01 02
235	15/0137Z E+32MIN	42		1. ACQUISITION OF S/C BY DSIF 42 (42)	01 02
236	15/0140Z E+35MIN	TRACK CHIEF		1. REPORT ACQUISITION OF S/C BY DSIF 42.	01 02
237	OCCULTATION-30	11,12		1. START OPEN LOOP RECORDERS	01
238	15/0150Z E+45MIN	11,12,42 GTS/DIS GTS/DIS		1. BEGIN TAKING 1SEC/10SEC DOPPLER 1. STOP PSUEDO REDISUAL PROGRAM, LOAD OPEN LOOP RECEIVER PROGRAM AND COMPUTE OPEN LOOP PREDICTS.	01 02 03

7/14/65 MA-64 SEQUENCE PAGE 89

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
239	15/0153Z E+48MIN	41			1. WOOMERA RISE	01 02
240	15/0158Z E- 0H53M	TRACK CHIEF			1. IF COMMAND CONDITION DOES NOT EXIST INSTRUCT DSIF-11 TO TURN OFF COMMAND MODULATION (11)	01 02
241	15/0200Z E+55MIN	ALL			1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS,RED)	01 02
242		ALL GTS/DIS OPS 1			1. LAST TIME FOR COMMAND TO GET INTO S/C 1. LOAD PSUEDO RESIDUAL PROGRAM. 1. RUN TDP/ODG/ODP (RED)	01 02 03
243	15/0204Z E+59MIN	GTS/DIS			1. START COMPUTATION AND TRANSMISSION OF OCCULTATION RESIDUALS. REMOVE MEAN FROM RESIDUALS. SET S.S.NO.3.	01 02
244	15/0212Z E+67MIN	S/C			1. SPACECRAFT ENTERS OCCULTATION REGION	01 02
245	15/0223Z E+78MIN	11			1. START SANBORN RECORDER AT SPEED OF 10MM/SEC.	01 02
246	15/0224Z E+79MIN	DSIF GTS/DIS 11,12,42			1. LOSS OF RF SIGNAL AT EARTH. NOTE. UPON EXIT FROM OCCULTATION THE COMMAND LOOP WILL NOT BE LOCKED-UP UNLESS A NON-STANDARD CONDITION IS FOUND TO EXIST. IN SUCH AN EVENT, DIRECTIONS WILL BE GIVEN AT THAT TIME. 1. STOP COMPUTATION OF RESIDUALS. 1. STOP TAKING 1SEC/10SEC DATA. 2. TURN OFF TAPE PUNCHES	01 02 03 04 05 06 07
247	15/0225Z	11			1. TX OFF.	01
248	15/0226Z E+81MIN	GTS/DIS			1. REWIND RESIDUAL TAPE + XMIT 1SEC PSUEDO RESIDUALS.	01 02
249	15/0229Z E+84MIN	11,12			1. TURN OFF OPEN LOOP RECORDERS.	01 02

7/14/65 MA-64 SEQUENCE PAGE 90

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
250	15/0230Z E+85MIN		FPAA, GTS/DIS, 11,12,13	1. CHECK FREQUENCIES WITH TDA FOR STATION 13 XA SETTING AND ALL ONE AND TWO WAY RECEIVER SETTINGS CHANGE PAPER TAPE AT 11,12,42 CHANGE OPEN-LOOP RECORDER TAPES AT 11,12.	01 02 03
			OPS. 1	1. PREFORM AO AND USER PROGRAM PROCESSING ON SCIENCE DATA RECEIVED SINCE 1400Z(USE NORMAL CRUISE PROCESSING PROGRAM TAPE).	04 05
				2. TAKE A5 DISC DUMP	06
				3. RUN MARCAM.	07
			13	1. TX ON AT XA FOR 0253Z.	08
251	15/0245Z E+100MIN		TRACK	1. REQUEST DSIF-13 TO TURN ON THE 100KW TRANSMITTER. (13)	01 02
252	15/0302Z E+117MIN		GTS/DIS	1. LOAD OPEN LOOP RECEIVER PROGRAM.	01 02
253	15/0305Z E+120MIN		S/C	1. SPACECRAFT EXISTS OCCULTATION REGION	01 02
254	15/0310Z E+125MIN		OPS 1	1. RUN TRAJX (RED)	01
			GTS/DIS	1. LOAD PSUEDO RESIDUAL PROGRAM	02
255	15/0312Z E+127MIN		11,12	1. START OPEN LOOP RECORDERS.	01 02
256	15/0317Z E+132MIN		11,12,42	1. RF SIGNAL OBSERVED AT EARTH.	01
				2. START DOPPLER PUNCHES AT REACQUISITION OF SIGNAL AT 1SEC-10SEC SAMPLE.	02 03
				3. DSIF ACQUIRES THE SPACE CRAFT 3-WAY.	04
257			GTS/DIS	1. START COMPUTATION AND PLOTTING DOPPLER REDISUALS.	01
			SPACE	1. REPORT ENCOUNTER SCIENCE OFF TO BUSS CHEIF (X)	02
			11	1. REPORT EXACT TIME FROM CDC RECORDINGS OF STATION 11-RECEIVER IN 2WAY LOCK. (11)	03 04
			TRACK	1. REPORT ACQUISITIONS TO SFOD (MAR NET)	05
258	15/0337Z E+152MIN		GTS	1. STOP COMPUTING DOPPLER RESIDUALS AND BEGIN COMPUTING CUMULATIVE DOPPLER RESIDUALS.	01 02
			11,12	1. TURN OFF OPEN OPEN LOOP RECORDERS	03

7/14/65 MA-64 SEQUENCE PAGE 91

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
259	15/0355Z E+170MIN	11,12,41,42			1. STOP TAKING 1SEC/10SEC DOPPLER AND START TAKING 60SEC DOPPLER.	01 02
260	15/0400Z E+175MIN	13,11			1. TRANSFER S/C TWO-WAY TO DSIF 11.	01 02
		OPS. 1			1. PERFORM AD AND USER PROGRAM PROCESSING FOR SCIENCE DATA RECEIVED SINCE 0230Z(DISTRIBUTE BY 0500Z). (RED)	03 04
261	15/0501Z E+236MIN	S/C			1. CC+S MT-8	01 02
262	15/0513Z E+248MIN	BUSS			1. CC+S MT-8 EVENT RECEIVED	01 02
263	15/051351Z E+248MIN 51SEC	BUSS			1. REPORT MT-8 EVENT TO MAR CHIEF. (MAR OPS)	01 02
264 EC	15/0513 52.4Z E+248MIN 52.4S	BUSS			1. MT-8 OBSERVED IN DATA (NOMINAL)	01 02
265	15/0514Z E+249MIN	SFOD TRACK	 CHIEF		1. REPORT MT-8 EVENT TO PROJECT MANAGER. (MAR NET) 1. DIRECT 2WAY TRANSFER TO DSIF-42 (11,42)	01 02
266	15/0520Z E+255MIN	MAR	I/O		1. ENABLE ALL SCIENCE ALARMS.	01 02
267	15/0530Z E+265MIN	TRACK			1. INSTRUCT DSIF 11 TO BEGIN XA CHANGE FOR XA OF TIME 0600Z.	01 02
268	15/0540Z E+275MIN	TRACK			1. REPORT XA CHANGE COMPLETE	01 02
269	15/0600Z E+295MIN	OPS 1			1. RUN TDP/ODG/ODP (RED)	01 02
		TRACK			1. DIRECT TWO-WAY TRANSFER TO 42(11,42)	03
270	15/0624Z E+319MIN	11 TRACK	 CHIEF		1. DSIF-11 LOST S/C ON HORIZON. END OF PASS. 1. REPORT LOSS OF S/C BY DSIF-11 TO MAR CHIEF (MAR OPS,RED)	01 02

7/14/65 MA-64 SEQUENCE PAGE 92

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
271	15/0625Z E+320MIN	TRACK			1. REPORT DSIF 42 TWO -WAY LOCK. (MAR OPS, RED)	01 02
272	15/0630Z E+325MIN	12			1. GOLDSTONE - ECHO SET	01 02
273	15/0800Z E+415MIN	COMM			1. UP 1 TTY WITH 51	01 02
274	15/0810Z E+425MIN	OPS 1			1. RUN TRAJX PROGRAM (RED)	01 02
275	15/0815Z E+430MIN	TRACK			1. INSTRUCT DSIF 42 TO BEGIN XA CHANGE FOR XA OF TIME 1120Z	01 02
276	15/0830Z E+445MIN	COMM			1. UP 1 TTY, VOICE, ANALOG WITH 51	01 02
277	15/0900Z E+475MIN	OPS 1 ALL COMM			1. RUN FLY BY FINE PRINT (RED) 1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS,RED) 1. PATCH DSIF-51 TO BUILDING 168. PRIME STATION SHOULD BE PATCHED TO BUILDING 168 AUTOMATICALLY UNTIL PLAYBACK IS COMPLETE.	01 02 03 04 05
278	15/0910Z E+485MIN	OPS1			1. RUN AGCM PROGRAM. (RED)	01 02
279	15/0930Z E+505MIN	51			1. DSIF-51 HAS ACQUIRED THE S/C. START SENDING RT TRACKING AND T/M TO SFOF VIA TTY. (51)	01 02
280	15/1000Z E+535MIN	OPS 1 COMM			1. RUN TDP/ODG/ODP (RED) 1. UP 1 TTY WITH 61	01 02
281	15/1121Z E+616MIN	TRACK			1. INSTRUCT DSIF-42 TO TURN OFF TRANSMITTER (42)	01 02
282	15/1141Z E+636MIN	S/C			1. CC+S MT-9 AT CY - 1 NO. 83	01 02

7/14/65 MA-64 SEQUENCE PAGE 93

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
283	15/1145Z E+640MIN	BUSS		1. VERIFY 1-WAY LOCK (MAR OPS)	01 02
284	15/1153Z E+648MIN	S/C		1. CC+S MT-9 AT CY-1 (INITIATE TAPE PLAYBACK)	01 02
		BUSS		1. REPORT MT-9 EVENT TO MAR CHIEF (MAR OPS) 2. START PLAYBACK 3. 4-1 DATA	03 04 05
		MAR I/O		1. INSTRUCT DATA CHIEF TO SWITCH TO PROCESSING MODE 1 DATA. (RED)	06
285 EC	15/1153 53.9Z E+648MIN 53.9S	BUSS		1. CYCLIC 83 AND MT-9 OBSERVED IN DATA (NOMINAL)	01 02
286	15/1200Z E+655MIN	OPS 1		1. PERFORM AD AND USER PROGRAM PROCESSING ON SCIENCE DATA RECEIVED SINCE 0400 (DISTRIBUTE BY 1500) LINK STATION SHOULD BE MANNED AND EQUIPMENT ON STANDBY BY 1200. S-C 4020 SHOULD BE MANNED AND ON STANDBY. RANGER PROGRAMMER SHOULD BE IN MSA. (RED) (DELIVER BY 1300)	01 02 03 04 05
287	15/1238Z E+693MIN	MAR CHIEF		1. REQUEST MODE 4 PROCESSING (X)	01 02
288	15/1241Z E+696MIN	S/C		1. MODE 4 DATA AT S/C. START OF PICTURE NO. 1	01 02
289	15/1248Z E+703MIN	42		1. DSIF-42 LOST S/C OVER HORIZON. END OF TRACK.	01 02
290	15/1253Z E+708MIN	BUSS		1. MODE 4 SEEN IN DATA. 1. START OF PIX. 1.	01 02
291	15/1315Z E+730MIN			1. PROCESS MODE 4 DATA TO GIVE DECIMAL AND 4020 DISPLAY	01 02
292	15/1330Z E+745MIN			1. PROCESS MODE 4 DATA TO GIVE DECIMAL AND 4020 DISPLAY.	01 02
		COMM		1. UP 1 TTY, VOICE, ANALOG WITH 61	03

7/14/65 MA-64 SEQUENCE PAGE 94

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
293	15/1345Z E+760MIN			1. PROCESS MODE 4 DATA TO GIVE DECIMAL AND 4020 DISPLAY	01 02
294	15/1352Z E+767MIN	42		1. WOOMERA SET	01 02
295	15/1400Z E+775MIN			1. PROCESS MODE 4 DATA TO GIVE DECIMAL AND 4020 DISPLAY	01 02
296	15/1500Z E+835MIN			1. PROCESS MODE 4 DATA TO GIVE DECIMAL AND 4020 DISPLAY	01 02
297	15/1700Z E+955MIN			1. PROCESS MODE 4 DATA TO GIVE DECIMAL AND 4020 DISPLAY (LINK TAPE MUST BE PREVIOUSLY DEGAUSSED).	01 02
298	15/1900Z E+1075MIN			1. PROCESS MODE 4 DATA TO GIVE DECIMAL AND 4020 DISPLAY.	01 02
299	15/1912Z E+1087MIN	OPS 1		1. RUN AGCM (RED)	01 02
300	15/1932Z E+1107MIN	11		1. DSIF-11 HAS ACQUIRED THE S/C. START RT TRACKING AND T/M TO SFOF VIA TTY.	01 02
301	15/2051Z E+1186MIN	51		1. DSIF-51 LOST S/C OVER HORIGON. END OF TRACK.	01 02
302	15/2120Z E+1215MIN	TRACK		1. INSTRUCT DSIF-11 TO TURN ON THEIR TRANSMITTER (2-WAY DURING MODE 1).	01 02
303	15/2128Z E+1223MIN	BUSS		1. END OF PIX. 1 2. 4-1 DATA.	01 02
304	15/2129Z E+1224MIN	MAR I/O		1. INSTRUCT DATA CHIEF TO PROCESS MODE 1 DATA. (RED) 2. PROCESS MODE 4 DATA TO GIVE DECIMAL AND LINK DISPLAY (LINK TAPE MUST BE PREVIOUSLY DEGAUSSED). 3. LINK FILM SHOULD BE AVAILABLE BEFORE START OF NEXT PICTURE.	01 02 03 04

7/14/65 MA-64 SEQUENCE PAGE 95

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
305	15/2200Z E+1255MIN	ALL		1. ALL STATIONS REPORT STATUS TO MAR CHIEF WITH A GO/NO-GO INDICATION. IF NO-GO GIVE REASON. (MAR OPS)	01 02
306	15/2230Z E+1285MIN	TRACK		1. REQUEST DSIF-11 TO TURN OFF THEIR TRANSMITTER (11)	01 02
307	15/2313Z E+1328MIN	MAR I/O		1. INSTRUCT DATA CHIEF TO PROCESS MODE 1 DATA. (RED)	01 02
308	15/2328Z E+1343MIN	BUSS		1. START OF PICTURE NO. 2 PLAY BACK NOTE. AT THIS POINT IF ALL OPERATIONS ARE NORMAL A SEMI-CRUISE OPERADION WILL BE ESTABLISHED.)	01 02 03
309	16/0000Z E+1375MIN	42 41 51 61 11 12,13		1. RISE 0133, SET 1248 2. RISE 0151, SET 1350 3. RISE 0928, SET 2050 4. RISE 1130, SET 2250 5. RISE 1931, SET 0619 6. RISE 1901, SET 0625	01 02 03 04 05 06
310	16/0803Z E+30H58M	BUSS		1.-END OF PIX. 2 2. 4-1 DATA	01 02
311	16/1003Z E+38H58M	BUSS		1. START OF PIX. 3	01 02
312	16/1838Z E+41H33M	BUSS		1. END OF PIX. 3 2. 4-1 DATA.	01 02
313	16/2038Z E+43H33M	BUSS		1. START OF PIX. 4	01 02
314	17/0000Z E+46H55M	42 41 51 61 11 12,13		1. RISE 0133, SET 1248 2. RISE 0149, SET 1348 3. RISE 0926, SET 2048 4. RISE 1125, SET 2250 5. RISE 1930, SET 0617 6. RISE 1859, SET 0623	01 02 03 04 05 06

7/14/65 MA-64 SEQUENCE PAGE 96

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
315	17/0513Z E+52H8M	BUSS		1. END OF PIX. 4 2. 4-1 DATA.	01 02
316	17/0713Z E+54H8M	BUSS		1. START OF PIX. 5	01 02
317	17/1548Z E+62H43M	BUSS		1. END OF PIX. 5 2. 4-1 DATA.	01 02
318	17/1748Z E+64H43M	BUSS		1. START OF PIX. 6	01 02
319	18/0000Z E+70H55M	42 41 51 61 11 12,13		1. RISE 0128, SET 1244 2. RISE 0147, SET 1346 3. RISE 0924, SET 2046 4. RISE 1125, SET 2245 5. RISE 1929, SET 0615 6. RISE 1857, SET 0620	01 02 03 04 05 06
320	18/0223Z E+73H18M	BUSS		1. END OF PIX. 6 2. 4-1 DATA.	01 02
321	18/0423Z E+75H18M	BUSS		1. START OF PIX. 7	01 02
322	18/0634 08.8Z E+77H29M8.8S	BUSS		1. CYCLIC 84 OBSERVED IN DATA (NOMINAL)	01 02
323	18/1258Z E+83H53M	BUSS		1. END OF PIX. 7 2. 4-1 DATA.	01 02
324	18/1458Z E+85H53M	BUSS		1. START OF PIX. 8	01 02
325	18/2333Z E+94H28M	BUSS		1. END OF PIX. 8 2. 4-1 DATA.	01 02
326	19/0000Z	42		1. RISE 0126, SET 1243	01

7/14/65 MA-64 SEQUENCE PAGE 97

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
358	24/0000Z	42		1. RISE 0116, SET 1235	01
	E+214H55M	41		2. RISE 0137, SET 1336	02
		51		3. RISE 0912, SET 2052	03
		61		4. RISE 1110, SET 2250	04
		11		5. RISE 1920, SET 0605	05
		12,13		6. RISE 1849, SET 0606	06
359	24/0633Z	BUSS		1. END OF PIX. 20	01
	E+221H28M			2. 4-1 DATA.	02
360	24/0833Z	BUSS		1. START OF PIX. 21	01
	E+223H28M				02
361	24/1708Z	BUSS		1. END OF PIX. 21	01
	E+232H03M			2. 4-1 DATA.	02
362	25/0000Z	42		1. RISE 0115, SET 1233	01
	E+238H55M	41		2. RISE 0135, SET 1334	02
		51		3. RISE 0909, SET 2050	03
		61		4. RISE 1110, SET 2250	04
		11		5. RISE 1918, SET 0602	05
		12,13		6. RISE 1848, SET 0604	06
363	26/0000Z	42		1. RISE 0112, SET 1232	01
	E+262H55M	41		2. RISE 0133, SET 1332	02
		51		3. RISE 0907, SET 2048	03
		61		4. RISE 1105, SET 2250	04
		11		5. RISE 1916, SET 0600	05
		12,13		6. RISE 1847, SET 0602	06
364	26/1434 52.9Z	BUSS		1. CYCLIC 87 OBSERVED IN DATA (NOMINAL)	01
	E+277H29M52.9S				02
365	27/0000Z	42		1. RISE 0110, SET 1232	01
	E+286H55M	41		2. RISE 0131, SET 1330	02
		51		3. RISE 0905, SET 2047	03
		61		4. RISE 1105, SET 2245	04
		11		5. RISE 1915, SET 0557	05
		12,13		6. RISE 1846, SET 0559	06

7/14/65 MA-64 SEQUENCE PAGE 101

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
338	20/1953Z	BUSS		1. START OF PIX. 13	01
	E+138H48M				02
339	21/0000Z	42		1. RISE 0122, SET 1240	01
	E+142H55M			2. RISE 0142, SET 1341	02
		51		3. RISE 0917, SET 2041	03
		61		4. RISE 1115, SET 2240	04
		11		5. RISE 1925, SET 0609	05
		12,13		6. RISE 1853, SET 0613	06
340	21/0114 23.6Z	BUSS		1. CYCLIC 85 OBSERVED IN DATA (NOMINAL)	01
	E+144H09M23.6S				02
341	21/0428Z	BUSS		1. END OF PIX. 13	01
	E+147H23M			2. 4-1 DATA.	02
342	21/0628Z	BUSS		1. START OF PIX. 14	01
	E+149H23M				02
343	21/1503Z	BUSS		1. END OF PIX. 14	01
	E+157H58M			2. 4-1 DATA.	02
344	21/1703Z	BUSS		1. START OF PIX. 15	01
	E+159H58M				02
345	22/0000Z	42		1. RISE 0120, SET 1238	01
	E+166H55M	41		2. RISE 0140, SET 1339	02
		51		3. RISE 0915, SET 2039	03
		61		4. RISE 1115, SET 2240	04
		11		5. RISE 1923, SET 0606	05
		12,13		6. RISE 1852, SET 0611	06
346	22/0138Z	BUSS		1. END OF PIX. 15	01
	E+168H35M			2. 4-1 DATA.	02
347	22/0338Z	BUSS		1. START OF PIX. 16	01
	E+170H35M				02

7/14/65 MA-64 SEQUENCE PAGE 99

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
348	22/1213Z	BUSS			1. END OF PIX. 16	01
	E+179H8M				2. 4-1 DATA.	02
349	22/1413Z	BUSS			1. START OF PIX. 17	01
	E+181H8M					02
350	22/2248Z	BUSS			1. END OF PIX. 17	01
	E+189H45M				2. 4-1 DATA.	02
351	23/0000Z	42			1. RISE 0118, SET 1237	01
	E+190H55M	41			2. RISE 0138, SET 1338	02
		51			3. RISE 0913, SET 2038	03
		61			4. RISE 1115, SET 2240	04
		11			5. RISE 1922, SET 0605	05
		12,13			6. RISE 1850, SET 0609	06
352	23/0048Z	BUSS			1. START OF PIX. 18	01
	E+191H45M					02
353	23/0923Z	BUSS			1. END OF PIX. 18	01
	E+200H18M				2. 4-1 DATA.	02
354	23/1123Z	BUSS			1. START OF PIX. 19	01
	E+202H18M					02
355	23/1954 38.5Z	BUSS			1. CYCLIC 86 OBSERVED IN DATA (NOMINAL)	01
	E+210H49M38.5S					02
356	23/1958Z	BUSS			1. END OF PIX. 19	01
	E+210H53M				2. 4-1 DATA.	02
357	23/2158Z	BUSS			1. START OF PIX. 20	01
	E+212H53M					02

7/14/65 MA-64 SEQUENCE PAGE 100

ITEM	TIME	STATION	REPORTED	BY	EVENT	LINE NO.
327	E+94H55M				2. RISE 0145, SET 1345	01
		51			3. RISE 0922, SET 2045	02
		61			4. RISE 1120, SET 2245	03
		11			5. RISE 1927, SET 0613	04
		12,13			6. RISE 1856, SET 0618	05
328	19/0133Z	BUSS			1. START OF PIX. 9	01
	E+96H28M					02
329	19/1008Z	BUSS			1. END OF PIX. 9	01
	E+105H03M				2. 4-1 DATA.	02
330	19/1208Z	BUSS			1. START OF PIX. 10	01
	E+107H03M					02
331	19/2043Z	BUSS			1. END OF PIX. 10	01
	E+115H38M				2. 4-1 DATA.	02
332	19/2243Z	BUSS			1. START OF PIX. 11	01
	E+117H38M					02
333	20/0000Z	42			1. RISE 0124, SET 1242	01
	E+118H55M	41			2. RISE 0144, SET 1343	02
		51			3. RISE 0920, SET 2043	03
		61			4. RISE 1120, SET 2245	04
		11			5. RISE 1926, SET 0611	05
		12,13			6. RISE 1854, SET 0616	06
334	20/0330Z	BUSS			2. TRACK CHANGE	01
	E+122H25M					02
335	20/0718Z	BUSS			1. END OF PIX. 11	01
	E+126H13M				2. 4-1 DATA.	02
336	20/0918Z	BUSS			1. START OF PIX. 12	01
	E+128H13M					02
337	20/1753Z	BUSS			1. END OF PIX. 12	01
	E+136H48M				2. 4-1 DATA.	02

7/14/65 MA-64 SEQUENCE PAGE 98

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
366	28/0000Z	42		1. RISE 0108, SET 1231	01
	E+310H55M	41		2. RISE 0129, SET 1329	02
		51		3. RISE 0903, SET 2045	03
		61		4. RISE 1105, SET 2245	04
		11		5. RISE 1913, SET 0555	05
		12,13		6. RISE 1844, SET 0557	06
367	29/0000Z	42		1. RISE 0107, SET 1230	01
	E+334H55M	41		2. RISE 0128, SET 1327	02
		51		3. RISE 0900, SET 2043	03
		61		4. RISE 1100, SET 2245	04
		11		5. RISE 1911, SET 0553	05
		12,13		6. RISE 1843, SET 0555	06
368	29/0915 07.3Z	BUSS		1. CYCLIC 88 OBSERVED IN DATA (NOMINAL)	01
	E+343H10M7.3S				02
369	30/0000Z	42		1. RISE 0105, SET 1229	01
	E+358H55M	41		2. RISE 0126, SET 1325	02
		51		3. RISE 0858, SET 2041	03
		61		4. RISE 1100, SET 2240	04
		11		5. RISE 1910, SET 0550	05
		12,13		6. RISE 1841, SET 0552	06
370	31/0000Z	42		1. RISE 0103, SET 1228	01
	E+E+382H55M	41		2. RISE 0124, SET 1323	02
		51		3. RISE 0857, SET 2040	03
		61		4. RISE 1055, SET 2240	04
		11		5. RISE 1908, SET 0548	05
		12,13		6. RISE 1840, SET 0550	06
371	8/1/0000Z	42		1. RISE 0100, SET 1227	01
	E+406H557	41		2. RISE 0123, SET 1322	02
		51		3. RISE 0854, SET 2038	03
		61		4. RISE 1055, SET 2240	04
		11		5. RISE 1907, SET 0546	05
		12,13		6. RISE 1838, SET 0548	06

7/14/65 MA-64 SEQUENCE PAGE 102

ITEM	TIME	STATION	REPORTED BY	EVENT	LINE NO.
372	1/0355 21.8Z	BUSS		1. CYCLIC 89 OBSERVED IN DATA (NOMINAL)	01
	E+410H50M21.8S				02
373	8/2/0000Z	42		1. RISE 0058, SET 1226	01
	E+430H55M	41		2. RISE 0121, SET 1320	02
		51		3. RISE 0852, SET 2036	03
		61		4. RISE 1050, SET 2235	04
		11		5. RISE 1906, SET 0543	05
		12,13		6. RISE 1837, SET 0545	06
374	8/3/0000Z	42		1. RISE 0056, SET 1225	01
	E+454H55M	41		2. RISE 0119, SET 1318	02
		51		3. RISE 0849, SET 2034	03
		61		4. RISE 1050, SET 2235	04
		11		5. RISE 1904, SET 0541	05
		12,13		6. RISE 1836, SET 0543	06
375	8/4/0000Z	42		1. RISE 0053, SET 1224	01
	E+478H55M	41		2. RISE 0117, SET 1316	02
		51		3. RISE 0848, SET 2033	03
		61		4. RISE 1050, SET 2235	04
		11		5. RISE 1902, SET 0539	05
"		12			06
				6. RISE 1834, SET 0541	07

7/14/65 MA-64 SEQUENCE PAGE 103