NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MARINER MARS 1964 HANDBOOK

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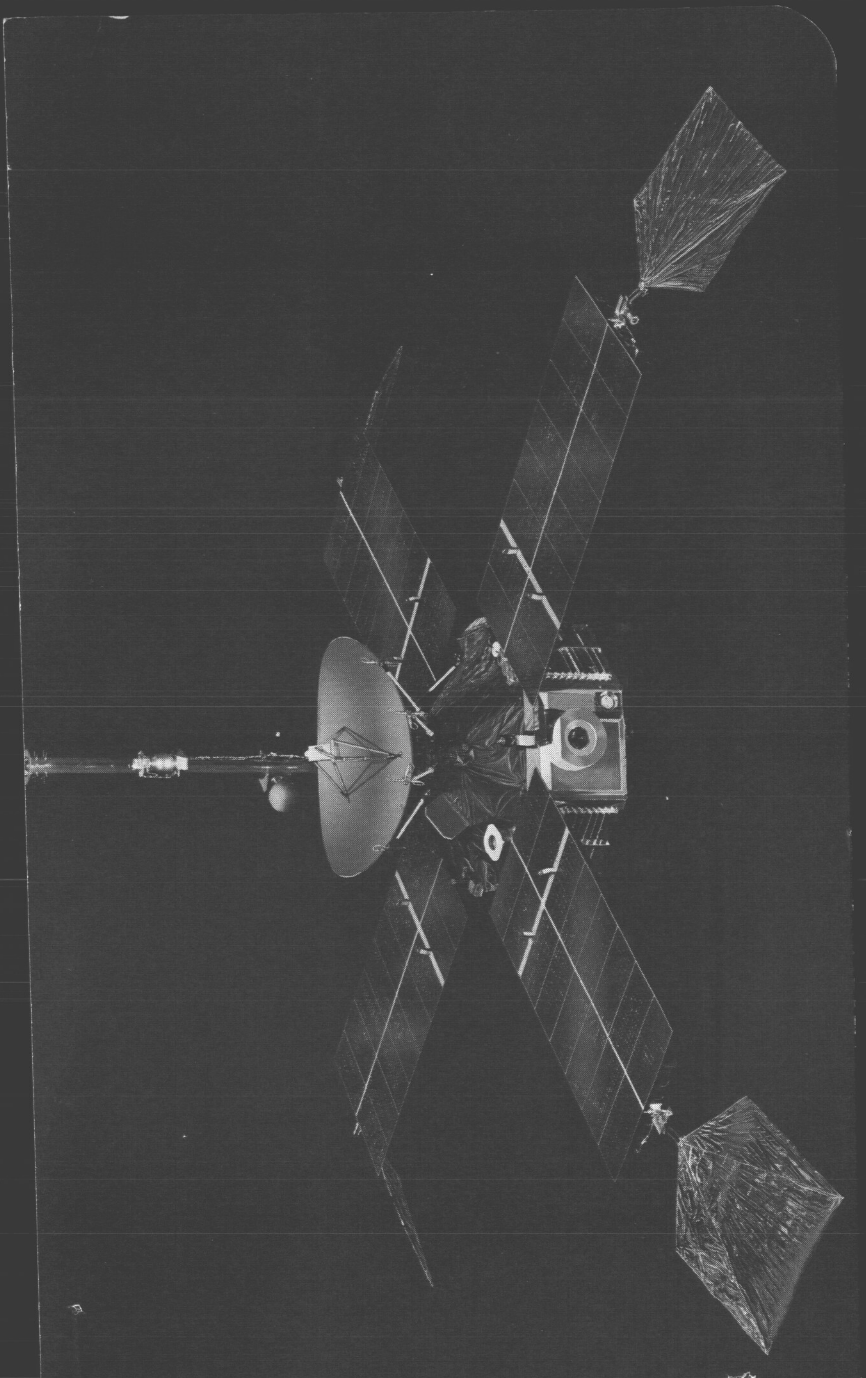

Preface

This book presents a compilation of significant technical data relative to Mariner Mars 1964. Its purpose is to collect, in one location, a wide variety of statistical information that would otherwise be scattered throughout a large number of miscellaneous documents. The information presented here pertains primarily to the Mariner spacecraft, itself; it does not include the Launch Vehicle System, the ground support equipment, the Deep Space Network System, or other areas of the total Mariner Mars 1964 project.

The primary Mariner Mars 1964 mission is considered in this book to have ended on October 1, 1965. Historical data are carried only to that date, although some orbital parameters are projected to 1967 and 1971 in the tables and figures.

It is expected that the user of this handbook will have some familiarity with the terminology, operational procedures, and engineering concepts related to an interplanetary spacecraft project and, specifically, to the Mariner Mars 1964 project. The handbook's function is more to remind those who already know than to instruct those who don't.

A list of documents pertaining to the Mariner Mars 1964 mission is included (Table 25) for reference purposes. The list is complete as of the publication date of this handbook, but many articles and reports are still being prepared and will continue to be published for some time to come.

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TABLES

FIGURES

FIGURES (Cont'd)

ABSORPTIVITY STANDARD

reference designation of subsystem	11FM1
reflective properties (α/ϵ)	
aluminum silicone sample	0.89
black sample	1.04
polished aluminum sample	5.0
white sample	0.28
resistors, number of in each sample	13
samples	
number of	4
types of	black, white, aluminum silicone, polished aluminum
surfaces	
aluminum silicone sample	UC11659
black sample	Cat-a-lac
polished aluminum sample	aluminum
white sample	ARF-2
temperature	
history (see Figs. 10 through 13)	
measurement accuracy	within 0.2 °F
steps measured per sample	12
weight	approx. 1 lb

ACQUISITION (see Sun Acquisition, Star Acquisition)

ALBEDO (see Mars)

ALPHA PARTICLES (see Scientific Data, Cosmic Ray Telescope)

ALTITUDE

above Mars at closest approach	9,846.6 km 6,118.4 mi
above Mars during encounter sequence (see Fig. 39)	
above Earth and Mars during mission (see Table 3)	
above Mars at closest approach prior to midcourse maneuver	249,452 km 155,009 mi

ANTENNA (see High-Gain Antenna, Low-Gain Antenna)

APHELION (see Orbit Data)

ASTRONOMICAL UNIT (see Orbit Data)

ATMOSPHERE, MARTIAN (see Scientific Data)

ATTITUDE CONTROL (see also Canopus Tracker, Earth Detector, Gyro Control System, Solar Vanes, Solar Sensors)

electrical components, number of (see Table 9)	1397
electronics, location of	Bay VII
flight nozzle thrust levels (at 15 psi)	
pitch and yaw	2.32×10^{-3} lb
roll	3.90×10^{-3} lb
gas	
consumption near Earth	0.00376 lb/day
consumption near Mars	0.00338 lb/day
lifetime remaining at end of mission	3.16 yr
pressure vessel, diameter	9 in.
pressure vessel designed nitrogen capacity (2 each)	2.50 lb
pressurization in vessels	2500 psi ±300 psi @ 70°F
weight at launch	5.18 lb
weight at end of mission	4.08 lb
weight consumed during mission	1.10 lb
weight vs time (see Fig. 26)	
gas jets	
number of	12
location of (see Fig. 3)	
gas valve	
response time to open	5 msec
response time to close	5 msec
valve inlet pressure	15 psi
gyro operation time after Canopus sensor acquires an object	200 sec
pitch and yaw	
deadband (observed)	±8.6 mrad
rate increment (observed)	±18.4 μrad/sec
reference designations of subassemblies (see Table 8)	
roll	
commanded roll searches, number performed (DC-21)	15
deadband observed	±4.5 mrad
rate increment, observed	±14.0 μrad/sec
roll searches, total number performed	25
roll transients, total number observed from DC-15 to encounter	40

ATTITUDE CONTROL (Cont'd)

roll rate	
magnetometer calibration	3.5 mrad/sec
Canopus search	2.0 mrad/sec
star acquisition diagram (see Fig. 9)	
star acquisition sequences	
first sequence	Markab, Regulus, Naos, Gamma Velorum, Canopus
after aborted midcourse maneuver	5 non-Canopus stars, Regulus, Naos, Canopus
after successful midcourse maneuver	Gamma Velorum, Canopus
after loss of Canopus	Gamma Velorum
after loss of Gamma Velorum	Canopus
thrust levels (see flight nozzle, above)	
weight, subsystem	63.29 lb

BATTERY (see Power)

BAYS, SUBSYSTEM LOCATIONS IN

attitude control and central computer and sequencer	Bay VII
data encoder and command subsystem	Bay IV
power	Bay I
power regulator and battery	Bay VIII
propulsion	Bay II
RF communications	Bay VI
RF communications (transmitter)	Bay V
RF communications (receiver) and tape recorder	
scientific equipment and data automation system	Bay III

BIBLIOGRAPHY (see Table 25)

BIT RATE

capability	33-1/3 and 8-1/3 bps
at launch	33-1/3 bps
changeover to 8-1/3 bps (see MT-6)	

BLACK SPACE PICTURE SEQUENCE

date	30 Aug 1965
time	20:30:00
day of flight	275
communication time (one way)	15 min 56 sec
Earth–probe–Sun angle	33.4 deg

BLACK SPACE PICTURE SEQUENCE (Cont'd)

Canopus–probe–Sun angle	77.6 deg
spacecraft celestial longitude	248.8 deg
spacecraft celestial lattitude	0.95 deg
Earth celestial longitude	336.4 deg
Mars celestial longitude	251.7 deg
spacecraft distance from Earth	274,250,430 km 170,419,217 mi
spacecraft distance from Mars	17,846,073 km 11,089,036 mi
spacecraft distance from Sun	235,311,890 km 146,222,808 mi
distance traveled along heliocentric arc	614,017,547 km 381,614,386 mi
spacecraft velocity relative to Earth	80,469.2 mph
spacecraft velocity relative to Mars	10,370.4 mph
spacecraft velocity relative to Sun	48,310.2 mph
commands sent, number of	11
pictures recorded, number of	10-1/2
pictures played back, number of	5

BOOSTER REGULATORS (see Power)

CANOPUS ACQUISITION (see Attitude Control, Canopus Tracker)

CANOPUS–PROBE–SUN ANGLE

midcourse maneuver	102.2 deg
changeover to traveling wave tube amplifier	103.1 deg
DC-15 Canopus gate override event	103.5 deg
MT-6 changeover to 8-1/3 bps	104.1 deg
cover drop event	101.4 deg
MT-1 Canopus cone angle update	99.3 deg
MT-5 changeover to high-gain antenna	98.5 deg
MT-2 Canopus cone angle update	94.5 deg
MT-3 Canopus cone angle update	89.8 deg
MT-4 Canopus cone angle update	85.3 deg
closest approach	82.2 deg
black space picture sequence	77.6 deg
end of mission	75.3 deg
from end of mission through 1971 (see Fig. 47)	

CANOPUS TRACKER

cone angle at launch (preset)	100.2 deg
cone angle change increment	4.6 deg
cone angle limits	75 to 105 deg

CANOPUS TRACKER (Cont'd)

cone angle updates (see also MT-1, MT-2, MT-3, MT-4 major headings)	
MT-1 (27 February 1965)	95.7 deg
MT-2 (2 April 1965)	91.1 deg
MT-3 (7 May 1965)	86.5 deg
MT-4 (10 June 1965)	82.0 deg
Option 1, DC-17 (27 August 1965)	77.8 deg
electrical components, number of	289
electron aperture dimensions	0.160 × 0.012 in.
field of view	
cone direction	11 deg
clock direction	4 deg
excursion of cone field of view	34 deg
focal length	0.8 in.
high-gate limit	8 × Canopus brightness
high voltage value at Canopus intensity	1000 v
light level required for 0.04 × Canopus	0.21 ft-c
linear range	±0.85 deg
null accuracy	0.125 deg
power required	1.45 w
reference designation of unit	7CS8
roll search rate of spacecraft for star acquisition	0.116 deg/sec
scale factor	8 v/deg ±20%
sensitivity threshold	0.04 × Canopus brightness
speed	
effective	f/1.0
geometric	f/0.6
weight	5.30 lb

CAVITY AMPLIFIER (see Radio)

CELESTIAL LATITUDE, MARINER IV

midcourse maneuver	1.31 deg
changeover to traveling wave tube amplifier	3.22 deg
DC-15 Canopus gate override event	4.21 deg
MT-6 changeover to 8-1/3 bps	7.63 deg
cover drop event	0.12 deg
MT-1 Canopus cone angle update	0.13 deg
MT-5 changeover to high-gain antenna	0.13 deg
MT-2 Canopus cone angle update	0.12 deg
MT-3 Canopus cone angle update	0.10 deg
MT-4 Canopus cone angle update	7.23 deg
closest approach	4.56 deg

CELESTIAL LATITUDE, MARINER IV (Cont'd)

black space picture sequence	0.95 deg
end of mission	1.5 deg
from end of mission through 1966 (see Table 4)	
through 1971 (see Fig. 40)	

CELESTIAL LONGITUDE, EARTH

injection	66.4 deg
midcourse maneuver	73.6 deg
changeover to traveling wave tube amplifier	81.6 deg
DC-15 Canopus gate override event	85.9 deg
MT-6 changeover to 8-1/3 bps	103.0 deg
cover drop event	142.4 deg
MT-1 Canopus cone angle update	158.8 deg
MT-5 changeover to high-gain antenna	164.8 deg
MT-2 Canopus cone angle update	192.6 deg
MT-3 Canopus cone angle update	226.8 deg
MT-4 Canopus cone angle update	263.2 deg
closest approach	292.4 deg
black space picture sequence	336.4 deg
end of mission	7.6 deg
from end of mission through 1966 (see Table 4)	

CELESTIAL LONGITUDE, MARINER IV

injection	66.4 deg
midcourse maneuver	74.3 deg
changeover to traveling wave tube amplifier	83.0 deg
DC-15 Canopus gate override event	87.6 deg
MT-6 changeover to 8-1/3 bps	105.0 deg
cover drop event	140.0 deg
MT-1 Canopus cone angle update	152.5 deg
MT-5 changeover to high-gain antenna	156.9 deg
MT-2 Canopus cone angle update	175.2 deg
MT-3 Canopus cone angle update	195.0 deg
MT-4 Canopus cone angle update	213.8 deg
closest approach	227.8 deg
black space picture sequence	248.8 deg
end of mission	263.4 deg
from end of mission through 1966 (see Table 4)	
through 1971 (see Fig. 46)	

CELESTIAL LONGITUDE, MARS

launch	124.4 deg
midcourse maneuver	127.5 deg
changeover to traveling wave tube amplifier	131.0 deg
DC-15 Canopus gate override event	132.9 deg

CELESTIAL LONGITUDE, MARS (Cont'd)

MT-6 changeover to 8-1/3 bps	140.3 deg
cover drop event	157.3 deg
MT-1 Canopus cone angle update	164.4 deg
MT-5 changeover to high-gain antenna	167.0 deg
MT-2 Canopus cone angle update	179.4 deg
MT-3 Canopus cone angle update	195.1 deg
MT-4 Canopus cone angle update	212.9 deg
closest approach	227.8 deg
black space picture sequence	251.7 deg
end of mission	269.6 deg

CENTER OF GRAVITY (see Spacecraft)

CENTRAL COMPUTER AND SEQUENCER

basic timing frequency output	38.4 kc
central clock oscillator	
frequency	307.2 kc
frequency error during flight (see Fig. 25)	
frequency stability	±0.01% @ −10 to +75°C
command descriptions (see Table 20)	
commands	
launch phase	L-1 through L-3
midcourse maneuver phase	M-1 through M-7
cruise phase	MT-1 through MT-9
midcourse maneuver turn timing	TM2-B
cyclic, every 66-2/3 hr	CY-1
commands, number of	21
cyclics, number of as of end of mission	111
electrical components, number of (see Table 9)	2574
frequency outputs	38.4 kc, 1 pulse/ 66-2/3 hr
location on spacecraft	Bay VII
operation time, prelaunch	650 hr
operating temperature range (FA temperatures)	14 to 167°F
power required (2.4-kc square wave)	
during boost	11 w
during cruise	5.5 w
reference designations of subassemblies (see Table 8)	
voltages required for operation	
input (2.4-kc square wave)	50 v ac ±20%
internal dc voltages	65 vdc ±20%, 28 vdc ±20%, 16 vdc ±20%

CENTRAL COMPUTER AND SEQUENCER (Cont'd)

weight (see also Table 10)	11.38 lb

CHRONOLOGY (see Dates, Event Times)

CLOCK (see Central Computer and Sequencer)

CLOCK ANGLE

explanation of (see Fig. 4)
Earth clock angle through 1971 (see Fig. 43)

CLOSEST APPROACH TO MARS (see also Encounter)

date	15 Jul 1965
day of flight	228
time	01:00:58
communication time (one way)	12 min, 1.5 sec
Earth–probe–Sun angle	39.4 deg
Canopus–probe–Sun angle	82.2 deg
spacecraft celestial longitude	227.8 deg
spacecraft celestial lattitude	4.56 deg
Earth celestial longitude	292.4 deg
Mars celestial longitude	227.8 deg
spacecraft distance from Earth	216,303,650 km 134,411,080 mi
spacecraft distance from Sun	232,500,420 km 144,475,760 mi
distance traveled along heliocentric arc	524,373,100 km 325,900,000 mi
spacecraft distance from center of Mars	13,200.6 km 8,202.4 mi
spacecraft altitude above Martian surface	9,846.6 km 6118.4 mi
spacecraft velocity relative to Earth	66,732.4 mph
spacecraft velocity relative to Mars	11,379.0 mph
spacecraft velocity relative to Sun	47,479.1 mph

COGNIZANT ENGINEERS AND SCIENTISTS (see Personnel)

COMMAND SUBSYSTEM

command bit rate	1 bps
command format (see Fig. 15)	
location on spacecraft	Bay IV
number of bits per command word	26
number of direct commands (DC)	29
electrical components, number of (see Table 9)	2787
number of quantitative commands (QC)	1

COMMAND SUBSYSTEM (Cont'd)

number of significant bits per DC command	9
number of significant bits per QC command	26
power required, nominal	<2.50 w
reference designations of subassemblies (see Table 8)	
subsystems using commands	
attitude control	8
central computer and sequencer (includes QC commands)	4
data automation system	2
data encoder	6
power	4
pyrotechnic	5
radio	6
video storage	1
total (Note: some commands have multiple destinations)	36
weight (see Table 10)	10.12 lb

COMMANDS

command descriptions (see Tables 21 and 22)	
number of commands sent as of end of mission	
total	79
QC commands (Note: QC1-1, -2, and -3 are considered as one QC command)	3
DC commands	76
to establish first Canopus lock	3
during aborted midcourse maneuver	5
to reestablish Canopus lock	10
during midcourse maneuver	4
to reestablish Canopus lock	2
during changeover to traveling wave tube amplifier	1
during Canopus gate override event	1
during cover drop event	12
during encounter	11
to reestablish cruise mode after picture playback	3
during aborted black space picture sequence	12
during maneuver inhibit sequence	2
for final (optional) cone angle update	1
during black space picture sequence and playback	11
to end mission	1

COMMANDS (Cont'd)

number of commands sent, by function

DC-2	21
DC-3	3
DC-4	1
DC-7	1
DC-12	1
DC-13	2
DC-14	2
DC-15	1
DC-16	2
DC-17	1
DC-21	15
DC-22	1
DC-24	3
DC-25	4
DC-26	8
DC-27	2
DC-28	6
DC-29	2

command sequences (Note: repetitive transmissions are not shown)

to establish or reestablish Canopus lock	DC-21
aborted midcourse maneuver	QC-1, DC-29, DC-14, DC-27, DC-13, DC-21
midcourse maneuver	QC-1, DC-29, DC-14, DC-27, DC-21
changeover to traveling wave tube amplifier	DC-7
Canopus gate override event	DC-15
cover drop event	DC-3, DC-2, DC-26, DC-2, DC-28, DC-25, DC-24, DC-28, DC-3, DC-2, DC-26, DC-2
encounter	DC-25, DC-24, DC-3, DC-16, DC-26, DC-2
return to cruise mode after picture playback	DC-28, DC-26, DC-2
aborted black space picture sequence	DC-25, DC-28, DC-26, DC-2
maneuver inhibit sequence	DC-13, QC-1
final (optional) cone angle update	DC-17

COMMANDS (Cont'd)

command sequences (cont'd)	
black space picture sequence and playback	DC-25, DC-3, DC-24, DC-16, DC-2, DC-26, DC-22, DC-4, DC-28, DC-26, DC-2
end of mission	DC-12
Mariner III commands	
number of DC commands sent	11
number of QC commands sent	2

COMMUNICATION (see also Radio, Telemetry)

world record for communication distance set at end of mission	307,342,393 km 191,014,539 mi
66-million mile communication record exceeded	29 Apr 1965

COMMUNICATION TIMES, ONE WAY

midcourse maneuver	3.35 sec
changeover to traveling wave tube amplifier	13.8 sec
DC-15 Canopus gate override event	17.7 sec
MT-6 changeover to 8-1/3 bps	33.2 sec
cover drop event	1 min, 29 sec
MT-1 Canopus cone angle update	2 min, 7 sec
MT-5 changeover to high-gain antenna	2 min, 25 sec
MT-2 Canopus cone angle update	4 min, 0 sec
MT-3 Canopus cone angle update	6 min, 31 sec
MT-4 Canopus cone angle update	9 min, 34 sec
closest approach	12 min, 1.5 sec
maneuver inhibit sequence	15 min, 40 sec
black space picture sequence	15 min, 56 sec
end of mission	17 min, 6 sec

COMPUTER (see Central Computer and Sequencer)

CONE ANGLE (see Figs. 4 and 8)

Canopus cone angle during flight (see Canopus–Probe–Sun Angle)
Canopus cone angle through 1971 (see Fig. 47)
Earth cone angle through 1971 (see Fig. 42)
update events (see MT-1, MT-2, MT-3, MT-4, major headings)
update mechanics (see Canopus Tracker)

CONJUNCTION (see Orbit Data)

CONTRACTORS (see Table 24)

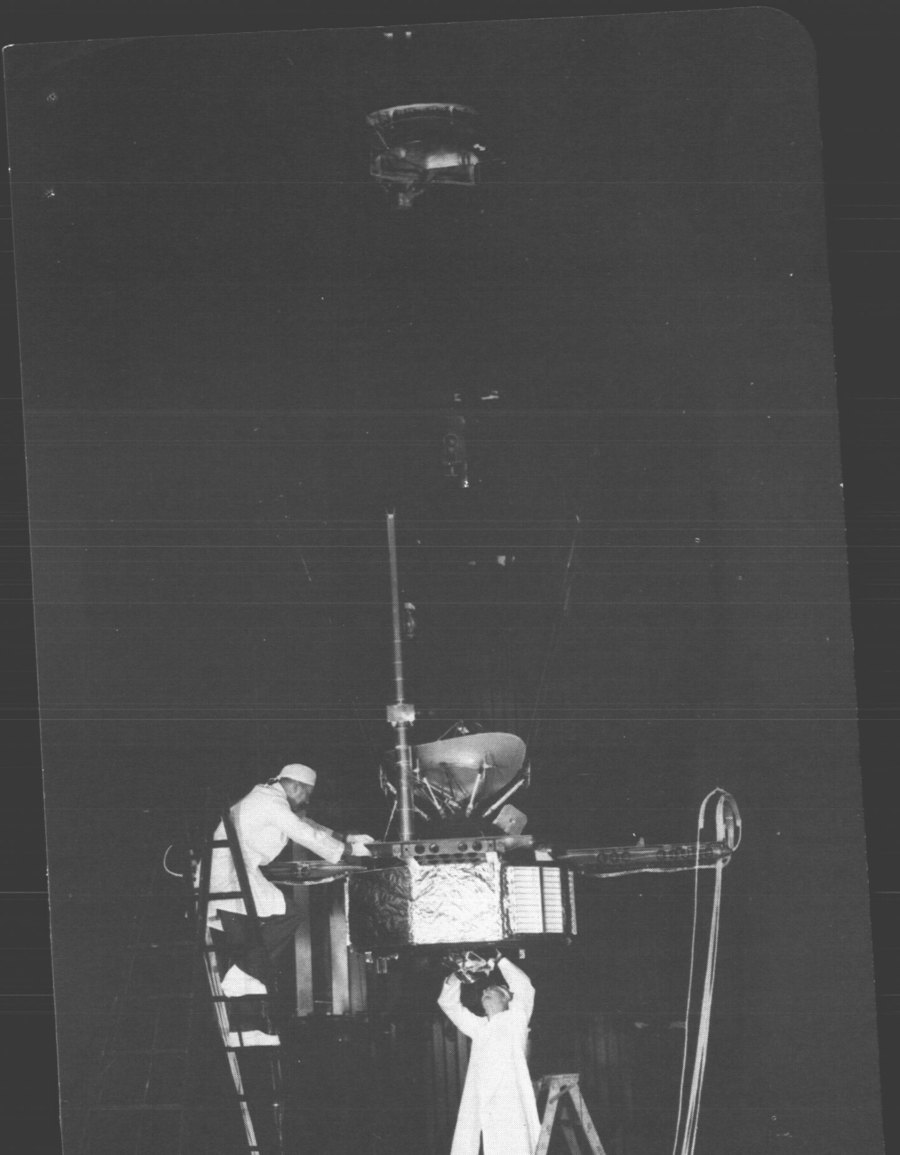
COSMIC DUST DETECTOR

detection levels, number of	8
distance beyond Earth's orbit at peak activity	approx. 58 million km approx. 36 million mi
electrical components, number of (see Table 9)	721
equivalent sensitivity	
detection of particles with masses	$>10^{-13}$ gm
at velocities of	>2 km/sec
look angles	
cone direction	90 and 270 deg
clock direction	90 and 270 deg
microphone threshold	$6 \pm 0.7 \times 10^{-5}$ dyne sec
particle momentum, minimum measurable	1.96×10^{-3} dyne sec
plate dimensions	22×22 cm
power required	0.23 w
reference designation of instrument	24A1
scientific results (see Scientific Data)	
sensors, number of	2
spacecraft celestial longitude at period of peak activity	190 deg
thickness of plate	0.030 in.
time of peak activity during flight	40 days before encounter
total number of hits recorded (to end of mission)	approx. 235
weight (see Table 10)	2.10 lb

COSMIC RAY TELESCOPE

counting rate	
detector D_1	approx. 3 counts/sec
double coincidence rate	approx. 1.8 counts/min
triple coincidence rate	approx. 2.5 counts/min
electrical components, number of (see Table 9)	1196
electron penetration	>40 kev

Mariner IV is tested in the Jet Propulsion Laboratory space simulator before being committed to launch.



COSMIC RAY TELESCOPE (Cont'd)

field of view, detectors D_1 and D_2	20 deg half-angle cone
geometrical factor, detector D_1	4 cm^2 sterad
look angle, cone direction	180 deg
maximum operating temperature of detectors	50°C
measurement ranges	
protons and alpha particles	1 to 170 Mev/nucleon
alpha particles	>180 Mev/nucleon
noise level	30 kev
number of detectors	3
power required	0.598 w
reference designation of instrument	21A1
scientific results (see Scientific Data)	
surface area of detectors D_1 and D_2	2.4 cm^2
surface area of detector D_3	5 cm^2
weight (see Table 10)	2.58 lb
window thickness, all detectors	500 μ

COST INFORMATION

(**NOTE**: JPL costs include current plans for FY 66 and FY 67. Data do not include possible 1967 reacquisition. Launch vehicle and DSN support estimates are provided by NASA. Information included here is not absolutely precise, due to varying cost collection methods.)

spacecraft, operational support equipment, operations, data reduction, analyses, and reports (including \$83.8 million to JPL and \$0.6 million to GSFC and other Centers for scientific experiments and analyses).	\$84.4 million
launch vehicles (Lewis Research Center)	\$25.1 million
Note: The cost of GSFC launch operations, non-JPL AFETR operations, and applicable non-procurement expenses at other Centers are not known.	
DSN support, tracking, and operations (Office of Tracking and Data Acquisition estimate)	\$15.5 million
total mission cost	\$125.0 million
cost per mile to end of mission; \$125 million/418,749,386 mi	<30¢
cost per data bit; \$125 million/325.5 million bits (assuming 7 bits/measurement)	<39¢
cost per measurement; \$125 million/46.5 million measurements	<\$2.69

COVER DROP

date	11 Feb 1965
day of flight	75
time	03:29:29 to 10:49:35
communication time (one way)	1 min 29 sec
Earth–probe–Sun angle	13.2 deg
Canopus–probe–Sun angle	101.4 deg
spacecraft celestial longitude	140.0 deg
spacecraft celestial lattitude	0.12 deg
Earth celestial longitude	142.4 deg
Mars celestial longitude	157.3 deg
spacecraft distance from Earth	26,608,046 km 16,534,239 mi
spacecraft distance from Sun	173,451,360 km 107,782,670 mi
spacecraft distance from Mars	98,233,187 km 61,039,272 mi
distance traveled along heliocentric arc	203,333,481 km 126,372,580 mi
spacecraft velocity relative to Earth	16,146.5 mph
spacecraft velocity relative to Mars	32,593.7 mph
spacecraft velocity relative to Sun	64,646.3 mph
number of commands sent	12
command sequence (see Commands)	
total time for exercise	7 hr, 20 min, 6 sec

CRUISE MODE

mode designation	Data Mode 2
engineering measurements, number per data frame	140
scientific measurements, number per data frame	280
interruptions of cruise mode	
midcourse maneuver, 5 December 1964	1 hr, 41 min
cover drop, 11 February 1965	7 hr, 20 min
encounter, 14-15 July 1965	2 hr, 21 min
picture playback, 15 July to 3 August 1965	15 hr, 54 min
pictures of black space, 30 August to 2 September 1965	9 hr, 19 min
total cruise mode interruption time (to end of mission)	36 hr, 35 min
total time in cruise mode (to end of mission)	7,338 hr
time between data samples (see Table 20)	

CYCLICS

first event seen in data (29 November 1964)	16:59:10
frequency of cyclic events	every 66-2/3 hr
last event seen in data (1 October 1965)	06:39:58
total number of cyclic events	111

DATA (see Telemetry)

DATA AUTOMATION SUBSYSTEM

electrical components, number of (includes 382 components in analog/pulse width converters; see Table 9)	13,727
location on spacecraft	Bay III
power required	
average cruise	6.5 w
average encounter	5.6 w
peak encounter	8.0 w
reference designations of subassemblies (see Table 8)	
telemetry format (see Figs. 16 through 19)	
weight (see Table 10)	11.78 lb

DATA ENCODER SUBSYSTEM

bits, number of in binary word outputs	7
commutator channels, number of	100
electrical components, number of (see Table 9)	7413
location on spacecraft	Bay IV
power required	5.2 w
reference designations of subassemblies (see Table 8)	
telemetry commutation (see Fig. 22)	
telemetry format (see Telemetry)	
time between samples (see Table 20)	
weight (see Table 10)	22.43 lb

DATA MODES (see Telemetry)

DATES (see also Event Times, Time Spans)

first consideration of a Mariner Mars mission	14 May 1962
official go-ahead received from NASA	5 Nov 1962
NASA quarterly review of project	14 Aug 1963
NASA quarterly review of project	14 Nov 1963
blanket freeze on entire spacecraft design	6 Jan 1964
NASA quarterly review of project	25 Feb 1964
first use of project P-List	6 May 1964

DATES (see also Event Times, Time Spans) (Cont'd)

NASA quarterly review of project	18 May 1964
occultation experiment approved	15 Jun 1964
NASA Headquarters review	23 Jul 1964
Mariner III shipped to AFETR	23 Aug 1964
NASA Headquarters review	25 Aug 1964
Mariner IV shipped to AFETR	10 Sept 1964
President Johnson's visit to AFETR	15 Sept 1964
NASA launch readiness review	7 Oct 1964
Mariner III launch	5 Nov 1964
begin all-metal shroud effort	11 Nov 1964
first all-metal shroud flown to AFETR	22 Nov 1964
Mariner IV mated to Agena D	24 Nov 1964
Mariner IV launch	28 Nov 1964
first Canopus acquisition	30 Nov 1964
first midcourse maneuver attempt	4 Dec 1964
midcourse maneuver	5 Dec 1964
solar plasma probe failure	6 Dec 1964
changeover to traveling wave tube amplifier	13 Dec 1964
DC-15 Canopus gate override event	17 Dec 1964
MT-6 changeover to 8-1/3 bps	3 Jan 1965
Sun–spacecraft opposition (to within 1 deg)	28 Jan 1965
cover drop event	11 Feb 1965
NASA quarterly review of project	23 Feb 1965
MT-1 Canopus cone angle update	27 Feb 1965
MT-5 changeover to high-gain antenna	5 Mar 1965
ionization chamber failure	17 Mar 1965
MT-2 Canopus cone angle update	2 Apr 1965
66-million mile communication record exceeded	29 Apr 1965
position in space farther from Sun than any other live spacecraft reached (132.7 million miles)	4 May 1965
MT-3 Canopus cone angle update	7 May 1965
NASA quarterly review of project	25 May 1965
MT-4 Canopus cone angle update	14 June 1965
encounter with Mars	15 Jul 1965
picture playback start	15 Jul 1965
end of first picture playback sequence	24 Jul 1965
second picture playback sequence start	24 Jul 1965
White House press conference and awards	29 Jul 1965
NASA quarterly reveiw of project	2 Aug 1965
end of second picture playback sequence	3 Aug 1965
aborted black space picture sequence	21 Aug 1965
maneuver inhibit sequence	26 Aug 1965
aphelion of heliocentric orbit	26 Aug 1965

DATES (see also Event Times, Time Spans) (Cont'd)

option 1 Canopus cone angle update (DC-17)	27 Aug 1965
black space picture sequence	31 Aug 1965
return to Data Mode 2 after black space pictures	2 Sept 1965
end of mission (DC-12)	1 Oct 1965
NASA quarterly review of project	28 Oct 1965
maximum Earth–spacecraft range	3 Jan 1966
Sun–spacecraft conjunction	1 Apr 1966
perihelion of heliocentric orbit	5 Jun 1966
first completed trip around Sun	6 Jun 1966
aphelion of heliocentric orbit	22 Mar 1967
Sun–spacecraft opposition	15 Aug 1967
closest approach to Earth	8 Sept 1967
perihelion of heliocentric orbit	25 Dec 1967

DC-15 CANOPUS GATE OVERRIDE EVENT

date	17 Dec 1964
day of flight	19
time	17:30:00
communication time (one way)	17.7 sec
Earth–probe–Sun angle	51.8 deg
Canopus–probe–Sun angle	103.5 deg
spacecraft celestial longitude	87.6 deg
spacecraft celestial lattitude	4.21 deg
Earth celestial longitude	85.9 deg
Mars celestial longitude	132.9 deg
spacecraft distance from Earth	5,300,071 km 3,293,464 mi
spacecraft distance from Sun	150,353,950 km 93,429,944 mi
spacecraft distance from Mars	177,567,240 km 110,335,170 mi
distance traveled along heliocentric arc	56,295,412 km 34,987,826 mi
spacecraft velocity relative to Earth	6,957.5 mph
spacecraft velocity relative to Mars	54,338.0 mph
spacecraft velocity relative to Sun	73,181.5 mph

DEIMOS (see Mars)

DETECTORS (see Canopus Tracker, Earth Detector)

DIMENSIONS

spacecraft height, overall	9.5 ft
spacecraft span with solar panels extended	22.5 ft
width of octagon (at points)	54.5 in.

DIPOLE MOMENT OF EARTH	8.06×10^{25} gauss/cm^3

DIPOLE MOMENT OF MARS (see Scientific Data)

DISTANCE OF MARINER IV FROM EARTH

weekly intervals during flight (see Table 3)	
midcourse maneuver	2,022,244 km 1,256,622 mi
changeover to traveling wave tube amplifier	4,158,654 km 2,584,188 mi
DC-15 Canopus gate override event	5,300,071 km 3,293,464 mi
MT-6 changeover to 8-1/3 bps	9,914,631 km 6,160,952 mi
cover drop event	26,608,046 km 16,534,239 mi
MT-1 Canopus cone angle update	38,281,029 km 23,787,831 mi
MT-5 changeover to high-gain antenna	43,383,627 km 26,958,585 mi
MT-2 Canopus cone angle update	73,300,692 km 45,549,050 mi
MT-3 Canopus cone angle update	117,544,150 km 73,041,934 mi
MT-4 Canopus cone angle update	172,429,480 km 107,146,670 mi
closest approach	216,303,650 km 134,401,000 mi
black space picture sequence	274,250,430 km 170,419,217 mi
end of mission	307,415,414 km 191,059,922 mi
from end of mission through 1966 (see Table 4)	
from end of mission through 1971 (see Fig. 41)	
at 1967 closest approach, 8 September 1967	46,946,445 km 29,172,521 mi

DISTANCE OF MARINER IV FROM CENTER OF MARS (see also Altitude)

launch	208,700,000 km 130,000,000 mi
midcourse maneuver	197,286,320 km 122,588,040 mi
changeover to traveling wave tube amplifier	184,427,040 km 114,597,650 mi

DISTANCE OF MARINER IV FROM CENTER OF MARS (Cont'd)

DC-15 Canopus gate override event	177,567,240 km 110,335,170 mi
MT-6 changeover to 8-1/3 bps	151,243,810 km 93,978,547 mi
cover drop event	98,233,187 km 61,039,272 mi
MT-1 Canopus cone angle update	80,185,156 km 49,824,746 mi
MT-5 changeover to high-gain antenna	74,165,511 km 46,084,312 mi
MT-2 Canopus cone angle update	50,357,019 km 31,290,400 mi
MT-3 Canopus cone angle update	28,830,578 km 17,914,490 mi
MT-4 Canopus cone angle update	11,808,201 km 7,337,276 mi
closest approach	13,200.6 km 8,202.4 mi
black space picture sequence	17,846,073 km 11,089,036 mi
end of mission	31,148,769 km 19,359,086 mi

from end of mission through 1971 (see Fig. 45)

DISTANCE OF MARINER IV FROM SUN

weekly intervals during flight (see Table 3)

launch	149,599,660 km 92,961,228 mi
midcourse maneuver	148,215,700 km 92,101,235 mi
changeover to traveling wave tube amplifier	149,486,790 km 92,891,091 mi
DC-15 Canopus gate override event	150,353,950 km 93,429,944 mi
MT-6 changeover to 8-1/3 bps	155,536,560 km 96,650,418 mi
cover drop event	173,451,360 km 107,782,670 mi
MT-1 Canopus cone angle update	182,045,500 km 113,123,074 mi
MT-5 changeover to high-gain antenna	185,229,220 km 115,101,437 mi

DISTANCE OF MARINER IV FROM SUN (Cont'd)

MT-2 Canopus cone angle update	199,543,810 km 123,996,524 mi
MT-3 Canopus cone angle update	214,853,380 km 133,509,890 mi
MT-4 Canopus cone angle update	226,861,550 km 140,971,760 mi
closest approach	232,500,420 km 144,475,760 mi
black space picture sequence	235,311,890 km 146,222,808 mi
end of mission	233,262,008 km 144,973,280 mi

from end of mission through 1966 (see Table 4)
from end of mission through 1971 (see Fig. 44)

DISTANCE TRAVELED ALONG HELIOCENTRIC ARC BY MARINER IV (see also Fig. 35)

midcourse maneuver	24,875,140 km 15,460,000 mi
changeover to traveling wave tube amplifier	44,971,252 km 27,949,815 mi
DC-15 Canopus gate override event	56,295,412 km 34,987,826 mi
MT-6 changeover to 8-1/3 bps	103,651,827 km 64,420,029 mi
cover drop event	203,333,481 km 126,372,580 mi
MT-1 Canopus cone angle update	244,773,888 km 152,127,960 mi
MT-5 changeover to high-gain antenna	256,593,103 km 159,473,650 mi
MT-2 Canopus cone angle update	319,883,118 km 198,808,650 mi
MT-3 Canopus cone angle update	392,994,369 km 244,247,588 mi
MT-4 Canopus cone angle update	468,615,715 km 291,246,560 mi
closest approach	524,373,100 km 325,900,000 mi
black space picture sequence	614,017,547 km 381,614,386 mi
end of mission	673,767,762 km 418,749,386 mi
in one complete revolution around Sun	1,241,738,400 km 771,745,432 mi

from end of mission through 1966 (see Table 4)

DOCUMENTS (see Table 25)

EARTH CLOCK ANGLE THROUGH 1971 (see Fig. 43)

EARTH DETECTOR

field of view	
cone direction	83 deg
clock direction	26 deg
look angle, cone direction	0 deg
reference designation of instrument	7ED6
sensitivity threshold	0.001 ft-c

EARTH DIPOLE MOMENT — 8.06×10^{25} gauss/cm^3

EARTH–PROBE–SUN ANGLE

midcourse maneuver	65.8 deg
changeover to traveling wave tube amplifier	56.8 deg
DC-15 Canopus gate override event	51.8 deg
MT-6 changeover to 8-1/3 bps	30.8 deg
cover drop event	13.2 deg
MT-1 Canopus cone angle update	24.9 deg
MT-5 changeover to high-gain antenna	28.2 deg
MT-2 Canopus cone angle update	38.2 deg
MT-3 Canopus cone angle update	42.6 deg
MT-4 Canopus cone angle update	42.0 deg
closest approach	39.4 deg
black space picture sequence	33.4 deg
end of mission	28.3 deg
from end of mission through 1971 (see Fig. 42)	

ECLIPTIC

celestial lattitude of spacecraft through 1971 (see Fig. 40)	
inclination of spacecraft heliocentric orbit to ecliptic, pre-encounter	0.12 deg
inclination of spacecraft heliocentric orbit to ecliptic, post-encounter (see Fig. 40)	2.540 deg

ELECTRONS (see Scientific Data, Trapped Radiation Detector Cosmic Ray Telescope)

ENCOUNTER (see also Closest Approach)

date	14-15 Jul 1965
day of flight	228
start of encounter sequence (DC-25)	14:27:55

ENCOUNTER (Cont'd)

commands	
number sent	11
sequence of (see major heading, Commands)	
orbit parameters (see Closest Approach)	
sequence of events (see Event Times)	
total time for event (first command to exit occultation)	12 hr, 57 min, 11 sec

END OF MISSION

date	1 Oct 1965
day of flight	307
time of DC-12 command transmission	21:30:17
effect of DC-12 command observed on Earth	22:05:07
communication time (one way)	17 min, 6 sec
Earth–probe–Sun angle	28.3 deg
Canopus–probe–Sun angle	75.3 deg
spacecraft celestial longitude	263.4 deg
spacecraft celestial latitude	1.5 deg
Earth celestial longitude	7.6 deg
Mars celestial longitude	269.6 deg
spacecraft distance from Earth	307,415,414 km 191,059,922 mi
spacecraft distance from Sun	233,262,008 km 144,973,280 mi
spacecraft distance from Mars	31,148,769 km 19,359,086 mi
distance traveled along heliocentric arc	673,767,762 km 418,749,386 mi
spacecraft velocity relative to Earth	90,499 mph
spacecraft velocity relative to Mars	10,748 mph
spacecraft velocity relative to Sun	48,810 mph
number of commands sent	1 (DC-12)
duration of flight	7,375 hr, 25 min, 22 sec

ENGINEERING CHANGE REQUESTS

mechanical subsystems	
attitude control	127
central computer and sequencer	32
command	19
cosmic dust detector	10
cosmic ray telescope	13
data automation subsystem	32
data encoder	38

ENGINEERING CHANGE REQUESTS (Cont'd)

mechanical subsystems (cont'd)	
helium magnetometer	17
ionization chamber	13
operational support equipment	207
planetary scan subsystem	29
power	79
post-injection propulsion	14
pyrotechnics	27
radio	69
solar plasma probe	45
tape recorder	51
television	37
thermal control	30
trapped radiation detector	9
wiring and cabling	105
system level	155
total	1159

ENVIRONMENTAL TESTS (see also Tables 12 through 17)

design changes resulting from subsystem flight-acceptance tests, number of	12
design changes resulting from subsystem type-approval tests, number of	36
environmental test waivers granted	69
part failures resulting from subsystem flight-acceptance tests, number of	19
part failures resulting from subsystem type-approval tests, number of	16

ESCAPE VELOCITY

Earth	25,005 mph
Mariner IV	25,598 mph
Mars	11,250 mph

EVENT TIMES, GMT (see also Time Spans)

Launch of Mariner III, **5 November 1964**	
liftoff	19:22:04
violent spacecraft shock observed	19:23:48
Atlas booster engine cutoff	19:24:18
Atlas booster separation	19:24:21
Atlas sustainer engine cutoff	19:27:07
Atlas vernier engine cutoff	19:27:25
Shroud ejection (unsuccessful)	19:27:27

EVENT TIMES, GMT (Cont'd)

Launch of Mariner III, **5 November 1964**

Atlas/Agena separation	19:27:29
Agena first burn ignition	19:28:19
Agena first burn cutoff	19:30:46
Agena second burn ignition	19:54:05
Agena second burn cutoff	19:55:01
Agena/spacecraft separation	19:58:23
DC-15 transmitted	23:06:02
Gyros off	23:12:09
DC-25 transmitted	23:21:23
DC-26 transmitted	23:29:05
science instruments off	23:32:00
QC1-1 transmitted	23:51:58
QC1-1 transmitted	23:57:58
QC1-1 transmitted, **6 November 1964**	00:00:00
QC1-2 transmitted	00:01:30
QC1-3 transmitted	00:03:00
DC-27 transmitted	00:05:00
DC-29 transmitted	00:08:00
DC-13 transmitted	00:14:00
DC-1 transmitted	00:38:41
DC-28 transmitted	02:37:25
QC1-1 transmitted	03:28:03
QC1-2 transmitted	03:30:25
QC1-3 transmitted	03:32:35
DC-27 transmitted	03:25:27
DC-14 transmitted	03:45:00
DC-19 transmitted	03:45:55
last telemetry received	04:05:55

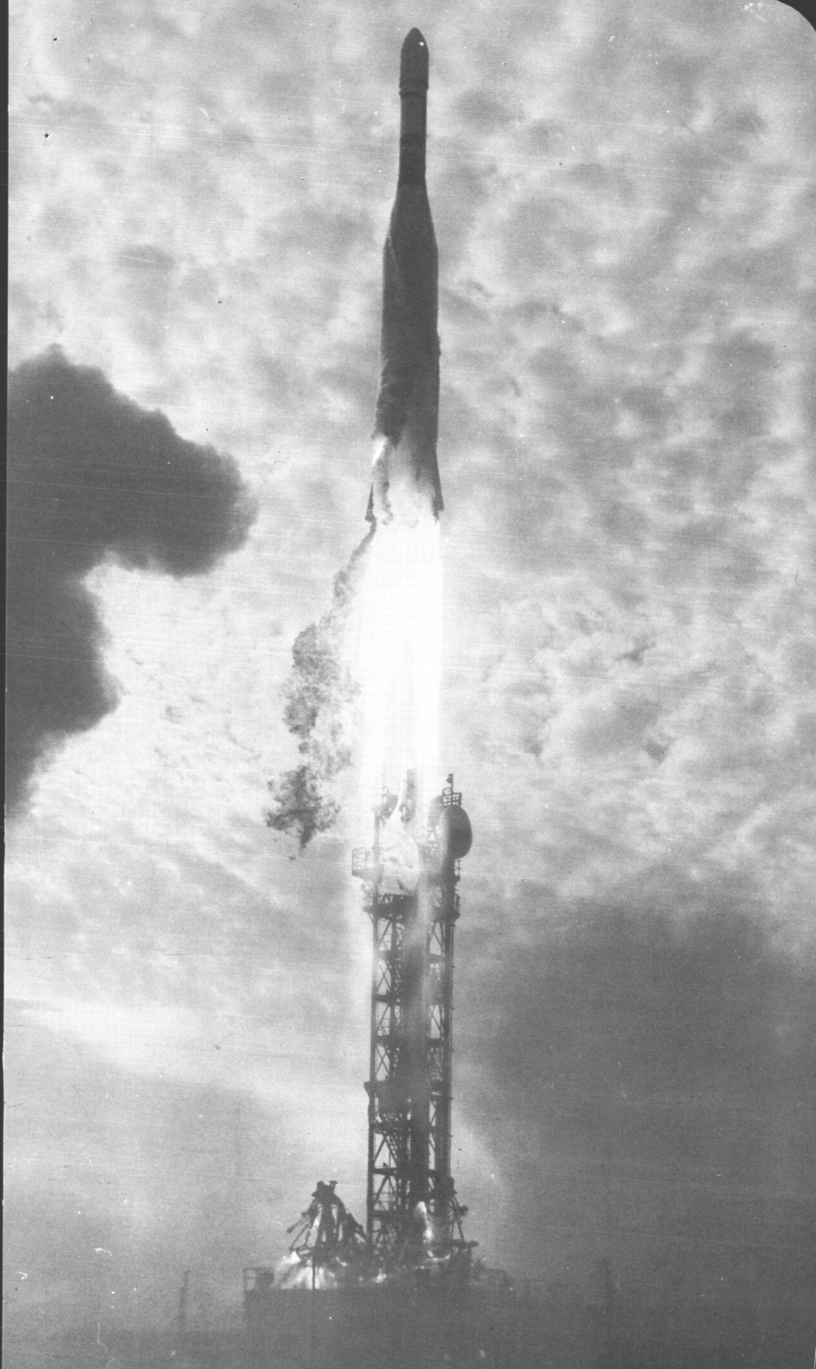
Launch of Mariner IV, **28 November 1964**

liftoff	14:22:01
Atlas booster engine cutoff	14:24:15
Atlas booster separation	14:24:17
Atlas sustainer engine cutoff	14:27:00
Atlas vernier engine cutoff	14:27:18
shroud ejection	14:27:21
Atlas/Agena separation	14:27:23
Agena first burn ignition	14:28:14
Agena first burn cutoff	14:30:39
Agena second burn ignition	15:02:53
Agena second burn cutoff (injection)	15:04:28
Agena/spacecraft separation	15:07:10
solar panels deployed	15:15:00
Sun acquisition start	15:19:02
Sun acquisition complete	15:30:57

EVENT TIMES, GMT (Cont'd)

first Canopus acquisition, **30 November 1964**	11:02:47
first midcourse maneuver attempt, **4 December 1964**	
QC1-1 transmitted	13:05:00
QC1-2 transmitted	13:10:00
QC1-3 transmitted	13:15:00
DC-29 transmitted	13:45:00
DC-14 transmitted	14:05:00
DC-27 transmitted	14:35:00
DC-13 (stop maneuver) transmitted	14:47:31
first DC-21 transmitted	15:22:00
last DC-21 transmitted	23:58:00
Canopus acquired, **5 December 1964**	00:02:44
second midcourse maneuver attempt, **5 December 1964**	
QC1-1 transmitted	13:05:00
QC1-2 transmitted	13:10:00
QC1-3 transmitted	13:15:00
DC-29 transmitted	13:45:00
DC-14 transmitted	14:05:00
DC-27 transmitted	14:25:00
end of motor burn	16:09:30
Sun acquisition started	16:15:11
Sun acquisition completed	16:21:07
Gamma Velorum acquired	16:47:56
DC-21 transmitted	16:52:00
Canopus acquired	16:58:19
changeover to traveling wave tube amplifier, **13 December 1964**	
DC-7 transmitted	14:09:00
traveling wave tube amplifier operation observed	14:10:38
DC-15 Canopus gate override event, **17 December 1964**	17:30:00
MT-6 changeover to 8-1/3 bps, **3 January 1965** (Earth time)	16:59:54
cover drop event, **11 February 1965**	
DC-3 transmitted	03:29:29
DC-2 transmitted	03:36:13
DC-26 transmitted	03:53:15
DC-2 transmitted	04:15:51

Mariner IV is launched from Cape Kennedy on November 28, 1964 at 14:22:01 GMT. The launch vehicle is an Atlas D/Agena D combination.



EVENT TIMES, GMT (Cont'd)

cover drop event, **11 July 1965**	
DC-28 transmitted	04:32:39
DC-25 transmitted	06:54:43
DC-24 transmitted	08:59:23
DC-28 transmitted	09:13:51
DC-3 transmitted	09:30:56
DC-2 transmitted	10:21:20
DC-26 transmitted	10:27:08
DC-2 transmitted	10:49:35
*MT-1 Canopus cone angle update, **27 February 1965** (see MT-1, MT-2, MT-3, MT-4 major headings)	17:02:19
*MT-5 changeover to high-gain antenna, **5 March 1965**	13:02:37
*MT-2 Canopus cone angle update, **2 April 1965** (see MT-1, MT-2, MT-3, MT-4 major headings)	14:25:15
*MT-3 Canopus cone angle update, **7 May 1965** (see MT-1, MT-2, MT-3, MT-4 major headings)	14:28:15
*MT-4 Canopus cone angle update, **14 June 1965** (see MT-1, MT-2, MT-3, MT-4 major headings)	15:51:45
encounter, **14 July 1965**	
Station 51 command lock	13:34:00
DC-25 transmitted	14:27:55
DC-25 received at spacecraft	14:40:32.8
DC-25 observed in data	14:52:31
MT-7 (spacecraft time)	15:41:48.9
MT-7 verified	15:53:49
DC-24 transmitted	17:10:18
DC-24 received at spacecraft	17:22:55
DC-24 verified in data	17:34:55
Goldstone (11) acquisition, one-way	19:37:23
two-way RF transfer from Station 51 to Station 11	20:10
DSIF 51 end of track	20:53:01
DSIF 11 command modulation turn on	21:00:30
DC-3 transmitted	22:10:29
DC-3 received at spacecraft	22:23:07

*Shows time that event was seen on Earth

EVENT TIMES, GMT (Cont'd)

encounter, **14 July 1965**

DC-3 verified in data	22:35:08
wide angle acquisition (spacecraft time)	23:42:00.3
wide angle acquisition seen in data	23:54:42
DC-16 transmitted, **15 July 1965**	00:11:57
narrow angle acquisition, spacecraft time	00:17:21.1
DSIF 12 switched to rubidium standard No. 2	00:22:15
DC-16 received at spacecraft	00:24:36
narrow angle acquisition seen in data	00:29:22.5
first DAS start tape command seen in data	00:30:31
first end-of-tape signal at spacecraft	00:30:54.3
DC-26 transmitted	00:31:42
DC-2 number 1 transmitted	00:32:40
false end-of-tape signal seen on Earth	00:34:31.7
DC-16 verified in data	00:36:37
DC-2 number 2 transmitted	00:37:00
false end-of-tape signal seen on Earth	00:40:24.5
DC-2 number 3 transmitted	00:42:00
first end-of-tape signal seen on Earth	00:42:55.7
tape recorder stopped, spacecraft time	00:43:45.1
data encoder switched to Mode 2, spacecraft time	00:43:45.1
DC-26 received at spacecraft	00:44:21.5
DC-2 number 4 transmitted	00:47:00
DC-2 number 5 transmitted	00:52:00
Mode 2 data seen on Earth	00:55:46.6
DC-26 verified in data	00:56:23.0
DC-2 number 6 transmitted	00:57:00
time of closest approach	01:00:57
DSIF 42 rise	01:44:00
DSIF 11 command modulation turn-off	01:55:30
enter occultation, spacecraft time	02:19:11
end of signal on ground	02:31:12
exit occultation, spacecraft time	03:13:04
exit occultation verified in data	03:25:06
pickup signal at Station 41	03:25:29
pickup signal at Station 42	03:25:47
MT-8, spacecraft time	05:01:49
MT-8 observed on Earth	05:13:52
MT-9, spacecraft time	11:41:49.8
MT-9 observed on ground	11:53:53.3
Mode 4, spacecraft time	12:49:54
first picture signal received	13:01:58

EVENT TIMES, GMT (Cont'd)

picture playback sequence (see Table 6)	
return to cruise mode, **3 August 1965**	
DC-28 transmitted	03:08:33
DC-26	03:14:33
DC-2	03:20:33
DC-28 received at spacecraft	03:22:37
DC-26 received at spacecraft	03:28:37
DC-2 received at spacecraft	03:34:37
DC-28 seen in data	03:36:02
DC-26 seen in data	03:42:02
DC-2 seen in data	03:48:02
maneuver inhibit sequence, **26 August 1965**	
DC-13 transmitted	21:06:52
QC1-1 transmitted	21:15:16
DC-13 received at spacecraft	21:22:32
QC1-2 transmitted	21:23:40
QC1-1 received at spacecraft	21:30:56
QC1-3 transmitted	21:32:04
DC-13 verified in data	21:37:42
QC1-2 received at spacecraft	21:39:20
QC1-1 verified in data	21:46:06
QC1-3 received at spacecraft	21:47:44
QC1-2 verified in data	21:54:32
QC1-3 verified in data	22:02:54
option 1 Canopus cone angle update, **27 August 1965**	
DC-17 transmitted	19:40:00
DC-17 received at spacecraft	19:55:30
DC-17 verified in data	20:11:01
Canopus cone angle update verified	20:28:30
black space picture sequence, **30 August 1965**	
DC-25 transmitted	20:30:00
DC-25 received at spacecraft	20:45:56
DC-25 verified in data	21:01:33
DC-3 transmitted	21:10:24
DC-3 received at spacecraft	21:26:20
DC-3 verified in data	21:41:53
DC-24 transmitted	22:48:38
DC-24 received at spacecraft	23:04:29
DC-24 verified in data	23:21:00
DC-16 transmitted	23:35:26
DC-16 received at spacecraft	23:51:22
DC-2 transmitted, **31 August 1965**	00:05:00
DC-16 verified in data	00:06:52
DC-2 received at spacecraft	00:20:15

EVENT TIMES, GMT (Cont'd)

black space picture sequence, **30 August 1965**	
Mode 2 data observed on Earth	00:33:05
DC-2 verified in data	00:36:50
DC-26 transmitted	00:44:00
DC-22 transmitted	00:49:00
DC-26 received at spacecraft	00:59:56
DC-22 received at spacecraft	01:04:56
DC-26 verified in data	01:15:14
DC-22 verified in data	01:19:33
DC-4 transmitted	01:25:00
DC-4 received at spacecraft	01:40:57
Mode 1 data observed on Earth	01:56:16
start of picture number 1	02:00:46
return to cruise mode after black space pictures, **2 September 1965**	
DC-28 transmitted	06:17:00
DC-26 transmitted	06:23:00
DC-2 transmitted	06:29:00
DC-28 received at spacecraft	06:33:05
DC-26 received at spacecraft	06:39:05
DC-2 received at spacecraft	06:45:05
DC-28 verified in data	06:48:32
DC-26 verified in data	06:54:32
Mode 2 data observed on Earth	07:00:32
end of mission, **1 October 1965**	
DC-12 transmitted	21:30:17
loss of signal	22:05:07

EXCITERS (see Radio)

EXPERIMENTERS (see Table 7)

FIELD AND PARTICLES

experiments, number of	6
experimental results (see Scientific Data)	
principal investigators (see Table 7)	

FIELDS OF VIEW

Canopus tracker	
cone direction	11 deg
clock direction	4 deg
cosmic ray telescope	20 deg half-angle cone

FIELD OF VIEW (Cont'd)

Earth detector	
cone direction	83 deg
clock direction	26 deg
narrow-angle Mars gate	2.5 × 1.5 deg
planetary scan wide-angle sensor	48.5 deg cone
Sun gate	2.2 deg half-angle cone
high-gain antenna (see major heading High-Gain Antenna)	
solar plasma probe	30 deg half-angle cone
television camera	1.05 × 1.05 deg
trapped radiation detectors	30 deg half-angle cone

FREQUENCY (see Radio)

FUEL (see Propulsion)

GAS (see Attitude Control)

GRAVITATIONAL CONSTANT (see Orbit Data)

GREENWICH MEAN TIMES OF MISSION EVENTS (see Event Times)

GYRO CONTROL SUBSYSTEM

gyros, number of	3
input angle storage capability	6 deg
operating temperature range	85 to 130°F
power required	18 w
reference designation of subsystem	7A2
weight (see Table 10)	10.87 lb

HELIUM MAGNETOMETER

dynamic range	$\pm 360\ \gamma$
electrical components, number of (see Table 9)	802
intervals between consecutive simultaneous–triaxial observations in one 50.4-sec data frame, at 8-1/3 bps	6.0 sec, 3.6 sec, 9.6 sec, and 31.2 sec
noise threshold	$0.1\ \gamma$ rms/axis
power required	7.30 w
reference designations of subassemblies (see Table 8)	
resolution of telemetered magnetic data	$0.35\ \gamma$ per axis
scientific results (see Scientific Data)	

HELIUM MAGNETOMETER (Cont'd)

sensitivity threshold	$\leq$0.25
sensors, number of	3
weight (see Table 10)	6.77 lb

HIGH-GAIN ANTENNA

angle of antenna to Canopus tracker optical axis (measured in XY plane)	259 deg
back radiation	−20 to 125 db
beam patterns (see Fig. 7)	
beamwidth at −3 db, major axis of pattern	15 to 16 deg
beamwidth at −3 db, minor axis of pattern	12 to 13 deg
beamwidth at first null, major axis of pattern	36 deg
beamwidth at first null, minor axis of pattern	20 deg
depth of parabola	8 in.
distance of feed from parabolic vertex	16 in.
ellipse major axis length	46 in.
ellipse minor axis length	21.2 in.
ellipticity on axis, 2116 Mc	6.5 db
ellipticity on axis, 2298 Mc	0.6 db
fundamental resonant frequency	120 cps
look angle of boresight	
cone direction	38 deg
clock direction	259 deg
orientation with respect to Earth (see Fig. 6)	
peak gain at 2116 Mc	21.8 db
peak gain at 2298 Mc	23.3 db
polarization	right-hand circular
reference designation of subsystem	2E1
reflector material	aluminum honeycomb
variation from true parabolic surface	0.040 in. = 0.007 wavelength
VSWR, 2116 Mc	1.22 to 1
VSWR, 2298 Mc	1.14 to 1
weight of antenna and support truss	4.44 lb
weight of parabolic reflector	2.05

INJECTION (see Event Times)

INSTRUMENTS, FIELD AND PARTICLES (see Cosmic Dust Detector, Cosmic Ray Telescope, Helium Magnetometer, Ionization Chamber, Solar Plasma Probe, Trapped Radiation Detector; see also Scientific Data from Mariner IV, Telemetry)

INTERFEROMETER EFFECT (see Fig. 27)

INVESTIGATORS (see Table 7)

IONIZATION CHAMBER

diameter of shell	5 in.
electrical components, number of (see Table 9)	361
Geiger-Mueller tube failure date	6 Feb 1965
measurement ranges	
electrons	>0.5 Mev
protons	>10 Mev
α particles	>40 Mev
potential between fiber and collector	310 v
power required	0.460 w
pressure of argon inside shell	4 atm
reference designation of instrument	26A1
scientific results (see Scientific Data)	
sensors, number of	2
temperature variation during flight (see Fig. 31)	
thickness of steel shell	0.010 in.
weight (see Table 10)	2.90 lb

LATITUDE (see Celestial Latitude)

LAUNCH DATA FOR MARINER III (see also Event Times)

Agena D serial number	6931
Atlas D serial number	289D
date of launch	5 Nov 1964
launch azimuth	102.9 deg
launch complex	13
parking orbit coast time	23 min, 18 sec

LAUNCH DATA FOR MARINER IV (see also Event Times)

Agena D serial number	6932
Atlas D serial number	288D
C_3 vs launch window (see Fig. 24)	
launch azimuth	91.4 deg
launch complex	12
launch date	28 Nov 1964
parking orbit coast time	32 min, 14 sec
spacecraft–Agena separation velocity	approx. 2 ft/sec
spacecraft velocity at injection, nominal	25,598 mph
time from liftoff to injection	42 min, 27 sec
time from liftoff to spacecraft separation	45 min, 9 sec
time of injection, 28 November 1964	15:04:28

LIFE TESTS

total life test hours	
attitude control electronics	9,346 hr
attitude control gyros and gyro electronics	9,816 hr
battery (5 units in test)	6,540 hr
	2,112 hr
	6,192 hr
	5,496 hr
	4,800 hr
Canopus sensor (2 units in test)	4,736 hr
	5,062 hr
central computer and sequencer (2 units in test)	10,395 hr
	2,360 hr
command subsystem	9,285 hr
cosmic dust detector	3,502 hr
data automation system (2 units in test)	3,780 hr
	2,790 hr
data encoder	8,982 hr
Earth detector	9,268 hr
helium magnetometer	6,752 hr
ionization chamber	7,009 hr
jet vane actuators	6,820 hr
narrow-angle Mars gate	8,210 hr
planetary scan subsystem	4,418 hr
power subsystem	8,638 hr
pyrotechnic control assembly	7,892 hr
radio subsystem	4,216 hr
scan actuator, dampers, science cover latch actuator	4,320 hr
solar plasma probe	3,976 hr
solar pressure control assembly	4,950 hr
sun sensors	7,765 hr
television subsystem	2,722 hr
trapped radiation detector	7,009 hr

LONGITUDE (see Celestial Longitude)

LOOK ANGLES (see also Fig. 5)

Canopus tracker	
clock direction	0 deg
cone direction	75 to 105 deg
cosmic dust detector	
cone direction	90 and 270 deg
clock direction	90 and 270 deg

LOOK ANGLES (Cont'd)

cosmic ray telescope, cone direction	180 deg
Earth detector, cone direction	0 deg
high-gain antenna	
cone direction	38 deg
clock direction	259 deg
narrow-angle Mars gate	
cone direction	120.10 deg
clock direction	camera direction +0.10 deg
plasma probe	
cone direction	10 deg
clock direction	190 deg
Sun gate, cone direction	0 deg
Sun sensors, cone direction	0 and 180 deg
trapped radiation detector	
clock direction, all detectors	169 deg
cone direction, detector A	135 deg
cone direction, detectors A, B, and C	70 deg
television camera	
cone direction	120.00 deg
clock direction	116.35 to 296.35 deg
wide angle acquisition sensor	
cone direction	119.70 deg
clock direction	camera direction +24 deg

LOUVERS (see Temperature Control)

LOW-GAIN ANTENNA

ellipticity on axis, 2116 Mc	4.3 db
ellipticity on axis, 2298 Mc	2.1 db
ground plane diameter	7 in.
peak gain at 2116 Mc	6.4 db
peak gain at 2298 Mc	5.4 db
polarization	right-hand circular
reference designation of subsystem	2E2
VSWR, 2116 Mc	1.4 to 1
VSWR, 2298 Mc	1.3 to 1
waveguide	
inside diameter of	3.875 in.
length of	88 in.
thickness of tubing	0.025 in.
weight, antenna and support structure	3.87 lb

MAGNETIC FIELDS

Mars (see Scientific Data)	
solar panel magnetic measurements	
magnetometer X axis	0 γ
magnetometer Y axis	0 γ
magnetometer Z axis	-1.6 γ
spacecraft magnetic fields, without solar panels	
magnetometer X axis	$+5$ γ
magnetometer Y axis	$+11.5$ γ
magnetometer Z axis	$+31.7$ γ

MAGNETOMETER (see Helium Magnetometer)

MANEUVER INHIBIT SEQUENCE

date	26 Aug 1965
time	21:06:56
day of flight	271
communication time, one way	15 min, 40 sec
Earth–probe–Sun angle	34.0 deg
Canopus–probe–Sun angle	77.9 deg
spacecraft celestial longitude	247.0 deg
spacecraft celestial lattitude	0.9 deg
Earth celestial longitude	332.5 deg
Mars celestial longitude	249.6 deg
spacecraft distance from Earth	269,664,180 km 167,561,550 mi
spacecraft distance from Sun	235,326,760 km 146,225,270 mi
spacecraft distance from Mars	16,253,118 km 10,099,219 mi
spacecraft velocity relative to Earth	79,225.6 mph
spacecraft velocity relative to Mars	10,308.5 mph
spacecraft velocity relative to Sun	48,306.5 mph
number of commands sent	2
command sequence	DC-13, QC-1

MARINER III

date shipped to AFETR	23 Aug 1964
launch data (see Launch Data, Time Spans)	
launch date	5 Nov 1964
launch events (see Event Times)	
orbital information (see Orbit Data)	

MARS

albedo, average	0.15
atmosphere	10 gm/cm^2 4.1 to 7.0 mb
celestial longitudes (see Celestial Longitudes, Mars)	
data resulting from Mariner IV flight (see Scientific Data)	
day, length (in Earth hours)	24 hr, 37 min, 22.62 sec
Deimos	
angle between camera pointing direction and Deimos during picture taking	6 deg
closest distance to spacecraft	14,000 km
direction of revolution	east to west
distance from center of Mars	14,600 mi
inclination of orbit to Mars equator	1.6 deg
period of revolution	30 hr, 18 min
size	6-mi diam
density, mean	3.96 gm/cm^3
density relative to Earth	0.71 (71% of Earth's)
diameter, mean (nominal)	4200 mi
diameter relative to Earth	0.536
distance from Earth	
minimum, closest approach	34,600,000 mi
maximum	248,000,000 mi
maximum closest approach distance	61,000,000 mi
distance from Sun	
minimum	128,200,000 mi
maximum	154,500,000 mi
mean distance	141,500,000 mi
escape velocity	3.2 mi/sec 11,520 mph
escape velocity relative to Earth	0.449
gravity relative to Earth	0.38 (38%)
inclination of equatorial plane to orbital plane	25.2 deg
intensity of sunlight on surface relative to Earth	0.43 (43%)
mass of Sun ÷ mass of Mars	
W. de Sitter (1938)	3,085,000 ±5000
E. K. Rabe (1949)	3,110,000 ±7700
H. C. Urey (1952)	3,079,000 ±6000
Mariner IV (preliminary)	3,098,600 ±3000
mass relative to Earth	0.107
North Pole tilt during encounter, direction of	toward Earth

MARS (Cont'd)

opposition dates	9 Mar 1965 15 Apr 1967 31 May 1969 10 Aug 1971 25 Oct 1973
orbital data	
orbital eccentricity	0.093
orbital inclination to ecliptic	1.85 deg
period of orbit	
Earth days	686.98
Martian days	669
orbital velocity relative to Sun, average	15 mi/sec 54,000 mph
Phobos	
angle between camera pointing direction and Phobos during picture taking	13 deg
closest distance to spacecraft	1500 km
direction of revolution	west to east
distance from center of Mars	5,800 mi
inclination of orbit to Mars equator	1.1 deg
period of revolution	7 hr, 39 min
size	10-mi diam
radius of Mars	
prior to encounter	3378 km 2099 mi
uncertainty in pre-encounter radius	50 to 75 km
seasons, average length of (in Earth days)	
spring	199 days
summer	183 days
autumn	147 days
winter	158 days
season locations during encounter	
northern hemisphere	summer
southern hemisphere	winter
subsolar point, location of at encounter	15.3 deg N latitude
surface area relative to Earth	0.25

MASS (see Scientific Data)

MATERIALS (see Spacecraft Structure, Absorptivity Standard)

MEASUREMENTS (see Scientific Data, Telemetry; see also Cosmic Dust Detector, Cosmic Ray Telescope, Helium Magnetometer, Ionization Chamber, Solar Panel Probe, Trapped Radiation Detector, and Figs. 10–13, 23, and 25–34)

MIDCOURSE MANEUVER (see also Event Times)

date	5 Dec 1964
time	13:05:00 to 16:21:07
day of flight	7
communication time (one way)	3.35 sec
Earth–probe–Sun angle	65.8 deg
Canopus–probe–Sun angle	102.2 deg
spacecraft celestial longitude	74.3 deg
spacecraft celestial latitude	1.31 deg
Earth celestial longitude	73.6 deg
Mars celestial longitude	127.5 deg
spacecraft distance from Earth	2,022,244 km 1,256,622 mi
spacecraft distance from Sun	148,215,700 km 92,101,235 mi
spacecraft distance from Mars	197,286,320 km 122,588,040 mi
distance traveled along heliocentric arc	24,875,140 km 15,460,000 mi
spacecraft velocity relative to Earth	7,050 mph
spacecraft velocity relative to Mars	59,396 mph
spacecraft velocity relative to Sun	74,150 mph
number of commands sent	6
total time for event	3 hr, 16 min, 7 sec
computed ideal parameters	
pitch turn	−39.23 deg
roll turn	+156.08 deg
motor burn time	20.0666 sec
velocity increment	16.7049 m/sec
commanded parameters	
pitch turn	−39.16 deg
roll turn	+156.06 deg
motor burn time	20.06 sec
velocity increment	16.699 m/sec

Watching . . . listening . . . waiting . . . as Mariner IV approaches the planet Mars


RE PLOT
S/C STATUS
MODE II
TIME NEXT CYCLIC
RADIO TWT GO
COMMAND OFF
POWER GO
CC&S GO
DATA ENC GO
ATT CONT GO
PROP GO
TEMP GO
DAS GO
CRT GO
TRD GO
EVENT REG
PS&L OUT
BATT

MIDCOURSE MANEUVER (Cont'd)

spacecraft actual performance*	
pitch turn	−39.63 deg
roll turn	+156.62 deg
motor burn time	20.06 sec
velocity increment	17.085 m/sec or 38.2 mi/hr
flight angle correction	1/4 deg

MIDCOURSE MOTOR (see Propulsion)

MT-1 CANOPUS CONE ANGLE UPDATE EVENT

date	27 Feb 1965
day of flight	91
time	17:02:19
cone angle setting	95.7 deg
communication time (one way)	2 min, 7 sec
Earth–probe–Sun angle	24.9 deg
Canopus–probe–Sun angle	99.3 deg
spacecraft celestial longitude	152.5 deg
spacecraft celestial latitude	0.13 deg
Earth celestial longitude	158.8 deg
Mars celestial longitude	164.4 deg
spacecraft distance from Earth	38,281,029 km 23,787,831 mi
spacecraft distance from Sun	182,045,500 km 113,123,074 mi
spacecraft distance from Mars	80,185,156 km 49,824,746 mi
distance traveled along heliocentric arc	244,773,888 km 152,127,960 mi
spacecraft velocity relative to Earth	21,231.3 mph
spacecraft velocity relative to Mars	27,494.4 mph
spacecraft velocity relative to Sun	61,787.3 mph

MT-2 CANOPUS CONE ANGLE UPDATE EVENT

date	2 Apr 1965
day of flight	125
time	14:25:15
cone angle setting	91.1 deg
communication time (one way)	4 min
Earth–probe–Sun angle	38.2 deg
Canopus–probe–Sun angle	94.5 deg

*Based on orbit determinations made in April 1965

MT-2 CANOPUS CONE ANGLE UPDATE EVENT (Cont'd)

spacecraft celestial longitude	175.2 deg
spacecraft celestial latitude	0.12 deg
Earth celestial longitude	192.6 deg
Mars celestial longitude	179.4 deg
spacecraft distance from Earth	73,300,692 km 45,549,050 mi
spacecraft distance from Sun	199,543,810 km 123,996,524 mi
spacecraft distance from Mars	50,357,019 km 31,290,400 mi
distance traveled along heliocentric arc	319,883,118 km 198,808,650 mi
spacecraft velocity relative to Earth	32,703.7
spacecraft velocity relative to Mars	19,060.0
spacecraft velocity relative to Sun	56,373.6

MT-3 CANOPUS CONE ANGLE UPDATE EVENT

date	7 May 1965
day of flight	160
time	14:28:15
cone angle setting	86.5 deg
communication time (one way)	6 min, 31 sec
Earth–probe–Sun angle	42.6 deg
Canopus–probe–Sun angle	89.8 deg
spacecraft celestial longitude	195.0 deg
spacecraft celestial latitude	0.10 deg
Earth celestial longitude	226.8 deg
Mars celestial longitude	195.1 deg
spacecraft distance from Earth	117,544,150 km 73,041,934 mi
spacecraft distance from Sun	214,853,380 km 133,509,890 mi
spacecraft distance from Mars	28,830,578 km 17,914,490 mi
distance traveled along heliocentric arc	392,994,369 km 244,247,588 mi
spacecraft velocity relative to Earth	32,703.7 mph
spacecraft velocity relative to Mars	13,367.4 mph
spacecraft velocity relative to Sun	51,998.1 mph

MT-4 CANOPUS CONE ANGLE UPDATE EVENT

date	14 Jun 1965
day of flight	198
time	15:51:45
cone angle setting	82.0 deg

MT-4 CANOPUS CONE ANGLE UPDATE EVENT (Cont'd)

communication time (one way)	9 min, 34 sec
Earth–probe–Sun angle	42.0 deg
Canopus–probe–Sun angle	85.3 deg
spacecraft celestial longitude	213.8 deg
spacecraft celestial latitude	7.23 deg
Earth celestial longitude	263.2 deg
Mars celestial longitude	212.9 deg
spacecraft distance from Earth	172,429,480 km 107,146,670 mi
spacecraft distance from Sun	226,861,550 km 140,971,760 mi
spacecraft distance from Mars	11,808,201 km 7,337,276 mi
distance traveled along heliocentric arc	468,615,715 km 291,246,560 mi
spacecraft velocity relative to Earth	56,174.8 mph
spacecraft velocity relative to Mars	10,374.4 mph
spacecraft velocity relative to Sun	48,751.0 mph

MT-5 CHANGEOVER TO HIGH-GAIN ANTENNA

date	5 Mar 1965
day of flight	97
time	13:02:37
communication time (one way)	2 min, 25 sec
Earth–probe–Sun angle	28.2 deg
Canopus–probe–Sun angle	98.5 deg
spacecraft celestial longitude	156.9 deg
spacecraft celestial latitude	0.13 deg
Earth celestial longitude	164.8 deg
Mars celestial longitude	167.0 deg
spacecraft distance from Earth	43,383,627 km 26,958,585 mi
spacecraft distance from Sun	185,229,220 km 115,101,437 mi
spacecraft distance from Mars	74,165,511 km 46,084,312 mi
distance traveled along heliocentric arc	256,593,103 km 159,473,650 mi
spacecraft velocity relative to Earth	23,242.1 mph
spacecraft velocity relative to Mars	25,788.7 mph
spacecraft velocity relative to Sun	60,764.2 mph

MT-6 CHANGEOVER TO 8-1/3 bps

date	3 Jan 1965
day of flight	36

MT-6 CHANGEOVER TO 8-1/3 bps (Cont'd)

time	16:59:54
communication time (one way)	33.2 sec
Earth–probe–Sun angle	30.8 deg
Canopus–probe–Sun angle	104.1 deg
spacecraft celestial longitude	105.0 deg
spacecraft celestial latitude	7.63 deg
Earth celestial longitude	103.0 deg
Mars celestial longitude	140.3 deg
spacecraft distance from Earth	9,914,631 km 6,160,952 mi
spacecraft distance from Sun	155,536,560 km 96,650,418 mi
spacecraft distance from Mars	151,243,810 km 93,978,547 mi
distance traveled along heliocentric arc	103,651,827 km 64,420,029 mi
spacecraft velocity relative to Earth	7,710.5 mph
spacecraft velocity relative to Mars	47,319.7 mph
spacecraft velocity relative to Sun	71,146.8 mph

MT-7 EVENT (see Encounter)

MT-8 EVENT (see Event Times)

MT-9 EVENT (see Event Times)

NARROW-ANGLE ACQUISITION (see Event Times, Narrow-Angle Mars Gate)

NARROW-ANGLE MARS GATE

electrical components, number of	9
field of view	2.5 × 1.5 deg
focal length	1.5 in.
lens diameter	0.5 in.
look angle (see also Fig. 35)	
cone direction	120.10 deg
clock direction	camera direction +0.10 deg
operating temperature	−30 to 55°C
power required	0.03 w
reference designation of instrument	7 MG1
scan limits, clock angle	116.45 to 296.45 deg
size	1 in. diam × 4 in.
subsystem weight	0.16 lb
Sun rejection angle	22 deg off axis

NASA QUARTERLY REVIEWS (see Dates)

OCCULTATION EXPERIMENT

enter occultation	
time at spacecraft (15 July 1965)	02:19:11
time observed on Earth	02:31:12
point of entrance	55-deg S latitude 177-deg E longitude
Mars time at point of entrance	afternoon
altitude above Mars	22,433 km 13,942 mi
height of ionosphere at point of entrance	100 to 200 km 62 to 75 mi
exit occultation	
time at spacecraft (15 July 1965)	03:13:04
time observed on Earth	03:25:06
point of emergence	60-deg N latitude 34-deg W longitude
Mars time at point of emergence	just before sunrise
altitude above Mars	35,916 km 22,322 mi
range rate accuracy	0.005 ft/s
scientific results (see Scientific Data)	

OPPOSITION (see Orbit Data)

ORBIT DATA, MARINER III

aphelion distance	196,119,120 km 121,868,420 mi
closest approach to Mars	
distance of	67,374,294 km 41,866,386 mi
date of	15 Apr 1965
time of	20:17:51
orbital period around Sun	448.7 days
perihelion distance	147,081,040 km 91,396,158 mi

ORBIT DATA, MARINER IV

aphelion	
dates of	26 Aug 1965 22 Mar 1967
distance of	235,331,000 km 146,228,000 mi
spacecraft velocity relative to Sun	48,500 mph
celestial parameters	
astromical unit	
pre-launch	149,598,500 km 92,960,507 mi
pre-encounter, 10 July 1965	149,599,660 km 92,961,228 mi
post encounter	not yet determined
radius of Mars used for orbit determination	3,378 km 2,099 mi
solar radiation constant used in orbit determinations	103,100,000 kg-km $\times 10^6/\text{sec}^2$
universal constant of gravitation used in orbit determinations	0.6671×10^{-19} $\text{km}^3/\text{kg sec}^2$
celestial position (see also Table 4)	
celestial latitude of spacecraft through 1971 (see Fig. 40)	
nearest approach of spacecraft to Earth–Sun line on dark side (angle viewed from Earth)	within 1 deg
Sun–spacecraft conjunction	1 Apr 1966
Sun–spacecraft opposition	28 Jan 1965 15 Aug 1967
closest approach to Mars (see also major heading, Closest Approach to Mars)	
altitude above Mars	9,846.6 km 6,118.4 mi
altitude above Mars, prior to midcourse maneuver	249,452 km 155,009 mi
date of	15 Jul 1965
distance from center of Mars	13,200.6 km 8,202.4 mi
time of	01:00:57

ORBIT DATA, MARINER IV (Cont'd)

Earth–spacecraft range (see also Tables 3 and 4)	
maximum range	348 million km 216 million mi
maximum range, date of	3 Jan 1966
minimum range, after encounter	46,946,445 km 29,172,521 mi
heliocentric orbit	
date of first completed trip around Sun	6 Jun 1966
eccentricity of	0.1732
inclination to ecliptic, before encounter	0.1288 deg
inclination to ecliptic, after encounter (see Fig. 40)	2 540 deg
inclination to Mars orbit	58.19 deg
longitude of ascending node	226.75 deg
orbital period	567.12 days
pre- and post-encounter (see Fig. 36)	
semi-major axis	200,590,000 km 124,641,000 mi
semi-minor axis	197,580,650 km 127,776,610 mi
miscellaneous data	
aiming point diagram (see Fig. 37)	
angle of celestial longitude of Earth between launch and closest approach	225.9 deg
angle of celestial longitude of spacecraft between launch and closest approach	161.4 deg
B vector	
distance between initial aiming point (in B plane) and actual point hit	3,295 km 2,048 mi
increase in B vector during encounter	850 km 528 mi
closest approach to Earth after encounter	
date of	8 Sept 1967
time of	06:36:19.09
deflection of spacecraft from ecliptic at Mars	16.489 deg
encounter velocities and altitudes (see Fig. 39)	
near-Mars trajectory parameters (see Fig. 38)	

ORBIT DATA, MARINER IV (Cont'd)

perihelion	
argument of perihelion	200.63 deg
dates of	5 Jun 1966
	25 Dec 1967
distance of	165,849,000 km
	103,054,000 mi
spacecraft velocity relative to Sun	68,200 mph

PARKING ORBIT (see Launch Data)

PARTS FAILURE SUMMARY (see Table 26)

PARTS, NUMBER OF (see Spacecraft)

PERIHELION (see Orbit Data)

PERSONNEL

(Note: Multiple names for one position are given in order of service)

NASA	
Program Manager	G. A. Reiff
Program Engineer	A. Edwards
Program Scientist	J. M. Weldon
	E. A. Gaugler
Project Manager	J. N. James
	D. Schneiderman
Assistant Project Managers	T. H. Parker
	W. A. Collier
Project Staff	
Program Engineer	D. E. Shaw
Mission Analysis	E. Cutting
	N. R. Haynes
Launch Constraints	J. S. Reuyl
Launch Vehicle Integration	J. Q. Spaulding
	G. W. Haddock
	A. N. Williams
Quality Control	R. A. Welnick
Reliability	F. A. Paul
	F. H. Wright
Contract Administration	L. T. White
Reports Coordination	R. M. Van Buren
Fiscal Control	F. Fairfield
Project Scientist	C. W. Snyder
	R. K. Sloan
Assistant Project Scientist	H. R. Anderson

PERSONNEL (Cont'd)

Scientific Investigators (see Table 7)	
System Managers	
Spacecraft System Manager	D. Schneiderman
	J. R. Casani
Launch Vehicle System Manager	S. C. Himmel
SFO System Manager	M. S. Johnson
	T. S. Bilbo
DSN System Manager	N. A. Renzetti
Project Representatives	
Computer Applications	F. G. Curl
Deep Space Network (DSN)	J. R. Hall
	A. T. Burke
	W. L. Brown
Environmental Requirements	J. E. Maclay
	J. R. Hyde
Environmental Testing	D. S. Hess
	J. O. Stoker
Guidance and Control and Power	J. D. Acord
	D. R. Thomas
	K. M. Dawson
Launch Constraints	J. S. Reuyl
Launch Vehicle Integration	J. Q. Spaulding
	G. W. Haddock
	A. N. Williams
Procurement	L. T. White
Propulsion	B. W. Schmitz
	T. Groudle
Quality Assurance	D. C. Mesnard
	R. A. Welnick
Reliability	F. A. Paul
	F. H. Wright
Spacecraft System Engineer	J. R. Casani
	A. G. Conrad
Spacecraft Operations (ground and launch)	M. T. Goldfine
Space Flight Operations (SFO)	D. W. Douglas
Space Sciences	H. G. Trostle
	R. K. Sloan
Systems Analysis and Trajectories	E. Cutting
	N. R. Haynes
Stores/Supply	C. H. Fields
Structures and Thermal Control	W. J. Schimandle
	J. N. Wilson
	J. D. Schmuecker
	L. N. Dumas

PERSONNEL (Cont'd)

Project Representatives (cont'd)

Telecommunications	J. N. Bryden
	T. C. Sorensen
	R. L. Balluff
	J. A. Hunter
Cognizant Engineers	
absorptivity standard	J. Brandt
	D. W. Lewis
	T. O. Thostesen
attitude control gas system	J. B. Dahlgren
attitude control packaging	F. W. Brocksieper
attitude control subsystem	
Project Engineer	W. H. Benjamin
analyst	H. K. Bouvier
attitude control subsystem OSE	J. F. Petralia
autopilot	J. F. South
battery	W. L. Long
cabling	W. B. Pierce
Canopus tracker	E. S. Davis
central computer and sequencer	
Project Engineer	N. H. Herman
cognizant engineer	U. S. Lingon
central computer and sequencer OSE	D. L. Ross
cosmic dust detector	D. K. Schofield
cosmic ray telescope	R. J. Holman
data automation system	D. W. Slaughter
	W. J. Schneider
	D. L. Nay
data encoder	W. C. Apel
electrical converters	R. L. Spencer
ground command	A. R. Lowe
ground handling equipment	R. M. Norman
ground telemetry	R. L. Balluff
guidance and control analysis	D. R. Thomas
helium magnetometer	D. D. Norris
inertial sensors	P. J. Hand
ionization chamber	L. G. Despain
jet vane actuators	C. Casabianca
low-gain antenna dampers	P. T. Lyman
mechanical subsystems	R. A. Barlow
	P. T. Lyman

PERSONNEL (Cont'd)

Cognizant engineers (cont'd)

midcourse maneuver plan	H. J. Gordon
orbit determination	G. W. Null
pin pullers and squibs	A. G. Benedict
planetary scan actuator	E. L. Floyd
planetary scan sensor	R. Y. Wong
planetary scan subsystem	G. Coyle
power OSE	L. A. Packard, Jr.
power subsystem (Project Engineer)	K. M. Dawson
power subsystem contract	G. C. Cleven
primary structure	J. J. Lansford
propulsion system	B. W. Schmitz
	T. A. Groudle
pyrotechnic arming switch	J. C. Randall
pyrotechnic subsystem	M. L. Moore
radio OSE	S. J. Burks
radio subsystem	T. A. Cocca
science OSE	G. Hentosz
	R. Rotter
science system integration	W. G. Fawcett
science system support	W. Powell
scientific instruments packaging	J. Casler
separation initiated timer	G. Coyle
solar panel actuator	L. E. Elliott
solar panel dampers	P. T. Lyman
solar panel structure	R. L. Moore
solar panels	J. V. Goldsmith
solar plasma probe	R. A. Graham
solar pressure vane control	T. J. Donlin
solar pressure vanes (mechanical)	J. C. Randall
space sciences (Project Engineer)	F. L. Schutz
	W. G. Fawcett
spacecraft analysis	J. P. Holmes
spacecraft antennas (electrical)	J. F. Boreham
spacecraft antennas (mechanical)	W. E. Layman
spacecraft command	A. J. Spear
spacecraft mechanical development	J. Schmuecker
Sun sensors	L. F. Schmidt
superstructure	R. J. Spehalski
system OSE integration	H. B. Phillips
television electronics	J. D. Allen
television optics	R. A. Becker
temperature control	D. W. Lewis
temperature control louvers	G. Coyle

PERSONNEL (Cont'd)

Cognizant engineers (cont'd)	
temperature control shields	R. J. Spehalski
	H. D. VonDelden
temperature control testing	M. B. Gram
trajectories	D. A. Tito
trapped radiation detector	D. K. Schofield
video storage subsystem	W. M. Trester
Cognizant Scientists	
cosmic dust detector	B. V. Connor
cosmic ray telescope	H. R. Anderson
helium magnetometer	E. J. Smith
ionization chamber	H. R. Anderson
occultation experiment	A. Kliore
science ground data handling	K. Heftman
	S. Gunter
	M. Sander
solar plasma probe	C. W. Snyder
spacecraft television system	A. G. Herriman
trapped radiation detector	H. R. Anderson
	R. Lockhart
Space Flight Operations	
Director (SFOD)	D. W. Douglas
Assistant Director	D. F. Beauchamp
operations controllers	D. P. Backofen
	F. L. House
	M. D. Johnson
	C. L. Morgan
	T. M. Taylor
	D. G. Tustin
Engineering Planner	B. A. Pirtle
Administrative Aid	D. C. Schultheis
Data Coordinator	F. L. House
Space Flight Operation Facility	
Manager	D. B. Sparks
	D. A. Nelson
assistants	A. Ternstrom
	F. J. Walker
DSIF Operations	
Manager	W. L. Brown
assistants	J. T. Hatch
	C. K. Hornbeck
	E. S. Martin
Computer Applications	
Project Engineer	F. G. Curl

PERSONNEL (Cont'd)

Space Flight Operations (cont'd)	
Spacecraft Performance Analysis and Command (SPAC)	
Director	A. G. Conrad
assistants	R. K. Case
	R. F. Draper
	R. F. Miles
	R. A. Neilson
	P. H. Steinbrook
Space Sciences Analysis and Command	
Director	R. K. Sloan
assistants	H. R. Anderson
	W. G. Fawcett
	S. Z. Gunter
Flight Path Analysis and Command	
Director	N. R. Haynes

PHOBOS (see Mars)

PHOTOGRAPHS (see Picture Data)

PICTURE DATA (see also Fig. 20)

area	
average of all pictures	97,032 km^2
	35,512 mi^2
least amount shown	24,325 mi^2
picture showing least amount of	picture 14
Martian surface covered	1%
closest shot, slant range	picture 17
closest shot, slant range distance	11,976 km
	7,400 mi
craters	
number of in 21 pictures	approx. 70
range in sizes of visible craters	3 to 93 mi
data bits	
number per picture element	6
number per line	1200
number per picture	198,900
total number played back in 21 pictures plus 22 lines	4,199,340
duration of picture taking sequence at spacecraft	25 min, 12 sec

The operations room . . . scene of many tense moments during the encounter sequence


-0002
0082
FLT PATH
TASK
START
PARAMETER
VALUE

PICTURE DATA (Cont'd)

first picture	
time taken, at spacecraft (15 July 1965)	00:18:33.1
location of first indication of light	element 29 of line 6
date of first press release (PDT)	15 Jul 1965
time of first press release (PDT)	9:00 PM
locations of pictures on planet (see Fig. 20)	
number of pictures taken	21 plus 22 lines
path of pictures across planet	
latitudinal direction	33.4 N to 50.5-deg S
longitudinal direction	171.5 to 252.6 deg
region covered, latitudinal direction	83.9 deg
region covered, longitudinal direction	81.1 deg
picture elements	
picture dimensions, nominal	200 × 200 elements
picture dimensions, actual	195 × 170 elements
number per picture (excluding sync and line information)	33,150
total number in 21 pictures plus 22 lines	699,890
playback, first	
first picture start date	15 Jul 1965
first picture start time	13:01:58 GMT
last picture end date	24 Jul 1965
last picture end time	19:26:33
elapsed time, first picture start—last picture end	9 day, 6 hr, 24 min, 35 sec
playback, second	
first picture start date	24 Jul 1965
first picture start time	21:23:53
last picture end date	3 Aug 1965
last picture end time	03:36:02
elapsed time, first picture start—last picture end	9 days, 6 hr, 14 min, 9 sec
playback, total time	18 days, 12 hr, 38 min, 44 sec
shades of gray	
number of	64
digits used to represent	0 to 63

PICTURE DATA (Cont'd)

shades of gray (cont'd)	
digit for black	63
digit for white	0
straightest Sun angle	13.6 deg
straightest Sun angle, picture with	picture 3
straightest view angle	20.5 deg
straightest view, picture with	pictures 11 and 12
surface dimensions covered by pictures, average (see also Table 5)	
east–west	312 km 194 mi
north–south	311 km 193 mi
time between MT-9 and first picture	1 hr, 7 min
transmission time	
per element	0.72 sec
per line	2 min, 24 sec
per picture, average time	8 hr, 35 min, 39 sec
for Data Mode 1 telemetry between pictures, average	1 hr, 57 min, 3 sec

PLANETARY ACQUISITION (see Wide-Angle Acquisition)

PLANETARY SCAN PLATFORM

angular position (clock angle)	
when pinned	238.3 deg
after cover drop event	177.9 deg
attempted by DC-24 at encounter	179.43 deg
actual setting after DC-24 at encounter	178.69 deg
offset from nominal at encounter	0.74 deg
backlash of platform	21.47 min of arc
electrical components, number of (see Table 9)	502
field of view of wide-angle acquisition sensor	48.5 deg cone
look angle of wide-angle acquisition sensor	
cone direction	119.7 deg
clock direction	camera direction +0.24 deg
planet tracking accuracy	±1 deg + 1% of planet angular diam
power required	4.65 w @ 2.4 kc 2.81 w @ 400 cps

PLANETARY SCAN PLATFORM (Cont'd)

reference designations of subassemblies (see Table 8)	
scan cycle	180 deg
scan limits, clock angle (see also Fig. 5)	116.59 to 296.59 deg
scan rate	0.5 deg/sec
search cycles, number performed	
at cover drop event	10
at encounter	14
temperature range, operating	−40 to +80°C
time per cycle at cover drop event, average	11 min, 51 sec
time per cycle at encounter, average	11 min, 53.2 sec
weight (see Table 10)	6.85 lb

PLASMA PROBE (see Solar Plasma Probe)

POST-INJECTION PROPULSION SYSTEM (see Propulsion)

POWER SUBSYSTEM (see also Solar Panels)

battery	
life	1200 whr
type	silver-zinc
number of cells	18
voltage reading at Sun acquisition, 28 November 1964	34.5 v
voltage reading at end of mission	37.2 v
electrical components, number of, excluding solar cells (see Table 9)	901
inverters, number of	4
location of power regulator and battery	Bay VIII
location of power subsystem on spacecraft	Bay I
output voltages	
2.4 kc square wave	50 vac ±2%
400 cps square wave	28 and 32.5 vac ±5%
400 cps step square wave (to gyros)	27 vac ±10%
power consumption during cruise, average	170 w
reference designation of subassemblies (see Table 8)	
regulators, number of	2
regulator output voltage	52 vdc ±1%
regulator power capability	150 w
solar panel power output (see Fig. 28)	
telemetry points, number of	22
weight, including solar panels (see Table 10)	149.97 lb

PRINCIPAL INVESTIGATORS (see Table 7)

PROBLEM/FAILURE REPORTS

total		1461
after launch		70
before launch		
	attitude control	111
	central computer and sequencer	59
	command	31
	cosmic dust detector	17
	cosmic ray telescope	32
	data automation subsystem	91
	data encoder	38
	helium magnetometer	8
	ionization chamber	21
	launch vehicle interface	17
	operational support equipment	288
	planetary scan subsystem	48
	post-injection propulsion	16
	power	63
	pyrotechnics	24
	radio	134
	solar plasma probe	44
	spacecraft	27
	television	54
	thermal control	12
	trapped radiation detector	9
	ultraviolet photometer	6
	video storage (tape recorder)	51
	wiring and cabling	55
	miscellaneous	27
	total	1391

PROPULSION SYSTEM

amount of fuel used during midcourse		
	maneuver	4.19 lb
burn time capability		
	at launch	103 sec
	after midcourse maneuver	81 sec
burn time during midcourse maneuver		20.06 sec
characteristic velocity		4340 ft/sec
location on spacecraft		Bay II
maximum thrust vector deflection		
	capability, 2 jet vanes deflected 25 deg	±5.0 deg

PROPULSION SYSTEM (Cont'd)

motor alignment at launch	
horizontal offset	0.010 in.
vertical offset	0.002 in.
motor tilt angle	2.00 deg
nitrogen temperature variation during flight (see Fig. 32)	
nozzle expansion ratio	44:1
operating temperature range	+35 to +125°F
propellant flow rate	0.21487 lbm/sec
reference designation of subsystem	10A1
specific heat ratio	1.38
stagnation chamber pressure	189.4 psia
throat area, ambient	0.15 in.^{2}
type of fuel	anhydrous hydrazine
uncertainty in motor pointing accuracy	2.5 mrad max.
vacuum specific impulse (without jet vanes)	236.0 lbf-sec/lbm
vacuum specific impulse, 4 jet vanes deflected 10 deg	232.7 lbf-sec/lbm
vacuum thrust, without jet vanes	50.71 lbf
vacuum thrust, 4 jet vanes deflected 10 deg	50.00 lbf
vacuum thrust coefficient, without jet vanes	1.7500
weight, subsystem (see Table 10)	47.55 lb
weight of fuel after midcourse maneuver	17.01 lb
weight, total dry unserviced	26.68 lb
weight, wet	
nitrogen gas	1.00 lb
oxidizer	0.113 lb
propellant	21.56 lb
squibs	0.62 lb
total wet weight	49.99 lb

PROTONS (see Scientific Data, Trapped Radiation Detector, Cosmic Ray Telescope)

PUBLICATIONS (see Table 25)

PYROTECHNICS

electrical components, number of (see Table 9)	208
pinpullers, number of	9
pyrotechnic control unit	
number of electrical components	565
power required	0.48 w
weight	3.92 lb

PYROTECHNICS (Cont'd)

squibs	
number of	29
power required to fire	212 w (or 1-msec peak)
weight, subsystem (see Table 10)	12.21 lb

QUARTERLY REVIEWS, NASA (see Dates)

RADIATION (see Cosmic Ray Telescope, Ionization Chamber, Scientific Data from Mariner IV, Trapped Radiation Detector)

RADIO (see also High-Gain Antenna, Low-Gain Antenna)

cavity amplifier output (nominal)	0.5 w and 7 w (+38 dbm)
dc power input to cavity power amplifier	38.8 w
dc power input to traveling wave tube amplifier	60.3 w
dynamic range to threshold (nominal)	80 db
electrical components, number of (see Table 9)	1571
exciter output (nominal)	0.5 w (+27 dbm)
interferometer effect during Mariner IV flight (see Fig. 27)	
location of subsystem on spacecraft	Bay V and Bay VI
maximum receiver gain (nominal)	193 db
noise temperature (maximum) including preselector (nominal)	3370°K
nominal down-link frequency for VCO (zero static phase error)	2297.591400 Mc @ 25°C
nominal one-way transmission frequency at 25°C	
exciter A	2297.586552 Mc
exciter B	2297.592936 Mc
nominal up-link frequency for VCO (zero static phase error)	2115.698747 Mc @ 25°C
reference designations of subassemblies (see Table 8)	
threshold level, carrier (nominal)	−151 dbm
threshold level, telemetry (nominal)	−163 dbm
traveling wave tube amplifier output, nominal	10 w (+40 dbm)

RADIO (Cont'd)	
weight, subsystem (see Table 10)	34.40 lb
2.4 kc power input to receiver	7.5 w
2.4 kc power input to exciters and control unit	13 w
RANGE (see Orbit Data)	
RECEIVER (see Radio)	
REDUNDANCY (see Table 11)	
REFERENCE DESIGNATIONS (see Table 8)	
RELIABILITY, PART FAILURE SUMMARY (see Table 26)	
REPORTS (see Table 25)	
ROLL RATE	
Canopus sensor off	3.5 mrad/sec
Canopus sensor on	2.0 mrad/sec
SCAN PLATFORM (see Planetary Scan Platform)	
SCIENCE SUBSYSTEM (see also Narrow-Angle Mars Gate, Planetary Scan Platform, Television Subsystem)	
ancillaries	data automation system narrow-angle Mars gate planetary scan system
components, number of	18,152
instruments, number of	6
instruments, field and particle (see also headings by instrument name)	solar plasma probe ionization chamber trapped radiation detector cosmic ray telescope cosmic dust detector helium magnetometer
location of electronics on spacecraft	Bay III
power required by field and particle instrument plus data automation system	15.4 w
reference designations of science instruments (see Table 8)	
weight (see Table 10)	59.41 lb

SCIENTIFIC DATA FROM MARINER IV

dipole, estimated ratio of Mars' to Earth's	
cosmic ray telescope	1/1000
trapped radiation detector	1/1000 to 5/10,000
solar plasma probe	1/1000
helium magnetometer	3/10,000 to 1/10,000
dipole moment of Earth	8.06×10^{25} gauss/cm^3
distance of spacecraft above Earth–Sun line while in Earth's shadow	300,000 km
geocentric distance of spacecraft while in Earth's shadow	20 million km
magnetic field at surface of Mars	
trapped radiation detector	$<200\ \gamma$
helium magnetometer	$<100\ \gamma$
mass of Sun ÷ mass of Mars	
W. de Sitter (1938)	3,085,000 ±5,000
E. K. Rabe (1949)	3,110,000 ±7,700
H. C. Urey (1952)	3,079,000 ±6,000
Mariner IV (preliminary)	3,098,600 ±3,000
number of scientific measurements to end of mission (see Fig. 23)	23 million
solar flares	
dates observed	9–11 Jan 1965 5–10 Feb 1965 25–27 May 1965 1–3 Jun 1965 5–6 Jun 1965 13–19 Jun 1965 29 Jun–1 Jul 1965 6 Jul 1965 14–15 Jul 1965 4 Aug 1965 6–9 Aug 1965 27–30 Aug 1965

SCIENTIFIC DATA FROM MARINER IV (Cont'd)

solar flares (cont'd)	
number of clearly identifiable flares observed	
Class III flares	0
Class II flares	6
Class I flares	6
Total	12
cosmic dust detector	
cumulative cosmic dust flux	
between 1 and 1.25 AU	7.3×10^{-5} particles/m^2 sec (π sterad)
between 1.25 and 1.36 AU	2.1×10^{-4} particles/m^2 sec (π sterad)
between 1.36 and 1.43 AU (peak flux)	3.3×10^{-4} particles/m^2 sec (π sterad)
between 1.43 and 1.49 AU	2.2×10^{-4} particles/m^2 sec (π sterad)
at encounter	1.8×10^{-4} particles/m^2 sec (π sterad)
distance beyond Earth's orbit at maximum cosmic dust activity	36 million mi
distance from Earth at maximum cosmic dust activity	99 million mi
distance from Mars at maximum cosmic dust activity	10 million mi
total number of hits at end of mission (see Fig. 34)	approx. 235
cosmic ray telescope	
average observed cosmic ray intensity (protons and alpha particles >1 Mev)	3 counts/min
helium magnetometer	
average strength of interplanetary magnetic field	5 γ
maximum fluctuation in field strength	± 25 γ
ionization chamber	
average ionization rate observed	1000 ion pairs/sec cm^3 STPA
maximum ionization rate observed (during 5 February 1965 flare)	190,000 ion pairs/sec cm^3 STPA

ionization chamber (cont'd)	
average specific ionization observed	235 ion pairs/cm STPA
maximum specific ionization observed (during 5 February 1965 flare)	670 ion pairs/cm STPA
occultation experiment	
atmosphere, Martian	
density of, estimated	4.1 to 7.0 mb 10 gm/cm^2
scale height of, estimated	8 to 10 km
surface number, density of	1.43 $\pm$0.1 to 175 $\pm$0.1 $\times$ 10^{-5} gm/cm^3
surface mass, density of	1.9 $\pm$0.1 to 2.5 $\pm$0.15 $\times$ 10^{17} mol/cm
temperature of at occultation sampling point	170 $\pm$20 to 180 $\pm$20°K
ionosphere, Martian	
electron density, peak	9 $\pm$1.0 $\times$ 10^4 electrons/cc at 125 km altitude
height of at entering point (maximum electron density)	100–120 km 62–75 mi
temperature of	$<$200°K at 120–200 km
refractivity of Martian surface	3.6 $\pm$0.2 **N** units
solar plasma probe (preliminary data)	
minimum solar wind density observed, 29 November to 4 December 1964	4.0/cm^3
maximum solar wind density observed, 29 November to 4 December 1964	14.5/cm^3
minimum solar wind velocity observed, 29 November to 4 December 1964	345 km/sec
maximum solar wind velocity observed, 29 November to 4 December 1964	467 km/sec
minimum solar wind flux observed, 29 November to 4 December 1964	1.6 $\times$ 10^7/cm^2 sec
maximum solar wind flux observed, 29 November to 4 December 1964	5.5 $\times$ 10^7/cm^2 sec
minimum solar wind velocity observed, first 3 months of 1965	275 km/sec

SCIENTIFIC DATA FROM MARINER IV (Cont'd)

solar plasma probe (cont'd)	
maximum solar wind velocity observed, first 3 months of 1965	600 km/sec
velocity of solar wind at encounter	330 km/sec
density of solar wind at encounter	$2/cm^3$
solar wind pressure on spacecraft at encounter	0.5×10^{-8} dyne/cm^2
trapped radiation detector	
average count rate during mission	
electrons >40 kev, protons >500 kev	0.7 counts/sec
protons between 0.5 and 11 Mev	0.1 counts/sec
maximum count rate (during 5 February 1965 flare)	
electrons >40 kev, protons >500 kev	60 counts/sec
protons between 0.5 and 11 Mev	9 counts/sec
outermost detected limit of Earth's magnetosphere	25.7 R_E at Sun–Earth–probe angle of 112 deg

SEPARATION (see Event Time)

SOLAR ENERGY (see Solar Panels)

SOLAR FLARES (see Scientific Data)

SOLAR PANELS (see also Power)

cells	
type	p on n
material	boron diffused silicon
number per panel	28,224
number per section	1764
number of series cells per row	84
number of standard cells for telemetry monitoring	3
size of each solar cell	1 × 2 cm
dimensions	
linear	71.4 × 35.5 in.
area of each panel	17.6 sq ft or 2554.7 sq in.
total solar panel area	70.4 sq ft

The first closeup picture of Mars, taken by Mariner IV at a range of 10,500 miles

SOLAR PANELS (Cont'd)

magnetic fields (see major heading, Magnetic Fields)	
panel sections	
area of each section	4.4 sq ft
number per panel	4
number of parallel rows per section	21
maximum voltage output per section	50 v
power	
output watts available (see Fig. 28)	
near earth, at 55°C	700 w
at closest approach, at −10°C	325 w
solar panel power demands	
before encounter	164 w
during encounter	197 w
during picture playback	147 w
after picture playback	164 w
reference designations of subassemblies (see Table 8)	
solar constant	
at Earth	1.49×10^8 km
at Mars	2.32×10^8 km
solar energy	
near Earth	135 mw/cm^2
near Mars	58.8 mw/cm^2
solar intensity during flight (see Fig. 30)	
temperatures of solar panels during flight (see Fig. 29)	
weight of all panels (see Table 10)	79.02 lb
weight of each panel	18.5 lb

SOLAR PLASMA PROBE

diameter of viewing aperture	2.5 in.
electrical components, number of (see Table 9)	1290
field of view	30 deg half-angle cone
grids, number of	4
look angle	
cone direction	10 deg
clock direction	9 deg
measurement ranges (positive ions)	
flux density	5×10^{-5} to 5×10^{-9} particles/cm^2
energy spectrum	30 ev to 10 kev

SOLAR PLASMA PROBE (Cont'd)

power required	
average	2.65 w
peak	2.90 w
reference designations of subassemblies (see Table 8)	
scientific results (see Scientific Data)	
sensors, number of	1
weight (see Table 10)	6.41 lb

SOLAR RADIATION (see Solar Panels)

SOLAR VANES

angular operating range of solar vane	±26 deg
area of each vane	7 sq ft
force of solar particles on each vane (nominal)	10^{-6} lb
maximum restoring torque over 0.5-deg limit cycle	0.85 dyne cm
thermal actuator illumination at spacecraft off-angle of 5 deg	50%
total dynamic range of thermal actuator	5 deg
total solar vane area	28 sq ft.

SOLAR WIND (see Scientific Data, Solar Plasma Probe)

SPACECRAFT

clock angle 0-deg reference	Canopus tracker view direction, Bay VIII, 34 deg from −Y axis
configuration (see Fig. 1)	
electrical components, total number of (see Table 9)	39,220
functions with alternate operations, number of	18
options available for 18 functions, number of	53
redundant items (see Table 11)	
redundant items, number of	13
spacecraft area presented to solar radiation	11.12 sq meters
spacecraft center-of-gravity position (measured)	
X axis	+0.698 in.
Y axis	−0.023 in.
Z axis	−12.293 in.

SPACECRAFT (Cont'd)

spacecraft magnetic field (at magnetometer, without solar panels)	
magnetometer X axis	$+5\ \gamma$
magnetometer Y axis	$+11.5\ \gamma$
magnetometer Z axis	$+31.7\ \gamma$
total number of parts	138,000
weight	574.74 lb

SPACECRAFT STRUCTURE

boost dampers	
nominal damping rate	15 lb/in./sec
nominal spring rate	185 lb/in.
damper tube material	aluminum alloy
damper spring material	beryllium copper
cruise dampers	
damping ratio	0.15 to 0.70 matched to within 0.1
damper body material	polished aluminum
damper shaft material	titanium alloy
dimensions of electronic package cases	15 × 16-1/2 in.
high-gain antenna material	aluminum honeycomb
low-gain antenna dampers	
nominal damping rate, short damper	5.5 lb/in./sec
nominal damping rate, long damper	11 lb/in./sec
nominal spring rate, short damper	160 lb/in.
nominal spring rate, long damper	320 lb/in.
damper tube material	aluminum alloy
damper spring material	beryllium copper
octagon	
material	forged magnesium
flatness of octagon rings	0.010 in./54 in.
bolts and screws material	titanium
scan platform material	machined aluminum
science cover material	bonded aluminum honeycomb
secondary structure material	0.035 aluminum tubing
solar panel material	0.5 in. corrugated aluminum alloy

SPACECRAFT STRUCTURE (Cont'd)

spacecraft feet	
number of	8
width of	1 in.
weight (see Table 10)	78.44 lb

SPACECRAFT VELOCITY (see Velocity)

SQUIBS (see Pyrotechnics)

STAR ACQUISITION (see Attitude Control, Canopus Tracker)

STAR MAP

number of stars stored in computer	423 + Milky Way and Zodiacal light

SUBCONTRACTORS (see Table 24)

SUBSYSTEMS (see Attitude Control, Central Computer and Sequencer, Command, Data Encoder, High-Gain Antenna, Low-Gain Antenna, Power, Propulsion, Pyrotechnics, Radio, Science Subsystem, Structure, Tape Recorder, Temperature Control, Wiring and Cabling)

SUN ACQUISITION (see Event Times)

SUN–PROBE DISTANCE (see Distance from Sun)

SUN SENSORS

field of view of Sun gate	2.2 deg half-angle cone
number of sensor assemblies	4
number of sensor cells	16
number of primary cells	4
number of secondary cells	12
reference designations of subassemblies (see Table 8)	

TAPE RECORDER

bit capacity, minimum acceptable	5.24×10^6
bit error rate	<1 in 10^4 bits
electrical components, number of (see Table 9)	1479
interval between pictures during record	approx. 24 or 72 sec

TAPE RECORDER (Cont'd)

interval between pictures during playback	approx. 2 hr
location on spacecraft	Bay V
operating temperature range	−10 to +70°C
playback frequency	8-1/3 bps
power required, nominal	3 w record, 4 w playback
record frequency	10.7 kc
record-to-playback speed ratio	1284/1
recording sequence (see Fig. 14)	
reference designations of subassemblies (see Table 8)	
tape length	330 ft loop
tape speed, playback	0.01 in./sec
tape speed, record	12.84 in./sec
tape width	1/4 in.
total recording time during encounter	1520 ±20 sec, or 25 min, 20 sec, ±20 sec
VCO frequency, nominal	1512 cps
weight, subsystem (see Table 10)	16.89 lb

TELEMETRY

bits telemetered from spacecraft, total number (assuming 7 bits per measurement)	325.5 million
channel allocations (see also Table 19)	
scientific channels	39 (Data Mode 2) 61 (Data Mode 3)
housekeeping channels	10
engineering channels	90
communications measurements	11
current measurements	13
event counters	4
position measurements	13
pressure measurements	7
temperature measurements	33
voltage measurements	5
miscellaneous measurements	4
channel characteristics	
data channel modulation loss	+4.6 db ±0.4 db
synchronization channel effective noise bandwidth	+0.5 db ±0.4 db
synchronization channel modulation loss	+10.5 db +0.4, −0.0 db
synchronization channel threshold signal/noise ratio	+13.5 db ±0.5 db

TELEMETRY (Cont'd)

data frames	
bits per data frame	420
cycle time (8-1/3 bps)	50.4 sec
cycle time (33-1/3 bps)	12.6 sec
number of complete science measurements per data frame	
cosmic dust detector	1/2
cosmic ray telescope	1/2
helium magnetometer	4
ionization chamber	1/4
solar plasma probe	1/36
trapped radiation detector	1/8
Data Modes, number of	4
Data Mode formats	
Data Mode 1	
science bits per data frame	0
engineering bits per data frame	420
Data Mode 2	
science bits per data frame	280
engineering bits per data frame	140
Data Mode 3	
science bits per data frame	420
engineering bits per data frame	0
Data Mode 4	
science picture bits per data frame	420
engineering bits per data frame	0
encoding type	sampled data, digital phase shift keying with pseudo-noise synchronization
engineering format (see Figs. 16 and 22)	
error probabilities	
bit error probability at threshold	5×10^{-3}
required ST/N/B* for bit error probability of 5×10^{-3}	± 7.1 db-cps/bps ± 1.2 db
word error probability at threshold	1 word in 28
measurements, number of	
engineering measurements, to end of mission (see Fig. 23)	13 million

*signal power per bit to noise power in unit bandwidth

TELEMETRY (Cont'd)

measurements, number of (cont'd)	
housekeeping measurements, to end of mission	10.5 million
scientific measurements, to end of mission (see Fig. 23)	23 million
total number of measurements to end of mission (see Fig. 19)	46.5 million
telemetry resolution (commutation) at 8-1/3 bps	50.4 sec
telemetry resolution (commutation) at 33-1/3 bps	12.6 sec
time	
between samples (see Table 20)	
science data off during picture playback, 15 July to 3 August 1965	18 days, 12 hr, 38 min, 44 sec
time spent in Data Mode 1	102 hr, 47 min
time spent in Data Mode 2	7,338 hr
time spent in Data Mode 3	6 hr, 14 min
time spent in Data Mode 4	403 hr, 25 min
transmission rates	33-1/3, 8-1/3 bps
word length	7 bits

TELEVISION PICTURES (see Picture Data)

TELEVISION SUBSYSTEM (see also Picture Data)

electrical components, number of (see Table 9)	2003
exposure time	80 ms or 200 ms
field of view	1.05 × 1.05 deg
filter window wavelengths	
green	4800 to 5600 Å
red	5400 to 6500 Å
focal length	12 in.
frequency	
readout frequency	83.3 kc
record frequency	10.7 kc
gain control for brightness compensation	64:1
image erase time	24 sec
look angle of camera (see also Fig. 5)	
cone direction	120.00 deg
clock direction	116.35 to 296.35 deg
picture size in elements	
nominal	200 × 200
actual	195 × 170
number of picture elements per picture	33,150

TELEVISION SUBSYSTEM (Cont'd)

number of data bits per picture element word	6
total number of data bits per picture	198,900
number of data bits used for frame count, etc.	12,200
power required	8 w
readout time	24 sec
reference designations of subassemblies (see Table 8)	
sensitivity threshold	0.0075 ft-c sec
shades of gray, number of	64
time between exposures (see Fig. 14)	
type of telescope	f/8 Cassegrain
vidicon image size	0.22 × 0.22 in.
weight, subsystem (see Table 10)	11.28 lb

TEMPERATURE CONTROL (see also Absorptivity Standard)

assemblies, number of	40
louvers	
angular change of louvers relative to temperature	90 deg/30°F
louver area for each bay	1.4 sq ft
total louver area	8.4 sq ft
louver positioning error	±5 deg
louver position telemetry inaccuracy	±15 deg
number per assembly	22 (11 pairs)
total number of louvers	132 (66 pairs)
weight of all louvers	8.57 lb
parts, number of in system	1200
shielding	
amount of octagon covered by shielding	85%
material of blanket layers	0.00025 aluminized mylar
number of layers in lower blanket	22
number of layers in upper blanket	31
weight of thermal passive type shielding	8 lb
temperatures during flight, typical (see Figs. 29 through 33)	
weight, subsystem (see Table 10)	15.53 lb

TESTING

environmental tests (see Environmental Tests)
life tests (see Life Tests)
system tests (see Fig. 21 and Table 18)

THERMAL BLANKET (see Temperature Control)

THERMAL SHIELDS (see Temperature Control)

THRUST (see Propulsion System)

TIME CONVERSION (see Table 2)

TIMES, GMT (see Event Times)

TIME SPANS (see also Event Times)

Mariner III parking orbit coast time	23 min, 18 sec
Mariner III launch to battery failure, elapsed time	8 hr, 43 min
elapsed times, Mariner IV	
launch to booster engine cutoff	2 min, 14 sec
launch to booster engine separation	5 min, 16 sec
launch to sustainer engine cutoff	4 min, 59 sec
launch to vernier engine cutoff	5 min, 17 sec
launch to shroud ejection	5min, 20 sec
launch to Atlas/Agena separation	5 min, 22 sec
launch to Agena first burn ignition	6 min, 13 sec
launch to Agena first burn cutoff	8 min, 38 sec
launch to Agena second burn ignition	40 min, 52 sec
launch to Agena second burn cutoff	42 min, 27 sec
launch to spacecraft separation	45 min, 9 sec
launch to solar panel deployment	53 min, 3 sec
launch to Sun acquisition	68 min, 56 sec
launch to Canopus acquisition	20 hr, 40 min
launch to midcourse maneuver completion	7 days, 3 hr, 7 min
launch to start of cover drop event	74 days, 13 hr, 7 min
launch to closest approach	228 days, 10 hr, 38 min, 56 sec
launch to end of mission	307 days, 7 hr, 25 min, 22 sec
spacecraft separation to Sun acquisition	23 min, 47 sec
MT-9 event to first picture transmission	1 hr, 8 min, 5 sec
event durations, Mariner IV	
parking orbit coast time	32 min, 14 sec
Agena first burn duration	2 min, 25 sec
Agena second burn duration	1 min, 35 sec
aborted midcourse maneuver sequence (start to Canopus re-acquisition)	9 hr, 57 min, 44 sec
midcourse maneuver sequence (start to Canopus re-acquisition)	3 hr, 53 min, 19 sec
midcourse maneuver motor burn time	20.06 sec
cover drop event	7 hr, 20 min, 6 sec
encounter sequence (first command to exit occultation)	12 hr, 57 min, 11 sec
television picture sequence at spacecraft	25 min, 12 sec
occultation duration	53 min, 53 sec

TIME SPANS (Cont'd)

event durations, Mariner IV (cont'd)	
picture playback duration	
first playback sequence	9 days, 6 hr, 24 min, 35 sec
second playback sequence	9 days, 6 hr, 14 min, 9 sec
total playback duration	18 days, 12 hr, 38 min, 44 sec
maneuver inhibit sequence	39 min, 48 sec
black space picture sequence and playback	2 days, 9 hr, 59 min
end of mission event	34 min, 50 sec

TIMING (see Central Computer and Sequencer)

TRAJECTORY (see Orbit Data)

aiming point diagram (see Fig. 37)

ecliptic view of pre- and post-encounter trajectory (see Fig. 36)

TRANSPONDER (see Radio)

TRAPPED RADIATION DETECTOR

counting rates	
detectors A, B, C	0.6 to 10^7 counts/sec
detector D_1	0.071 to 10^6 counts/sec
detector D_2	0.059 to 10^6 counts/sec
detection levels (number of detectors)	5
electrical components, number of (see Table 9)	283
field of view (all detectors)	30 deg half-angle cone
geometric factor, omnidirectional	
detector A	approx. 0.15 cm^2
detector B	approx. 0.15 cm^2
detector C	approx. 0.15 cm^2
geometric factor, unidirectional	
detector A	$0.044 \pm .005$ cm^2 sterad
detector B	$0.055 \pm .005$ cm^2 sterad
detector C	$0.050 \pm .005$ cm^2 sterad
detector D_1	$0.065 \pm .003$ cm^2 sterad
detector D_2	$0.065 \pm .003$ cm^2 sterad

TRAPPED RADIATION DETECTOR (Cont'd)

look angle		
detector A		
cone direction		135 deg
clock direction		169 deg
detectors B, C, D_1, D_2		
cone direction		70 deg
clock direction		160 deg
measurement ranges		
detector A	electrons	$\geq$45 kev
	protons	$\geq$670 $\pm$30 kev
detector B	electrons	$\geq$150 kev
	protons	$\geq$3.1 Mev
detector C	electrons	$\geq$40 kev
	protons	$>$550 $\pm$20 kev
detector D_1	electrons	none
	protons	0.5 to 11.0 Mev
detector D_2	electrons	none
	protons	0.88 to 4.0 Mev
power required		0.44 w
scientific results (see Scientific Data)		
sensors, number of		4
weight (see Table 10)		2.17 lb

TRAVELING WAVE TUBE AMPLIFIER (see Radio)

TRAVELING WAVE TUBE AMPLIFIER CHANGEOVER

date	13 Dec 1964
day of flight	15
time	14:09:00
communication time (one way)	13.8 sec
Earth–probe–Sun angle	56.8 deg
Canopus–probe–Sun angle	103.1 deg
spacecraft celestial longitude	83.0 deg
spacecraft celestial latitude	3.22 deg
Earth celestial longitude	81.6 deg
Mars celestial longitude	131.0 deg
spacecraft distance from Earth	4,158,654 km 2,584,188 mi
spacecraft distance from Sun	149,486,790 km 92,891,091 mi
spacecraft distance from Mars	184,427,040 km 114,597,650 mi

TRAVELING WAVE TUBE AMPLIFIER CHANGEOVER (Cont'd)

distance traveled along heliocentric arc	44,971,252 km
	27,949,815 mi
spacecraft velocity relative to Earth	6,961.4 mph
spacecraft velocity relative to Mars	56,114.4 mph
spacecraft velocity relative to Sun	73,567.3 mph

VELOCITY AT ENCOUNTER (see Fig. 39)

VELOCITY PERIODICALLY DURING FLIGHT (see Table 3)

VELOCITY OF MARINER IV RELATIVE TO EARTH

periodically during flight (see Table 3)	
injection	25,598 mph
midcourse maneuver	7,049.9 mph
changeover to traveling wave tube amplifier	6,961.4 mph
DC-15 Canopus gate override event	6,957.5 mph
MT-6 changeover to 8-1/3 bps	7,710.5 mph
cover drop event	16,146.5 mph
MT-1 Canopus cone angle update	21,231.3 mph
MT-5 changeover to high-gain antenna	23,242.1 mph
MT-2 Canopus cone angle update	32,703.7 mph
MT-3 Canopus cone angle update	44,315.7 mph
MT-4 Canopus cone angle update	56,174.8 mph
closest approach	66,732.4 mph
black space picture sequence	80,469.2 mph
end of mission	90,499 mph

VELOCITY OF MARINER IV RELATIVE TO MARS

periodically during flight (see Table 3)	
midcourse maneuver	59,396.1 mph
changeover to traveling wave tube amplifier	56,114.4 mph
DC-15 Canopus gate override event	54,338.0 mph
MT-6 changeover to 8-1/3 bps	47,319.7 mph
cover drop event	32,593.7 mph
MT-1 Canopus cone angle update	27,494.4 mph
MT-5 changeover to high-gain antenna	25,788.7 mph
MT-2 Canopus cone angle update	19,060.0 mph
MT-3 Canopus cone angle update	13,367.4 mph
MT-4 Canopus cone angle update	10,374.4 mph
closest approach	11,379.0 mph
black space picture sequence	10,370.4 mph
end of mission	10,748 mph

VELOCITY OF MARINER IV RELATIVE TO SUN

periodically during flight (see Table 3)	
midcourse maneuver	74,149.7 mph
changeover to traveling wave tube amplifier	73,567.3 mph
DC-15 Canopus gate override event	73,181.5 mph
MT-6 changeover to 8-1/3 bps	71,146.8 mph
cover drop event	64,646.3 mph
MT-1 Canopus cone angle update	61,787.3 mph
MT-5 changeover to high-gain antenna	60,764.2 mph
MT-2 Canopus cone angle update	56,373.6 mph
MT-3 Canopus cone angle update	51,998.1 mph
MT-4 Canopus cone angle update	48,751.0 mph
closest approach	47,479.1 mph
black space picture sequence	48,310.2 mph
end of mission	48,810 mph
at aphelion of heliocentric orbit	48,500 mph
at perihelion of heliocentric orbit	68,200 mph

VENDORS (see Table 24)

VIDEO STORAGE SUBSYSTEM (see Tape Recorder)

VOLTAGE CONTROLLED OSCILLATOR (see Radio)

WEIGHT

subsystem weights (see Table 10)	
total spacecraft weight	574.74 lb

WIDE ANGLE ACQUISITION (see also Planetary Scan Platform)

date of wide angle acquisition	14 Jul 1965
field of view of sensor	48.5 deg cone
look angle of sensor (see also Fig. 5)	
cone direction	119.7 deg
clock direction	camera direction + 1.0 deg
sensor scan limits, in clock angle	116.59 to 296.59 deg
time of wide angle acquisition	23:42:41

WIRING AND CABLING

number of disconnect plugs, 1 to 69 contacts in each	350
number of electrical components (see Table 9)	5
number of separate solder or mechanical connections	8000
number of wires	4000
total length of wiring	6000 ft
weight of all wiring (see Table 10)	45.69 lb

Table 1. Chronological reference: date and day of mission

Date	November 1964			December 1964																
	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
DAY OF YEAR	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352
DAY OF MISSION	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Date	December 1964														January 1965					
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6
DAY OF YEAR	353	354	355	356	357	358	359	360	361	362	363	364	365	366	001	002	003	004	005	006
DAY OF MISSION	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39

Date	January 1965																			
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
DAY OF YEAR	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023	024	025	026
DAY OF MISSION	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59

Date	January 1966					February 1965														
	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DAY OF YEAR	027	028	029	030	031	032	033	034	035	036	037	038	039	040	041	042	043	044	045	046
DAY OF MISSION	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79

Table 1. (Cont'd)

Date	February 1965													March 1965						
	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7
DAY OF YEAR	047	048	049	050	051	052	053	054	055	056	057	058	059	060	061	062	063	064	065	066
DAY OF MISSION	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99

Date	March 1965																			
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
DAY OF YEAR	067	068	069	070	071	072	073	074	075	076	077	078	079	080	081	082	083	084	085	086
DAY OF MISSION	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119

Date	March 1965				April 1965															
	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DAY OF YEAR	087	088	089	090	091	092	093	094	095	096	097	098	099	100	101	102	103	104	105	106
DAY OF MISSION	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139

Date	April 1965														May 1965					
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6
DAY OF YEAR	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126
DAY OF MISSION	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159

Date	May 1965																			
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
DAY OF YEAR	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146
DAY OF MISSION	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179

Date	May 1965					June 1965														
	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DAY OF YEAR	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166
DAY OF MISSION	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199

Date	June 1965															July 1965				
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
DAY OF YEAR	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186
DAY OF MISSION	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219

Date	July 1965																			
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
DAY OF YEAR	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206
DAY OF MISSION	220	221	222	223	224	225	226	227	230	231	232	233	234	235	236	237	238	239	228	229

Table 1. (Cont'd)

Date	July 1965						August 1965													
	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DAY OF YEAR	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226
DAY OF MISSION	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259

Date	August 1965																	September 1965		
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3
DAY OF YEAR	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241·	242	243	244	245	246
DAY OF MISSION	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279

Date	September 1965																			
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
DAY OF YEAR	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266
DAY OF MISSION	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299

Date	September 1965							October 1965
	24	25	26	27	28	29	30	1
DAY OF YEAR	267	268	269	270	271	272	273	274
DAY OF MISSION	300	301	302	303	304	305	306	307

Table 2. Time conversion guide

GMT	EDT	EST	PDT	PST	Tidbinbilla	Woomera	Madrid and So. Africa
0100	2100	2000	1800	1700	1100	1030	0300
0200	2200	2100	1900	1800	1200	1130	0400
0300	2300	2200	2000	1900	1300	1230	0500
0400	2400	2300	2100	2000	1400	1330	0600
0500	0100	2400	2200	2100	1500	1430	0700
0600	0200	0100	2300	2200	1600	1530	0800
0700	0300	0200	2400	2300	1700	1630	0900
0800	0400	0300	0100	2400	1800	1730	1000
0900	0500	0400	0200	0100	1900	1830	1100
1000	0600	0500	0300	0200	2000	1930	1200
1100	0700	0600	0400	0300	2100	2030	1300
1200	0800	0700	0500	0400	2200	2130	1400
1300	0900	0800	0600	0500	2300	2230	1500
1400	1000	0900	0700	0600	2400	2330	1600
1500	1100	1000	0800	0700	0100	2430	1700
1600	1200	1100	0900	0800	0200	0130	1800
1700	1300	1200	1000	0900	0300	0230	1900
1800	1400	1300	1100	1000	0400	0330	2000
1900	1500	1400	1200	1100	0500	0430	2100
2000	1600	1500	1300	1200	0600	0530	2200
2100	1700	1600	1400	1300	0700	0630	2300
2200	1800	1700	1500	1400	0800	0730	2400
2300	1900	1800	1600	1500	0900	0830	0100
2400	2000	1900	1700	1600	1000	0930	0200

Table 3. Mariner IV range and velocity table[a]

Calendar day	Date	Spacecraft range, mi			Spacecraft velocity, mph		
		Earth altitude[a]	Mars altitude[b]	Sun distance[c]	Relative to Earth	Relative to Mars	Relative to Sun
335	11/30/64	454,854	127,320,300	91,806,877	7,288	61,438	74,533
342	12/07/64	1,616,955	120,399,290	92,275,319	7,010	58,500	74,003
349	12/14/64	2,788,810	113,338,860	93,045,395	6,958	55,593	73,460
356	12/21/64	3,957,057	106,353,390	94,095,101	6,983	52,658	72,767
363	12/28/64	5,140,378	99,490,719	95,400,976	7,230	49,718	71,929
4	1/04/65	6,386,601	92,794,734	96,935,379	7,849	46,802	70,967
11	1/11/65	7,757,549	86,303,297	98,668,215	8,819	43,941	69,903
18	1/18/65	9,309,648	80,047,522	100,568,380	10,059	41,157	68,762
25	1/25/65	11,095,356	74,051,669	102,604,990	11,602	38,470	67,566
32	2/01/65	13,172,707	68,333,452	104,748,230	13,425	35,895	66,337
39	2/08/65	15,583,782	62,904,576	106,970,100	15,415	33,440	65,092
46	2/15/65	18,344,914	57,771,406	109,244,720	17,485	31,112	63,846
53	2/22/65	21,461,321	52,935,664	111,548,620	19,674	28,912	62,612
60	3/01/65	24,940,864	48,395,084	113,860,710	21,982	26,844	61,401
67	3/08/65	28,778,825	44,144,044	116,162,290	24,333	24,904	60,220
74	3/15/65	32,954,101	40,174,063	118,436,880	26,660	23,093	59,077
81	3/22/65	37,444,573	36,474,257	120,670,080	29,010	21,408	57,975
88	3/29/65	42,236,768	33,031,715	122,849,340	31,412	19,846	56,919
95	4/05/65	47,310,403	29,831,813	124,963,790	33,813	18,407	55,912

102	4/12/65	52,633,411	26,858,486	127,004,060	36,145	17,087	54,955
109	4/19/65	58,176,037	24,094,484	128,962,040	38,455	15,885	54,050
116	4/26/65	63,884,221	21,536,385	130,819,970	40,775	14,807	53,203
123	5/03/65	69,802,859	19,134,772	132,594,170	43,101	13,839	52,404
130	5/10/65	75,864,141	16,886,212	134,286,140	45,348	12,986	51,659
137	5/17/65	82,036,585	14,771,290	135,837,540	47,551	12,246	50,967
144	5/24/65	88,299,813	12,770,771	137,298,650	49,771	11,619	50,329
151	5/31/65	94,630,924	10,865,944	138,648,340	51,995	11,100	49,744
158	6/07/65	100,996,690	9,038,929	139,883,930	54,147	10,684	49,213
165	6/14/65	107,366,060	7,272,980	141,003,170	56,250	10,365	48,735
172	6/21/65	113,719,490	5,552,758	142,004,200	58,371	10,133	48,310
179	6/28/65	120,036,340	3,864,521	142,885,450	60,514	9,979	47,937
186	7/05/65	126,285,960	2,196,254	143,645,750	62,601	9,892	47,616
193	7/12/65	132,439,450	537,167	144,284,700	64,662	9,876	47,340
196[d]	7/15/65	134,398,880	6,118.4	144,468,580	66,678	11,518	47,171
200	7/19/65	138,374,080	1,125,242	144,824,240	67,467	9,869	48,968
207	7/26/65	143,540,240	2,599,538	145,255,710	69,543	9,900	48,693
214	8/02/65	149,228,280	4,267,851	145,635,210	71,763	9,966	48,542
221	8/09/65	154,772,430	5,948,908	145,921,360	73,921	10,053	48,427

[a]Data are for 20:00 GMT 12:00 PM PST (weekly, Monday) through 19 April 1965
19:00 GMT 12:00 PM PDT (weekly, Monday) 26 April through 19 July 1965
00:00 GMT 4:00 PM PDT (weekly, Monday) 26July through 4 October 1965

[b]Measured from surface

[c]Measured from center

[d]01:00:58 GMT

Table 3. (Cont'd)

Calendar day	Date	Spacecraft range, mi			Spacecraft velocity, mph		
		Earth altitude[a]	Mars altitude[b]	Sun distance[c]	Relative to Earth	Relative to Mars	Relative to Sun
228	8/16/65	160,159,080	7,645,293	146,113,720	76,080	10,154	48,351
235	8/23/65	165,377,230	9,358,083	146,212,000	78,279	10,262	48,312
242	8/30/65	170,407,350	11,086,937	146,216,030	80,469	10,370	48,310
249	9/06/65	175,225,750	12,830,158	146,125,810	82,594	10,474	48,346
256	9/13/65	179,820,720	14,584,765	145,941,530	84,710	10,569	48,420
263	9/20/65	184,184,830	16,346,549	145,663,520	86,862	10,651	48,532
270	9/27/65	188,303,110	18,110,153	145,292,300	89,016	10,715	48,680
277	10/04/65	192,155,480	19,869,142	144,828,550	91,102	10,759	48,867

[a]Data are for 20:00 GMT 12:00 PM PST (weekly, Monday) through 19 April 1965
19:00 GMT 12:00 PM PDT (weekly, Monday) 26 April through 19 July 1965
00:00 GMT 4:00 PM PDT (weekly, Monday) 26July through 4 October 1965

[b]Measured from surface

[c]Measured from center

Table 4. Earth and spacecraft positions, October 1965 through December 1967

Date	Spacecraft celestial position		Spacecraft distance from Earth		Spacecraft distance from Sun		Distance traveled, mi	Earth longitude
	Longitude, deg	Latitude, deg	km	mi	km	mi		
Oct. 1, 1965	263.4	1.5	306,647,310	190,550,638	233,416,970	145,045,305	417,698,544	7.6
10	267.6	1.7	314,213,400	195,252,207	232,321,820	144,364,779	428,269,991	16.4
20	272.3	1.8	321,756,400	199,939,427	231,145,690	143,633,932	440,095,450	26.4
30	277.0	1.9	328,347,470	204,035,118	229,412,230	142,556,760	452,022,160	36.4
Nov. 9	281.9	2.1	333,944,940	207,513,386	226,956,110	141,030,527	464,068,270	46.5
19	286.8	2.2	338,561,580	210,382,166	224,607,240	139,570,939	476,251,790	56.4
29	291.9	2.3	342,184,730	212,633,591	221,996,290	137,948,495	488,590,530	66.5
Dec. 10	297.6	2.4	345,030,960	214,402,239	218,838,670	135,986,350	502,363,290	77.7
20	302.9	2.5	346,642,240	215,403,488	215,727,250	134,052,913	515,084,490	87.9
30	308.4	2.5	347,351,410	215,844,166	212,407,680	131,990,132	528,013,670	98.0
Jan. 9, 1966	314.0	2.5	347,223,140	215,764,459	208,904,410	129,813,200	541,166,530	108.3
19	319.9	2.5	346,356,900	215,226,178	205,246,101	127,539,927	554,557,730	118.5
29	326.0	2.5	344,820,770	214,271,626	201,466,230	125,191,115	568,200,560	128.6
Feb. 8	332.3	2.4	342,726,100	212,969,999	197,603,620	122,790,889	582,106,500	138.8
18	338.9	2.3	340,205,300	211,403,573	193,702,900	120,366,982	596,284,710	148.9
28	345.8	2.2	337,356,170	209,633,124	189,814,850	117,950,948	610,741,450	159.0

Table 4. (Cont'd)

Date	Spacecraft celestial position		Spacecraft distance from Earth		Spacecraft distance from Sun		Distance traveled, mi	Earth longitude
	Longitude, deg	Latitude, deg	km	mi	km	mi		
Mar. 10	352.9	2.0	334,316,720	207,744,410	185,996,510	115,578,231	625,479,300	169.0
20	0.3	1.8	331,228,300	205,825,266	182,310,960	113,288,030	640,496,440	178.9
30	8.0	1.6	328,191,590	203,938,254	178,826,510	111,122,793	655,785,780	188.8
Apr. 9	16.0	1.3	325,339,460	202,165,940	175,615,300	109,127,347	671,334,120	198.7
19	24.3	1.0	322,788,730	200,580,917	172,751,070	107,347,515	687,121,480	208.5
29	32.9	0.6	320,608,850	199,226,339	170,306,110	105,828,217	703,120,750	218.2
May 9	41.7	0.2	318,892,990	198,160,104	168,347,450	104,611,105	719,297,590	227.9
19	50.6	−0.2	317,702,020	197,420,035	166,932,640	103,731,942	735,610,960	237.5
29	59.7	−0.6	317,046,970	197,012,987	166,105,480	103,217,945	752,014,240	247.2
Jun. 8	68.8	−0.9	316,959,340	196,958,534	165,892,570	103,085,643	768,456,900	256.8
18	77.9	−1.3	317,430,000	197,251,002	166,300,880	103,339,367	784,886,640	266.3
28	87.0	−1.6	318,404,790	197,856,737	167,317,180	103,970,896	801,251,770	275.9
Jul. 8	96.0	−1.9	319,853,460	198,756,940	168,909,210	104,960,183	817,503,410	285.4
18	104.6	−2.1	321,704,010	199,906,872	171,028,430	106,277,066	833,597,500	294.9
28	113.1	−2.3	323,849,840	201,240,291	173,613,850	107,883,646	849,496,180	304.5
Aug. 7	121.3	−2.4	326,215,480	202,710,299	176,596,330	109,736,959	865,168,590	314.0
17	129.2	−2.5	328,686,510	204,245,797	179,902,710	111,791,544	880,591,170	323.6
27	136.9	−2.5	331,127,700	205,762,753	183,459,400	114,001,671	895,747,320	333.3

Sept. 6	144.2	−2.5	333,442,910	207,201,424	187,195,200	116,323,097	910,626,930	343.0
16	151.2	−2.4	335,500,990	208,480,315	191,043,260	118,714,282	925,225,630	352.7
26	158.0	−2.4	337,165,560	209,514,679	194,942,300	121,137,145	939,543,830	2.5
Oct. 6	164.5	−2.2	338,345,050	210,247,614	198,837,170	123,557,417	953,586,060	12.3
16	170.7	−2.1	338,916,000	210,602,402	202,679,020	125,944,743	967,360,100	22.2
26	176.7	−1.9	338,765,890	210,509,124	206,425,090	128,272,551	980,876,340	32.1
Nov. 5	182.5	−1.8	337,828,620	209,926,704	210,038,260	130,517,775	994,147,250	42.1
15	188.2	−1.6	336,008,210	208,795,501	213,486,610	132,660,579	1,007,186,840	52.2
25	193.6	−1.4	333,235,440	207,072,502	216,742,880	134,684,026	1,020,010,340	62.3
Dec. 5	198.9	−1.2	329,484,470	204,741,650	219,783,850	136,573,684	1,032,633,870	72.4
15	204.0	−1.0	324,700,650	201,768,984	222,589,960	138,317,401	1,045,074,250	82.6
25	209.0	−0.8	318,870,060	198,145,855	225,144,730	139,904,935	1,057,348,790	92.7
Jan. 4, 1967	213.9	−0.6	312,013,790	193,885,369	227,434,440	141,327,761	1,069,475,110	102.9
14	218.7	−0.3	304,124,410	188,982,908	229,447,710	142,578,807	1,081,471,150	113.1
24	223.5	−0.1	295,244,920	183,465,193	231,175,250	143,652,300	1,093,354,990	123.3
Feb. 3	228.1	0.1	285,439,610	177,372,174	232,609,560	144,543,581	1,105,144,880	133.4
13	232.8	0.3	274,744,700	170,726,357	233,744,740	145,248,981	1,116,859,150	143.6
23	237.3	0.5	263,250,820	163,584,060	234,576,340	145,765,738	1,128,516,140	153.7
Mar. 5	241.9	0.7	251,052,700	156,004,148	235,101,170	146,091,867	1,140,134,270	163.7
15	246.4	0.8	238,219,490	148,029,591	235,317,320	146,226,183	1,151,731,990	173.7
25	251.0	1.0	224,874,020	139,736,716	235,223,990	146,168,187	1,163,327,750	183.6
Apr. 4	255.5	1.2	211,125,520	131,193,398	234,821,540	145,918,105	1,174,939,970	193.5
14	260.1	1.4	197,064,850	122,456,098	234,111,470	145,476,867	1,186,587,080	203.4
24	264.7	1.6	182,832,960	113,612,401	233,096,470	144,846,146	1,198,287,520	213.1

Table 4. (Cont'd)

Date	Spacecraft celestial position		Spacecraft distance from Earth		Spacecraft distance from Sun		Distance traveled, mi	Earth longitude
	Longitude, deg	Latitude, deg	km	mi	km	mi		
May 4	269.4	1.7	168,542,330	104,732,204	231,780,490	144,028,396	1,210,059,640	222.8
14	274.1	1.9	154,300,940	95,882,604	230,168,880	143,026,942	1,221,921,780	232.5
24	278.9	2.0	140,262,650	87,159,211	228,268,510	141,846,052	1,233,892,090	242.1
Jun. 3	283.8	2.1	126,544,830	78,634,957	226,087,940	140,491,046	1,245,988,800	251.7
13	288.7	2.2	113,283,500	70,394,367	223,637,710	138,968,473	1,258,229,790	261.3
23	293.8	2.3	100,659,060	62,549,540	220,930,580	137,286,262	1,270,632,760	270.9
Jul. 1	298.0	2.4	91,118,347	56,620,941	218,590,110	135,831,894	1,280,683,450	278.5
11	303.4	2.5	80,057,457	49,747,704	215,461,160	133,887,565	1,293,421,400	288.0
21	308.9	2.5	70,197,076	43,620,463	212,125,960	131,815,072	1,306,368,740	297.6
31	314.6	2.5	61,775,438	38,387,257	208,609,280	129,629,807	1,319,541,010	307.1
Aug. 10	320.4	2.5	55,080,496	34,227,020	204,940,160	127,349,815	1,332,952,760	316.7
20	326.6	2.5	50,364,587	31,296,554	201,152,470	124,996,145	1,346,617,100	326.3
30	332.9	2.4	47,694,097	29,637,112	197,285,490	122,593,203	1,360,545,400	335.9
Sept. 9	339.5	2.3	46,950,602	29,175,104	193.384,350	120,169,035	1,374,746,600	345.6
19	346.4	2.2	47,753,396	29,673,960	189,500,350	117,755,517	1,389,226,700	355.4
29	353.5	2.0	49,607,575	30,826,147	185,691,100	115,388,450	1,403,988,000	5.2

Oct. 9	1.0	1.8	52,086,088	32,366,295	182,020,170	113,107,334	1,419,028,200	15.0
19	8.7	1.6	54,816,463	34,056,736	178,556,270	110,954,866	1,434,339,600	24.9
29	16.7	1.3	57,573,213	35,775,995	175,371,780	108,976,024	1,449,908,600	34.9
Nov. 8	25.1	0.9	60,250,895	37,439,906	172,540,440	107,216,629	1,465,714,600	44.9
18	33.6	0.6	62,782,061	39,012,773	170,134,230	105,721,411	1,481,729,700	54.9
28	42.4	0.2	65,203,679	40,517,566	168,219,520	104,531,610	1,497,919,200	65.1
Dec. 8	51.4	−0.2	67,601,249	42,007,416	166,852,790	103,682,324	1,514,241,400	75.2
18	60.4	−0.6	70,057,985	43,534,032	166,076,540	103,199,962	1,530,649,400	85.4
28	69.6	−1.0	72,723,148	45,190,164	165,915,680	103,100,004	1,547,092,300	95.5

Table 5. Picture data

Location			Sun angle	View angle	Slant range		Surface coverage						Filter
							km			mi			
Picture No.	Lat °N (center)	Long °E (center)			km	mi	X side	Y side	Area	X side	Y side	Area	
1	33.3	171.6	25.4	77.2	16,822	10,500		646			410		Red
2	23.0	173.8	19.5	70.2	16,296	10,100	844	460	388,240	524	286	149,864	Green
3	10.3	177.0	13.6	56.1	15,316	9,500	492	348	171,216	306	216	66,096	Green
4	5.3	178.3	14.4	50.9	14,948	9,300	428	330	141,240	266	205	54,530	Red
5	−3.3	181.1	19.3	42.1	14,332	8,900	352	308	108,416	218	191	41,638	Red
6	−7.1	182.5	22.3	38.2	14,066	8,700	328	298	97,744	204	185	37,740	Green
7	−14.2	185.4	28.6	31.2	13,599	8,400	292	288	84,096	181	179	32,399	Green
8	−17.5	187.0	31.8	28.7	13,393	8,300	280	284	79,520	174	176	30,624	Red
9	−23.7	190.5	38.0	24.0	13,025	8,100	260	280	72,800	161	174	28,014	Red
10	−26.7	192.4	41.1	22.3	12,863	8,000	252	278	70,056	156	173	26,988	Green
11	−32.2	196.8	47.2	20.5	12,578	7,800	238	275	65,450	148	172	25,456	Green
12	−34.8	199.3	50.3	20.5	12,455	7,700	234	278	65,052	145	173	25,085	Red
13	−39.8	205.2	56.5	22.4	12,248	7,600	226	280	63,280	140	174	24,360	Red
14	−42.1	208.6	59.6	24.2	12,164	7,600	224	282	63,168	139	175	24,325	Green
15	−46.1	216.6	66.0	29.0	12,039	7,500	220	290	63,800	137	180	24,660	Green
16	−47.9	221.4	69.3	31.9	12,000	7,500	222	298	66,156	138	185	25,530	Red
17	−50.5	232.6	76.2	38.7	11,976	7,400	224	320	71,680	139	199	27,661	Red

18	−51.2	239.1	79.8	42.5	11,996	7,400	230	336	77,280	143	209	29,887	Green
19	−50.9	254.2	87.7	51.4	12,123	7,500	248	390	96,720	154	242	37,268	Green
20	−49.6	262.6											Red
21	−42.2	282.2											Red
22													Green

Table 6. Picture playback data

Picture No.	First playback							Second playback						
	Start reception		End reception		Transmission time			Start reception		End reception		Transmission time		
	July	GMT	July	GMT	hr	min	sec	July	GMT	July	GMT	hr	min	sec
1	15	13:01:58	15	21:38:07	8	36	09	24	21:21:53	25	05:57:54	8	36	01
2	15	22:32:27	16	08:08:03	8	35	36	25	07:53:36	25	16:29:15	8	35	39
3	16	10:04:28	16	18:39:54	8	35	26	25	18:24:31	26	03:00:09	8	35	38
4	16	20:35:12	17	05:10:12	8	35	00	26	04:56:24	26	13:32:03	8	35	39
5	17	07:07:45	17	15:43:18	8	35	33	26	15:27:47	27	00:03:39	8	35	52
6	17	17:40:32	18	02:16:10	8	35	38	27	02:00:57	27	10:36:39	8	35	42
7	18	04:13:25	18	12:49:03	8	35	38	27	12:33:01	27	21:08:41	8	35	40
8	18	14:46:13	18	23:21:51	8	35	38	27	23:04:57	28	07:40:41	8	35	44
9	19	01:19:32	19	09:55:35	8	36	03	28	09:37:00	28	18:12:00	8	35	00
10	19	11:52:52	19	20:28:29	8	35	37	28	20:09:57	29	04:45:32	8	35	35

Table 6. (Cont'd)

Picture No.	First playback							Second playback						
	Start reception		End reception		Transmission time			Start reception		End reception		Transmission time		
	July	GMT	July	GMT	hr	min	sec	July	GMT	July	GMT	hr	min	sec
11	19	22:25:33	20	07:01:26	8	35	53	29	06:43:10	29	15:19:13	8	36	03
12	20	08:57:42	20	17:33:15	8	35	33	29	17:16:43	30	01:51:00	8	34	17
13	20	19:28:51	21	04:04:32	8	35	41	30	03:46:24	30	12:21:00	8	34	36
14	21	06:01:22	21	14:37:00	8	35	38	30	14:20:00	30	22:55:28	8	35	28
15	21	16:34:43	22	01:10:21	8	35	38	31	00:52:46	31	09:29:00	8	36	14
16	22	03:07:13	22	11:42:53	8	35	40	31	11:27:00	31	20:02:15	8	35	15
17	22	13:40:59	22	22:16:37	8	35	38	31	21:59:57	1	06:34:57	8	35	00
18	23	00:15:04	23	08:50:41	8	35	37	1	08:33:00	1	17:09:00	8	36	00
19	23	10:48:08	23	19:23:48	8	35	40	1	19:07:10	2	03:42:00	8	34	50
20	23	21:21:10	24	05:56:50	8	35	40	2	05:40:00	2	14:15:27	8	35	27
21	24	07:55:01	24	16:30:40	8	35	39	2	16:14:48	3	00:49:48	8	35	00
22	24	18:28:33	24	19:26:33	0	58	00	3	02:46:00	3	03:46:02	0	60	02

Table 7. List of scientific investigators

Experiment	Investigators	Affiliation
Television	R. B. Leighton[a]	California Institute of Technology
	B. C. Murray	California Institute of Technology
	R. P. Sharp	California Institute of Technology
	R. K. Sloan	Jet Propulsion Laboratory
	R. D. Allen	Jet Propulsion Laboratory
Helium Magnetometer	E. J. Smith[a]	Jet Propulsion Laboratory
	P. J. Coleman, Jr.	University of California, Los Angeles
	L. Davis, Jr.	California Institute of Technology
	D. E. Jones	Brigham Young University and Jet Propulsion Laboratory
Solar-plasma Probe	H. L. Bridge[a]	Massachusetts Institute of Technology
	A. Lazarus	Massachusetts Institute of Technology
	C. W. Snyder	Jet Propulsion Laboratory
Ionization Chamber	H. V. Neher[a]	California Institute of Technology
	H. R. Anderson	Jet Propulsion Laboratory
Trapped-Radiation Detector	J. A. Van Allen[a]	State University of Iowa
	L. A. Frank	State University of Iowa
	S. M. Krimijis	State University of Iowa
Cosmic Ray Telescope	J. A. Simpson[a]	University of Chicago
	J. O'Gallagher	University of Chicago
Cosmic Dust Detector	W. M. Alexander[a]	National Aeronautics and Space Administration/Goddard Space Flight Center
	O. E. Berg	National Aeronautics and Space Administration/Goddard Space Flight Center
	C. W. McCracken	National Aeronautics and Space Administration/Goddard Space Flight Center

[a]Principal investigator

Table 7. (Cont'd)

Experiment	Investigators	Affiliation
Cosmic Dust Detector	L. Secretan	National Aeronautics and Space Administration/Goddard Space Flight Center
	J. L. Bohn	Temple University, Philadelphia
	O. P. Fuchs	Temple University, Philadelphia
Occultation	A. J. Kliore[a]	Jet Propulsion Laboratory
	D. L. Cain	Jet Propulsion Laboratory
	G. S. Levy	Jet Propulsion Laboratory
	V. R. Eshelman	Stanford Electronics Laboratory
	F. Drake	Cornell University

[a]Principal investigator

Table 8. Unit reference designations

Subsystem	Unit	Ref. No.
Antennas	High-gain antenna	2E1
	Low-gain antenna	2E2
Attitude Control	Control system electronics	7A1
	Control gyros and electronics	7A2
	Attitude +X/−Y gas subsystem	7GA1
	Gas vessel	7GV1
	Gas regulator	7GR1
	4-jet gas manifold	7GM41
	2-jet gas manifold	7GM21
	Attitude control −X/+Y gas subsystem	7GA2
	Gas vessel	7GV11
	Gas regulator	7GR11
	4-jet gas manifold	7GM411
	2-jet gas manifold	7GM211
	Primary Sun sensor	7PS2
	Primary Sun sensor	7PS6
	Secondary Sun sensor	7SS2
	Secondary Sun sensor	7SS6
	Sun gate detector	7SG2
	Earth detector	7ED6
	Canopus sensor	7CS8
	Canopus Sun shutter	7CS8/A

Table 8. (Cont'd)

Subsystem	Unit	Ref. No.
Central Computer and Sequencer	Central clock	5A1
	Launch counter	5A2
	End counter	5A3
	Maneuver clock	5A4
	Maneuver duration	5A5
	Address regulator and maneuver duration output	5A6
	Input decoder	5A7
	Central computer and sequencer transformer-rectifier	5A8
	Relay hold transformer-rectifier	5A9
Command	Command detector No. 1	3A1
	Command detector No. 2	3A2
	Command detector No. 3	3A3
	Command program control	3A4
	Command decoder No. 1	3A5
	Command decoder No. 2	3A6
	Command decoder and power supply	3A7
Data Automation	DAS buffers memory	20A1
	RT DAS logic	20A2
	NRT DAS logic	20A3
	RT DAS logic	20A4
	DAS transformer-rectifier	20A5
Data Encoder	Pseudonoise generators	6A1
	Modulator, mixer, transfer register, data selector	6A2
	Analog to digital converter	6A3
	Analog to digital converter	6A4
	Event counters	6A5
	Functional switching	6A6
	Decks 100, 110	6A7
	Decks 210, 220	6A8
	Decks 200, 300	6A9
	Decks 400, 410	6A10
	Decks 420, 430	6A11
	Low level amplifier	6A12
	Power supply	6A13

Table 8. (Cont'd)

Subsystem	Unit	Ref. No.
Planetary Scan Platform	Scan sensor and preamplifier	31A1
	Scan electronics and transformer-rectifier	31A2
	Scan electronics	31A3
	Scan actuator	31A4
	Science cover	31A5
Post-injection Propulsion System	Post-injection propulsion system	10A
Power	Power regulator	4A8
	Power distribution subassembly	4A11
	Power synchronizer	4A12
	Battery charger assembly	4A13
	Battery assembly	4A14
	2400-cps inverter	4A15
	2400-cps inverter	4A16
	400-cps 1-phase inverter	4A17
	400-cps 3-phase inverter	4A18
	Pyrotechnics control assembly	8A1
	Pyrotechnics control assembly	8A2
Radio	Receiver assembly	2RA1
	Receiver assembly	2RA2
	Receiver transformer-rectifier	2TR1
	Exciter assembly	2RE1
	Attenuator	2AT1
	Directional coupler high-gain antenna	2DC1
	Directional coupler low-gain antenna	2DC2
	Oscillator temperature transducer	2TT1
	4 Port circulator switch	2CS1
	5 Port circulator switch	2CS2
	Cavity filter No. 1	2CF1
	Cavity filter No. 2	2CF2
	Power amplifier	2PA1
	Control unit	2CC1
	Power amplifier power supply	2PS2
	Traveling wave tube power supply	2PS3
	Traveling wave tube	2PA2
	Exciters transformer-rectifier	2TR2

Table 8. (Cont'd)

Subsystem	Unit	Ref. No.
Science Instruments	Cosmic dust detector	24A1
	Trapped radiation detector	25A1
	Cosmic ray telescope	21A1
	Ionization chamber	26A1
	Plasma probe sensor	32A1
	Plasma probe electronics	32A2
	Plasma probe electronics	32A3
	Plasma probe electronics	32A4
	Magnetometer electronics transformer-rectifier	33A2
	Magnetometer electronics	33A3
	Magnetometer sensor	33A1
	Narrow-angle Mars gate	7MG1
	UV photometer (deleted, replaced by SPITS)	34A1
Solar Panels	Solar panel +X	4A1
	Solar pressure control	7PC1
	Solar panel −X	4A5
	Solar panel pressure control	7PC5
	Solar panel +Y	4A3
	Solar panel pressure control	7PC3
	Solar panel −Y	4A7
	Solar panel pressure control	7PC7
	Solar panel fuse assembly	7PC10
Tape Recorder	Tape machine	16A1
	Tape electronics No. 1	16A2
	Tape electronics No. 2	16A3
	Tape electronics No. 3 and transformer-rectifier	16A4
	Tape electronics	16A5
Television	Optics TV	36A1
	Camera head	36A2
	TV video channel and computer	36A3
	TV deflection and control	36A4
	TV encoder	36A5
	TV transformer-rectifier	36A6
Temperature Control	Absorptivity standard	11FM1

Table 9. Electrical components

Subsystem	Capacitors	Diodes	Resistors	Transistors	Other	Subsystem totals
Attitude control	280	349	573	121	74	1,397
Cabling	2	—	3	—	—	5
Central computer and sequencer	255	734	1,058	266	261	2,574
Command	406	791	1,195	345	50	2,787
Cosmic dust detector	148	70	365	117	21	721
Cosmic ray telescope	257	256	480	193	10	1,196
Data automation system	917	4,382	4,374	1,210	2,844	13,727
Data encoder	1,614	1,475	3,316	915	93	7,413
Helium magnetometer	208	79	390	101	24	802
Ionization chamber	69	41	212	20	19	361
Planetary scan	82	96	212	65	47	502
Power	125	228	359	121	68	901

Pyrotechnics	30	44	102	2	30	208
Radio	413	227	633	123	175	1,571
Solar plasma probe	137	375	528	241	9	1,290
Television	366	413	942	254	28	2,003
Trapped radiation detector	59	40	135	39	10	283
Tape recorder	202	295	730	215	37	1,479
Total subsystem components:	5,570	9,895	15,607	4,348	3,800	39,220

Notes: These numbers are based on preliminary information provided by Quality Assurance and Reliability.

Other includes inductors, relays, transformers, cores, controlled rectifiers and switches, crystals, thermistors, fuses, transducers, sensitors, tubes.

Other does **not** include connectors.

Table 10. Weights

Item	Weight, lb	
Engineering subsystems		
Antennas	7.43	
Central computer and sequencer	11.38	
Command	10.12	
Data encoder	22.43	
Guidance and control	63.29	
Power	70.95	
Propulsion	47.55	
Pyrotechnics	12.21	
Radio	34.40	
Solar panels	79.02	
Structure	78.44	
System wiring	45.69	
Tape recorder	16.89	
Temperature control	15.53	
Total, engineering subsystems		515.33
Science subsystem		
Cosmic dust detector	2.10	
Cosmic ray telescope	2.58	
Data automation system	11.78	
Helium magnetometer	6.77	
Ionization chamber	2.90	
Planetary scan	6.85	
Solar plasma probe	6.41	
Television	11.28	
Trapped radiation detector	2.17	
Ultraviolet photometer simulator	6.57	
Total, science subsystem		59.41
Total Spacecraft		574.74

Table 11. Redundant items on Mariner IV

Item	Type of redundancy	Description
RF power amplifiers	Block	Two complete power amplifiers plus associated power supplies switchable either by internal logic or by ground command. Only one operates at any time.
RF exciters	Block	Two identical exciters switchable either by internal logic or by ground command. Only one operates at any time.
Pyrotechnics assemblies	Block	Two identical half systems, both on line continuously after separation.
Pyrotechnic arming switch	Block	Two separation-activated switches: pyrotechnic arming switch, and separation initiated timer. Either one can power both pyrotechnic half systems.
Attitude control gas system	Block	Two half systems and pressure bottles. Both operate continuously after attitude control turn-on.
Power booster regulator	Block	Failure sensing circuit detects over/under voltage condition at main booster output. Switches maneuver booster on and main booster off.
Power frequency control	Block	Primary control is a 38.4-kc synchronization signal from the CC&S. In the absence of this, synchronization is derived from an oscillator internal to power, or the inverters will free-run at approximately 2.4-kc.
Analog to digital converter and pseudonoise code generator	Block	Two identical units switchable by ground command. Only one operating at any time.

Table 11. (Cont'd)

Item	Type of redundancy	Description
Cruise science control relay	Functional	Either separation or ground command DC-2 controls the primary cruise science power supply relay. A secondary relay is driven by CC&S MT-7 or ground command DC-25 to ensure cruise science "on" during encounter.
Science cover drop	Functional	Solenoid actuated via pyrotechnic control assembly is primary; backup is via lanyard.
End of TV record sequence	Functional	Primary is second end-of-tape signal; secondary is inhibition of "start record" commands after 11 nonreal-time science frames.
Spacecraft cruise and encounter events	Functional	CC&S events are primary; backup is via ground command.
Midcourse trajectory correction	Block	Duplicate pyrotechnic-actuated valves provide the capability for two midcourse maneuvers.

Table 12. Types of environmental tests

Major tests	
System level	Subsystem level
Vibration Shock Acoustic Thermal-vacuum Electromagnetic interference S-band RF	Bench handling Transportation vibration Humidity Explosive atmosphere Shock Static acceleration Low-frequency vibration Complex wave vibration Thermal-vacuum Thermal shock RF interference Magnetics

(cont'd)

Table 12. (Cont'd)

Miscellaneous tests	
Type	**Description**
Structural test model	Basic structure static test Vibration Modal survey Acoustic Electromagnetic interference Low-speed impact (handling) Shroud cavity purging Solar panel deployment
Temperature control model	Space simulator thermal-vacuum Stray light reflectance Prelaunch cooling Solar vane thermal
Developmental test model	Simulated midcourse interaction Acoustic Shroud/adapter/spacecraft combined vibration Antenna pattern
Extra test model	Adapter/spacecraft static Spacecraft separation Spacecraft/umbilical connector retraction
Launch vehicle interface	Shroud wind-tunnel Launch vehicle shroud contamination Shroud acoustic Shroud RF attenuation Solar panel/shroud impact simulation

Table 12. (Cont'd)

Miscellaneous tests	
Type	**Description**
Other tests	Noise measurements of Cape Kennedy operations RF noise survey of space simulator Damped structure feasibility Electronic packaging development Preliminary match-mate Solar vane deployment Solar vane actuator impact High-gain antenna and Canopus tracker temperature control High-gain antenna combined heating and vibration Thermal shield outgassing Thermal blanket ballooning Solar panel temperature spectrum Solar panel transporter Low-gain antenna extreme temperature Electronic assembly shipping container Solar panel structural development

Table 13. Assembly level environmental test requirements

Test	TA test level	FA test level
Bench handling	Free fall corner drop	Not applicable
Drop test	Height variable to weight	Not applicable
Transportation vibration	1.3 g 2 to 35 cps	Not applicable
	3.0 g 35 to 48 cps	Not applicable
	5.0 g 48 to 500 cps	Not applicable
Explosive atmosphere	Fuel and air during assembly operation	Not applicable
Humidity	75% humidity and varied temperature	Not applicable
Shock	Five 200 g, 0.7 ± 0.2 msec pulses, 3 axes	Not applicable
Static acceleration	± 14 g, 3 axes 5 min	

Vibration Low frequency (all assemblies)	±1.5 in., 1 to 4.4 cps 3 g peak from 4.4 to 15 cps	3 min	Not applicable	
Complex wave (assemblies ≥ 10 lb)	16.4 **g** rms noise	180 sec	9.0 **g** rms noise	6 sec
	5.0 **g** rms noise plus 2.0 **g** rms sine, 15 to 40 cps 9.0 **g** rms sine, 40 to 250 cps [a]4.5 **g** rms sine, 250 to 2000 cps	600 sec	3.0 **g** rms noise plus 1.5 **g** rms sine, 15 to 40 cps 6.0 **g** rms sine, 40 to 250 cps [b]3.0 **g** rms sine, 250 to 2000 cps	200 sec
			9.0 **g** rms noise	6 sec
Vacuum/temperature	−10°C (+14°F) +75°C (+167°F) 10^{-4} mm Hg	4 hr 12 days	0°C (32°F) 55°C (131°F) 10^{-4} mm Hg	2 hr 40 hr
Thermal shock (for external assemblies)	+75° to −46°C (167° to −50°F)		Not applicable	

[a]9.0 **g** for assemblies ≤ 10 lb

[b]6.0 **g** for assemblies ≤ 10 lb

Table 14. System level environmental test requirements

Test	TA level		FA level	
Space simulator				
Part I: (Systems validation)—Launch through Encounter & Playback	10 days @ 10^{-5} mm Hg (or less)		250 hr @ 10^{-5} mm Hg (or less)	
Part II: (Temperature Control Verification)	108 hrs @ 30 to 134 w simulated solar intensity		134 hr @ 30 to 134 w simulated solar intensity	
Vibration: Sinusoidal	Roll Axis		Roll Axis	
	5–15 cps, 1.5 **g** rms	1.6 min	20–20020 cps, 0.5 **g** rms	3-1/4 min
	15–450 cps, 1.5 **g** rms	8.3 min		
	450–800 cps, 5.0 **g** rms	0.8 min		
	800–2000 cps, 10.0 **g** rms	1.3 min		
	(and reverse sweep)			
	3 Lateral Axes		2 Lateral Axes	
	5–150 cps, 0.75 **g** rms	5.1 min	20–200–20 cps, 0.5 **g** rms	3-1/4 min per axis
	150–400 cps, 1.25 **g** rms	1.5 min		
	450–800 cps, 5.00 **g** rms	0.8 min		
	800–2000 cps, 10.00 **g** rms	1.3 min		
	(and reverse sweep)			

Vibration: Noise	Roll Axis and 3 Lateral Axes Shaped spectra, 18.1 **g** rms overall 550–2000 cps, 0.2 g^2/cps 3.0 min 3 db/octave roll-off below 550 cps	Roll Axis and 2 Lateral Axes Shaped spectra, 10.7 **g** rms overall 550–2000 cps, 0.07 g^2/cps 1 min 3 db/octave roll-off below 550 cps
Vibration: Torsional	Two 69 cps pulses, 205 rad/sec^2 0.14 sec 20–150–20 cps 12.86 rad/sec^2 6.0 min 50–150–50 cps 154 rad/sec^2 11.0 min	Not applicable
Acoustic	Approx. 142 db shaped spectrum, 90 sec	Not applicable
Shock	Shroud V-band release firing Spacecraft separation and V-band release firing All spacecraft pyrotechnics fired	Not applicable Not applicable All spacecraft pyrotechnics fired
Electromagnetic interference—RF susceptibility	Launch complex RF Agena telemetry RF C-band beacon	Launch complex RF Agena telemetry RF C-band beacon

Table 15. Subsystem environmental test summary

Environment	No. of sub-systems in test	Total items in test	Total failures	Failure rate, %
TA tests				
Bench handling	22	39	0	0
Package drop	25	39	0	0
Transportation vibration	27	85	0	0
Humidity	31	51	5	9.8
Explosive atmosphere	18	19	0	0
Shock	49	116	3	2.6
Acceleration	46	89	0	0
Low frequency vibration	51	90	6	6.7
Complex wave vibration	54	154	24	15.6
Vacuum/Temperature	50	95	19	20.0
Thermal shock	26	28	1	3.6
FA tests				
Vacuum/Temperature	41	310	28	9.0
Complex wave vibration	49	538	26	4.8
Temperature	2	21	1	4.76
Totals				
TA tests		805	58	avg 7.2
FA tests		869	55	avg 6.33
		1674	113	avg 6.86

Table 16. System level environmental test summary

Problem	TA	FA
Interface problems resolved through systems environmental tests	3	3
Component changes which should have been detected at assembly level	1	2
Failure in structure or component that could only be detected at systems level	3	1
Changes indicating need for closer project monitoring of major project systems	1	2

Table 17. Performance comparison between TA and FA tests: vibration and vacuum/temperature

	Vibration				Vacuum/Temperature				
Type	No. tests	Pass	Fail	Failure rate	No. tests	Pass	Fail	Failure rate	Overall failure rate, %
TA	244	214	30	12.3	95	76	19	20.0	14.5
FA	538	512	26	4.8	310	282	28	9.0	6.3

Table 18. Spacecraft tests

At JPL	At AFETR
Subsystem tests	System tests
Subsystem interface tests	Spacecraft/Agena adapter matchmate
System tests	Electrical test
Attitude control quantitative leak test	RF loop calibration
Electrical modal survey	Dummy run countdown
Space simulator test	Umbilical release test
Vibration test	Cooling test
Weight and center-of-gravity measurement	Joint flight-acceptance composite tests
Free mode test	Science instrument calibrations
Magnetic mapping	Magnetic mapping
Agena/spacecraft interface test	Spacecraft/Agena matchmate
Midcourse motor dynamic test	Final system test
Launch countdown dummy run	Final electrical tests
Space Flight Operations/spacecraft/Deep Space Network compatibility test	Spacecraft post-matchmate checkout
Current loop test	

Table 19. Telemetering channel assignment

Channel	Measurement	Measured range		Accuracy, %	Time between samples, sec			
					Data Mode 1		Data Mode 2	
		Parameter	Voltage		33-1/3 bps	8-1/3 bps	33-1/3 bps	8-1/3 bps
100	Synchronization	"1111111"	Digital	3	4.20	16.8	12.6	50.4
101	Deck 200	—	0 to 3 vdc	3				
102	Deck 210	—	0 to 3 vdc	3				
103	Receiver AGC (coarse)	−90 dbm to −150 dbm	0 to 3 vdc	3				
104	Command detector monitor	$-3.4 < \Delta 2f_s < +3.4$ cps	Digital	—				
105	Pitch gyro Fine Sun sensor	±20 mrad/sec ±15 mrad	±1.5 vdc	3				
106	Yaw gyro Fine Sun sensor	±20 mrad/sec ±15 mrad						
107	Roll gyro Earth position detector	±20 mrad/sec 0 to 0.1 ft-c	±1.5 vdc	3	4.20	16.8	12.6	50.4

108	Canopus intensity	2 to 10 × Canopus	0 to 3 vdc	3	4.20	16.8	12.6	50.4
109	Power switching and logic output voltage	23 to 53 v	0 to 3 vdc					
110	Deck 220	—	0 to 3 vdc					
111	Receiver SPE	±600 cps	±1.5 vdc					
112	Pitch position	±20 deg						
113	Yaw position	±20 deg						
114	Roll position	±26 mrad						
	Roll search	±26 mrad	±1.5 vdc	3				
115	Event counter 1	—	Digital	—				
	Pyro amplifiers	—		—				
	Gyros on	—		—				
	Solar panel 4A1 open	—		—				
115	Event counter 2	—		—				
	CC&S events	—		—				
	Solar panel 4A3 open	—	Digital	—	4.20	16.8	12.6	50.4

Table 19. (Cont'd)

Channel	Measurement	Measured range		Accuracy, %	Time between samples, sec			
					Data Mode 1		Data Mode 2	
		Parameter	Voltage		33-1/3 bps	8-1/3 bps	33-1/3 bps	8-1/3 bps
116	Event counter 3	—	Digital	—	4.20	16.8	12.6	50.4
	Pyro arm	—		—				
	Pyro amplifiers	—		—				
	Solar panel 4A5 open	—		—				
	End of tape loop	—		—				
116	Event counter 4	—		—				
	Command events	—		—				
	Sun acquire	—		—				
	Solar panel 4A7 open	—		—				
	Scan platform unlatched	—	Digital	—				
117	Thrust chamber pressure	0 to 300 psia	0 to +3 vdc	3				
118	Propulsion nitrogen tank pressure	0 to 4000 psia	0 to +3 vdc	3				
119	Propellant tank pressure	0 to 500 psia	0 to +3 vdc	3	4.20	16.8	12.6	50.4

200	Synchronization	"1111111"	Digital	—	42.0	168.	126.	504.
201	Low deck position	0 to 19	Digital	—	↓	↓	↓	↓
202	Deck 300	—	0 to 3 vdc	3	↓	↓	↓	↓
203	Dual booster regulator input current	0 to 10 amp	↓	↓	↓	↓	↓	↓
204	Power switching and logic current to comm. converter	0 to 5 amp	↓	↓	↓	↓	↓	↓
205	Main booster regulator output current	0 to 5 amp	↓	↓	↓	↓	↓	↓
206	Battery voltage	23 to 40 v	↓	↓	↓	↓	↓	↓
207	2400 cps inverter output voltage	40 to 60 v	↓	↓	↓	↓	↓	↓
208	Attitude control X, −Y gas pressure	0 to 4000 psia	↓	↓	↓	↓	↓	↓
209	Attitude control −X, Y gas pressure	0 to 4000 psia	0 to 3 vdc	↓	↓	↓	↓	↓
210	Receiver local oscillator drive	0 to 3 mw	0 to 100 mv	3	↓	↓	↓	↓
211	Decks 400 and 410	—	↓	5	↓	↓	↓	↓
212	Decks 420 and 430	—	↓	5	↓	↓	↓	↓
213	High-gain antenna drive	0 to 14 w	0 to 100 mv	3	42.0	168.	126.	504.

Table 19. (Cont'd)

Channel	Measurement	Measured range		Accuracy, %	Time between samples, sec			
					Data Mode 1		Data Mode 2	
		Parameter	Voltage		33-1/3 bps	8-1/3 bps	33-1/3 bps	8-1/3 bps
214	Low-gain antenna drive	0 to 14 w	0 to 100 mv	3	42.0	168.	126.	504.
215	Receiver AGC (fine)	−118 dbm to −142 dbm	0 to 100 mv	3	↓	↓	↓	↓
216	Battery charge current	0 to 1 amp	0 to 3 vdc	3				
217	Propellant temperature	25 to 150°F	500 to 600Ω	5				
218	Attitude control X, −Y gas temperature	25 to 150°F	500 to 600Ω	5				
219	Attitude control −X, Y gas temperature	25 to 150°F	500 to 600Ω	5				
220	CC&S timing of events	—	Digital	—				
221	Maneuver booster regulator output current	0 to 5 amp	0 to 3 vdc	3	42.0	168.	126.	504.

222	Solar panel 4A1 current	0 to 5 amp	0 to 3 vdc	3	42.0	168.	126.	504.
223	Solar panel 4A5 current	0 to 5 amp						
224	Solar panel 4A3 current	0 to 5 amp						
225	Solar panel 4A7 current	0 to 5 amp						
226	Battery current drain	0 to 10 amp						
227	2.4-kc inverter output current	0 to 2.5 amp						
228	Oxidizer pressure	0 to 500 psia						
229	Exciter power output	0 to 0.6 w			42.0	168.	126.	504.
300	Cathode	0 to 135 ma			420.	1680.	1260.	5040.
	Helix current	0 to 16 ma	0 to 3 vdc					
301	Exciter voltage 1	0 to −25 vdc	±1.5 vdc					
302	Exciter voltage 2	0 to −15 vdc	±1.5 vdc					
303	Canopus sensor cone angle	47 to 105 deg	±1.5 vdc					
304	Recorder pressure	0 to 40 psia	0 to 3 vdc					
305	Solar vane position, +X	15 to 55 deg	0 to 3 vdc					
306	Solar vane position, −X	15 to 55 deg	0 to 3 vdc	3	420.	1680.	1260.	5040.

Table 19. (Cont'd)

Channel	Measurement	Measured range		Accuracy, %	Time between samples, sec			
					Data Mode 1		Data Mode 2	
		Parameter	Voltage		33-1/3 bps	8-1/3 bps	33-1/3 bps	8-1/3 bps
307	Solar vane position, +Y	15 to 55 deg	0 to 3 vdc	3	420.	1680.	1260.	5040.
308	Solar vane position, −Y	15 to 55 deg	0 to 3 vdc	3	420.	1680.	1260.	5040.
309	CC&S 28-v monitor	0 to 56 v	0 to 3 vdc	3	420.	1680.	1260.	5040.
400	Synchronization	"1111111"	Digital	—	840.	3360.	2520.	10,080
401	Bay I temperature	25 to 150°F	500 to 600Ω	5				
402	Bay III temperature	25 to 150°F						
403	Spare	—						
404	Bay V temperature	25 to 150°F						
405	Bay VI temperature	25 to 150°F						
406	Bay VII louver position indication	500 to 600Ω	500 to 600Ω	5	840.	3360.	2520.	10,080

407	Power regulator assembly temperature	25 to 175°F	500 to 600Ω	5	840.	3360.	2520.	10,080
408	Propulsion nitrogen tank temperature	25 to 150°F						
409	Solar panel 4A1 front temperature	−40 to 160°F						
410	Canopus sensor temperature	−50 to 150°F						
411	Scan actuator temperature	25 to 200°F						
412	Absorptivity standard temperature 1	0 to 140°F						
413	Absorptivity standard temperature 2	130 to 275°F						
414	Science cover and spacecraft identification	500 to 600Ω	500 to 600Ω					
415	Standard cell current	0 to 100 ma	0 to 100 mv					
416	Radiation resistant cell current	0 to 100 ma	0 to 100 mv					
417	Standard cell voltage	0 to 1 v	0 to 100 mv					
418	Television temperature	−60 to 150°F	500 to 600Ω					
419	Ionization chamber temperature	−20 to 200°F	500 to 600Ω					
420	Temperature reference	—	500 to 600Ω	5	840.	3360.	2520.	10,080

Table 19. (Cont'd)

Channel	Measurement	Measured range		Accuracy, %	Time between samples, sec			
					Data Mode 1		Data Mode 2	
		Parameter	Voltage		33-1/3 bps	8-1/3 bps	33-1/3 bps	8-1/3 bps
421	Bay II temperature	25 to 150°F	500 to 600Ω	5	840.	3360.	2520.	10,080
422	Bay III louver position indication	500 to 600Ω						
423	Bay IV temperature	25 to 150°F						
424	Crystal oscillator temperature	25 to 150°F						
425	Bay I louver position indication	500 to 600Ω						
426	Bay VII temperature	25 to 150°F						
427	Spare	—						
428	Battery temperature	25 to 150°F						
429	Solar panel 4A5 front temperature	−40 to 160°F						
430	Lower ring temperature above Canopus	25 to 150°F	500 to 600Ω	5	840.	3360.	2520.	10,080

431	Upper ring temperature under Sun sensor	25 to 150°F	500 to 600Ω	5	840.	3360.	2520.	10,080
432	Absorptivity standard temperature 3	130 to 275°F						
433	Absorptivity standard temperature 4	75 to 275°F						
434	Upper thermal shield temperature	70 to 300°F						
435	Lower thermal shield temperature	−300 to 0°F						
436	Recorder temperature	25 to 150°F						
437	34A1 temperature	−50 to 150°F						
438	Trapped radiation temperature	25 to 150°F						
439	Magnetometer temperature	−75 to 150°F	500 to 600Ω	5	840.	3360.	2520.	10,080

Table 20. Time between telemetry samples

Rate, bps/sec		Data Mode 1					Data Mode 2		
		Channel No.					Channel No.		
		100-119	100-119	200-229	200-229	300-309	300-309	400-439	400-439
8-1/3	sec	16.8	168.	1680.	3360.	50.4	504.	5040.	10080.
	min	0.280	2.80	28.0	56.0	0.842	8.42	84.2	168.
33-1/3	sec	4.20	42.0	420.	840.	12.6	126.	1260.	2520.
	min	0.070	0.700	7.00	14.0	0.210	2.10	21.0	42.0

Table 21. List of ground commands

Command No.	Command name	Command address	
		Binary	Octal
DC-1	Command Data Mode 1	110 000 011 00	6 030
DC-2	Command Data Mode 2, Turn-on cruise science	110 011 011 10	6 332
DC-3	Command Data Mode 3	110 101 011 00	6 530
DC-4	Command Data Mode 4	110 011 101 00	6 350
DC-5	Command switch data rate	110 000 101 00	6 050
DC-6	Command switch ADC/PNG[a]	110 000 110 00	6 060
DC-7	Switch power amplifier	110 001 001 00	6 110
DC-8	Switch exciters	110 110 101 10	6 652
DC-9	Switch ranging	110 110 011 10	6 632
DC-10	Transmit high, receive low	110 110 000 00	6 600
DC-11	Transmit high, receive high	110 101 110 00	6 560
DC-12	Transmit low, receive low	110 101 101 00	6 550
DC-13	Maneuver command inhibit, Inhibit propulsion command	110 010 111 00	6 270
DC-14	Remove maneuver inhibit	110 010 100 00	6 240
DC-15	Canopus gate inhibit override	110 001 100 00	6 140
DC-16	Narrow angle acquisition	110 101 000 00	6 500
DC-17	Cycle Canopus cone angle	110 010 001 00	6 210
DC-18	Gyros on: inertial control, Positive roll	110 100 100 00	6 440
DC-19	Gyros off: normal control	110 100 010 00	6 420
DC-20	Remove roll control	110 111 100 00	6 740
DC-21	Roll override: negative increment	110 111 010 00	6 720
DC-22	Track change	110 111 001 00	6 710

[a]Analog-to-digital converter/pseudonoise generator

Table 21. (Cont'd)

Command No.	Command name	Command address	
		Octal	Binary
DC-23	Arm second propulsion maneuver	110 001 111 00	6 170
DC-24	Inhibit scan search	110 100 001 00	6 410
DC-25	Turn-on planet science Unlatch cover	110 010 010 00	6 220
DC-26	Turn-off planet science, cruise science, and battery charger	110 011 110 00	6 360
DC-27	Initiate midcourse maneuver	110 100 111 00	6 470
DC-28	Turn on battery charger, turn off 2.4 kc to	110 110 110 10	6 662
DC-29	Arm first propulsion maneuver	110 001 010 00	6 120
QC-1	Maneuver command bits to CC&S		
QC1-1	10 pitch turn duration	110 011 000 11	6 303
QC1-2	01 roll turn duration	110 011 000 00	6 300
QC1-3	11 motor burn duration	110 011 000 10	6 302

[a]Analog-to-digital converter/pseudonoise generator

Table 22. Description of ground commands

Command	Effect
DC-1	Transfers the data encoder to Data Mode 1 operation (all engineering words) as soon as the transfer is acceptable to the data encoder transfer logic.
DC-2	Transfers the data encoder to Data Mode 2 operation (20 engineering words, 40 science words) as soon as the transfer is acceptable to the data encoder transfer logic; applies 2.4-kc power to the cruise science instruments.
DC-3	Transfers the data encoder to Data Mode 3 operation (all science words) as soon as the transfer is acceptable to the data encoder transfer logic.
DC-4	Transfers the data encoder to Data Mode 4/Data Mode 1 operation (television picture data or engineering data) as soon as the transfer is acceptable to the data encoder transfer logic. If television picture data is available from the video storage tape recorder, television data is telemetered; if no television data is present (as between television pictures), then engineering data is telemetered; removes 2.4-kc power from the cruise science instruments.
DC-5	Transfers the data encoder from one bit rate to the other. The data encoder can operate at either 8-1/3 or 33-1/3 bps.
DC-6	Transfers the data encoder from one analog-to-digital converter/pseudonoise generator (ADC/PNG) to the other. The data encoder has two ADC/PNG's, A and B.
DC-7	Transfers the radio from one power amplifier to the other. The radio subsystem has two power amplifiers, A (traveling-wave tube) and B (cavity).
DC-8	Changes the radio from one exciter to the other. The radio subsystem has two exciters, A and B.
DC-9	Turns the spacecraft radio ranging-receiver either on or off.
DC-10	Causes the radio subsystem circulator switches to be conditioned so that the spacecraft transmits via the high-gain antenna and receives via the low-gain antenna.
DC-11	Causes the radio subsystem circulator switches to be conditioned so that the spacecraft transmits and receives via the high-gain antenna.

Table 22. (Cont'd)

Command	Effect
DC-12	Causes the radio subsystem circulator switches to be conditioned so that the spacecraft transmits and receives via the low-gain antenna.
DC-13	Removes the attitude control excitation power from the CC&S control lines so that the attiude control functions that are controlled by the CC&S are disabled. DC-13 also prevents the pyrotechnics control circuitry from firing the motor start and stop squibs.
DC-14	Reverses the stae of all the relays acted upon by DC-13. DC-14, therefore, is a reset for DC-13 and reverts the attitude control and pyrotechnics subsystems back to CC&S control.
DC-15	Causes the Canopus tracker roll error signal to be applied to the roll gas jet electronics at all times, regardless of whether or not the roll acquisition logic is satisfied, and also prevents the roll search signal from being applied to the roll channel, and roll acquisition logic violations from turning on the gyros.
DC-16	Initiates a narrow-angle acquisition signal and thereby conditions the data automation subsystem (DAS) logic to begin the television picture taking sequence and to transfer the data encoder to Data Mode 3.
DC-17	Causes a step change in the Canopus tracker cone angle by changing the voltage on the deflection plates of the Canopus tracker's image dissector.
DC-18	Turns on the gyros (in the inertial mode) and the Canopus tracker Sun shutter, and turns off the Canopus tracker. DC-18 also turns on the turn command generator and conditions the attitude control circuitry for commanded roll turns. Succeeding DC-18's cause clockwise 2.25-deg roll turns.
DC-19	Serves as the reset for DC-15, DC-18, and DC-20.
DC-20	Turns off the Canopus tracker and turns on the Canopus tracker Sun shutter; also inhibits the roll acquisition logic from turning on the gyros.

Table 22. (Cont'd)

Command	Effect
DC-21	Simulates a Canopus acquisition logic violation, turns on the gyros, and applies a negative roll search signal to the roll gas jet electronics; thereby causing the spacecraft to counterclockwise roll search to acquire a new target. DC-21 will also cause the spacecraft to roll turn 2.25-deg counterclockwise if preceded by a DC-18.
DC-22	Changes video storage tape tracks by applying power to a record head and gating the output of the playback amplifiers.
DC-23	Sets relays in the pyrotechnics subsystem so that CC&S commands, M-6 and M-7 are routed to the squibs allotted to the second motor burn.
DC-24	Removes 400-cps single-phase power from the scan platform drive motor.
DC-25	Causes 2.4-kc power to be applied to encounter science loads, the video storage subsystem, and also the cruise science loads if 2.4-kc power was off to cruise science; while at the same time applying 52 vdc from the booster-regulator to the 400-cps single-phase inverter, which in turn supplies power to the scan subsystem drive motor and the video storage subsystem record motor. DC-25 also enables the battery charger boost mode and causes the pyrotechnics subsystem to energize the solenoid that releases the scan platform science cover.
DC-26	Removes 2.4-kc power from all of the science loads (video storage 2.4-kc power remains on) and 52-vdc power from the 400-cps single-phase inverter; also enables the battery charger boost mode.
DC-27	Starts the maneuver sequence by issuing the CC&S command M-1 (turn on gyros), by applying power to the maneuver clock, and by removing the maneuver clamp and a flip-flop reset signal from the CC&S maneuver circuitry.
DC-28	Removes 2.4-kc power from the video storage subsystem and enables the charge mode of the battery charger.

Table 22. (Cont'd)

Command	Effect
DC-29	Sets relays in the pyrotechnics subsystem so that the CC&S commands M-6 and M-7 are routed to the squibs allotted to the first motor burn.
QC1-1	Sets pitch turn polarity and preloads the CC&S pitch shift register so that, at a counting rate of 1 pps, the register will fill in the required time interval for the attitude control subsystem to pitch turn the spacecraft the amount required for a given midcourse maneuver.
QC1-2	Sets roll turn polarity and preloads the CC&S roll shift register so that, at a counting rate of 1 pps, the register will fill in the required time interval for the attitude control subsystem to roll turn the spacecraft the amount required for a given midcourse maneuver.
QC1-3	Preloads the CC&S velocity shift register so that, at a counting rate of 20 pps, the register will fill in the time interval necessary for the midcourse motor to burn so that the spacecraft obtains the required velocity change for a given midcourse maneuver.

Table 23. Description of central computer and sequencer commands

Set	Reset	System designation	Function
X	0	L-1	Deploy solar panels, vanes, scan platform
X	0	L-2	Turn attitude control Sun acquire on
X	0	L-3	Turn attitude control Canopus acquire and solar vanes on
X	X	M-1	Gyros on, data encoder to Data Mode 1
X	X	M-2	Spacecraft on inertial, autopilot on, Sun and Canopus off
X	X	M-3	Turn polarity (set if plus)

Columns 1 and 2 specify the conditions to give a telemetry event to counter 2. An X in a column indicates a channel 2 event, A ZERO indicates no channel 2 event. PARENTHESES around a command indicate a reset.

Table 23. (Cont'd)

Set	Reset	System designation	Function
X	X	M-4	Pitch turn start
		(M-4)	Pitch turn stop
		(M-3)	Turn polarity reset
X	X	M-5	Roll turn start
X	X	M-3	Turn polarity (set if plus)
		(M-5)	Roll turn stop
		(M-3)	Turn polarity reset
X	0	M-6	Midcourse motor ignition
X	0	M-7	Midcourse motor turn off
		(M-1) (M-2)	Attitude reacquire Sun and Canopus Data encoder to Data Mode 2 Auto pilot off, spacecraft to normal
X	0		Midcourse counter reset for next start
X	0	MT-6	Change data encoder bit rate to 8-1/3 bps
X	0	MT-1	Change Canopus cone angle
X	0	MT-5	Transfer to transmit via high-gain antenna
X	0	MT-2	Change Canopus cone angle
X	0	MT-3	Change Canopus cone angle
X	0	MT-4	Change Canopus cone angle
X	0	MT-7	Encounter science on (or all science on) Battery charger off Deploy science platform cover
X	0	MT-8	Encounter science off (or all science off)
X	0	MT-9	Data encoder to Data Mode 4, cruise science off, start playback
X	0	CY-1	Backup switching to radio

Columns 1 and 2 specify the conditions to give a telemetry event to counter 2. An X in a column indicates a channel 2 event, A ZERO indicates no channel 2 event. PARENTHESES around a command indicate a reset.

Table 24. Contractors and major subcontractors

Name	Responsibility
Contractors	
General Dynamics/Astronautics San Diego, Calif.	Atlas (purchased through the Space Systems Division of USAF Systems Command)
Rocketdyne Division of North American Aviation, Inc. Canoga Park, Calif.	Atlas propulsion systems
General Electric Co. Defense Electronics Division Syracuse, N. Y.	Atlas radio command guidance
Burroughs Corporation Defense, Space, & Special Systems Group Paoli, Pa.	Ground guidance computer
Lockheed Missiles and Space Co. (LMSC) Sunnyvale, Calif.	Agena D (purchased directly by Lewis Research Center)
Bell Aerosystems Co. Buffalo, New York	Agena D propulsion system
Jet Propulsion Laboratory California Institute of Technology Pasadena, Calif.	Spacecraft
Major subcontractors	
Advanced Structures Division Whittaker Corp. La Mesa, Calif.	Spacecraft high-gain antennas
Airrite Products Division of Electrada Corp. Los Angeles, Calif,	Midcourse propulsion fuel tanks, nitrogen tanks
Alpha-Tronics Corp. Monrovia, Calif.	Data automation system analog-to-pulse width converters
Anadite Co. Los Angeles, Calif.	Surface treatment of structural elements and chassis

Table 24. (Cont'd)

Name	Responsibility
Major subcontractors	
Anchor Plating Co. El Monte, Calif.	Gold plating
Applied Development Corp. Monterey Park, Calif.	Ground telemetry decommutators, printer programmers
Astrodata Inc. Anaheim, Calif.	Time code generator/translators, ground command read-write-verify equipment, encoder simulator, and spacecraft system test data system
Barnes Engineering Co. Stamford, Conn.	Canopus star tracker electronics
Bendix Corp. Scintilla Division Santa Ana, Calif.	Connectors
Bergman Manufacturing Co. San Rafael, Calif.	Chassis forgings
Cannon Electric Co. Los Angeles, Calif.	Connectors
CBS Laboratories Division of Columbia Broadcasting System, Inc. Stamford, Conn.	Image dissector tubes for Canopus star trackers
Computer Control Co. Inc. Framingham, Mass.	Real time data automation system logic cards for scientific instruments, operational support equipment, DAS voltage-to-pulse-width converters
Correlated Data Systems Corp. Glendale, Calif.	Spacecraft external power source and solar panel simulators, voltage controlled oscillators
Data-Tronix Corp. King of Prussia, Pa.	Voltage controlled oscillators

Table 24. (Cont'd)

Name	Responsibility
Major subcontractors	
Delco Radio Division General Motors Corp. Kokomo, Ind.	Telemetry format simulators
Digital Equipment Corp. Los Angeles, Calif.	Data automation system operational support data system
Dunlap and Whitehead Manufacturing Co. Van Nuys, Calif.	Midcourse propulsion and structural elements
Dynamics Instrumentation Co. Monterey Park, Calif.	Ground telemetry consoles, assembly of planetary scan subsystem electronics
The Electric Storage Battery Co. Raleigh, N. C.	Spacecraft batteries
Electro-Optical Systems, Inc. Pasadena, Calif.	Ionization chamber assemblies, assembly and test of spacecraft solar panels, modification and test of spacecraft power system, spacecraft assembly cables
Electronic Memories, Inc. Los Angeles, Calif.	Magnetic counter assemblies for spacecraft central computer and sequencer
Engineered Electronics Co. Santa Ana, Calif.	Non-real time data automation system
Fargo Rubber Corp. Los Angeles, Calif.	Midcourse propulsion fuel tank bladders
Farrand Optical New York, N. Y.	Television optical systems
Franklin Electronics, Inc. Bridgeport, Pa.	Ground telemetry high speed digital printers
General Dynamics Corp. General Dynamics/Electronics San Diego, Calif.	Assembly of television subsystems
General Electrodynamics Corp. Garland, Texas	Vidicons and television tube test set

Table 24. (Cont'd)

Name	Responsibility
Major subcontractors	
Grindley Manufacturing Co. Los Angeles, Calif.	Midcourse propulsion jet vanes, fuel manifolds, oxidizer cartridge shell, and supports
Hi-Shear Corp. Torrance, Calif,	Squibs
Hughes Aircraft Co. Microwave Tube Division Los Angeles, Calif.	Traveling wave tubes
IMC Magnetics Corp. Westbury, N. Y.	Solar vane actuators
International Data Systems, Inc. Dallas, Texas	Ground command modulation checker, telemetry power supplies
Kearfott Division General Precision, Inc. Los Angeles, Calif.	Gyroscopes, jet vane actuators
Lawrence Industries, Inc. Burbank, Calif.	Printed circuits
Lockheed Aircraft Service Co. Division Lockheed Aircraft Corp. Ontario, Calif.	Spacecraft low-level positioners
Lockheed Electronics Co. Division Lockheed Aircraft Corp. Los Angeles, Calif.	Solar cell modules and magnetic shift register for central computer and sequencer
Magnamill Los Angeles, Calif.	Structural elements and chassis
Massachusetts Institute of Technlogy Division of Sponsored Research Cambridge, Mass.	Solar plasma probes
Metal Bellows Corp. Chatsworth, Calif.	Midcourse propulsion oxidizer bellows assembly
Milbore Co. Glendale, Calif.	Midcourse propulsion engine components

Table 24. (Cont'd)

Name	Responsibility
Major subcontractors	
Mincom Division Minnesota Mining and Manufacturing Co. Camarillo, Calif.	Ground telemetry tape recorders
Motorola, Inc. Military Electronics Division Scottsdale, Arizona	Spacecraft transponders, command systems and associated operational support equipment, and DSIF equivalent operational support equipment
Nortronics A Division of Northrop Corp. Palos Verdes Estates, Calif.	Development and support of attitude control electronics
Philco Corp. Palo Alto, Calif.	Integrated circuit sequence generator system, spacecraft antenna feeds and spacecraft antenna subsystem tests
Proto Spec Pasadena, Calif.	Chassis and subchassis
Pyronetics, Inc. Santa Fe Springs, Calif.	Midcourse propulsion system explosive actuated valves
Rantec Corp. Calabasas, Calif.	S-band circulator switches, pre-selection and band rejection filters
Raymond Engineering Laboratory, Inc. Middletown, Conn.	Spacecraft video storage tape recorder
Ryan Aeronautical Co. Aerospace Division San Diego, Calif.	Spacecraft solar panel structure
Siemens and Halske AG Munich, West Germany	RF amplifier tubes
Space Technology Laboratories El Segundo, Calif.	Spacecraft central computer and sequencer and associated operational support equipment
Sperry Utah Co. A Division of Sperry Rand Corp. Salt Lake City, Utah	Magnetometer mapping fixture

Gerbasi, M. J.	Mariner C Clamshell Shroud (Pyro) Separation Analysis (Lockheed Missiles and Space Co., Sunnyvale, Calif.)	LMSC A632682	24 Jan 1964
Grosso, D. S.	Model 1738 Tape Recorder/Reproducer: General Test Requirements (prepared for JPL by Raymond Engineering Lab., Inc., Middletown, Conn.)	NASA CR-64630 JPL 950105	16 Jun 1964
Hanley, J. R. and Hill, H. G.	AGE Systems Design Analysis of Agena D/Mariner C Model 43205 Vehicles 6931 and 6932 (Lockheed Missiles and Space Co., Sunnyvale, Calif.)	LMSC 925672A	1 Aug 1963
Hughes, W. R. and Bean, E. E.	Reliability Analysis of the Mariner C Spacecraft (prepared for JPL by Planning Research Corp., Los Angeles, Calif.)	PRC-R-433 JPL 950759	9 Dec 1963
Hunter, J. H.	Mariner Mars 1964 Telecommunication System (JPL)	TR 32-836	1 Dec 1965
James, J. N., et al.	Mariner IV Mission to Mars, Part I (JPL)	TR 32-782	15 Sep 1965
Johnson, N. E.	Investigation of Fiberglass Shroud Materials (JPL)	TM 33-214	1 Apr 1965
Juchnowycz, S.	1-1/2 Inch Rugged Image Dissector Tube, Final Repórt, 25 Feb. to 18 Sep. 1964	NASA CR-60195 JPL 950848	12 Oct 1964
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 (JPL)	TR 32-674	16 Oct 1964
Krimigis, S. M., et al.	Observations with University of Iowa Equipment on Mariner IV: Nov. 1964–Feb. 1965, Prelim Report (Univ. of Iowa, Iowa City)	Research Rept. 65-5	22 Feb 1965

Table 25a. (Cont'd)

Author	Title and Originator	No.	Date
Krimigis, S. M., et al.	Observations with University of Iowa Equipment on Mariner IV: May–Oct. 1965, Prelim Report (Univ. of Iowa, Iowa City)	Research Rept. 65-6	25 Oct 1965
Long, J. J.	Mariner C Exit Optics Assembly and Cooling System (prepared for JPL by Santa Barbara Research Center, Goleta, Calif.)	Final Report JPL 950548 NASA CR-56173	6 Apr 1964
Mathison, R. P.	Mariner Mars 1964 Telemetry and Command System (JPL)	TR 32-684	1 Jun 1965
Pedersen, E. S.	Heat-Sterilizable Power Source Study for Advanced Mariner Missions (JPL)	TM 33-180	1 Jul 1964
Pefley, R. K.	Temperature Control, A Case History of the Mariner Spacecraft (JPL)	TM 33-189	1 Mar 1965
Prince, M. B.	Ionization Chamber Geiger Tube Instrument Fabrication Program (prepared for JPL by Electro Optical Systems, Pasadena, Calif.)	Final Report JPL 950658 EOS 5030-Final	28 Mar 1964
Robinson, J. C.	Ground-Based Photography of the Mariner IV Region of Mars (New Mexico State Univ., University Park, Observatory)	N65-32884 NASA CR-64466	Aug 1965
Tombaugh, C. W.	Provisional Topographic Map of Mars, Mariner IV Region (New Mexico State Univ., Univ. Park, Observatory)	N65-33258 NASA CR-64772 TN 701-66-8	Jul 1965

Wilson, J. H.	The Odyssey of Mariner IV (JPL)	TM 33-229	Jul 1965
	Fabrication, Assembly and Test of Mariner C Solar Cell Modules (prepared for JPL by Propulsion Div., Lockheed Aircraft Corp. Burbank, Calif.)	Final Report JPL 950796	8 May 1964
	JPL Low-Field Magnetometer (Texas Instruments, Inc., Apparatus Div., Dallas, Texas)	Final Eng. Report JPL 950355	26 May 1964
	Mariner C Spacecraft System: Test Plan (Applied Systems Corp., Palo Alto, Calif.)	TR 63-35-39	1 Mar 1963
	Mariner C Spacecraft/S-01A Interface Preliminary Design Study (Lockheed Missiles and Space Co.)	LMSC A306661	10 Dec 1962
	Mariner-Mars 1964: Data Transmission Test (AFETR, Air Force Systems Command)	OD-4340	18 Sep 1964
	Mariner Mars 1964 Mission and Spacecraft Development Project Report (JPL)	TR 32-740	In Pub
	Mariner-Mars 1964 Spacecraft: RF Systems Test (AFETR, Air Force Systems Command)	OD-4341	16 Sep 1964
	Mariner Mars 1964 Final Report, Volume I (U.S. Government Printing Office, Washington, D.C.)	(Order by title)	In Prep
	Mariner Mars 1964 Final Report, Volume II (U.S. Government Printing Office, Washington, D.C.)	(Order by title)	In Prep

Table 25a. (cont'd)

Author	Title and Originator	No.	Date
	Mariner Mars 1964 Project Report, Mission and Spacecraft Development, Volume I: Basic Report (JPL)	TR 32-740 Vol. I	In Pub.
	Mariner Mars 1964 Project Report, Mission and Spacecraft Development, Volume II: Appendixes (JPL)	TR 32-740 Vol. II	In Prep
	Mariner Mars 1964 Project Report, Mission Operations (JPL)	TR 32-740	In Prep
	Mariner Mars 1964 Project Report, Spacecraft Performance and Analysis (JPL)	TR 32-740	In Prep
	Mariner Mars 1964 Project Report, Scientific Experiments (JPL)	TR 32-740	In Prep
	Mariner Mars 1964 Project Report, Television Experiment, Part I: Investigators' Report (JPL)	TR 32-740	In Prep
	Mariner Mars 1964 Project Report, Television Experiment, Part II: Picture Element Matrices (JPL)	TR 32-740	In Prep
	Mariner IV (Government Printing Office, Washington, D.C.)	NASA Facts Vol. II No. 9	1965
	Redundant Path Tests and Interaction Tests Mariner C Proof Test Model (Applied Systems Corp., Palo Alto, Calif.)	TR 63-35-40	22 Mar 1963

Table 24. (Cont'd)

Name	Responsibility
Major subcontractors	
State University of Iowa Iowa City, Iowa	Trapped radiation detectors
Sterer Engineering and Manufacturing Co. North Hollywood, Calif.	Valves and regulators for attitude control gas system
Texas Instruments, Inc. Apparatus Division Dallas, Texas	Spacecraft video storage subsystem electronics, spacecraft data encoders and associated operational support equipment, helium magnetometers, attitude control gyro electronics assemblies, data demodulators
Textron Electronics, Inc. Heliotek Division Sylmar, Calif.	Silicon photovoltaic solar cells
Thompson Ramo Wooldridge, Inc. Redondo Beach, Calif.	Thermal control louvers, and power converters
Univac Division of Sperry Rand Corp. St. Paul, Minn.	Spacecraft data automation system buffer memory
The University of Chicago Chicago, Ill.	Spacecraft cosmic ray telescopes
WEMS, Inc. Hawthorne, Calif.	Spacecraft television electronics modules, spacecraft attitude control electronic modules
Wyman Gordon Corp. Los Angeles, Calif.	Spacecraft structural forgings

In addition to these subcontractors, there were over 1,000 individual firms contributing to Mariner.

Table 25. Related documents
a. Reports

Author	Title and Originator	No.	Date
Andrews, J. D., et al.	Reliability Assessment of the 1964 Mariner Mars Spacecraft (prepared for JPL by Planning Research Corp., Los Angeles, Calif.)	NASA CR-59375 PRC-R-362	22 Jul 1963
Becker, R. A.	Analysis of Solar Panel Effect on Louver Performance (JPL)	TR 32-687	1 Jun 1965
Becker, R. A.	Design and Test Performance of Mariner IV Television Optical System (JPL)	TR 32-773	1 Jul 1965
Bright, D. R.	Preliminary Separation Tests of the ASP 855 Mariner C V-Band Clamp Installation TA 5675 (Lockheed Missiles and Space Co., Sunnyvale, Calif.)	NASA 3-3802	13 Dec 1963
Clarke, V. C., Jr.	Trajectory Design for Ranger and Mariner Missions (JPL)	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 (JPL)	TR 32-729	1 Jul 1965
Gabel, R. H. and Skerik, J.	Mariner C-64: Trapped Radiation Detector, Unit 25, 17 May 1963 to 30 Dec. 1964 (prepared for JPL by State Univ. of Iowa, Iowa City)	Final Eng. Report 17 May–30 Dec. 1964 JPL 950613 NASA CR-63743	19 Feb 1965

Author	Title	Source	Date
	Reliability Model Formulation for the Mariner-Mars Spacecraft (Planning Research Corp., Los Angeles, Calif.)	PRC R-322	6 May 1963
	Study of Spacecraft Testing Philosophies and Techniques (GE Missile and Space Div., Spacecraft Dept., Valley Forge, Pa.)	R-64SD4370 Final Report JPL 950830	23 Nov 1964
	Tracking and Data Acquisition Support for Mariner Mars 1964 (JPL)	TM 33-239	1 Jan 1965
	Tracking and Data Acquisition Support for Mariner Mars 1964, Volume II (JPL)	TM 33-239 Vol. II	In Prep
	Worst-Case Analysis Report for Mariner C Encoder (prepared for JPL by Texas Instruments, Dallas, Texas)	JPL 950463	1 Aug 1963

b. Periodicals

Author	Title	Source	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

Table 25b. (Cont'd)

Author	Title	Source	Date
Casani, J. R., et al.	Mariner IV: A Point of Departure	Astronaut & Aeronaut 3:16—24	3 Aug 1965
Ewing, A.	Canals May Be Craters	Sci. NL 88:103	14 Aug 1965
Fink, D. E.	Mars Vehicle Becomes Major Scientific Program	Aviation W. 82:116—18+	15 Mar 1965
Haynes, N. R., et al.	Mariner IV Flight Path to Mars	Astronaut & Aeronaut 3:28—33	Jun 1965
James, J. N.	Managing the Mariner Mars Project	Astronaut & Aeronaut 3:34—41	Aug 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., et al.	Mariner IV Occultation Experiment	Astronaut & Aeronaut 3:72—80	Jul 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
Lindsey, R.	Mars Atmosphere Probe Proposed	Miss & Roc	8 Feb 1965
Mathison, R. P.	Mariner Mars 1964 Telemetry and Command System	IEEE Spectrum 2:76–84	Jul 1965
Miller, B.	JPL Facing Mariner C Avionics Problems	Aviation W 80:16–17	29 Jun 1964
Normyle, W. J.	Planetary Exploration Hopes Buoyed by Mariner Flight	Aviation W 83:86–7	9 Aug 1965
O'Gallagher, J. J. and Simpson, J. A.	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
Schmuecker, J. D. and Wilson, J. N.	Structural and Mechanical Design of Mariner Mars	Astronaut & Aeronaut 3:26–33	Aug 1965
Shipley, W. S. and Maclay, J. E.	Mariner IV Environmental Testing	Astronaut & Aeronaut 3:42–48	Aug 1965
Smith, E. J., et al.	Magnetic Field Measurements Near Mars	Science 149:1241–1242	10 Sep 1965

Table 25b. (Cont'd)

Author	Title	Source	Date
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 1963
Taylor, H.	Webb Says Mariner Winning Mars Race: Zond a Month Behind	Miss & Roc 16:15	15 Feb 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
	Craters Found on Mars	Sci NL 88:82	7 Aug 1965
	Journey to July: Mariner IV	Newsweek 64:67	7 Dec 1964
	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

Table 25b. (Cont'd)

Author	Title	No.	Date
	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
	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

Table 25. (Cont'd)
c. NASA 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
News Conference on Initial Scientific Interpretation of Mariner IV Photography	N65-29786 CSCL 22A	29 Jul 1965

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

Table 26. Part hour-and-failure summary

Category	Operation time, hr						
	Transistor	Resistor	Capacitor	Diode	Transformer	Relay	Coil
Pre-Launch Mariner IV	3,847,480	13,203,842	5,451,111	8,411,010	524,839	102,231	45,210
Post-Launch Mariner IV	23,198,442	80,935,046	32,964,356	49,646,268	2,576,558	623,688	247,798
Total Mariner IV	27,045,922	94,138,888	38,415,467	58,057,278	3,101,397	725,919	293,008
Total Mariner Mars 1964	88,741,399	309,316,230	124,139,330	193,807,690	10,165,600	2,372,226	899,430
Failure type	**Number of failures**						
Class 1 Pre-Launch Mariner IV	1	2	3	0	1	0	4
Class 3 Pre-Launch Mariner IV	1	2	1	0	0	0	0
Class 3 Post-Launch Mariner IV	0	0	0	0	0	0	0
Class 1 Total Mariner IV	1	2	3	0	1	0	4
Class 3 Total Mariner IV	1	2	1	0	0	0	0
Class 3 Total Mariner Mars 1964 Program	10	3	4	4	0	1	0

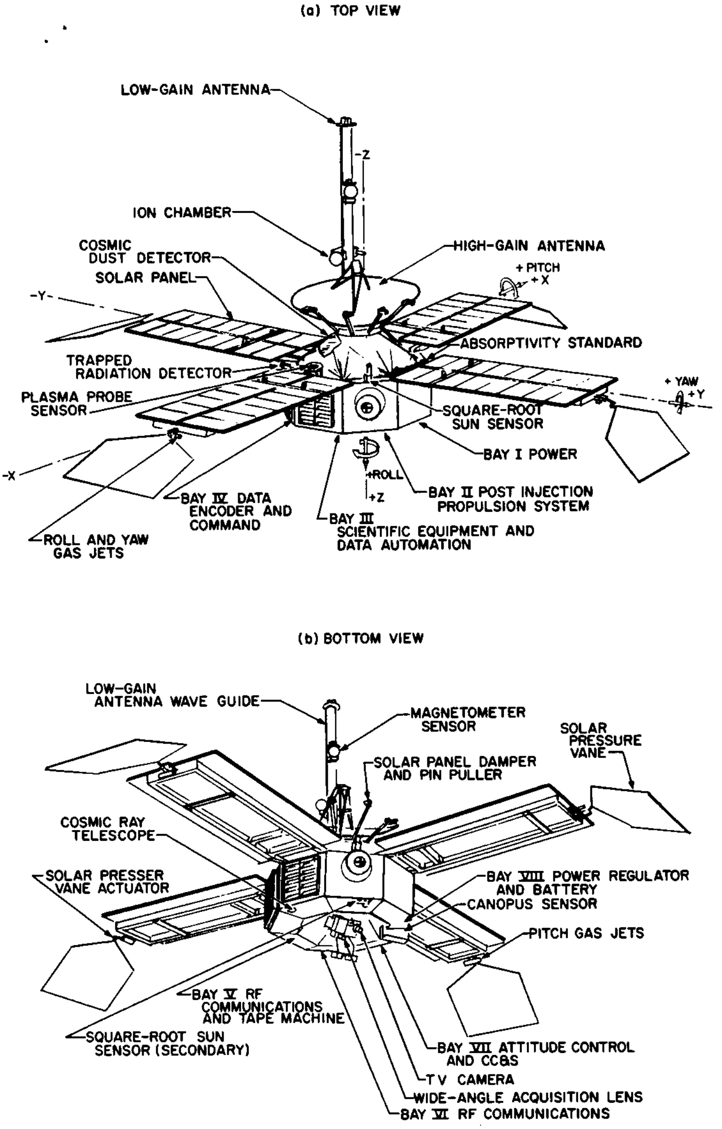


Fig. 1. Mariner Mars 1964 spacecraft: (a) Top view, (b) Bottom view

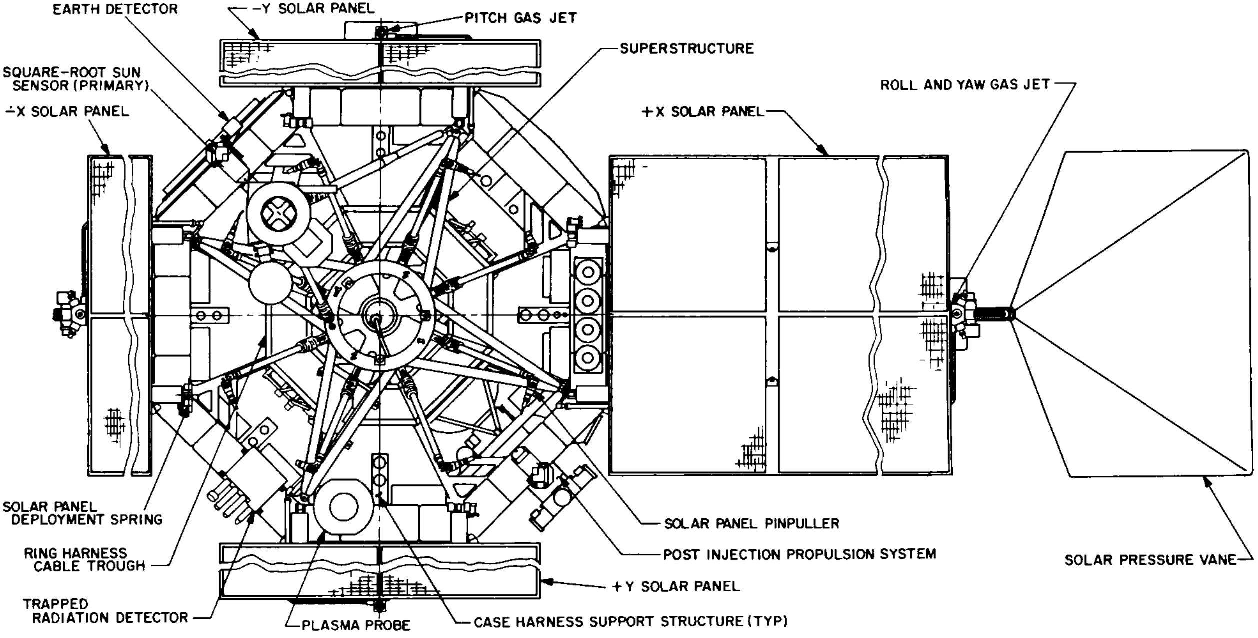


Fig. 2. Spacecraft mechanical configuration: (a) Top view, solar panels extended

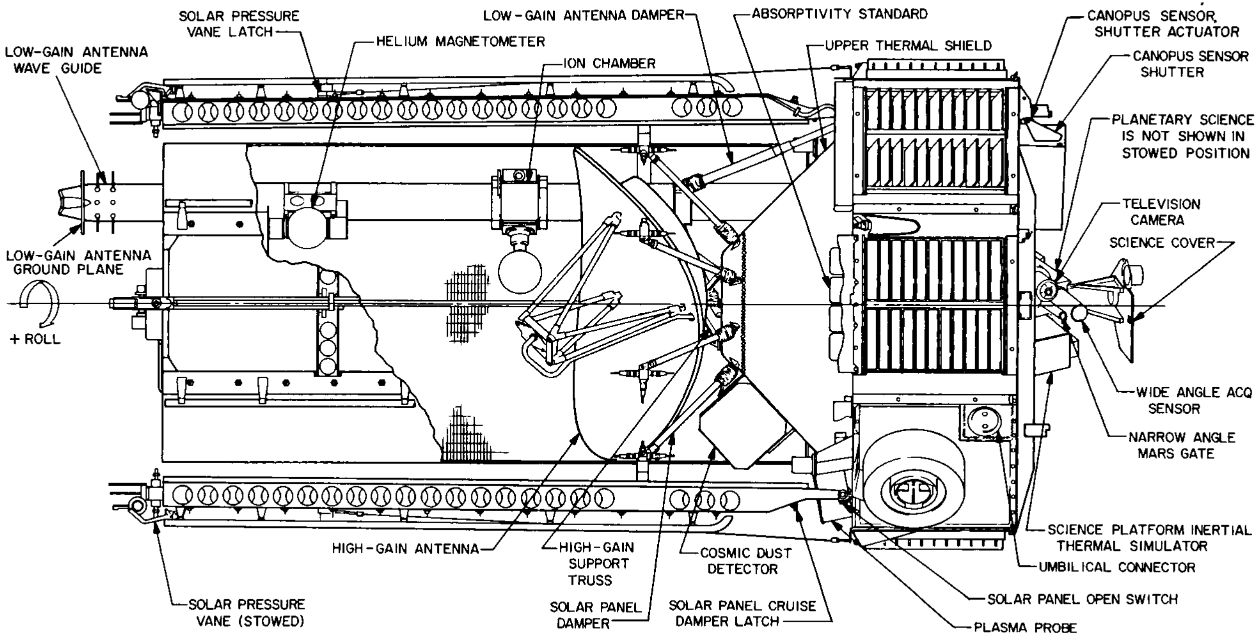


Fig. 2. Spacecraft mechanical configuration: (b) side view, solar panels folded

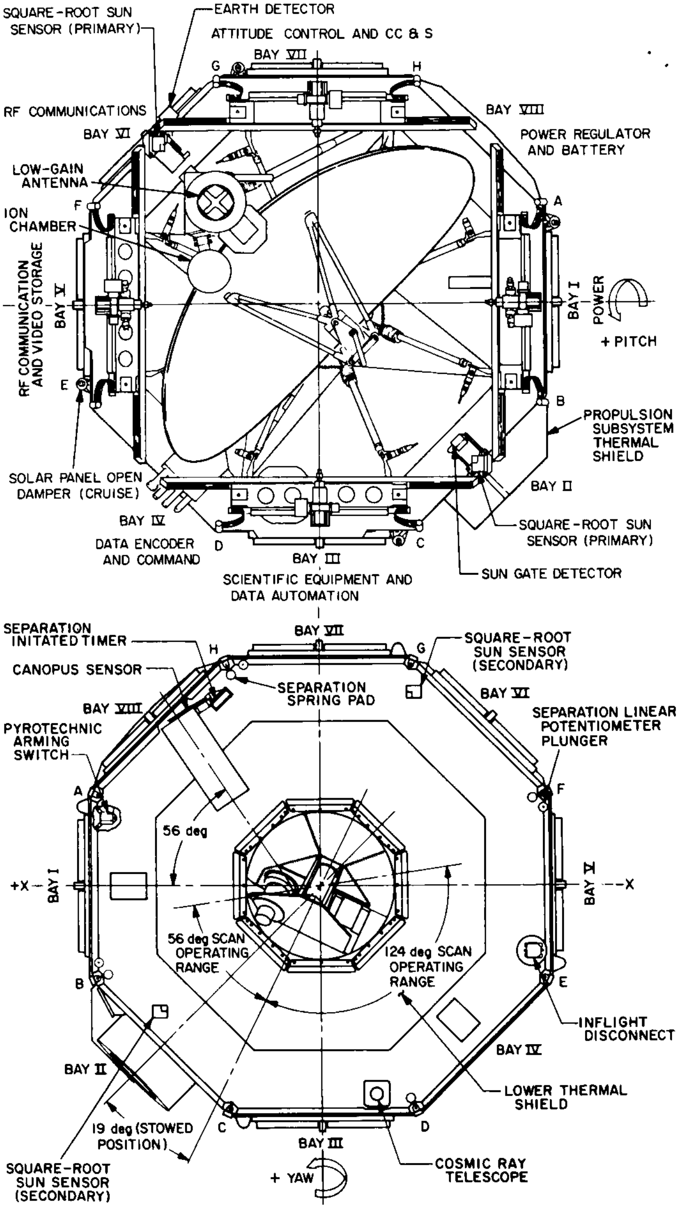


Fig. 2. Spacecraft mechanical configuration: (c) top and bottom views

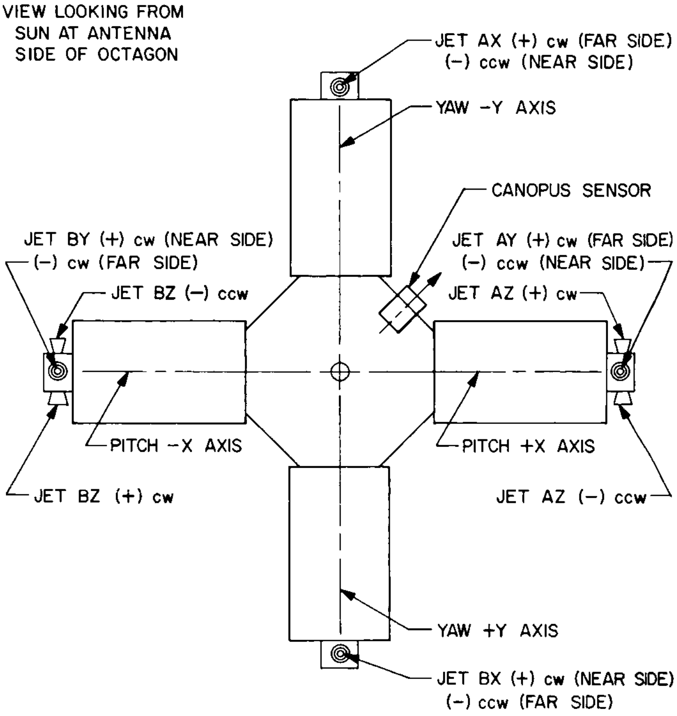


Fig. 3. Attitude control gas jet configuration

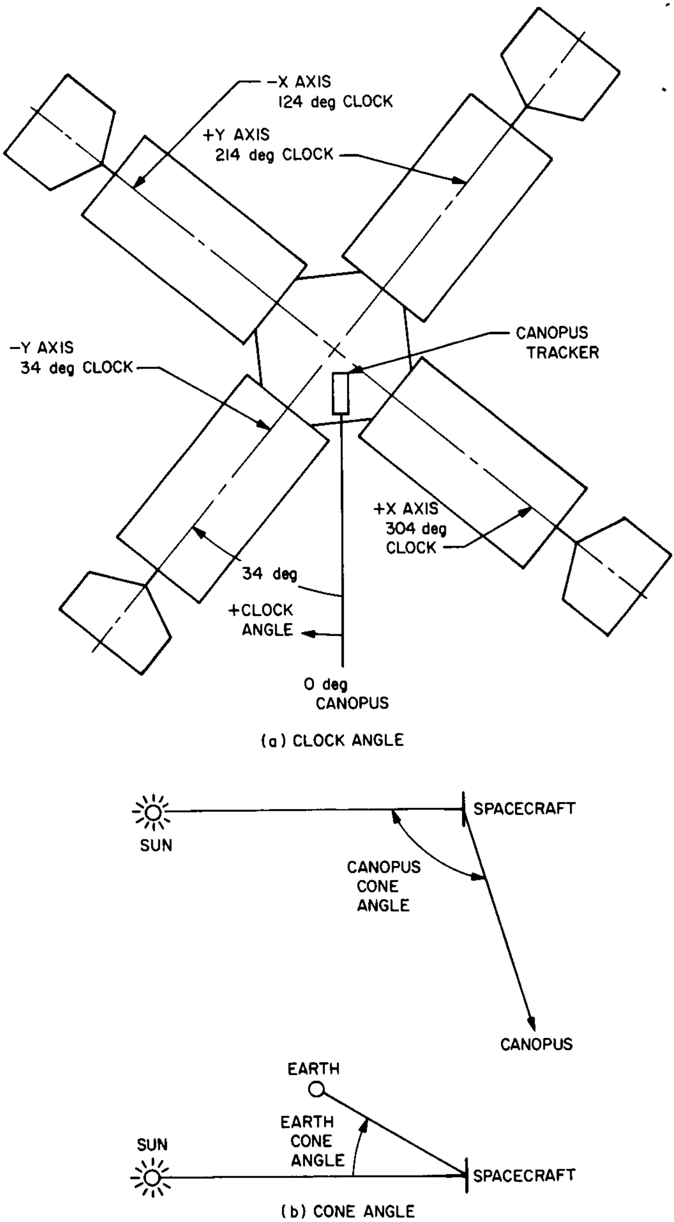


Fig. 4. Clock- and cone-angle descriptive diagram: (a) Clock angle, (b) Cone angle

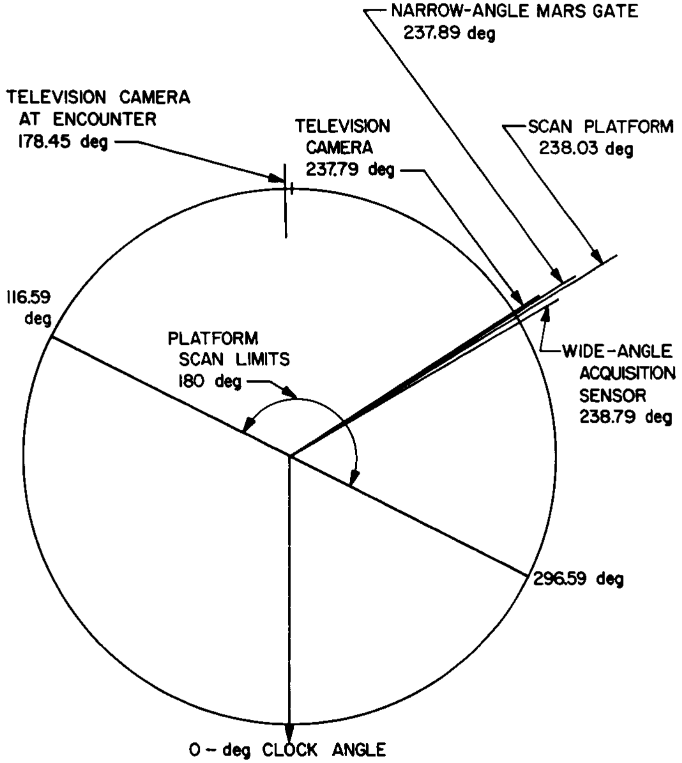


Fig. 5. Planetary scan platform relative look angles, shown with platform in pinned position

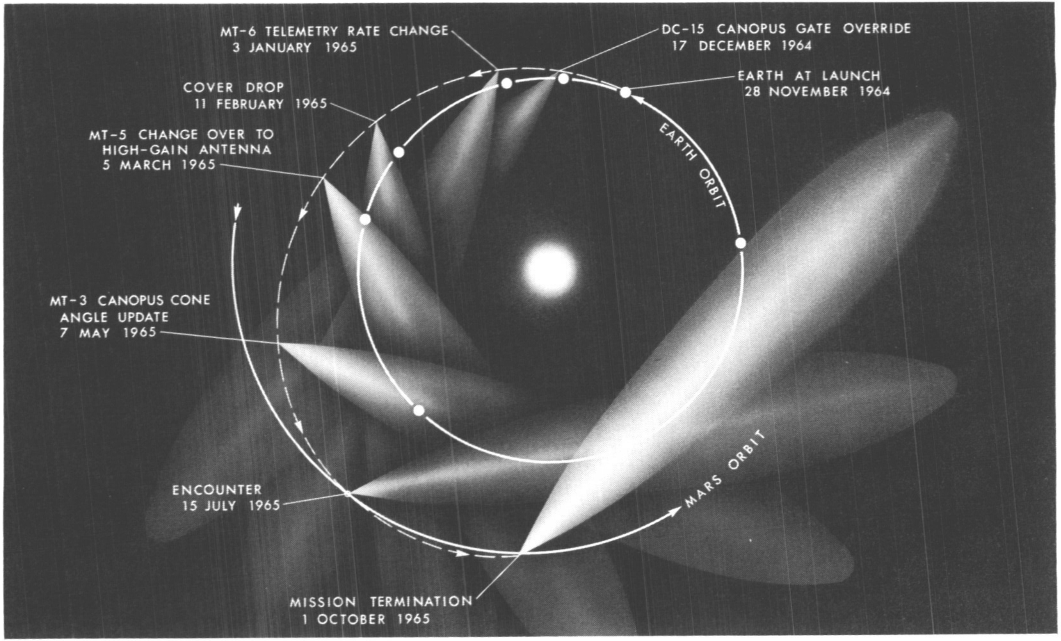


Fig. 6. High-gain antenna look angles during flight

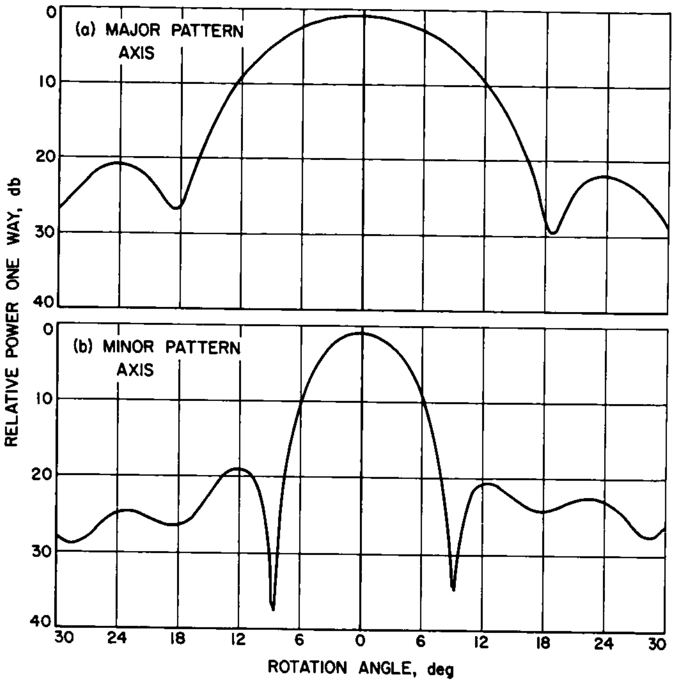


Fig. 7. High-gain antenna beamwidths: (a) Major pattern axis, (b) Minor pattern axis

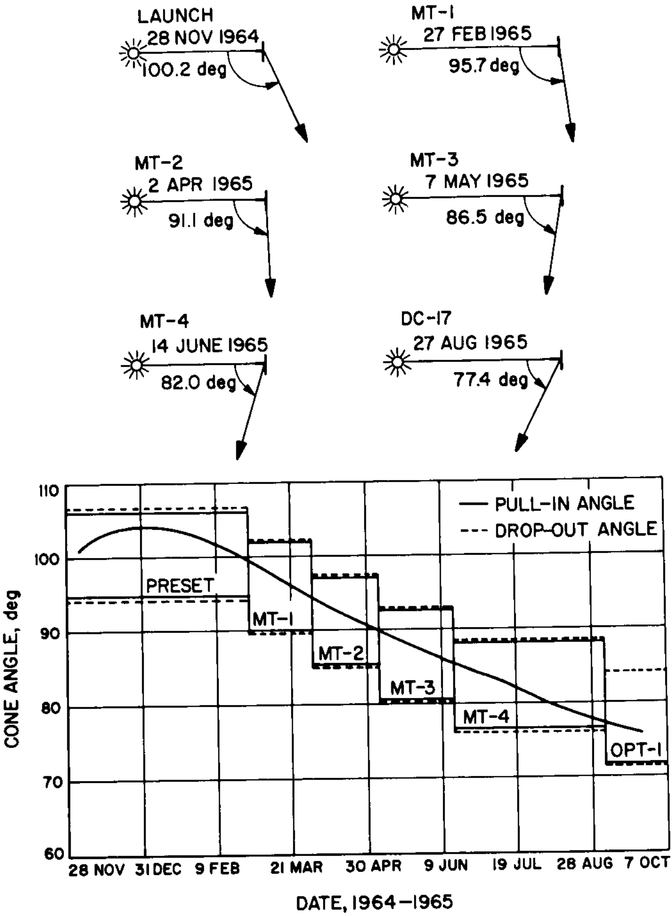


Fig. 8. Canopus cone angle update diagram

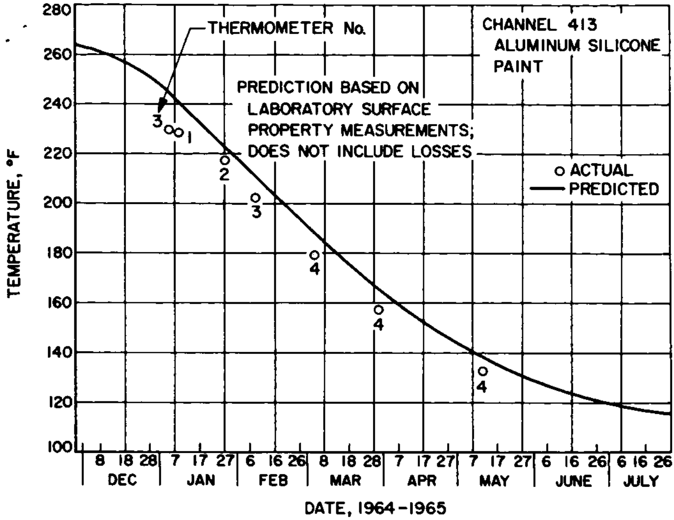


Fig. 12. Absorptivity standard: aluminum silicone sample temperature history

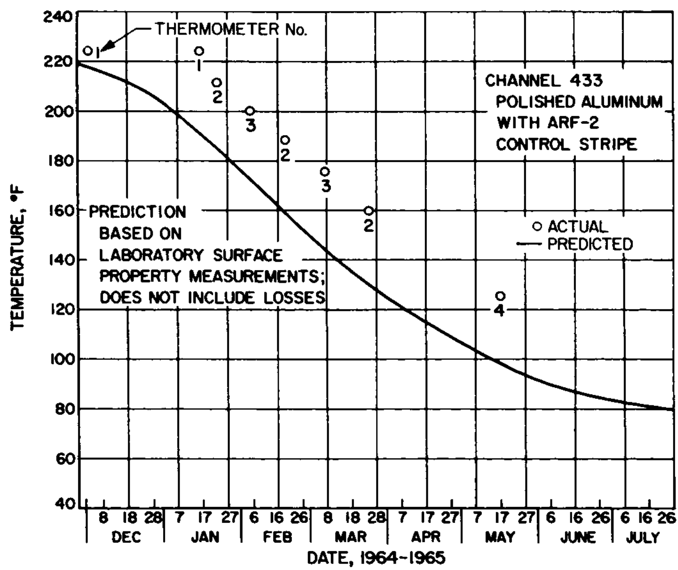
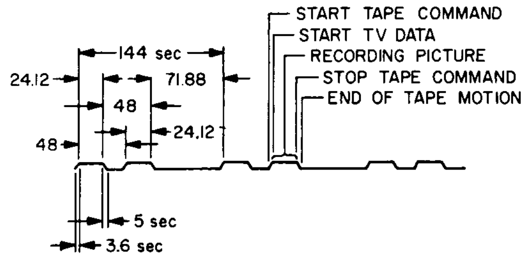
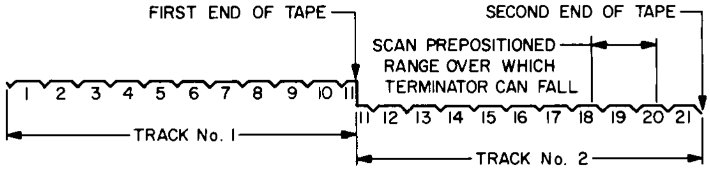


Fig. 13. Absorptivity standard: polished aluminum sample temperature history



(a) TIMING SEQUENCE OF RECORDING



(b) VIDEO TAPE AFTER A NORMAL RECORD SEQUENCE

Fig. 14. Video recording timing sequence

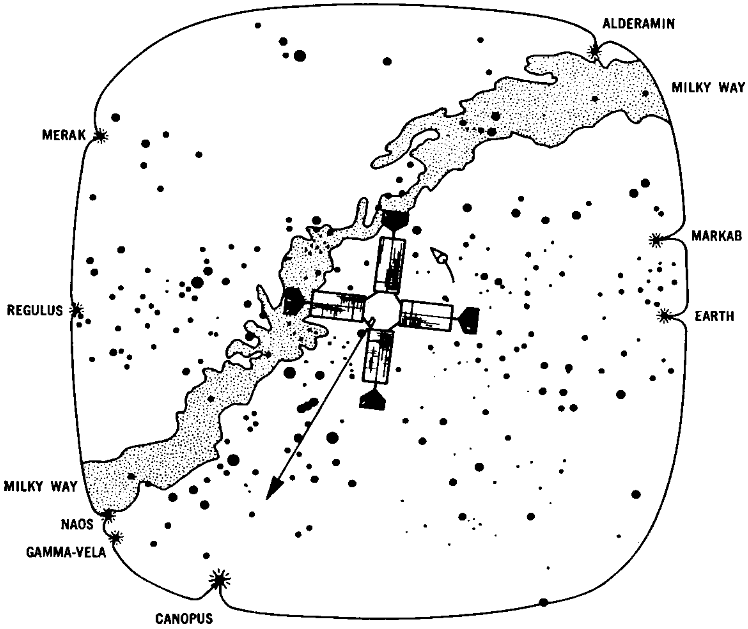


Fig. 9. Star acquisition diagram

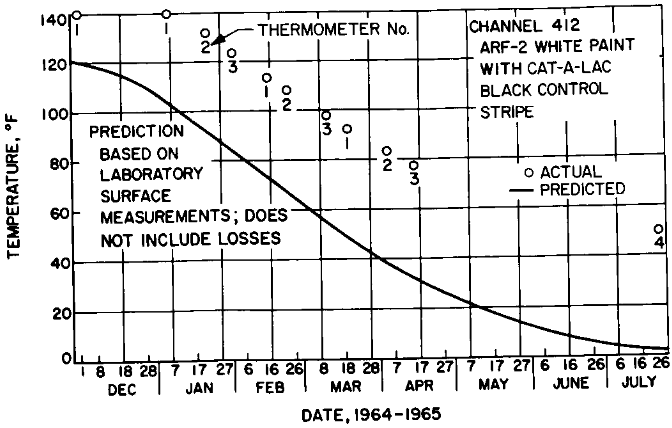


Fig. 10. Absorptivity standard: white sample temperature history

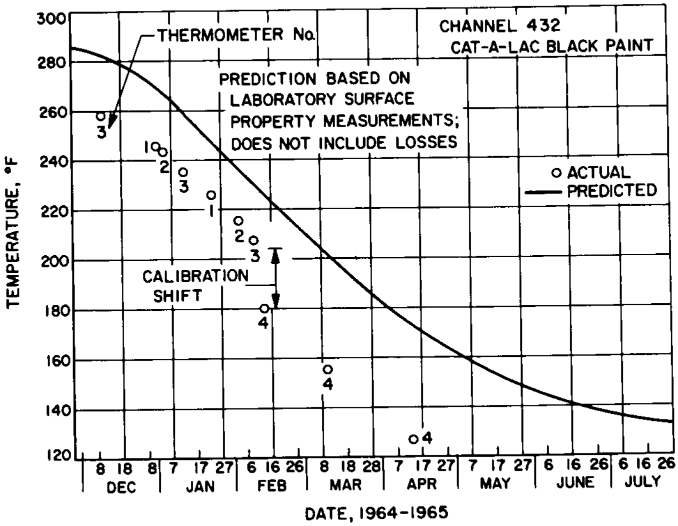


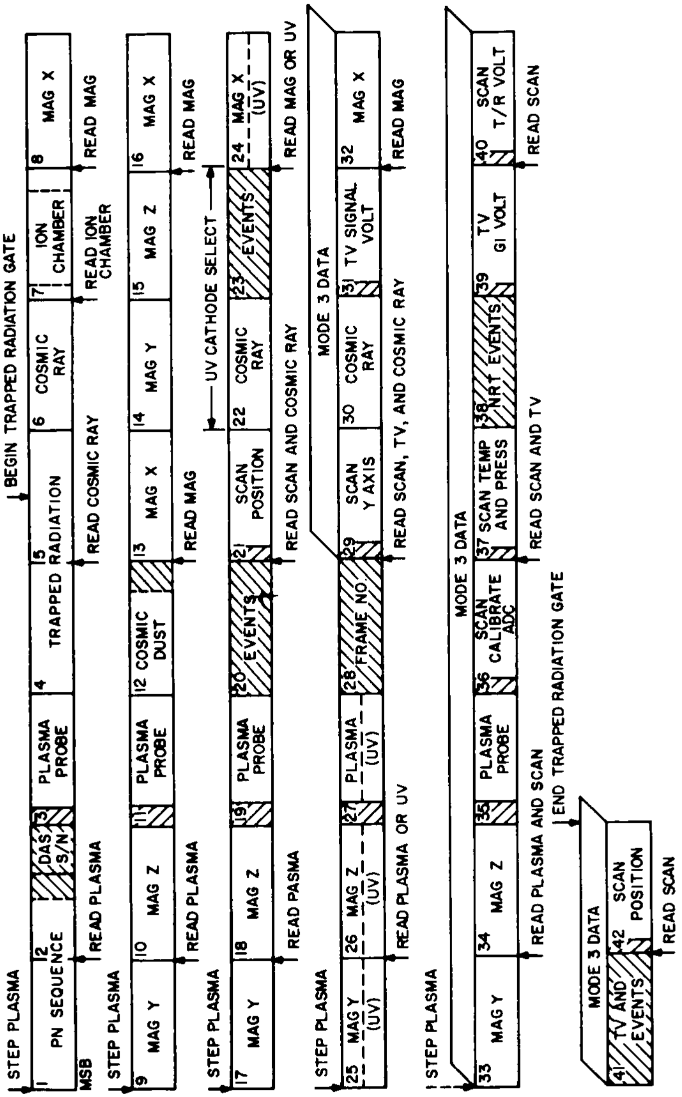
Fig. 11. Absorptivity standard: black sample temperature history

DC COMMANDS																										
COMMAND BIT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
COMMAND BIT IDENTIFICATION	COMMAND DECODER START			COMMAND ADDRESS						ADDRESS PARITY SEE NOTE NO.1		BITS 12-26 HAVE NO SIGNIFICANCE IN DC'S. IN QC'S THEY FORM PART OF THE CC&S COMMAND. REFER TO QUANTITIVE COMMAND FORMAT.														
COMMAND BIT VALUE	1	1	0	VARIABLE								ZERO FOR DC'S; VARIABLE FOR QC'S														

QC COMMANDS																										
COMMAND BIT NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
CC&S COMMAND BIT NO.									1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CC&S COMMAND BIT IDENTIFICATION									CC&S ADDRESS: SEE NOTE NO. 2			CC&S ADDRESS: REGISTER SELECTOR		ODD PARITY	TIME VALUE (SEE NOTE NO. 5)											POLARITY
QC COMMAND BIT VALUES: PITCH TURN	1	1	0	0	1	1	0	0	0	1	1	1	0		VARIABLE											
QC COMMAND BIT VALUES: ROLL TURN	1	1	0	0	1	1	0	0	0	0	0	0	1		VARIABLE											
QC COMMAND BIT VALUES: MOTOR BURN	1	1	0	0	1	1	0	0	0	1	0	1	1		VARIABLE											

1. COMMAND BIT NOS. 10 AND 11 ARE ADJUSTED TO ENSURE AGAINST SINGLE BIT ERRORS CAUSING AN INCORRECT COMMAND WORD OUTPUT
2. COMMAND BIT NOS. 9-11 (CC&S COMMAND BIT NOS. 1-3) ARE NOT USED QUANTITATIVELY BY CC&S BUT ARE USED TO REMAIN COMPATIBLE WITH PREVIOUSLY DESIGNED HARDWARE (MR 62)
3. COMMAND BIT NO. 14 (CC&S COMMAND BIT NO. 6) IS ADJUSTED IN QC'S TO GIVE AN ODD NUMBER OF *ONE* BITS IN COMMAND BIT NOS. 9-26 (CC&S BIT NOS. 1-8)
4. COMMAND BIT NO. 26 (CC&S COMMAND BIT NO. 18) MUST BE A *ONE* TO PRODUCE A cw (POSITIVE) SPACECRAFT ROTATION ABOUT THE SPECIFIED SPACECRAFT AXIS; A *ZERO* IN THIS BIT POSITION WILL RESULT IN A ccw (NEGATIVE) SPACECRAFT ROTATION ABOUT THE SPECIFIED SPACECRAFT AXIS. POLARITY BIT FOR MOTOR BURN COMMAND IS ALWAYS *ONE*
5. COMMAND BIT NOS. 15-25 (CC&S COMMAND BIT NOS. 7-17) ARE A PSEUDO-BINARY CODE REPRESENTATION OF THE TURN OR MOTOR BURN DURATION

Fig. 15. Command format


BEGIN TRAPPED RADIATION GATE
STEP PLASMA
MSB
1 PN SEQUENCE
2
DAS 3 S/N
PLASMA PROBE
4 TRAPPED
5 RADIATION
6 COSMIC RAY
7 ION CHAMBER
8 MAG X
READ PLASMA
READ COSMIC RAY
READ ION CHAMBER
READ MAG
STEP PLASMA
9 MAG Y
10 MAG Z
11
PLASMA PROBE
12 COSMIC DUST
13
14 MAG X
15 MAG Y
MAG Z
16 MAG X
READ PLASMA
READ MAG
READ MAG
UV CATHODE SELECT
STEP PLASMA
17 MAG Y
18 MAG Z
19
PLASMA PROBE
20 EVENTS
21 SCAN POSITION
22 COSMIC RAY
23 EVENTS
24 MAG X (UV)
READ PASMA
READ SCAN AND COSMIC RAY
READ MAG OR UV
MODE 3 DATA
STEP PLASMA
25 MAG Y (UV)
26 MAG Z (UV)
27 PLASMA (UV)
28 FRAME NO.
29 SCAN Y AXIS
30 COSMIC RAY
31 TV SIGNAL VOLT
32 MAG X
READ PLASMA OR UV
READ SCAN, TV, AND COSMIC RAY
READ MAG
MODE 3 DATA
STEP PLASMA
33 MAG Y
34 MAG Z
35
PLASMA PROBE
36 SCAN CALIBRATE ADC
37 SCAN TEMP AND PRESS
38 NRT EVENTS
39
TV GI VOLT
40 SCAN T/R VOLT
READ PLASMA AND SCAN
READ SCAN AND TV
READ SCAN
END TRAPPED RADIATION GATE
MODE 3 DATA
41 TV AND EVENTS
42 SCAN POSITION
READ SCAN

1. WORDS 24, 25, 26, AND 27 CONTAIN UV DATA WHEN NRT POWER IS ON.
2. FOR DETAILS OF WORDS MARKED ▨, SEE BELOW.
3. BITS MARKED ▧ ARE ALWAYS 0 BECAUSE THESE ARE UNIPOLAR ANALOG CONVERSIONS.
4. DAS WORD LENGTH IS 10 BITS.
5. SCIENCE DATA WORD LENGTH IS 1 TO 20 BITS.
6. DATA MODE 2 FORMAT IS 28 WORDS PER DATA FRAME.
7. DATA MODE 3 FORMAT IS 42 WORDS PER DATA FRAME.

WORD	BIT[a]	EVENT	WORD	BIT[a]	EVENT
2	1	PN SEQUENCE	20	1	MAG CAL 4
	2	PN SEQUENCE		2	MAG CAL 3
	3	PN SEQUENCE		3	MAG CAL 2
	4	PN SEQUENCE		4	MAG CAL 1
	5	PN SEQUENCE		5	NAMGA[bc]
	6	WAA[b]		6	SCAN PIV[bc]
	7	NAA[b]		7	NRT PWR ON
	8	DAS S/N		8	CR CAL
	9	DAS S/N		9	CD CAL/MAG IGNITION
	10	DAS S/N		10	CD READ
12	1	COSMIC DUST	41	1	TV SHUTTER TIME
	2	COSMIC DUST		2	TV AAC 3
	3	COSMIC DUST		3	TV AAC 2
	4	COSMIC DUST		4	TV AAC 1
	5	COSMIC DUST		5	TV PLANT IN VIEW[c]
	6	COSMIC DUST		6	TV FILTER POSITION
	7	COSMIC DUST		7	INHIBIT SCAN[c]
	8	COSMIC DUST		8	SHUTTER/END OF LOOP
	9	CALIBRATE		9	START-STOP TAPE
	10	FRAME COUNT MSB		10	CD READ

[a] BIT 1 IS MOST SIGNIFICANT BIT.
[b] IS ALWAYS ONE IF NRT POWER IS OFF.
[c] INDICATES THAT ZERO EQUALS OCCURRENCE OF EVENT.

Fig. 16. Data automation system real-time format

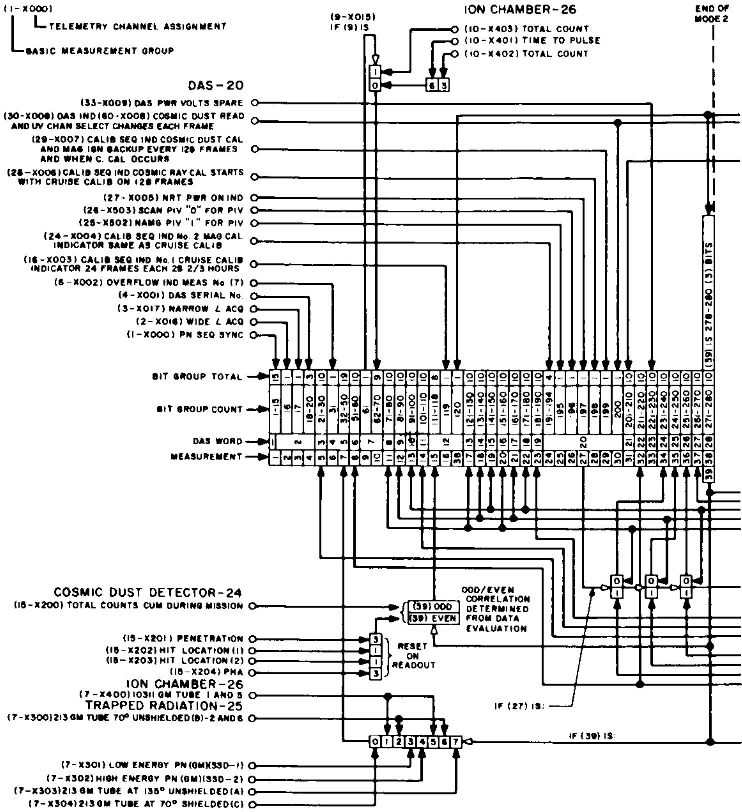
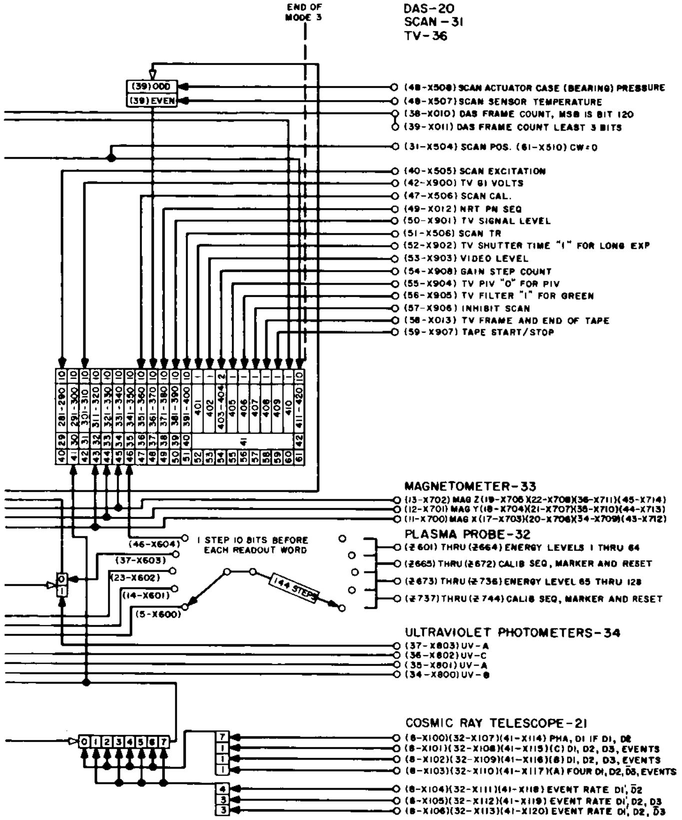
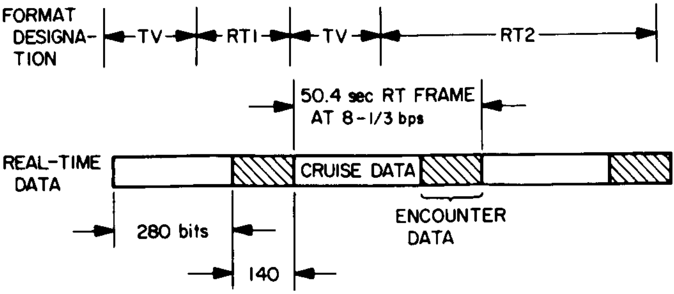


Fig. 17. Data automation system real-time science telemetry format


END OF MODE 3
DAS-20
SCAN-31
TV-36
(39) ODD
(39) EVEN
(48-X508) SCAN ACTUATOR CASE (BEARING) PRESSURE
(48-X507) SCAN SENSOR TEMPERATURE
(38-X010) DAS FRAME COUNT, MSB IS BIT 120
(39-X011) DAS FRAME COUNT LEAST 3 BITS
(31-X504) SCAN POS. (61-X510) CW=0
(40-X505) SCAN EXCITATION
(42-X900) TV 61 VOLTS
(47-X506) SCAN CAL.
(49-X012) NRT PN SEQ
(50-X901) TV SIGNAL LEVEL
(51-X506) SCAN TR
(52-X902) TV SHUTTER TIME "1" FOR LONG EXP
(53-X903) VIDEO LEVEL
(54-X908) GAIN STEP COUNT
(55-X904) TV PIV "0" FOR PIV
(56-X905) TV FILTER "1" FOR GREEN
(57-X906) INHIBIT SCAN
(58-X013) TV FRAME AND END OF TAPE
(59-X907) TAPE START/STOP
MAGNETOMETER-33
(13-X702) MAG Z (19-X706)(22-X708)(36-X711)(45-X714)
(12-X701) MAG Y (18-X704)(21-X707)(35-X710)(44-X713)
(11-X700) MAG X (17-X703)(20-X706)(34-X709)(43-X712)
(46-X604)
(37-X603)
(23-X602)
(14-X601)
(5-X600)
1 STEP 10 BITS BEFORE EACH READOUT WORD
144 STEPS
PLASMA PROBE-32
(Z601) THRU (Z664) ENERGY LEVELS 1 THRU 64
(Z665) THRU (Z672) CALIB SEQ, MARKER AND RESET
(Z673) THRU (Z736) ENERGY LEVEL 65 THRU 128
(Z737) THRU (Z744) CALIB SEQ, MARKER AND RESET
ULTRAVIOLET PHOTOMETERS-34
(37-X803) UV-A
(36-X802) UV-C
(35-X801) UV-A
(34-X800) UV-B
COSMIC RAY TELESCOPE-21
(8-X100)(32-X107)(41-X114) PHA, D1 IF D1, D2
(8-X101)(32-X108)(41-X115)(C) D1, D2, D3, EVENTS
(8-X102)(32-X109)(41-X116)(B) D1, D2, D3, EVENTS
(8-X103)(32-X110)(41-X117)(A) FOUR D1, D2, D̄3, EVENTS
(8-X104)(32-X111)(41-X118) EVENT RATE D1', D̄2
(8-X105)(32-X112)(41-X119) EVENT RATE D1', D2, D3
(8-X106)(32-X113)(41-X120) EVENT RATE D1', D2, D̄3



During the 24 sec of each TV block, the buffers A and B are alternately loaded and dumped into the tape machine. Every 120 msec, the following data are loaded into one of the buffers:

31 bits	PN sequence
4 bits	NRT frame count
3 bits	Subframe count
9 bits	Line number
3 bits	TV AAC 1, 2, 3, or filter position, shutter time and ZERO (sub-commutated every other line)
1 bit	Real-time data
10 bits	TV performance data: signal level and G1 voltage (sub-commutated every other line)
1200 bits	TV picture data, 200 elements
1261 bits	Total load

Total number of bits for 24 sec:
1261 × 200 = 252,200 bits/block
or 504,400 bits/NRT frame

Fig. 18. Data automation system encounter timing

During the 24 sec of the RT1 block, only buffer A is loaded as follows:

80 bits	Tape servo bits
31 bits	PN sequence
4 bits	NRT frame count
3 bits	Subframe count
9 bits	Line number
3 bits	Spare
200 bits	Real-time data
330 bits	Total/NRT frame

During the 72 sec of the RT2 block, only buffer B is loaded as follows:

80 bits	Tape servo bits
31 bits	PN sequence
4 bits	NRT frame count
3 bits	Subframe count
9 bits	Line number
3 bits	Spare
600 bits	Real-time data
730 bits	Total/NRT frame

The total number of bits recorded on the tape machine is variable, depending on the accuracy and stability of the 10.7-kc bit synchronization clock; at 10.7 kc, 1284 bits are recorded on the tape machine each time a buffer is read out. The nominal total number of bits recorded on the tape machine during each 144 sec frame is then:

2 TV Blocks	513,600 of which 504,400 are significant
RT1 Block	1,284 of which 330 are significant
RT2 Block	1,284 of which 730 are significant
	516,168 total bits recorded

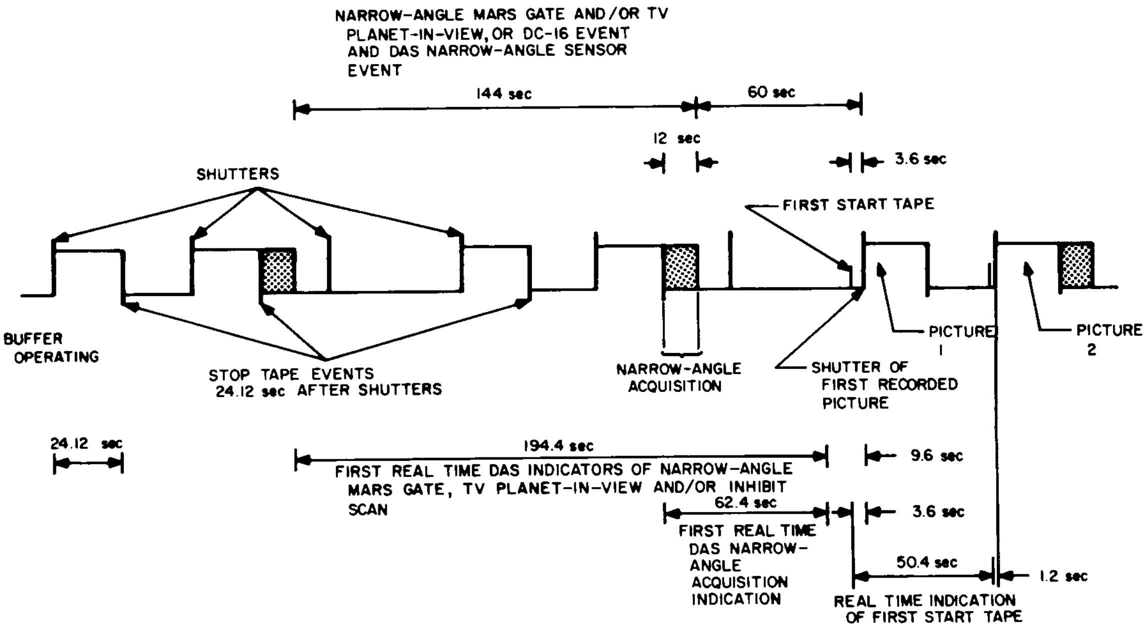


Fig. 19. Data automation system non-real-time sequencing at narrow-angle acquisition

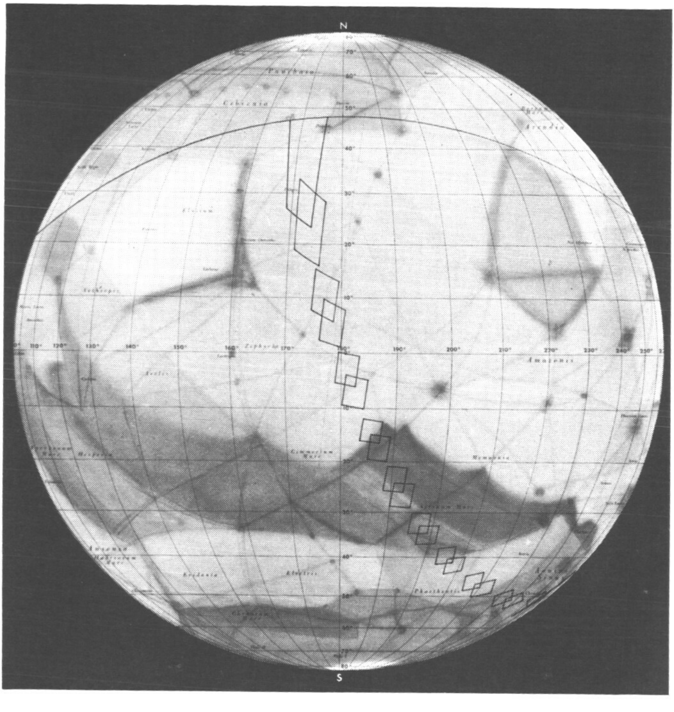
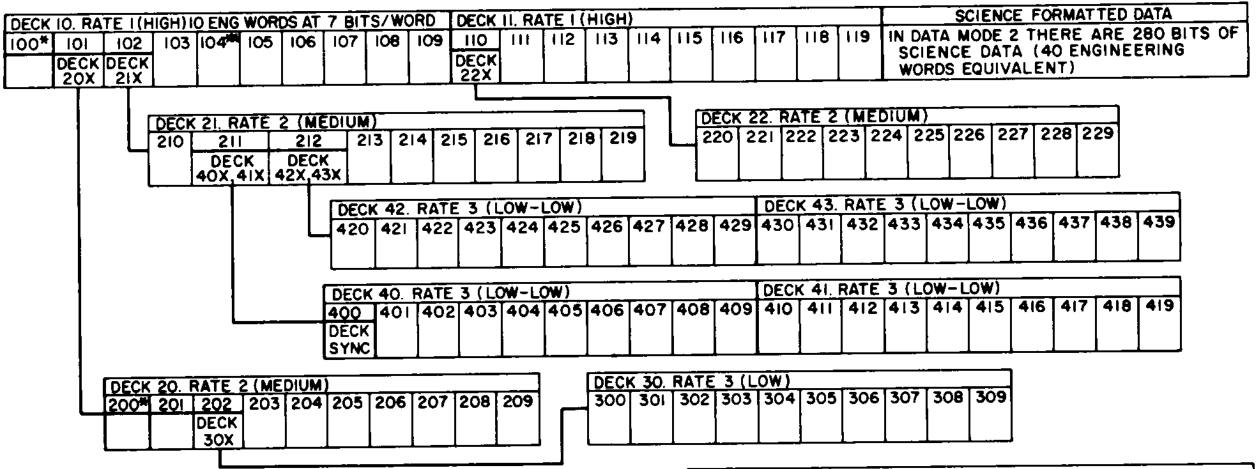


Fig. 20. Locations of photographed portions of Martian surface



MODE	PHASE	TELEMETRY
1	MIDCOURSE	ENGINEERING ONLY
2	LAUNCH AND CRUISE	ENGINEERING AND REAL TIME SCIENCE
3	ENCOUNTER	REAL TIME SCIENCE ONLY
4	POST-ENCOUNTER	ENGINEERING AND NON-REAL TIME SCIENCE

DECK RATE		TIME BETWEEN SAMPLES			
		DATA MODE 1		DATA MODE 2	
		33-1/3 bps	8-1/3 bps	33-1/3 bps	8-1/3 bps
1	HIGH	4.20 sec	16.8 sec	12.6 sec	50.4 sec
2	MED	42.0 sec	168 sec (2.8 min)	126 sec (2.1 min)	504 sec (8.4 min)
3	LOW	420 sec (7 min)	1680 sec (28 min)	1260 sec (21 min)	5040 sec (1.4 hr)
	LOW-LOW	840 sec (14 min)	3360 sec (56 min)	2520 sec (42 min)	10,080 sec (2.8 hr)

* DECK SYNC WORD (7 LOGIC ONES)

** COMMAND DETECTOR MONITOR
DN ≤ 31 = IN LOCK
DN ≥ 32 = OUT OF LOCK

NOTE: FOR CHANNEL ASSIGNMENTS, SEE TABLE 19.

Fig. 21. Data encoder telemetry commutation

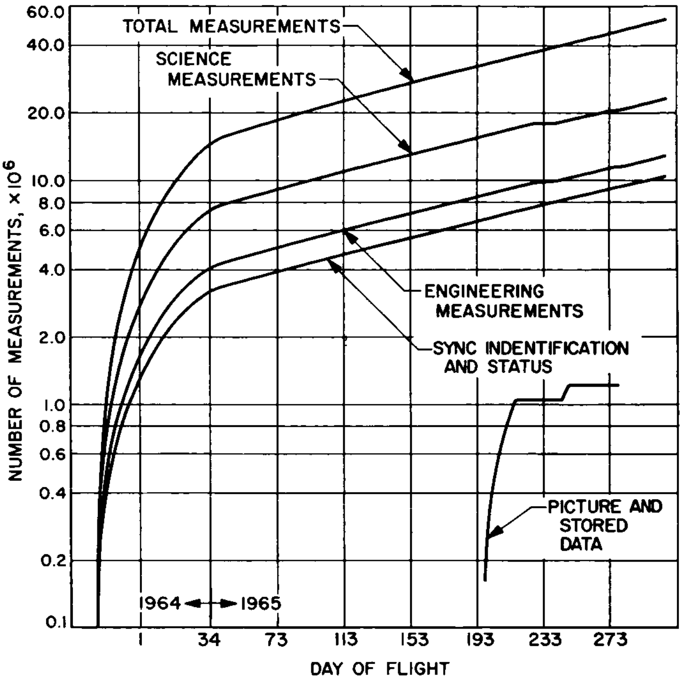


Fig. 22. Quantity of telemetry measurements vs time

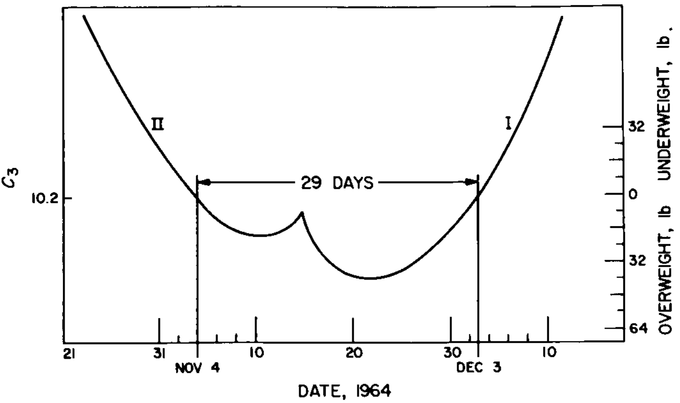


Fig. 23. C_3 vs launch period

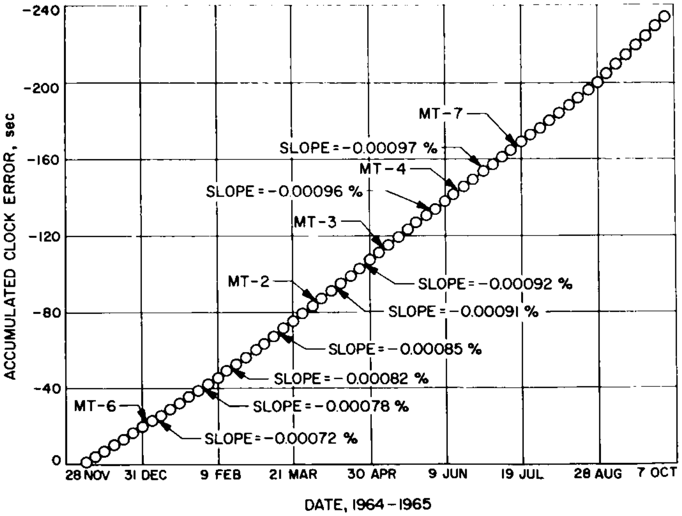


Fig. 24. Central computer and sequencer clock frequency error vs time error

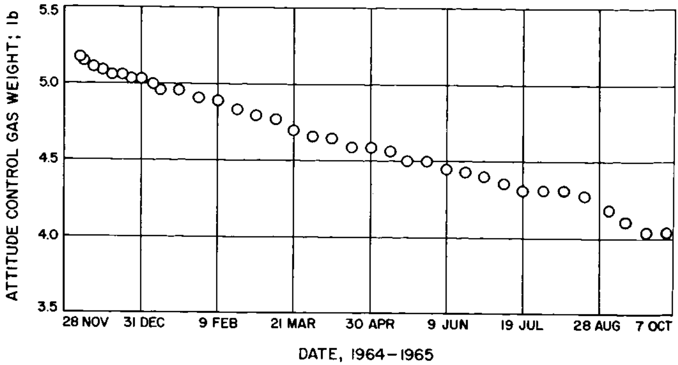


Fig. 25. Attitude control gas weight vs time

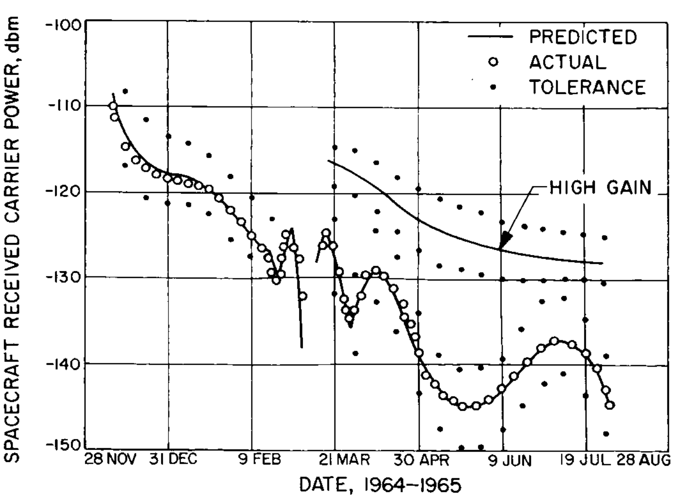


Fig. 26. Received carrier power vs time, showing interferometer effect

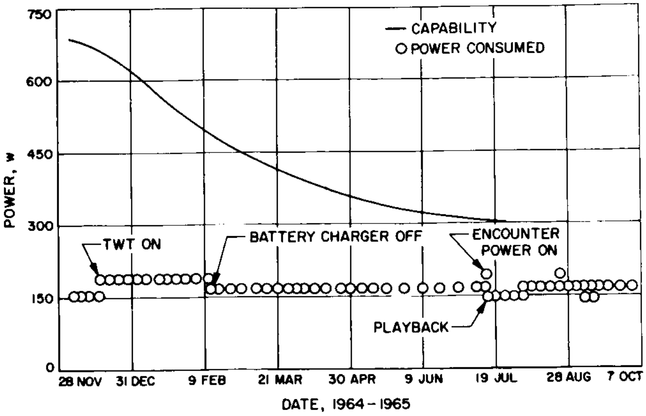


Fig. 27. Solar panel power capability vs time

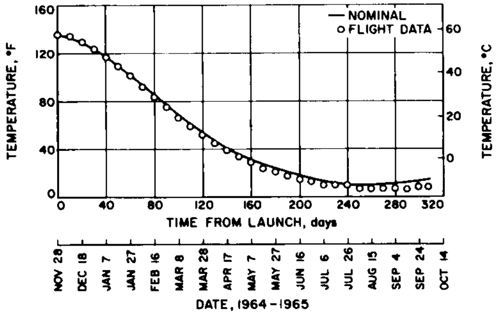


Fig. 28. Solar panel temperature vs time

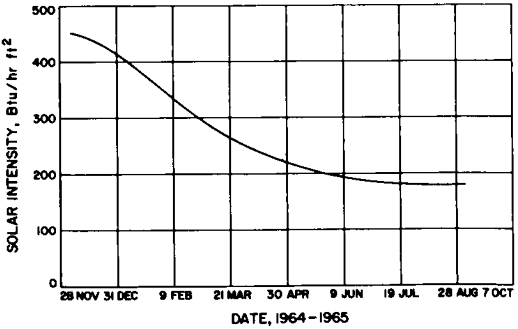


Fig. 29. Solar intensity vs time

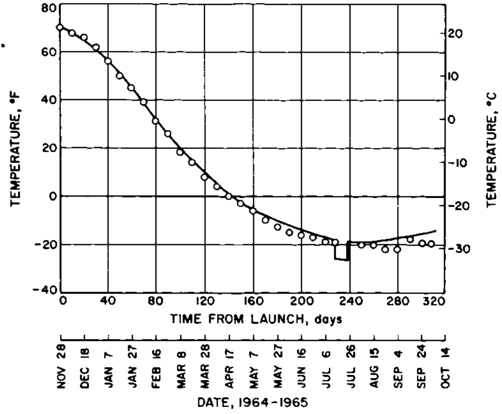


Fig. 30. Ionization chamber temperature vs time

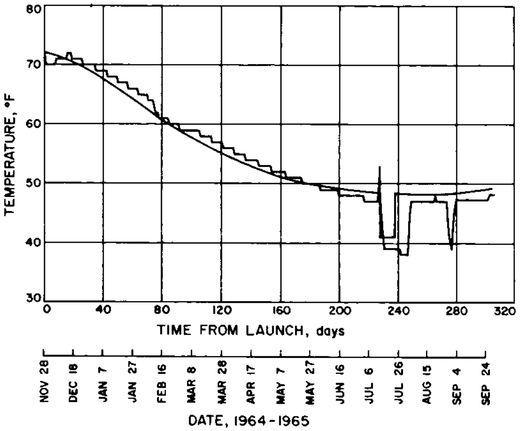


Fig. 31. Propulsion-system nitrogen temperature vs time

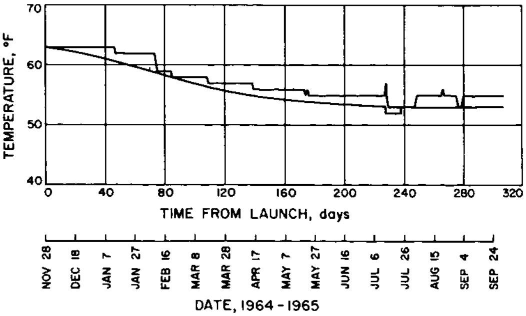


Fig. 32. Lower ring temperature vs time

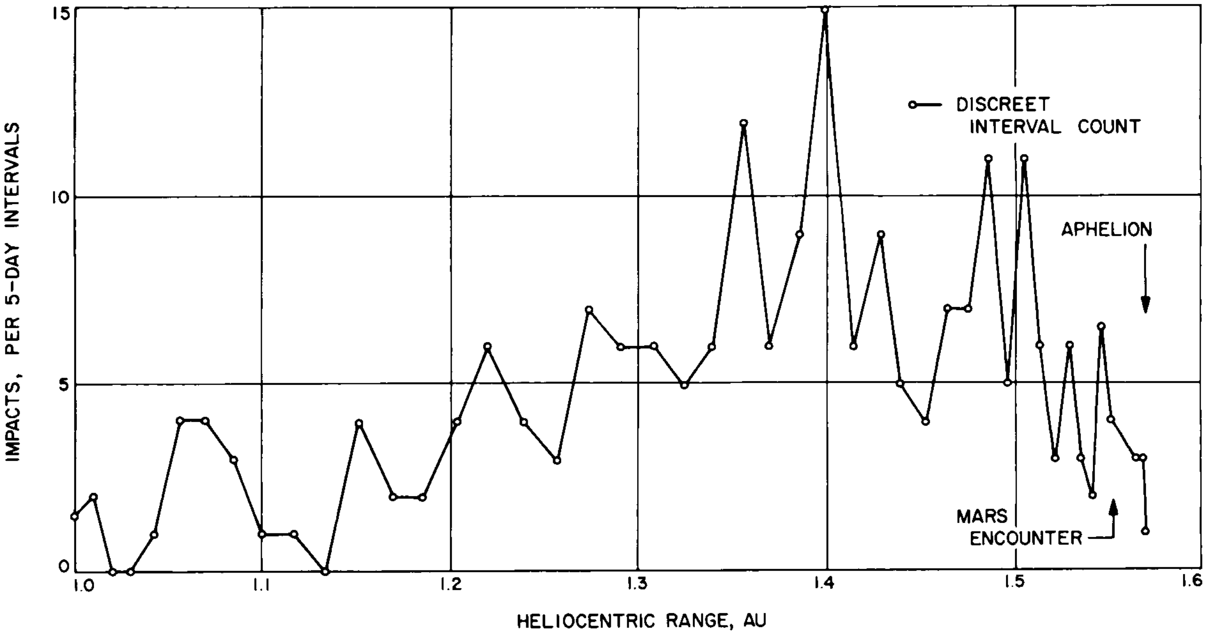


Fig. 33. Cosmic dust impacts vs range

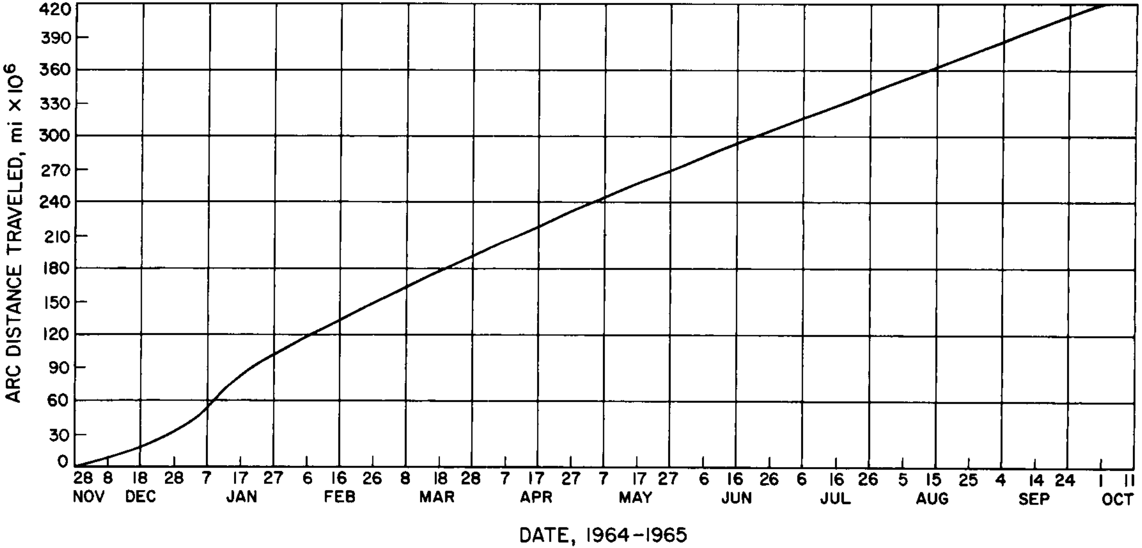


Fig. 34. Distance traveled along heliocentric arc vs time

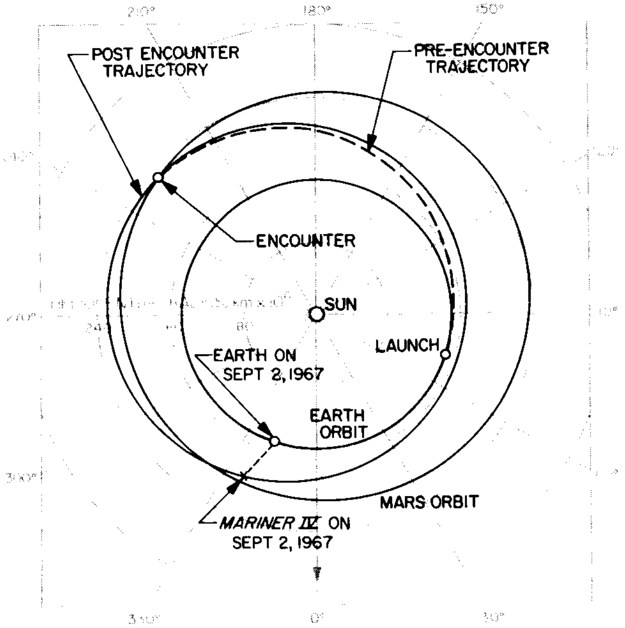


Fig. 35. Pre- and post-encounter trajectory, ecliptic view

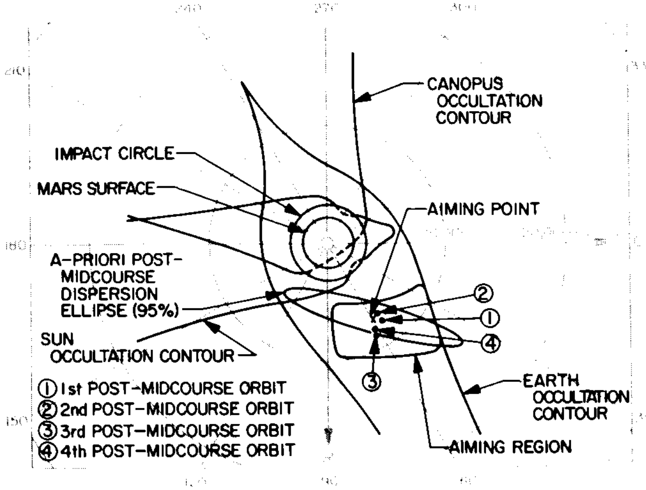


Fig. 36. Aiming zones: (a) Aiming point diagram, (b) Trajectories at Mars

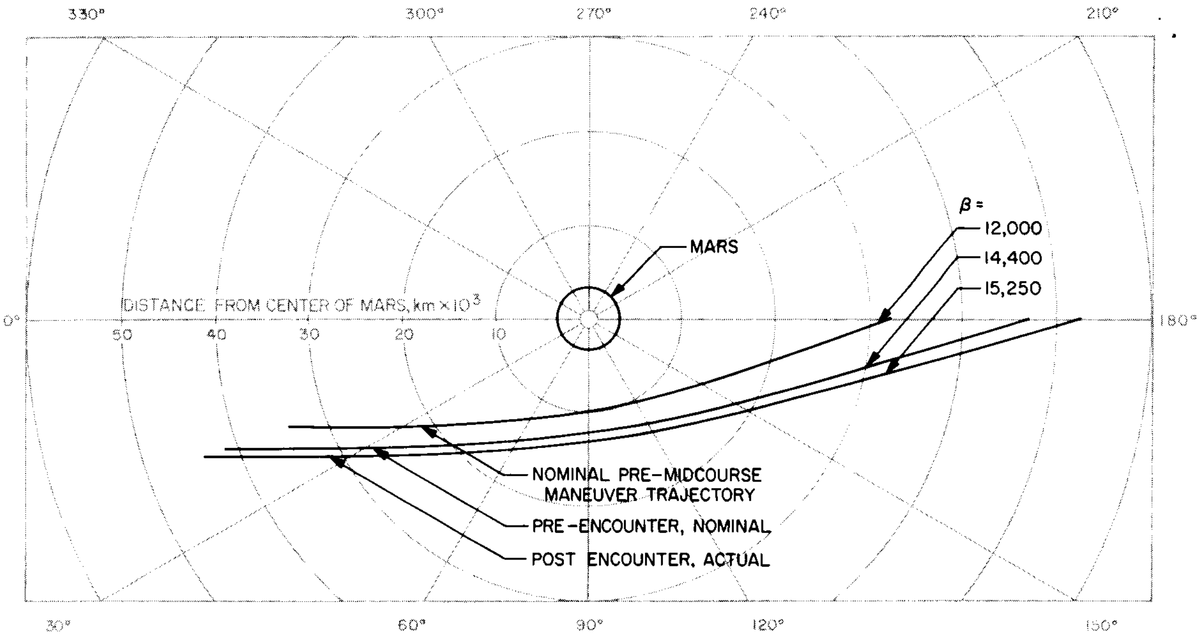


Fig. 37. Near-Mars trajectory parameters

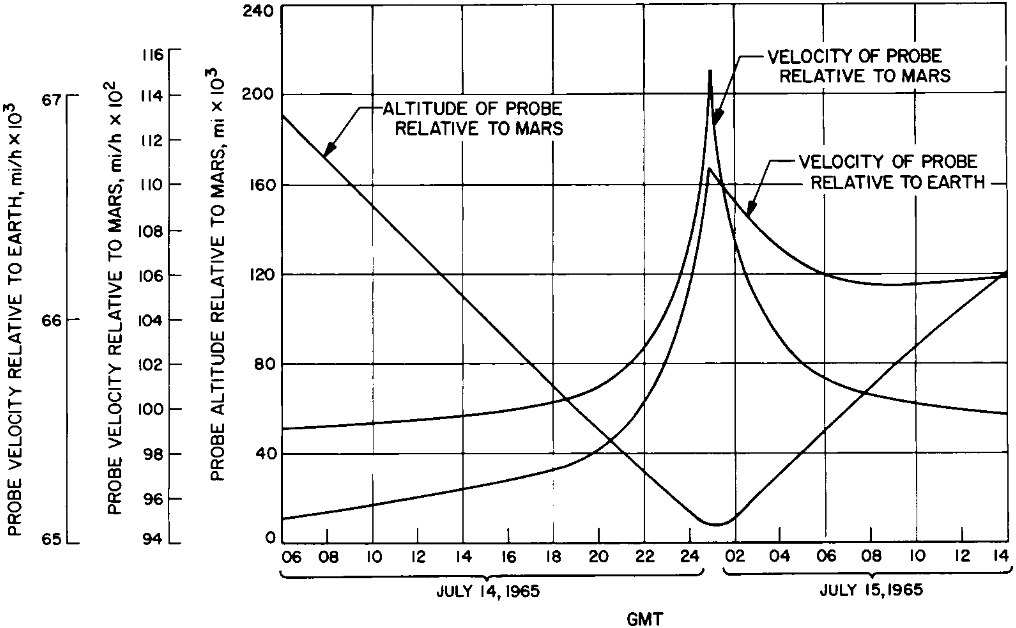


Fig. 38. Encounter velocities and attitudes

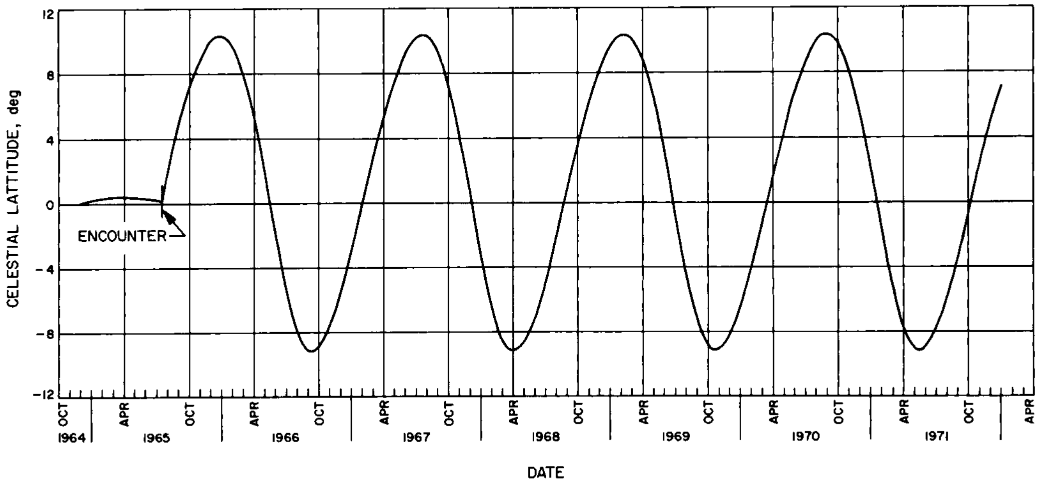


Fig. 39. Spacecraft celestial latitude, 1965—1967

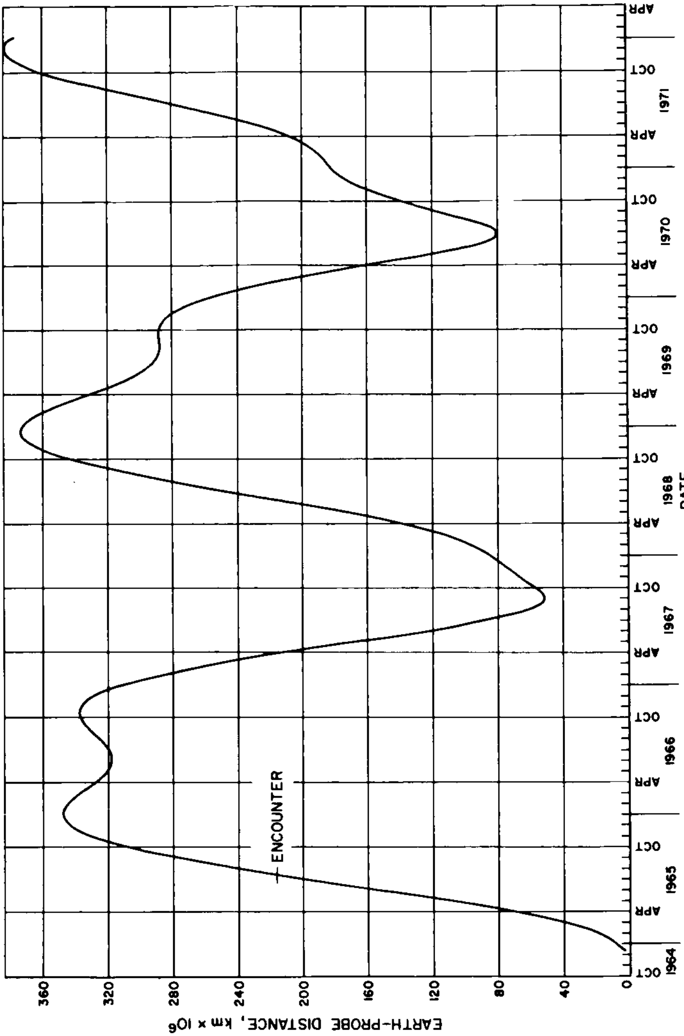


Fig. 40. Spacecraft distance from Earth, 1965–1971

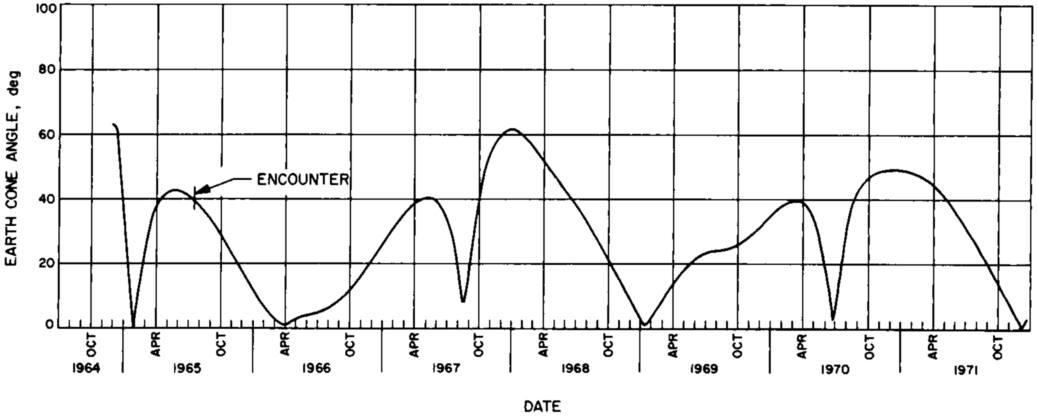


Fig. 41. Earth cone angle, 1965–1971

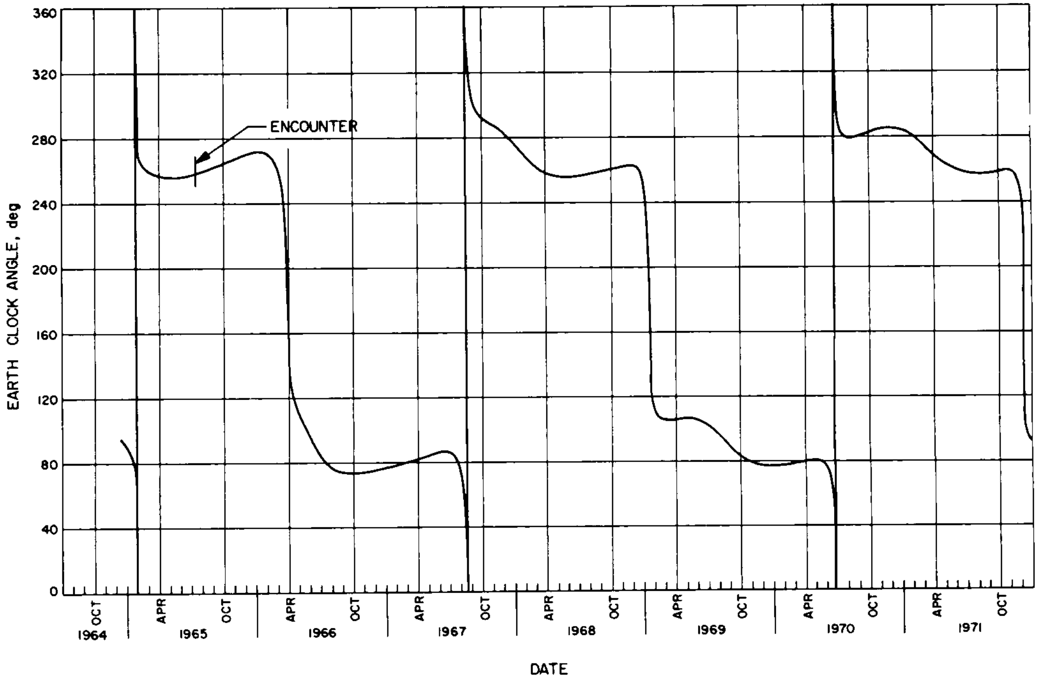


Fig. 42. Earth clock angle, 1965–1971

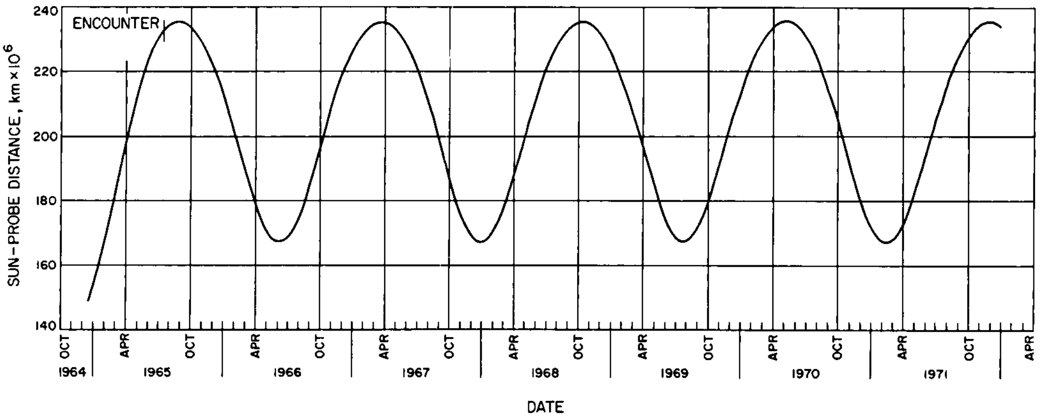


Fig. 43. Spacecraft distance from Sun, 1965–1971

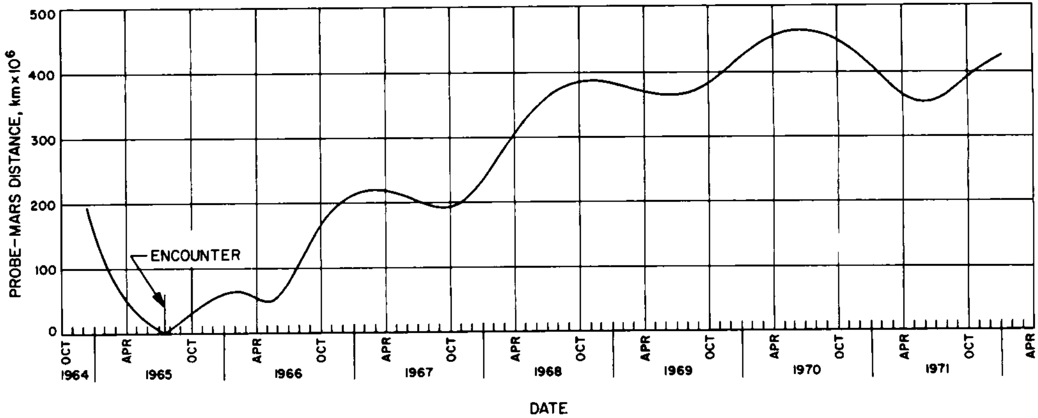


Fig. 44. Spacecraft distance from Mars, 1965–1971

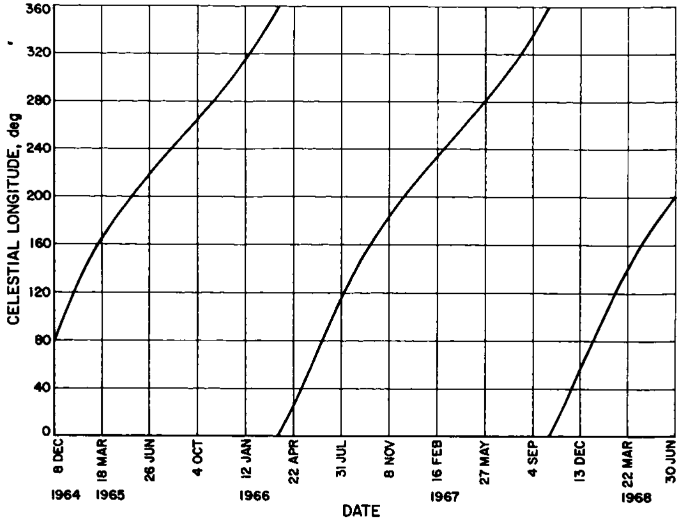


Fig. 45. Spacecraft celestial longitude, 1965–1968

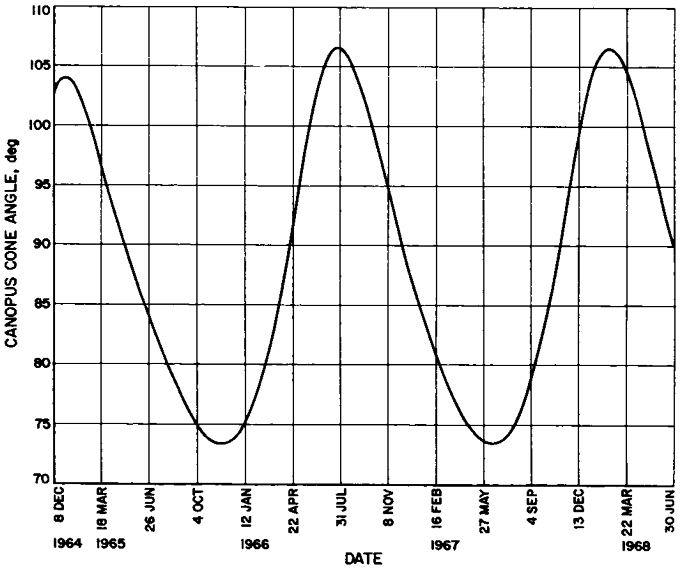


Fig. 46. Canopus cone angle, 1965–1968