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APOLLO 15 PHOTOGRAPH EVALUATION (APE) DATA BOOK

Mathematical Physics Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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APOLLO PROGRAM

APOLLO 15 PHOTOGRAPH EVALUATION (APE) DATA BOOK

By H. H. Cunningham
Mission Design Section
TRW Systems

June 13, 1972

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

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APOLLO 15 PHOTOGRAPH EVALUATION (APE) DATA BOOK

By H. H. Cunningham

Mission Design Section
TRW Systems Group

1.0 INTRODUCTION

This is a catalog of the Apollo 15 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 15 3-inch mapping camera photography and Apollo 15 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 DATA

The first and last frame figures which appear in this data book are consolidations of typical Apollo photograph evaluation data groups. In microfilm of the actual data, each data group occupies three or four frames. The following are frame by frame descriptions of those data.

2.1 First Frame

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

GET - Time interval from sidereal GMT time of launch to film exposure time (hours, minutes, seconds).

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.

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.

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

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.

Altitude difference - Difference between computed vehicle altitude and the vertical component of laser altimeter slant range.

Sigmas - Values of the following sigmas that appear in these data are unrealistic and are to be disregarded. Sigma (Seleno), Sigma Nadir Longitude, Sigma Nadir Latitude and Sigma Spacecraft Radius. These values were derived under an assumed doppler noise which ignores major contributions to the real data noise. An optimal system noise of approximately 0.01 Hz was assumed for the doppler noise, whereas the real data may be accurate to only 3 Hz due to large uncertainties in the lunar gravitational field and due to unmodeled vehicle thrusting.

All other sigma values appearing in these data are valid. These, associated with camera aiming parameters, properly consider uncertainties in camera mounting angles, uncertainties in vehicle attitude measurements and uncertainties in film exposure time definition.

2.2 Second Frame

The second frame of each data group contains three self explanatory entries which are:

- Definition of the vector from the spacecraft to the principal intersection point in the instantaneous inertial selenographic coordinate system.
- Relationship between the camera axes and selenocentric coordinate systems.
- Relationship between the camera axes and the nadir point centered local horizontal coordinate systems.

2.3 Third and Fourth Frames

The third and final frame entries for all 3-inch mapping camera sequences presents the positions (Latitude and Longitude) of the projections of the film corner points onto the mean lunar surface.

The third and fourth frame data for all pan camera sequences except that for REV 63 are in error and should be disregarded. The third frame of each REV 63 entry presents the positions of the projections of the corner points of the camera outer field of view onto the mean lunar surface. The fourth frame presents the positions of the projections of the camera inner field of view corner points onto the mean lunar surface.

3.0 APOLLO 15 3-INCH MAPPING CAMERA DATA

Mission: Apollo 15, Target: Strip photography

Rev: Rev 4, Camera: 3-Inch Mapping Frames: 72 Through: 104

Coverage Interval:

From: 24.96 S Lat., 177.07 E Long., To: 16.78 S Lat., 142.6 E Long.

From: 84 Hr 43 Min 19.97 Sec, To: 84 Hr 54 Min 13 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 99 H 11 M 34.160 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 4. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5175791.43	$\dot{X}$ =	582.8512
Y =	330685.92	$\dot{Y}$ =	5508.7802
Z =	2492551.4	$\dot{Z}$ =	371.0212

- Telemetered Data Tape

Data Source: Station tape

Bit Rate: High

Date Edited: 1 Sept. 1971

Edited Data Tape No. A09550 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no significant data gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary:

These photo evaluation data are for a sequence of near vertical photography starting at 175.5 deg. E.Longitude and ending at 142.6 deg. E. Longitude, taken along a line starting at 25 deg. S. Latitude and ending at 17 deg. S. Latitude. Throughout the sequence tilt was maintained near zero (less than 0.8 deg) so that the vehicle nadir and principal intersection point remain essentially coincident.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	30	2	17	20.758
GET			3	12	43	19.966

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1421.7424774	-543.1986084	-1032.0208282	-.9153199	1.1309677	.6986531
SELENOGRAPHIC	-1665.1661987	84.0931139	-775.6502380	.0088158	1.6017186	.1985808
SIGMA(SELENO)	.01	1.98	.25	.002	.000	.001

LONGITUDE OF NADIR POINT	177.1089420 DEG	LATITUDE OF NADIR POINT	-24.9486315 DEG
SIGMA NADIR LONGITUDE	.0011873 DEG	SIGMA NADIR LATITUDE	.0001415 DEG
LONG OF CAMERA AXIS INTERSECT	177.0724411 DEG	LATI OF CAMERA AXIS INTERSECT	-24.9630084 DEG
SPACECRAFT RADIUS	1838.8809967 KM	SPACECRAFT ALTITUDE	100.7909698 KM
SIGMA SPACECRAFT RADIUS	.0000036 KM	AZIMUTH OF VELOCITY VECTOR	277.4912796 DEG
MEAN ALTITUDE RATE	-.0184979 KM/SEC	HORIZONTAL VELOCITY	1.6138704 KM/SEC
TILT AZIMUTH	246.5081749 DEG	TILT ANGLE	.6221254 DEG
SIGMA TILT AZIMUTH	.1852602 DEG	SIGMA TILT ANGLE	.0019891 DEG
SUN ELEVATION AT PRIN GRND PNT	3.0106421 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.6881981 DEG
LONGITUDE OF SUBSOLAR POINT	90.5140724 DEG	LATITUDE OF SUBSOLAR POINT	.2581512 DEG
ALPHA	-.5958205 DEG	SWING ANGLE	238.8228798 DEG
EMISSION ANGLE	.6582311 DEG	SIGMA SWING ANGLE	.1852601 DEG
PHASE ANGLE	87.5851421 DEG	NORTH DEVIATION ANGLE	172.2976055 DEG
PHI	.5322901 DEG	X-TILT	-.3220729 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020002 DEG
KAPPA	-172.3158855 DEG	Y-TILT	-.5322817 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019998 DEG
OMEGA	-.3220729 DEG	HEADING	-62.3128901 DEG
SIGMA OMEGA	.0020002 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	104.6089983 KM
SPACECRAFT ALTITUDE(LASER)	104.6028357 KM	ALTITUDE DIFFERENCE	3.8118658 KM

	X	Y	Z	MAGNITUDE (KM)
SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	.90780457	-.03587440	.41765630	100.797272

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.58407100+00	.69237117+00	.42365463+00
.25911932+00	.65366594+00	-.71104001+00
-.76923227+00	-.30552077+00	-.56119413+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99097056+00	.13375750+00	.92899338-02
-.13370938+00	-.99100459+00	.56212032-02
.99582503-02	.43282825-02	.99994109+00

LATITUDE	LONGITUDE
-26.869	174.259
-22.324	175.003
-22.896	-179.994
-27.531	179.389

Figure 1(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	30	2	28	13.850
GET			3	12	54	13.055

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1751.7910614	243.6745396	-430.9956245	-.0621600	1.2102269	1.0912518
SELENOGRAPHIC	-1383.4097748	1060.2915649	-525.2290955	.8302950	1.2920957	.5481262
SIGMA(SELENO)	1.03	1.60	.68	.001	.001	.001

LONGITUDE OF NADIR POINT	142.5322361 DEG	LATITUDE OF NADIR POINT	-16.7694778 DEG
SIGMA NADIR LONGITUDE	.0010863 DEG	SIGMA NADIR LATITUDE	.0003831 DEG
LONG OF CAMERA AXIS INTERSECT	142.5528831 DEG	LATI OF CAMERA AXIS INTERSECT	-16.7794547 DEG
SPACECRAFT RADIUS	1820.4137878 KM	SPACECRAFT ALTITUDE	82.3237610 KM
SIGMA SPACECRAFT RADIUS	.0000080 KM	AZIMUTH OF VELOCITY VECTOR	290.1440239 DEG
MEAN ALTITUDE RATE	-.0365472 KM/SEC	HORIZONTAL VELOCITY	1.6303101 KM/SEC
TILT AZIMUTH	116.7826557 DEG	TILT ANGLE	.4676142 DEG
SIGMA TILT AZIMUTH	.2448450 DEG	SIGMA TILT ANGLE	.0020031 DEG
SUN ELEVATION AT PRIN GRND PNT	35.9029036 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	282.9498787 DEG
LONGITUDE OF SUBSOLAR POINT	90.4216871 DEG	LATITUDE OF SUBSOLAR POINT	.2580087 DEG
ALPHA	.4752964 DEG	SWING ANGLE	96.5290003 DEG
EMISSION ANGLE	.4896893 DEG	SIGMA SWING ANGLE	.2448443 DEG
PHASE ANGLE	53.6217117 DEG	NORTH DEVIATION ANGLE	159.7528915 DEG
PHI	-.4644873 DEG	X-TILT	-.0531572 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-159.7458801 DEG	Y-TILT	.4644871 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	-.0531572 DEG	HEADING	-69.7463074 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	79.6769991 KM
SPACECRAFT ALTITUDE(LASER)	79.6743488 KM	ALTITUDE DIFFERENCE	-2.6494122 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.75632802	-.58885279	.28499178	82.326645

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.52403853-01	.74895538+00	.66728643+00
.26433593+00	.65469018+00	-.70817172+00
-.96300592+00	.13927684+00	-.23069812+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.93813821+00	.34616618+00	-.81067408-02
-.34618442+00	-.93816596+00	.92776754-03
-.72842781-02	.36767896-02	.99996674+00

LATITUDE	LONGITUDE
-17.885	139.909
-14.275	141.333
-15.617	145.055
-19.201	143.705

Figure 1(b) - Last Frame

Mission: Apollo 15, Target: Strip Photography

Rev: 15, Camera: 24 Inch Panoramic Frames: 134* Through: 162

Coverage Interval:

From: 5.1 Deg. S Lat., 104.5 Deg. E Long., To: 9.6 Deg. N Lat., 73.5 Deg. E Long.

From: 106 Hr 6 Min 50.62 Sec, To: 106 Hr 18 Min 11.93 Sec GET

Date Processed: 12/22/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at midpoint of each camera sweep

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

* Only state vector data are provided for the early part of this photographic sequence (Frames 104 through 133) since telemetered vehicle attitude data are unavailable for that period of coverage.

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 120 H, 14 M, 30.2 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 15 . For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5417171.14	$\dot{X}$ = 332.4323
Y = 364506.69	$\dot{Y}$ = -5354.1936
Z = 2636255.82	$\dot{Z}$ = -14.8552

- Telemetered Data Tape

Data Source: Station

Bit Rate: High

Date Edited: 18 Dec. 1971

Edited Data Tape No. A09550 File No.: 2 Location: Bldg. 12, MSC

Remarks: There are no telemetered vehicle attitude data for the early part of this interval. 105 H 54 M 15 Sec - 106 H 6 M 37 Sec GET (Fms 104 through 134)

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: **These photo evaluation data are for a strip of near vertical photography starting at 140.5 deg. E Long. and extending WNW to 73.5 deg. E Long. Only state vector information is provided for the initial region of coverage, 140.5 deg. E Long. - 104.5 deg. E Long. (Fms 104 through 133); where vehicle attitude data are unavailable. Full photo evaluation data are provided for the remainder of the sequence. Throughout the sequence, tilt was maintained near zero so that the principal intersection point and vehicle nadir remain near coincident.**

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	30	23	40	51.410
GET			4	10	6	50.618

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1630.2091980	863.7500534	210.8296661	.6568151	.9579859	1.1290330
SELENOGRAPHIC	-464.1824112	1790.3902893	-164.7199039	1.4013815	.4241405	.6928877
SIGMA(SELENO)	1.73	.52	.90	.000	.002	.000

LONGITUDE OF NADIR POINT	104.5346718 DEG	LATITUDE OF NADIR POINT	-5.0892091 DEG
SIGMA NADIR LONGITUDE	.0009785 DEG	SIGMA NADIR LATITUDE	.0004840 DEG
LONG OF CAMERA AXIS INTERSECT	104.5318775 DEG	LATI OF CAMERA AXIS INTERSECT	-5.0919555 DEG
SPACECRAFT RADIUS	1856.9047546 KM	SPACECRAFT ALTITUDE	118.8147583 KM
SIGMA SPACECRAFT RADIUS	.0000046 KM	AZIMUTH OF VELOCITY VECTOR	295.4225540 DEG
MEAN ALTITUDE RATE	-.0028283 KM/SEC	HORIZONTAL VELOCITY	1.6198010 KM/SEC
TILT AZIMUTH	225.3797798 DEG	TILT ANGLE	.0576749 DEG
SIGMA TILT AZIMUTH	2.0019340 DEG	SIGMA TILT ANGLE	.0020377 DEG
SUN ELEVATION AT PRIN GRND PNT	64.5575018 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	281.3684769 DEG
LONGITUDE OF SUBSOLAR POINT	79.6227789 DEG	LATITUDE OF SUBSOLAR POINT	.2407541 DEG
ALPHA	-.0342807 DEG	SWING ANGLE	199.5576935 DEG
EMISSION ANGLE	.0617703 DEG	SIGMA SWING ANGLE	2.0019610 DEG
PHASE ANGLE	25.4767296 DEG	NORTH DEVIATION ANGLE	154.1785355 DEG
PHI	.0191473 DEG	X-TILT	-.0538980 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-154.1788139 DEG	Y-TILT	-.0191473 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.0538980 DEG	HEADING	-64.1787930 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	116.6490002 KM
SPACECRAFT ALTITUDE(LASER)	116.6489439 KM	ALTITUDE DIFFERENCE	-2.1650194 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	.25067974	-.96406131	.08800821	118.8148819

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.40185915+00	.58778665+00	.70215108+00
.25904730+00	.66249415+00	-.70284840+00
-.87829594+00	.46433640+00	.11396479+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.90015759+00	.43556432+00	.33418265-03
-.43556381+00	-.90015730+00	.94069708-03
.71057394-03	.70121363-03	.99999952+00

LATITUDE	LONGITUDE
-6.327	100.919
-1.484	103.285
-3.824	108.149
-8.684	105.803

Figure 2(a) – First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	30	23	52	12.725
GET			4	10	18	11.931

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-927.1373901	1329.0637665	898.7229767	1.3460627	.3665580	.8296238
SELENOGRAPHIC	518.2380524	1752.1688232	308.2709579	1.3863143	-.5337732	.6540215
SIGMA(SELENO)	1.72	.66	.85	.000	.002	.000

LONGITUDE OF NADIR POINT	73.5233898 DEG	LATITUDE OF NADIR POINT	9.5763087 DEG
SIGMA NADIR LONGITUDE	.0010026 DEG	SIGMA NADIR LATITUDE	.0004657 DEG
LONG OF CAMERA AXIS INTERSECT	73.4865198 DEG	LATI OF CAMERA AXIS INTERSECT	9.6157198 DEG
SPACECRAFT RADIUS	1853.0237885 KM	SPACECRAFT ALTITUDE	114.9337921 KM
SIGMA SPACECRAFT RADIUS	.0000090 KM	AZIMUTH OF VELOCITY VECTOR	294.1729774 DEG
MEAN ALTITUDE RATE	-.0082050 KM/SEC	HORIZONTAL VELOCITY	1.6230718 KM/SEC
TILT AZIMUTH	317.3142853 DEG	TILT ANGLE	.8108113 DEG
SIGMA TILT AZIMUTH	.1413324 DEG	SIGMA TILT ANGLE	.0020003 DEG
SUN ELEVATION AT PRIN GRND PNT	78.8635025 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	146.9911270 DEG
LONGITUDE OF SUBSOLAR POINT	79.5264454 DEG	LATITUDE OF SUBSOLAR POINT	.2405943 DEG
ALPHA	.8499444 DEG	SWING ANGLE	293.1181717 DEG
EMISSION ANGLE	.8644535 DEG	SIGMA SWING ANGLE	.1413322 DEG
PHASE ANGLE	10.2864462 DEG	NORTH DEVIATION ANGLE	155.8132992 DEG
PHI	.7456670 DEG	X-TILT	.3183221 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-155.8018398 DEG	Y-TILT	-.7456555 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.3183221 DEG	HEADING	-65.8059807 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020002 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-114.9337921 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	-.27093488	-.94985834	-.15608785	114.946076

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.82011028+00	.23853680+00	.52011480+00
.26021355+00	.65406657+00	-.71027158+00
-.50961562+00	.71784195+00	.47433624+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.91208568+00	.40979316+00	.13013776-01
-.40988744+00	-.91211913+00	-.55557400-02
.95934056-02	-.10401476-01	.99989989+00

LATITUDE	LONGITUDE
8.219	70.087
12.940	72.232
10.843	77.100
6.024	74.899

Figure 2(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

ev: 16, Camera: 3-Inch Mapping Frames: 279 Through: 427

Coverage Interval:

From: 25.2 deg. S Lat., 169.2 deg. E Long., To: 25.0 deg. N Lat., 13.8 deg.W Long.

From: 107 Hr 43 Min 27.059 Sec, To: 108 Hr 43 Min 48.864 Sec GET

ate Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 122 H, 12 M, 41.84 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 16 . For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5418330.03	$\dot{X}$ = 304.2696
Y = 351625.64	$\dot{Y}$ = -5355.8441
Z = 2636094.12	$\dot{Z}$ = 15.0709

- Telemetered Data Tape

Data Source: Station tape

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09550 File No.: 3 Location: Bldg. 12, MSC

Remarks: There were no significant data gaps in the telemetered vehicle attitude data for this interval.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary:

These photo evaluation data are for a sequence of near vertical photography starting at 169.0 deg. E Longitude and ending at 14.0 deg. W Longitude, taken along a line starting at 25 deg. S Latitude and ending at 25 deg. N Latitude. Throughout the sequence tilt was maintained near zero (less than 0.8 deg.) so that the vehicle nadir and principal intersection point remain essentially coincident.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	1	17	27.854
GET			4	11	43	27.059

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1351.8586121	-646.5402679	-1090.2982941	-1.0361913	1.0785546	.6306305
SELENOGRAPHIC	-1647.0096893	315.2675323	-788.8294220	.2232298	1.6004065	.1534106
SIGMA(SELENO)	.28	1.98	.19	.002	.000	.001

LONGITUDE OF NADIR POINT	169.1636353 DEG	LATITUDE OF NADIR POINT	-25.1925685 DEG
SIGMA NADIR LONGITUDE	.0011906 DEG	SIGMA NADIR LATITUDE	.0001160 DEG
LONG OF CAMERA AXIS INTERSECT	169.1712303 DEG	LATI OF CAMERA AXIS INTERSECT	-25.1977382 DEG
SPACECRAFT RADIUS	1853.1827545 KM	SPACECRAFT ALTITUDE	115.0927277 KM
SIGMA SPACECRAFT RADIUS	.0000021 KM	AZIMUTH OF VELOCITY VECTOR	276.1385384 DEG
MEAN ALTITUDE RATE	.0085689 KM/SEC	HORIZONTAL VELOCITY	1.6231136 KM/SEC
TILT AZIMUTH	126.9427872 DEG	TILT ANGLE	.1299099 DEG
SIGMA TILT AZIMUTH	.8797262 DEG	SIGMA TILT ANGLE	.0020237 DEG
SUN ELEVATION AT PRIN GRND PNT	-.4349108 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.0599365 DEG
LONGITUDE OF SUBSOLAR POINT	78.8032141 DEG	LATITUDE OF SUBSOLAR POINT	.2393913 DEG
ALPHA	.1107554 DEG	SWING ANGLE	120.8843889 DEG
EMISSION ANGLE	.1384764 DEG	SIGMA SWING ANGLE	.8797229 DEG
PHASE ANGLE	90.3241558 DEG	NORTH DEVIATION ANGLE	173.9448490 DEG
PHI	-.1114493 DEG	X-TILT	-.0666604 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-173.9414768 DEG	Y-TILT	.1114492 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.0666604 DEG	HEADING	-83.9416037 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	114.3859987 KM
SPACECRAFT ALTITUDE(LASER)	114.3857098 KM	ALTITUDE DIFFERENCE	-.7070179 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.88897315	-.17200997	.42442822	115.093048

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.63275655+00	.66792552+00	.39178395+00
.25543030+00	.65766954+00	-.70867907+00
-.73100927+00	-.34834785+00	-.58675319+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99441297+00	.10554187+00	-.19451547-02
-.10554423+00	-.99441388+00	.11634435-02
-.18114962-02	.13622297-02	.99999747+00

	LATITUDE	LONGITUDE
	-27.480	165.909
	-22.279	166.636
	-22.830	172.278
	-28.036	171.785

Figure 3(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	2	17	49.657
GET			4	12	43	48.864

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1382.8614960	594.1196136	1052.7375641	.9873663	-1.1142629	-.6824263
SELENOGRAPHIC	1617.5921021	-396.1399803	774.6026764	-.3100327	-1.5970137	-.1886967
SIGMA(SELENO)	.38	1.98	.23	.002	.000	.001

LONGITUDE OF NADIR POINT	-13.7606201 DEG	LATITUDE OF NADIR POINT	24.9439514 DEG
SIGMA NADIR LONGITUDE	.0012071 DEG	SIGMA NADIR LATITUDE	.0001379 DEG
LONG OF CAMERA AXIS INTERSECT	-13.7774681 DEG	LATI OF CAMERA AXIS INTERSECT	24.9616246 DEG
SPACECRAFT RADIUS	1836.7199860 KM	SPACECRAFT ALTITUDE	98.6299591 KM
SIGMA SPACECRAFT RADIUS	.0000023 KM	AZIMUTH OF VELOCITY VECTOR	262.8337555 DEG
MEAN ALTITUDE RATE	-.0081832 KM/SEC	HORIZONTAL VELOCITY	1.6376859 KM/SEC
TILT AZIMUTH	319.1546288 DEG	TILT ANGLE	.4117041 DEG
SIGMA TILT AZIMUTH	.2803338 DEG	SIGMA TILT ANGLE	.0019872 DEG
SUN ELEVATION AT PRIN GRND PNT	-1.7745771 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.9103746 DEG
LONGITUDE OF SUBSOLAR POINT	78.2911377 DEG	LATITUDE OF SUBSOLAR POINT	.2385356 DEG
ALPHA	.2783451 DEG	SWING ANGLE	325.7203712 DEG
EMISSION ANGLE	.4351001 DEG	SIGMA SWING ANGLE	.2803335 DEG
PHASE ANGLE	91.4962626 DEG	NORTH DEVIATION ANGLE	186.5735283 DEG
PHI	.2318979 DEG	X-TILT	.3402035 DEG
SIGMA PHI	.0019998 DEG	SIGMA X-TILT	.0020002 DEG
KAPPA	173.4350929 DEG	Y-TILT	-.2318938 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019998 DEG
OMEGA	.3402035 DEG	HEADING	-96.5662918 DEG
SIGMA OMEGA	.0020002 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	101.6699982 KM
SPACECRAFT ALTITUDE(LASER)	101.6673775 KM	ALTITUDE DIFFERENCE	3.0374184 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.88401792	.21165289	-.41679175	98.632660

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.60699147+00	-.68431128+00	-.40407851+00
.25705627+00	.65019055+00	-.71496447+00
.75198635+00	.33010644+00	.57056669+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99343209+00	-.11435174+00	.40472990-02
.11432676+00	-.99342540+00	-.59376361-02
.46996715-02	-.54359097-02	.99997422+00

LATITUDE	LONGITUDE
22.394	-15.907
26.881	-16.540
27.421	-11.501
22.889	-10.993

Figure 3(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 22, Camera: 3-Inch Mapping Frames: 457 Through: 604

Coverage Interval:

From: 25.0 Deg. S Lat., 161.8 Deg. E Long., To: 24.8 Deg. N Lat., 20.6 Deg.W Long.

From: 119 Hr 34 Min 48.944 Sec, To: 120 Hr 35 Min 4.35 Sec GET

Date Processed: 12/21/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 134 H, 1 M, 55.32 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 22 . For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5428075.02 $\dot{X}$ = 192.7182

Y = 346707.01 $\dot{Y}$ = -5353.9628

Z = 2622460.91 $\dot{Z}$ = 225.6916

- Telemetered Data Tape

Data Source: Station tape

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09550 File No.: 4 Location: Bldg. 12, MSC

Remarks: There were no significant gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: **These photo evaluation data are for a near vertical sequence of photography starting at 161.8 deg. E. Long., 25.02 deg. S. Lat., and extending WNW to 20.6 deg. W. Long., 24.8 deg. N. Lat. Throughout the sequence a near zero (less than 1 deg.) tilt is maintained so that the principal intersection point remains essentially coincident with the vehicle nadir.**

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	13	8	49.737
GET			4	23	34	48.944

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1368.4932709	-631.7159271	-1079.1252594	-1.0225044	1.0800297	.6488660
SELENOGRAPHIC	-1595.7704010	524.0339966	-784.3821564	.4177396	1.5587112	.1700579
SIGMA(SELENO)	.52	1.93	.22	.002	.000	.001

LONGITUDE OF NADIR POINT	161.8203697 DEG	LATITUDE OF NADIR POINT	-25.0326748 DEG
SIGMA NADIR LONGITUDE	.0011875 DEG	SIGMA NADIR LATITUDE	.0001309 DEG
LONG OF CAMERA AXIS INTERSECT	161.8429089 DEG	LATI OF CAMERA AXIS INTERSECT	-25.0162013 DEG
SPACECRAFT RADIUS	1853.7395020 KM	SPACECRAFT ALTITUDE	115.6495056 KM
SIGMA SPACECRAFT RADIUS	.0000055 KM	AZIMUTH OF VELOCITY VECTOR	276.7927933 DEG
MEAN ALTITUDE RATE	.0090685 KM/SEC	HORIZONTAL VELOCITY	1.6225993 KM/SEC
TILT AZIMUTH	51.1140924 DEG	TILT ANGLE	.3944713 DEG
SIGMA TILT AZIMUTH	.2906311 DEG	SIGMA TILT ANGLE	.0020017 DEG
SUN ELEVATION AT PRIN GRND PNT	.7425528 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.5993690 DEG
LONGITUDE OF SUBSOLAR POINT	72.7692642 DEG	LATITUDE OF SUBSOLAR POINT	.2290919 DEG
ALPHA	.3245249 DEG	SWING ANGLE	44.3125901 DEG
EMISSION ANGLE	.4206956 DEG	SIGMA SWING ANGLE	.2906314 DEG
PHASE ANGLE	88.9329147 DEG	NORTH DEVIATION ANGLE	173.2071075 DEG
PHI	-.2754670 DEG	X-TILT	.2821548 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-173.1990108 DEG	Y-TILT	.2754637 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.2821548 DEG	HEADING	-83.1976519 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	118.4200001 KM
SPACECRAFT ALTITUDE(LASER)	118.4172001 KM	ALTITUDE DIFFERENCE	2.7676946 KM
SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.85740985	-.28720284	.42703966	115.652435

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.62251256+00	.66902975+00	.40605090+00
.25474193+00	.66380035+00	-.70318215+00
-.73998980+00	-.33430171+00	-.58365875+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99294919+00	.11844332+00	-.48077290-02
-.11841973+00	-.99295136+00	-.49245108-02
-.53571152-02	-.43204721-02	.99997636+00

LATITUDE	LONGITUDE
-27.329	158.482
-22.105	159.319
-22.735	164.942
-27.948	164.402

Figure 4(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	14	9	5.147
GET			5	0	35	4.354

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1390.3745117	587.5011139	1045.4720001	.9812188	-1.1126358	-.6950171
SELENOGRAPHIC	1559.3576050	-588.2919617	770.4719467	-.4951290	-1.5486064	-.2011540
SIGMA(SELENO)	.01	1.92	.26	.002	.001	.001

LONGITUDE OF NADIR POINT	-20.6697693 DEG	LATITUDE OF NADIR POINT	24.8106763 DEG
SIGMA NADIR LONGITUDE	.0012059 DEG	SIGMA NADIR LATITUDE	.0001498 DEG
LONG OF CAMERA AXIS INTERSECT	-20.6478701 DEG	LATI OF CAMERA AXIS INTERSECT	24.8041127 DEG
SPACECRAFT RADIUS	1836.1128845 KM	SPACECRAFT ALTITUDE	98.0228882 KM
SIGMA SPACECRAFT RADIUS	.0000060 KM	AZIMUTH OF VELOCITY VECTOR	262.3679466 DEG
MEAN ALTITUDE RATE	-.0087325 KM/SEC	HORIZONTAL VELOCITY	1.6381769 KM/SEC
TILT AZIMUTH	108.2716322 DEG	TILT ANGLE	.3711503 DEG
SIGMA TILT AZIMUTH	.3086879 DEG	SIGMA TILT ANGLE	.0020027 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.5419474 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.5726767 DEG
LONGITUDE OF SUBSOLAR POINT	72.2582226 DEG	LATITUDE OF SUBSOLAR POINT	.2281970 DEG
ALPHA	-.3690642 DEG	SWING ANGLE	115.9520636 DEG
EMISSION ANGLE	.3921080 DEG	SIGMA SWING ANGLE	.3086879 DEG
PHASE ANGLE	92.9110184 DEG	NORTH DEVIATION ANGLE	187.6718121 DEG
PHI	-.3336901 DEG	X-TILT	-.1624049 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	172.3198776 DEG	Y-TILT	.3336888 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.1624049 DEG	HEADING	-97.6810751 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	100.4639997 KM
SPACECRAFT ALTITUDE(LASER)	100.4618959 KM	ALTITUDE DIFFERENCE	2.4390078 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.84628498	.32584786	-.42145569	98.025070

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.59878980+00	-.67875858+00	-.42513243+00
.25261113+00	.66377819+00	-.70397872+00
.76002529+00	.31414211+00	.56892563+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99101061+00	-.13355655+00	-.58239345-02
.13364189+00	-.99102558+00	.28344964-02
-.61505139-02	.20307075-02	.99997906+00

	LATITUDE	LONGITUDE
	22.257	-22.785
	26.738	-23.554
	27.333	-18.518
	22.871	-17.955

Figure 4(b) - Last Frame

Mission: Apollo 15, Target: Forward Oblique Strip Photography

Rev: 23, Camera: 3-Inch Mapping Frames: 753 Through: 869

Coverage Interval:

From: 21.3 Deg. S Lat., 138.15 Deg. E Long., To: 24.6 Deg. N Lat., 19.6 Deg.W Long.

From: 121 Hr 39 Min 46.55 Sec, To: 122 Hr 32 Min 30.53 Sec GET

Date Processed: 12/30/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 136 H, o M, 7.20 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 23. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5428943.73	$\dot{X}$ = 178.5119
Y = 349599.12	$\dot{Y}$ = -5352.9837
Z = 2618976.06	$\dot{Z}$ = 259.6515

- Telemetered Data Tape

Data Source: Station

Bit Rate: High

Date Edited: 22 Dec. 1971

Edited Data Tape No. A09556 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were two significant gaps in telemetered vehicle attitude data within the interval of this sequence:

1) 121 H, 58 M, 51 Sec - 122 H, 3 M, 51 Sec (Frames 796 through 805)
2) 122 H, 8 M, 51 Sec - 122 H, 18 M, 24 Sec (Frames 818 through 837)

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary:

These photo evaluation data are for a strip of forward oblique photography starting at 138 deg. E Long., 21.3 deg. S Lat., and ending at 19.6 deg. W Long., 24.6 deg. N Lat. Throughout the sequence a forward tilt of 24.5 ±0.5 deg. is maintained causing the principal intersection point to lead the vehicle nadir by approximately 2 deg. throughout the sequence. For the regions between 83.8 - 70.28 deg. E Long. (Frames 796 - 805) and 56.2 - 27.4 deg. E Long. (Frames 818 - 837) where telemetered vehicle attitude data are unavailable, only vehicle state vector data are provided. State vector data only are provided for frame 847 as a result of some computer erratic.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	15	13	47.341
GET			5	1	39	46.549

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1678.2039185	-187.1997890	-771.1396179	-.5670278	1.2013841	.9275478
SELENOGRAPHIC	-1325.1416168	1111.4311829	-674.3803711	.8836286	1.3007383	.3904734
SIGMA(SELENO)	1.09	1.61	.50	.001	.001	.001

LONGITUDE OF NADIR POINT	140.0125523 DEG	LATITUDE OF NADIR POINT	-21.3018453 DEG
SIGMA NADIR LONGITUDE	.0011192 DEG	SIGMA NADIR LATITUDE	.0002868 DEG
LONG OF CAMERA AXIS INTERSECT	138.1488533 DEG	LATI OF CAMERA AXIS INTERSECT	-21.3071021 DEG
SPACECRAFT RADIUS	1856.3589172 KM	SPACECRAFT ALTITUDE	118.2689209 KM
SIGMA SPACECRAFT RADIUS	.0000087 KM	AZIMUTH OF VELOCITY VECTOR	285.0790520 DEG
MEAN ALTITUDE RATE	.0061521 KM/SEC	HORIZONTAL VELOCITY	1.6202024 KM/SEC
TILT AZIMUTH	266.8492393 DEG	TILT ANGLE	23.8796437 DEG
SIGMA TILT AZIMUTH	.0051369 DEG	SIGMA TILT ANGLE	.0019188 DEG
SUN ELEVATION AT PRIN GRND PNT	21.7615480 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	279.2605591 DEG
LONGITUDE OF SUBSOLAR POINT	71.7094851 DEG	LATITUDE OF SUBSOLAR POINT	.2272320 DEG
ALPHA	-25.2128444 DEG	SWING ANGLE	269.9802284 DEG
EMISSION ANGLE	25.6175916 DEG	SIGMA SWING ANGLE	.0051698 DEG
PHASE ANGLE	93.3743734 DEG	NORTH DEVIATION ANGLE	182.2098217 DEG
PHI	23.8796403 DEG	X-TILT	-.0080038 DEG
SIGMA PHI	.0019189 DEG	SIGMA X-TILT	.0020927 DEG
KAPPA	176.8673191 DEG	Y-TILT	-23.8796413 DEG
SIGMA KAPPA	.0019845 DEG	SIGMA Y-TILT	.0019190 DEG
OMEGA	-.0080038 DEG	HEADING	-93.1291428 DEG
SIGMA OMEGA	.0020927 DEG	SIGMA HEADING	.0021856 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	127.9600000 KM
SPACECRAFT ALTITUDE(LASER)	117.0063543 KM	ALTITUDE DIFFERENCE	-1.2625666 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.91867603	-.24296292	.31145361	130.215164

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.59545732+00	.79298574+00	.12885729+00
.34592619+00	.39783766+00	-.84974124+00
-.72509702+00	-.46140954+00	-.51120995+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.91303453+00	-.49913917-01	.40481669+00
.54648446-01	-.99850561+00	.13969343-03
.40420478+00	.22250114-01	.91439789+00

LATITUDE	LONGITUDE
-18.807	140.845
-15.442	130.505
-27.598	130.416
-23.692	141.165

Figure 5(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	16	6	31.319
GET			5	2	32	30.527

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1324.4000397	658.5891800	1088.5119324	1.0513349	-1.0794203	-.6417864
SELENOGRAPHIC	1579.2913361	-516.6924133	781.9854279	-.4430926	-1.5682398	-.1632051
SIGMA(SELENO)	.55	1.94	.21	.002	.001	.001

LONGITUDE OF NADIR POINT	-18.1164055 DEG	LATITUDE OF NADIR POINT	25.2018349 DEG
SIGMA NADIR LONGITUDE	.0012127 DEG	SIGMA NADIR LATITUDE	.0001206 DEG
LONG OF CAMERA AXIS INTERSECT	-19.5867558 DEG	LATI OF CAMERA AXIS INTERSECT	24.6339660 DEG
SPACECRAFT RADIUS	1836.4730682 KM	SPACECRAFT ALTITUDE	98.3830719 KM
SIGMA SPACECRAFT RADIUS	.0000045 KM	AZIMUTH OF VELOCITY VECTOR	263.8311157 DEG
MEAN ALTITUDE RATE	-.0093106 KM/SEC	HORIZONTAL VELOCITY	1.6377298 KM/SEC
TILT AZIMUTH	247.2440281 DEG	TILT ANGLE	23.9571347 DEG
SIGMA TILT AZIMUTH	.0050929 DEG	SIGMA TILT ANGLE	.0019308 DEG
SUN ELEVATION AT PRIN GRND PNT	-.6773539 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.4402399 DEG
LONGITUDE OF SUBSOLAR POINT	71.2622757 DEG	LATITUDE OF SUBSOLAR POINT	.2264423 DEG
ALPHA	23.3175933 DEG	SWING ANGLE	271.0583763 DEG
EMISSION ANGLE	25.4064846 DEG	SIGMA SWING ANGLE	.0051217 DEG
PHASE ANGLE	67.3710375 DEG	NORTH DEVIATION ANGLE	202.3854694 DEG
PHI	23.9535081 DEG	X-TILT	.4297392 DEG
SIGMA PHI	.0019223 DEG	SIGMA X-TILT	.0020876 DEG
KAPPA	156.2768116 DEG	Y-TILT	-23.9527934 DEG
SIGMA KAPPA	.0019885 DEG	SIGMA Y-TILT	.0019206 DEG
OMEGA	.4297392 DEG	HEADING	-113.9141045 DEG
SIGMA OMEGA	.0020876 DEG	SIGMA HEADING	.0021871 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	111.3889999 KM
SPACECRAFT ALTITUDE(LASER)	101.7927856 KM	ALTITUDE DIFFERENCE	3.4097137 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.83874265	-.11956774	-.53123847	108.266342

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.92475701+00	-.24160409+00	-.29402713+00
.38212467-01	.82766750+00	-.55991627+00
.37863480+00	.50655102+00	.77462366+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.83542751+00	-.37045654+00	.40598381+00
.40230704+00	-.91547402+00	-.75002934-02
.37444618+00	.15706420+00	.91384953+00

LATITUDE	LONGITUDE
27.400	-18.263
26.543	-27.607
18.039	-22.748
23.671	-16.483

Figure 5(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 27, Camera: 3-Inch Mapping Frames: 870 Through: 1013

Coverage Interval:

From: 24.68 Deg. S Lat., 153.86 Deg E Long., To: 25.05 Deg. N Lat., 23.3 Deg.W Long.

From: 129 Hr 27 Min 59.70 Sec, To: 130 Hr 26 Min 39.44 Sec GET

Date Processed: 12/15/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 143 H, 52 M, 43.2 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 = 5442492.29	$\dot{X}$ = 109.9227
Y = 349488.17	$\dot{Y}$ = -5343.3417
Z = 2596805.03	$\dot{Z}$ = 400.1378

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09556 File No.: 2 Location: Bldg. 12, MSC

Remarks: There were no significant gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: **These photo evaluation data are for a sequence of near vertical photography starting at 154 deg. E Long. and ending at 23.3 deg. W Long., on a line beginning at 25 deg. S Lat. and ending at 25 deg. N Lat. Throughout the sequence tilt is maintained at less than 0.8 deg. so that the principal point and vehicle nadir remain essentially coincidental.**

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	23	2	.494
GET			5	9	27	59.703

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1414.5172272	-582.5801849	-1046.4925995	-.9754159	1.0966664	.6918764
SELENOGRAPHIC	-1512.1930237	741.6766052	-773.6882324	.6140476	1.4879316	.2044787
SIGMA(SELENO)	.76	1.84	.27	.001	.001	.001

LONGITUDE OF NADIR POINT	153.8737030 DEG	LATITUDE OF NADIR POINT	-24.6720324 DEG
SIGMA NADIR LONGITUDE	.0011805 DEG	SIGMA NADIR LATITUDE	.0001597 DEG
LONG OF CAMERA AXIS INTERSECT	153.8609447 DEG	LATI OF CAMERA AXIS INTERSECT	-24.6801836 DEG
SPACECRAFT RADIUS	1853.4846344 KM	SPACECRAFT ALTITUDE	115.3946075 KM
SIGMA SPACECRAFT RADIUS	.0000083 KM	AZIMUTH OF VELOCITY VECTOR	278.1200790 DEG
MEAN ALTITUDE RATE	.0090655 KM/SEC	HORIZONTAL VELOCITY	1.6225376 KM/SEC
TILT AZIMUTH	234.8896370 DEG	TILT ANGLE	.2135211 DEG
SIGMA TILT AZIMUTH	.5335184 DEG	SIGMA TILT ANGLE	.0020187 DEG
SUN ELEVATION AT PRIN GRND PNT	3.4312019 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.8216133 DEG
LONGITUDE OF SUBSOLAR POINT	67.7389660 DEG	LATITUDE OF SUBSOLAR POINT	.2201185 DEG
ALPHA	-.1819900 DEG	SWING ANGLE	226.3018150 DEG
EMISSION ANGLE	.2279267 DEG	SIGMA SWING ANGLE	.5335176 DEG
PHASE ANGLE	86.7507782 DEG	NORTH DEVIATION ANGLE	171.4069557 DEG
PHI	.1543303 DEG	X-TILT	-.1474707 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020002 DEG
KAPPA	-171.4127007 DEG	Y-TILT	-.1543298 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019998 DEG
OMEGA	-.1474707 DEG	HEADING	-81.4123011 DEG
SIGMA OMEGA	.0020002 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-115.3946075 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.81800431	-.39780734	.41547353	115.395477

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.60094621+00	.67134200+00	.43377827+00
.24074161+00	.66953065+00	-.70268918+00
-.76217266+00	-.31784994+00	-.56397191+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98878488+00	.14932256+00	.26935591-02
-.14931573+00	-.98878617+00	.25738461-02
.30476909-02	.21427753-02	.99999310+00

LATITUDE	LONGITUDE
-26.821	150.554
-21.660	151.516
-22.417	157.130
-27.631	156.372

Figure 6(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	0	0	39.440
GET			5	10	26	38.646

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1340.5363464	642.7541580	1077.2768402	1.0364625	-1.0837968	-.6591221
SELENOGRAPHIC	1527.2378540	-658.1497955	777.8684998	-.5769104	-1.5227722	-.1779079
SIGMA(SELENO)	.71	1.89	.23	.001	.001	.001

LONGITUDE OF NADIR POINT	-23.3132019 DEG	LATITUDE OF NADIR POINT	25.0676587 DEG
SIGMA NADIR LONGITUDE	.0012109 DEG	SIGMA NADIR LATITUDE	.0001351 DEG
LONG OF CAMERA AXIS INTERSECT	-23.2981951 DEG	LATI OF CAMERA AXIS INTERSECT	25.0521138 DEG
SPACECRAFT RADIUS	1835.9455109 KM	SPACECRAFT ALTITUDE	97.8554840 KM
SIGMA SPACECRAFT RADIUS	.0000073 KM	AZIMUTH OF VELOCITY VECTOR	263.2683525 DEG
MEAN ALTITUDE RATE	-.0093989 KM/SEC	HORIZONTAL VELOCITY	1.6380251 KM/SEC
TILT AZIMUTH	138.8323765 DEG	TILT ANGLE	.3667750 DEG
SIGMA TILT AZIMUTH	.3111895 DEG	SIGMA TILT ANGLE	.0020103 DEG
SUN ELEVATION AT PRIN GRND PNT	-.3962450 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.5727968 DEG
LONGITUDE OF SUBSOLAR POINT	67.2416639 DEG	LATITUDE OF SUBSOLAR POINT	.2192110 DEG
ALPHA	-.2527835 DEG	SWING ANGLE	145.7885685 DEG
EMISSION ANGLE	.3874645 DEG	SIGMA SWING ANGLE	.3111901 DEG
PHASE ANGLE	90.6490335 DEG	NORTH DEVIATION ANGLE	186.9507484 DEG
PHI	-.2062041 DEG	X-TILT	-.3032882 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	173.0440922 DEG	Y-TILT	.2062012 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	-.3032882 DEG	HEADING	-96.9570065 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	100.3979988 KM
SPACECRAFT ALTITUDE(LASER)	100.3959465 KM	ALTITUDE DIFFERENCE	2.5404625 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.82829414	.36153420	-.42804420	97.857620

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.63526555+00	-.65826230+00	-.40389161+00
.24872337+00	.66949604+00	-.69993687+00
.73114595+00	.34418852+00	.58903305+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99263091+00	-.12112370+00	-.35988822-02
.12110386+00	-.99262568+00	.52933525-02
-.42134927-02	.48185200-02	.99999956+00

LATITUDE	LONGITUDE
22.561	-25.450
27.034	-26.166
27.579	-21.109
23.109	-20.619

Figure 6(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 33, Camera: 3-Inch Mapping Frames: 1014 Through: 1161

Coverage Interval:

From: 25.0 Deg. S Lat., 150.8 Deg. E Long., To: 24.9 Deg. N Lat., 31.3 Deg.W Long.

From: 141 Hr 17 Min 39.28 Sec, To: 142 Hr 17 Min 47.805 Sec GET

Date Processed: 12/15/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 155 H, 41 M, 29.62 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 33. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5474202.62	$\dot{X}$ = 9.5580
Y = 345994.58	$\dot{Y}$ = -5318.0142
Z = 2547196.41	$\dot{Z}$ = 608.6019

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 10 Dec. 1971

Edited Data Tape No. A09556 File No.: 3 Location: Bldg. 12, MSC

Remarks: There were three significant gaps in the telemetered vehicle attitude data in the time interval of this sequence.

1) 141 H, 25 M, 11 Sec - 141 H, 33 M, 13 Sec GET - Fms 1032 through 1051
2) 141 H, 35 M, 45 Sec - 141 H, 37 M, 33 Sec GET - Fms 1058 through 1061
3) 141 H, 44 M, 41 Sec - 141 H, 49 M, 3 Sec GET - Fms 1079 through 1088

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a sequence of near vertical photography starting at 151 deg. E Long., and ending at 31 deg. W Long., proceeding from 25 deg. S Lat. along a line to 25 deg. N Lat. Throughout the coverage tilt is maintained near zero (less than 1.0 deg.) so that the principal intersection point and vehicle nadir are essentially coincident. Only vehicle state vector data are provided for the three periods of photographic coverage for which vehicle attitude data is not available. These three periods are:

1) 128 deg. E Long. - 101.8 deg. E Long. (Fms 1032 - 1051)
2) 96 deg E Long. - 90.2 deg. E Long. (Fms 1058 - 1061)
3) 72 deg. E Long. - 59.4 deg. E Long. (Fms 1079 - 1088)

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	10	51	40.077
GET			5	21	17	39.280

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1351.1351471	-650.6555023	-1086.3392944	-1.0449437	1.0619432	.6464074
SELENOGRAPHIC	-1464.7628937	818.4455719	-783.3698807	.7055143	1.4523521	.1743450
SIGMA(SELENOG)	.87	1.80	.24	.001	.001	.001

LONGITUDE OF NADIR POINT	150.8054466 DEG	LATITUDE OF NADIR POINT	-26.0265653 DEG
SIGMA NADIR LONGITUDE	.0011893 DEG	SIGMA NADIR LATITUDE	.0001410 DEG
LONG OF CAMERA AXIS INTERSECT	150.8106098 DEG	LATI OF CAMERA AXIS INTERSECT	-26.0036373 DEG
SPACECRAFT RADIUS	1851.7698975 KM	SPACECRAFT ALTITUDE	113.6798706 KM
SIGMA SPACECRAFT RADIUS	.0000095 KM	AZIMUTH OF VELOCITY VECTOR	276.9717369 DEG
MEAN ALTITUDE RATE	.0100893 KM/SEC	HORIZONTAL VELOCITY	1.6239691 KM/SEC
TILT AZIMUTH	11.5367802 DEG	TILT ANGLE	.3577958 DEG
SIGMA TILT AZIMUTH	.3201683 DEG	SIGMA TILT ANGLE	.0020031 DEG
SUN ELEVATION AT PRIN GRND PNT	.7379227 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.5746803 DEG
LONGITUDE OF SUBSOLAR POINT	61.7222800 DEG	LATITUDE OF SUBSOLAR POINT	.2088779 DEG
ALPHA	.0724381 DEG	SWING ANGLE	4.8548677 DEG
EMISSION ANGLE	.3812280 DEG	SIGMA SWING ANGLE	.3201690 DEG
PHASE ANGLE	89.1896238 DEG	NORTH DEVIATION ANGLE	173.3198318 DEG
PHI	-.0302787 DEG	X-TILT	.3564916 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-173.3179989 DEG	Y-TILT	.0302781 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.3564916 DEG	HEADING	-83.3178082 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	112.5519981 KM
SPACECRAFT ALTITUDE(LASER)	112.5498085 KM	ALTITUDE DIFFERENCE	-1.1300621 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.76812294	-.44179927	.42857395	113.682251

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.63728010+00	.65964185+00	.39643032+00
.25151921+00	.66674384+00	-.70156299+00
-.72843133+00	-.34687928+00	-.59081524+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99320673+00	.11636207+00	-.52845221-03
-.11635655+00	-.99318796+00	-.62219125-02
-.12488464-02	-.61181698-02	.99998055+00

LATITUDE	LONGITUDE
-27.295	147.550
-22.170	148.363
-22.759	153.897
-27.911	153.361

Figure 7(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	11	51	48.599
GET			5	22	17	47.805

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1368.0713196	615.9367981	1059.1562500	1.0097055	-1.0908421	-.6869273
SELENOGRAPHIC	1424.4996338	-864.8885269	771.7369003	-.7717914	-1.4300485	-.2015195
SIGMA(SELENO)	.95	1.77	.27	.001	.001	.001

LONGITUDE OF NADIR POINT	-31.2641373 DEG	LATITUDE OF NADIR POINT	24.8482716 DEG
SIGMA NADIR LONGITUDE	.0012055 DEG	SIGMA NADIR LATITUDE	.0001560 DEG
LONG OF CAMERA AXIS INTERSECT	-31.2651598 DEG	LATI OF CAMERA AXIS INTERSECT	24.8682048 DEG
SPACECRAFT RADIUS	1836.5209351 KM	SPACECRAFT ALTITUDE	98.4309082 KM
SIGMA SPACECRAFT RADIUS	.0000099 KM	AZIMUTH OF VELOCITY VECTOR	262.3664017 DEG
MEAN ALTITUDE RATE	-.0098577 KM/SEC	HORIZONTAL VELOCITY	1.6374114 KM/SEC
TILT AZIMUTH	357.3200989 DEG	TILT ANGLE	.3524234 DEG
SIGMA TILT AZIMUTH	.3254252 DEG	SIGMA TILT ANGLE	.0020010 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.1602507 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.7688227 DEG
LONGITUDE OF SUBSOLAR POINT	61.2124510 DEG	LATITUDE OF SUBSOLAR POINT	.2078987 DEG
ALPHA	.0095071 DEG	SWING ANGLE	4.8698668 DEG
EMISSION ANGLE	.3723346 DEG	SIGMA SWING ANGLE	.3254245 DEG
PHASE ANGLE	92.1507893 DEG	NORTH DEVIATION ANGLE	187.5502548 DEG
PHI	-.0299142 DEG	X-TILT	.3510934 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	172.4501457 DEG	Y-TILT	.0299136 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	.3510934 DEG	HEADING	-97.5496778 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	100.6679983 KM
SPACECRAFT ALTITUDE(LASER)	100.6660986 KM	ALTITUDE DIFFERENCE	2.2351904 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	-.77799232	.47202360	-.41463437	98.432892

TRANSFORHATION MATRIX FROM SELENOCENTRIC TO CAMERA

.62037449+00	-.66532087+00	-.41531150+00
.23984369+00	.66509232+00	-.70719665+00
.74673324+00	.33911694+00	.57217938+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99133120+00	-.13138570+00	-.52209073-03
.13138641+00	-.99131224+00	-.61276969-02
.28753854-03	-.61431582-02	.99998113+00

LATITUDE	LONGITUDE
22.257	-33.380
26.742	-34.098
27.344	-29.082
22.847	-28.490

Figure 7(b) - Last Frame

Mission: Apollo 15, Target: Aft Oblique Strip Photography

Rev: 34, Camera: 3-Inch Mapping Frames: 1309 Through: 1429

Coverage Interval:

From: 25.4 Deg. S Lat., 153.8 Deg. E Long., To: 25.9 Deg. N Lat., 8.85 Deg.W Long.

From: 143 Hr 15 Min 24 Sec, To: 144 Hr 9 Min 49.4 Sec GET

Date Processed: 1/6/72, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

HOPE Version Used: B-6.1

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: 0.69583333 Min.

Base Time: Yr 1971 Month 7 Day 26 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: 157 H, 39 M, 36.52 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 34. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5479461.92	$\dot{X}$ = -3.2394
Y = 349266.05	$\dot{Y}$ = -5313.2396
Z = 2535865.22	$\dot{Z}$ = 644.7040

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09554 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no significant gaps in the telemetered vehicle attitude data employed for this sequence

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of aft oblique photography starting at 154 deg. E Long., 25.4 deg. S Lat., and ending at 8.8 deg. W Long., 25.9 deg. N Lat. Throughout all except the first four frames (1309 through 1312) of photography an aft tilt of 25 ±0.6 deg. is maintained with the camera optical axis held essentially in the plane of flight. This camera attitude results in a principal intersection point which trails the vehicle nadir point by approximately 2 deg. Tilt was somewhat erratic over the first four frames of the sequence varying between 20 and 25 deg.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	12	49	24.788
GET			5	23	15	23.994

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1306.0519104	-694.7761917	-1112.5924683	-1.0885464	1.0394323	.6114318
SELENOGRAPHIC	-1478.7138824	784.6271210	-790.0082932	.6846650	1.4656118	.1497252
SIGMA(SELENO)	.85	1.82	.21	.001	.001	.001

LONGITUDE OF NADIR POINT	152.0489292 DEG	LATITUDE OF NADIR POINT	-25.2641234 DEG
SIGMA NADIR LONGITUDE	.0011948 DEG	SIGMA NADIR LATITUDE	.0001240 DEG
LONG OF CAMERA AXIS INTERSECT	153.8463478 DEG	L[illegible] OF CAMERA AXIS INTERSECT	-25.3725352 DEG
SPACECRAFT RADIUS	1851.0395813 KM	SPACECRAFT ALTITUDE	112.9495850 KM
SIGMA SPACECRAFT RADIUS	.0000094 KM	AZIMUTH OF VELOCITY VECTOR	276.0233994 DEG
MEAN ALTITUDE RATE	.0103999 KM/SEC	HORIZONTAL VELOCITY	1.6244991 KM/SEC
TILT AZIMUTH	94.2014112 DEG	TILT ANGLE	23.4888084 DEG
SIGMA TILT AZIMUTH	.0050185 DEG	SIGMA TILT ANGLE	.0019998 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.9095516 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	268.8482285 DEG
LONGITUDE OF SUBSOLAR POINT	60.7241507 DEG	LATITUDE OF SUBSOLAR POINT	.2069567 DEG
ALPHA	25.0352194 DEG	SWING ANGLE	89.0866041 DEG
EMISSION ANGLE	25.1171811 DEG	SIGMA SWING ANGLE	.0050184 DEG
PHASE ANGLE	67.8762817 DEG	NORTH DEVIATION ANGLE	175.9778214 DEG
PHI	-23.4861472 DEG	X-TILT	.3640407 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-174.9608650 DEG	Y-TILT	23.4856458 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.3640407 DEG	HEADING	-84.8026791 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0021806 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-112.9495850 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	.55735513	-.74573186	.36501951	123.919739

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.32595069+00	.74739359+00	.57892917+00
.25918688+00	.65955646+00	-.70555462+00
-.90716355+00	-.79925191-01	-.40869754+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.91338918+00	.83081902-01	-.39851930+00
-.87834449-01	-.99611477+00	-.63536650-02
-.39749884+00	.29200347-01	.91713799+00

LATITUDE	LONGITUDE
-20.009	161.298
-22.817	151.289
-27.476	150.905
-31.192	160.799

Figure 8(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	13	43	50.152
GET			6	0	9	49.358

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	907.7172699	991.5716095	1257.1141663	1.3589641	-.8438815	-.3326719
SELENOGRAPHIC	1627.7668152	-304.3448296	803.2747574	-.3314342	-1.5994448	.0389588
SIGMA(SELENO)	.41	1.98	.05	.002	.000	.001

LONGITUDE OF NADIR POINT	-10.5903625 DEG	LATITUDE OF NADIR POINT	25.8769498 DEG
SIGMA NADIR LONGITUDE	.0012212 DEG	SIGMA NADIR LATITUDE	.0000345 DEG
LONG OF CAMERA AXIS INTERSECT	-8.8484621 DEG	LATI OF CAMERA AXIS INTERSECT	25.8583820 DEG
SPACECRAFT RADIUS	1840.5164642 KM	SPACECRAFT ALTITUDE	102.4264679 KM
SIGMA SPACECRAFT RADIUS	.0000038 KM	AZIMUTH OF VELOCITY VECTOR	271.7166862 DEG
MEAN ALTITUDE RATE	-.0116379 KM/SEC	HORIZONTAL VELOCITY	1.6338168 KM/SEC
TILT AZIMUTH	90.2986689 DEG	TILT ANGLE	24.7612782 DEG
SIGMA TILT AZIMUTH	.0047775 DEG	SIGMA TILT ANGLE	.0019990 DEG
SUN ELEVATION AT PRIN GRND PNT	18.8093691 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	99.2570324 DEG
LONGITUDE OF SUBSOLAR POINT	60.2628222 DEG	LATITUDE OF SUBSOLAR POINT	.2060632 DEG
ALPHA	-26.1164916 DEG	SWING ANGLE	89.7192020 DEG
EMISSION ANGLE	26.3287418 DEG	SIGMA SWING ANGLE	.0047779 DEG
PHASE ANGLE	97.2714777 DEG	NORTH DEVIATION ANGLE	178.7703228 DEG
PHI	-24.7610164 DEG	X-TILT	.1176044 DEG
SIGMA PHI	.0019992 DEG	SIGMA X-TILT	.0020010 DEG
KAPPA	-179.4463634 DEG	Y-TILT	24.7609618 DEG
SIGMA KAPPA	.0019998 DEG	SIGMA Y-TILT	.0019993 DEG
OMEGA	.1176044 DEG	HEADING	-89.3921185 DEG
SIGMA OMEGA	.0020010 DEG	SIGMA HEADING	.0022025 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-102.4264679 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	-.72518361	.56167884	-.39827829	113.513168

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.55604495+00	-.67934011+00	-.47886433+00
.22506851+00	.67768886+00	-.70005847+00
.80009388+00	.28148672+00	.52972359+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.90801197+00	.96339788-02	-.41883346+00
-.96626785-02	-.99995115+00	-.20525830-02
-.41883281+00	.21832976-02	.90806079+00

LATITUDE	LONGITUDE
30.839	-1.466
27.998	-11.409
23.785	-11.422
20.318	-2.426

Figure 8(b) - Last Frame

Mission: Apollo 15, Target: North Oblique Strip Photography

Rev: 35, Camera: 3-Inch Mapping Frames: 1429 Through: 1560

Coverage Interval:

From: 21.9 Deg. S Lat., 149.2 Deg. E Long., To: 27.9 Deg. N. Lat., 32.1 Deg. W Long.

From: 145 Hr 14 Min 29.45 Sec, To: 144 Hr 14 Min 7.76 Sec GET

Date Processed: 1/5/72, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 159 H, 37 M, 41.96 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 35. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5485733.12	$\dot{X}$ =	-12.3841
Y =	356217.25	$\dot{Y}$ =	-5307.3467
Z =	2523730.72	$\dot{Z}$ =	682.2122

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 22 Dec. 1971

Edited Data Tape No. A09554 File No.: 2 Location: Bldg. 12, MSC

Remarks: There were no significant gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of side oblique photography starting at 149.2 deg. E Long., 22 deg. S Lat., and ending at 32 deg. W Long., 27.9 deg. N Lat. Throughout the sequence the camera is aimed Northward, essentially normal to the plane of flight, with tilt maintained at 40 ±0.5 deg. This camera attitude yielded photo footprints whose Northward corners were above the lunar horizon. These corners are indicated in the data by having a zero longitude and ****** latitude. A computer erratic resulted in the provision of state vector data only for frames 1463 and 1541.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	14	48	30.246
GET			6	1	14	29.451

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1348.3118439	-652.5328847	-1087.2970123	-1.0479594	1.0600885	.6459195
SELENOGRAPHIC	-1433.6978302	869.8651047	-783.4564819	.7570579	1.4267485	.1745589
SIGMA(SELENO)	.94	1.77	.24	.001	.001	.001

LONGITUDE OF NADIR POINT	148.7536221 DEG	LATITUDE OF NADIR POINT	-25.0415983 DEG
SIGMA NADIR LONGITUDE	.0011902 DEG	SIGMA NADIR LATITUDE	.0001414 DEG
LONG OF CAMERA AXIS INTERSECT	149.1705036 DEG	LATI OF CAMERA AXIS INTERSECT	-21.9168994 DEG
SPACECRAFT RADIUS	1850.9345703 KM	SPACECRAFT ALTITUDE	112.8445740 KM
SIGMA SPACECRAFT RADIUS	.0000096 KM	AZIMUTH OF VELOCITY VECTOR	276.9810257 DEG
MEAN ALTITUDE RATE	.0102256 KM/SEC	HORIZONTAL VELOCITY	1.6245055 KM/SEC
TILT AZIMUTH	7.0604553 DEG	TILT ANGLE	39.5778451 DEG
SIGMA TILT AZIMUTH	.0031389 DEG	SIGMA TILT ANGLE	.0020001 DEG
SUN ELEVATION AT PRIN GRND PNT	-.4282990 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.3932953 DEG
LONGITUDE OF SUBSOLAR POINT	59.7146554 DEG	LATITUDE OF SUBSOLAR POINT	.2049968 DEG
ALPHA	4.1397471 DEG	SWING ANGLE	-.1154200 DEG
EMISSION ANGLE	42.7258425 DEG	SIGMA SWING ANGLE	.0031389 DEG
PHASE ANGLE	85.2787390 DEG	NORTH DEVIATION ANGLE	170.7686672 DEG
PHI	-.0954104 DEG	X-TILT	39.5777535 DEG
SIGMA PHI	.0025947 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-173.0893002 DEG	Y-TILT	.0735386 DEG
SIGMA KAPPA	.0025948 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	39.5777535 DEG	HEADING	-83.0285082 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-112.8445740 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.32757943	-.29035220	.89910361	149.809784

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.63952147+00	.65533119+00	.40193698+00
.65213380+00	.73930511+00	-.16777708+00
-.40710420+00	.15481907+00	-.90016512+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99260586+00	.12137541+00	-.12834900-02
-.92739707-01	-.76516099+00	-.63712475+00
-.78313337-01	-.63229468+00	.77075968+00

	LATITUDE	LONGITUDE
********	********	.000
********	********	.000
-24.579	-25.128	146.307
		151.272

Figure 9(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	15	48	8.557
GET			6	2	14	7.764

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1335.7801361	649.8338623	1080.3198547	1.0435012	-1.0739903	-.6615279
SELENOGRAPHIC	1416.1110840	-873.7100677	777.7812805	-.7896947	-1.4221703	-.1838021
SIGMA(SELENO)	.98	1.76	.25	.001	.001	.001

LONGITUDE OF NADIR POINT	-31.6736946 DEG	LATITUDE OF NADIR POINT	25.0527885 DEG
SIGMA NADIR LONGITUDE	.0012088 DEG	SIGMA NADIR LATITUDE	.0001427 DEG
LONG OF CAMERA AXIS INTERSECT	-32.0696740 DEG	LATI OF CAMERA AXIS INTERSECT	27.8680363 DEG
SPACECRAFT RADIUS	1836.7589874 KM	SPACECRAFT ALTITUDE	98.6689911 KM
SIGMA SPACECRAFT RADIUS	.0000095 KM	AZIMUTH OF VELOCITY VECTOR	263.0482826 DEG
MEAN ALTITUDE RATE	-.0101747 KM/SEC	HORIZONTAL VELOCITY	1.6369997 KM/SEC
TILT AZIMUTH	352.9105072 DEG	TILT ANGLE	40.4833565 DEG
SIGMA TILT AZIMUTH	.0030805 DEG	SIGMA TILT ANGLE	.0020001 DEG
SUN ELEVATION AT PRIN GRND PNT	-1.0350933 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.2217903 DEG
LONGITUDE OF SUBSOLAR POINT	59.2091327 DEG	LATITUDE OF SUBSOLAR POINT	.2040090 DEG
ALPHA	5.1076391 DEG	SWING ANGLE	359.2430000 DEG
EMISSION ANGLE	43.3208289 DEG	SIGMA SWING ANGLE	.0030805 DEG
PHASE ANGLE	86.3095407 DEG	NORTH DEVIATION ANGLE	189.1832237 DEG
PHI	.6461148 DEG	X-TILT	40.4790945 DEG
SIGMA PHI	.0026294 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	173.9057522 DEG	Y-TILT	-.4914583 DEG
SIGMA KAPPA	.0026294 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	40.4790945 DEG	HEADING	-96.5137053 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-98.6689911 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.86065941	.43685756	.26157382	132.527802

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.64629470+00	-.65589625+00	-.39000421+00
-.38005859+00	.27154657+00	-.92077664+00
.70983829+00	.70431706+00	-.81901818-02

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99350821+00	-.11343666+00	.85774600-02
.80753146-01	-.75634418+00	-.64917054+00
.80127235-01	-.64426353+00	.76059458+00

LATITUDE	LONGITUDE
********	.000
********	.000
25.006	-33.916
25.456	-29.560

Figure 9(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 38, Camera: 3-Inch Mapping Frames: 1560 Through: 1704

Coverage Interval:

From: 25.0 Deg. S Lat., 145.7 Deg. E Long., To: 25.2 Deg. N Lat., 33.6 Deg.W Long.

From: 151 Hr 9 Min 35.86 Sec, To: 152 Hr 8 Min 53.93 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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, 31 M, 53.11 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 =	5507373.81	$\dot{X}$ =	-56.8619
Y =	354401.39	$\dot{Y}$ =	-5288.5850
Z =	2486896.38	$\dot{Z}$ =	785.4631

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: Dec. 8, 1971

Edited Data Tape No. A09554 File No.: 3 Location: Bldg. 12, MSC

Remarks: Telemetered vehicle attitude data are not available for the interval 151 H, 21 M, 29 Sec - 151 H, 23 M, 48 Sec (Fms 1589 through 1593).

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo reduction data are for a strip of near vertical photography starting at 146 deg. E Long., 25 deg S Lat., and extending WNW to 33.6 deg. W Long., 25.2 deg. N Lat. Omitted from the sequence is a 5 frame gap (Fms 1589 through 1593) covering the region, 108.8 deg. E. Long. to 101.5 deg. E Long., for which state vector data only are provided. Throughout the sequence tilt is maintained near zero (less than 1 deg.) so that the principal intersection point remains essentially coincident with the vehicle nadir.

APOLLO 15 A15 R-38 MAP 12771 FIN PAGE - 1560

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	20	43	35.861
GET			6	7	9	35.068

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1343.0096741	-657.7243500	-1089.0276184	-1.0544398	1.0553786	.6450424
SELENOGRAPHIC	-1385.6388855	943.0149078	-782.9337311	.8302262	1.3862515	.1754381
SIGMA(SELENO)	1.03	1.72	.25	.001	.001	.001

LONGITUDE OF NADIR POINT	145.7622395 DEG	LATITUDE OF NADIR POINT	-25.0381975 DEG
SIGMA NADIR LONGITUDE	.0011914 DEG	SIGMA NADIR LATITUDE	.0001465 DEG
LONG OF CAMERA AXIS INTERSECT	145.7288399 DEG	LATI OF CAMERA AXIS INTERSECT	-25.0157626 DEG
SPACECRAFT RADIUS	1849.9344330 KM	SPACECRAFT ALTITUDE	111.8444061 KM
SIGMA SPACECRAFT RADIUS	.0000113 KM	AZIMUTH OF VELOCITY VECTOR	277.0172081 DEG
MEAN ALTITUDE RATE	.0105439 KM/SEC	HORIZONTAL VELOCITY	1.6252815 KM/SEC
TILT AZIMUTH	306.5466957 DEG	TILT ANGLE	.5855064 DEG
SIGMA TILT AZIMUTH	.1961972 DEG	SIGMA TILT ANGLE	.0019962 DEG
SUN ELEVATION AT PRIN GRND PNT	.8002930 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.5931625 DEG
LONGITUDE OF SUBSOLAR POINT	56.7048845 DEG	LATITUDE OF SUBSOLAR POINT	.1990513 DEG
ALPHA	-.5043251 DEG	SWING ANGLE	299.9740372 DEG
EMISSION ANGLE	.6231468 DEG	SIGMA SWING ANGLE	.1961973 DEG
PHASE ANGLE	89.7040157 DEG	NORTH DEVIATION ANGLE	173.4149227 DEG
PHI	.5071215 DEG	X-TILT	.2924746 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-173.4261398 DEG	Y-TILT	-.5071149 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.2924746 DEG	HEADING	-83.4287262 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-111.8444061 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.75147089	-.50149465	.42871273	111.850632

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.64855609+00	.65366861+00	.38999021+00
.24983095+00	.66678067+00	-.70213100+00
-.71899898+00	-.35793973+00	-.59575137+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99337136+00	.11443465+00	.88507086-02
-.11448250+00	-.99341209+00	-.51046229-02
.82082556-02	-.60841533-02	.99994785+00

LATITUDE	LONGITUDE
-27.260	142.626
-22.249	143.400
-22.778	148.866
-27.896	148.360

Figure 10(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	21	42	54.725
GET			6	8	8	53.928

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1310.7735748	676.4713135	1095.7589722	1.0692773	-1.0582781	-.6435308
SELENOGRAPHIC	1385.8484802	-919.3733215	781.4123383	-.8408484	-1.3930547	-.1726590
SIGMA(SELENO)	1.04	1.73	.24	.001	.001	.001

LONGITUDE OF NADIR POINT	-33.5603371 DEG	LATITUDE OF NADIR POINT	25.1669319 DEG
SIGMA NADIR LONGITUDE	.0012100 DEG	SIGMA NADIR LATITUDE	.0001385 DEG
LONG OF CAMERA AXIS INTERSECT	-33.5825577 DEG	LATI OF CAMERA AXIS INTERSECT	25.1905544 DEG
SPACECRAFT RADIUS	1837.5060425 KM	SPACECRAFT ALTITUDE	99.4160156 KM
SIGMA SPACECRAFT RADIUS	.0000109 KM	AZIMUTH OF VELOCITY VECTOR	263.4802361 DEG
MEAN ALTITUDE RATE	-.0105952 KM/SEC	HORIZONTAL VELOCITY	1.6362240 KM/SEC
TILT AZIMUTH	319.5938301 DEG	TILT ANGLE	.5424405 DEG
SIGMA TILT AZIMUTH	.2093221 DEG	SIGMA TILT ANGLE	.0020192 DEG
SUN ELEVATION AT PRIN GRND PNT	.2790871 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.9124117 DEG
LONGITUDE OF SUBSOLAR POINT	56.2021723 DEG	LATITUDE OF SUBSOLAR POINT	.1980431 DEG
ALPHA	.3710906 DEG	SWING ANGLE	326.4676018 DEG
EMISSION ANGLE	.5734771 DEG	SIGMA SWING ANGLE	.2093217 DEG
PHASE ANGLE	89.3498144 DEG	NORTH DEVIATION ANGLE	186.8844814 DEG
PHI	.2996425 DEG	X-TILT	.4521417 DEG
SIGMA PHI	.0019997 DEG	SIGMA X-TILT	.0020004 DEG
KAPPA	173.1275768 DEG	Y-TILT	-.2996332 DEG
SIGMA KAPPA	.0020001 DEG	SIGMA Y-TILT	.0019996 DEG
OMEGA	.4521417 DEG	HEADING	-96.8747959 DEG
SIGMA OMEGA	.0020004 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-99.4160156 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.76011378	.49689634	-.41871358	99.420731

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.66331185+00	-.63828553+00	-.39065201+00
.23120519+00	.67127819+00	-.70422272+00
.71173140+00	.37679853+00	.59284177+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99279653+00	-.11969844+00	.52295619-02
.11965536+00	-.99278408+00	-.78912789-02
.61363985-02	-.72086743-02	.99995523+00

LATITUDE	LONGITUDE
22.580	-35.707
27.093	-36.366
27.666	-31.290
23.099	-30.743

Figure 10(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 44, Camera: 3-Inch Mapping Frames: 1704 Through: 1852

Coverage Interval:

From: 25.0 Deg. S Lat., 139.7 Deg. E Long., To: 25.0 Deg. N Lat., 41.2 Deg. W Long.

From: 162 Hr 59 Min 45.29 Sec, To: 163 Hr 59 Min 32.42 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 177 H, 20 M, 11.13 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 44 . For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5559192.33 $\dot{X}$ = -132.2273

Y = 353857.69 $\dot{Y}$ = -5243.1508

Z = 2396110.96 $\dot{Z}$ = 990.9455

- Telemetered Data Tape

Data Source: Station tapes

Bit Rate: High

Date Edited: 8 Dec. 1971

Edited Data Tape No. A09624 File No.: 1 Location: Bldg. 12, MSC

Remarks: Telemetered vehicle attitude data are unavailable for the interval 163 H, 17 M, 17 Sec - 163 H, 19 M, 2.7 Sec GET, (Frames 1748 through 1751).

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo reduction data are for a strip of near vertical photography starting at 140 deg. E Long., 25 deg. S Lat., and extending WNW to 41.2 deg. W Long., 26 deg N Lat. Coverage, except for vehicle state vectors, is omitted for the region 87 deg. E Long. to 81.2 deg. E Long. (Frames 1748 through 1751) where telemetered vehicle attitude data is unavailable.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	8	2	8	33	46.091
	GET			6	18	59	45.293

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1334.9353943	-665.5744019	-1091.1101227	-1.0647539	1.0475052	.6450668
SELENOGRAPHIC	-1276.2961426	1084.2988434	-781.6183624	.9725591	1.2920598	.1782958
SIGMA(SELENO)	1.20	1.60	.24	.001	.001	.001

LONGITUDE OF NADIR POINT	139.6498756 DEG	LATITUDE OF NADIR POINT	-25.0194061 DEG
SIGMA NADIR LONGITUDE	.0011928 DEG	SIGMA NADIR LATITUDE	.0001447 DEG
LONG OF CAMERA AXIS INTERSECT	139.6667252 DEG	LATI OF CAMERA AXIS INTERSECT	-25.0081992 DEG
SPACECRAFT RADIUS	1848.1241913 KM	SPACECRAFT ALTITUDE	110.0341644 KM
SIGMA SPACECRAFT RADIUS	.0000096 KM	AZIMUTH OF VELOCITY VECTOR	277.1285248 DEG
MEAN ALTITUDE RATE	.0110089 KM/SEC	HORIZONTAL VELOCITY	1.6269179 KM/SEC
TILT AZIMUTH	53.7275753 DEG	TILT ANGLE	.2992798 DEG
SIGMA TILT AZIMUTH	.3802469 DEG	SIGMA TILT ANGLE	.0020178 DEG
SUN ELEVATION AT PRIN GRND PNT	.8452959 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.6003761 DEG
LONGITUDE OF SUBSOLAR POINT	50.6865792 DEG	LATITUDE OF SUBSOLAR POINT	.1866905 DEG
ALPHA	.2544352 DEG	SWING ANGLE	46.7824345 DEG
EMISSION ANGLE	.3182134 DEG	SIGMA SWING ANGLE	.3802477 DEG
PHASE ANGLE	88.9002647 DEG	NORTH DEVIATION ANGLE	173.0619793 DEG
PHI	-.2180169 DEG	X-TILT	.2048517 DEG
SIGMA PHI	.0019998 DEG	SIGMA X-TILT	.0020002 DEG
KAPPA	-173.0556698 DEG	Y-TILT	.2180155 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019998 DEG
OMEGA	.2048517 DEG	HEADING	-83.0548878 DEG
SIGMA OMEGA	.0020002 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-110.0341644 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.68685953	-.58905654	.42571864	110.035767

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.64604491+00	.64979990+00	.40048231+00
.24199779+00	.67197240+00	-.69992147+00
-.72392201+00	-.35526489+00	-.59137455+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99268552+00	.12091761+00	-.38050788-02
-.12090419+00	-.99265769+00	-.35753296-02
-.42094613-02	-.30890337-02	.99998641+00

LATITUDE	LONGITUDE
-27.199	136.470
-22.213	137.270
-22.824	142.650
-27.806	142.108

Figure 11(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	2	9	33	33.219
GET			6	19	59	32.424

STATE VECTOR 1950.0	X	Y	Z	X DOT	Y DOT	Z DOT
	1333.6358643	657.3802795	1082.6330414	1.0489941	-1.0625446	-.6656144
SELENOGRAPHIC	1255.0570679	-1097.3381348	776.8581009	-1.0091564	-1.2716976	-.1918873
SIGMA(SELENO)	1.25	1.57	.26	.001	.001	.001

LONGITUDE OF NADIR POINT	-41.1642838 DEG	LATITUDE OF NADIR POINT	24.9848387 DEG
SIGMA NADIR LONGITUDE	.0012036 DEG	SIGMA NADIR LATITUDE	.0001484 DEG
LONG OF CAMERA AXIS INTERSECT	-41.1732712 DEG	LATI OF CAMERA AXIS INTERSECT	24.9642398 DEG
SPACECRAFT RADIUS	1839.2464905 KM	SPACECRAFT ALTITUDE	101.1564636 KM
SIGMA SPACECRAFT RADIUS	.0000097 KM	AZIMUTH OF VELOCITY VECTOR	262.7395210 DEG
MEAN ALTITUDE RATE	-.0109477 KM/SEC	HORIZONTAL VELOCITY	1.6346912 KM/SEC
TILT AZIMUTH	201.5955048 DEG	TILT ANGLE	.3807144 DEG
SIGMA TILT AZIMUTH	.3041379 DEG	SIGMA TILT ANGLE	.0019813 DEG
SUN ELEVATION AT PRIN GRND PNT	-1.1484499 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.2604561 DEG
LONGITUDE OF SUBSOLAR POINT	50.1799941 DEG	LATITUDE OF SUBSOLAR POINT	.1856207 DEG
ALPHA	.1530957 DEG	SWING ANGLE	209.2242489 DEG
EMISSION ANGLE	.4028156 DEG	SIGMA SWING ANGLE	.3041384 DEG
PHASE ANGLE	90.9953785 DEG	NORTH DEVIATION ANGLE	187.6323128 DEG
PHI	.1858451 DEG	X-TILT	-.3321922 DEG
SIGMA PHI	.0019994 DEG	SIGMA X-TILT	.0020006 DEG
KAPPA	172.3704662 DEG	Y-TILT	-.1858419 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019994 DEG
OMEGA	-.3321922 DEG	HEADING	-97.6284637 DEG
SIGMA OMEGA	.0020006 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-101.1564636 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.68200586	.59305247	-.42796819	101.1580029

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.650409960+00	-.642093500+00	-.405811330+00
.237099300+00	.679179770+00	-.694621240+00
.721630690+00	.356571010+00	.593985270+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.991144520+00	-.132748060+00	.324354800-02
.132765150+00	-.991130510+00	.579781470-02
.244513090-02	.617711610-02	.999977980+00

LATITUDE	LONGITUDE
22.397	-43.297
26.974	-44.093
27.619	-38.888
22.987	-38.325

Figure 11(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 50, Camera: 3-Inch Mapping Frames: 1852 Through: 1946

Coverage Interval:

From: 26.1 Deg. S Lat., 126.4 Deg. E Long., To: 23.0 Deg. N Lat., 13.7 Deg. E Long.

From: 174 Hr 52 Min 24.95 Sec, To: 175 Hr 31 Min 59.73 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 189 H, 9 M, 7.67 Sec .

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 50. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5445685.09	$\dot{X}$ =	-246.0737
Y =	356948.16	$\dot{Y}$ =	-5217.1922
Z =	2619968.86	$\dot{Z}$ =	1146.3435

- Telemetered Data Tape

Data Source: Station tapes

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09624 File No.: 2 Location: Bldg. 12, MSC

Remarks: There were no telemetered vehicle attitude data gaps within the interval.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo reduction data are for a sequence of essentially vertical photography starting at 126 deg. E Long., 26 deg. S Lat., and ending at 13.7 deg. E Long., 23 deg. N Lat. Throughout all except a short interval of the sequence, tilt is maintained less than 1 deg. so that the principal intersection point and the vehicle nadir remain essentially coincident. During the excepted interval (Frames 1925 through 1934) the pitch rate of the vehicle was sharply reduced then increased back to orbital rate resulting in a steady increase of tilt to 7+ deg. then a sharp reduction back to near zero.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	8	2	20	26	25.744
	GET			7	6	52	24.946

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1437.6694794	-498.4774170	-1056.5066071	-.9569388	1.0394049	.7994811
SELENOGRAPHIC	-987.0872574	1339.0660400	-814.9480591	1.1734408	1.0732483	.3262503
SIGMA(SELENO)	1.45	1.33	.46	.001	.001	.001

LONGITUDE OF NADIR POINT	126.3956347 DEG	LATITUDE OF NADIR POINT	-26.0993710 DEG
SIGMA NADIR LONGITUDE	.0011766 DEG	SIGMA NADIR LATITUDE	.0002666 DEG
LONG OF CAMERA AXIS INTERSECT	126.3592701 DEG	LATI OF CAMERA AXIS INTERSECT	-26.0710065 DEG
SPACECRAFT RADIUS	1852.4522705 KM	SPACECRAFT ALTITUDE	114.3622742 KM
SIGMA SPACECRAFT RADIUS	.0000201 KM	AZIMUTH OF VELOCITY VECTOR	283.0564270 DEG
MEAN ALTITUDE RATE	.0070094 KM/SEC	HORIZONTAL VELOCITY	1.6233061 KM/SEC
TILT AZIMUTH	310.9614258 DEG	TILT ANGLE	.6574875 DEG
SIGMA TILT AZIMUTH	.1743532 DEG	SIGMA TILT ANGLE	.0020002 DEG
SUN ELEVATION AT PRIN GRND PNT	7.3638391 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	273.8205986 DEG
LONGITUDE OF SUBSOLAR POINT	44.6485791 DEG	LATITUDE OF SUBSOLAR POINT	.1736377 DEG
ALPHA	-.5588523 DEG	SWING ANGLE	297.8595657 DEG
EMISSION ANGLE	.7007433 DEG	SIGMA SWING ANGLE	.1743534 DEG
PHASE ANGLE	83.1948109 DEG	NORTH DEVIATION ANGLE	166.8842640 DEG
PHI	.5812496 DEG	X-TILT	.3072247 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-166.8965778 DEG	Y-TILT	-.5812412 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.3072247 DEG	HEADING	-76.8996944 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-114.3622742 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.53783045	-.71500866	.44665537	114.370300

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.59415919+00	.63813876+00	.48964650+00
.23632769+00	.72038013+00	-.65207484+00
-.76884593+00	-.27171931+00	-.57883041+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97392459+00	.22664486+00	.10144399-01
-.22670629+00	-.97394835+00	-.53620565-02
.86648725-02	-.75220187-02	.99993421+00

LATITUDE	LONGITUDE
-23.818	130.225
-22.447	123.935
-28.232	122.308
-29.554	128.863

Figure 12(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	2	21	6	.526
GET			7	7	31	59.729

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-248.2946415	1276.8031464	1311.4865417	1.5695760	-.1320217	.4120187
SELENOGRAPHIC	1651.6017914	401.6889114	723.0013809	.1649884	-1.5527462	.4609946
SIGMA(SELENO)	.21	1.92	.58	.002	.000	.001

LONGITUDE OF NADIR POINT	13.6695989 DEG	LATITUDE OF NADIR POINT	23.0428653 DEG
SIGMA NADIR LONGITUDE	.0011275 DEG	SIGMA NADIR LATITUDE	.0003418 DEG
LONG OF CAMERA AXIS INTERSECT	13.6955332 DEG	LATI OF CAMERA AXIS INTERSECT	23.0174162 DEG
SPACECRAFT RADIUS	1847.1257172 KM	SPACECRAFT ALTITUDE	109.0357208 KM
SIGMA SPACECRAFT RADIUS	.0000076 KM	AZIMUTH OF VELOCITY VECTOR	288.0735512 DEG
MEAN ALTITUDE RATE	-.0097046 KM/SEC	HORIZONTAL VELOCITY	1.6280563 KM/SEC
TILT AZIMUTH	136.8351212 DEG	TILT ANGLE	.5561552 DEG
SIGMA TILT AZIMUTH	.2059605 DEG	SIGMA TILT ANGLE	.0020008 DEG
SUN ELEVATION AT PRIN GRND PNT	52.4899025 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	123.2345409 DEG
LONGITUDE OF SUBSOLAR POINT	44.3132815 DEG	LATITUDE OF SUBSOLAR POINT	.1728934 DEG
ALPHA	-.5748402 DEG	SWING ANGLE	118.8444910 DEG
EMISSION ANGLE	.5910776 DEG	SIGMA SWING ANGLE	.2059617 DEG
PHASE ANGLE	38.0847225 DEG	NORTH DEVIATION ANGLE	162.0008354 DEG
PHI	-.4871193 DEG	X-TILT	-.2682911 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-162.0083237 DEG	Y-TILT	.4871139 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.2682911 DEG	HEADING	-72.0106030 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-109.0357208 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.89298142	-.21035016	-.39791580	109.041183

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.96470931+00	-.81788258-01	.25029312+00
.23049766+00	.72185457+00	-.65253098+00
-.12730576+00	.68719475+00	.71623184+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.95107931+00	.30882987+00	-.85016394-02
-.30887549+00	-.95109090+00	.46825482-02
-.66398293-02	.70793977-02	.99995280+00

LATITUDE	LONGITUDE
24.781	17.617
26.511	11.701
21.170	9.905
19.416	15.634

Figure 12(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 60, Camera: 3-Inch Mapping Frames: 1946 Through: 2091

Coverage Interval:

From: 27.15 Deg. S Lat., 122.6 Deg. E Long., To: 27.3 Deg. N Lat., 6.8 Deg.W Long.

From: 194 Hr 35 Min 34.6 Sec, To: 195 Hr 35 Min 0.4 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 208 H, 51 M, 11.11 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 =	5574224.19	$\dot{X}$ =	-354.9182
Y =	354480.73	$\dot{Y}$ =	-5106.8394
Z =	2379220.06	$\dot{Z}$ =	1496.9973

- Telemetered Data Tape

Data Source: Station tape

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09624 File No.: 3 Location: Bldg. 12, MSC

Remarks: There are no telemetered vehicle attitude data for the interval 194 H, 40 M, 4.2 Sec - 194 H, 44 M, 17 Sec GET (Fms 1958 through 1967).

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photog[illegible] position and lighting data. Each tabulation presents the resul[illegible]f computations for a specified time within the range covered by the magazine

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a sequence of near vertical photography starting at 123 deg. E Long., 27 deg. S Lat., and extending WNW to 56.8 deg. W Long., 27 deg. N Lat. Vehicle state vectors only are provided for the region 109 deg. E Long. to 95 deg. E Long. (Fms 1958 through 1967) for which vehicle attitude data are unavailable.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND		
	GMT	71	8	3	16	9	10.773		
	GET			8	2	35	9.976		
STATE VECTOR	X	Y		Z		X DOT	Y DOT	Z DOT	
1950.0	-1282.7921600	-656.2279892		-1164.4372711		-1.1206557	.9607374	.6763722	
SELENOGRAPHIC	-919.5272522	1364.2565155		-851.6917496		1.2511160	1.0069038	.2392031	
SIGMA(SELENO)	1.55	1.25		.33		.001	.001	.001	

LONGITUDE OF NADIR POINT	123.9805002 DEG	LATITUDE OF NADIR POINT	-27.3696384 DEG
SIGMA NADIR LONGITUDE	.0012035 DEG	SIGMA NADIR LATITUDE	.0001969 DEG
LONG OF CAMERA AXIS INTERSECT	123.9709721 DEG	LATI OF CAMERA AXIS INTERSECT	-27.3759668 DEG
SPACECRAFT RADIUS	1852.5941162 KM	SPACECRAFT ALTITUDE	114.5040894 KM
SIGMA SPACECRAFT RADIUS	.0000148 KM	AZIMUTH OF VELOCITY VECTOR	279.7443542 DEG
MEAN ALTITUDE RATE	.0105324 KM/SEC	HORIZONTAL VELOCITY	1.6236249 KM/SEC
TILT AZIMUTH	233.2075760 DEG	TILT ANGLE	.1607125 DEG
SIGMA TILT AZIMUTH	.7125855 DEG	SIGMA TILT ANGLE	.0020187 DEG
SUN ELEVATION AT PRIN GRND PNT	.5166159 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.4370270 DEG
LONGITUDE OF SUBSOLAR POINT	34.6306858 DEG	LATITUDE OF SUBSOLAR POINT	.1505157 DEG
ALPHA	-.1361410 DEG	SWING ANGLE	223.6570187 DEG
EMISSION ANGLE	.1711773 DEG	SIGMA SWING ANGLE	.7125920 DEG
PHASE ANGLE	89.6195240 DEG	NORTH DEVIATION ANGLE	170.4452515 DEG
PHI	.1107345 DEG	X-TILT	-.1160486 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-170.4498653 DEG	Y-TILT	-.1107343 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.1160486 DEG	HEADING	-80.4496422 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-114.5040894 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	.49863373	-.73578661	.45823843	114.504578

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.68628736+00	.59576713+00	.41721827+00
.27527858+00	.71953657+00	-.65689921+00
-.67156288+00	-.35683136+00	-.62802250+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98613826+00	.16591411+00	.19326766-02
-.16591026+00	-.98613872+00	.20254293-02
.22419442-02	.16707324-02	.99999613+00

LATITUDE	LONGITUDE
-29.452	120.554
-24.343	121.644
-25.180	127.317
-30.343	126.465

Figure 13(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	17	9	1.170
GET			8	3	35	.374

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1277.8974304	646.6755295	1151.8575134	1.1102827	-.9778636	-.6995269
SELENOGRAPHIC	893.4269791	-1366.7980957	843.5864105	-1.2840885	-.9822064	-.2543033
SIGMA(SELENO)	1.59	1.22	.35	.001	.001	.001

LONGITUDE OF NADIR POINT	-56.8287964 DEG	LATITUDE OF NADIR POINT	27.3217728 DEG
SIGMA NADIR LONGITUDE	.0012216 DEG	SIGMA NADIR LATITUDE	.0002022 DEG
LONG OF CAMERA AXIS INTERSECT	-56.8326001 DEG	LATI OF CAMERA AXIS INTERSECT	27.3277650 DEG
SPACECRAFT RADIUS	1837.9300232 KM	SPACECRAFT ALTITUDE	99.8399963 KM
SIGMA SPACECRAFT RADIUS	.0000147 KM	AZIMUTH OF VELOCITY VECTOR	260.1195793 DEG
MEAN ALTITUDE RATE	-.0104944 KM/SEC	HORIZONTAL VELOCITY	1.6364826 KM/SEC
TILT AZIMUTH	330.5409889 DEG	TILT ANGLE	.1201279 DEG
SIGMA TILT AZIMUTH	.9548295 DEG	SIGMA TILT ANGLE	.0020279 DEG
SUN ELEVATION AT PRIN GRND PNT	-.7812214 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.4281950 DEG
LONGITUDE OF SUBSOLAR POINT	34.1239300 DEG	LATITUDE OF SUBSOLAR POINT	.1492977 DEG
ALPHA	.0612102 DEG	SWING ANGLE	340.2180328 DEG
EMISSION ANGLE	.1268618 DEG	SIGMA SWING ANGLE	.9548436 DEG
PHASE ANGLE	90.7200127 DEG	NORTH DEVIATION ANGLE	189.6808224 DEG
PHI	.0405456 DEG	X-TILT	.1127426 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	170.3210239 DEG	Y-TILT	-.0405455 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.1127426 DEG	HEADING	-99.6790600 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-99.8399963 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	-.48742202	.74379686	-.45736857	99.840240

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.68260330+00	-.59755858+00	-.42068560+00
.22511287+00	.71960225+00	-.65688407+00
.69525313+00	.35368957+00	.62572107+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98576470+00	-.16812903+00	.70765318-03
.16812742+00	-.98576325+00	-.19677277-02
.10284212-02	-.18207701-02	.99999786+00

LATITUDE	LONGITUDE
24.649	-58.892
29.157	-59.852
29.946	-54.662
25.404	-53.886

Figure 13(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 62, Camera: 3-Inch Mapping Frames: 2091 Through: 2206

Coverage Interval:

From: 15.9 Deg. S Lat., 83.2 Deg. E Long., To: 27.3 Deg. N Lat., 58.9 Deg. W Long.

From: 198 Hr 44 Min 40.7 Sec, To: 199 Hr 32 Min 2.02 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1736.09 Km

  Ephemeris-Universal Time Difference: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 212 H, 47 M, 33.35 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 62. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5602038.66	$\dot{X}$ =	-362.7224
Y =	358193.68	$\dot{Y}$ =	-5082.7231
Z =	2319751.64	$\dot{Z}$ =	1565.8407

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 7 Dec. 1971

Edited Data Tape No. A09569 File No.: 2 Location: Bldg. 12, MSC

Remarks: There were no significant gimbal data gaps within the interval.

- AFE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a near vertical strip of photography starting at 83.2 deg. E Long., 16 deg. S Lat. and extending WNW to 59 deg. W Long., 27 deg. N Lat. Throughout the sequence, a near zero (less than 1 deg.) tilt is maintained such that the principal intersection point and vehicle nadir remain essentially coincident.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	20	18	41.462
GET			8	6	44	40.664

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1796.2511139	145.7121296	-452.1584511	-.2065907	1.1115338	1.1585694
SELENOGRAPHIC	210.1791592	1774.9752502	-507.4297218	1.4846436	.0137926	.6450683
SIGMA(SELENO)	1.84	.11	.88	.000	.002	.000

LONGITUDE OF NADIR POINT	83.2469082 DEG	LATITUDE OF NADIR POINT	-15.8490558 DEG
SIGMA NADIR LONGITUDE	.0010193 DEG	SIGMA NADIR LATITUDE	.0004873 DEG
LONG OF CAMERA AXIS INTERSECT	83.2382889 DEG	LATI OF CAMERA AXIS INTERSECT	-15.8692123 DEG
SPACECRAFT RADIUS	1858.0089417 KM	SPACECRAFT ALTITUDE	119.9189148 KM
SIGMA SPACECRAFT RADIUS	.0000229 KM	AZIMUTH OF VELOCITY VECTOR	294.5259933 DEG
MEAN ALTITUDE RATE	.0049493 KM/SEC	HORIZONTAL VELOCITY	1.6187495 KM/SEC
TILT AZIMUTH	202.3596478 DEG	TILT ANGLE	.3158990 DEG
SIGMA TILT AZIMUTH	.3627330 DEG	SIGMA TILT ANGLE	.0020010 DEG
SUN ELEVATION AT PRIN GRND PNT	37.4651670 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	282.7785110 DEG
LONGITUDE OF SUBSOLAR POINT	32.5177565 DEG	LATITUDE OF SUBSOLAR POINT	.1454069 DEG
ALPHA	-.0577027 DEG	SWING ANGLE	178.2399521 DEG
EMISSION ANGLE	.3376793 DEG	SIGMA SWING ANGLE	.3627326 DEG
PHASE ANGLE	52.5917954 DEG	NORTH DEVIATION ANGLE	155.8776665 DEG
PHI	-.0097076 DEG	X-TILT	-.3157511 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-155.8803482 DEG	Y-TILT	.0097074 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.3157511 DEG	HEADING	-65.8804035 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-119.9189148 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.11119979	-.95692537	.26819478	119.920868

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.12291524+00	.69150715+00	.71183543+00
.21877634+00	.71850908+00	-.66021323+00
-.96800245+00	.74582425-01	-.23960120+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.91269443+00	.40864266+00	-.16942624-03
-.40863735+00	-.91268014+00	.55108682-02
.20974297-02	.50989301-02	.99998481+00

LATITUDE	LONGITUDE
-17.162	79.513
-12.217	81.847
-14.423	86.981
-19.400	84.700

Figure 14(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	21	6	2.815
GET			8	7	32	2.021

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1275.2182617	649.8920441	1153.5459137	1.1129837	-.9749572	-.6983871
SELENOGRAPHIC	845.0446930	-1397.5153198	843.8364029	-1.3176476	-.9360313	-.2543010
SIGMA(SELENO)	1.63	1.17	.41	.001	.001	.001

LONGITUDE OF NADIR POINT	-58.8398339 DEG	LATITUDE OF NADIR POINT	27.3251872 DEG
SIGMA NADIR LONGITUDE	.0012219 DEG	SIGMA NADIR LATITUDE	.0002322 DEG
LONG OF CAMERA AXIS INTERSECT	-58.8779511 DEG	LATI OF CAMERA AXIS INTERSECT	27.3324347 DEG
SPACECRAFT RADIUS	1838.2626038 KM	SPACECRAFT ALTITUDE	100.1725769 KM
SIGMA SPACECRAFT RADIUS	.0000271 KM	AZIMUTH OF VELOCITY VECTOR	260.1235046 DEG
MEAN ALTITUDE RATE	-.0108478 KM/SEC	HORIZONTAL VELOCITY	1.6360940 KM/SEC
TILT AZIMUTH	282.0255051 DEG	TILT ANGLE	.6039720 DEG
SIGMA TILT AZIMUTH	.1892645 DEG	SIGMA TILT ANGLE	.0020061 DEG
SUN ELEVATION AT PRIN GRND PNT	-.8173189 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.4149275 DEG
LONGITUDE OF SUBSOLAR POINT	32.1167488 DEG	LATITUDE OF SUBSOLAR POINT	.1444284 DEG
ALPHA	.6233665 DEG	SWING ANGLE	291.7602386 DEG
EMISSION ANGLE	.6388075 DEG	SIGMA SWING ANGLE	.1892647 DEG
PHASE ANGLE	90.1939554 DEG	NORTH DEVIATION ANGLE	189.7531891 DEG
PHI	.5608806 DEG	X-TILT	.2238834 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	170.2662258 DEG	Y-TILT	-.5608844 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	.2238834 DEG	HEADING	-99.7359705 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-100.1725769 KM

SELENOGRAPHIC DIRECTION COSINES	X	Y	Z	MAGNITUDE (KM)
OF CAMERA AXIS	-.46901510	.75572323	-.45706370	100.178467

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.69106480+00	-.59183250+00	-.41492604+00
.22201976+00	.72011931+00	-.65736998+00
.68784929+00	.36216356+00	.62904770+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98555023+00	-.16910001+00	.97891229-02
.16906917+00	-.98559639+00	-.39074928-02
.10308891-01	-.21960216-02	.99994460+00

LATITUDE	LONGITUDE
24.658	-60.863
29.146	-61.814
29.974	-56.622
25.384	-55.827

Figure 14(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 63, Camera: 3-Inch Mapping Frames: 2206 Through: 2351

Coverage Interval:

From: 27.3 Deg S Lat., 120.5 Deg E Long., To: 27.2 Deg. N Lat., 60.3 Deg W Long.

From: 200 Hr 30 Min 48.31 Sec, To: 201 Hr 30 Min 39.29 Sec GET

Date Processed: 1/6/72, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: _____

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 =	5615994.30	$\dot{X}$ =	-367.7504
Y =	357003.71	$\dot{Y}$ =	-5070.78
Z =	2289724.61	$\dot{Z}$ =	1598.78

- Telemetered Data Tape

Data Source: Station tapes

Bit Rate: High

Date Edited: 4 Jan. 1972

Edited Data Tape No. A09569 File No.: 3 Location: Bldg. 12, MSC

Remarks: There are two significant gaps in the telemetered vehicle attitude data for the interval of this sequence:
1) 201 H, 25 M, 34.8 Sec - 201 H, 26 M, 45 Sec (Frames 2338 - 2341)
2) 201 H, 28 M, 41.8 Sec - 201 H, 29 M, 51.7 Sec (Frames 2346 - 2349)

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

- ±20 ms in onboard clock bias definition
- ± 5 ms in onboard clock drift rate definition
- ± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of near vertical photography starting at 120.5 deg. E Long., 27.3 deg. S Lat., and ending at 60.3 deg. W Long., 27.2 deg. N Lat. Throughout the sequence tilt is maintained essentially zero such that the principal intersection point and vehicle nadir remain near coincident. State vector data are provided for the two regions of coverage where vehicle attitude data are unavailable. The intervals are:

1) 41.4 deg. W Long., 29 deg. N Lat. - 48.2 deg. W Long., 28.6 deg. N Lat. (Frames 2338 through 2341).
2) 52.3 deg. W Long., 28.3 deg. N Lat. - 59 deg. W Long., 27.4 deg. N Lat. (Frames 2346 through 2349).

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	22	4	49.311
GET			8	8	30	48.516

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1286.2710266	-654.0350494	-1160.3730621	-1.1188936	.9602213	.6817071
SELENOGRAPHIC	-836.5447845	1417.2140045	-848.7743759	1.3075338	.9323702	.2443641
SIGMA(SELENO)	1.62	1.16	.37	.001	.001	.001

LONGITUDE OF NADIR POINT	120.5522575 DEG	LATITUDE OF NADIR POINT	-27.2826583 DEG
SIGMA NADIR LONGITUDE	.0012031 DEG	SIGMA NADIR LATITUDE	.0002136 DEG
LONG OF CAMERA AXIS INTERSECT	120.5085239 DEG	LATI OF CAMERA AXIS INTERSECT	-27.2800062 DEG
SPACECRAFT RADIUS	1851.6804810 KM	SPACECRAFT ALTITUDE	113.5904846 KM
SIGMA SPACECRAFT RADIUS	.0000208 KM	AZIMUTH OF VELOCITY VECTOR	279.9460907 DEG
MEAN ALTITUDE RATE	.0108805 KM/SEC	HORIZONTAL VELOCITY	1.6243331 KM/SEC
TILT AZIMUTH	273.8934441 DEG	TILT ANGLE	.5961457 DEG
SIGMA TILT AZIMUTH	.1920394 DEG	SIGMA TILT ANGLE	.0020032 DEG
SUN ELEVATION AT PRIN GRND PNT	.9213514 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.6363411 DEG
LONGITUDE OF SUBSOLAR POINT	31.6190572 DEG	LATITUDE OF SUBSOLAR POINT	.1432099 DEG
ALPHA	-.6339630 DEG	SWING ANGLE	263.9085770 DEG
EMISSION ANGLE	.6350441 DEG	SIGMA SWING ANGLE	.1920394 DEG
PHASE ANGLE	89.7126112 DEG	NORTH DEVIATION ANGLE	169.9952316 DEG
PHI	.5926811 DEG	X-TILT	-.0632477 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-170.0153675 DEG	Y-TILT	-.5926807 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	-.0632477 DEG	HEADING	-80.0147142 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-113.5904846 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.46052480	-.75977036	.45898356	113.597046

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.69146771+00	.58932301+00	.41781658+00
.22097986+00	.72319295+00	-.65433918+00
-.68777925+00	-.36012544+00	-.63029316+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98479957+00	.17338602+00	.10344045-01
-.17338398+00	-.98485363+00	.11038809-02
.10378778-01	-.70636036-03	.99994594+00

LATITUDE	LONGITUDE
-24.872	124.221
-23.824	117.882
-29.631	116.551
-30.630	123.253

Figure 15(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	23	4	40.079
GET			8	9	30	39.287

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1282.2721710	645.0618744	1148.7116394	1.1071329	-.9768112	-.7046881
SELENOGRAPHIC	811.0905426	-1419.2486420	841.3154755	-1.3382519	-.9045516	-.2595321
SIGMA(SELENO)	1.66	1.13	.38	.001	.001	.001

LONGITUDE OF NADIR POINT	-60.2538643 DEG	LATITUDE OF NADIR POINT	27.2339211 DEG
SIGMA NADIR LONGITUDE	.0012194 DEG	SIGMA NADIR LATITUDE	.0002184 DEG
LONG OF CAMERA AXIS INTERSECT	-60.2977018 DEG	LATI OF CAMERA AXIS INTERSECT	27.2022154 DEG
SPACECRAFT RADIUS	1838.4409637 KM	SPACECRAFT ALTITUDE	100.3509674 KM
SIGMA SPACECRAFT RADIUS	.0000207 KM	AZIMUTH OF VELOCITY VECTOR	259.9208641 DEG
MEAN ALTITUDE RATE	-.0108467 KM/SEC	HORIZONTAL VELOCITY	1.6359320 KM/SEC
TILT AZIMUTH	230.8914719 DEG	TILT ANGLE	.8704033 DEG
SIGMA TILT AZIMUTH	.1321684 DEG	SIGMA TILT ANGLE	.0019929 DEG
SUN ELEVATION AT PRIN GRND PNT	-1.1891136 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.2290545 DEG
LONGITUDE OF SUBSOLAR POINT	31.1122980 DEG	LATITUDE OF SUBSOLAR POINT	.1419648 DEG
ALPHA	.7219683 DEG	SWING ANGLE	240.8578453 DEG
EMISSION ANGLE	.9206064 DEG	SIGMA SWING ANGLE	.1321683 DEG
PHASE ANGLE	90.4672041 DEG	NORTH DEVIATION ANGLE	189.9827919 DEG
PHI	.7601545 DEG	X-TILT	-.4238113 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	170.0308304 DEG	Y-TILT	-.7601338 DEG
SIGMA KAPPA	.0020001 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	-.4238113 DEG	HEADING	-99.9635515 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020002 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-100.3509674 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.44916341	.76224121	-.46609071	100.363220

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.69011587+00	-.59151094+00	-.41695899+00
.22839890+00	.72472198+00	-.65008606+00
.68671247+00	.35340161+00	.63524266+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98483130+00	-.17300638+00	.13266448-01
.17311357+00	-.98487404+00	.73960355-02
.11786091-01	.95812071-02	.99988469+00

LATITUDE	LONGITUDE
30.121	-57.919
29.265	-63.746
24.136	-62.637
25.078	-57.013

Figure 15(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 70, Camera: 3-Inch Mapping Frames: 2351 Through: 2492

Coverage Interval:

From: 27.2 Deg. S Lat., 113.4 Deg. E Long., To: 27.4 Deg. N Lat., 65.3 Deg. W Long.

From: 214 Hr 20 Min 18.35 Sec, To: 215 Hr 19 Min 32.56 Sec GET

Date Processed: 12/15/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

HOPE Version Used: B-6.1

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: 0.69583333 Min.

Base Time: Yr 1971 Month 7 Day 26 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: 228 H, 32 M, 49.06 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 70 . For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5715995.09	$\dot{X}$ =	-363.6069
Y =	363293.87	$\dot{Y}$ =	-4985.8444
Z =	2051514.40	$\dot{Z}$ =	1824.5026

- Telemetered Data Tape

Data Source: MSFN

Bit Rate: High

Date Edited: 10 Dec. 1971

Edited Data Tape No. A09578 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no significant gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

  Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

  Range Zero-Clock Zero Time Difference 0.79 Sec

  REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a sequence of near vertical photography starting at 113 deg. E Long., 27 deg. S Lat., and extending WNW to 65 deg. W Long., 27 deg. N Lat. Throughout the sequence a near zero tilt is maintained exceeding 1 deg. only for short intervals and never in excess of 2 deg. The principal intersection point and the vehicle nadir remain essentially coincident throughout the sequence.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND		
	GMT	71	8	4	11	54	19.141		
	GET			8	22	20	18.347		
STATE VECTOR	X	Y		Z	X DOT	Y DOT		Z DOT	
1950.0	-1275.3837891	-665.3931122		-1160.1049347	-1.1314700	.9512390		.6808473	
SELENOGRAPHIC	-655.1160049	1507.9464264		-843.8695679	1.4145445	.7660435		.2467272	
SIGMA(SELENO)	1.75	.95		.36	.001	.001		.001	

LONGITUDE OF NADIR POINT	113.4821711 DEG	LATITUDE OF NADIR POINT	-27.1700711 DEG
SIGMA NADIR LONGITUDE	.0012060 DEG	SIGMA NADIR LATITUDE	.0002129 DEG
LONG OF CAMERA AXIS INTERSECT	113.4348583 DEG	LATI OF CAMERA AXIS INTERSECT	-27.1694436 DEG
SPACECRAFT RADIUS	1848.0246738 KM	SPACECRAFT ALTITUDE	109.9346771 KM
SIGMA SPACECRAFT RADIUS	.0000198 KM	AZIMUTH OF VELOCITY VECTOR	280.0127106 DEG
MEAN ALTITUDE RATE	.0109609 KM/SEC	HORIZONTAL VELOCITY	1.6273957 KM/SEC
TILT AZIMUTH	270.8436584 DEG	TILT ANGLE	.6656582 DEG
SIGMA TILT AZIMUTH	.1717071 DEG	SIGMA TILT ANGLE	.0020041 DEG
SUN ELEVATION AT PRIN GRND PNT	.9755068 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	270.6418953 DEG
LONGITUDE OF SUBSOLAR POINT	24.5958192 DEG	LATITUDE OF SUBSOLAR POINT	.1255574 DEG
ALPHA	-.7076981 DEG	SWING ANGLE	260.7347488 DEG
EMISSION ANGLE	.7077590 DEG	SIGMA SWING ANGLE	.1717070 DEG
PHASE ANGLE	89.7321920 DEG	NORTH DEVIATION ANGLE	169.8695354 DEG
PHI	.6569196 DEG	X-TILT	-.1071616 DEG
SIGMA PHI	.0019997 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	-169.8916912 DEG	Y-TILT	-.6569185 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	-.1071616 DEG	HEADING	-79.8904619 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-109.9346771 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.36509372	-.81122240	.45675464	109.942581

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.69863498+00	.56153757+00	.43546565+00
.21364920+00	.72547387+00	-.65418351+00
-.68256734+00	-.38810555+00	-.63134794+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98440921+00	.17651909+00	.11465139-01
-.17550926+00	-.98447595+00	.18703210-02
.11615439-01	-.17104687-03	.99993257+00

LATITUDE	LONGITUDE
-24.855	117.022
-23.824	110.903
-29.440	109.605
-30.412	116.072

Figure 16(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	4	12	53	33.351
GET			8	23	19	32.556

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1235.4175873	693.0732574	1177.1957855	1.1510994	-.9455634	-.6685892
SELENOGRAPHIC	63.2570267	-1485.1902924	848.3906555	-1.4179564	-.7741305	-.2371775
SIGMA(SELENO)	1.75	.96	.35	.001	.001	.001

LONGITUDE OF NADIR POINT	-65.2953606 DEG	LATITUDE OF NADIR POINT	27.4271045 DEG
SIGMA NADIR LONGITUDE	.0012198 DEG	SIGMA NADIR LATITUDE	.0001998 DEG
LONG OF CAMERA AXIS INTERSECT	-65.3105888 DEG	LATI OF CAMERA AXIS INTERSECT	27.4124329 DEG
SPACECRAFT RADIUS	1841.8460999 KM	SPACECRAFT ALTITUDE	103.7561035 KM
SIGMA SPACECRAFT RADIUS	.0000196 KM	AZIMUTH OF VELOCITY VECTOR	260.7845039 DEG
MEAN ALTITUDE RATE	-.0110304 KM/SEC	HORIZONTAL VELOCITY	1.6327623 KM/SEC
TILT AZIMUTH	222.6690731 DEG	TILT ANGLE	.3344040 DEG
SIGMA TILT AZIMUTH	.3447401 DEG	SIGMA TILT ANGLE	.0019920 DEG
SUN ELEVATION AT PRIN GRND PNT	.5854769 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	90.1636629 DEG
LONGITUDE OF SUBSOLAR POINT	24.0943229 DEG	LATITUDE OF SUBSOLAR POINT	.1242649 DEG
ALPHA	.2392623 DEG	SWING ANGLE	231.5951939 DEG
EMISSION ANGLE	.3543613 DEG	SIGMA SWING ANGLE	.3447387 DEG
PHASE ANGLE	89.1752548 DEG	NORTH DEVIATION ANGLE	188.9329472 DEG
PHI	.2619195 DEG	X-TILT	-.2076280 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	171.0730495 DEG	Y-TILT	-.2619177 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	-.2076280 DEG	HEADING	-98.9260054 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-103.7561035 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.37372291	.80289863	-.46441096	103.757980

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.71147785+00	-.57849690+00	-.39892419+00
.22247447+00	.73668757+00	-.65343028+00
.66690397+00	.37632116+00	.64334151+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98789718+00	-.15515712+00	.45713109-02
.15517413+00	-.98788041+00	.30237839-02
.39536557-02	.42891778-02	.99998304+00

LATITUDE	LONGITUDE
30.423	-62.749
29.595	-68.829
24.312	-67.770
25.147	-61.938

Figure 16(b) - Last Frame

Mission: Apollo 15, Target: South Oblique Strip Photography

Rev: 71, Camera: 3-Inch Mapping Frames: 2494 Through: 2623

Coverage Interval:

From: 21.7 Deg. S Lat., 80.1 Deg. E Long., To: 24.5 Deg. N Lat., 66.1 Deg.W Long.

From: 216 Hr 28 Min 36.04 Sec, To: 217 Hr 18 Min 7.10 Sec GET

Date Processed: 1/5/72, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  Constants Used:

  Lunar Potential Model: 1-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziell)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 230 H, 30 M, 56.42 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 71. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5729308.51	$\dot{X}$ =	-357.7284
Y =	366059.75	$\dot{Y}$ =	-4974.3685
Z =	2013057.85	$\dot{Z}$ =	1855.8189

- Telemetered Data Tape

Data Source: MSFN

Bit Rate: High

Date Edited: 27 Dec. 1971

Edited Data Tape No. A09668 File No.: 1 Location: Bldg. 12, MSC

Remarks:
Telemetered vehicle attitude data are not available for the initial nine minutes nor for the final minute of this photographic sequence. Valid vehicle attitude data were available only for the interval 216 H, 28 M, 34 Sec to 217 H, 18 M, 26 Sec (Frames 2514 through 2621).

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of side oblique photography. For approximately the initial nine minutes of photographic coverage vehicle attitude data are unavailable. This is also the case for the final one minute of the sequence. Only vehicle state vector information are provided at film exposure times throughout these intervals (Frames 2494 through 2514, Frames 2622 and 2623). Throughout the sequence the camera optical axis is directed Southward, essentially normal to the plane of flight, at a tilt of 40 deg. ±0.5 deg. As a result of this camera attitude, the principal intersection point position falls slightly to the rear and approximately 3 deg. South of the vehicle nadir, with the Southward edge of the photograph above the horizon. The above horizon photo frame corners are indicated by a Long=000, Lat=****.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	4	14	2	36.839
GET			9	0	28	36.042

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1743.6876373	-44.1845894	-625.3069839	-.4304136	1.1159646	1.0969571
SELENOGRAPHIC	260.7190971	1735.5970154	-594.2526703	1.5148414	-.0194621	.5820862
SIGMA(SELENO)	1.87	.10	.77	.000	.002	.001

LONGITUDE OF NADIR POINT	81.4569788 DEG	LATITUDE OF NADIR POINT	-18.7056870 DEG
SIGMA NADIR LONGITUDE	.0010579 DEG	SIGMA NADIR LATITUDE	.0004370 DEG
LONG OF CAMERA AXIS INTERSECT	80.0983192 DEG	LATI OF CAMERA AXIS INTERSECT	-21.7297385 DEG
SPACECRAFT RADIUS	1852.9456635 KM	SPACECRAFT ALTITUDE	114.8556671 KM
SIGMA SPACECRAFT RADIUS	.0000203 KM	AZIMUTH OF VELOCITY VECTOR	292.3575706 DEG
MEAN ALTITUDE RATE	.0082373 KM/SEC	HORIZONTAL VELOCITY	1.6228937 KM/SEC
TILT AZIMUTH	202.6587048 DEG	TILT ANGLE	40.2142816 DEG
SIGMA TILT AZIMUTH	.0030974 DEG	SIGMA TILT ANGLE	.0020003 DEG
SUN ELEVATION AT PRIN GRND PNT	30.7138262 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	283.8543282 DEG
LONGITUDE OF SUBSOLAR POINT	23.5096893 DEG	LATITUDE OF SUBSOLAR POINT	.1227530 DEG
ALPHA	-24.0449944 DEG	SWING ANGLE	180.0006275 DEG
EMISSION ANGLE	43.4967542 DEG	SIGMA SWING ANGLE	.0030973 DEG
PHASE ANGLE	74.0301771 DEG	NORTH DEVIATION ANGLE	149.5102577 DEG
PHI	.0005229 DEG	X-TILT	-40.2142863 DEG
SIGMA PHI	.0026187 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	-157.3421192 DEG	Y-TILT	-.0003993 DEG
SIGMA KAPPA	.0026189 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	-40.2142863 DEG	HEADING	-67.3417788 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-114.8556671 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.11013735	-.94118448	-.31943938	154.140656

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.26156850+00	.68393036+00	.68104415+00
-.44372828+00	.54141113+00	-.71412825+00
-.85713892+00	-.48899205+00	.16186303+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.92281920+00	.38523326+00	.69698330-05
-.29417346+00	-.70469804+00	.64564810+00
.24873012+00	.59581435+00	.76363511+00

LATITUDE	LONGITUDE
-19.787	83.635
-18.000	79.127
********	.000
********	.000

Figure 17(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	4	14	52	7.898
GET			9	1	18	7.104

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1241.5170135	688.1011810	1173.9053650	1.1460474	-.9475880	-.6737464
SELENOGRAPHIC	647.5558777	-1501.8650513	847.3336411	-1.4344566	-.7412194	-.2412677
SIGMA(SELENO)	1.77	.93	.38	.001	.001	.001

LONGITUDE OF NADIR POINT	-66.6758537 DEG	LATITUDE OF NADIR POINT	27.3878566 DEG
SIGMA NADIR LONGITUDE	.0012186 DEG	SIGMA NADIR LATITUDE	.0002121 DEG
LONG OF CAMERA AXIS INTERSECT	-66.1415224 DEG	LATI OF CAMERA AXIS INTERSECT	24.4607861 DEG
SPACECRAFT RADIUS	1841.9830322 KM	SPACECRAFT ALTITUDE	103.8930359 KM
SIGMA SPACECRAFT RADIUS	.0000234 KM	AZIMUTH OF VELOCITY VECTOR	260.6201897 DEG
MEAN ALTITUDE RATE	-.0109193 KM/SEC	HORIZONTAL VELOCITY	1.6325029 KM/SEC
TILT AZIMUTH	170.5586739 DEG	TILT ANGLE	40.2558537 DEG
SIGMA TILT AZIMUTH	.0030947 DEG	SIGMA TILT ANGLE	.0020103 DEG
SUN ELEVATION AT PRIN GRND PNT	.7494345 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	90.2072601 DEG
LONGITUDE OF SUBSOLAR POINT	23.0904865 DEG	LATITUDE OF SUBSOLAR POINT	.1216654 DEG
ALPHA	-6.9033188 DEG	SWING ANGLE	179.9404850 DEG
EMISSION ANGLE	43.2220974 DEG	SIGMA SWING ANGLE	.0030945 DEG
PHASE ANGLE	95.8823013 DEG	NORTH DEVIATION ANGLE	192.4818325 DEG
PHI	-.0503903 DEG	X-TILT	-40.2558346 DEG
SIGMA PHI	.0026203 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	170.6366558 DEG	Y-TILT	.0364562 DEG
SIGMA KAPPA	.0026205 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	-40.2558346 DEG	HEADING	-99.3959112 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-103.8930359 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.05485425	.39494833	-.91706423	139.185547

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.70612212+00	-.57798845+00	-.40904865+00
.60039308+00	.79499239+00	-.86967166-01
.37545668+00	-.18416412+00	.90835887+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98658355+00	-.16325547+00	-.67118726-03
.12416328+00	-.75279859+00	.64620169+00
-.10600138+00	.63744855+00	.76316645+00

LATITUDE	LONGITUDE
27.515	-64.313
26.835	-68.945
********	.000
********	.000

Figure 17(b) - Last Frame

Mission: Apollo 15, Target: Strip photography

Rev: 72, Camera: 3-Inch Mapping Frames: 2623 Through: 2752

Coverage Interval:

From: 26.8 Deg. S Lat., 109.7 Deg. E Long., To: 27.3 Deg. N Lat., 68.0 Deg.W Long.

From: 218 Hr 17 Min 46.74 Sec, To: 219 Hr 16 Min 38.92 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 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: 232 H, 29 M, 2.0 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 72. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5743623.34	$\dot{X}$ =	-352.7828
Y =	366342.93	$\dot{Y}$ =	-4962.4335
Z =	1975192.34	$\dot{Z}$ =	1885.7199

- Telemetered Data Tape

Data Source: MSFN

Bit Rate: High

Date Edited: 9 Dec. 1971

Edited Data Tape No. A09668 File No.: 2 Location: Bldg. 12, MSC

Remarks: There are no gimbal data for the interval 218 H, 19 M, 0.5 Sec - 218 H, 20 M, 56 Sec (Frames 2626 through 2630).

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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.

Uncertainties Assumed:

± 1 degree in camera positioning angle

±0.2 mrad in each gimbal angle

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of near vertical photography starting at 110 deg. E Long., 27 deg. S Lat., and extending WNW to 68 deg. W Long., 27 deg. N Lat. Omitted from the sequence is the region 106 deg. E Long. – 99 deg. E Long. (Frames 2626 through 2630) where vehicle attitude data are not available. Throughout the sequence a near zero (less than 1 deg.) tilt is maintained so that the principal intersection point and vehicle nadir remain essentially coincident.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	4	15	51	47.534
GET			9	2	17	46.736

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1307.8762970	-637.7938309	-1137.4284973	-1.1027500	.9654740	.7093505
SELENOGRAPHIC	-554.6697540	1551.7440186	-833.9646072	1.4562454	.6773413	.2682047
SIGMA(SELENO)	1.80	.85	.42	.001	.001	.001

LONGITUDE OF NADIR POINT	109.6693954 DEG	LATITUDE OF NADIR POINT	-26.8429580 DEG
SIGMA NADIR LONGITUDE	.0012007 DEG	SIGMA NADIR LATITUDE	.0002403 DEG
LONG OF CAMERA AXIS INTERSECT	109.6543150 DEG	LATI OF CAMERA AXIS INTERSECT	-26.8316023 DEG
SPACECRAFT RADIUS	1846.9068451 KM	SPACECRAFT ALTITUDE	108.8168182 KM
SIGMA SPACECRAFT RADIUS	.0000253 KM	AZIMUTH OF VELOCITY VECTOR	280.8312378 DEG
MEAN ALTITUDE RATE	.0106402 KM/SEC	HORIZONTAL VELOCITY	1.6282401 KM/SEC
TILT AZIMUTH	310.1609573 DEG	TILT ANGLE	.2812471 DEG
SIGMA TILT AZIMUTH	.4124734 DEG	SIGMA TILT ANGLE	.0019795 DEG
SUN ELEVATION AT PRIN GRND PNT	2.5609217 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.4314041 DEG
LONGITUDE OF SUBSOLAR POINT	22.5854180 DEG	LATITUDE OF SUBSOLAR POINT	.1203513 DEG
ALPHA	-.2331212 DEG	SWING ANGLE	298.6582680 DEG
EMISSION ANGLE	.2988709 DEG	SIGMA SWING ANGLE	.4124724 DEG
PHASE ANGLE	87.6721859 DEG	NORTH DEVIATION ANGLE	168.4905052 DEG
PHI	.2467691 DEG	X-TILT	.1348679 DEG
SIGMA PHI	.0019992 DEG	SIGMA X-TILT	.0020008 DEG
KAPPA	-168.4966354 DEG	Y-TILT	-.2467684 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019992 DEG
OMEGA	.1348679 DEG	HEADING	-78.4972172 DEG
SIGMA OMEGA	.0020008 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-108.8168182 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.30337102	-.83756667	.45436558	108.818222

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.67813917+00	.58516353+00	.44464684+00
.20848753+00	.73333368+00	-.64711248+00
-.70474123+00	-.34612908+00	-.61930166+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97990587+00	.19941370+00	.43069077-02
-.19942498+00	-.97991022+00	-.23538868-02
.37509993-02	-.31654652-02	.99998800+00

LATITUDE	LONGITUDE
-28.752	106.345
-23.923	107.573
-24.873	112.920
-29.784	111.932

Figure 18(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	4	16	50	39.715
GET			9	3	16	38.921

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1246.9345856	685.8751144	1170.3723755	1.1421508	-.9484081	-.6779497
SELENOGRAPHIC	614.0098801	-1517.8985901	844.9957275	-1.4491962	-.7095428	-.2449113
SIGMA(SELENO)	1.79	.89	.39	.001	.001	.001

LONGITUDE OF NADIR POINT	-67.9760246 DEG	LATITUDE OF NADIR POINT	27.2966592 DEG
SIGMA NADIR LONGITUDE	.0012163 DEG	SIGMA NADIR LATITUDE	.0002184 DEG
LONG OF CAMERA AXIS INTERSECT	-68.0475140 DEG	LATI OF CAMERA AXIS INTERSECT	27.3029501 DEG
SPACECRAFT RADIUS	1842.5639648 KM	SPACECRAFT ALTITUDE	104.4739380 KM
SIGMA SPACECRAFT RADIUS	.0000249 KM	AZIMUTH OF VELOCITY VECTOR	260.4748230 DEG
MEAN ALTITUDE RATE	-.0107217 KM/SEC	HORIZONTAL VELOCITY	1.6319897 KM/SEC
TILT AZIMUTH	275.6721077 DEG	TILT ANGLE	1.0619926 DEG
SIGMA TILT AZIMUTH	.1074431 DEG	SIGMA TILT ANGLE	.0020089 DEG
SUN ELEVATION AT PRIN GRND PNT	-.0649719 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.8324814 DEG
LONGITUDE OF SUBSOLAR POINT	22.0870531 DEG	LATITUDE OF SUBSOLAR POINT	.1190506 DEG
ALPHA	1.1200359 DEG	SWING ANGLE	285.1897354 DEG
EMISSION ANGLE	1.1258532 DEG	SIGMA SWING ANGLE	.1074429 DEG
PHASE ANGLE	88.9449368 DEG	NORTH DEVIATION ANGLE	189.5516589 DEG
PHI	1.0248767 DEG	X-TILT	.2782438 DEG
SIGMA PHI	.0019997 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	170.4845028 DEG	Y-TILT	-1.0248647 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	.2782438 DEG	HEADING	-99.5204792 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020003 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-104.4739380 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.35059170	.81751814	-.45689118	104.492966

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.71625906+00	-.57198886+00	-.39975192+00
.21132286+00	.72373554+00	-.65692420+00
.66506810+00	.38605127+00	.63925654+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98606873+00	-.16537360+00	.17886308-01
.16531248+00	-.98622923+00	-.48562512-02
.18443100-01	-.18317990-02	.99982829+00

LATITUDE	LONGITUDE
24.548	-70.049
29.187	-71.008
30.060	-65.612
25.250	-64.801

Figure 18(b) - Last Frame

4.0 APOLLO 15 24-INCH PANORAMIC CAMERA DATA

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 4, Camera: 24 Inch Panoramic Frames: 8844 Through: 8944

Coverage Interval:

From: 25.1 Deg. S Lat., 178.3 Deg. E Long., To: 16.5 Deg. S Lat., 141.9 Deg. E Long.

From: 84 Hr 42 Min 57.64 Sec, To: 84 Hr 54 Min 15.25 Sec GET

Date Processed: 12/7/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 99 H 11 M 34.160 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 4. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5175791.43	$\dot{X}$ =	582.8512
Y =	330685.92	$\dot{Y}$ =	5508.7802
Z =	2492551.4	$\dot{Z}$ =	371.0212

- Telemetered Data Tape

Data Source: Station tape

Bit Rate: High

Date Edited: 1 Sept. 1971

Edited Data Tape No. A09550 File No.: 1 Location: Bldg. 12, MSC

Remarks: There were no significant data gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of panoramic photography starting at 178.3 deg. E Long., 25.1 deg. S Lat. and ending at 141.9 deg. E Long., 16.5 deg. S Lat. The coverage from 178.3 deg E Long. to 169.6 deg. E Long. (Frames 8844 through 8857) was vertical - over the remainder of the sequence the camera was in its oscillating mode starting in its forward position at Frame 8858 and ending in its forward position at Frame 8944.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	30	2	16	58.433
GET			3	12	42	57.642

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1401.0300140	-568.3391571	-1047.4143677	-.9401571	1.1211926	.6803441
SELENOGRAPHIC	-1665.0387573	48.2216115	-779.9307632	-.0205812	1.6028825	.1848801
SIGMA(SELENO)	.03	1.98	.23	.002	.000	.001

LONGITUDE OF NADIR POINT	178.3411064 DEG	LATITUDE OF NADIR POINT	-25.0899169 DEG
SIGMA NADIR LONGITUDE	.0011895 DEG	SIGMA NADIR LATITUDE	.0001317 DEG
LONG OF CAMERA AXIS INTERSECT	178.3080826 DEG	LATI OF CAMERA AXIS INTERSECT	-26.0991023 DEG
SPACECRAFT RADIUS	1839.2855377 KM	SPACECRAFT ALTITUDE	101.1955109 KM
SIGMA SPACECRAFT RADIUS	.0000035 KM	AZIMUTH OF VELOCITY VECTOR	276.9711609 DEG
MEAN ALTITUDE RATE	-.0177414 KM/SEC	HORIZONTAL VELOCITY	1.6135138 KM/SEC
TILT AZIMUTH	252.9166775 DEG	TILT ANGLE	.5373211 DEG
SIGMA TILT AZIMUTH	.2142239 DEG	SIGMA TILT ANGLE	.0019921 DEG
SUN ELEVATION AT PRIN GRND PNT	1.8908682 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	271.1713409 DEG
LONGITUDE OF SUBSOLAR POINT	90.5172310 DEG	LATITUDE OF SUBSOLAR POINT	.2581561 DEG
ALPHA	-.5400218 DEG	SWING ANGLE	245.6706505 DEG
EMISSION ANGLE	.5686371 DEG	SIGMA SWING ANGLE	.2142238 DEG
PHASE ANGLE	88.6491461 DEG	NORTH DEVIATION ANGLE	172.7396191 DEG
PHI	.4895799 DEG	X-TILT	-.2213493 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-172.7552643 DEG	Y-TILT	-.4895762 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	-.2213493 DEG	HEADING	-82.7533693 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020001 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-101.1955109 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.90665117	-.01729036	.42152663	101.200226

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.59879788+00	.68565332+00	.41390897+00
.25964424+00	.65508366+00	-.70954221+00
-.75764504+00	-.31740332+00	-.57028870+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.99197616+00	.12613606+00	.85446131-02
-.12610695+00	-.99200907+00	.38632650-02
.89636348-02	.27547188-02	.99995607+00

Figure 19(a) - First Frame

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	7	30	2	28	16.043
	GET			3	12	54	15.249

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1751.9239502	246.3280869	-428.6016655	-.0590365	1.2097896	1.0920188
SELENOGRAPHIC	-1381.5800171	1063.1311188	-524.0260239	.8327674	1.2901978	.5490625
SIGMA(SELENO)	1.03	1.60	.68	.001	.001	.001

LONGITUDE OF NADIR POINT	142.4215794 DEG	LATITUDE OF NADIR POINT	-16.7306933 DEG
SIGMA NADIR LONGITUDE	.0010859 DEG	SIGMA NADIR LATITUDE	.0003837 DEG
LONG OF CAMERA AXIS INTERSECT	141.8546124 DEG	LATI OF CAMERA AXIS INTERSECT	-16.5322666 DEG
SPACECRAFT RADIUS	1820.3335724 KM	SPACECRAFT ALTITUDE	82.2435455 KM
SIGMA SPACECRAFT RADIUS	.0000080 KM	AZIMUTH OF VELOCITY VECTOR	290.1758499 DEG
MEAN ALTITUDE RATE	-.0365908 KM/SEC	HORIZONTAL VELOCITY	1.6303821 KM/SEC
TILT AZIMUTH	289.9841003 DEG	TILT ANGLE	12.0292675 DEG
SIGMA TILT AZIMUTH	.0095976 DEG	SIGMA TILT ANGLE	.0019998 DEG
SUN ELEVATION AT PRIN GRND PNT	36.6100721 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	283.0837593 DEG
LONGITUDE OF SUBSOLAR POINT	90.4213762 DEG	LATITUDE OF SUBSOLAR POINT	.2580082 DEG
ALPHA	-12.5360638 DEG	SWING ANGLE	269.6926918 DEG
EMISSION ANGLE	12.6076188 DEG	SIGMA SWING ANGLE	.0095974 DEG
PHASE ANGLE	65.9141369 DEG	NORTH DEVIATION ANGLE	159.9943104 DEG
PHI	12.0290976 DEG	X-TILT	-.0640437 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-159.7153649 DEG	Y-TILT	-12.0290903 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	-.0640437 DEG	HEADING	-69.7017059 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020449 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-82.2435455 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.84550074	-.40347721	.34976367	84.180603

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.25767038+00	.75552694+00	.60231641+00
.26415783+00	.65470012+00	-.70822898+00
-.92742275+00	-.23383056-01	-.36827523+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.91730479+00	.33929033+00	.20840828+00
-.34668411+00	-.93798123+00	.11177727-02
.19586234+00	-.71226520-01	.97809131+00

Figure 19(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 15, Camera: 24 Inch Panoramic Frames: 9066* Through: 9151

Coverage Interval:

From: 5.7 Deg. S Lat., 105.9 Deg. E Long., To: 9.8 Deg. N Lat., 72.97 Deg. E Long.

From: 106 Hr 6 Min 38.72 Sec, To: 106 Hr 18 Min 6.23 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  Constants Used:

  Lunar Potential Model: L-1

  Ephemeris: JPL DE 19 (Double Precision)

  Libration Model: RTCC (Koziel)

  Lunar Radius: 1738.09 Km

  Ephemeris-Universal Time Difference: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at midpoint of each camera sweep

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

* Photo coverage starts at 139 deg. E Long. (Frames 8945). Only state vector data are provided for Frames 8945 through 9065 since vehicle attitude data are not available for the time interval of those photos.

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 120 H, 14 M, 30.2 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 15 . For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5417171.14	$\dot{X}$ = 332.4323
Y = 364506.69	$\dot{Y}$ = -5354.1936
Z = 2636255.82	$\dot{Z}$ = -14.8552

- Telemetered Data Tape

Data Source: Station

Bit Rate: High

Date Edited: 8 Dec. 1971

Edited Data Tape No. A09550 File No.: 2 Location: Bldg. 12, MSC

Remarks: There are no telemetered vehicle attitude data for the early part of this interval. 105 H 54 M 15 Sec - 106 H 6 M 37 Sec GET (Fms 8945 through 9065)

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo reduction data are for a sequence of stereo and vertical panoramic photography starting at approximately 139 deg. E Long. and ending at 73 deg. E Long. (Frames 8945 through 9151). Only state vector data are provided for the first 121 frames (8945 through 9065) where gimbal data are not available. Photo evaluation data are then provided for two sequences of stereo photography; for the coverage intervals 105.9 deg. E Long. through 98.5 deg. E Long. (Frames 9066 through 9087) and 83 deg. E Long. through 73 deg. E Long. (Frames 9119 through 9151). In addition, data are provided for the vertical coverage from 99 deg. E Long. through 81.7 deg. E Long. (Frames 9088 through 9118). Coverage starts near 5 deg. S Lat. and extends in a direction slightly North of West to near 8 deg. N Lat. The corner points of the inner and outer fields of view provided in the data are in error.

APOLLO 15 AIS R-15 PAN 12/71 FIN PAGE - 9066

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	7	30	23	40	39.513
	GET			4	10	6	38.719

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1637.9348297	852.3062744	197.3863754	.6419267	.9658069	1.1308933
SELENOGRAPHIC	-480.8857307	1785.2321014	-172.9541378	1.3970648	.4404762	.6913487
SIGMA(SELENO)	1.73	.55	.89	.000	.002	.000

LONGITUDE OF NADIR POINT	105.0758610 DEG	LATITUDE OF NADIR POINT	-5.3442425 DEG
SIGMA NADIR LONGITUDE	.0009793 DEG	SIGMA NADIR LATITUDE	.0004830 DEG
LONG OF CAMERA AXIS INTERSECT	105.8635464 DEG	LATI OF CAMERA AXIS INTERSECT	-5.7213563 DEG
SPACECRAFT RADIUS	1856.9377441 KM	SPACECRAFT ALTITUDE	118.8477173 KM
SIGMA SPACECRAFT RADIUS	.0000048 KM	AZIMUTH OF VELOCITY VECTOR	295.3734512 DEG
MEAN ALTITUDE RATE	-.0027184 KM/SEC	HORIZONTAL VELOCITY	1.6197745 KM/SEC
TILT AZIMUTH	115.7252741 DEG	TILT ANGLE	12.4992284 DEG
SIGMA TILT AZIMUTH	.0092410 DEG	SIGMA TILT ANGLE	.0020000 DEG
SUN ELEVATION AT PRIN GRND PNT	63.1335163 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	281.9534035 DEG
LONGITUDE OF SUBSOLAR POINT	79.6244593 DEG	LATITUDE OF SUBSOLAR POINT	.2407568 DEG
ALPHA	12.0733056 DEG	SWING ANGLE	89.8858662 DEG
EMISSION ANGLE	13.3692256 DEG	SIGMA SWING ANGLE	.0092410 DEG
PHASE ANGLE	14.2062783 DEG	NORTH DEVIATION ANGLE	154.8454895 DEG
PHI	-12.4992089 DEG	X-TILT	.0247017 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-154.1633015 DEG	Y-TILT	12.4992080 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.0247017 DEG	HEADING	-64.1578226 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020485 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-118.8477173 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.06684009	-.99776030	-.00260106	121.938156

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.5742963E+00	.4782588E+00	.6644187E+00
.2606326E+00	.6625593E+00	-.7022005E+00
-.7760504E+00	.5764404E+00	.2558555E+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.8786673E+00	.4255626E+00	-.2164261E+00
-.4358076E+00	-.9000396E+00	-.4311264E-03
-.1949755E+00	.9394134E-01	.9762989E+00

Figure 20(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	30	23	52	7.027
GET			4	10	18	6.233

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-934.7956314	1326.9585114	893.9845581	1.3419758	.3723883	.8335595
SELENOGRAPHIC	510.3057632	1755.1960754	304.5404930	1.3885803	-.5260531	.6553672
SIGMA(SELENO)	1.72	.65	.85	.000	.002	.000

LONGITUDE OF NADIR POINT	73.7887354 DEG	LATITUDE OF NADIR POINT	9.4591120 DEG
SIGMA NADIR LONGITUDE	.0010019 DEG	SIGMA NADIR LATITUDE	.0004664 DEG
LONG OF CAMERA AXIS INTERSECT	72.9705229 DEG	LATI OF CAMERA AXIS INTERSECT	9.8388119 DEG
SPACECRAFT RADIUS	1853.0704498 KM	SPACECRAFT ALTITUDE	114.9804230 KM
SIGMA SPACECRAFT RADIUS	.0000089 KM	AZIMUTH OF VELOCITY VECTOR	294.2167244 DEG
MEAN ALTITUDE RATE	-.0081702 KM/SEC	HORIZONTAL VELOCITY	1.6230313 KM/SEC
TILT AZIMUTH	295.2754784 DEG	TILT ANGLE	13.2123165 DEG
SIGMA TILT AZIMUTH	.0087504 DEG	SIGMA TILT ANGLE	.0020000 DEG
SUN ELEVATION AT PRIN GRND PNT	78.3947468 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	145.4159622 DEG
LONGITUDE OF SUBSOLAR POINT	79.5272522 DEG	LATITUDE OF SUBSOLAR POINT	.2405956 DEG
ALPHA	-8.1382646 DEG	SWING ANGLE	271.0721560 DEG
EMISSION ANGLE	14.1038470 DEG	SIGMA SWING ANGLE	.0087504 DEG
PHASE ANGLE	7.0858087 DEG	NORTH DEVIATION ANGLE	156.6016254 DEG
PHI	13.2100832 DEG	X-TILT	.2450385 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-155.7683010 DEG	Y-TILT	-13.2099603 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.2450385 DEG	HEADING	-65.8258171 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020544 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-114.9804230 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.07411074	-.99521145	-.06373188	118.322876

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.68737436+00	.39898971+00	.61208138+00
.25944512+00	.65495317+00	-.70973550+00
-.67838393+00	.64665551+00	.34875766+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.88816444+00	.39867602+00	.22852011+00
-.41042387+00	-.91188478+00	-.42767160-02
.20667900+00	-.97588527-01	.97352981+00

Figure 20(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 16, Camera: 24 Inch Panoramic Frames: 9152 Through: 9424

Coverage Interval:

From: 8.8 Deg. N Lat., 74.5 Deg. E Long., To: 24.9 Deg. N Lat., 14.4 Deg.W Long.

From: 108 Hr 15 Min 42.26 Sec, To: 108 Hr 43 Min 45.3 Sec GET

Date Processed: 12/3/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 122 H, 12 M, 41.84 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 16 . For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5418330.03	$\dot{X}$ = 304.2696
Y = 351625.64	$\dot{Y}$ = -5355.8441
Z = 2636094.12	$\dot{Z}$ = 15.0709

- Telemetered Data Tape

Data Source: Station tape

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09550 File No.: 3 Location: Bldg. 12, MSC

Remarks: There were no significant data gaps in the telemetered vehicle attitude data for this interval.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

General Description

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of panoramic stereo photography starting at 74.5 deg. E Long., 8.8 deg. N Lat., and extending to 14.4 deg. W Long., 24.9 deg. N Lat. Until late in the sequence (Frame 9371) the scan direction of the camera is such that the principal intersection point falls slightly NW of nadir in the fore position and SE of nadir in the aft position. For the remainder of the sequence it falls NE of nadir in the fore position and SW of nadir in the aft position. The field of view corner point positions included in these data are in error.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	7	31	1	49	43.050
	GET			4	12	15	42.257

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1008.2115250	1302.6460724	850.1793365	1.3014529	.4284295	.8691668
SELENOGRAPHIC	465.5171356	1773.5749512	271.8599472	1.4001206	-.4781284	.6662116
SIGMA(SELENO)	1.73	.59	.83	.000	.002	.000

LONGITUDE OF NADIR POINT	75.2930918 DEG	LATITUDE OF NADIR POINT	8.4333290 DEG
SIGMA NADIR LONGITUDE	.0009955 DEG	SIGMA NADIR LATITUDE	.0004544 DEG
LONG OF CAMERA AXIS INTERSECT	74.5082006 DEG	LATI OF CAMERA AXIS INTERSECT	8.7978178 DEG
SPACECRAFT RADIUS	1853.6941681 KM	SPACECRAFT ALTITUDE	115.6041412 KM
SIGMA SPACECRAFT RADIUS	.0000037 KM	AZIMUTH OF VELOCITY VECTOR	294.5712318 DEG
MEAN ALTITUDE RATE	-.0081459 KM/SEC	HORIZONTAL VELOCITY	1.6225352 KM/SEC
TILT AZIMUTH	295.2169342 DEG	TILT ANGLE	12.6582110 DEG
SIGMA TILT AZIMUTH	.0091271 DEG	SIGMA TILT ANGLE	.0019999 DEG
SUN ELEVATION AT PRIN GRND PNT	80.5503864 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	154.7136326 DEG
LONGITUDE OF SUBSOLAR POINT	78.5296001 DEG	LATITUDE OF SUBSOLAR POINT	.2389345 DEG
ALPHA	-9.7735834 DEG	SWING ANGLE	270.0613785 DEG
EMISSION ANGLE	13.5155782 DEG	SIGMA SWING ANGLE	.0091272 DEG
PHASE ANGLE	8.6324805 DEG	NORTH DEVIATION ANGLE	155.5745640 DEG
PHI	12.6582042 DEG	X-TILT	.0134501 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-154.8429508 DEG	Y-TILT	-12.6582040 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	.0134501 DEG	HEADING	-64.8459682 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-115.6041412 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.05674566	-.99709839	-.05074179	118.683390

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.65817666+00	.40850569+00	.63239755+00
.26362019+00	.66175987+00	-.70183913+00
-.70520062+00	.62864690+00	.32786456+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.88316797+00	.41472219+00	.21913451+00
-.42510091+00	-.90514588+00	-.23474832-03
.19825136+00	-.93361594-01	.97569484+00

Figure 21(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	2	17	46.091
GET			4	12	43	45.297

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1379.3335876	598.0900726	1055.1657867	.9912641	-1.1125813	-.6794514
SELENOGRAPHIC	1618.6932373	-390.4276772	775.2716751	-.3054511	-1.5981270	-.1865090
SIGMA(SELENO)	.38	1.98	.23	.002	.000	.001

LONGITUDE OF NADIR POINT	-13.5606880 DEG	LATITUDE OF NADIR POINT	24.9665442 DEG
SIGMA NADIR LONGITUDE	.0012075 DEG	SIGMA NADIR LATITUDE	.0001362 DEG
LONG OF CAMERA AXIS INTERSECT	-14.3701783 DEG	LATI OF CAMERA AXIS INTERSECT	24.9044960 DEG
SPACECRAFT RADIUS	1836.7492065 KM	SPACECRAFT ALTITUDE	98.6591797 KM
SIGMA SPACECRAFT RADIUS	.0000023 KM	AZIMUTH OF VELOCITY VECTOR	262.9179077 DEG
MEAN ALTITUDE RATE	-.0082067 KM/SEC	HORIZONTAL VELOCITY	1.6376602 KM/SEC
TILT AZIMUTH	265.3389168 DEG	TILT ANGLE	12.7440255 DEG
SIGMA TILT AZIMUTH	.0090719 DEG	SIGMA TILT ANGLE	.0019987 DEG
SUN ELEVATION AT PRIN GRND PNT	-2.3135920 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	88.6619301 DEG
LONGITUDE OF SUBSOLAR POINT	78.2916431 DEG	LATITUDE OF SUBSOLAR POINT	.2385364 DEG
ALPHA	13.4531330 DEG	SWING ANGLE	271.8140373 DEG
EMISSION ANGLE	13.4806738 DEG	SIGMA SWING ANGLE	.0090722 DEG
PHASE ANGLE	78.8607225 DEG	NORTH DEVIATION ANGLE	166.6792488 DEG
PHI	12.7378490 DEG	X-TILT	.4001058 DEG
SIGMA PHI	.0019998 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	173.5695477 DEG	Y-TILT	-12.7375338 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019998 DEG
OMEGA	.4001058 DEG	HEADING	-96.5209055 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020505 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-98.6591797 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.90376923	-.00818288	-.42794183	101.298294

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.75716700+00	-.59552103+00	-.26842665+00
.25683848+00	.64924211+00	-.71590402+00
.60060983+00	.47311663+00	.64453748+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96908003+00	-.11077087+00	.22048521+00
.11199445+00	-.99368424+00	-.69831071-02
.21986621+00	.17925947-01	.97536536+00

Figure 21(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 27, Camera: 24 Inch Panoramic Frames: 9425 Through: 9433

Coverage Interval:

From: 25.4 Deg. N Lat., 4 Deg. E Long., To: 25.6 Deg. N Lat. 1.04 Deg. E Long.

From: 130 Hr 18 Min 21.05 Sec, To: 130 Hr 19 Min 13.69 Sec GET

Date Processed: 12/3/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 143 H. 52 M. 43.2 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 = 5442492.29	$\dot{X}$ = 109.9227
Y = 349488.17	$\dot{Y}$ = -5343.3417
Z = 2596805.03	$\dot{Z}$ = 400.1378

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09556 File No.: 4 Location: Bldg. 12, MSC

Remarks: There were no significant gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of panoramic stereo photography starting at 4 deg. E Long., 25.4 deg. N Lat., and ending at 1 deg. E Long. 25.6 deg. N Lat. Throughout the sequence the principal intersection falls slightly NW of nadir when the camera is in the fore position and slightly SE of nadir when it is in the aft position. All field of view corner point locations included in these data are in error.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	7	31	23	52	21.838
	GET			5	10	18	21.046

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	712.3837738	1102.8189697	1290.9724121	1.4464128	-.7356125	-.1864190
SELENOGRAPHIC	1657.8755035	140.7086487	788.6443710	.0609347	-1.6266798	.1348614
SIGMA(SELENO)	.08	2.01	.17	.002	.000	.001

LONGITUDE OF NADIR POINT	4.8512306 DEG	LATITUDE OF NADIR POINT	25.3605611 DEG
SIGMA NADIR LONGITUDE	.0012099 DEG	SIGMA NADIR LATITUDE	.0001061 DEG
LONG OF CAMERA AXIS INTERSECT	4.0094337 DEG	LATI OF CAMERA AXIS INTERSECT	25.4308994 DEG
SPACECRAFT RADIUS	1841.2794342 KM	SPACECRAFT ALTITUDE	103.1894073 KM
SIGMA SPACECRAFT RADIUS	.0000042 KM	AZIMUTH OF VELOCITY VECTOR	275.4376450 DEG
MEAN ALTITUDE RATE	-.0116809 KM/SEC	HORIZONTAL VELOCITY	1.6333262 KM/SEC
TILT AZIMUTH	275.4650383 DEG	TILT ANGLE	12.6349679 DEG
SIGMA TILT AZIMUTH	.0091433 DEG	SIGMA TILT ANGLE	.0020000 DEG
SUN ELEVATION AT PRIN GRND PNT	24.0407801 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	101.9740400 DEG
LONGITUDE OF SUBSOLAR POINT	67.3119869 DEG	LATITUDE OF SUBSOLAR POINT	.2193396 DEG
ALPHA	13.2761325 DEG	SWING ANGLE	269.6894913 DEG
EMISSION ANGLE	13.3986644 DEG	SIGMA SWING ANGLE	.0091433 DEG
PHASE ANGLE	52.6701221 DEG	NORTH DEVIATION ANGLE	174.7237034 DEG
PHI	12.6347919 DEG	X-TILT	-.0679170 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-174.2319832 DEG	Y-TILT	-12.6347833 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.0679170 DEG	HEADING	-84.2167568 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020496 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-103.1894073 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.86906517	-.29228745	-.39911624	105.908554

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.94995834+00	-.30817953+00	.51035017-01
.25296386+00	.66316511+00	-.70442253+00
.18324400+00	.68208311+00	.70794373+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97081765+00	.98325246-01	.21873566+00
-.10050092+00	-.99493621+00	.11853743-02
.21774456+00	-.20832333-01	.97578347+00

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Figure 22(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	7	31	23	53	14.479
GET			5	10	19	13.685

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	787.7212982	1062.9092407	1279.7570343	1.4153766	-.7804182	-.2396203
SELENOGRAPHIC	1659.2849884	54.7239094	794.8821335	-.0079269	-1.6307290	.1020849
SIGMA(SELENO)	.02	2.02	.13	.002	.000	.001

LONGITUDE OF NADIR POINT	1.8869537 DEG	LATITUDE OF NADIR POINT	25.5846632 DEG
SIGMA NADIR LONGITUDE	.0012152 DEG	SIGMA NADIR LATITUDE	.0000811 DEG
LONG OF CAMERA AXIS INTERSECT	1.0398587 DEG	LATI OF CAMERA AXIS INTERSECT	25.6203737 DEG
SPACECRAFT RADIUS	1840.6680603 KM	SPACECRAFT ALTITUDE	102.5780334 KM
SIGMA SPACECRAFT RADIUS	.0000034 KM	AZIMUTH OF VELOCITY VECTOR	274.1664929 DEG
MEAN ALTITUDE RATE	-.0115431 KM/SEC	HORIZONTAL VELOCITY	1.6338699 KM/SEC
TILT AZIMUTH	272.8535118 DEG	TILT ANGLE	12.7536358 DEG
SIGMA TILT AZIMUTH	.0090597 DEG	SIGMA TILT ANGLE	.0020000 DEG
SUN ELEVATION AT PRIN GRND PNT	21.3823013 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	100.5565710 DEG
LONGITUDE OF SUBSOLAR POINT	67.3045464 DEG	LATITUDE OF SUBSOLAR POINT	.2193260 DEG
ALPHA	13.3541849 DEG	SWING ANGLE	268.3075485 DEG
EMISSION ANGLE	13.5201923 DEG	SIGMA SWING ANGLE	.0090597 DEG
PHASE ANGLE	55.2479758 DEG	NORTH DEVIATION ANGLE	175.8897800 DEG
PHI	12.7482564 DEG	X-TILT	-.3735724 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-175.4957714 DEG	Y-TILT	-12.7479814 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.3735724 DEG	HEADING	-86.4112511 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020505 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-102.5780334 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.87669314	-.24951920	-.41127765	105.332321

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.94048457+00	-.33923320+00	.20239657-01
.25530667+00	.66598959+00	-.70091102+00
.22429293+00	.66436333+00	.71296150+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.97222374+00	.78031154-01	.22066307+00
-.78531075-01	-.99689029+00	.65200225-02
.22048562+00	-.10989969-01	.97532834+00

Figure 22(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 33, Camera: 24 Inch Panoramic Frames: 9434 Through: 9578

Coverage Interval:

From: 8.5 Deg. N Lat., 58.9 Deg. E Long., To: 21.6 Deg. N Lat., 22.1 Deg. E Long.

From: 141 Hr 46 Min 27.5 Sec, To: 142 Hr 1 Min 33.44 Sec GET

Date Processed: 12/13/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 155 H, 41 M, 29.62 Sec.

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 33. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X = 5474202.62	$\dot{X}$ = 9.5580
Y = 345994.58	$\dot{Y}$ = -5318.0142
Z = 2547196.41	$\dot{Z}$ = 608.6019

● Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 10 Dec. 1971

Edited Data Tape No. A09556 File No.: 3 Location: Bldg. 12, MSC

Remarks: There was one significant gap in the telemetered vehicle attitude data in the time interval of this sequence, 141 H, 46 M, 27.5 Sec - 141 H, 49 M, 3.84 Sec GET - Fm 9434 through 9457.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of panoramic stereo photography starting at approximately 66.5 deg. E Long., and ending at 22.1 deg. E Long., 21.6 deg. N Lat. Only state vector data are provided for the first 24 frames of this sequence, since vehicle attitude data are not available for that interval. Evaluation data coverage starts at 58.9 deg. E Long., 8.5 deg. N Lat. and continues to 22.1 deg. E Long., 21.6 deg. N Lat. (Frames 9458 through 9578). Throughout the sequence the principal intersection point falls slightly NW of nadir when the camera is in the fore position and slightly SE of nadir when in the aft position. All field of view corner point locations included in these data are in error.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	8	1	11	23	4.179
	GET			5	21	49	3.384

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1082.7087250	1261.3552856	823.3302917	1.2598879	.4848528	.8974136
SELENOGRAPHIC	928.3202362	1584.6116333	261.4873009	1.2186109	-.8330620	.6698852
SIGMA(SELENO)	1.51	1.03	.87	.001	.002	.000

LONGITUDE OF NADIR POINT	59.6367512 DEG	LATITUDE OF NADIR POINT	8.1034580 DEG
SIGMA NADIR LONGITUDE	.0009919 DEG	SIGMA NADIR LATITUDE	.0004712 DEG
LONG OF CAMERA AXIS INTERSECT	58.8811340 DEG	LATI OF CAMERA AXIS INTERSECT	8.4666369 DEG
SPACECRAFT RADIUS	1855.0331573 KM	SPACECRAFT ALTITUDE	116.9431305 KM
SIGMA SPACECRAFT RADIUS	.0000069 KM	AZIMUTH OF VELOCITY VECTOR	294.7124290 DEG
MEAN ALTITUDE RATE	-.0073595 KM/SEC	HORIZONTAL VELOCITY	1.6209877 KM/SEC
TILT AZIMUTH	295.9602509 DEG	TILT ANGLE	12.1496601 DEG
SIGMA TILT AZIMUTH	.0095010 DEG	SIGMA TILT ANGLE	.0020003 DEG
SUN ELEVATION AT PRIN GRND PNT	81.3524647 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	162.6146030 DEG
LONGITUDE OF SUBSOLAR POINT	61.4560838 DEG	LATITUDE OF SUBSOLAR POINT	.2083672 DEG
ALPHA	-9.7227839 DEG	SWING ANGLE	271.4277573 DEG
EMISSION ANGLE	12.9809248 DEG	SIGMA SWING ANGLE	.0095011 DEG
PHASE ANGLE	9.4242347 DEG	NORTH DEVIATION ANGLE	156.1537228 DEG
PHI	12.1460000 DEG	X-TILT	.3004639 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-155.4355354 DEG	Y-TILT	-12.1458306 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	.3004639 DEG	HEADING	-65.5001984 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020458 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-116.9431305 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.33251429	-.94194658	-.04659259	119.809647

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.63530859+00	.44091319+00	.63401785+00
.24473890+00	.66372163+00	-.70680717+00
-.73245198+00	.60420950+00	.31375946+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.88959344+00	.40540740+00	.21040061+00
-.41571111+00	-.90948153+00	-.52440602-02
.18922951+00	-.92130952-01	.97760120+00

Figure 23(a) - First Frame

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT		71	8	1	11	35	34.235
GET				5	22	1	33.442

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	21.7366916	1335.5624390	1276.5935974	1.5783166	-.2957856	.2658131
SELENOGRAPHIC	1584.8715363	669.5357971	673.6429901	.4602048	-1.5121360	.3884394
SIGMA(SELENO)	.57	1.87	.50	.002	.001	.001

LONGITUDE OF NADIR POINT	22.9018323 DEG	LATITUDE OF NADIR POINT	21.3823624 DEG
SIGMA NADIR LONGITUDE	.0011309 DEG	SIGMA NADIR LATITUDE	.0002892 DEG
LONG OF CAMERA AXIS INTERSECT	22.0692596 DEG	LATI OF CAMERA AXIS INTERSECT	21.6210334 DEG
SPACECRAFT RADIUS	1847.6717224 KM	SPACECRAFT ALTITUDE	109.5816956 KM
SIGMA SPACECRAFT RADIUS	.0000090 KM	AZIMUTH OF VELOCITY VECTOR	285.0157280 DEG
MEAN ALTITUDE RATE	-.0115789 KM/SEC	HORIZONTAL VELOCITY	1.6275744 KM/SEC
TILT AZIMUTH	287.2767296 DEG	TILT ANGLE	12.6272051 DEG
SIGMA TILT AZIMUTH	.0091465 DEG	SIGMA TILT ANGLE	.0020005 DEG
SUN ELEVATION AT PRIN GRND PNT	46.1308651 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	113.9962254 DEG
LONGITUDE OF SUBSOLAR POINT	61.3501101 DEG	LATITUDE OF SUBSOLAR POINT	.2081635 DEG
ALPHA	13.2565271 DEG	SWING ANGLE	272.1702194 DEG
EMISSION ANGLE	13.4377657 DEG	SIGMA SWING ANGLE	.0091465 DEG
PHASE ANGLE	30.5678403 DEG	NORTH DEVIATION ANGLE	165.6376171 DEG
PHI	12.6184379 DEG	X-TILT	.4743200 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020001 DEG
KAPPA	-164.8410625 DEG	Y-TILT	-12.6179987 DEG
SIGMA KAPPA	.0020001 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	.4743200 DEG	HEADING	-74.9472427 DEG
SIGMA OMEGA	.0020001 DEG	SIGMA HEADING	.0020495 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-109.5816956 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.77759143	-.55510289	-.29531735	112.476074

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.94879539+00	-.14841446-01	.31554256+00
.24592906+00	.66162580+00	-.70835732+00
-.19825804+00	.74968726+00	.63139749+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.94236403+00	.25343596+00	.21844980+00
-.26148856+00	-.96517101+00	-.82783514-02
.20874337+00	-.64923327-01	.97581310+00

Figure 23(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 38, Camera: 24 Inch Panoramic Frames: 9579 Through: 9808

Coverage Interval:

From: 22.8 Deg. S Lat., 132.1 Deg. E Long., To: 24.7 Deg. N Lat., 0.4 Deg. E Long.

From: 151 Hr 13 Min 29.21 Sec, To: 151 Hr 59 Min 5.93 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

HOPE Version Used: B-6.1

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: 0.69583333 Min.

Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 165 H, 31 M, 53.11 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 =	5507373.81	$\dot{X}$ =	-56.8619
Y =	354401.39	$\dot{Y}$ =	-5288.5850
Z =	2486896.38	$\dot{Z}$ =	785.4631

- Telemetered Data Tape

Data Source: MSFN and station tapes

Bit Rate: High

Date Edited: 8 Dec. 1971

Edited Data Tape No. A09554 File No.: 3 Location: Bldg. 12, MSC

Remarks: Telemetered vehicle attitude data are not available for the interval 151 H, 21 M, 29 Sec - 151 H, 23 M, 48 Sec (Fms 9658 through 9681).

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.582563	.4761836	.6586878
-.2518852	-.6647384	.7033325
.7727705	-.5756492	-.2673084

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of panoramic stereo data starting at 132 deg. E Long., 22.8 deg. S Lat., and extending to 0.4 deg. E Long., 24.7 deg. N Lat. Only state vector data are provided for the interval 108 deg. E Long. through 102.4 deg. E Long. (Frames 9658 through 9681) since vehicle attitude data are unavailable for that interval. Throughout the sequence the principal intersection point falls slightly NW of the nadir point when the camera is in the fore position and slightly SE of the nadir point when in the aft position. Photography was omitted for the interval 151 H, 37 M through 151 H, 57 M, 28 Sec the interval between Frames 9790 and 9791; 65.4 deg E Long. to 4.1 deg. E Long. All field of view corner location point locations contained in these data are in error.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	20	47	30.003
GET			6	7	13	29.209

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1559.7831116	-398.4685822	-916.0392914	-.7908188	1.1512532	.8272564
SELENOGRAPHIC	-1162.5683441	1246.1074371	-725.5891571	1.0624588	1.1868509	.3125660
SIGMA(SELENO)	1.31	1.47	.42	.001	.001	.001

LONGITUDE OF NADIR POINT	133.0136299 DEG	LATITUDE OF NADIR POINT	-23.0624361 DEG
SIGMA NADIR LONGITUDE	.0011521 DEG	SIGMA NADIR LATITUDE	.0002455 DEG
LONG OF CAMERA AXIS INTERSECT	132.1320438 DEG	LATI OF CAMERA AXIS INTERSECT	-22.8499503 DEG
SPACECRAFT RADIUS	1852.2495575 KM	SPACECRAFT ALTITUDE	114.1595306 KM
SIGMA SPACECRAFT RADIUS	.0000144 KM	AZIMUTH OF VELOCITY VECTOR	282.2208366 DEG
MEAN ALTITUDE RATE	.0091608 KM/SEC	HORIZONTAL VELOCITY	1.6232534 KM/SEC
TILT AZIMUTH	284.4961090 DEG	TILT ANGLE	12.5497524 DEG
SIGMA TILT AZIMUTH	.0092114 DEG	SIGMA TILT ANGLE	.0019985 DEG
SUN ELEVATION AT PRIN GRND PNT	13.2971115 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	275.9385529 DEG
LONGITUDE OF SUBSOLAR POINT	56.6718125 DEG	LATITUDE OF SUBSOLAR POINT	.1989851 DEG
ALPHA	-13.2416029 DEG	SWING ANGLE	271.9580383 DEG
EMISSION ANGLE	13.3888720 DEG	SIGMA SWING ANGLE	.0092114 DEG
PHASE ANGLE	89.9362545 DEG	NORTH DEVIATION ANGLE	167.5042953 DEG
PHI	12.5426588 DEG	X-TILT	.4253767 DEG
SIGMA PHI	.0019997 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	-167.4151821 DEG	Y-TILT	-12.5423081 DEG
SIGMA KAPPA	.0020001 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	.4253767 DEG	HEADING	-77.5098133 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020488 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-114.1595306 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.75194203	-.49759226	.43241776	117.144791

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.65488012+00	.64367367+00	.39600031+00
.24428760+00	.67616314+00	-.69507320+00
-.71516120+00	-.35845160+00	-.60009749+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.95303378+00	.21111128+00	.21716054+00
-.21787870+00	-.97594756+00	-.74241548-02
.21036991+00	-.54390127-01	.97610772+00

Figure 24(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	1	21	33	6.726
GET			6	7	59	5.933

STATE VECTOR 1950.0	X	Y	Z	X DOT	Y DOT	Z DOT
	535.6671753	1180.9369812	1311.3942108	1.5063568	-.6193323	-.0742499
SELENOGRAPHIC	1673.7724304	-11.8576459	774.3716965	-.1149027	-1.6145617	.1954082
SIGMA(SELENO)	.14	2.00	.24	.002	.000	.001

LONGITUDE OF NADIR POINT	-.4059029 DEG	LATITUDE OF NADIR POINT	24.8270969 DEG
SIGMA NADIR LONGITUDE	.0011948 DEG	SIGMA NADIR LATITUDE	.0001486 DEG
LONG OF CAMERA AXIS INTERSECT	.4249300 DEG	LATI OF CAMERA AXIS INTERSECT	24.7411923 DEG
SPACECRAFT RADIUS	1844.2630463 KM	SPACECRAFT ALTITUDE	106.1730194 KM
SIGMA SPACECRAFT RADIUS	.0000033 KM	AZIMUTH OF VELOCITY VECTOR	277.7831726 DEG
MEAN ALTITUDE RATE	-.0118514 KM/SEC	HORIZONTAL VELOCITY	1.6303249 KM/SEC
TILT AZIMUTH	96.3229122 DEG	TILT ANGLE	12.2210604 DEG
SIGMA TILT AZIMUTH	.0094523 DEG	SIGMA TILT ANGLE	.0019991 DEG
SUN ELEVATION AT PRIN GRND PNT	30.7399483 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	105.6415310 DEG
LONGITUDE OF SUBSOLAR POINT	56.2852306 DEG	LATITUDE OF SUBSOLAR POINT	.1982099 DEG
ALPHA	-12.8551868 DEG	SWING ANGLE	88.4883032 DEG
EMISSION ANGLE	12.9802401 DEG	SIGMA SWING ANGLE	.0094524 DEG
PHASE ANGLE	72.0981779 DEG	NORTH DEVIATION ANGLE	171.9861012 DEG
PHI	-12.2169367 DEG	X-TILT	.3199654 DEG
SIGMA PHI	.0019998 DEG	SIGMA X-TILT	.0020002 DEG
KAPPA	-172.1996479 DEG	Y-TILT	12.2167437 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019998 DEG
OMEGA	.3199654 DEG	HEADING	-82.1303682 DEG
SIGMA OMEGA	.0020002 DEG	SIGMA HEADING	.0020463 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-106.1730194 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.87571031	.21660557	-.43152460	108.791008

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.84326559+00	-.50221237+00	-.18889276+00
.23960697+00	.66651496+00	-.70593639+00
.48113583+00	.55003187+00	.68262239+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96814956+00	.13381890+00	-.21161041+00
-.13571961+00	-.99073149+00	-.55844205-02
-.21039644+00	.23313150-01	.97733818+00

Figure 24(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 50, Camera: 24 Inch Panoramic Frames: 9809 Through: 9827

Coverage Interval:

From: 25.7 Deg. N Lat., 3.4 Deg. E Long., To: 27 Deg. N Lat., 3.1 Deg. W Long.

From: 175 Hr 34 Min 56.12 Sec, To: 175 Hr 36 Min 53.71 Sec GET

Date Processed: 12/3/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

HOPE Version Used: B-6.1

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: 0.69583333 Min.

Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 189 H, 9 M, 7.67 Sec .

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 50. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5445685.09	$\dot{X}$ =	-246.0737
Y =	356948.16	$\dot{Y}$ =	-5217.1922
Z =	2619968.86	$\dot{Z}$ =	1146.3435

- Telemetered Data Tape

Data Source: Station tapes

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09624 File No.: 2 Location: Bldg. 12, MSC

Remarks: There were no gimbal data gaps within the interval.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of panoramic stereo photography atarting at 3.4 deg. E Long., 25.7 deg. N Lat., and extending to 3.07 deg. W Long., 27 deg. N Lat. Throughout the sequence the principal intersection point falls slightly NW of nadir when the camera is in its fore position and slightly SE of nadir when it is in its aft position. All field of view corner point positions included in these data are in error.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	8	2	21	8	56.910
	GET			7	7	34	56.118

STATE VECTOR 1950.0	X	Y	Z	X DOT	Y DOT	Z DOT
SELENOGRAPHIC	30.4401097	1238.1742096	1368.0065002	1.5845859	-.3051848	.2274717
SIGMA(SELENO)	1660.6746368	123.2761488	795.2398758	-.0638333	-1.5889282	.3564070
	.08	1.97	.44	.002	.000	.001

LONGITUDE OF NADIR POINT	4.2454236 DEG	LATITUDE OF NADIR POINT	25.5268807 DEG
SIGMA NADIR LONGITUDE	.0011751 DEG	SIGMA NADIR LATITUDE	.0002691 DEG
LONG OF CAMERA AXIS INTERSECT	3.4269552 DEG	LATI OF CAMERA AXIS INTERSECT	25.6996033 DEG
SPACECRAFT RADIUS	1845.3844147 KM	SPACECRAFT ALTITUDE	107.2943878 KM
SIGMA SPACECRAFT RADIUS	.0000047 KM	AZIMUTH OF VELOCITY VECTOR	284.1991768 DEG
MEAN ALTITUDE RATE	-.0100000 KM/SEC	HORIZONTAL VELOCITY	1.6296002 KM/SEC
TILT AZIMUTH	283.3484268 DEG	TILT ANGLE	12.0788298 DEG
SIGMA TILT AZIMUTH	.0095578 DEG	SIGMA TILT ANGLE	.0020000 DEG
SUN ELEVATION AT PRIN GRND PNT	43.0617847 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	116.4342403 DEG
LONGITUDE OF SUBSOLAR POINT	44.2883787 DEG	LATITUDE OF SUBSOLAR POINT	.1728380 DEG
ALPHA	12.2661870 DEG	SWING ANGLE	269.2493973 DEG
EMISSION ANGLE	12.8368119 DEG	SIGMA SWING ANGLE	.0095578 DEG
PHASE ANGLE	34.5530534 DEG	NORTH DEVIATION ANGLE	166.5689354 DEG
PHI	12.0778297 DEG	X-TILT	-.1570695 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-165.9175797 DEG	Y-TILT	-12.0777838 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.1570695 DEG	HEADING	-75.8839684 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020453 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-107.2943878 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.88567323	-.26991000	-.37779824	109.879135

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.95471501+00	-.37690403-01	.29512492+00
.23054515+00	.72072797+00	-.65375838+00
-.18806427+00	.69219261+00	.69677915+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.94833668+00	.23848785+00	.20923941+00
-.24331656+00	-.96994300+00	.27413764-02
.20360399+00	-.48311697-01	.97786061+00

Figure 25(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	2	21	10	54.506
GET			7	7	36	53.708

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	216.2817268	1195.6721191	1387.3274384	1.5732434	-.4170491	.1007908
SELENOGRAPHIC	1644.2038574	-64.4191380	832.7850418	-.2162465	-1.5915888	.2815422
SIGMA(SELENO)	.27	1.97	.35	.002	.000	.001

LONGITUDE OF NADIR POINT	-2.2436752 DEG	LATITUDE OF NADIR POINT	26.8443866 DEG
SIGMA NADIR LONGITUDE	.0012037 DEG	SIGMA NADIR LATITUDE	.0002153 DEG
LONG OF CAMERA AXIS INTERSECT	-3.0714267 DEG	LATI OF CAMERA AXIS INTERSECT	26.9662631 DEG
SPACECRAFT RADIUS	1844.2036285 KM	SPACECRAFT ALTITUDE	106.1136017 KM
SIGMA SPACECRAFT RADIUS	.0000031 KM	AZIMUTH OF VELOCITY VECTOR	281.3400192 DEG
MEAN ALTITUDE RATE	-.0100640 KM/SEC	HORIZONTAL VELOCITY	1.6306396 KM/SEC
TILT AZIMUTH	279.5625343 DEG	TILT ANGLE	12.0557355 DEG
SIGMA TILT AZIMUTH	.0095760 DEG	SIGMA TILT ANGLE	.0019999 DEG
SUN ELEVATION AT PRIN GRND PNT	37.2501926 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	112.4973059 DEG
LONGITUDE OF SUBSOLAR POINT	44.2717748 DEG	LATITUDE OF SUBSOLAR POINT	.1728011 DEG
ALPHA	12.2969745 DEG	SWING ANGLE	268.2585793 DEG
EMISSION ANGLE	12.8038797 DEG	SIGMA SWING ANGLE	.0095760 DEG
PHASE ANGLE	40.3668861 DEG	NORTH DEVIATION ANGLE	169.2953491 DEG
PHI	12.0503353 DEG	X-TILT	-.3636653 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-168.7344475 DEG	Y-TILT	-12.0500891 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.3636653 DEG	HEADING	-78.6568117 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020451 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-106.1136017 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.89560835	-.17102941	-.41065145	108.658249

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.96870403+00	-.11089157+00	.22207110+00
.23195219+00	.72295024+00	-.65080029+00
-.88377983-01	.68194280+00	.72604638+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.95886256+00	.19235142+00	.20876672+00
-.19535267+00	-.98071247+00	.63471140-02
.20596091+00	-.34697164-01	.97794989+00

Figure 25(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 60, Camera: 24 Inch Panoramic Frames: 9828 Through: 9929

Coverage Interval:

From: 8.1 Deg. N Lat., 39.3 Deg. E Long., To: 25.3 Deg. N Lat., 4.6 Deg. W Long.

From: 195 Hr 4 Min 30.21 Sec, To: 195 Hr 19 Min 45.95 Sec GET

Date Processed: 12/3/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

HOPE Version Used: B-6.1

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: 0.69583333 Min.

Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 208 H, 51 M, 11.11 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 =	5574224.19	$\dot{X}$ =	-354.9182
Y =	354480.73	$\dot{Y}$ =	-5106.8394
Z =	2379220.06	$\dot{Z}$ =	1496.9973

- Telemetered Data Tape

Data Source: Station tape

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09624 File No.: 3 Location: Bldg. 12, MSC

Remarks: There were no significant gaps in the telemetered vehicle attitude data for this interval

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a strip of panoramic stereo photography starting at 39.3 deg. E Long., 8.1 deg. N Lat. and extending to 12.7 deg. E Long., 20.1 Deg. N Lat. (Frames 9828 through 9919) and for two mono test cycles. Frames 9920 through 9924 and Frames 9925 through 9929. Throughout the stereo coverage the principal intersection point falls slightly NW of the nadir point when the camera is in its fore position and slightly SE of the nadir point when in the aft position. Throughout the test cycles, nadir and the principal intersection point are essentially coincident. All field of view corner point locations included in these data are in error.

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	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	16	38	31.007
GET			0	3	4	30.212

STATE VECTOR 1950.0	X	Y	Z	X DOT	Y DOT	Z DOT
	-1319.7027740	1078.5091858	738.5615082	1.0844605	.6046945	1.0395765
SELENOGR PHIC	1408.2602234	1185.5262604	248.1958961	.8388022	-1.1632934	.7520564
SIGMA(SELENO)	1.04	1.44	.94	.001	.001	.000

LONGITUDE OF NADIR POINT	40.0919261 DEG	LATITUDE OF NADIR POINT	7.6787674 DEG
SIGMA NADIR LONGITUDE	.0009610 DEG	SIGMA NADIR LATITUDE	.0005124 DEG
LONG OF CAMERA AXIS INTERSECT	39.3194108 DEG	LATI OF CAMERA AXIS INTERSECT	8.0731758 DEG
SPACECRAFT RADIUS	1857.4903717 KM	SPACECRAFT ALTITUDE	119.4003448 KM
SIGMA SPACECRAFT RADIUS	.0000041 KM	AZIMUTH OF VELOCITY VECTOR	297.9768257 DEG
MEAN ALTITUDE RATE	-.0060327 KM/SEC	HORIZONTAL VELOCITY	1.6193510 KM/SEC
TILT AZIMUTH	297.3197174 DEG	TILT ANGLE	12.3174348 DEG
SIGMA TILT AZIMUTH	.0093753 DEG	SIGMA TILT ANGLE	.0020000 DEG
SUN ELEVATION AT PRIN GRND PNT	80.6732140 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	212.0757027 DEG
LONGITUDE OF SUBSOLAR POINT	34.3822408 DEG	LATITUDE OF SUBSOLAR POINT	.1499191 DEG
ALPHA	-10.9705530 DEG	SWING ANGLE	269.1881561 DEG
EMISSION ANGLE	13.1783233 DEG	SIGMA SWING ANGLE	.0093753 DEG
PHASE ANGLE	16.7319818 DEG	NORTH DEVIATION ANGLE	152.5913277 DEG
PHI	12.3162355 DEG	X-TILT	-.1731834 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-151.8871346 DEG	Y-TILT	-12.3161778 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.1731834 DEG	HEADING	-61.8493233 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020471 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-119.4003448 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.62864586	-.77696926	-.03351319	122.414444

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.49946118+00	.48863864+00	.71538164+00
.22370072+00	.72500996+00	-.65139730+00
-.83695669+00	.48537904+00	.25280545+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.86141773+00	.46093385+00	.21330625+00
-.47120783+00	-.88201697+00	.30226150-02
.18953297+00	-.97907888-01	.97698066+00

Figure 26(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	16	53	46.739
GET			8	3	19	45.945

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-27.3542285	1245.5547791	1365.9876251	1.5856647	-.2617834	.2542933
SELENOGRAPHIC	1666.3952789	-134.6206512	789.3549118	-.3115689	-1.5548356	.3646081
SIGMA(SELENO)	.39	1.92	.45	.002	.000	.001

LONGITUDE OF NADIR POINT	-4.6186409 DEG	LATITUDE OF NADIR POINT	25.2744253 DEG
SIGMA NADIR LONGITUDE	.0011660 DEG	SIGMA NADIR LATITUDE	.0002736 DEG
LONG OF CAMERA AXIS INTERSECT	-4.6416428 DEG	LATI OF CAMERA AXIS INTERSECT	25.2590199 DEG
SPACECRAFT RADIUS	1848.8042297 KM	SPACECRAFT ALTITUDE	110.7142029 KM
SIGMA SPACECRAFT RADIUS	.0000028 KM	AZIMUTH OF VELOCITY VECTOR	284.5529709 DEG
MEAN ALTITUDE RATE	-.0119420 KM/SEC	HORIZONTAL VELOCITY	1.6270492 KM/SEC
TILT AZIMUTH	233.4843426 DEG	TILT ANGLE	.4064425 DEG
SIGMA TILT AZIMUTH	.2814672 DEG	SIGMA TILT ANGLE	.0020038 DEG
SUN ELEVATION AT PRIN GRND PNT	44.8294392 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	117.7070665 DEG
LONGITUDE OF SUBSOLAR POINT	34.2529931 DEG	LATITUDE OF SUBSOLAR POINT	.1496083 DEG
ALPHA	.1852699 DEG	SWING ANGLE	218.2463379 DEG
EMISSION ANGLE	.4322237 DEG	SIGMA SWING ANGLE	.2814631 DEG
PHASE ANGLE	44.9839673 DEG	NORTH DEVIATION ANGLE	164.7709351 DEG
PHI	.2515737 DEG	X-TILT	-.3191549 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-164.7625980 DEG	Y-TILT	-.2515698 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	-.3191549 DEG	HEADING	-74.7611942 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020000 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-110.7142029 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.89997706	.06698630	-.43075994	110.717178

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.97161096+00	-.16162251+00	.17277237+00
.23570527+00	.72418280+00	-.64807576+00
-.20375039-01	.67040093+00	.74171925+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.96482939+00	.26284021+00	.43907063-02
-.26281504+00	-.96483010+00	.55702740-02
.57002695-02	.42203922-02	.99997485+00

Figure 26(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 61, Camera: 24 Inch Panoramic Frames: 9930 Through: 9941

Coverage Interval:

From: 24.1 Deg. N Lat., 1.07 Deg. W Long., To: 25.2 Deg. N Lat., 5.14 Deg. W Long.

From: 197 Hr 16 Min 51.57 Sec, To: 195 Hr 18 Min 24.29 Sec GET

Date Processed: 12/6/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

  HOPE Version Used: B-6.1

  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: 0.69583333 Min.

  Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

  Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 210 H, 49 M, 22.63 Sec

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 61. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5588264.69	$\dot{X}$ =	-3584.7096
Y =	357332.44	$\dot{Y}$ =	-5094.6204
Z =	2349669.17	$\dot{Z}$ =	1531.8581

- Telemetered Data Tape

Data Source: MSFN

Bit Rate: High

Date Edited: 1 Dec. 1971

Edited Data Tape No. A09569 File No.: 1 Location: Bldg. 12, MSC

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

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

1. Mission title
2. Magazine identification
3. State vector identification
4. Date of data origin
5. Status of data PRL = preliminary, FIN = final
6. Frame number within the sequence

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary:These photo evaluation data are for a strip of panoramic photographs starting as vertical photography at 1.07 deg. W Long. (Frame 9930), remaining vertical through 4.5 deg. W Long. (Frame 9933); then stereo coverage from 3.2 deg. W Long. through 5.14 deg. W Long. (Frames 9934 through 9941). Throughout the vertical coverage the principal intersection points and vehicle nadir remain essentially coincident. Throughout the stereo coverage the principal intersection point is slightly NW of the nadir point when the camera is in its fore position and slightly SE of the nadir point when it is in its aft position. All field of view corner points included in these data are in error.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	8	3	18	52	25.084
	GET			8	5	18	24.287

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-17.8676424	1243.6960602	1368.0612488	1.5857000	-.2669939	.2472712
SELENOGRAPHIC	1661.4529877	-175.4196854	792.1443100	-.3484120	-1.5478444	.3600834
SIGMA(SELENO)	.43	1.92	.45	.002	.000	.001

LONGITUDE OF NADIR POINT	-6.0270805 DEG	LATITUDE OF NADIR POINT	25.3676207 DEG
SIGMA NADIR LONGITUDE	.0011671 DEG	SIGMA NADIR LATITUDE	.0002704 DEG
LONG OF CAMERA AXIS INTERSECT	-5.1396046 DEG	LATI OF CAMERA AXIS INTERSECT	25.1693125 DEG
SPACECRAFT RADIUS	1848.9701538 KM	SPACECRAFT ALTITUDE	110.8801270 KM
SIGMA SPACECRAFT RADIUS	.0000025 KM	AZIMUTH OF VELOCITY VECTOR	284.3851013 DEG
MEAN ALTITUDE RATE	-.0119577 KM/SEC	HORIZONTAL VELOCITY	1.6268479 KM/SEC
TILT AZIMUTH	103.6898861 DEG	TILT ANGLE	12.7238231 DEG
SIGMA TILT AZIMUTH	.0090822 DEG	SIGMA TILT ANGLE	.0019996 DEG
SUN ELEVATION AT PRIN GRND PNT	45.2751455 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	118.0610342 DEG
LONGITUDE OF SUBSOLAR POINT	33.2483234 DEG	LATITUDE OF SUBSOLAR POINT	.1471823 DEG
ALPHA	-13.2845217 DEG	SWING ANGLE	89.4932976 DEG
EMISSION ANGLE	13.5505170 DEG	SIGMA SWING ANGLE	.0090822 DEG
PHASE ANGLE	57.9452386 DEG	NORTH DEVIATION ANGLE	165.8012905 DEG
PHI	-12.7233369 DEG	X-TILT	.1115923 DEG
SIGMA PHI	.0019999 DEG	SIGMA X-TILT	.0020002 DEG
KAPPA	-165.8158855 DEG	Y-TILT	12.7233124 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019999 DEG
OMEGA	.1115923 DEG	HEADING	-75.7906857 DEG
SIGMA OMEGA	.0020002 DEG	SIGMA HEADING	.0020503 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-110.8801270 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.83183861	.30301137	-.46500390	113.857040

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.95347970+00	-.30124330+00	-.11352848-01
.22026294+00	.72188811+00	-.65601958+00
.20581710+00	.62300082+00	.75465843+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.94560169+00	.23943762+00	-.22024310+00
-.24503819+00	-.96951141+00	-.19476513-02
-.21399466+00	.52126247-01	.97544307+00

Figure 27(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 63, Camera: 24 Inch Panoramic Frames: 9942 Through: 165

Coverage Interval:

From: 25.2 Deg. S Lat., 109.9 Deg. E Long., To: 6.9 Deg. N Lat., 38.7 Deg. E Long.

From: 200 Hr 33 Min 45.86 Sec, To: 200 Hr 59 Min 42.9 Sec GET

Date Processed: 1/4/72, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

HOPE Version Used: B-6.1

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: 0.69583333 Min.

Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: _____

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 =	5615994.30	$\dot{X}$ =	-367.7504
Y =	357003.71	$\dot{Y}$ =	-5070.78
Z =	2289724.61	$\dot{Z}$ =	1598.78

- Telemetered Data Tape

Data Source: Station tapes

Bit Rate: High

Date Edited: 4 Jan. 1972

Edited Data Tape No. A09569 File No.: 3 Location: Bldg. 12, MSC

Remarks: There are no significant gaps in the telemetered vehicle attitude data for the interval of this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for two strips of stereo panoramic photography and a single sequence of mono panoramic photography. The first stereo strip starts at 109.9 deg. E Long., 25.2 deg. S Lat (Frame 9942) and ends at 65.4 deg. E Long., 7.6 deg. S Lat. (Frame 93). The sequence of mono photography starts at 64.1 deg. E Long., 6.9 deg. S Lat. (Frame 94) and ends at 51.5 deg. E Long., 0.1 deg. S Lat. (Frame 117). The second strip of stereo photography starts at 50.4 deg. E Long., 0.5 deg. N Lat. (Frame 118) and ends at 38.7 deg. E Long., 6.9 deg. N Lat. (Frame 165). All stereo photography is essentially along the plane of flight with the camera optical axis in its central position directed approximately at the vehicle nadir. Throughout the mono sequence, a near zero tilt is maintained so that the principal intersection point and vehicle nadir remain near coincident.

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	22	7	46.650
GET			8	8	33	45.857

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1468.3203888	-476.5245628	-1025.9140930	-.9301719	1.0376278	.8315570
SELENOGRAPHIC	-594.7404175	1565.0153351	-795.3307419	1.4059661	.7274131	.3570824
SIGMA(SELENO)	1.74	.91	.50	.001	.001	.001

LONGITUDE OF NADIR POINT	110.8078995 DEG	LATITUDE OF NADIR POINT	-25.4099398 DEG
SIGMA NADIR LONGITUDE	.0011622 DEG	SIGMA NADIR LATITUDE	.0002912 DEG
LONG OF CAMERA AXIS INTERSECT	109.9030561 DEG	LATI OF CAMERA AXIS INTERSECT	-25.1943185 DEG
SPACECRAFT RADIUS	1853.5209961 KM	SPACECRAFT ALTITUDE	115.4309998 KM
SIGMA SPACECRAFT RADIUS	.0000220 KM	AZIMUTH OF VELOCITY VECTOR	284.2702293 DEG
MEAN ALTITUDE RATE	.0098348 KM/SEC	HORIZONTAL VELOCITY	1.6227094 KM/SEC
TILT AZIMUTH	284.5727196 DEG	TILT ANGLE	12.5139679 DEG
SIGMA TILT AZIMUTH	.0092315 DEG	SIGMA TILT ANGLE	.0019998 DEG
SUN ELEVATION AT PRIN GRND PNT	10.5033073 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	275.1651993 DEG
LONGITUDE OF SUBSOLAR POINT	31.5940280 DEG	LATITUDE OF SUBSOLAR POINT	.1431485 DEG
ALPHA	-13.1779509 DEG	SWING ANGLE	269.9883232 DEG
EMISSION ANGLE	13.3599437 DEG	SIGMA SWING ANGLE	.0092314 DEG
PHASE ANGLE	92.6666842 DEG	NORTH DEVIATION ANGLE	165.4162579 DEG
PHI	12.5139657 DEG	X-TILT	-.0025283 DEG
SIGMA PHI	.0019998 DEG	SIGMA X-TILT	.0020002 DEG
KAPPA	-165.4158821 DEG	Y-TILT	-12.5139663 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019998 DEG
OMEGA	-.0025283 DEG	HEADING	-75.4153214 DEG
SIGMA OMEGA	.0020002 DEG	SIGMA HEADING	.0020406 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-115.4309998 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	.50096675	-.72792544	.46814192	118.434067

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

-.72773574+00	.56617004+00	.38710731+00
.21902473+00	-.72670315+00	-.65108953+00
-.64994526+00	-.38904240+00	-.65285318+00

LATITUDE	LONGITUDE
-25.952	114.614
-21.388	99.056
-22.687	98.561
-26.516	114.469

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.94478523+00	.24582838+00	.21667758+00
-.25180115+00	-.96777894+00	.99126790-09
.20970688+00	-.54517948-01	.97624326+00

LATITUDE	LONGITUDE
-25.489	112.596
-23.810	106.341
-24.681	106.058
-26.110	112.426

Figure 28(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	3	22	33	43.649
GET			8	8	59	42.854

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-1344.2013550	1062.2916107	718.4116745	1.0618682	.6239626	1.0508976
SELENOGRAPHIC	1454.7137909	1131.3334351	235.2626362	.7969704	-1.1901707	.7547258
SIGMA(SELENO)	.99	1.47	.95	.001	.001	.000

LONGITUDE OF NADIR POINT	37.8722682 DEG	LATITUDE OF NADIR POINT	7.2751516 DEG
SIGMA NADIR LONGITUDE	.0009590 DEG	SIGMA NADIR LATITUDE	.0005180 DEG
LONG OF CAMERA AXIS INTERSECT	38.6720014 DEG	LATI OF CAMERA AXIS INTERSECT	6.8787040 DEG
SPACECRAFT RADIUS	1857.8094635 KM	SPACECRAFT ALTITUDE	119.7194672 KM
SIGMA SPACECRAFT RADIUS	.0000050 KM	AZIMUTH OF VELOCITY VECTOR	298.0569305 DEG
MEAN ALTITUDE RATE	-.0051444 KM/SEC	HORIZONTAL VELOCITY	1.6189989 KM/SEC
TILT AZIMUTH	116.4938068 DEG	TILT ANGLE	12.6472787 DEG
SIGMA TILT AZIMUTH	.0091362 DEG	SIGMA TILT ANGLE	.0019997 DEG
SUN ELEVATION AT PRIN GRND PNT	80.0818463 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	227.5172558 DEG
LONGITUDE OF SUBSOLAR POINT	31.3742905 DEG	LATITUDE OF SUBSOLAR POINT	.1426091 DEG
ALPHA	-9.9366976 DEG	SWING ANGLE	88.5611610 DEG
EMISSION ANGLE	13.5344275 DEG	SIGMA SWING ANGLE	.0091361 DEG
PHASE ANGLE	13.5671563 DEG	NORTH DEVIATION ANGLE	152.6092720 DEG
PHI	-12.6434153 DEG	X-TILT	.3149966 DEG
SIGMA PHI	.0020000 DEG	SIGMA X-TILT	.0020000 DEG
KAPPA	-152.1022549 DEG	Y-TILT	12.6432204 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0020000 DEG
OMEGA	.3149966 DEG	HEADING	-62.0315948 DEG
SIGMA OMEGA	.0020000 DEG	SIGMA HEADING	.0020497 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-119.7194672 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.87456107	-.43190894	-.22044862	122.910065

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.79642309+00	.25375618+00	.54892454+00
.22427616+00	.71903414+00	-.65779177+00
-.56161415+00	.64699126+00	.51574389+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.86179032+00	.45761269+00	-.21887935+00
-.46788798+00	-.88377061+00	-.54976994-02
-.19595500+00	.97673121-01	.97573639+00

LATITUDE	LONGITUDE
2.094	49.099
9.223	34.823
8.689	34.546
.825	48.354

LATITUDE	LONGITUDE
5.573	42.133
8.350	36.580
7.763	36.270
4.744	41.676

Figure 28(b) - Last Frame

Mission: Apollo 15, Target: Panoramic Strip Photography

Rev: 72, Camera: 24 Inch Panoramic Frames: 166 Through: 372

Coverage Interval:

From: 17.17 Deg. N Lat., 8.06 Deg. E Long., To: 27.3 Deg. N Lat., 67.8 Deg. W Long.

From: 218 Hr 53 Min 12.67 Sec, To: 219 Hr 16 Min 35.24 Sec GET

Date Processed: 12/14/71, APE Version Used: 7.

INPUT DATA

- Trajectory Tape:

HOPE Version Used: B-6.1

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: 0.69583333 Min.

Base Time: Yr 1971 Month 7 Day 26 Hr 0 Min 0 Sec 0

Computation Interval: Computation at midpoint of each camera sweep

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

Initial State Vector Used:

Coordinate System: Selenographic (Instantaneous Inertial)

Time From Base: 232 H, 29 , 2.0 Sec -

Type: One Revolution Solution

Description: This vector was determined from a solution based on a fit of data from Rev 72. For the solution the energy of the orbit was constrained to be an analytically determined value.

Units: Feet, Second, Degree

Components:

X =	5743623.34	$\dot{X}$ =	-352.7828
Y =	366342.93	$\dot{Y}$ =	-4962.4335
Z =	1975192.34	$\dot{Z}$ =	1885.7199

- Telemetered Data Tape

Data Source: MSFN

Bit Rate: High

Date Edited: 9 Dec. 1971

Edited Data Tape No. A09668 File No.: 2 Location: Bldg. 12, MSC

Remarks: There were no significant data gaps in the telemetered vehicle attitude data employed for this sequence.

- APE Card Inputs:

Time Of Launch: Yr 1971 Month 7 Day 26 Hr 13 Min 34 Sec 0

Range Zero-Clock Zero Time Difference 0.79 Sec

REFSMMAT Used:

.0550754	.6626837	.7468715
-.2300948	-.7194511	.6553216
.9716085	-.2079433	.1128561

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

±21.2132034 ms film exposure RSS time uncertainty including:

±20 ms in onboard clock bias definition
± 5 ms in onboard clock drift rate definition
± 5 ms in universal to sidereal time conversion

OUTPUT

General Description:

The output is a listing of two-page tabulations of computed spacecraft state camera orientation and photograph position and lighting data. Each tabulation presents the results of computations for a specified time within the range covered by the magazine.

Format:

Generally the format will be that 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 computed value of the tilt angle are substituted for the tabulation.

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

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

All entries of the second page of each tabulation are self explanatory except the photograph frame corner locations. These appear above or below the corresponding frame corner number on the left-hand side of the page.

OUTPUT Summary: These photo evaluation data are for a sequence of panoramic photography starting at 8.06 deg. E Long. (Frame 166) as stereo and remaining stereo through 56.5 deg. W Long. (Frame 357); then changed there to vertical and remaining vertical over the remainder of the sequence until 67.84 deg. W Long. (Frame 372). Data for frame 310 are omitted since vehicle attitude data are unavailable for that time. Throughout the stereo sequence the principal intersection point falls slightly WNW when the camera is in the fore position and slightly ESE when the camera is in the aft position. Throughout the vertical photography the principal intersection point and nadir remain essentially coincident. All field of view corner point locations included in these data are in error.

		YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
	GMT	71	8	4	16	27	13.469
	GET			9	2	53	12.671

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	-821.8098907	1241.0412903	1107.6565552	1.4132999	.2583118	.7506383
SELENOGRAPHIC	1754.3953247	275.9059906	537.0577240	.0393484	-1.4961678	.6225217
SIGMA(SELENO)	.05	1.85	.77	.002	.000	.001

LONGITUDE OF NADIR POINT	8.9374492 DEG	LATITUDE OF NADIR POINT	16.8255510 DEG
SIGMA NADIR LONGITUDE	.0010345 DEG	SIGMA NADIR LATITUDE	.0004365 DEG
LONG OF CAMERA AXIS INTERSECT	8.0562456 DEG	LATI OF CAMERA AXIS INTERSECT	17.1692986 DEG
SPACECRAFT RADIUS	1855.3862000 KM	SPACECRAFT ALTITUDE	117.2961731 KM
SIGMA SPACECRAFT RADIUS	.0000045 KM	AZIMUTH OF VELOCITY VECTOR	293.7136192 DEG
MEAN ALTITUDE RATE	-.0050873 KM/SEC	HORIZONTAL VELOCITY	1.6209497 KM/SEC
TILT AZIMUTH	292.3192024 DEG	TILT ANGLE	13.2206767 DEG
SIGMA TILT AZIMUTH	.0087487 DEG	SIGMA TILT ANGLE	.0019990 DEG
SUN ELEVATION AT PRIN GRND PNT	67.9319115 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	139.1383762 DEG
LONGITUDE OF SUBSOLAR POINT	22.2854633 DEG	LATITUDE OF SUBSOLAR POINT	.1195689 DEG
ALPHA	7.1431499 DEG	SWING ANGLE	268.8313446 DEG
EMISSION ANGLE	14.1308041 DEG	SIGMA SWING ANGLE	.0087494 DEG
PHASE ANGLE	11.3723003 DEG	NORTH DEVIATION ANGLE	157.3758221 DEG
PHI	13.2180303 DEG	X-TILT	-.2672595 DEG
SIGMA PHI	.0019997 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	-156.5431080 DEG	Y-TILT	-13.2178835 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	-.2672595 DEG	HEADING	-66.4803343 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020545 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-117.2961731 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.91247460	-.35766964	-.19865177	120.714828

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.74685280+00	.31251154+00	.58698171+00
.20864027+00	.72800137+00	-.65305676+00
-.63141121+00	.61020531+00	.47850733+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.89263168+00	.38849169+00	.22865473+00
-.39805468+00	-.91734978+00	.46645419-02
.21156846+00	-.86853400-01	.97349637+00

Figure 29(a) - First Frame

	YEAR	MONTH	DAY	HOUR	MINUTE	SECOND
GMT	71	8	4	16	50	36.037
GET			9	3	16	35.244

STATE VECTOR	X	Y	Z	X DOT	Y DOT	Z DOT
1950.0	1242.7271576	689.3597183	1172.8596649	1.1457387	-.9464268	-.6745725
SELENOGRAPHIC	619.3515930	-1515.2747803	845.8920364	-1.4474122	-.7139280	-.2424741
SIGMA(SELENO)	1.79	.89	.39	.001	.001	.001

LONGITUDE OF NADIR POINT	-67.7682610 DEG	LATITUDE OF NADIR POINT	27.3273931 DEG
SIGMA NADIR LONGITUDE	.0012169 DEG	SIGMA NADIR LATITUDE	.0002167 DEG
LONG OF CAMERA AXIS INTERSECT	-67.8406858 DEG	LATI OF CAMERA AXIS INTERSECT	27.3381197 DEG
SPACECRAFT RADIUS	1842.6034088 KM	SPACECRAFT ALTITUDE	104.5133820 KM
SIGMA SPACECRAFT RADIUS	.0000249 KM	AZIMUTH OF VELOCITY VECTOR	260.5699158 DEG
MEAN ALTITUDE RATE	-.0107275 KM/SEC	HORIZONTAL VELOCITY	1.6319550 KM/SEC
TILT AZIMUTH	279.4818649 DEG	TILT ANGLE	1.0846902 DEG
SIGMA TILT AZIMUTH	.1050856 DEG	SIGMA TILT ANGLE	.0020110 DEG
SUN ELEVATION AT PRIN GRND PNT	.1183977 DEG	SUN AZIMUTH AT PRINCIPAL GRND PNT	89.9271851 DEG
LONGITUDE OF SUBSOLAR POINT	22.0875757 DEG	LATITUDE OF SUBSOLAR POINT	.1190520 DEG
ALPHA	1.1340276 DEG	SWING ANGLE	288.9208832 DEG
EMISSION ANGLE	1.1499077 DEG	SIGMA SWING ANGLE	.1050854 DEG
PHASE ANGLE	88.7475739 DEG	NORTH DEVIATION ANGLE	189.4743557 DEG
PHI	1.0260485 DEG	X-TILT	.3516922 DEG
SIGMA PHI	.0019997 DEG	SIGMA X-TILT	.0020003 DEG
KAPPA	170.5639172 DEG	Y-TILT	-1.0260292 DEG
SIGMA KAPPA	.0020000 DEG	SIGMA Y-TILT	.0019997 DEG
OMEGA	.3516922 DEG	HEADING	-99.4423857 DEG
SIGMA OMEGA	.0020003 DEG	SIGMA HEADING	.0020003 DEG
SCALE FACTOR	.0000000 M/KM	LASER SLANT RANGE	.0000000 KM
SPACECRAFT ALTITUDE(LASER)	.0000000 KM	ALTITUDE DIFFERENCE	-104.5133820 KM

SELENOGRAPHIC DIRECTION COSINES OF CAMERA AXIS	X	Y	Z	MAGNITUDE (KM)
	-.35389281	.81646895	-.45622179	104.533249

TRANSFORMATION MATRIX FROM SELENOCENTRIC TO CAMERA

.71849544+00	-.57051686+00	-.39783755+00
.21027527+00	.72339971+00	-.65762988+00
.66298462+00	.38884876+00	.63972504+00

TRANSFORMATION MATRIX FROM LOCAL HORIZONTAL TO CAMERA

-.98629286+00	-.16402939+00	.17906631-01
.16394421+00	-.98645046+00	-.61381478-02
.18670845-01	-.31183546-02	.99982087+00

Figure 29(b) - Last Frame

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END

DATE

FILMED

AUG 11