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APOLLO 16 PHOTOGRAPH EVALUATION (APE) DATA BOOK

Mathematical Physics Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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PROJECT APOLLO

APOLLO 16 PHOTOGRAPH EVALUATION (APE) DATA BOOK

By H. H. Cunningham
TRW Systems Group

January 24, 1973

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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By H. H. Cunningham

Mission Design Section
TRW Systems Group

1.0 INTRODUCTION

This is a catalog of the Apollo 16 photographic evaluation data available at the National Aeronautics and Space Administration, Manned Spacecraft Center. Section 2 provides explanation and definition of all the photographic evaluation data elements. Sections 3 and 4 present data summaries for all of the lightside sequences of Apollo 16 3-inch mapping camera photography and Apollo 16 24-inch panoramic camera photography respectively. Each data summary includes a brief description of the trajectory reconstruction, telemetered data used, and the constants employed for the data processing. They also contain a brief resume of the apparent data trends throughout the sequence and the data for the first and last frame of the sequence.

2.0 EXPLANATION OF APOLLO PHOTOGRAPH EVALUATION (APE) DATA

The first and last frame figures appearing in the data book are typical Apollo 16 photo evaluation data groups. The microfilm of data for each Apollo 16 mapping camera photo sequence also contains two frames that contain stellar camera star pattern definitions. These star patterns are companion to identified map camera photos of the sequence.

GMT - Sidereal time of film exposure (year, month, day, hour, minute, second) - (UT1 - USNO).

CTE - Central clock time of film exposure which is recorded on the film (hour, minute, second).

1950 state vector - Mean of 1950 moon centered, inertial, cartesian coordinates of the spacecraft position (km) and velocity (km/sec).

Selenographic state vector - Selenographic, instantaneous inertial cartesian coordinates of vehicle position (km) and velocity (km/sec).

Nadir Point (Longitude, Latitude) - Intersection with the mean lunar surface, of the vector from the moon's center of mass to the spacecraft.

Camera Axis Intersect (Longitude, Latitude) - Position of principal intersection point - Intersection of camera optical axis direction with mean lunar surface.

Spacecraft radius - Vector from moon center of mass to spacecraft.

Spacecraft altitude - Height of spacecraft above mean lunar surface.

Scale Factor - Proportionality constant relating dimensions on the film to dimensions on the mean lunar surface.

Azimuth of Velocity Vector - Angle, measured positive clockwise in the local horizontal plane at nadir, between North and the projection of the vehicle velocity vector onto the local horizontal plane.

Mean altitude rate - Rate of change in spacecraft altitude above the mean lunar surface.

Horizontal velocity - Component of spacecraft velocity parallel to the lunar local horizontal plane at the nadir point.

Tilt azimuth - Angle, measured positive clockwise in the local horizontal plane at the principal intersection point, between North and the projection of a vector along the camera optical axis onto that local horizontal plane.

Tilt - Angle between the camera optical axis direction and the lunar local vertical at the principal intersection point.

Sun Elevation at Prin Grnd Pnt - Angle between the vector from the sun to the principal intersection point and the lunar local horizontal plane at that point.

Sun Azimuth at Principal Grnd Pnt - Angle, measured positive clockwise in the lunar local horizontal plane, from North to the projection of the vector from the sun to the principal intersection point onto that plane.

Subsolar Point (longitude, latitude) - Intersection with the mean lunar surface, of a vector from the moon's center of mass to the sun's center.

Alpha - Angle between the camera optical axis and the projection of the lunar local vertical at the principal intersection point onto the plane of the phase angle (measure of surface tilt toward or away from the sun).

Swing - Angle between the camera Y axis and the projection of the line between the vehicle nadir and principal intersection point onto the camera X-Y plane.

Emission Angle - Angle between the camera optical axis and the lunar local vertical at the principal intersection point.

Phase Angle - Angle between the camera optical axis and the vector from the sun to the principal intersection point.

North Deviation Angle - Angle, measured positive clockwise in the camera X-Y plane, from the camera X axis to lunar North.

Phi, Kappa, Omega - Angles which rotate the camera axes coordinate system into the nadir point centered lunar local horizontal system, where:

ϕ - primary right-handed rotation about the camera Y axis.

ω - secondary right-handed rotation about the intermediate X-axis.

κ - final right-handed rotation about the local vertical (local horizontal Z-axis).

X-tilt - (Lateral tilt) Angle from the local horizontal plane at the nadir point to the camera Y-axis.

Y-tilt - (Longitudinal tilt) Angle from the local horizontal plane at the nadir point to the camera X-axis.

Heading - Angle, measured positive clockwise in the lunar local horizontal plane at the nadir point, from North to the projection of the camera X-axis onto that plane.

Laser slant range - Telemetered laser altimeter readout.

Spacecraft altitude (Laser) - Vertical component of laser altimeter slant range based on the assumption that the laser altimeter was aligned along the 3-inch mapping camera optical axis.

Selenographic direction Cosines - Direction definition of vector from the spacecraft to the principal intersection point in the instantaneous inertial selenographic coordinate system.

Coordinate Transformation Matrices - Selenocentric coordinate system to camera axes coordinate system and local horizontal coordinate system to the camera axes coordinate system.

Photograph Footprint - Latitudes and Longitudes of field of view corner point projections onto the lunar surface (full field of view only for mapping camera, full field of view and inner field of view for panoramic camera).

Sigmas - First order uncertainties in selected camera aiming parameters arising from uncertainties in camera mounting angles, vehicle attitude measurements and film exposure times.

The following data group is substituted when vehicle attitude is unavailable for the APE computations.

IFRAME - Photograph frame number which corresponds to page number of the standard printout.

GMT - Sidereal time of film exposure (year, month, day, hour, minute, second) - (UT1-USNO).

CTE - Central clock time of film exposure which is recorded on the film (hour, minute, second).

1950 state vector - Mean of 1950 moon cnetered, inertial, cartesian coordinates of the spacecraft position (er) and velocity (er/min).

Selenographic state vector - Selenographic, instantaneous inertial cartesian coordinates of vehicle position (er) and velocity (km/sec).

Note: 6378.16 km/er should be used for conversion of these state vectors to the standard APE units of km and km/sec.

3.0 APOLLO 16 3-INCH MAPPING CAMERA DATA

Mission: Apollo 16, Target: Vertical strip photography

Rev: 3/4, Camera: 3 Inch Mapping Frames: 1 Through: 26

Coverage Interval:

From: 8.9 Deg N Lat., 165.1 Deg W Long., To: 7.3 Deg N Lat., 167.8 Deg. E Long.

From: 80 Hr 37 Min 19.713 Sec, To: 80 Hr 46 Min 10.164 Sec. CTE

Date Processed: 8/15/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.709933

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable ($1x10^{-14}$ - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 97 H, 33 M, 25.0508 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 3. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5499597.68	$\dot{X}$ =	1550.9475
Y =	1526310.53	$\dot{Y}$ =	-5313.7704
Z =	-896763.06	$\dot{Z}$ =	135.0770

● Telemetered Data Tape

Data Source: Station Tapes

Bit Rate: High

Date Edited: 7/18/72

Edited Data Tape No. A10084 File No.: 1 Location: Bldg. 12 Library at MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644766
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a short sequence of vertical photography beginning at 165.1 deg W Long. and ending at 167.8 deg E Long. Throughout the sequence, tilt is maintained at 0.8±0.15 deg. Star patterns companion to frames 5 and 20 are included in data for this sequence.

APOLLO 16 REVS 3/4 MAP 8/72F PAGE - 1

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	20	2	31	19.086
CTE			3	8	37	19.713

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-962.2854286	1302.6090617	878.9333104	1.3681973	.8143821	.2577884
SELENOGRAPHIC	-1758.7891498	-469.3699571	285.7620473	-.4069953	1.5601298	-.0445718

LONGITUDE OF NADIR POINT	-165.0576477 DEG	LATITUDE OF NADIR POINT	8.9216267 DEG
-165 DEG, 3 MIN, 27.5317383 SEC			8 DEG, 55 MIN, 17.8560734 SEC
LONG OF CAMERA AXIS INTERSECT	-165.0930206 DEG	LATI OF CAMERA AXIS INTERSECT	8.9382163 DEG
-165 DEG, 5 MIN, 37.7540588 SEC			8 DEG, 56 MIN, 17.5749207 SEC
SPACECRAFT RADIUS	1842.6359863 KM	SPACECRAFT ALTITUDE	104.5459899 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	268.4854305 DEG
MEAN ALTITUDE RATE	-.0158447 KM/SEC	HORIZONTAL VELOCITY	1.4128519 KM/SEC
TILT AZIMUTH	299.9046135 DEG	TILT ANGLE	.6549395 DEG
SIGMA TILT AZIMUTH	.0174874 DEG	SIGMA TILT ANGLE	.0002001 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.1929264 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.8907433 DEG
LONGITUDE OF SUBSOLAR POINT	102.4452867 DEG	LATITUDE OF SUBSOLAR POINT	1.5256268 DEG
102 DEG, 26 MIN, 43.0321741 SEC			1 DEG, 31 MIN, 32.2566032 SEC
ALPHA	-.6390054 DEG	SWING ANGLE	296.6135305 DEG
EMISSION ANGLE	.6942887 DEG	SIGMA SWING ANGLE	.0174873 DEG
PHASE ANGLE	92.8319559 DEG	NORTH DEVIATION ANGLE	181.7104752 DEG
PHI	.5855146 DEG	X-TILT	.2933691 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	178.2924538 DEG	Y-TILT	-.5855049 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2933691 DEG	HEADING	-91.7105447 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	97.5539999 KM	LASER SLANT RANGE	97.5476265 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.95248203	.26491964	-.15031821	104.553230

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.83734070+00	.52073221+00	.16642886+00
-.12802211+00	.48275058+00	-.86634994+00
-.53147986+00	.70412350+00	.47089195+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99950221+00	-.29848644-01	.10218845-01
.29797493-01	-.99954284+00	-.51202352-02
.10366920-01	-.48131791-02	.99993467+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
11.691	-162.439
6.361	-162.341
6.144	-167.734
11.475	-167.964

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION	-5 HR, 20 MIN, 58.3 SEC	DECLINATION	65 DEG, 32 MIN, 25.4 SEC

Figure 1(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	20	2	40	9.537
CTE			3	8	46	10.164

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-158.3662025	1576.9209158	914.9188161	1.6072357	.1984819	-.1259581
SELENOGRAPHIC	-1774.7055689	381.4571826	231.8327641	.3509528	1.5783427	-.1553498

LONGITUDE OF NADIR POINT	167.8693447 DEG	LATITUDE OF NADIR POINT	7.2781181 DEG
	167 DEG, 52 MIN, 9.6409607 SEC		7 DEG, 16 MIN, 41.2250662 SEC
LONG OF CAMERA AXIS INTERSECT	167.8293438 DEG	LATI OF CAMERA AXIS INTERSECT	7.2867640 DEG
	167 DEG, 49 MIN, 45.6376648 SEC		7 DEG, 17 MIN, 12.3502779 SEC
SPACECRAFT RADIUS	1829.9824778 KM	SPACECRAFT ALTITUDE	91.8924814 KM
SCALE FACTOR	.0008207 M/KM	AZIMUTH OF VELOCITY VECTOR	264.4066220 DEG
MEAN ALTITUDE RATE	-.0310289 KM/SEC	HORIZONTAL VELOCITY	1.6240099 KM/SEC
TILT AZIMUTH	282.2956276 DEG	TILT ANGLE	.7670238 DEG
SIGMA TILT AZIMUTH	.0149246 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	24.5332365 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	268.3463974 DEG
LONGITUDE OF SUBSOLAR POINT	102.3703576 DEG	LATITUDE OF SUBSOLAR POINT	1.5256887 DEG
	102 DEG, 22 MIN, 13.2873058 SEC		1 DEG, 31 MIN, 32.4794054 SEC
ALPHA	-.7850340 DEG	SWING ANGLE	287.7188858 DEG
EMISSION ANGLE	.8085634 DEG	SIGMA SWING ANGLE	.0149245 DEG
PHASE ANGLE	66.2516479 DEG	NORTH DEVIATION ANGLE	185.9244063 DEG
PHI	.7315326 DEG	X-TILT	.2337199 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	174.5781574 DEG	Y-TILT	-.7315264 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2337199 DEG	HEADING	-95.4248277 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.97281207	-.19570270	-.12384316	91.901173

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.98674386+00	.14993726+00	-.62091386-01
-.12807261+00	.48448739+00	-.86537239+00
-.99669005-01	.86185315+00	.49726784+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99543993+00	-.94531999-01	.12767200-01
.94487049-01	-.99551773+00	-.40791708-02
.13095511-01	-.28642366-02	.99991021+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
9.833	169.967
5.187	170.372
4.694	165.682
9.433	165.185

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 54 MIN, 47.8 SEC DECLINATION 65 DEG, 51 MIN, 30.1 SEC

Figure 1(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 17, Camera: 3-Inch Mapping Frames: 27 Through: 176

Coverage Interval:

From: 9.0 Deg N Lat., 179.2 Deg W Long., To: 8.8 Deg S Lat., 3.4 Deg W Long.

From: 105 Hr 29 Min 13.306 Sec, To: 106 Hr 30 Min 23.518 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziel1)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710000

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 124 H, 18 M, 14.404 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 17. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5768436.96	$\dot{X}$ =	1386.1866
Y =	1600918.51	$\dot{Y}$ =	-5162.0522
Z =	-968674.79	$\dot{Z}$ =	-38.4413

- Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/18/72

Edited Data Tape No. AT0084 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical photography starting at 179.2 deg W Long. and ending at 3.4 deg W Long. Throughout the sequence tilt is maintained in the range 0.02 - 0.808 deg. Star patterns companion to frames 32 and 170 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	3	23	12.676
CTE			4	9	29	13.306

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-954.8898561	1316.8619101	888.7441642	1.3698990	.8355799	.2582159
SELENOGRAPHIC	-1829.8981794	-26.5779198	289.7211109	-.0432496	1.6238561	-.0520885

LONGITUDE OF NADIR POINT	-179.1678791 DEG	LATITUDE OF NADIR POINT	8.9958203 DEG
	-179 DEG, 10 MIN, 4.3647766 SEC		8 DEG, 59 MIN, 44.9530220 SEC
LONG OF CAMERA AXIS INTERSECT	-179.1517735 DEG	LATI OF CAMERA AXIS INTERSECT	9.0180361 DEG
	-179 DEG, 9 MIN, 6.3844299 SEC		9 DEG, 1 MIN, 4.9300575 SEC
SPACECRAFT RADIUS	1852.8820955 KM	SPACECRAFT ALTITUDE	114.7920991 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	268.0776134 DEG
MEAN ALTITUDE RATE	.0112755 KM/SEC	HORIZONTAL VELOCITY	1.6251982 KM/SEC
TILT AZIMUTH	35.6019816 DEG	TILT ANGLE	.4137304 DEG
SIGMA TILT AZIMUTH	.0277091 DEG	SIGMA TILT ANGLE	.0001999 DEG
SUN ELEVATION AT PRIN GRND PNT	-.7900076 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.6811371 DEG
LONGITUDE OF SUBSOLAR POINT	89.8041269 DEG	LATITUDE OF SUBSOLAR POINT	1.5363193 DEG
	89 DEG, 48 MIN, 14.8569202 SEC		1 DEG, 32 MIN, 10.7494354 SEC
ALPHA	.2461420 DEG	SWING ANGLE	37.3190869 DEG
EMISSION ANGLE	.4409940 DEG	SIGMA SWING ANGLE	.0277092 DEG
PHASE ANGLE	90.5438814 DEG	NORTH DEVIATION ANGLE	181.7170065 DEG
PHI	-.2507905 DEG	X-TILT	.3289776 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	178.2815666 DEG	Y-TILT	.2507864 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.3289776 DEG	HEADING	-91.7169933 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	111.6210003 KM	LASER SLANT RANGE	111.6180897 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.98854869	.01015445	-.15056022	114.795289

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.6491940*00	.5043435*00	.1565472*00
-.1277971*00	.4839036*00	-.8657396*00
-.5123839*00	.7151747*00	.4753817*00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.9995419*00	-.2996241*-01	-.4377034*-02
.2998731*-01	-.9996337*00	-.6741709*-02
-.4203044*-02	-.5870321*-02	.9999739*00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
12.091	-176.180
6.131	-176.080
5.978	177.980
11.888	177.721

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -5 HR, 20 MIN, 1.3 SEC DECLINATION 65 DEG, 31 MIN, 26.7 SEC

Figure 2(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	4	24	22.888
CTE			4	10	30	23.518

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	848.8461987	-1366.9112871	-901.2306427	-1.4379982	+.7478386	-.1979633
SELENOGRAPHIC	1818.9706193	-108.9905780	-284.0245541	-.0972906	-1.6283770	.0722074

LONGITUDE OF NADIR POINT	-3.4289959 DEG	LATITUDE OF NADIR POINT	-8.8591925 DEG
-3 DEG, 25 MIN,	44.3851519 SEC	-8 DEG, 51 MIN,	33.0929661 SEC
LONG OF CAMERA AXIS INTERSECT	-3.4182429 DEG	LATI OF CAMERA AXIS INTERSECT	-8.8445922 DEG
-3 DEG, 25 MIN,	5.6743383 SEC	-8 DEG, 50 MIN,	40.5319691 SEC
SPACECRAFT RADIUS	1844.2350737 KM	SPACECRAFT ALTITUDE	106.1450774 KM
SCALE FACTOR	.0007136 M/KM	AZIMUTH OF VELOCITY VECTOR	272.5058106 DEG
MEAN ALTITUDE RATE	-.0108443 KM/SEC	HORIZONTAL VELOCITY	1.6328124 KM/SEC
TILT AZIMUTH	36.0450106 DEG	TILT ANGLE	.2956738 DEG
SIGMA TILT AZIMUTH	.0386870 DEG	SIGMA TILT ANGLE	.0002004 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.9075890 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.8966795 DEG
LONGITUDE OF SUBSOLAR POINT	89.2859498 DEG	LATITUDE OF SUBSOLAR POINT	1.5367645 DEG
89 DEG, 17 MIN,	9.4193029 SEC	1 DEG, 32 MIN,	12.3522377 SEC
ALPHA	-.1893841 DEG	SWING ANGLE	33.5649007 DEG
EMISSION ANGLE	.3137094 DEG	SIGMA SWING ANGLE	.0386874 DEG
PHASE ANGLE	93.0970001 DEG	NORTH DEVIATION ANGLE	177.5202701 DEG
PHI	-.1634597 DEG	X-TILT	.2463521 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-177.5209846 DEG	Y-TILT	.1634582 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2463521 DEG	HEADING	-87.5202816 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.98546471	.06208963	.15812708	106.146577

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.87898552+00	-.46058282+00	-.12348257+00
-.13551971+00	.48956311+00	-.86137238+00
.45718575+00	-.74039955+00	-.49273695+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99905955+00	.43265565-01	-.28528800-02
-.43253068-01	-.99905489+00	-.42996417-02
-.30362994-02	-.41722110-02	.99998638+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.201	-.531
-11.683	-.750
-11.433	-6.310
-5.979	-6.051

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 47 MIN, 28.7 SEC DECLINATION 53 DEG, 40 MIN, 49.3 SEC

Figure 2(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 18, Camera: 3-Inch Mapping Frames: 309 Through: 453

Coverage Interval:

From: 9.1 Deg N Lat., 174.0 Deg W Long., To: 9.0 Deg S Lat., 1.6 Deg W Long.

From: 107 Hr 26 Min 4.151 Sec, To: 108 Hr 28 Min 20.58 Sec. CTE

Date Processed: 8/18/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.71000

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 126 H, 16 M, 46.4972 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 18. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5769560.47	$\dot{X}$ =	1384.6915
Y =	1601230.32	$\dot{Y}$ =	-5161.2314
Z =	-968788.38	$\dot{Z}$ =	-52.6562

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/14/72

Edited Data Tape No. A09829 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical photography starting at 174.0 deg W Long. and ending at 1.6 deg W Long. Throughout the sequence tilt is maintained within the range 0.0231 - 0.684 deg. Star patterns companion to frames 315 and 445 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT1972	4	21	5	20	3.521	
C/E	4	11	26	4.151		

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1117.8467920	1705.0004704	851.8216608	1.2713135	.9559552	.3405561
SELENOGRAPHIC	-1817.5149559	-192.4979050	294.6042590	-.1866503	1.6157382	-.0248728

LONGITUDE OF NADIR POINT	-173.9541874 DEG	LATITUDE OF NADIR POINT	9.1547580 DEG
	-173 DEG, 57 MIN, 15.0746155 SEC		9 DEG, 9 MIN, 24.3286228 SEC
LONG OF CAMERA AXIS INTERSECT	-173.9839039 DEG	LATI OF CAMERA AXIS INTERSECT	9.1548917 DEG
	-173 DEG, 59 MIN, 2.0539856 SEC		9 DEG, 9 MIN, 17.6102257 SEC
SPACECRAFT RADIUS	1851.2719211 KM	SPACECRAFT ALTITUDE	113.1819248 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	269.0484864 DEG
MEAN ALTITUDE RATE	.0112817 KM/SEC	HORIZONTAL VELOCITY	1.6266049 KM/SEC
TILT AZIMUTH	266.3626671 DEG	TILT ANGLE	.4515211 DEG
SIGMA TILT AZIMUTH	.0253886 DEG	SIGMA TILT ANGLE	.0001999 DEG
SUN ELEVATION AT PRIN GRND PNT	-6.8606272 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	272.6799698 DEG
LONGITUDE OF SUBSOLAR POINT	88.8143130 DEG	LATITUDE OF SUBSOLAR POINT	1.5371699 DEG
	88 DEG, 48 MIN, 51.5268230 SEC		1 DEG, 32 MIN, 13.8117313 SEC
ALPHA			267.1736906 DEG
EMISSION ANGLE	-.4778622 DEG	SWING ANGLE	.0253883 DEG
PHASE ANGLE	.4807920 DEG	SIGMA SWING ANGLE	180.0107706 DEG
PHI	97.3384914 DEG	NORTH DEVIATION ANGLE	-.0222576 DEG
SIGMA PHI	.4508503 DEG	X-TILT	.0002000 DEG
KAPPA	.0002000 DEG	SIGMA X-TILT	-.4508503 DEG
SIGMA KAPPA	179.1890297 DEG	Y-TILT	.0002000 DEG
OMEGA	.0002000 DEG	SIGMA Y-TILT	-90.8107955 DEG
SIGMA OMEGA	-.0222576 DEG	HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0002000 DEG	SIGMA HEADING	110.1725779 KM
	110.1759996 KM	LASER SLANT RANGE	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.99082787	.11178847	-.15962463	113.185666

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.78130005+00	.58708288+00	.21190560+00
-.13244397+00	.48771818+00	-.86289604+00
-.60994162+00	.64611511+00	.45880983+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99986895+00	-.14150142-01	.78687405-02
.14153620-01	-.99989976+00	.38846755-03
.78623770-02	.49980209-03	.99996895+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
12.089	-171.057
6.278	-171.019
6.154	-176.907
12.045	-177.039

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION	-5 HR, 23 MIN, 55.5 SEC	DECLINATION	64 DEG, 53 MIN, 6.8 SEC

Figure 3(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	6	22	19.950
CTE			4	12	28	20.580

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	928.8029621	-1323.2300415	-889.1844795	-1.3984912	-.8074537	-.2368896
SELENOGRAPHIC	1821.7375622	-51.5518338	-287.8825919	-.0475101	-1.6303354	.0602086

LONGITUDE OF NADIR POINT	-1.6209330 DEG	LATITUDE OF NADIR POINT	-8.9764507 DEG
	-1 DEG, 37 MIN, 15.3586006 SEC		-8 DEG, 58 MIN, 35.2224541 SEC
LONG OF CAMERA AXIS INTERSECT	-1.5987739 DEG	LATI OF CAMERA AXIS INTERSECT	-8.9716662 DEG
	-1 DEG, 35 MIN, 55.5858421 SEC		-8 DEG, 58 MIN, 17.9983807 SEC
SPACECRAFT RADIUS	1845.0641516 KM	SPACECRAFT ALTITUDE	106.9741553 KM
SCALE FACTOR	.0007080 M/KM	AZIMUTH OF VELOCITY VECTOR	272.0806954 DEG
MEAN ALTITUDE RATE	-.0107513 KM/SEC	HORIZONTAL VELOCITY	1.6320733 KM/SEC
TILT AZIMUTH	77.6713467 DEG	TILT ANGLE	.3640467 DEG
SIGMA TILT AZIMUTH	.0314285 DEG	SIGMA TILT ANGLE	.0002003 DEG
SUN ELEVATION AT PRIN GRND PNT	-.1267786 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.4633455 DEG
LONGITUDE OF SUBSOLAR POINT	88.2868070 DEG	LATITUDE OF SUBSOLAR POINT	1.5376235 DEG
	88 DEG, 17 MIN, 12.5050879 SEC		1 DEG, 32 MIN, 15.4447174 SEC
ALPHA	-.3795580 DEG	SWING ANGLE	75.4674090 DEG
EMISSION ANGLE	.3863967 DEG	SIGMA SWING ANGLE	.0314289 DEG
PHASE ANGLE	90.5063362 DEG	NORTH DEVIATION ANGLE	177.7858969 DEG
PHI	-.3523256 DEG	X-TILT	.0913964 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-177.7864189 DEG	Y-TILT	.3523252 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.0913964 DEG	HEADING	-87.7858571 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.98695026	.03413768	.15736519	106.976947

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.85631259+00	-.49616759+00	-.14334050+00
-.13711319+00	.48599424+00	-.86313937+00
.49792435+00	-.71946326+00	-.48419412+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99923454+00	.38633736-01	-.61491954-02
-.38624599-01	-.99925252+00	-.15951678-02
-.62063135-02	-.13564468-02	.99997981+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.292	1.302
-11.836	1.121
-11.593	-4.501
-6.110	-4.253

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 44 MIN, 38.4 SEC DECLINATION 53 DEG, 56 MIN, 29.2 SEC

Figure 3(b) - Last Frame

Mission: Apollo 16, Target: Forward oblique strip photography

Rev: 25, Camera: 3-Inch Mapping Frames: 454 Through: 586

Coverage Interval:

From: 8.9 Deg N Lat., 168.7 Deg E Long., To: 8.9 Deg S Lat., 11.2 Deg W Long.

From: 121 Hr 21 Min 0.271 Sec, To: 122 Hr 20 Min 41.319 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710033

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 140 H, 6 M, 33.1186 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 25. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5779557.93	$\dot{X}$ =	1374.1722
Y =	1604004.94	$\dot{Y}$ =	-5153.9858
Z =	-961912.32	$\dot{Z}$ =	-151.7528

- Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/20/72

Edited Data Tape No. A09829 File No.: 1 Location: Bldg. 12, MSC

Remarks: The vehicle attitude data used for this sequence contained the following gaps:

1. 121 H, 35 M, 20 Sec - 121 H, 38 M, 28 Sec AET (Fms 486 - 492)
2. 121 H, 45 M, 8 Sec - 121 H, 46 M, 58 Sec AET (Fms 508 - 511)
3. 121 H, 48 M, 10 Sec - 121 H, 50 M, 46 Sec AET (Fms 515 - 520)

Spurious vehicle attitude data point resulted in weak data for the interval 121 H, 41 M, 40 Sec - 121 H, 42 M, 40 Sec AET (Fms 500 and 501)

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of 25 deg forward oblique photography starting at 168.7 deg E Long. and ending at 11.2 deg W Long. Throughout the sequence tilt was maintained within the range 24.41 - 25.696 deg. There were no vehicle attitude data available for the computation of data for frames 486 through 492, 508 through 511, and 515 through 520. A spurious inner gimbal angle value resulted in questionable data for frame 500 and of the omission of data for frame 501. Star patterns companion to frames 460 and 580 are included in these data.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	19	14	59.639
CTE			5	1	21	.271

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-908.9071391	1340.7734560	896.4332883	1.3950367	.8043073	.2304997
SELENOGRAPHIC	-1803.5030637	302.7904526	288.2237486	.2498253	1.6060981	-.0648382

LONGITUDE OF NADIR POINT	170.4694824 DEG	LATITUDE OF NADIR POINT	8.9565670 DEG
	170 DEG, 28 MIN, 10.1367187 SEC		8 DEG, 57 MIN, 23.6413765 SEC
LONG OF CAMERA AXIS INTERSECT	168.6951141 DEG	LATI OF CAMERA AXIS INTERSECT	8.8562318 DEG
	168 DEG, 41 MIN, 42.4108887 SEC		8 DEG, 51 MIN, 22.4345112 SEC
SPACECRAFT RADIUS	1851.3179868 KM	SPACECRAFT ALTITUDE	113.2279905 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	267.6362095 DEG
MEAN ALTITUDE RATE	.0092163 KM/SEC	HORIZONTAL VELOCITY	1.6266488 KM/SEC
TILT AZIMUTH	266.8617516 DEG	TILT ANGLE	25.0298302 DEG
SIGMA TILT AZIMUTH	.0004728 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	3.2479877 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.0576286 DEG
LONGITUDE OF SUBSOLAR POINT	81.7426457 DEG	LATITUDE OF SUBSOLAR POINT	1.5432472 DEG
	81 DEG, 44 MIN, 33.5246086 SEC		1 DEG, 32 MIN, 35.6898308 SEC
ALPHA	-26.7025208 DEG	SWING ANGLE	269.7590144 DEG
EMISSION ANGLE	26.7856671 DEG	SIGMA SWING ANGLE	.0004728 DEG
PHASE ANGLE	113.4521542 DEG	NORTH DEVIATION ANGLE	182.6030486 DEG
PHI	25.0296352 DEG	X-TILT	-.1019584 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.0801086 DEG	Y-TILT	-25.0295928 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.1019584 DEG	HEADING	-92.8722827 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002207 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.94907660	.26902739	-.16394469	125.864147

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.57073567+00	.75458722+00	.32381942+00
-.14601313+00	.48133444+00	-.86429007+00
-.80804759+00	.44599927+00	.38489438+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.90495113+00	-.45403957-01	.42308631+00
.50939564-01	-.99870015+00	.17795084-02
.42245549+00	.23162216-01	.90608763+00

PHOTOGRAPH FOOTPRINT LATITUDE	LONGITUDE
11.314	171 166
6.660	171.397
2.221	161.721
14.473	160.869

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -5 HR, 28 MIN, 34.3 SEC DECLINATION 64 DEG, 0 MIN, 53.1 SEC

Figure 4(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	20	14	40.687
CTE			5	2	20	41.319

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	923.2110167	-1328.1867515	-891.8052460	-1.3988943	-.8052352	-.2301183
SELENOGRAPHIC	1799.5187675	-300.3860560	-288.4712253	-.2670774	-1.6070624	.0654468

LONGITUDE OF NADIR POINT	-9.4767659 DEG	LATITUDE OF NADIR POINT	-8.9850446 DEG
	-9 DEG, 28 MIN, 36.3571358 SEC		-8 DEG, 59 MIN, 6.1605549 SEC
LONG OF CAMERA AXIS INTERSECT	-11.1842252 DEG	LATI OF CAMERA AXIS INTERSECT	-8.8938432 DEG
	-11 DEG, 11 MIN, 3.2107258 SEC		-8 DEG, 53 MIN, 37.9354263 SEC
SPACECRAFT RADIUS	1847.0828961 KM	SPACECRAFT ALTITUDE	108.9928998 KM
SCALE FACTOR	.0006258 M/KM	AZIMUTH OF VELOCITY VECTOR	272.2787326 DEG
MEAN ALTITUDE RATE	-.0090688 KM/SEC	HORIZONTAL VELOCITY	1.6303632 KM/SEC
TILT AZIMUTH	272.9620857 DEG	TILT ANGLE	25.0232689 DEG
SIGMA TILT AZIMUTH	.0004729 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.6302929 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.8478899 DEG
LONGITUDE OF SUBSOLAR POINT	81.2372082 DEG	LATITUDE OF SUBSOLAR POINT	1.5436798 DEG
	81 DEG, 14 MIN, 13.9495468 SEC		1 DEG, 32 MIN, 37.2473145 SEC
ALPHA	26.6320424 DEG	SWING ANGLE	270.5785770 DEG
EMISSION ANGLE	26.7124459 DEG	SIGMA SWING ANGLE	.0004729 DEG
PHASE ANGLE	66.0001068 DEG	NORTH DEVIATION ANGLE	177.8940965 DEG
PHI	25.0221484 DEG	X-TILT	.2447267 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-177.5621872 DEG	Y-TILT	-25.0219044 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2447267 DEG	HEADING	-87.6764197 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002207 DEG
ACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.94898579	-.26985569	.16310697	121.116552

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.56345960+00	-.75564728+00	-.33393198+00
-.14147484+00	.48649197+00	-.86215453+00
.81393986+00	-.43854625+00	-.38102365+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.90540117+00	.36737896-01	.42296472+00
-.42534628-01	-.99908586+00	-.42712741-02
.42242108+00	-.21857880-01	.90613608+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.756	-8.600
-11.235	-8.788
-14.256	-18.469
-2.624	-17.873

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 27 MIN, 2.6 SEC DECLINATION 54 DEG, 56 MIN, 39.7 SEC

Figure 4(b) - Last Frame

Mission: Apollo 16, Target: South oblique strip photography

Rev: 26, Camera: 3-Inch Mapping Frames: 587 Through: 718

Coverage Interval:

From: 5.8 Deg N Lat., 168.9 Deg E Long., To: 12.1 Deg S Lat., 10.0 Deg W Long.

From: 123 Hr 20 Min 9.313 Sec, To: 124 Hr 19 Min 21.654 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710033

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 142 H, 5 M, 5.9449 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 26. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5780616.20	$\dot{X}$ =	1372.8671
Y =	1604298.64	$\dot{Y}$ =	-5153.0986
Z =	-959733.43	$\dot{Z}$ =	-165.8222

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/19/72

Edited Data Tape No. A10808 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle
±0.2 mrad in each gimbal angle
±20 ms in onboard clock bias definition
±5 ms in onboard clock drift rate
±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a strip of 40 deg S oblique photography starting at 168.9 deg E Long. and ending at 10.0 deg W Long. Throughout the sequence tilt is maintained within the range 39.53 - 40.51 deg. Data for frame 697 were omitted due to a computer erratic. Star patterns companion to frames 595 and 715 are included in these data.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	21	14	8.681
CTE			5	3	20	9.313

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-889.1905910	1351.6342434	899.4517919	1.4049872	.7900675	.2201367
SELENOGRAPHIC	-1793.0294712	359.3125302	287.2775352	.2998825	1.5975023	-.0686486

LONGITUDE OF NADIR POINT	168.6683559	DEG
168 DEG, 40 MIN,	6.0813904	SEC
LONG OF CAMERA AXIS INTERSECT	168.8592777	DEG
168 DEG, 51 MIN,	33.3998108	SEC
SPACECRAFT RADIUS	1851.1046867	KM
SCALE FACTOR	.0000000	M/KM
MEAN ALTITUDE RATE	.0089584	KM/SEC
TILT AZIMUTH	176.5502052	DEG
SIGMA TILT AZIMUTH	.0003136	DEG
SUN ELEVATION AT PRIN GRND PNT	2.0195999	DEG
LONGITUDE OF SUBSOLAR POINT	80.7336223	DEG
80 DEG, 44 MIN,	1.0402679	SEC
ALPHA	1.9734787	DEG
EMISSION ANGLE	42.7805815	DEG
PHASE ANGLE	85.2760181	DEG
PHI	-.6189836	DEG
SIGMA PHI	.0002596	DEG
KAPPA	177.5208569	DEG
SIGMA KAPPA	.0002597	DEG
OMEGA	-39.6182194	DEG
SIGMA OMEGA	.0002000	DEG
SPACECRAFT ALTITUDE (LASER)	.0000000	KM

LATITUDE OF NADIR POINT	8.9279598	DEG
8 DEG, 55 MIN,	40.6552792	SEC
LATI OF CAMERA AXIS INTERSECT	5.7753173	DEG
5 DEG, 46 MIN,	31.1423206	SEC
SPACECRAFT ALTITUDE	113.0146903	KM
AZIMUTH OF VELOCITY VECTOR	267.5022369	DEG
HORIZONTAL VELOCITY	1.6268003	KM/SEC
TILT ANGLE	39.6222587	DEG
SIGMA TILT ANGLE	.0002001	DEG
SUN AZIMUTH AT PRINCIPAL GRND PNT	271.3485374	DEG
LATITUDE OF SUBSOLAR POINT	1.5441104	DEG
1 DEG, 32 MIN,	38.7974453	SEC
SWING ANGLE	179.2523186	DEG
SIGMA SWING ANGLE	.0003135	DEG
NORTH DEVIATION ANGLE	183.7273182	DEG
X-TILT	-39.6182196	DEG
SIGMA X-TILT	.0002000	DEG
Y-TILT	.4768058	DEG
SIGMA Y-TILT	.0002000	DEG
HEADING	-92.8738627	DEG
SIGMA HEADING	.0002000	DEG
LASER SLANT RANGE	.0000000	KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.64169499	-.16772912	-.74839460	150.148568

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.86932854+00	.47870534+00	.12291913+00
-.41175652+00	.83905539+00	-.35558769+00
-.27335763+00	.27850980+00	.92652485+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99870777+00	-.50135602-01	-.83217352-02
.33320310-01	-.76958951+00	.63766897+00
-.38374296-01	.63656767+00	.77026555+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
8.863	171.019
********	.000
********	.000
8.638	166.425

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 19 MIN, 31.5 SEC DECLINATION 26 DEG, 43 MIN, 39.8 SEC

Figure 5(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	22	13	21.022
CTE			5	4	19	21.654

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	X_{DOT} (KM/S)	Y_{DOT} (KM/S)	Z_{DOT} (KM/S)
1950.0	942.5871550	-1317.0317648	-888.6907372	-1.3884687	-.8198893	-.2392045
SELENOGRAPHIC	1797.6458557	-312.2628663	-289.4403575	-.2777693	-1.6050436	.0629438

LONGITUDE OF NADIR POINT	-9.8543228	DEG
	-9 DEG, 51 MIN, 15.5620480	SEC
LONG OF CAMERA AXIS INTERSECT	-9.9501669	DEG
	-9 DEG, 57 MIN, .6009865	SEC
SPACECRAFT RADIUS	1847.3804266	KM
SCALE FACTOR	.0005172	M/KM
MEAN ALTITUDE RATE	-.0088522	KM/SEC
TILT AZIMUTH	181.7125072	DEG
SIGMA TILT AZIMUTH	.0003088	DEG
SUN ELEVATION AT PRIN GRND PNT	-.5033054	DEG
LONGITUDE OF SUBSOLAR POINT	80.2322547	DEG
	80 DEG, 13 MIN, 56.1168623	SEC
ALPHA	2.5310799	DEG
EMISSION ANGLE	43.4995618	DEG
PHASE ANGLE	88.1621027	DEG
PHI	-.5584007	DEG
SIGMA PHI	.0002624	DEG
KAPPA	-177.4252338	DEG
SIGMA KAPPA	.0002625	DEG
OMEGA	-40.3594694	DEG
SIGMA OMEGA	.0002000	DEG
SPACECRAFT ALTITUDE (LASER)	.0000000	KM

LATITUDE OF NADIR POINT	-9.0140173	DEG
	-9 DEG, 0 MIN, 50.4624367	SEC
LATI OF CAMERA AXIS INTERSECT	-12.1494929	DEG
	-12 DEG, 8 MIN, 58.1742954	SEC
SPACECRAFT ALTITUDE	109.2904303	KM
AZIMUTH OF VELOCITY VECTOR	272.1912372	DEG
HORIZONTAL VELOCITY	1.6300637	KM/SEC
TILT ANGLE	40.3626719	DEG
SIGMA TILT ANGLE	.0002000	DEG
SUN AZIMUTH AT PRINCIPAL GRND PNT	88.5283995	DEG
LATITUDE OF SUBSOLAR POINT	1.5445386	DEG
	1 DEG, 32 MIN, 40.3390217	SEC
SWING ANGLE	179.3429795	DEG
SIGMA SWING ANGLE	.0003088	DEG
NORTH DEVIATION ANGLE	177.0959534	DEG
X-TILT	-40.3594698	DEG
SIGMA X-TILT	.0002000	DEG
Y-TILT	.4254966	DEG
SIGMA Y-TILT	.0002000	DEG
HEADING	-87.7868541	DEG
SIGMA HEADING	.0002000	DEG
LASER SLANT RANGE	.0000000	KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.84468489	.12708362	-.51995883	146.850549

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.85271480+00	-.50171932+00	-.14544838+00
.22143343+00	-.99986091-01	-.97053845+00
.47312224+00	-.85979964+00	.19209346+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99922655+00	.38616014-01	-.74262484-02
-.34231182-01	-.76122732+00	.64758104+00
.19353858-01	.64733436+00	.76196039+00

PHOTOGRAPH FOOTPRINT LATITUDE	LONGITUDE
-9.308	-7.598
*********	.000
*********	.000
-9.137	-12.049

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION 11 HR, 51 MIN, 38.7 SEC

DECLINATION 80 DEG, 15 MIN, 26.9 SEC

Figure 5(b) - Last Frame

Mission: Apollo 16, Target: North oblique strip photography

Rev: 27, Camera: 3-Inch Mapping Frames: 718 Through: 850

Coverage Interval:

From: 12.2 Deg N Lat., 169.8 Deg E Long., To: 5.9 Deg S Lat., 9.8 Deg W Long.

From: 125 Hr 18 Min 17.940 Sec, To: 126 Hr 17 Min 56.657 Sec. CT

Date Processed: 8/19/72, APE Version Used: 8

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710050

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 144 H, 3 M, 38.265 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 27. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5781927.47	$\dot{X}$ =	1371.6206
Y =	1604662.56	$\dot{Y}$ =	-5151.9782
Z =	-957309.61	$\dot{Z}$ =	-179.8616

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/19/72

Edited Data Tape No. A10808 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no vehicle attitude data available for computation of data for frames 755 through 769.

APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a series of 40 deg North oblique strip photography starting at 169.8 deg E Long. and ending at 9.8 deg W Long. Throughout the sequence tilt is maintained within the range 39.46 - 40.48 deg. There were no vehicle attitude data available for the computation of data for frames 755 through 769. Star patterns companion to frames 715 and 845 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	23	12	17.308
CTE			5	5	18	17.940

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-952.8048919	1313.9286982	888.4704687	1.3725321	.8377722	.2512750
SELENOGRAPHIC	-1799.2474834	319.5671784	290.1910958	.2664064	1.6044886	-.0590740

LONGITUDE OF NADIR POINT	169.9286327	DEG	
169 DEG, 55 MIN,	43.0778503	SEC	
LONG OF CAMERA AXIS INTERSECT	169.7600822	DEG	
169 DEG, 45 MIN,	36.2960815	SEC	
SPACECRAFT RADIUS	1850.3041804	KM	
SCALE FACTOR	.0000000	M/KM	
MEAN ALTITUDE RATE	.0087919	KM/SEC	
TILT AZIMUTH	357.0201225	DEG	
SIGMA TILT AZIMUTH	.0003116	DEG	
SUN ELEVATION AT PRIN GRND PNT	.2998743	DEG	
LONGITUDE OF SUBSOLAR POINT	79.7331618	DEG	
79 DEG, 43 MIN,	59.3824196	SEC	
ALPHA	-3.2816371	DEG	
EMISSION ANGLE	43.0944681	DEG	
PHASE ANGLE	92.8716507	DEG	
PHI	.6554903	DEG	
SIGMA PHI	.0002608	DEG	
KAPPA	178.0415306	DEG	
SIGMA KAPPA	.0002608	DEG	
OMEGA	39.9191966	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	.0000000	KM	

LATITUDE OF NADIR POINT	9.0231931	DEG	
9 DEG, 1 MIN,	23.4952354	SEC	
LATI OF CAMERA AXIS INTERSECT	12.1896533	DEG	
12 DEG, 11 MIN,	22.7517986	SEC	
SPACECRAFT ALTITUDE	112.2141840	KM	
AZIMUTH OF VELOCITY VECTOR	267.8445972	DEG	
HORIZONTAL VELOCITY	1.6274741	KM/SEC	
TILT ANGLE	39.9236789	DEG	
SIGMA TILT ANGLE	.0002000	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	271.5158272	DEG	
LATITUDE OF SUBSOLAR POINT	1.5449644	DEG	
1 DEG, 32 MIN,	41.8716717	SEC	
SWING ANGLE	359.2166419	DEG	
SIGMA SWING ANGLE	.0003116	DEG	
NORTH DEVIATION ANGLE	183.0998128	DEG	
X-TILT	39.9191969	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	-.5027239	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-92.3791094	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	.0000000	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.85053868	-.11718102	.51269149	149.790892

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.84102344+00	.51902129+00	.15263196+00
.22719001+00	-.82789587-01	-.97032499+00
-.49098291+00	.85074253+00	-.18754442+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99909959+00	-.41509763-01	.87740743-02
.26210586-01	-.76650219+00	-.64170663+00
.33362361-01	-.64089885+00	.76689999+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
********	.000
9.298	172.159
9.112	167.590
********	.000

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION 9 HR, 54 MIN, 45.1 SEC DECLINATION 70 DEG, 56 MIN, 45.1 SEC

Figure 6(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT1972		4	22	0	11	56.025
CTE			5	6	17	56.657

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	968.5704073	-1301.6516185	-884.2714007	-1.3741267	-.8393178	-.2515921
SELENOGRAPHIC	1797.1695398	-316.3040229	-290.6800481	-.2816107	+1.6041049	.0593299

LONGITUDE OF NADIR POINT	-9.9818968 DEG	LATITUDE OF NADIR POINT	-9.0508803 DEG
	-9 DEG, 58 MIN, 54.8283291 SEC		-9 DEG, 3 MIN, 3.1691265 SEC
LONG OF CAMERA AXIS INTERSECT	-9.8358533 DEG	LATI OF CAMERA AXIS INTERSECT	-5.9044043 DEG
	-9 DEG, 50 MIN, 9.0720177 SEC		-5 DEG, 54 MIN, 15.8554173 SEC
SPACECRAFT RADIUS	1847.7990908 KM	SPACECRAFT ALTITUDE	109.7090945 KM
SCALE FACTOR	.0005154 M/KM	AZIMUTH OF VELOCITY VECTOR	272.0642463 DEG
MEAN ALTITUDE RATE	-.0086390 KM/SEC	HORIZONTAL VELOCITY	1.6296643 KM/SEC
TILT AZIMUTH	2.6447422 DEG	TILT ANGLE	40.3677320 DEG
SIGMA TILT AZIMUTH	.0003088 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	.7717810 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.3663683 DEG
LONGITUDE OF SUBSOLAR POINT	79.2280896 DEG	LATITUDE OF SUBSOLAR POINT	1.5453946 DEG
	79 DEG, 13 MIN, 41.1224270 SEC		1 DEG, 32 MIN, 43.4206295 SEC
ALPHA	-3.4333587 DEG	SWING ANGLE	.1536138 DEG
EMISSION ANGLE	43.5175378 DEG	SIGMA SWING ANGLE	.0003087 DEG
PHASE ANGLE	92.3709555 DEG	NORTH DEVIATION ANGLE	176.6891680 DEG
PHI	-.1305861 DEG	X-TILT	40.3675562 DEG
SIGMA PHI	.0002625 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-177.5568848 DEG	Y-TILT	.0994942 DEG
SIGMA KAPPA	.0002625 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	40.3675561 DEG	HEADING	-87.4723016 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.63560667	.14221335	.75880137	147.439267

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.84016970+00	-.52142724+00	-.14909246+00
-.44865766+00	.82272139+00	-.34904985+00
.30466560+00	-.22636935+00	-.92516791+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99902553+00	.44102286-01	.17365002-02
-.32478087-01	-.76121262+00	-.64768858+00
-.29886447-01	-.64700103+00	.76190319+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
********	.000
-8.926	-7.732
-8.732	-12.194
********	.000

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 1 MIN, 8.2 SEC DECLINATION 14 DEG, 33 MIN, 8.1 SEC

Figure 6(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 28, Camera: 3-Inch Mapping Frames: 851 Through: 1001

Coverage Interval:

From: 9.1 Deg N Lat., 171.1 Deg E Long., To: 8. Deg S Lat., 15.3 Deg W Long.

From: 127 Hr 16 Min 28.493 Sec, To: 128 Hr 18 Min 13.475 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziel1)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710050

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 146 H, 2 M, 10.1686 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 28. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5782954.93	$\dot{X}$ =	1370.4210
Y =	1604947.71	$\dot{Y}$ =	-5151.1242
Z =	-954553.59	$\dot{Z}$ =	-193.8567

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/18/72

Edited Data Tape No. A10801 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical strip photography starting at 171.1 deg E Long. and ending at 15.3 deg W Long. Throughout the sequence tilt is maintained within the range 0.022 - 0.877 deg. Data for frame 956 were omitted due to a computer erratic. Star patterns companion to frames 860 and 995 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	1	10	27.860
CTE			5	7	16	28.493

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1011.7833934	1276.2020394	876.7985954	1.3395724	.8817903	.2804269
SELENOGRAPHIC	-1804.2263492	283.4344861	292.5837151	.2360510	1.6101041	-.0499218

LONGITUDE OF NADIR POINT	171.0720997 DEG	LATITUDE OF NADIR POINT	9.1015064 DEG
	171 DEG, 4 MIN, 19.5588684 SEC		9 DEG, 6 MIN, 5.4228687 SEC
LONG OF CAMERA AXIS INTERSECT	171.0670062 DEG	LATI OF CAMERA AXIS INTERSECT	9.1350888 DEG
	171 DEG, 4 MIN, 4.1024780 SEC		9 DEG, 8 MIN, 6.3196850 SEC
SPACECRAFT RADIUS	1849.6413321 KM	SPACECRAFT ALTITUDE	111.5513358 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	268.1720518 DEG
MEAN ALTITUDE RATE	.0085763 KM/SEC	HORIZONTAL VELOCITY	1.6280287 KM/SEC
TILT AZIMUTH	352.8073387 DEG	TILT ANGLE	.5274157 DEG
SIGMA TILT AZIMUTH	.0217088 DEG	SIGMA TILT ANGLE	.0002002 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.0592995 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.8981247 DEG
LONGITUDE OF SUBSOLAR POINT	78.7324652 DEG	LATITUDE OF SUBSOLAR POINT	1.5458162 DEG
	78 DEG, 43 MIN, 56.8746185 SEC		1 DEG, 32 MIN, 44.9384022 SEC
ALPHA	-.0884808 DEG	SWING ANGLE	364.7277141 DEG
EMISSION ANGLE	.5611945 DEG	SIGMA SWING ANGLE	.0217088 DEG
PHASE ANGLE	92.1478767 DEG	NORTH DEVIATION ANGLE	181.9211853 DEG
PHI	.0484587 DEG	X-TILT	.5251158 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	178.0793381 DEG	Y-TILT	-.0484567 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.5251158 DEG	HEADING	-91.9211058 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.97701106	-.15231680	-.14916093	111.556364

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.82499709+00	.53935611+00	.16874489+00
-.13421989+00	.47704590+00	-.86856907+00
-.54896700+00	.69391805+00	.46595381+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99943760+00	-.33523328-01	.84572840-03
.33514170-01	-.99939622+00	-.91648715-02
.11523708-02	-.91313611-02	.99995763+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
12.124	173.935
6.365	174.037
6.170	168.288
11.932	167.998

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -5 HR, 18 MIN, 7.9 SEC DECLINATION 65 DEG, 46 MIN, 30.2 SEC

Figure 7(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	2	12	12.842
CTE			5	8	18	13.475

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	851.3387362	-1368.3066316	-902.9598963	-1.4328962	-.7529505	-.1929934
SELENOGRAPHIC	1760.0078066	-483.2647867	-284.9647747	-.4273935	-1.5711525	.0786567

LONGITUDE OF NADIR POINT	-15.3539323 DEG	LATITUDE OF NADIR POINT	-8.8740734 DEG
	-15 DEG, 21 MIN, 14.1561413 SEC		-8 DEG, 52 MIN, 26.6641903 SEC
LONG OF CAMERA AXIS INTERSECT	-15.3386000 DEG	LATI OF CAMERA AXIS INTERSECT	-8.8833812 DEG
	-15 DEG, 20 MIN, 18.9601421 SEC		-8 DEG, 53 MIN, .1724911 SEC
SPACECRAFT RADIUS	1847.2620973 KM	SPACECRAFT ALTITUDE	109.1721010 KM
SCALE FACTOR	.0006943 M/KM	AZIMUTH OF VELOCITY VECTOR	272.7535957 DEG
MEAN ALTITUDE RATE	-.0083082 KM/SEC	HORIZONTAL VELOCITY	1.6300941 KM/SEC
TILT AZIMUTH	121.5696030 DEG	TILT ANGLE	.2830603 DEG
SIGMA TILT AZIMUTH	.0406899 DEG	SIGMA TILT ANGLE	.0001990 DEG
SUN ELEVATION AT PRIN GRND PNT	-3.7435274 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.0177040 DEG
LONGITUDE OF SUBSOLAR POINT	78.2095915 DEG	LATITUDE OF SUBSOLAR POINT	1.5462603 DEG
	5 DEG, 12 MIN, 34.5295143 SEC		1 DEG, 32 MIN, 46.5371132 SEC
ALPHA	-.2535366 DEG	SWING ANGLE	118.4547381 DEG
EMISSION ANGLE	.3008172 DEG	SIGMA SWING ANGLE	.0406905 DEG
PHASE ANGLE	93.9970789 DEG	NORTH DEVIATION ANGLE	177.0848168 DEG
PHI	-.2483696 DEG	X-TILT	-.1357228 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-177.0842113 DEG	Y-TILT	.2483689 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.1357228 DEG	HEADING	-87.0847992 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	111.0909996 KM	LASER SLANT RANGE	111.0896435 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.95202429	.26577244	.15170617	109.173517

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.87825839+00	-.46382166+00	-.11632581+00
-.13947378+00	.48115562+00	-.86546885+00
.45739393+00	-.74388090+00	-.48726993+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99869653+00	.50857425-01	-.43348410-02
-.50867998-01	-.99870257+00	.23688072-02
-.42088347-02	.25862154-02	.99998780+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.196	-12.358
-11.849	-12.593
-11.538	-18.351
-5.934	-18.008

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 45 MIN, 2.1 SEC DECLINATION 54 DEG, 7 MIN, 49.2 SEC

Figure 7(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 29, Camera: 3-Inch Mapping Frames: 1112 Through: 1291

Coverage Interval:

From: 8.0 Deg N Lat., 146.4 Deg W Long., To: 8.9 Deg S Lat., 15.3 Deg W Long.

From: 129 Hr 1 Min 15.585 Sec, To: 130 Hr 16 Min 43.909 Sec. CTF

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710050

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 148 H, 0 M, 41.6762 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 29. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5784335.91	$\dot{X}$ =	1369.2055
Y =	1605330.97	$\dot{Y}$ =	-5149.8936
Z =	-951581.37	$\dot{Z}$ =	-207.8020

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/19/72

Edited Data Tape No. A00460 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle
±0.2 mrad in each gimbal angle
±20 ms in onboard clock bias definition
±5 ms in onboard clock drift rate
±5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical strip photography starting at 146.4 deg W Long. and ending at 15.3 deg W Long. The sequence starts with a forward tilt of approximately 1.6 deg. Throughout the first twenty frames tilt changes to an aft value of 2.58 deg. From that point on, tilt is maintained less than 0.8 deg. Star patterns companion to frames 1120 and 1285 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	2	55	14.952
CTE			5	9	1	15.585

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1773.8155212	256.8697305	427.6619997	.3742831	1.4125283	.7316805
SELENOGRAPHIC	-1522.3230520	-1006.7466719	253.5495767	-.8874857	1.3652023	.1308243

LONGITUDE OF NADIR POINT	-146.5224323	DEG	
	-146 DEG, 31 MIN,	20.7563782	SEC
LONG OF CAMERA AXIS INTERSECT	-146.4460545	DEG	
	-146 DEG, 26 MIN,	45.7960510	SEC
SPACECRAFT RADIUS	1842.6322813	KM	
SCALE FACTOR	.0000000	M/KM	
MEAN ALTITUDE RATE	.0064178	KM/SEC	
TILT AZIMUTH	59.4936657	DEG	
SIGMA TILT AZIMUTH	.0079938	DEG	
SUN ELEVATION AT PRIN GRND PNT	-44.8231468	DEG	
LONGITUDE OF SUBSOLAR POINT	77.8451913	DEG	
	77 DEG, 50 MIN,	42.6887226	SEC
ALPHA	1.1898076	DEG	
EMISSION ANGLE	1.5470282	DEG	
PHASE ANGLE	133.6418209	DEG	
PHI	-1.2180841	DEG	
SIGMA PHI	.0001999	DEG	
KAPPA	-177.0982456	DEG	
SIGMA KAPPA	.0002000	DEG	
OMEGA	.8035727	DEG	
SIGMA OMEGA	.0002001	DEG	
SPACECRAFT ALTITUDE (LASER)	100.6180000	KM	

LATITUDE OF NADIR POINT	7.9090982	DEG	
	7 DEG, 54 MIN,	32.7535343	SEC
LATI OF CAMERA AXIS INTERSECT	7.9536601	DEG	
	7 DEG, 57 MIN,	13.1762409	SEC
SPACECRAFT ALTITUDE	104.5422849	KM	
AZIMUTH OF VELOCITY VECTOR	274.8886283	DEG	
HORIZONTAL VELOCITY	1.6341793	KM/SEC	
TILT ANGLE	1.4593156	DEG	
SIGMA TILT ANGLE	.0001969	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	280.2112198	DEG	
LATITUDE OF SUBSOLAR POINT	1.5465694	DEG	
	1 DEG, 32 MIN,	47.6496792	SEC
SWING ANGLE	56.5833656	DEG	
SIGMA SWING ANGLE	.0079937	DEG	
NORTH DEVIATION ANGLE	177.0815761	DEG	
X-TILT	.8035727	DEG	
SIGMA X-TILT	.0002001	DEG	
Y-TILT	1.2179642	DEG	
SIGMA Y-TILT	.0001999	DEG	
HEADING	-87.0811603	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	100.5853653	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.83946597	.52886672	-.12475296	104.578240

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.24833349+00	.87677203+00	.41182688+00
-.13267029+00	.45192337+00	-.88213596+00
-.95954626+00	.16442666+00	.22854929+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99847708+00	.50909829-01	-.21255885-01
-.50618536-01	-.99861958+00	-.14024530-01
-.21940502-01	-.12927211-01	.99967566+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
10.580	-143.474
5.101	-143.863
5.467	-149.202
10.758	-149.027

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -5 HR, 43 MIN, 21.6 SEC DECLINATION 64 DEG, 11 MIN, 2.2 SEC

Figure 8(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT1972		4	22	4	10	43.276
CTE			5	10	16	43.909

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	883.5827556	-1351.2713450	-898.5763059	-1.4172626	-.7771129	-.2082356
SELENOGRAPHIC	1760.7613622	-481.2458663	-286.7297559	-.4259229	-1.5712969	.0742662

LONGITUDE OF NADIR POINT	-15.2865591 DEG
	-15 DEG, 17 MIN, 11.6127777 SEC
LONG OF CAMERA AXIS INTERSECT	-15.2968605 DEG
	-15 DEG, 17 MIN, 48.6976433 SEC
SPACECRAFT RADIUS	1847.7262003 KM
SCALE FACTOR	.0006914 M/KM
MEAN ALTITUDE RATE	-.0081519 KM/SEC
TILT AZIMUTH	211.0922661 DEG
SIGMA TILT AZIMUTH	.0366596 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.7123947 DEG
LONGITUDE OF SUBSOLAR POINT	77.2061429 DEG
	77 DEG, 12 MIN, 22.1144128 SEC
ALPHA	.1771846 DEG
EMISSION ANGLE	.3320680 DEG
PHASE ANGLE	92.5352421 DEG
PHI	.1511416 DEG
SIGMA PHI	.0002000 DEG
KAPPA	-177.8449574 DEG
SIGMA KAPPA	.0002000 DEG
OMEGA	-.2733659 DEG
SIGMA OMEGA	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM

LATITUDE OF NADIR POINT	-8.9272233 DEG
	-8 DEG, 55 MIN, 38.0039692 SEC
LATI OF CAMERA AXIS INTERSECT	-8.9440974 DEG
	-8 DEG, 56 MIN, 38.7506390 SEC
SPACECRAFT ALTITUDE	109.6362040 KM
AZIMUTH OF VELOCITY VECTOR	272.5989262 DEG
HORIZONTAL VELOCITY	1.6296431 KM/SEC
TILT ANGLE	.3124087 DEG
SIGMA TILT ANGLE	.0002001 DEG
SUN AZIMUTH AT PRINCIPAL GRND PNT	88.8594122 DEG
LATITUDE OF SUBSOLAR POINT	1.5471104 DEG
	1 DEG, 32 MIN, 49.5973492 SEC
SWING ANGLE	208.9376071 DEG
SIGMA SWING ANGLE	.0366592 DEG
NORTH DEVIATION ANGLE	177.8442206 DEG
X-TILT	-.2733659 DEG
SIGMA X-TILT	.0002000 DEG
Y-TILT	-.1511399 DEG
SIGMA Y-TILT	.0002000 DEG
HEADING	-87.8442366 DEG
SIGMA HEADING	.0002000 DEG
LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.95436106	.25792439	.15056551	109.637936

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.86704925+00	-.47867969+00	-.13817158+00
-.12944835+00	.48424535+00	-.86530316+00
.48111191+00	-.73237440+00	-.48182888+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99928880+00	.37616162-01	.26378855-02
-.37603271-01	-.99928136+00	.47711170-02
.28153725-02	.46685211-02	.99998513+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.229	-12.364
-11.875	-12.511
-11.672	-18.314
-6.005	-18.029

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 48 MIN, 3.5 SEC DECLINATION 54 DEG, 10 MIN, 27.8 SEC

Figure 8(b) - Last Frame

Mission: Apollo 16, Target: North oblique strip photography

Rev: 37, Camera: 3-Inch Mapping Frames: 1291 Through: 1429

Coverage Interval:

From: 12.1 Deg N Lat., 157.3 Deg E Long., To: 6.8 Deg S Lat., 30.5 Deg W Long.

From: 145 Hr 7 Min 42.432 Sec, To: 146 Hr 9 Min 54.546 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710100

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 163 H, 48 M, 51.3162 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 37. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5796930.54	$\dot{X}$ =	1361.5228
Y =	1608826.39	$\dot{Y}$ =	-5139.3840
Z =	-918025.96	$\dot{Z}$ =	-317.2457

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: Variable

Date Edited: 7/21/72

Edited Data Tape No. A00460 File No.: 1 Location: Bldg. 12, MSC

Remarks: Vehicle attitude used for this sequence contained a gap in excess of 1 minute,145 H, 23 M, 21 Sec - 145 H, 24 M, 41 Sec AET (Frames 1326 through1328). Vehicle attitude data was low bit rate for the interval 145 H, 24 M, 41 Sec - 145 H, 28 M, 35 Sec AET, Frames 1329 through 1337.

APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
Φ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a strip of 40 deg N oblique photography starting at 157 deg E Long. and ending at 30.5 deg W Long. Throughout all the sequence except the final frame tilt is maintained within the range 39.5 - 40.46 deg. There were no vehicle attitude available for the computation of data for frames 1326 through 1328. Data for frame 1397 was omitted due to a computer erratic. Computations of data for frames 1329 through 1337 were based on low bit rate telemetered vehicle attitude data. Star patterns companion to frames 1295 and 1425 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	19	1	41.797
CTE			6	1	7	42.432

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-909.1233053	1336.5227191	894.1044166	1.3969785	.8099195	.2236704
SELENOGRAPHIC	-1685.7518779	698.3551703	287.6830431	.6063263	1.5114845	-.0730059

LONGITUDE OF NADIR POINT	157.4972763 DEG	LATITUDE OF NADIR POINT	8.9596232 DEG
	157 DEG, 29 MIN, 50.1947021 SEC		8 DEG, 57 MIN, 34.6435833 SEC
LONG OF CAMERA AXIS INTERSECT	157.3478260 DEG	LATI OF CAMERA AXIS INTERSECT	12.0616555 DEG
	157 DEG, 20 MIN, 52.1736145 SEC		12 DEG, 3 MIN, 41.9598770 SEC
SPACECRAFT RADIUS	1847.2197679 KM	SPACECRAFT ALTITUDE	109.1297715 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	267.3641491 DEG
MEAN ALTITUDE RATE	.0067316 KM/SEC	HORIZONTAL VELOCITY	1.6301549 KM/SEC
TILT AZIMUTH	357.3012352 DEG	TILT ANGLE	40.1325831 DEG
SIGMA TILT AZIMUTH	.0003103 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	2.5880461 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.0365295 DEG
LONGITUDE OF SUBSOLAR POINT	69.6629913 DEG	LATITUDE OF SUBSOLAR POINT	1.5533745 DEG
	69 DEG, 39 MIN, 46.7686558 SEC		1 DEG, 33 MIN, 12.1480751 SEC
ALPHA	-4.2320998 DEG	SWING ANGLE	.0761218 DEG
EMISSION ANGLE	43.2380926 DEG	SIGMA SWING ANGLE	.0003103 DEG
PHASE ANGLE	90.6882286 DEG	NORTH DEVIATION ANGLE	183.6041244 DEG
PHI	-.0641745 DEG	X-TILT	40.1325403 DEG
SIGMA PHI	.0002616 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.2016640 DEG	Y-TILT	.0490650 DEG
SIGMA KAPPA	.0002616 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	40.1325402 DEG	HEADING	-92.7569678 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.80197626	-.29938400	.51691711	146.074283

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.85909805+00	.49423783+00	.13296446+00
.20740304+00	-.98676769-01	-.97326609+00
-.46790434+00	.86370824+00	-.18727943+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99884220+00	-.48099582-01	-.85634520-03
.37326171-01	-.76364377+00	-.64455795+00
.30348948-01	-.64384363+00	.76455497+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
********	.000
9.258	159.713
9.047	155.272
********	.000

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION 9 HR, 35 MIN, 51.6 SEC DECLINATION 71 DEG, 28 MIN, 44.4 SEC

Figure 9(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	20	3	53.911
CTE			5	2	9	54.546

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	697.9695715	-1444.8250585	-920.1242427	-1.4924478	-.6402892	-.1131369
SELENOGRAPHIC	1575.1885169	-929.7925929	-274.9117405	-.8176976	-1.4035796	.1072627

LONGITUDE OF NADIR POINT	-30.5522423 DEG	LATITUDE OF NADIR POINT	-8.5473554 DEG
	-30 DEG, 33 MIN, 8.0722046 SEC		-8 DEG, 32 MIN, 50.4794884 SEC
LONG OF CAMERA AXIS INTERSECT	-30.4935358 DEG	LATI OF CAMERA AXIS INTERSECT	-6.8340782 DEG
	-30 DEG, 29 MIN, 36.7287254 SEC		-6 DEG, 50 MIN, 2.6814938 SEC
SPACECRAFT RADIUS	1849.6782408 KM	SPACECRAFT ALTITUDE	111.5802445 KM
SCALE FACTOR	.0005773 M/KM	AZIMUTH OF VELOCITY VECTOR	273.7846537 DEG
MEAN ALTITUDE RATE	-.0067458 KM/SEC	HORIZONTAL VELOCITY	1.6278908 KM/SEC
TILT AZIMUTH	1.9488684 DEG	TILT ANGLE	24.8297629 DEG
SIGMA TILT AZIMUTH	.0004763 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	-9.7448950 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.5916405 DEG
LONGITUDE OF SUBSOLAR POINT	69.1364494 DEG	LATITUDE OF SUBSOLAR POINT	1.5538011 DEG
	69 DEG, 8 MIN, 11.2179136 SEC		1 DEG, 33 MIN, 13.6841011 SEC
ALPHA	1.1469353 DEG	SWING ANGLE	358.9407592 DEG
EMISSION ANGLE	26.5440286 DEG	SIGMA SWING ANGLE	.0004763 DEG
PHASE ANGLE	99.7572823 DEG	NORTH DEVIATION ANGLE	176.7935749 DEG
PHI	.4900660 DEG	X-TILT	24.8252337 DEG
SIGMA PHI	.0002204 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-176.8840408 DEG	Y-TILT	-.4497794 DEG
SIGMA KAPPA	.0002204 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	24.8252337 DEG	HEADING	-87.0897984 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.71190379	.43680106	.54990711	123.811196

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.91431213+00	-.39519962+00	-.88603668-01
-.27703306+00	.76983877+00	-.57497908+00
.29544199+00	-.50116423+00	-.81335630+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99868025+00	.50769233-01	.77627862-02
-.49333934-01	-.90625084+00	-.41985184+00
-.14280599-01	-.41968071+00	.90755947+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-.243	-24.327
-9.455	-28.309
-9.229	-32.960
.683	-36.184

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 37 MIN, 17.5 SEC DECLINATION 29 DEG, 10 MIN, 25.5 SEC

NIRAM READ ERROR, L = -4
RECORD NUMBER 4

Figure 9(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 38, Camera: 3-Inch Mapping Frames: 1548 Through: 1694

Coverage Interval:

From: 9.2 Deg N Lat., 165.0 Deg E Long., To: 8.8 Deg S Lat., 26.6 Deg W Long.

From: 147 Hr 3 Min 49.405 Sec, To: 148 Hr 7 Min 8.172 Sec. GTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710100

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 165 H, 47 M, 22.5165 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 38. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5798599.49	$\dot{X}$ =	1360.7713
Y =	1609289.57	$\dot{Y}$ =	-5137.8823
Z =	-912614.82	$\dot{Z}$ =	-330.5843

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 8/4/72

Edited Data Tape No. A09043 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical strip photography starting at 165 deg E Long. and ending at 26.6 deg W Long. Throughout the sequence a tilt of less than 0.85 deg is maintained with a tilt of zero for frame 1591. Data for frames 1598 and 1676 were omitted due to a computer erratic. Star patterns companion to frames 1555 and 1685 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	20	57	48.770
CTE			6	3	3	49.405

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1130.7235517	1187.5697859	847.2679205	1.2648094	.9741985	.3361358
SELENOGRAPHIC	-1759.2981440	472.8307135	296.6847362	.4115852	1.5783260	-.0357413

LONGITUDE OF NADIR POINT	164.9566116	DEG	
	164 DEG, 57 MIN,	23.8018799	SEC
LONG OF CAMERA AXIS INTERSECT	164.9743061	DEG	
	164 DEG, 58 MIN,	27.5019836	SEC
SPACECRAFT RADIUS	1845.7303909	KM	
SCALE FACTOR	.0000000	M/KM	
MEAN ALTITUDE RATE	.0062717	KM/SEC	
TILT AZIMUTH	91.4844055	DEG	
SIGMA TILT AZIMUTH	.0405934	DEG	
SUN ELEVATION AT PRIN GRND PNT	-5.9585086	DEG	
LONGITUDE OF SUBSOLAR POINT	68.6800695	DEG	
	68 DEG, 40 MIN,	48.2501507	SEC
ALPHA	.2994984	DEG	
EMISSION ANGLE	.2995506	DEG	
PHASE ANGLE	95.6590900	DEG	
PHI	-.2816779	DEG	
SIGMA PHI	.0002000	DEG	
KAPPA	178.4422436	DEG	
SIGMA KAPPA	.0002000	DEG	
OMEGA	-.0149694	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	.0000000	KM	

LATITUDE OF NADIR POINT	9.2499150	DEG	
	9 DEG, 14 MIN,	59.6940136	SEC
LATI OF CAMERA AXIS INTERSECT	9.2494619	DEG	
	9 DEG, 14 MIN,	58.0628014	SEC
SPACECRAFT ALTITUDE	107.6403946	KM	
AZIMUTH OF VELOCITY VECTOR	268.6922904	DEG	
HORIZONTAL VELOCITY	1.6314585	KM/SEC	
TILT ANGLE	.2822802	DEG	
SIGMA TILT ANGLE	.0002000	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	272.5577240	DEG	
LATITUDE OF SUBSOLAR POINT	1.5541696	DEG	
	1 DEG, 33 MIN,	15.0106144	SEC
SWING ANGLE	93.0420528	DEG	
SIGMA SWING ANGLE	.0405940	DEG	
NORTH DEVIATION ANGLE	181.5578106	DEG	
X-TILT	-.0149694	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	.2816779	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-91.5578293	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	.0000000	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.95186305	-.26091986	-.16086503	107.641780

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.77998101+00	.59357773+00	.19823005+00
-.14509385+00	.47965760+00	-.86537643+00
-.60875064+00	.64621523+00	.46024831+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99961834+00	-.27185573-01	-.49161867-02
.27184602-01	-.99963039+00	.26126476-03
-.49215496-02	.12753491-03	.99998786+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
12.101	167.748
6.525	167.858
6.400	162.269
11.926	162.074

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -5 HR, 16 MIN, 22.1 SEC DECLINATION 65 DEG, 14 MIN, 42.0 SEC

Figure 10(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	22	1	7.537
CTE			6	4	7	8.172

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	843.4249148	-1376.1720749	-905.5037073	-1.4327433	-.7490433	-.1827568
SELENOGRAPHIC	1635.5549507	-818.0420555	-284.4632298	-.7206897	-1.4561467	.0863857

LONGITUDE OF NADIR POINT	-26.5724654	DEG	
	-26 DEG, 34 MIN,	20.8755112	SEC
LONG OF CAMERA AXIS INTERSECT	-26.5526421	DEG	
	-26 DEG, 33 MIN,	9.5115852	SEC
SPACECRAFT RADIUS	1850.7166532	KM	
SCALE FACTOR	.0006733	M/KM	
MEAN ALTITUDE RATE	-.0065444	KM/SEC	
TILT AZIMUTH	101.8943405	DEG	
SIGMA TILT AZIMUTH	.0372086	DEG	
SUN ELEVATION AT PRIN GRND PNT	-4.8789406	DEG	
LONGITUDE OF SUBSOLAR POINT	68.1441408	DEG	
	68 DEG, 8 MIN,	38.9069366	SEC
ALPHA	-.3208411	DEG	
EMISSION ANGLE	.3289073	DEG	
PHASE ANGLE	96.1997852	DEG	
PHI	-.3054783	DEG	
SIGMA PHI	.0002000	DEG	
KAPPA	-176.6225815	DEG	
SIGMA KAPPA	.0002000	DEG	
OMEGA	-.0457483	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	114.9860001	KM	

LATITUDE OF NADIR POINT	-8.8416615	DEG	
	-8 DEG, 50 MIN,	29.9812317	SEC
LATI OF CAMERA AXIS INTERSECT	-8.8457867	DEG	
	-8 DEG, 50 MIN,	44.8320866	SEC
SPACECRAFT ALTITUDE	112.6266569	KM	
AZIMUTH OF VELOCITY VECTOR	273.0442639	DEG	
HORIZONTAL VELOCITY	1.6269850	KM/SEC	
TILT ANGLE	.3089039	DEG	
SIGMA TILT ANGLE	.0001994	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	89.1822634	DEG	
LATITUDE OF SUBSOLAR POINT	1.5546007	DEG	
	1 DEG, 33 MIN,	16.5624046	SEC
SWING ANGLE	98.5173300	DEG	
SIGMA SWING ANGLE	.0372092	DEG	
NORTH DEVIATION ANGLE	176.6228707	DEG	
X-TILT	-.0457483	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	.3054782	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-86.6228247	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	114.9843283	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.88152149	.44680177	.15260419	112.628400

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.88039233+00	-.46219188+00	-.10665871+00
-.14646917+00	.47874519+00	-.86564994+00
.45115863+00	-.74644609+00	-.48915653+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99824920+00	.58907867-01	-.53315752-02
-.58912917-01	-.99826280+00	.79845796-03
-.52753672-02	.11111501-02	.99998547+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.088	-23.445
-11.929	-23.742
-11.557	-29.680
-5.775	-29.285

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 42 MIN, 25.7 SEC DECLINATION 54 DEG, 7 MIN, 35.9 SEC

Figure 10(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 39, Camera: 3-Inch Mapping Frames: 1837 Through: 1985

Coverage Interval:

From: 9.3 Deg N Lat., 163.6 Deg E Long., To: 9.1 Deg S Lat., 21.5 Deg W Long.

From: 149 Hr 2 Min 48.968 Sec, To: 150 Hr 4 Min 0.924 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710100

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 167 H, 45 M, 53.5361 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 39. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5800294.59	$\dot{X}$ =	1360.1109
Y =	1609760.02	$\dot{Y}$ =	-5136.1892
Z =	-906947.38	$\dot{Z}$ =	-343.8382

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/19/72

Edited Data Tape No. A07978 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

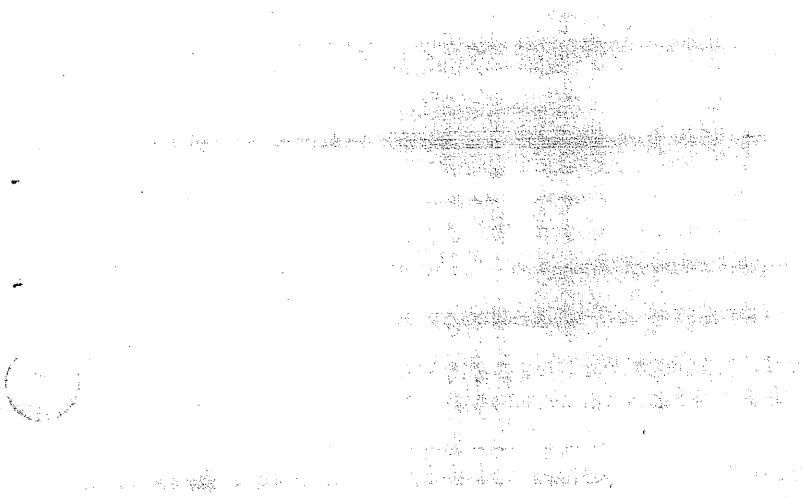
With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical strip photography starting at 163.6 deg E Long. and ending at 21.5 deg W Long. Throughout the sequence, tilt is maintained within the range of 0.19 and .74 deg. Star patterns companion to frames 1845 and 1980 are included in the data for this sequence.



	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	22	56	48.333
CTE			6	5	2	48.968

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1122.5630481	1193.1353358	849.0947763	1.2705674	.9690142	.3314756
SELENOGRAPHIC	-1746.6804696	515.6543817	296.4145991	.4500455	1.5681932	-.0378830

LONGITUDE OF NADIR POINT	163.5524349	DEG	
	163 DEG, 33 MIN,	8.7657166	SEC
LONG OF CAMERA AXIS INTERSECT	163.5675049	DEG	
	163 DEG, 34 MIN,	3.0175781	SEC
SPACECRAFT RADIUS	1845.1779496	KM	
SCALE FACTOR	.0000000	M/KM	
MEAN ALTITUDE RATE	.0061388	KM/SEC	
TILT AZIMUTH	33.0172091	DEG	
SIGMA TILT AZIMUTH	.0260646	DEG	
SUN ELEVATION AT PRIN GRND PNT	-5.5637045	DEG	
LONGITUDE OF SUBSOLAR POINT	67.6728300	DEG	
	67 DEG, 40 MIN,	22.1881199	SEC
ALPHA	.2391359	DEG	
EMISSION ANGLE	.4702693	DEG	
PHASE ANGLE	95.3247080	DEG	
PHI	-.2515029	DEG	
SIGMA PHI	.0002000	DEG	
KAPPA	178.4220695	DEG	
SIGMA KAPPA	.0002000	DEG	
OMEGA	.3646525	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	108.8669996	KM	

LATITUDE OF NADIR POINT	9.2442100	DEG	
	9 DEG, 14 MIN,	39.1560173	SEC
LATI OF CAMERA AXIS INTERSECT	9.2670971	DEG	
	9 DEG, 16 MIN,	1.5496159	SEC
SPACECRAFT ALTITUDE	107.0879533	KM	
AZIMUTH OF VELOCITY VECTOR	268.6172371	DEG	
HORIZONTAL VELOCITY	1.6318920	KM/SEC	
TILT ANGLE	.4430995	DEG	
SIGMA TILT ANGLE	.0001984	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	272.4942665	DEG	
LATITUDE OF SUBSOLAR POINT	1.5549782	DEG	
	1 DEG, 33 MIN,	17.9216766	SEC
SWING ANGLE	34.5937984	DEG	
SIGMA SWING ANGLE	.0260647	DEG	
NORTH DEVIATION ANGLE	181.5763482	DEG	
X-TILT	.3646525	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	.2514978	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-91.5763302	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	108.8637438	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.94640104	-.28378734	-.15423949	107.091351

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.78303894+00	.59013525+00	.19644454+00
-.14068498+00	.47570596+00	-.86827861+00
-.60585287+00	.65226090+00	.45551947+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99961196+00	-.27508418-01	-.43894503-02
.27536037-01	-.99960055+00	-.63643441-02
-.42127018-02	-.64827282-02	.99997010+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
12.121	166.340
6.576	166.419
6.447	160.891
11.946	160.664

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION	-5 HR, 18 MIN, 6.9 SEC	DECLINATION	65 DEG, 34 MIN, 32.1 SEC

Figure 11(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	23	58	.288
CTE			6	6	4	.924

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1010.4582407	-1279.1095108	-878.7515885	-1.3462714	-.8724869	-.2649362
SELENOGRAPHIC	1700.8503183	-671.1587546	-293.2668956	-.5933064	-1.5126903	.0602239

LONGITUDE OF NADIR POINT	-21.5342858 DEG	LATITUDE OF NADIR POINT	-9.1119621 DEG
	-21 DEG, 32 MIN, 3.4288216 SEC		-9 DEG, 6 MIN, 43.0634880 SEC
LONG OF CAMERA AXIS INTERSECT	-21.5400994 DEG	LATI OF CAMERA AXIS INTERSECT	-9.0902817 DEG
	-21 DEG, 32 MIN, 24.3577766 SEC		-9 DEG, 5 MIN, 25.0142097 SEC
SPACECRAFT RADIUS	1851.8507907 KM	SPACECRAFT ALTITUDE	113.7607944 KM
SCALE FACTOR	.0006666 M/KM	AZIMUTH OF VELOCITY VECTOR	272.1145494 DEG
MEAN ALTITUDE RATE	-.0062270 KM/SEC	HORIZONTAL VELOCITY	1.6259571 KM/SEC
TILT AZIMUTH	345.1696548 DEG	TILT ANGLE	.3427317 DEG
SIGMA TILT AZIMUTH	.0336591 DEG	SIGMA TILT ANGLE	.0001987 DEG
SUN ELEVATION AT PRIN GRND PNT	1.0424662 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.2576761 DEG
LONGITUDE OF SUBSOLAR POINT	67.1548081 DEG	LATITUDE OF SUBSOLAR POINT	1.5553916 DEG
	67 DEG, 9 MIN, 17.3092103 SEC		1 DEG, 33 MIN, 19.4095802 SEC
ALPHA	.0826192 DEG	SWING ANGLE	342.4986225 DEG
EMISSION ANGLE	.3650541 DEG	SIGMA SWING ANGLE	.0336590 DEG
PHASE ANGLE	88.8748951 DEG	NORTH DEVIATION ANGLE	177.3300258 DEG
PHI	.1030390 DEG	X-TILT	.3267668 DEG
SIGMA PHI	.0001999 DEG	SIGMA X-TILT	.0002001 DEG
KAPPA	-177.3294792 DEG	Y-TILT	-.1030373 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0001999 DEG
OMEGA	.3267668 DEG	HEADING	-87.3300662 DEG
SIGMA OMEGA	.0002001 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	116.3769999 KM	LASER SLANT RANGE	116.3749170 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.91815354	.36065966	.16406916	113.762962

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.82348374+00	-.54512060+00	-.15721991+00
-.15319724+00	.48047795+00	-.86352275+00
.54626465+00	-.68701131+00	-.47917676+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99891287+00	.46582198-01	.17983391-02
-.46591744-01	-.99889773+00	-.57031250-02
.15306089-02	-.57807246-02	.99998211+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.266	-18.436
-12.134	-18.694
-11.668	-24.672
-5.983	-24.375

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 35 MIN, 46.2 SEC DECLINATION 54 DEG, 1 MIN, 56.9 SEC

Figure 11(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 47, Camera: 3-Inch Mapping Frames: 2065 Through: 2219

Coverage Interval:

From: 9.2 Deg N Lat., 154.7 Deg E Long., To: 8.9 Deg S Lat., 34.5 Deg W Long.

From: 164 Hr 53 Min 53.882 Sec, To: 165 Hr 56 Min 22.777 Sec. CTE

Date Processed: _____, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710150

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 183 H, 33 M, 58.1984 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 47. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5813990.47	$\dot{X}$ =	1357.9511
Y =	1613561.06	$\dot{Y}$ =	-5123.2939
Z =	-852264.79	$\dot{Z}$ =	-446.3621

- Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/24/72

Edited Data Tape No. A10818 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical strip photography starting at 154.7 deg E Long. and ending at 34.5 deg W Long. Throughout the sequence tilt is maintained within the range 0.074 - 0.744 deg. Star patterns companion to frames 2070 and 2215 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	23	14	47	53.245
CTE			6	20	53	53.882

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1117.2834758	1193.6719041	846.6316515	1.2750872	.9700106	.3245581
SELENOGRAPHIC	-1693.9695499	776.6287390	295.9097509	.6871189	1.4825668	-.0443738

LONGITUDE OF NADIR POINT	154.7134495	DEG	LATITUDE OF NADIR POINT 9.2438573 DEG
154 DEG, 42 MIN,	48.4181213	SEC	9 DEG, 14 MIN, 37.8861523 SEC
LONG OF CAMERA AXIS INTERSECT	154.7365990	DEG	LATI OF CAMERA AXIS INTERSECT 9.2426229 DEG
154 DEG, 44 MIN,	11.7562866	SEC	9 DEG, 14 MIN, 33.4422684 SEC
SPACECRAFT RADIUS	1842.1049536	KM	SPACECRAFT ALTITUDE 104.0149572 KM
SCALE FACTOR	.0000000	M/KM	AZIMUTH OF VELOCITY VECTOR 268.3971388 DEG
MEAN ALTITUDE RATE	.0047069	KM/SEC	HORIZONTAL VELOCITY 1.6346212 KM/SEC
TILT AZIMUTH	93.0905104	DEG	TILT ANGLE .3824541 DEG
SIGMA TILT AZIMUTH	.0299455	DEG	SIGMA TILT ANGLE .0002001 DEG
SUN ELEVATION AT PRIN GRND PNT	-4.7932129	DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT 272.3695488 DEG
LONGITUDE OF SUBSOLAR POINT	59.6233044	DEG	LATITUDE OF SUBSOLAR POINT 1.5611708 DEG
59 DEG, 37 MIN,	23.8957500	SEC	1 DEG, 33 MIN, 40.2150249 SEC
ALPHA	.4051617	DEG	SWING ANGLE 94.4915512 DEG
EMISSION ANGLE	.4051941	DEG	SIGMA SWING ANGLE .0299458 DEG
PHASE ANGLE	94.3880510	DEG	NORTH DEVIATION ANGLE 181.4011960 DEG
PHI	-.3811340	DEG	X-TILT -.0299391 DEG
SIGMA PHI	.0002000	DEG	SIGMA X-TILT .0002000 DEG
KAPPA	178.5989723	DEG	Y-TILT .3811340 DEG
SIGMA KAPPA	.0002000	DEG	SIGMA Y-TILT .0002000 DEG
OMEGA	-.0299391	DEG	HEADING -91.4012268 DEG
SIGMA OMEGA	.0002000	DEG	SIGMA HEADING .0002000 DEG
SPACECRAFT ALTITUDE (LASER)	103.0209999	KM	LASER SLANT RANGE 103.0187044 KM

	X	Y	Z	MAGNITUDE (KM)
SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	.88952263	-.42758890	-.16098824	104.017411

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.78630483+00	.58552387+00	.19719758+00
-.14227714+00	.48219598+00	-.86443291+00
-.60123389+00	.65165090+00	.46245960+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99967888+00	-.24453044-01	-.66519937-02
.24450092-01	-.99970091+00	.52253629-03
-.66628598-02	.35974083-03	.99997772+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
11.991	157.423
6.602	157.517
6.503	152.121
11.829	151.951

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -5 HR, 17 MIN, 39.4 SEC DECLINATION 65 DEG, 8 MIN, 54.8 SEC

Figure 12(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	23	15	55	22.139
CTE			6	21	56	22.777

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	690.1[illegible]8163	-1350.[illegible]1953	-899.2126163	-1.4034068	-.7903643	-.2031800
SELENOGRAPHIC	1510.7359993	-[illegible]6.9162347	-267.1665292	-.9111133	-1.3410188	.0839962

LONGITUDE OF NADIR POINT	-34.4643912 DEG	LATITUDE OF NADIR POINT	-8.9069430 DEG
	-34 DEG, 27 MIN, 51.8004535 SEC		-8 DEG, 54 MIN, 24.9746690 SEC
LONG OF CAMERA AXIS INTERSECT	-34.4508505 DEG	LATI OF CAMERA AXIS INTERSECT	-8.8804654 DEG
	-34 DEG, 27 MIN, 3.0617523 SEC		-8 DEG, 53 MIN, 19.4754562 SEC
SPACECRAFT RADIUS	1854.7202307 KM	SPACECRAFT ALTITUDE	116.6302343 KM
SCALE FACTOR	.0006503 M/KM	AZIMUTH OF VELOCITY VECTOR	277.9720630 DEG
MEAN ALTITUDE RATE	-.0054162 KM/SEC	HORIZONTAL VELOCITY	1.6233880 KM/SEC
TILT AZIMUTH	35.9048696 DEG	TILT ANGLE	.3399682 DEG
SIGMA TILT AZIMUTH	.0334186 DEG	SIGMA TILT ANGLE	.0002017 DEG
SUN ELEVATION AT PRIN GRND PNT	-3.7432041 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.0024595 DEG
LONGITUDE OF SUBSOLAR POINT	59.0945549 DEG	LATITUDE OF SUBSOLAR POINT	1.5615582 DEG
	59 DEG, 5 MIN, 40.3976297 SEC		1 DEG, 33 MIN, 41.6094875 SEC
ALPHA	-.2177000 DEG	SWING ANGLE	32.8430241 DEG
EMISSION ANGLE	.3627383 DEG	SIGMA SWING ANGLE	.0334189 DEG
PHASE ANGLE	93.9609528 DEG	NORTH DEVIATION ANGLE	176.9383097 DEG
PHI	-.1843551 DEG	X-TILT	.2855891 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-176.9392490 DEG	Y-TILT	.1843529 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2855091 DEG	HEADING	-66.9383293 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	-.81193910	.56150756	.15957495	116.632425

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.86410058+00	-.46768575+00	-.12[illegible]+00
-.14867977+00	.[illegible]6247201+00	-.[illegible]6314315+00
.48071569+00	-.72758714+00	-.40955331+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99856747+00	.53410532-01	-.32175568-02
-.53394112-01	-.99856108+00	-.49844500-02
-.34792392-02	-.48055205-02	.99998240+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.000	-31.234
-12.047	-31.537
-11.707	-37.670
-5.696	-37.372

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 40 MIN, 55.5 SEC DECLINATION 63 DEG, 53 MIN, .7 SEC

Figure 12(b) - Last Frame

Mission: Apollo 16, Target: South oblique strip photography

Rev: 48, Camera: 3-Inch Mapping Frames: 2353 Through: 2500

Coverage Interval:

From: 7.8 Deg N Lat., 154.7 Deg E Long., To: 12.5 Deg S Lat., 31.4 Deg W Long.

From: 166 Hr 52 Min 24.891 Sec, To: 167 Hr 53 Min 51.395 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziel1)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710150

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 185 H, 32 M, 28.5367 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 48. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5815495.89	$\dot{X}$ =	1358.0589
Y =	1613978.86	$\dot{Y}$ =	-5121.7832
Z =	-844267.89	$\dot{Z}$ =	-458.6796

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/21/72

Edited Data Tape No. A10985 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = -95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of 40 deg south oblique strip photography starting at 154.7 deg E Long. and ending at 31.4 deg W Long. Over the first five frames, tilt is increased from its initial value of 23 deg to approximately 40 deg, then maintained within the range 39.5 - 40.6 deg. Star patterns companion to frames 2360 and 2495 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	23	16	46	24.253
CTE			6	22	52	24.891

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1144.3876682	1172.2839568	841.2939786	1.2561790	.9904858	.3382230
SELENOGRAPHIC	-1643.7974848	775.5767353	296.7472418	.6875115	1.4829575	-.0400939

LONGITUDE OF NADIR POINT	154.7411175	DEG	
	154 DEG, 44 MIN,	28.0229187	SEC
LONG OF CAMERA AXIS INTERSECT	154.7433128	DEG	
	154 DEG, 44 MIN,	35.9262085	SEC
SPACECRAFT RADIUS	1841.6928451	KM	
SCALE FACTOR	.0000000	M/KM	
MEAN ALTITUDE RATE	.0044090	KM/SEC	
TILT AZIMUTH	179.9142876	DEG	
SIGMA TILT AZIMUTH	.0005129	DEG	
SUN ELEVATION AT PRIN GRND PNT	-5.8499231	DEG	
LONGITUDE OF SUBSOLAR POINT	58.6203642	DEG	
	58 DEG, 37 MIN,	13.3111382	SEC
ALPHA	2.1171412	DEG	
EMISSION ANGLE	24.4019437	DEG	
PHASE ANGLE	94.3045235	DEG	
PHI	-.0371686	DEG	
SIGMA PHI	.0002172	DEG	
KAPPA	-179.9903717	DEG	
SIGMA KAPPA	.0002172	DEG	
OMEGA	-22.9484704	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	.0000000	KM	

LATITUDE OF NADIR POINT	9.2725965	DEG	
	9 DEG, 16 MIN,	21.3473225	SEC
LATI OF CAMERA AXIS INTERSECT	7.8191549	DEG	
	7 DEG, 49 MIN,	8.9576912	SEC
SPACECRAFT ALTITUDE	103.5528488	KM	
AZIMUTH OF VELOCITY VECTOR	268.5510500	DEG	
HORIZONTAL VELOCITY	1.6350308	KM/SEC	
TILT ANGLE	22.9485018	DEG	
SIGMA TILT ANGLE	.0002000	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	272.3914452	DEG	
LATITUDE OF SUBSOLAR POINT	1.5619033	DEG	
	1 DEG, 33 MIN,	42.8518295	SEC
SWING ANGLE	179.9122169	DEG	
SIGMA SWING ANGLE	.0005129	DEG	
NORTH DEVIATION ANGLE	180.0052856	DEG	
X-TILT	-22.9484705	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	.0342269	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-90.0048672	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	.0000000	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.76486147	-.36152198	-.53318739	113.060020

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.77373453+00	.59140653+00	.22709746+00
-.35777004+00	.70375773+00	-.61377980+00
-.52281490+00	.39365397+00	.75610920+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99999985+00	-.84949223-04	-.59737248-03
-.15473496-03	-.92085587+00	.38990311+00
-.58327996-03	.38990315+00	.92085568+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
10.133	156.925
2.209	159.629
2.224	149.870
10.132	152.563

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION	-4 HR, 22 MIN, 20.9 SEC	DECLINATION	43 DEG, 31 MIN, 5.1 SEC

Figure 13(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT1972		4	23	17	47	50.757
CTE			6	23	53	51.395

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1013.0376582	-1281.5922103	-879.9512890	-1.3416163	-.8751325	-.2596780
SELENOGRAPHIC	1565.4795888	-951.9662841	-293.3803204	-.8376055	-1.3882659	.0660199

LONGITUDE OF NADIR POINT	-31.3037348 DEG	LATITUDE OF NADIR POINT	-9.0972260 DEG
	-31 DEG, 18 MIN, 13.4452057 SEC		-9 DEG, 5 MIN, 50.0136852 SEC
LONG OF CAMERA AXIS INTERSECT	-31.4249482 DEG	LATI OF CAMERA AXIS INTERSECT	-12.4624853 DEG
	-31 DEG, 25 MIN, 29.8135757 SEC		-12 DEG, 27 MIN, 44.9471283 SEC
SPACECRAFT RADIUS	1855.5425518 KM	SPACECRAFT ALTITUDE	117.4525555 KM
SCALE FACTOR	.0004794 M/KM	AZIMUTH OF VELOCITY VECTOR	272.3338633 DEG
MEAN ALTITUDE RATE	-.0048723 KM/SEC	HORIZONTAL VELOCITY	1.6226842 KM/SEC
TILT AZIMUTH	182.0154285 DEG	TILT ANGLE	40.2813253 DEG
SIGMA TILT AZIMUTH	.0003093 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	.1261635 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.3721132 DEG
LONGITUDE OF SUBSOLAR POINT	58.1004289 DEG	LATITUDE OF SUBSOLAR POINT	1.5622791 DEG
	58 DEG, 6 MIN, 1.5440512 SEC		1 DEG, 33 MIN, 44.2048359 SEC
ALPHA	2.4466685 DEG	SWING ANGLE	179.8423754 DEG
EMISSION ANGLE	43.6486891 DEG	SIGMA SWING ANGLE	.0003093 DEG
PHASE ANGLE	87.3791313 DEG	NORTH DEVIATION ANGLE	177.2012788 DEG
PHI	-.1335867 DEG	X-TILT	-40.2811405 DEG
SIGMA PHI	.0002621 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-177.7779446 DEG	Y-TILT	.1019107 DEG
SIGMA KAPPA	.0002621 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-40.2811403 DEG	HEADING	-87.8643174 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.74272742	.42503968	-.51739467	157.892676

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.82660110+00	-.53848471+00	-.16359976+00
.24341893+00	-.79987446-01	-.96661742+00
.50742269+00	-.83883031+00	.19719507+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99930382+00	.37266005-01	-.17786771-02
-.29578775-01	-.76230755+00	.64653870+00
.22737941-01	.64614119+00	.76287910+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-9.403	-28.907
********	.000
********	.000
-9.226	-33.696

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION	-11 HR, 52 MIN, 4.4 SEC	DECLINATION	79 DEG, 11 MIN, 18.7 SEC

Figure 13(b) - Last Frame

Mission: Apollo 16, Target: Oblique strip photography

Rev: 59, Camera: 3-Inch Mapping Frames: 2501 Through: 2536

Coverage Interval:

From: 8.2 Deg S Lat., 15.7 Deg E Long., To: 9.2 Deg S Lat., 48.4 Deg W Long.

From: 189 Hr 31 Min 51.837 Sec, To: 189 Hr 44 Min 30.230 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710200

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 207 H, 16 M, 44.2062 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 59. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5816950.19	$\dot{X}$ =	1347.7703
Y =	1614382.49	$\dot{Y}$ =	-5105.6956
Z =	-879621.40	$\dot{Z}$ =	-601.5274

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/19/72

Edited Data Tape No. A13115 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.9802564	-.0079311	-.1975715
.1698344	-.4779295	.8618235
-.1012604	-.8783624	-.4671464

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar Camera Interlock Angles Used:

Ω = 95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of variable oblique strip photography starting at 15.7 deg E Long. and ending at 48.4 deg W Long. For the first frame of the sequence, the camera is directed slightly aft and to the south of nadir. Its direction is then immediately switched to a direction above the forward horizon and to the north such that tilt is approximately 72.6 deg. Over the remainder of the sequence, tilt is steadily decreased to a final value of 14.64 deg, with acquisition of the lunar surface for all frames beyond 2512. Star patterns companion to frames 2505 and 2530 are included on the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	24	15	16	44.206
CTE			7	21	31	51.837

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1831.4175843	192.8030533	-257.4599289	.0440653	-1.4132575	-.7905273
SELENOGRAPHIC	1773.0034060	492.0629471	-268.1081479	.4107997	-1.5562134	-.1833452

LONGITUDE OF NADIR POINT	15.5109698 DEG	LATITUDE OF NADIR POINT	-8.2901978 DEG
	15 DEG, 30 MIN, 39.4911289 SEC		-8 DEG, 17 MIN, 24.7122574 SEC
LONG OF CAMERA AXIS INTERSECT	15.6959108 DEG	LATI OF CAMERA AXIS INTERSECT	-8.1680931 DEG
	15 DEG, 41 MIN, 45.2789211 SEC		-8 DEG, 10 MIN, 5.1351070 SEC
SPACECRAFT RADIUS	1859.4485743 KM	SPACECRAFT ALTITUDE	121.3585780 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	263.9650879 DEG
MEAN ALTITUDE RATE	.0063194 KM/SEC	HORIZONTAL VELOCITY	1.6198878 KM/SEC
TILT AZIMUTH	56.3058143 DEG	TILT ANGLE	3.1474891 DEG
SIGMA TILT AZIMUTH	.0036686 DEG	SIGMA TILT ANGLE	.0001986 DEG
SUN ELEVATION AT PRIN GRND PNT	57.1179142 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	74.1579294 DEG
LONGITUDE OF SUBSOLAR POINT	47.1951298 DEG	LATITUDE OF SUBSOLAR POINT	1.5694611 DEG
	47 DEG, 11 MIN, 42.4673152 SEC		1 DEG, 34 MIN, 10.0597858 SEC
ALPHA	-3.2302664 DEG	SWING ANGLE	64.0197272 DEG
EMISSION ANGLE	3.3675179 DEG	SIGMA SWING ANGLE	.0036686 DEG
PHASE ANGLE	36.1001129 DEG	NORTH DEVIATION ANGLE	187.6740163 DEG
PHI	2.8299645 DEG	X-TILT	1.3782334 DEG
SIGMA PHI	.0001991 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-7.7479774 DEG	Y-TILT	2.8291451 DEG
SIGMA KAPPA	.0002001 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-1.3782334 DEG	HEADING	-97.6798514 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002002 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.96005660	-.21903580	.17411102	121.554757

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.28707600-01	-.86719288+00	-.49714416+00
-.19549298+00	.49261575+00	-.84800489+00
.98028484+00	.72843965-01	-.18367197+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98982232+00	-.13347460+00	-.49357834-01
.13477695+00	-.99058404+00	-.24052391-01
-.45682737-01	-.30459901-01	.99849150+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-4.350	18.608
-10.904	19.404
-11.492	13.111
-5.509	12.215

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION 6 HR, 42 MIN, 18.4 SEC DECLINATION -59 DEG, 43 MIN, 32.9 SEC

••••••• CAMERA POINTS OVER LUNAR HORIZON...NO INTERSECTION••••••• TILT = 72.503

Figure 14(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	24	15	38	7.929
CTE			7	21	44	30.230

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	843.7649052	-1374.3646785	-927.9667536	-1.4178884	-.7678045	-.1427806
SELENOGRAPHIC	1191.9874104	-1395.5101844	-306.0345064	-1.2157056	-1.0608309	.1304424

LONGITUDE OF NADIR POINT	-49.4974093	DEG	
	-49 DEG, 29 MIN,	50.6736374	SEC
LONG OF CAMERA AXIS INTERSECT	-48.4440165	DEG	
	-48 DEG, 26 MIN,	38.4592438	SEC
SPACECRAFT RADIUS	1860.6288669	KM	
SCALE FACTOR	.0005366	R/KM	
MEAN ALTITUDE RATE	-.0046357	KM/SEC	
TILT AZIMUTH	79.3619633	DEG	
SIGMA TILT AZIMUTH	.0008136	DEG	
SUN ELEVATION AT PRIN GRND PNT	-5.6386042	DEG	
LONGITUDE OF SUBSOLAR POINT	47.0141278	DEG	
	47 DEG, 0 MIN,	50.8602548	SEC
ALPHA	-15.4312494	DEG	
EMISSION ANGLE	15.6967484	DEG	
PHASE ANGLE	111.0771589	DEG	
PHI	-14.5895586	DEG	
SIGMA PHI	.0001969	DEG	
KAPPA	174.0177002	DEG	
SIGMA KAPPA	.0001997	DEG	
OMEGA	1.2145901	DEG	
SIGMA OMEGA	.0002033	DEG	
SPACECRAFT ALTITUDE (LASER)	127.7139997	KM	

LATITUDE OF NADIR POINT	-9.4669739	DEG	
	-9 DEG, 28 MIN,	1.1060429	SEC
LATI OF CAMERA AXIS INTERSECT	-9.2701356	DEG	
	-9 DEG, 16 MIN,	12.4883080	SEC
SPACECRAFT ALTITUDE	122.5388706	KM	
AZIMUTH OF VELOCITY VECTOR	274.6585863	DEG	
HORIZONTAL VELOCITY	1.6187034	KM/SEC	
TILT ANGLE	14.6389359	DEG	
SIGMA TILT ANGLE	.0001942	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	89.3254356	DEG	
LATITUDE OF SUBSOLAR POINT	1.5695676	DEG	
	1 DEG, 34 MIN,	10.4434204	SEC
SWING ANGLE	85.1887685	DEG	
SIGMA SWING ANGLE	.0008142	DEG	
NORTH DEVIATION ANGLE	185.4889888	DEG	
X-TILT	1.2145902	DEG	
SIGMA X-TILT	.0002033	DEG	
Y-TILT	14.5862079	DEG	
SIGMA Y-TILT	.0001971	DEG	
HEADING	-95.6661848	DEG	
SIGMA HEADING	.0002067	DEG	
LASER SLANT RANGE	123.5681028	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.42599157	.88115896	.20515864	126.956343

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.97666604+00	-.18488622+00	-.10927261+00
-.16571695-01	.57216487+00	-.81997123+00
.21412338+00	-.79902719+00	-.56187782+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96304130+00	-.95550298-01	-.25183641+00
.10419779+00	-.99433073+00	-.21197010-01
-.24838323+00	-.46654346-01	.96753765+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-4.270	-44.162
-12.957	-43.423
-12.186	-50.931
-6.837	-51.526

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -5 HR, 45 MIN, 37.3 SEC DECLINATION 49 DEG, 13 MIN, 49.3 SEC

Figure 14(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 60, Camera: 3-Inch Mapping Frames: 2687 Through: 2847

Coverage Interval:

From: 10.3 Deg N Lat., 143.5 Deg E Long., To: 9.6 Deg S Lat., 48.6 Deg W Long.

From: 190 Hr 39 Min 3.541 Sec, To: 191 Hr 42 Min 27.328 Sec. CTE

Date Processed: _____, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710200

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 209 H, 15 M, 21.8091 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 60. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5818377.56	$\dot{X}$ =	1348.4253
Y =	1614778.63	$\dot{Y}$ =	-5103.8798
Z =	-868651.57	$\dot{Z}$ =	-614.7152

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/19/72

Edited Data Tape No. A13115 File No.: 1 Location: Bldg. 12, MSC

Remarks: The vehicle attitude data recorder was off for nine minutes of the interval of this sequence (190 H, 42 M, 10.5 Sec - 190 H, 51 M, 1.4 Sec AET), the time interval of frames 2696 through 2720.

APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.9802564	-.0079311	-.1975715
.1698344	-.4779295	.8618235
-.1012604	-.8783624	-.4671464

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar camera Interlock Angles Used:

Ω = 95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of vertical strip photography starting at 143.5 deg E Long. and ending at 48.6 deg W Long. Throughout the sequence tilt is maintained within the range 0.017 - 0.883 degs. There were no vehicle attitude data available for the computation of data for frames 2696 through 2720. Star patterns companion to frames 2695 and 2840 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	24	16	33	2.900
CTE			7	22	39	3.541

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1102.7761317	1110.3568263	853.6944154	1.2209285	1.0412109	.3326254
SELENOGRAPHIC	-1459.7513770	1074.4796014	320.1266690	.9613119	1.3255289	-.0654127

LONGITUDE OF NADIR POINT	143.5504131	DEG	
143 DEG, 33 MIN,	1.4872742	SEC	
LONG OF CAMERA AXIS INTERSECT	143.5400687	DEG	
143 DEG, 32 MIN,	24.3191528	SEC	
SPACECRAFT RADIUS	1836.0629814	KM	
SCALE FACTOR	.0000000	M/KM	
MEAN ALTITUDE RATE	.0023506	KM/SEC	
TILT AZIMUTH	248.4072075	DEG	
SIGMA TILT AZIMUTH	.0604954	DEG	
SUN ELEVATION AT PRIN GRND PNT	-6.5931501	DEG	
LONGITUDE OF SUBSOLAR POINT	96.5496480	DEG	
96 DEG, 32 MIN,	58.3726788	SEC	
ALPHA	-.1828975	DEG	
EMISSION ANGLE	.2008550	DEG	
PHASE ANGLE	96.7760544	DEG	
PHI	.1796443	DEG	
SIGMA PHI	.0002000	DEG	
KAPPA	177.3474026	DEG	
SIGMA KAPPA	.0002000	DEG	
OMEGA	-.0616501	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	.0000000	KM	

LATITUDE OF NADIR POINT	10.2834284	DEG	
10 DEG, 17 MIN,	.3423500	SEC	
LATI OF CAMERA AXIS INTERSECT	10.2794076	DEG	
10 DEG, 16 MIN,	45.8674335	SEC	
SPACECRAFT ALTITUDE	99.9729850	KM	
AZIMUTH OF VELOCITY VECTOR	267.6600346	DEG	
HORIZONTAL VELOCITY	1.6386955	KM/SEC	
TILT ANGLE	.1898082	DEG	
SIGMA TILT ANGLE	.0001996	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	272.8080254	DEG	
LATITUDE OF SUBSOLAR POINT	1.5698391	DEG	
1 DEG, 34 MIN,	11.4205742	SEC	
SWING ANGLE	251.0588327	DEG	
SIGMA SWING ANGLE	.0604957	DEG	
NORTH DEVIATION ANGLE	182.6523935	DEG	
X-TILT	-.0616501	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	-.1796442	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-92.6524048	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	.0000000	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.79311063	-.58195991	-.17971697	99.973564

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.74300260+00	.63900011+00	.19906260+00
-.17636308+00	.47383956+00	-.86277008+00
-.64563395+00	.60593312+00	.46476001+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99892372+00	-.46276434-01	.31353776-02
.46279967-01	-.99892797+00	.10759972-02
.30822597-02	.12199044-02	.99999451+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
12.948	146.044
7.823	146.248
7.572	141.060
12.722	140.779

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION	-5 HR, 1 MIN, 40.0 SEC	DECLINATION	64 DEG, 57 MIN, 21.1 SEC

Figure 15(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	24	17	36	26.687
CTE			7	23	42	27.328

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	901.4534720	-1342.4479163	-921.6170056	-1.3902340	-.8102552	-.1709235
SELENOGRAPHIC	1215.5015404	-1374.7454698	-311.1166563	-1.1960300	-1.0809456	.1214900

LONGITUDE OF NADIR POINT	-48.5180178 DEG	LATITUDE OF NADIR POINT	-9.6225519 DEG
	-48 DEG, 31 MIN, 4.8639679 SEC		-9 DEG, 37 MIN, 21.1869049 SEC
LONG OF CAMERA AXIS INTERSECT	-48.5517092 DEG	LATI OF CAMERA AXIS INTERSECT	-9.6272575 DEG
	-48 DEG, 33 MIN, 6.1530304 SEC		-9 DEG, 37 MIN, 38.1268787 SEC
SPACECRAFT RADIUS	1861.2261214 KM	SPACECRAFT ALTITUDE	123.1361251 KM
SCALE FACTOR	.0006161 M/KM	AZIMUTH OF VELOCITY VECTOR	274.3415028 DEG
MEAN ALTITUDE RATE	-.0042874 KM/SEC	HORIZONTAL VELOCITY	1.6181364 KM/SEC
TILT AZIMUTH	261.9343910 DEG	TILT ANGLE	.4735102 DEG
SIGMA TILT AZIMUTH	.0241646 DEG	SIGMA TILT ANGLE	.0002001 DEG
SUN ELEVATION AT PRIN GRND PNT	-4.7622404 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.2117491 DEG
LONGITUDE OF SUBSOLAR POINT	46.0132327 DEG	LATITUDE OF SUBSOLAR POINT	1.5701486 DEG
	46 DEG, 0 MIN, 47.6377091 SEC		1 DEG, 34 MIN, 12.5350571 SEC
ALPHA	.5029798 DEG	SWING ANGLE	257.5940792 DEG
EMISSION ANGLE	.5070521 DEG	SIGMA SWING ANGLE	.0241848 DEG
PHASE ANGLE	94.2592640 DEG	NORTH DEVIATION ANGLE	175.6591556 DEG
PHI	.4624443 DEG	X-TILT	-.1017239 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-175.6598377 DEG	Y-TILT	-.4624436 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.1017239 DEG	HEADING	-85.6590166 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

3-105

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.65930095	.73332368	.16600792	123.140628

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.85392311+00	-.50843625+00	-.11094073+00
-.17087596+00	.47530794+00	-.86306663+00
.49154542+00	-.71803548+00	-.49275566+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99709874+00	.75689522-01	.80710759-02
-.75677551-01	-.99713080+00	.17754155-02
.81823504-02	.11595102-02	.99996585+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.692	-45.131
-13.024	-45.549
-12.579	-52.097
-6.167	-51.531

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 31 MIN, 10.7 SEC DECLINATION 53 DEG, 50 MIN, 26.7 SEC

Figure 15(b) - Last Frame

Mission: Apollo 16, Target: Vertical strip photography

Rev: 63, Camera: 3-Inch Mapping Frames: 2853 Through: 3000

Coverage Interval:

From: 10.0 Deg N Lat., 135.1 Deg E Long., To: 9.8 Deg S Lat., 49.6 Deg W Long.

From: 196 Hr 37 Min 29.669 Sec, To: 197 Hr 38 Min 28.820 Sec. CTE

Date Processed: 8/19/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710217

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 215 H, 11 M, 1.5503 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 63. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5820448.79	$\dot{X}$ =	1346.2527
Y =	1615353.46	$\dot{Y}$ =	-5099.2317
Z =	-833869.76	$\dot{Z}$ =	-652.6393

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: Variable

Date Edited: 8/3/72

Edited Data Tape No. A07736 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle data used for this sequence. Vehicle attitude data are low bit rate from the beginning of the sequence until an AET of 196 H, 49 M, 6.3 Sec (Frame 2885).

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.9802564	-.0079311	-.1975715
.1698344	-.4779295	.8618235
-.1012604	-.8783624	-.4671464

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis (camera positioning angle) was 37.75 degrees.

Stellar Camera Interlock Angles Used:

Ω = 95° 58' 12.727"
ϕ = 0° 7' 42.789"
κ = -0° 0' 25.534"

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: The photo evaluation data are for a sequence of vertical strip photography starting at 135.1 deg E Long. and ending at 49.6 deg W Long. Throughout the sequence tilt is maintained within the range 0.049 - .962 deg. Data for frames 2853 through 2884 are based on low bit rate vehicle attitude data. Star patterns companion to frames 2860 and 2995 are included in the data for this sequence.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	24	22	31	29.027
CTE			8	4	37	29.669

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-1054.9108240	1216.1642000	882.1317401	1.3092398	.9518025	.2630045
SELENOGRAPHIC	-1280.3789919	1276.1056436	319.7383906	1.1407203	1.1744926	-.0930042

LONGITUDE OF NADIR POINT	135.0957737	DEG	
	135 DEG, 5 MIN,	44.7853088	SEC
LONG OF CAMERA AXIS INTERSECT	135.1276913	DEG	
	135 DEG, 7 MIN,	39.6885681	SEC
SPACECRAFT RADIUS	1836.7692162	KM	
SCALE FACTOR	.0000000	M/KM	
MEAN ALTITUDE RATE	.0045874	KM/SEC	
TILT AZIMUTH	115.3440552	DEG	
SIGMA TILT AZIMUTH	.0184772	DEG	
SUN ELEVATION AT PRIN GRND PNT	-1.3118086	DEG	
LONGITUDE OF SUBSOLAR POINT	43.5173712	DEG	
	43 DEG, 31 MIN,	2.5363970	SEC
ALPHA	.5992646	DEG	
EMISSION ANGLE	.6535421	DEG	
PHASE ANGLE	90.7125578	DEG	
PHI	-.5426152	DEG	
SIGMA PHI	.0002000	DEG	
KAPPA	176.6188087	DEG	
SIGMA KAPPA	.0002000	DEG	
OMEGA	-.2973955	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	94.6429996	KM	

LATITUDE OF NADIR POINT	10.0304390	DEG	
	10 DEG, 1 MIN,	49.5804691	SEC
LATI OF CAMERA AXIS INTERSECT	10.0155505	DEG	
	10 DEG, 0 MIN,	55.9817791	SEC
SPACECRAFT ALTITUDE	97.6792198	KM	
AZIMUTH OF VELOCITY VECTOR	266.6698525	DEG	
HORIZONTAL VELOCITY	1.6398442	KM/SEC	
TILT ANGLE	.6187485	DEG	
SIGMA TILT ANGLE	.0002005	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	271.8280945	DEG	
LATITUDE OF SUBSOLAR POINT	1.5715348	DEG	
	1 DEG, 34 MIN,	17.5251961	SEC
SWING ANGLE	118.7267565	DEG	
SIGMA SWING ANGLE	.0184771	DEG	
NORTH DEVIATION ANGLE	183.3830922	DEG	
X-TILT	-.2973955	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	.5426079	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-93.3840082	DEG	
SIGMA HEADING	.0002000	DEG	
LASER SLANT RANGE	94.6374807	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.68996119	-.70143792	-.17871318	97.685236

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.80522916+00	.57270588+00	.15366815+00
-.17634550+00	.47871847+00	-.86007614+00
-.56613449+00	.66545970+00	.48647213+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99821155+00	-.59025104-01	-.94701534-02
.58977852-01	-.99824584+00	.51905071-02
-.97598660-02	.46226523-02	.99994169+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
12.670	137.555
7.616	137.841
7.362	132.760
12.333	132.445

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 57 MIN, 13.2 SEC DECLINATION 64 DEG, 54 MIN, 45.7 SEC

Figure 16(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT1972		4	24	23	32	28.178.
CTE			8	5	38	28.820

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	959.4363015	-1306.0459110	-912.6413057	-1.3607234	-.8535512	-.1982202
SELENOGRAPHIC	1187.3825922	-1396.3365953	-315.5230318	-1.2206657	-1.0566301	.1136539

LONGITUDE OF NADIR POINT	-49.6236382 DEG	LATITUDE OF NADIR POINT	-9.7672454 DEG
	-49 DEG, 37 MIN, 25.0973511 SEC		-9 DEG, 46 MIN, 2.0834827 SEC
LONG OF CAMERA AXIS INTERSECT	-49.6063557 DEG	LATI OF CAMERA AXIS INTERSECT	-9.7928740 DEG
	-49 DEG, 36 MIN, 22.8804016 SEC		-9 DEG, 47 MIN, 34.3463230 SEC
SPACECRAFT RADIUS	1859.8892685 KM	SPACECRAFT ALTITUDE	121.7992722 KM
SCALE FACTOR	.0006227 M/KM	AZIMUTH OF VELOCITY VECTOR	274.0538314 DEG
MEAN ALTITUDE RATE	-.0052940 KM/SEC	HORIZONTAL VELOCITY	1.6184207 KM/SEC
TILT AZIMUTH	146.3955746 DEG	TILT ANGLE	.4390726 DEG
SIGMA TILT AZIMUTH	.0262943 DEG	SIGMA TILT ANGLE	.0001985 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.8364544 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.8931007 DEG
LONGITUDE OF SUBSOLAR POINT	43.0014821 DEG	LATITUDE OF SUBSOLAR POINT	1.5718098 DEG
	43 DEG, 0 MIN, 5.3357343 SEC		1 DEG, 34 MIN, 18.5152817 SEC
ALPHA	-.2523141 DEG	SWING ANGLE	141.7155005 DEG
EMISSION ANGLE	.4698472 DEG	SIGMA SWING ANGLE	.0262943 DEG
PHASE ANGLE	93.0888367 DEG	NORTH DEVIATION ANGLE	175.3211952 DEG
PHI	-.2720395 DEG	X-TILT	-.3446480 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-175.3196030 DEG	Y-TILT	.2720346 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.3446480 DEG	HEADING	-85.3212375 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.63586741	.75431363	.16335112	121.803099

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.83957496+00	-.53150221+00	-.11233534+00
-.17884220+00	.46568309+00	-.86669187+00
.51296136+00	-.70756249+00	-.48603083+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99665643+00	.81568163-01	-.47478819-02
-.81596041-01	-.99664737+00	.60152062-02
-.42412646-02	.63825471-02	.99997064+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-6.889	-46.179
-13.220	-46.608
-12.670	-53.101
-6.408	-52.487

DIRECTION TO STELLAR PHOTO CENTER

RIGHT ASCENSION -4 HR, 25 MIN, 54.8 SEC DECLINATION

Figure 16(b) - Last Frame

4.0 APOLLO 16 24-INCH PANORAMIC CAMERA DATA

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 3, Camera: 24-Inch Panoramic Frames: 4091 Through: 4094

Coverage Interval:

From: 8.8 Deg N Lat., 168.5 Deg W Long., To: 8.9 Deg N Lat., 167.9 Deg W Long.

From: 80 Hr 38 Min 11.769 Sec, To: 80 Hr 38 Min 28.975 Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.709933

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 97 H, 33 M, 25.0508 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 3. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5499597.68	$\dot{X}$ =	1550.9475
Y =	1526310.53	$\dot{Y}$ =	-5313.7704
Z =	-896763.06	$\dot{Z}$ =	135.0770

● Telemetered Data Tape

Data Source: MSFN

Bit Rate: High

Date Edited: 7/18/72

Edited Data Tape No. A10084 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a five frame strip of stereo photography. Coverage starts at 168.5 deg W Long. and ends at 167.9 deg W Long. Throughout the coverage, tilt for the forward photos is approximately 1 deg higher than for the aft photos.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	20	2	32	11.142
CTE			3	8	38	11.769

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-890.0653735	1343.6036447	691.4137963	1.4060264	.7603448	.2216204
SELENOGRAPHIC	-1778.1532036	-387.4395691	283.1385600	-.3345442	1.5776791	-.0562040

LONGITUDE OF NADIR POINT	-167.7080135 DEG	LATITUDE OF NADIR POINT	8.8432649 DEG
	-167 DEG, 42 MIN, 28.8487244 SEC		8 DEG, 50 MIN, 35.7537746 SEC
LONG OF CAMERA AXIS INTERSECT	-168.5150509 DEG	LATI OF CAMERA AXIS INTERSECT	8.8374897 DEG
	-168 DEG, 30 MIN, 54.1831970 SEC		8 DEG, 50 MIN, 14.9630070 SEC
SPACECRAFT RADIUS	1841.7669992 KM	SPACECRAFT ALTITUDE	103.6770029 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	268.0768631 DEG
MEAN ALTITUDE RATE	-.0175363 KM/SEC	HORIZONTAL VELOCITY	1.6136132 KM/SEC
TILT AZIMUTH	269.6470871 DEG	TILT ANGLE	13.1122223 DEG
SIGMA TILT AZIMUTH	.0008816 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	1.1757364 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.3614044 DEG
LONGITUDE OF SUBSOLAR POINT	102.4379335 DEG	LATITUDE OF SUBSOLAR POINT	1.5256329 DEG
	102 DEG, 26 MIN, 16.5606165 SEC		1 DEG, 31 MIN, 32.2784615 SEC
ALPHA	-13.9024590 DEG	SWING ANGLE	271.7492634 DEG
EMISSION ANGLE	13.9096885 DEG	SIGMA SWING ANGLE	.0008816 DEG
PHASE ANGLE	102.7266855 DEG	NORTH DEVIATION ANGLE	182.0929709 DEG
PHI	13.1063217 DEG	X-TILT	.3967778 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.9434090 DEG	Y-TILT	-13.1060018 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.3967778 DEG	HEADING	-92.1489699 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002053 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	.89178278	.42648668	-.15110457	106.625305

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.73344560+00	.63393663+00	.24532015+00
-.12653318+00	.48191820+00	-.86703183+00
-.66786739+00	.60487954+00	.43367481+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97326728+00	-.36521075-01	.22675333+00
.35885713-01	-.99933191+00	-.69250231-02
.22685467+00	.13973199-02	.97392760+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
13.949	-168.412	11.305	-168.281
3.869	-168.019	6.421	-168.092
3.570	-168.737	6.276	-168.783
14.207	-169.192	11.400	-168.999

Figure 17(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	20	2	32	28.348
CTE			3	8	38	28.975

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-865.7707744	1356.5294850	895.1232087	1.4178882	.7421052	.2095468
SELENOGRAPHIC	-1783.7189831	-360.1683658	282.1385721	-.3104089	1.5827944	-.0600274

LONGITUDE OF NADIR POINT	-168.5843334 DEG	LATITUDE OF NADIR POINT	8.8132615 DEG
	-168 DEG, 35 MIN, 3.6003113 SEC		8 DEG, 48 MIN, 47.7414322 SEC
LONG OF CAMERA AXIS INTERSECT	-167.8575935 DEG	LATI OF CAMERA AXIS INTERSECT	8.8665766 DEG
	-167 DEG, 51 MIN, 27.3367310 SEC		8 DEG, 51 MIN, 59.6755886 SEC
SPACECRAFT RADIUS	1841.4605172 KM	SPACECRAFT ALTITUDE	103.3705209 KM
SCALE FACTOR	.0057273 M/KM	AZIMUTH OF VELOCITY VECTOR	267.9426114 DEG
MEAN ALTITUDE RATE	-.0180879 KM/SEC	HORIZONTAL VELOCITY	1.6138819 KM/SEC
TILT AZIMUTH	85.6981478 DEG	TILT ANGLE	11.9154662 DEG
SIGMA TILT AZIMUTH	.0009687 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	.5246239 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.4622841 DEG
LONGITUDE OF SUBSOLAR POINT	102.4355031 DEG	LATITUDE OF SUBSOLAR POINT	1.5256349 DEG
	102 DEG, 26 MIN, 7.8110218 SEC		1 DEG, 31 MIN, 32.2856855 SEC
ALPHA	12.5728508 DEG	SWING ANGLE	87.8071444 DEG
EMISSION ANGLE	12.6355541 DEG	SIGMA SWING ANGLE	.0009687 DEG
PHASE ANGLE	76.9023962 DEG	NORTH DEVIATION ANGLE	182.0166469 DEG
PHI	-11.9069887 DEG	X-TILT	.4526494 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.8437958 DEG	Y-TILT	11.9066118 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.4526494 DEG	HEADING	-92.0607604 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002044 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	.99084867	-.00996988	-.13460876	105.787130

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.95147753+00	.30604609+00	.32035913-01
-.12565602+00	.48145488+00	-.86741672+00
-.28069327+00	.82130205+00	.49655005+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97785235+00	-.35185641-01	-.20631710+00
.37622804-01	-.99926078+00	-.79001394-02
-.20588671+00	-.15487392-01	.97845329+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
14.217	-167.601
3.697	-167.265
3.915	-167.989
13.933	-168.349

LATITUDE	LONGITUDE
11.432	-167.574
6.360	-167.409
6.442	-168.098
11.298	-168.273

Figure 17(b) - Last Frame

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 17, Camera: 24-Inch Panoramic Frames: 4095 Through: 4347

Coverage Interval:

From: 8.9 Deg N Lat., 178.3 Deg E Long., To: 2.1 Deg S Lat., 89.5 Deg E Long.

From: 105 Hr 29 Min 46.252 Sec, To: 105 Hr 59 Min 26.977 Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710000

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 124 H, 18 M, 14.4040 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 17. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	57684369.59	$\dot{X}$ =	1386.1866
Y =	1600918.51	$\dot{Y}$ =	-5162.0522
Z =	-968674.79	$\dot{Z}$ =	-38.4413

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/18/72

Edited Data Tape No. A10084 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4657332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of stereo photography starting at 178.3 deg E Long. and ending at 89.5 deg E Long. Throughout the sequence a tilt magnitude of approximately 12.5 deg was maintained. Computations for frame 4249 were omitted as a result of a computer card reader failure.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	3	23	45.622
CTE			4	9	29	46.252

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-909.3640068	1342.8361762	896.8782295	1.3935708	.8018232	.2355342
SELENOGRAPHIC	-1830.5550221	27.0958074	287.8838683	.0031730	1.6238513	-.0594315

LONGITUDE OF NADIR POINT	179.1522846 DEG	LATITUDE OF NADIR POINT	8.9365070 DEG
	179 DEG, 9 MIN, 8.2246399 SEC		8 DEG, 56 MIN, 11.4251518 SEC
LONG OF CAMERA AXIS INTERSECT	178.3056278 DEG	LATI OF CAMERA AXIS INTERSECT	8.9101627 DEG
	178 DEG, 18 MIN, 20.2601624 SEC		8 DEG, 54 MIN, 36.5856743 SEC
SPACECRAFT RADIUS	1853.2518586 KM	SPACECRAFT ALTITUDE	115.1618623 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	267.8161734 DEG
MEAN ALTITUDE RATE	.0111691 KM/SEC	HORIZONTAL VELOCITY	1.6248740 KM/SEC
TILT AZIMUTH	268.2616577 DEG	TILT ANGLE	12.4103862 DEG
SIGMA TILT AZIMUTH	.0009306 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	1.7133036 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.2870178 DEG
LONGITUDE OF SUBSOLAR POINT	89.7994754 DEG	LATITUDE OF SUBSOLAR POINT	1.5363233 DEG
	89 DEG, 47 MIN, 58.1114960 SEC		1 DEG, 32 MIN, 10.7638264 SEC
ALPHA	-13.2270234 DEG	SWING ANGLE	270.2527417 DEG
EMISSION ANGLE	13.2472040 DEG	SIGMA SWING ANGLE	.0009306 DEG
PHASE ANGLE	101.5135775 DEG	NORTH DEVIATION ANGLE	181.9504863 DEG
PHI	12.4102677 DEG	X-TILT	.0543171 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	178.0148239 DEG	Y-TILT	-12.4102621 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.0543171 DEG	HEADING	-91.9971283 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002048 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.96683802	.20053106	-.15815034	118.106976

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.73585531+00	.63123518+00	.24506975+00
-.13032704+00	.48717982+00	-.86352225+00
-.66447857+00	.60348822+00	.44076087+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97604061+00	-.34035110-01	.21491025+00
.34640891-01	-.99939937+00	-.94801286-03
.21481336+00	.65193970-02	.97663334+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
14.564	178.431	11.638	178.570
3.299	178.845	6.213	178.768
2.968	178.037	6.057	178.000
14.837	177.570	11.737	177.779

Figure 18(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT1972	4	21	3	53	26.347	
CTE			4	9	59	26.977

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1583.8796796	936.8574007	281.7897672	.8187547	-1.1573246	-.7785707
SELENOGRAPHIC	-12.2699572	1860.5065457	-64.3967624	1.5975596	-.0018745	-.2524513

LONGITUDE OF NADIR POINT	90.3778572 DEG	LATITUDE OF NADIR POINT	-1.9823151 DEG
	90 DEG, 22 MIN, 40.2859497 SEC		-1 DEG, 58 MIN, 56.3342571 SEC
LONG OF CAMERA AXIS INTERSECT	89.4983664 DEG	LATI OF CAMERA AXIS INTERSECT	-2.1145118 DEG
	89 DEG, 29 MIN, 54.1188812 SEC		-2 DEG, 6 MIN, 52.2425437 SEC
SPACECRAFT RADIUS	1861.6611135 KM	SPACECRAFT ALTITUDE	123.5711172 KM
SCALE FACTOR	.0048016 M/KM	AZIMUTH OF VELOCITY VECTOR	261.0102047 DEG
MEAN ALTITUDE RATE	-.0036700 KM/SEC	HORIZONTAL VELOCITY	1.6173507 KM/SEC
TILT AZIMUTH	261.4309006 DEG	TILT ANGLE	12.2872610 DEG
SIGMA TILT AZIMUTH	.0009397 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	86.3486109 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	.7800902 DEG
LONGITUDE OF SUBSOLAR POINT	89.5480634 DEG	LATITUDE OF SUBSOLAR POINT	1.5365393 DEG
	89 DEG, 32 MIN, 53.0281734 SEC		1 DEG, 32 MIN, 11.5413952 SEC
ALPHA	-12.6750675 DEG	SWING ANGLE	270.7877109 DEG
EMISSION ANGLE	13.1760854 DEG	SIGMA SWING ANGLE	.0009397 DEG
PHASE ANGLE	13.0817814 DEG	NORTH DEVIATION ANGLE	189.1633378 DEG
PHI	12.2861401 DEG	X-TILT	.1676303 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	170.6612263 DEG	Y-TILT	-12.2860870 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.1676303 DEG	HEADING	-99.3752798 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002047 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

	X	Y	Z	MAGNITUDE (KM)
SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	.21688019	-.97619595	.00210799	126.682139

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.67666548+00	-.58775391+00	-.44347393+00
-.13951855+00	.48904267+00	-.86102952+00
.72295114+00	.64450188+00	.24891576+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96404571+00	-.15916943+00	.21279313+00
.16227089+00	-.98674191+00	-.29256958-02
.21043766+00	.31709626-01	.97709291+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
3.977	88.853	.832	89.405
-8.028	90.838	-4.922	90.353
-8.493	90.013	-5.190	89.559
4.163	87.918	.834	88.565

Figure 18(b) - Last Frame

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 18, Camera: 24-Inch Panoramic Frames: 4348 Through: 4612

Coverage Interval:

From: 2.2 Deg S Lat., 88.1 Deg E Long., To: 9.0 Deg S Lat., 1.8 Deg W Long.

From: 107 Hr 58 Min 25.361 Sec, To: 108 Hr 28 Min 8.256 Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710000

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 126 H, 16 M, 46.4972 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 18. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5769560.47	$\dot{X}$ =	1384.6915
Y =	1601230.32	$\dot{Y}$ =	-5161.2314
Z =	-968788.38	$\dot{Z}$ =	-52.6562

- Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/4/72

Edited Data Tape No. A09829 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of stereo photography starting at 88.1 deg E Long. and ending at 1.8 deg W Long. Throughout the sequence the magnitudes of forward and aft tilt oscillate about a mean value of 12.5 deg. Their maximum departure from the mean is maintained less than 1 degree. Data for frames 4384 and 4530 were omitted as the result of a computer card reader failure.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	5	52	24.731
CTE			4	11	58	25.361

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1587.4663469	931.3925323	277.2840926	.8131732	-1.1606439	-.7798125
SELENOGRAPHIC	30.7538782	1859.8605897	-66.3378142	1.5974086	-.0389349	-.2523622

LONGITUDE OF NADIR POINT	89.0526667 DEG	LATITUDE OF NADIR POINT	-2.0424903 DEG
	89 DEG, 3 MIN, 9.5999908 SEC		-2 DEG, 2 MIN, 32.9651999 SEC
LONG OF CAMERA AXIS INTERSECT	88.1531973 DEG	LATI OF CAMERA AXIS INTERSECT	-2.1650262 DEG
	88 DEG, 9 MIN, 11.5102386 SEC		-2 DEG, 9 MIN, 54.0943837 SEC
SPACECRAFT RADIUS	1861.2973754 KM	SPACECRAFT ALTITUDE	123.2073791 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	261.0148324 DEG
MEAN ALTITUDE RATE	-.0035168 KM/SEC	HORIZONTAL VELOCITY	1.6176554 KM/SEC
TILT AZIMUTH	262.2207603 DEG	TILT ANGLE	12.5680420 DEG
SIGMA TILT AZIMUTH	.0009191 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	86.2774000 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	5.9700980 DEG
LONGITUDE OF SUBSOLAR POINT	88.5402532 DEG	LATITUDE OF SUBSOLAR POINT	1.5374056 DEG
	88 DEG, 32 MIN, 24.9116135 SEC		1 DEG, 32 MIN, 14.6600533 SEC
ALPHA	-12.9606432 DEG	SWING ANGLE	271.1264366 DEG
EMISSION ANGLE	13.4752282 DEG	SIGMA SWING ANGLE	.0009191 DEG
PHASE ANGLE	13.0923233 DEG	NORTH DEVIATION ANGLE	188.7214784 DEG
PHI	12.5656952 DEG	X-TILT	.2450964 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	171.1213036 DEG	Y-TILT	-12.5655787 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2450964 DEG	HEADING	-98.9333272 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002049 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	.19942273	-.97989894	.00535187	126.455297

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.67811526+00	-.59090939+00	-.43701915+00
-.13702655+00	.48254384+00	-.86508680+00
.72206881+00	.64651187+00	.24625010+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96420787+00	-.15156558+00	.21755690+00
.15434160+00	-.98800828+00	-.42777260-02
.21559646+00	.29453463-01	.97603828+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
3.931	87.554	.778	88.083
-8.060	89.440	-4.970	88.983
-8.523	88.615	-5.234	88.189
4.133	86.616	.790	87.242

Figure 19(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	21	6	22	7.626
CTE			4	12	28	8.256

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	945.9825560	-1313.2007189	-886.2123836	-1.3894715	-.8201381	-.2454319
SELENOGRAPHIC	1822.2160755	-31.3971509	-288.6075298	-.0299249	-1.6307360	.0574345

LONGITUDE OF NADIR POINT	-.9871202 DEG	LATITUDE OF NADIR POINT	-8.9985898 DEG
	0 DEG, 59 MIN, 13.6325741 SEC		-8 DEG, 59 MIN, 54.9231148 SEC
LONG OF CAMERA AXIS INTERSECT	-1.7587395 DEG	LATI OF CAMERA AXIS INTERSECT	-8.9525315 DEG
	-1 DEG, 45 MIN, 31.4620399 SEC		-8 DEG, 57 MIN, 9.1132450 SEC
SPACECRAFT RADIUS	1845.1968766 KM	SPACECRAFT ALTITUDE	107.1068802 KM
SCALE FACTOR	.0055366 M/KM	AZIMUTH OF VELOCITY VECTOR	271.9819578 DEG
MEAN ALTITUDE RATE	-.0107874 KM/SEC	HORIZONTAL VELOCITY	1.6319562 M/SEC
TILT AZIMUTH	273.3979530 DEG	TILT ANGLE	12.1845711 DEG
SIGMA TILT AZIMUTH	.0009477 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	-.2859440 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.4884539 DEG
LONGITUDE OF SUBSOLAR POINT	88.2885468 DEG	LATITUDE OF SUBSOLAR POINT	1.5376220 DEG
	88 DEG, 17 MIN, 18.7686396 SEC		1 DEG, 32 MIN, 15.4393101 SEC
ALPHA	12.8975185 DEG	SWING ANGLE	271.3230213 DEG
EMISSION ANGLE	12.9481259 DEG	SIGMA SWING ANGLE	.0009478 DEG
PHASE ANGLE	77.3884840 DEG	NORTH DEVIATION ANGLE	178.0014428 DEG
PHI	12.1814179 DEG	X-TILT	.2792152 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-177.8952751 DEG	Y-TILT	-12.1812711 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2792152 DEG	HEADING	-87.9555495 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002046 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	-.96697230	-.19406057	.16524248	109.733179

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.72059700+00	-.64651096+00	-.25052666+00
-.13864428+00	.48838515+00	-.86154379+00
.67935092+00	-.58609179+00	-.44156393+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97686274+00	.34871601-01	.21100529+00
-.36725652-01	-.99931350+00	-.48732057-02
.21069042+00	-.12509774-01	.97747276+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
-3.714	-1.247	-6.437	-1.325
-14.126	-1.641	-11.474	-1.515
-14.360	-2.424	-11.561	-2.244
-3.411	-2.000	-6.293	-2.040

Figure 19(b) - Last Frame

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 28, Camera: 24-Inch Panoramic Frames: 4614 Through: 4627

Coverage Interval:

From: 9.0 Deg S Lat., 16.6 Deg E Long., To: 9.1 Deg S Lat., 13.9 Deg E Long.

From: 128 Hr 7 Min 32.439 Sec, To: 128 Hr 8 Min 58.758 Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710050

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 146 H, 2 M, 10.1686 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 28. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5782954.93	$\dot{X}$ =	1370.4210
Y =	1604947.71	$\dot{Y}$ =	-5151.1242
Z =	-954553.59	$\dot{Z}$ =	-193.8567

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/18/72

Edited Data Tape No. A10801 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a short strip of stereo photography starting at 16.6 deg E Long. and ending at 13.9 deg E Long. Throughout the sequence the magnitude of forward and aft tilt are maintained at approximately 12.5 deg.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	2	1	31.806
CTE			5	8	7	32.439

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1589.7810865	-698.4587998	-645.5421222	-.8104263	-1.2804201	-.5881402
SELENOGRAPHIC	1745.5638857	549.3072531	-288.5160175	.4697856	-1.5546377	-.0676652

LONGITUDE OF NADIR POINT	17.468140$_6$ DEG	LATITUDE OF NADIR POINT	-8.996708 DEG
	17 DEG, 28 MIN, 5.3061676 SEC		-8 DEG, 57 MIN, 34.8148155 SEC
LONG OF CAMERA AXIS INTERSECT	16.6248457 DEG	LATI OF CAMERA AXIS INTERSECT	-9.0112898 DEG
	16 DEG, 37 MIN, 29.4446754 SEC		-9 DEG, 0 MIN, 40.6434059 SEC
SPACECRAFT RADIUS	1852.5585631 KM	SPACECRAFT ALTITUDE	114.4685667 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	267.5414243 DEG
MEAN ALTITUDE RATE	-.0077785 KM/SEC	HORIZONTAL VELOCITY	1.6254288 KM/SEC
TILT AZIMUTH	266.3880272 DEG	TILT ANGLE	12.4502412 DEG
SIGMA TILT AZIMUTH	.0009275 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	27.6594982 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	83.4562654 DEG
LONGITUDE OF SUBSOLAR POINT	78.3000584 DEG	LATITUDE OF SUBSOLAR POINT	1.5461835 DEG
	78 DEG, 18 MIN, .2103996 SEC		1 DEG, 32 MIN, 46.2607098 SEC
ALPHA	13.2596039 DEG	SWING ANGLE	268.6508529 DEG
EMISSION ANGLE	13.2847749 DEG	SIGMA SWING ANGLE	.0009275 DEG
PHASE ANGLE	49.0777864 DEG	NORTH DEVIATION ANGLE	182.1781054 DEG
PHI	12.4468876 DEG	X-TILT	-.2908390 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.7054539 DEG	Y-TILT	-12.4467243 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.2908390 DEG	HEADING	-92.2303501 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002048 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.85751774	-.49541558	.13866047	117.414060

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.29735443+00	-.85411445+00	-.42669538+00
-.13513026+00	.48006016+00	-.86676528+00
.94515612+00	-.20007700+00	-.25816471+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97575714+00	-.38002450-01	.21553172+00
.40036139-01	-.99918534+00	.50760766-02
.21516323+00	.13582055-01	.97648361+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
-3.452	16.749	-6.313	16.884
-14.646	17.180	-11.705	17.092
-14.985	16.341	-1.862	16.313
-3.167	15.929	-6.215	16.114

Figure 20(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	2	2	58.125
CTE			5	8	8	58.758

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1515.3244882	-80.8710695	-694.4063218	-.9139160	-1.2302643	-.5434856
SELENOGRAPHIC	1781.1558962	413.2528780	-293.5218892	.3518939	-1.5868241	-.0482649

LONGITUDE OF NADIR POINT	13.0623053 DEG	LATITUDE OF NADIR POINT	-9.1198210 DEG
	13 DEG, 3 MIN, 44.2991924 SEC		-9 DEG, 7 MIN, 11.3554287 SEC
LONG OF CAMERA AXIS INTERSECT	13.9108593 DEG	LATI OF CAMERA AXIS INTERSECT	-9.0847652 DEG
	13 DEG, 54 MIN, 39.0936470 SEC		-9 DEG, 5 MIN, 5.1547050 SEC
SPACECRAFT RADIUS	1851.8772549 KM	SPACECRAFT ALTITUDE	113.7872586 KM
SCALE FACTOR	.0052197 M/KM	AZIMUTH OF VELOCITY VECTOR	268.2320466 DEG
MEAN ALTITUDE RATE	-.0079998 KM/SEC	HORIZONTAL VELOCITY	1.6260409 KM/SEC
TILT AZIMUTH	87.6713514 DEG	TILT ANGLE	12.5810752 DEG
SIGMA TILT AZIMUTH	.0009181 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	24.9992762 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	83.9894753 DEG
LONGITUDE OF SUBSOLAR POINT	78.2878766 DEG	LATITUDE OF SUBSOLAR POINT	1.5461939 DEG
	78 DEG, 17 MIN, 16.3556242 SEC		1 DEG, 32 MIN, 46.2979317 SEC
ALPHA	-13.3984538 DEG	SWING ANGLE	88.9514869 DEG
EMISSION ANGLE	13.4196705 DEG	SIGMA SWING ANGLE	.0009180 DEG
PHASE ANGLE	78.3968191 DEG	NORTH DEVIATION ANGLE	181.2242759 DEG
PHI	-12.5790266 DEG	X-TILT	.2283757 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	178.6746983 DEG	Y-TILT	12.5789246 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.2283757 DEG	HEADING	-91.2543406 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002049 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.98653938	-.00546885	.16343236	116.777364

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.72159503+00	-.64983630+00	-.23877491+00
-.14563588+00	.47983137+00	-.86515533+00
.67678095+00	-.58946984+00	-.44101339+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97576310+00	-.21365183-01	-.21778425+00
.22779656-01	-.99973256+00	-.39858981-02
-.21764090+00	-.88503613-02	.97598876+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
-3.161	14.257	-6.255	14.252
-14.895	14.553	-11.875	14.393
-14.619	13.713	-11.767	13.615
-3.489	13.447	-6.403	13.486

Figure 20(b) - Last Frame

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 38, Camera: 24-Inch Panoramic Frames: 4628 Through: 4716

Coverage Interval:

From: 9.0 Deg S Lat., 7.8 Deg E Long., To: 9.0 Deg S Lat., 22.2 Deg W Long.

From: 147 Hr 55 Min 37.543 Sec, To: 148 Hr 5 Min 26.523 Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710100

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 165 H, 47 M, 22.5165 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 38. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5798599.59	$\dot{X}$ =	1360.7713
Y =	1609289.57	$\dot{Y}$ =	-5137.8823
Z =	-912614.82	$\dot{Z}$ =	-330.5843

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 8/4/72

Edited Data Tape No. A09043 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a strip of stereo photography starting at 7.8 deg E Long. and ending at 22.2 deg W Long. Throughout the sequence the tilt magnitude for the aft photographs is slightly larger than for the forward photographs, with the difference increasing with time. The mean value of tilt magnitude is approximately 12 degrees, with the maximum variation from this mean value less than 0.6 deg.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	21	49	36.906
CTE			6	3	55	37.543

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1622.8406748	-644.3131226	-625.2243566	-.7554328	-1.3043928	-.6034328
SELENOGRAPHIC	1810.8720766	276.4888741	-289.7464004	.2292108	-1.6058067	-.0713981

LONGITUDE OF NADIR POINT	8.6810323 DEG	LATITUDE OF NADIR POINT	-8.9880570 DEG
	8 DEG, 40 MIN, 51.7162800 SEC		-8 DEG, 59 MIN, 17.0052624 SEC
LONG OF CAMERA AXIS INTERSECT	7.8110671 DEG	LATI OF CAMERA AXIS INTERSECT	-8.9983277 DEG
	7 DEG, 48 MIN, 39.8415756 SEC		-8 DEG, 59 MIN, 53.9798355 SEC
SPACECRAFT RADIUS	1854.6311633 KM	SPACECRAFT ALTITUDE	116.5411670 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	267.4235245 DEG
MEAN ALTITUDE RATE	-.0044369 KM/SEC	HORIZONTAL VELOCITY	1.6236178 KM/SEC
TILT AZIMUTH	269.2472000 DEG	TILT ANGLE	12.5867338 DEG
SIGMA TILT AZIMUTH	.0009182 DEG	SIGMA TILT ANGLE	.0001999 DEG
SUN ELEVATION AT PRIN GRND PNT	28.8804197 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	83.1821556 DEG
LONGITUDE OF SUBSOLAR POINT	68.2415738 DEG	LATITUDE OF SUBSOLAR POINT	1.5545224 DEG
	68 DEG, 14 MIN, 29.6657753 SEC		1 DEG, 33 MIN, 16.2807655 SEC
ALPHA	13.3398457 DEG	SWING ANGLE	271.5396973 DEG
EMISSION ANGLE	13.4460561 DEG	SIGMA SWING ANGLE	.0009182 DEG
PHASE ANGLE	47.7667819 DEG	NORTH DEVIATION ANGLE	182.2744117 DEG
PHI	12.5823243 DEG	X-TILT	.3354879 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.7444839 DEG	Y-TILT	-12.5821046 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.3354879 DEG	HEADING	-92.3303968 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002049 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.92049383	-.36096699	.14964605	119.611205

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.26055049+00	-.86269760+00	-.43343557+00
-.14942570+00	.47956583+00	-.86468987+00
.95382669+00	-.16052892+00	-.25386029+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97517772+00	-.39685385-01	.21783842+00
.39355332-01	-.99920812+00	-.58553351-02
.21789829+00	.28630898-02	.97596724+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
-3.217	7.926	-6.225	8.072
-14.635	8.376	-11.718	8.288
-14.971	7.537	-11.878	7.501
-2.928	7.071	-6.121	7.279

Figure 21(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	21	59	25.888
CTE			6	4	5	26.523

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	985.5015342	-1294.6387594	-883.3356657	-1.3608427	-.8540836	-.2531094
SELENOGRAPHIC	1702.3654575	-666.4953727	-292.0966563	-.5890338	-1.5147264	.0637103

LONGITUDE OF NADIR POINT		-21.3809061	DEG
	-21 DEG, 22 MIN,	51.2619781	SEC
LONG OF CAMERA AXIS INTERSECT		-22.1957281	DEG
	-22 DEG, 11 MIN,	44.6210289	SEC
SPACECRAFT RADIUS		1851.3737304	KM
SCALE FACTOR		.0052347	M/KM
MEAN ALTITUDE RATE		-.0063748	KM/SEC
TILT AZIMUTH		273.7159309	DEG
SIGMA TILT AZIMUTH		.0009494	DEG
SUN ELEVATION AT PRIN GRND PNT		-.5935221	DEG
LONGITUDE OF SUBSOLAR POINT		68.1584813	DEG
	68 DEG, 9 MIN,	30.5326867	SEC
ALPHA		12.9163529	DEG
EMISSION ANGLE		12.9730190	DEG
PHASE ANGLE		77.6773033	DEG
PHI		12.1638937	DEG
SIGMA PHI		.0002000	DEG
KAPPA		-177.4818363	DEG
SIGMA KAPPA		.0002000	DEG
OMEGA		.2582145	DEG
SIGMA OMEGA		.0002000	DEG
SPACECRAFT ALTITUDE (LASER)		.0000000	KM

LATITUDE OF NADIR POINT		-9.0776526	DEG
	-9 DEG, 4 MIN,	39.5492649	SEC
LATI OF CAMERA AXIS INTERSECT		-9.0244869	DEG
	-9 DEG, 1 MIN,	28.1528378	SEC
SPACECRAFT ALTITUDE		113.2837340	KM
AZIMUTH OF VELOCITY VECTOR		272.2374937	DEG
HORIZONTAL VELOCITY		1.6264314	KM/SEC
TILT ANGLE		12.1665952	DEG
SIGMA TILT ANGLE		.0001999	DEG
SUN AZIMUTH AT PRINCIPAL GRND PNT		88.5201378	DEG
LATITUDE OF SUBSOLAR POINT		1.5545892	DEG
	1 DEG, 33 MIN,	16.5209770	SEC
SWING ANGLE		271.2252778	DEG
SIGMA SWING ANGLE		.0009495	DEG
NORTH DEVIATION ANGLE		177.5925864	DEG
X-TILT		.2582145	DEG
SIGMA X-TILT		.0002000	DEG
Y-TILT		-12.1637682	DEG
SIGMA Y-TILT		.0002000	DEG
HEADING		-87.5374934	DEG
SIGMA HEADING		.0002046	DEG
LASER SLANT RANGE		.0000000	KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.97352739	.15529132	.16771709	116.062756

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.70315441+00	-.66519856+00	-.25116693+00
-.14820803+00	.48259769+00	-.86321136+00
.69541944+00	-.56974591+00	-.43792847+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97664666+00	.42001013-01	.21070667+00
-.43935647-01	-.99902420+00	-.45066771-02
.21031170+00	-.13658980-01	.97753894+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE
-3.467	-21.615
-14.524	-22.116
-14.770	-22.953
-3.135	-22.412

LATITUDE	LONGITUDE
-6.366	-21.717
-11.696	-21.959
-11.783	-22.732
-6.207	-22.473

Figure 21(b) - Last Frame

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 39, Camera: 24-Inch Panoramic Frames: 4717 Through: 4911

Coverage Interval:

From: 9.0 Deg N Lat., 156.7 Deg E Long., To: 1.5 Deg N Lat., 91.6 Deg E Long.

From: 149 Hr 4 Min 46.695 Sec, To: 149 Hr 26 Min 15.154 Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710100

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 167 H, 45 M, 53.5361 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 39. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5800294.59	$\dot{X}$ =	3160.1109
Y =	1609760.00	$\dot{Y}$ =	-5136.1892
Z =	-906947.38	$\dot{Z}$ =	-343.8382

- Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/19/72

Edited Data Tape No. A07978 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this interval.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of stereo photography starting at 156.7 deg E Long. and ending at 91.6 deg E Long. Throughout the sequence a tilt magnitude of 12.5 deg ±0.6 deg is maintained.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	22	58	46.060
CTE			6	5	4	46.695

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-967.1870384	1300.5628379	883.4584600	1.3666329	.8543909	.2518001
SELENOGRAPHIC	-1684.1451029	697.6819215	290.3592983	.6082456	1.5122498	-.0648889

LONGITUDE OF NADIR POINT	157.4974957 DEG	LATITUDE OF NADIR POINT	9.0500997 DEG
	157 DEG, 29 MIN, 50.9843445 SEC		9 DEG, 3 MIN, .3590298 SEC
LONG OF CAMERA AXIS INTERSECT	156.7167320 DEG	LATI OF CAMERA AXIS INTERSECT	8.9970291 DEG
	156 DEG, 43 MIN, .2352905 SEC		8 DEG, 59 MIN, 49.3046379 SEC
SPACECRAFT RADIUS	1845.9180137 KM	SPACECRAFT ALTITUDE	107.8280174 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	267.6555626 DEG
MEAN ALTITUDE RATE	.0064219 KM/SEC	HORIZONTAL VELOCITY	1.6312371 KM/SEC
TILT AZIMUTH	266.1241417 DEG	TILT ANGLE	12.2491976 DEG
SIGMA TILT AZIMUTH	.0009429 DEG	SIGMA TILT ANGLE	.0001999 DEG
SUN ELEVATION AT PRIN GRND PNT	1.1707726 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.3892365 DEG
LONGITUDE OF SUBSOLAR POINT	67.6562215 DEG	LATITUDE OF SUBSOLAR POINT	1.5549915 DEG
	67 DEG, 39 MIN, 22.3975468 SEC		1 DEG, 33 MIN, 17.9694557 SEC
ALPHA	-12.9641336 DEG	SWING ANGLE	268.1395209 DEG
EMISSION ANGLE	13.0221169 DEG	SIGMA SWING ANGLE	.0009430 DEG
PHASE ANGLE	101.7930870 DEG	NORTH DEVIATION ANGLE	181.9273963 DEG
PHI	12.2429329 DEG	X-TILT	-.3946604 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.9422989 DEG	Y-TILT	-12.2426380 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.3946603 DEG	HEADING	-91.9720630 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002047 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.97052143	-.17292936	-.16787968	110.501815

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.71051470+00	.65547011+00	.25598412+00
-.14131764+00	.48928013+00	-.86060111+00
-.68934616+00	.57529467+00	.44027022+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97667959+00	-.33629608-01	.21205210+00
.35905062-01	-.99933147+00	.68880681-02
.21167862+00	.14341194-01	.97723408+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
14.191	156.841	11.532	156.965
3.701	157.226	6.460	157.151
3.391	156.464	6.314	156.429
14.427	156.055	11.620	156.232

Figure 22(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	22	23	20	14.519
CTE			6	5	26	15.154

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	998.9666877	1428.4342165	631.8343315	1.3510841	-.6741950	-.5976409
SELENOGRAPHIC	-77.9803550	1851.5960239	55.5392211	1.6011053	.0800854	-.2592101

LONGITUDE OF NADIR POINT	92.4115982 DEG
92 DEG, 24 MIN,	41.7535400 SEC
LONG OF CAMERA AXIS INTERSECT	91.5785351 DEG
91 DEG, 34 MIN,	42.7262878 SEC
SPACECRAFT RADIUS	1854.0694099 KM
SCALE FACTOR	.0051232 M/KM
MEAN ALTITUDE RATE	.0048729 KM/SEC
TILT AZIMUTH	258.5740585 DEG
SIGMA TILT AZIMUTH	.0009239 DEG
SUN ELEVATION AT PRIN GRND PNT	65.9048853 DEG
LONGITUDE OF SUBSOLAR POINT	67.4744511 DEG
67 DEG, 28 MIN,	28.0238485 SEC
ALPHA	-13.2339654 DEG
EMISSION ANGLE	13.3569799 DEG
PHASE ANGLE	37.2639818 DEG
PHI	12.4984595 DEG
SIGMA PHI	.0002000 DEG
KAPPA	170.7210655 DEG
SIGMA KAPPA	.0002000 DEG
OMEGA	-.4761485 DEG
SIGMA OMEGA	.0002000 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM

LATITUDE OF NADIR POINT	1.7165695 DEG
1 DEG, 42 MIN,	59.6502972 SEC
LATI OF CAMERA AXIS INTERSECT	1.5480879 DEG
1 DEG, 32 MIN,	53.1162930 SEC
SPACECRAFT ALTITUDE	115.9794135 KM
AZIMUTH OF VELOCITY VECTOR	260.8057858 DEG
HORIZONTAL VELOCITY	1.6238910 KM/SEC
TILT ANGLE	12.5073693 DEG
SIGMA TILT ANGLE	.0001999 DEG
SUN AZIMUTH AT PRINCIPAL GRND PNT	270.3477478 DEG
LATITUDE OF SUBSOLAR POINT	1.5551367 DEG
1 DEG, 33 MIN,	18.4922218 SEC
SWING ANGLE	267.8008495 DEG
SIGMA SWING ANGLE	.0009239 DEG
NORTH DEVIATION ANGLE	188.9625223 DEG
X-TILT	-.4761485 DEG
SIGMA X-TILT	.0002000 DEG
Y-TILT	-12.4980216 DEG
SIGMA Y-TILT	.0002000 DEG
HEADING	-99.1733898 DEG
SIGMA HEADING	.0002048 DEG
LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.25309223	-.96474972	-.07212702	118.994429

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.92734444+00	-.24102902+00	-.28624677+00
-.13880125+00	.48881974+00	-.86127201+00
.34751466+00	.83842730+00	.41984918+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96381692+00	-.15564494+00	.21640590+00
.16123539+00	-.98688099+00	.83102628-02
.21227343+00	.42901861-01	.97626816+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
7.128	91.005	4.288	91.500
-4.090	92.833	-1.111	92.378
-4.542	92.052	-1.367	91.628
7.289	90.146	4.290	90.717

Figure 22(b) - Last Frame

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 47, Camera: 24-Inch Panoramic Frames: 4912 Through: 5203

Coverage Interval:

From: 9.0 Deg N Lat., 148.7 Deg E Long., To: 3.2 Deg S Lat., 54.1 Deg E Long.

From: 164 Hr 55 Min 35.071 Sec, To: 165 Hr 27 Min 26.740Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710150

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 183 H, 33 M, 58.1984 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 47. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5813990.47	$\dot{X}$ =	1357.9511
Y =	1613561.06	$\dot{Y}$ =	-5123.2939
Z =	-852264.80	$\dot{Z}$ =	-446.3621

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 7/24/72

Edited Data Tape No. A10818 File No.: 12 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.6699935	-.5998623	-.4373487
.1294099	-.4857332	.8644746
-.7310005	-.6357897	-.2478100

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally,the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of stereo photography that starts at 148.7 deg E Long. and ends at 54.1 deg E Long. Throughout the sequence a tilt magnitude of 12.5 ±0.6 deg is maintained. Generally the magnitude of aft photograph tilts exceed their forward photo counterparts.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	23	14	49	34.434
CTE			6	20	55	35.071

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	-983.9474474	1286.9048204	878.0222510	1.3586233	.8715172	.2559675
SELENOGRAPHIC	-1567.6872469	923.7526848	290.2367009	.8150420	1.4148404	-.0676767

LONGITUDE OF NADIR POINT	149.4914703 DEG	LATITUDE OF NADIR POINT	9.0626398 DEG
	149 DEG, 29 MIN, 29.2932129 SEC		9 DEG, 3 MIN, 45.5033970 SEC
LONG OF CAMERA AXIS INTERSECT	148.7096653 DEG	LATI OF CAMERA AXIS INTERSECT	9.0241902 DEG
	148 DEG, 42 MIN, 34.7950745 SEC		9 DEG, 1 MIN, 27.0846748 SEC
SPACECRAFT RADIUS	1842.6067593 KM	SPACECRAFT ALTITUDE	104.5167629 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	267.5674010 DEG
MEAN ALTITUDE RATE	.0052042 KM/SEC	HORIZONTAL VELOCITY	1.6341734 KM/SEC
TILT AZIMUTH	267.2105293 DEG	TILT ANGLE	12.6262773 DEG
SIGMA TILT AZIMUTH	.0009152 DEG	SIGMA TILT ANGLE	.0001999 DEG
SUN ELEVATION AT PRIN GRND PNT	1.1327848 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.4010696 DEG
LONGITUDE OF SUBSOLAR POINT	59.6090324 DEG	LATITUDE OF SUBSOLAR POINT	1.5611813 DEG
	59 DEG, 36 MIN, 32.5167561 SEC		1 DEG, 33 MIN, 40.2527905 SEC
ALPHA	-13.3610181 DEG	SWING ANGLE	269.7790712 DEG
EMISSION ANGLE	13.3993144 DEG	SIGMA SWING ANGLE	.0009152 DEG
PHASE ANGLE	102.2280531 DEG	NORTH DEVIATION ANGLE	182.5011824 DEG
PHI	12.6261840 DEG	X-TILT	-.0482929 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	177.4261189 DEG	Y-TILT	-12.6261794 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.0482929 DEG	HEADING	-92.5630632 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002050 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.93961948	-.30025033	-.16421015	107.269062

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.69581245+00	.07196155+00	.25359966+00
-.14723220+00	.47904477+00	-.86535472+00
-.70297059+00	.56478655+00	.43225970+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97484083+00	-.43637536-01	.21858913+00
.44907564-01	-.99899079+00	.84286983-03
.21833167+00	.10637984-01	.97581661+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
14.105	148.777	11.496	148.926
3.957	149.252	6.580	149.155
3.650	148.524	6.430	148.458
14.340	148.003	11.579	148.209

Figure 23(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	23	15	21	26.102
CTE			6	21	27	26.740

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1647.1490733	833.1928486	186.1669210	.7131593	-1.2210572	-.7963375
SELENOGRAPHIC	1109.6901708	1482.6883935	-110.4145265	1.2782677	-.9689635	-.2467221

LONGITUDE OF NADIR POINT	53.1876745	DEG	
53 DEG, 11 MIN,	15.6282806	SEC	
LONG OF CAMERA AXIS INTERSECT	54.0531096	DEG	
54 DEG, 3 MIN,	11.1947250	SEC	
SPACECRAFT RADIUS	1855.2542993	KM	
SCALE FACTOR	.0050776	M/KM	
MEAN ALTITUDE RATE	.0048790	KM/SEC	
TILT AZIMUTH	79.1162319	DEG	
SIGMA TILT AZIMUTH	.0009021	DEG	
SUN ELEVATION AT PRIN GRND PNT	82.8566198	DEG	
LONGITUDE OF SUBSOLAR POINT	59.3394070	DEG	
59 DEG, 20 MIN,	21.8653679	SEC	
ALPHA	-13.4563241	DEG	
EMISSION ANGLE	13.6904521	DEG	
PHASE ANGLE	20.1332927	DEG	
PHI	-12.8025609	DEG	
SIGMA PHI	.0002000	DEG	
KAPPA	171.1268406	DEG	
SIGMA KAPPA	.0002000	DEG	
OMEGA	.4570850	DEG	
SIGMA OMEGA	.0002000	DEG	
SPACECRAFT ALTITUDE (LASER)	.0000000	KM	

LATITUDE OF NADIR POINT	-3.4119457	DEG	
-3 DEG, 24 MIN,	43.0044079	SEC	
LATI OF CAMERA AXIS INTERSECT	-3.2454280	DEG	
-3 DEG, 14 MIN,	43.5407853	SEC	
SPACECRAFT ALTITUDE	117.1643030	KM	
AZIMUTH OF VELOCITY VECTOR	261.2502541	DEG	
HORIZONTAL VELOCITY	1.6228403	KM/SEC	
TILT ANGLE	12.8105786	DEG	
SIGMA TILT ANGLE	.0002000	DEG	
SUN AZIMUTH AT PRINCIPAL GRND PNT	47.7843165	DEG	
LATITUDE OF SUBSOLAR POINT	1.5613792	DEG	
1 DEG, 33 MIN,	40.9649563	SEC	
SWING ANGLE	87.9381152	DEG	
SIGMA SWING ANGLE	.0009021	DEG	
NORTH DEVIATION ANGLE	188.5572011	DEG	
X-TILT	.4570850	DEG	
SIGMA X-TILT	.0002000	DEG	
Y-TILT	12.8021468	DEG	
SIGMA Y-TILT	.0002000	DEG	
HEADING	-98.7692912	DEG	
SIGMA HEADING	.0002051	DEG	
LASER SLANT RANGE	.0000000	KM	

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.75607554	-.64682667	.09982504	120.365296

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.22913849+00	-.83437272+00	-.50131603+00
-.15288932+00	.47777593+00	-.86507515+00
.96131179+00	.27486795+00	-.18089794-01

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96374190+00	-.14866626+00	-.22158503+00
.15424262+00	-.98800079+00	-.79775535-02
-.21774011+00	-.41866165-01	.97510843+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
2.927	53.618	-.294	54.024
-9.076	55.477	-6.027	54.911
-8.899	54.600	-6.017	54.114
2.466	52.826	-.552	53.263

Figure 23(b) - Last Frame

Mission: Apollo 16, Target: Panoramic strip photography

Rev: 63, Camera: 24-Inch Panoramic Frames: 5204 Through: 5506

Coverage Interval:

From: 1.1 Deg S Lat., 57.6 Deg E Long., To: 9.9 Deg S Lat., 48.3 Deg W Long.

From: 197 Hr 2 Min 41.672 Sec, To: 197 Hr 37 Min 44.191 Sec. CTE

Date Processed: 8/5/72, APE Version Used: 8.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.4 (Relocatable)

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.710217

  Base Time: Yr 1972 Month 4 Day 16 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at each film exposure time

  Integration Interval: Variable (1×10^{-14} - 64 Min)

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 215 H, 11 M, 1.5503 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 63. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5820448.79	$\dot{X}$ =	1346.2527
Y =	1615353.46	$\dot{Y}$ =	-5099.2317
Z =	-833869.76	$\dot{Z}$ =	-652.6393

● Telemetered Data Tape

Data Source: Station Tape

Bit Rate: High

Date Edited: 8/3/72

Edited Data Tape No. A07736 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no gaps in the vehicle attitude data used for this sequence.

- APE Card Inputs:

Time of Launch: Yr 1972 Month 4 Day 16 Hr 17 Min 54 Sec 0

Range Zero-Clock Zero Time Difference 0.65 Sec

REFSMMAT Used:

.9802564	-.0079311	-.1975715
.1698344	-.4779295	.8618235
-.1012604	-.8783624	-.4671464

Camera Positioning Angles Used: The angle from the spacecraft body X-Z plane to the camera optical axis when positioned for vertical or "mono" photography (camera positioning angle) was 37.75 degrees.

The angle between the camera optical axis central position and its fore or aft positions (excursion angle) was 12.5 degrees.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±20 ms in onboard clock bias definition

±5 ms in onboard clock drift rate

±5 ms in universal to sidereal time conversion

General Description:

The basic output is a listing of single page tabulations of computed spacecraft state, camera orientation and photograph position and lighting data. Each tabulation presents the computation results for a specified photograph time. The basic data for each map camera sequence is preceded and followed by a star pattern description for a stellar photograph that is companion to a specific map camera photograph of the sequence.

Basic Data Format:

Generally, the format will be as shown in figures 1 and 2. However, when the calculated camera aiming direction is above the lunar horizon, a message to that effect along with the vehicle state vector and the computed value of tilt are substituted for the tabulation.

With the exception of its initial line, all entries of each tabulation are self explanatory. The initial line contains six entries that are from left to right:

1. Mission title
2. State vector identification
3. Date of data origin
4. Status of data PRE = preliminary, F = final
5. Page number within the sequence

Star Pattern Format:

The star pattern format is a star pattern plot preceded by identification, and field of view direction information. It is followed by a tabulation of the stellar camera diapositive coordinates and identification numbers of the plotted stars. All angular quantities are expressed in radian measure.

OUTPUT Summary: These photo evaluation data are for a sequence of stereo photography starting at 57.6 deg E Long. and ending at 48.3 deg W Long. Throughout the sequence a tilt magnitude of 12.5 ±0.9 deg is maintained. Data for frame 5302 was omitted due to a computer card reader failure.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	24	22	56	41.030
CTE			8	5	2	41.672

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1199.5076254	1321.1692716	488.5345002	1.2138650	-.8272356	-.6995372
SELENOGRAPHIC	969.6594998	1575.3843131	-29.9577363	1.3657465	-.8327144	-.2974262

LONGITUDE OF NADIR POINT	58.3874269 DEG	LATITUDE OF NADIR POINT	-.9277883 DEG
	58 DEG, 23 MIN, 14.7366714 SEC		0 DEG, 55 MIN, 40.0377846 SEC
LONG OF CAMERA AXIS INTERSECT	57.6252718 DEG	LATI OF CAMERA AXIS INTERSECT	-1.0671475 DEG
	57 DEG, 37 MIN, 30.9784698 SEC		-1 DEG, 4 MIN, 1.7308688 SEC
SPACECRAFT RADIUS	1850.1277647 KM	SPACECRAFT ALTITUDE	112.0377683 KM
SCALE FACTOR	.0000000 M/KM	AZIMUTH OF VELOCITY VECTOR	259.4717824 DEG
MEAN ALTITUDE RATE	.0115525 KM/SEC	HORIZONTAL VELOCITY	1.6269325 KM/SEC
TILT AZIMUTH	259.6299782 DEG	TILT ANGLE	11.8286748 DEG
SIGMA TILT AZIMUTH	.0009757 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	75.4392281 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	280.4178734 DEG
LONGITUDE OF SUBSOLAR POINT	43.3041993 DEG	LATITUDE OF SUBSOLAR POINT	1.5716489 DEG
	43 DEG, 18 MIN, 15.1174736 SEC		1 DEG, 34 MIN, 17.9360676 SEC
ALPHA	-12.3606477 DEG	SWING ANGLE	270.1975308 DEG
EMISSION ANGLE	12.6033406 DEG	SIGMA SWING ANGLE	.0009757 DEG
PHASE ANGLE	26.7130344 DEG	NORTH DEVIATION ANGLE	190.3519874 DEG
PHI	11.8285958 DEG	X-TILT	.0404909 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	169.4366264 DEG	Y-TILT	-11.8285923 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	.0404909 DEG	HEADING	-100.5718509 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002043 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.34157103	-.93962032	-.02104510	114.630800

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.85051410+00	-.35588675+00	-.36918585+00
-.17369004+00	.47558211+00	-.86235347+00
.48247831+00	.80446646+00	.34647988+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96215128+00	-.17957251+00	.20498451+00
.18332291+00	-.98305254+00	-.70669968-03
.20163744+00	.36898349-01	.97876492+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
4.370	56.942	1.590	57.486
-6.371	58.950	-3.593	58.453
-6.787	58.220	-3.845	57.742
4.497	56.110	1.569	56.732

Figure 24(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	1972	4	24	23	31	43.549
CTE			8	5	37	44.191

STATE VECTOR	X (KM)	Y (KM)	Z (KM)	XDOT (KM/S)	YDOT (KM/S)	ZDOT (KM/S)
1950.0	1019.4208633	-1266.9713586	-903.1046640	-1.3270816	-.8973084	-.2290982
SELENOGRAPHIC	1241.1052659	-1347.9851836	-320.3545190	-1.1792490	-1.1034444	.1028408

LONGITUDE OF NADIR POINT	-47.3638773 DEG	LATITUDE OF NADIR POINT	-9.9170840 DEG
-47 DEG, 21 MIN, 49.9582672 SEC		-9 DEG, 55 MIN, 1.5023232 SEC	
LONG OF CAMERA AXIS INTERSECT	-48.2563696 DEG	LATI OF CAMERA AXIS INTERSECT	-9.8610597 DEG
-48 DEG, 15 MIN, 22.9305267 SEC		-9 DEG, 51 MIN, 39.8147964 SEC	
SPACECRAFT RADIUS	1860.1164894 KM	SPACECRAFT ALTITUDE	122.0264930 KM
SCALE FACTOR	.0048635 M/KM	AZIMUTH OF VELOCITY VECTOR	273.6686404 DEG
MEAN ALTITUDE RATE	-.0048873 KM/SEC	HORIZONTAL VELOCITY	1.6182320 KM/SEC
TILT AZIMUTH	273.5692253 DEG	TILT ANGLE	12.3322833 DEG
SIGMA TILT AZIMUTH	.0009364 DEG	SIGMA TILT ANGLE	.0002000 DEG
SUN ELEVATION AT PRIN GRND PNT	-1.5142269 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.6674213 DEG
LONGITUDE OF SUBSOLAR POINT	43.0077742 DEG	LATITUDE OF SUBSOLAR POINT	1.5718065 DEG
43 DEG, 0 MIN, 27.9870472 SEC		1 DEG, 34 MIN, 18.5032940 SEC	
ALPHA	13.1616230 DEG	SWING ANGLE	269.2823541 DEG
EMISSION ANGLE	11.2133002 DEG	SIGMA SWING ANGLE	.0009363 DEG
PHASE ANGLE	78.3529234 DEG	NORTH DEVIATION ANGLE	175.7952683 DEG
PHI	12.3313460 DEG	X-TILT	-.1532716 DEG
SIGMA PHI	.0002000 DEG	SIGMA X-TILT	.0002000 DEG
KAPPA	-175.7296739 DEG	Y-TILT	-12.3313013 DEG
SIGMA KAPPA	.0002000 DEG	SIGMA Y-TILT	.0002000 DEG
OMEGA	-.1532716 DEG	HEADING	-85.6961660 DEG
SIGMA OMEGA	.0002000 DEG	SIGMA HEADING	.0002047 DEG
SPACECRAFT ALTITUDE (LASER)	.0000000 KM	LASER SLANT RANGE	.0000000 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.80709255	.56188526	.18134654	125.119012

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.68056717+00	-.69428888+00	-.23407519+00
-.17990073+00	.46004232+00	-.86520066+00
.71025633+00	-.54671688+00	-.44343728+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97417418+00	.73314081-01	.21356413+00
-.74461981-01	-.99722030+00	.26750910-02
.21316663+00	-.13296368-01	.97692539+00

PHOTOGRAPH FOOTPRINT

LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
-3.933	-47.446	-7.026	-47.650
-15.900	-48.382	-12.767	-48.097
-16.158	-49.320	-12.639	-48.944
-3.545	-48.290	-6.829	-48.457

NASA — MSC

Figure 24(b) - Last Frame

END

DATE

FILMED

MAR 20

1973