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NRO
National Reconnaissance Office

DATA BOOK

THE KH-8 CAMERA SYSTEM: DUAL MODE

(Vehicle 48 Series With High-Altitude Capability)

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Date

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PREFACE

This data book has been prepared by the National Reconnaissance Office in cooperation with the National Photographic Interpretation Center, the Imagery Exploitation Subcommittee of COMIREX, and the Defense Mapping Agency. It is intended to serve as a reference book for imagery analysts and others associated with the exploitation community who wish to become familiar with the KH-8 system and its imagery and who also wish to develop skills in preparing requests for special acquisitions, taking advantage of such factors as exposure, look angle, frame length, sun angle, area coverage, etc., to maximize the utility of the photography.

This book supercedes the data book entitled The KH-8 Camera System (Vehicle 48 Series) (TCS-5677/77 dated February 1977) by presenting new material that describes high-altitude acquisition capabilities (up to 470 nm) and some of the changes in the vehicle that were required to achieve these capabilities. Basic characteristics of the KH-8 vehicles flown on Missions 4348 through 4351 (number of recovery vehicles, stereo mirror positions, roll capabilities, number of film strands and capability of using different film types film titling, etc.) remain unchanged.

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PART I: SYSTEM DESCRIPTION

INTRODUCTION

The KH-8 dual-mode camera system, like its Block 48 camera system predecessors, is a satellite-borne photographic reconnaissance system designed to gather high-resolution photography. The KH-8 originally was designed for point target surveillance. The addition of an extended altitude capability (EAC) in the dual-mode configuration allows operation at higher altitudes, which results in wider swath coverage at greater ground resolved distances with search mode requirements.

Various system improvements and modifications have been incorporated, effective with Flight Model 52, to achieve this increase in flexibility and utility for the KH-8 camera system (see Table I).

TABLE I

DUAL-MODE IMPROVEMENTS

SYSTEM PERFORMANCE

- Extended altitude capability (68 to 470 nm)
- Multiple-range film drive speed control (two high, two low)
- 90 to 120 day lifetime
- Focus sensing possible over entire slant range
- Expose ancillary data at all film drive speeds
- Additional smear slits for high mode
- higher thrust SRV rocket motors
- Variable recovery sequence timers on both recovery vehicles

ACQUISITION CAPABILITY

- Increased area coverage at high altitude (17 million square nm potential)
- Crisis reaction capability
- Use of very high resolution films
- Increased frame potential (to 25,000)
- Sophisticated target conflicting and selection software
- Flexible modes of operation (i.e., can serve various mission scenarios)

As a consequence of these new capabilities, a KH-8 mission can now be flown in three different ways: (1) an entire mission at low altitudes to obtain the highest quality imagery of technical intelligence targets; (2)an entire mission at high altitudes - as high as 470 nm - to satisfy a significant portion of standing search requirements; or (3) a combination of missions, with half the film expended at high or low altitude and returned, and the remainder expended at the other altitude.

CAMERA SYSTEM CHARACTERISTICS

The dual-platen camera is a strip camera with several unique features that permit the imaging of targets over a wide range of altitudes, slant ranges, and exposure conditions. Since the camera system utilizes 9.5-inch wide and 5-inch wide films independently or simultaneously, two different film types may be available at any one time, offering wider latitude in imaging a target.* This freedom of choice is further enhanced by the availability of independent variable exposure mechanisms provided for each platen.

LIGHT PATH

Light is gathered from the scene beneath the vehicle and reflected by a tiltable mirror (the stereo mirror) to a focusing mirror at one end of the camera. This mirror concentrates the bundle of light and directs it through a correcting lens toward the imaging platens. The resulting focused ray of light is then imaged directly on the 9-inch film platen and, by means of a narrow reflecting prism, also on the 5-inch film platen. It is this imaging of a single ray of light on two separate platens that enables the system to take simultaneous or independent photography of a single target.

The reflecting prism for the 5-inch platen is below the optical axis of the 9-inch platen, causing the 5-inch line of sight (LOS) to be directed aft of the 9-inch LOS. The effect of this offset is illustrated in Figure 1, which also shows the magnitude of this offset in nautical miles as a function of slant range.

The stereo mirror can direct the line of sight at right angles to the vehicle motion (at the nadir if no vehicle roll is present) and 8.65 degrees forward and aft. The imaging capabilities realized by this flexibility are described in the section entitled "Modes of Operation."

IMAGE MOTION COMPENSATION (IMC)

Vehicle velocity, earth rotation, and variations in terrain elevation combine to produce considerable differential motion between an orbiting vehicle and a scene to be photographed (i.e., images projected on the platens are moving at different speeds depending on their position along the slit). The dual-mode camera system employs two means to eliminate this relative image motion during photography. First, the stereo mirror is rotated about the center of its supporting yoke to a calculated crab angle,

*For convenience's sake, the wider film subsystem is called the 9-inch subsystem through the rest of the manual.

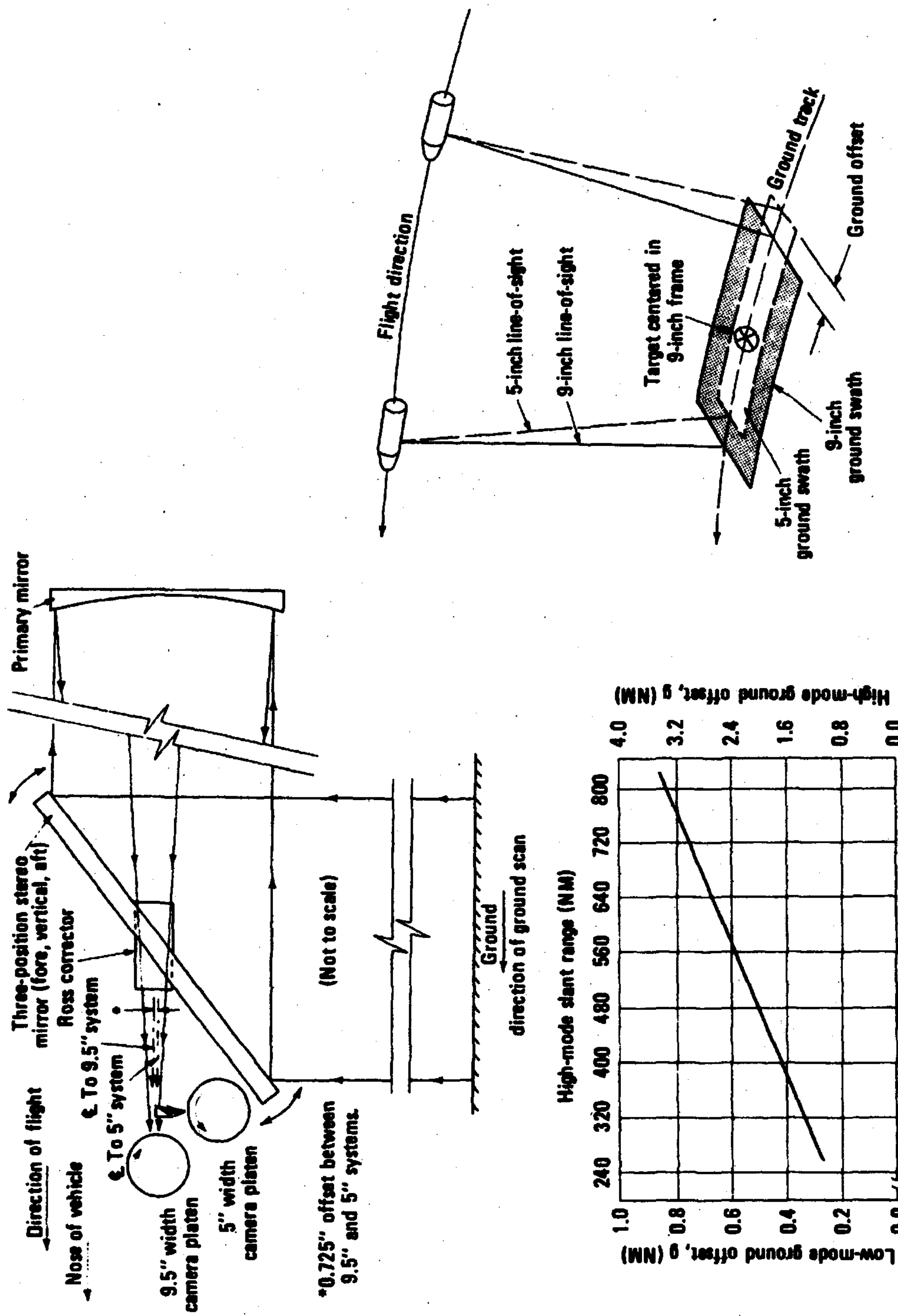

FIGURE 1. EFFECT ON POINTING OF SUBSYSTEM OFFSET

which reduces cross-track axial image velocity, within the discrete limits of the crab settings, to near zero. Selection of the crab angle for each frame is based on both image velocity vector alignment and pointing considerations. Second, the film is driven at a calculated speed that matches the in-track axial image velocity for the crabbed system.

Since differences in crab angle between the 9-inch subsystem and the 5-inch subsystem are negligible, pointing and IMC parameters for a given target are calculated for whichever of the two subsystems is the primary camera for that acquisition and used for both.

The displacement of the lines of sight between the 9-inch and 5-inch, subsystems as shown in Figure 1, require different film-drive speeds if proper image motion compensation (IMC) is to be achieved for both. Since there is only one film drive speed (FDS) memory in the command processor, only one film drive speed may be commanded at any given time. This presents a conflict in cases when the two subsystems are operating simultaneously with different FDS steps required for each. The operational software chooses which subsystem to optimize in such cases (usually the 9-inch subsystem is preferred), and the other subsystem is then operated at a less-than-optimum FDS, resulting in some minor image degradation (smear).

Film drive speed varies inversely with vehicle-to-target distance (slant range). Calculations of limiting cases (maximum and minimum speeds in inches/second) show that it is possible to obtain photographs with correct film-drive velocities at target ranges from 68 NM to about 470 NM.

EXPOSURE

In a frame camera, the amount of energy falling on the film is controlled by a combination of the shutter speed (exposure time) and the lens aperture. With a fixed aperture strip camera such as the KH-8, this energy is controlled entirely by the slit width.

Exposure for the KH-8 dual-mode system is controlled by positioning moveable blades in front of each platen which are capable of providing 16 slit openings for each subsystem, ranging from 0.0040" to 0.3000". The ratio between successive slit settings is approximately 1.334, and the maximum time needed to change from one slit to an adjacent one is 1.0 second.

The slits are also used to place additional information on the films to aid in post-flight analyses. Light-emitting diodes (LEDs), controlled by the camera electronics assembly modules, produce data tracks (vehicle clock information) in both subsystems. Interframe marks are produced along the edge of the film by apertures illuminated by incandescent lamps that are also controlled by the camera electronics assembly. The slit blades, in addition to controlling exposure levels, generate fiducial lines to delineate the main scene and provide the smear slits that create a double exposure for use in detecting and measuring smear.

FILM SWATH WIDTHS

Figure 2 graphs the approximate swath widths for each subsystem over a range of altitudes, obliquity angles, and stereo angles. Optical properties of the KH-8 dual-mode camera system are summarized in Table II. General system characteristics are summarized in Table III.

TABLE II

OPTICAL PROPERTIES SUMMARY

Effective focal length	175 inches
Aperture diameter (primary mirror)	43.5 inches
f number (9-inch system)	4.02 nominal
Type	Aspheric reflector with five-element Ross corrector
Configuration	Optical path folded by stereo mirror; optical axis passes through stereo mirror
Semi-field angle: 9-inch	1.45 degrees
Semi-field angle: 5-inch	0.74 degree
Stereo angle of line-of-sight, with respect to nadir (deg)	-8.65, 0, +8.65
Crab-angle range (deg)	-3.85 to +3.85
Peak static resolution, Vehicle 51 (geometric mean)	[redacted] lines/mm*

*Based on 2:1 contrast at film plane, threshold modulation $= 0.0170 + 2.07 \times 10^{-7} \nu^2$ for SO-409 at nominal exposure.

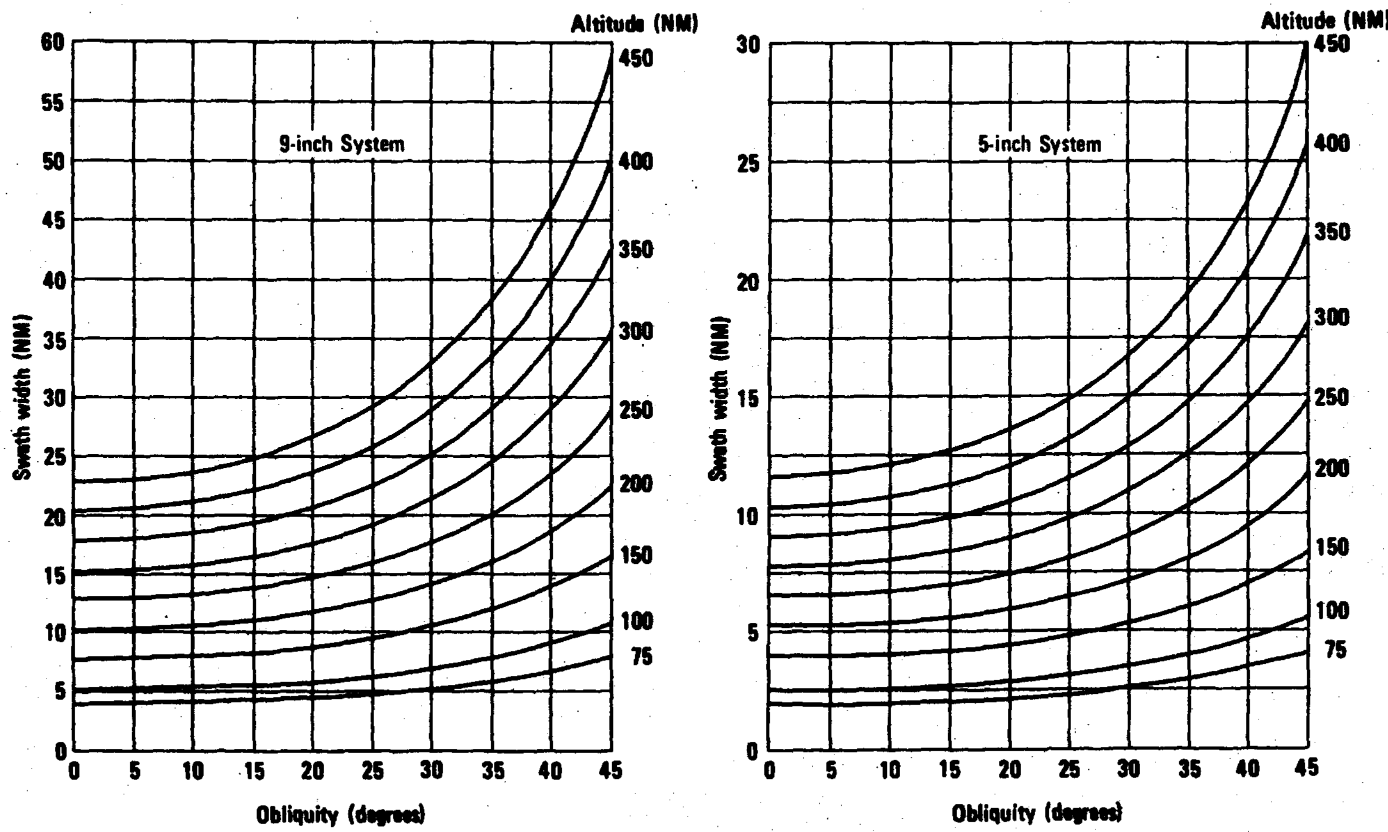

FIGURE 2. VARIATION IN SWATH WIDTH WITH ALTITUDE AND OBLIQUITY ANGLE (For stereo angle=0 (mirror centered); for stereo mirror in forward or aft position, multiply swath width by 1.0115.

TABLE III

KH-8 DUAL-MODE MISSION PARAMETER AND SYSTEM CHARACTERISTICS

ITEM	CHARACTERISTIC
Target ranges	68 to 470 nm
Theoretical orbit inclination	82 to 120 degrees (perigee anywhere in orbit)
Mission duration	90 to 120 days
Direction of travel during photography	North or south (south descending)
Film footages (feet)	
9-inch	11,500 (13,500 max. with 1.2-mil base)
5-inch	2,800 (3,600 max. with 1.2-mil base)
Potential number of frames	
9-inch	19,000 (27,000 max.)
5-inch	4,600 (6,100 max.)
No. of exposure slits (widths in inches)	16 (0.004 to 0.300)
Best resolution (GRD)	[redacted]
Nominal resolution	[redacted]
Beta angle range	±40 degrees
Spectral bandpass	400 to 780 nanometers
Spatial cutoff	[redacted] l/mm

FILM LOAD

The KH-8 dual-mode 9 x 5 system is capable of using both black-and-white and color films with thicknesses varying from 0.0015-inch (1.5 mils) to 0.0039-inch (3.9 mils) on either film supply. Under certain conditions it may be possible to accommodate thinner films, but thicker films, because of limitations imposed by mechanical clearances in some locations,are to be avoided. Film footages are shown in Table III.

MULTIPLE FILM TYPES

Color film provides a definite spectral information increase over black-and-white (B&W) film even though the image quality (tribar resolution) may not be as good. Similarly, color infrared film has the unique capability to record an image which is interpretable in terms of the health of agricultural crops and the presence of camouflage materials. The dual platens on this system make it possible to obtain both high resolution B&W imagery and color or color infrared imagery simultaneously over a single target or, as a means of ensuring maximum resolution, simultaneous coverage using two different, high-resolution, black-and-white films.

FILM MARKING DATA

Illustrations of the 9 and 5-inch films are shown in Figures 3 and 4. Descriptions of the major elements follow.

Fiducial Lines

The fiducial lines on both films are narrow bands of high exposure at each edge of the main scene and mark the limits of the imagery.

Data Tracks

There are two pairs of data tracks on each exposure mechanism, one designed for low mode and one for high mode. For either mode the two data tracks encoded on the film provide timing information in the form of light pulse exposures representing the vehicle timing signals. The two tracks, A and B, are identical and represent timing signal A inverted and logically summed with timing signal B. The data tracks are imaged at 500 pulses per second with an octal time word encoded every 0.2 seconds. The LED lamps that imprint the data tracks are offset along the axis of the film on either side of each slit centerline as a means of measuring film speed. The relative data lamp positions are the same for both the 9 and 5 slit mechanisms. The following table shows the data lamp positions and the effective aperture size at the platen:

Data lamp		Position with respect to slit ℄	Distance from slit ℄ along film axis (inches)	Effective aperture size at the platen (inches)
Low mode	A	Outside	0.05 after	0.001 x 0.005
	B	Inside	0.05 ahead	0.001 x 0.005
High mode	A	Outside	0.15 ahead	0.0005 x 0.005
	B	Inside	0.15 after	0.0005 x 0.005

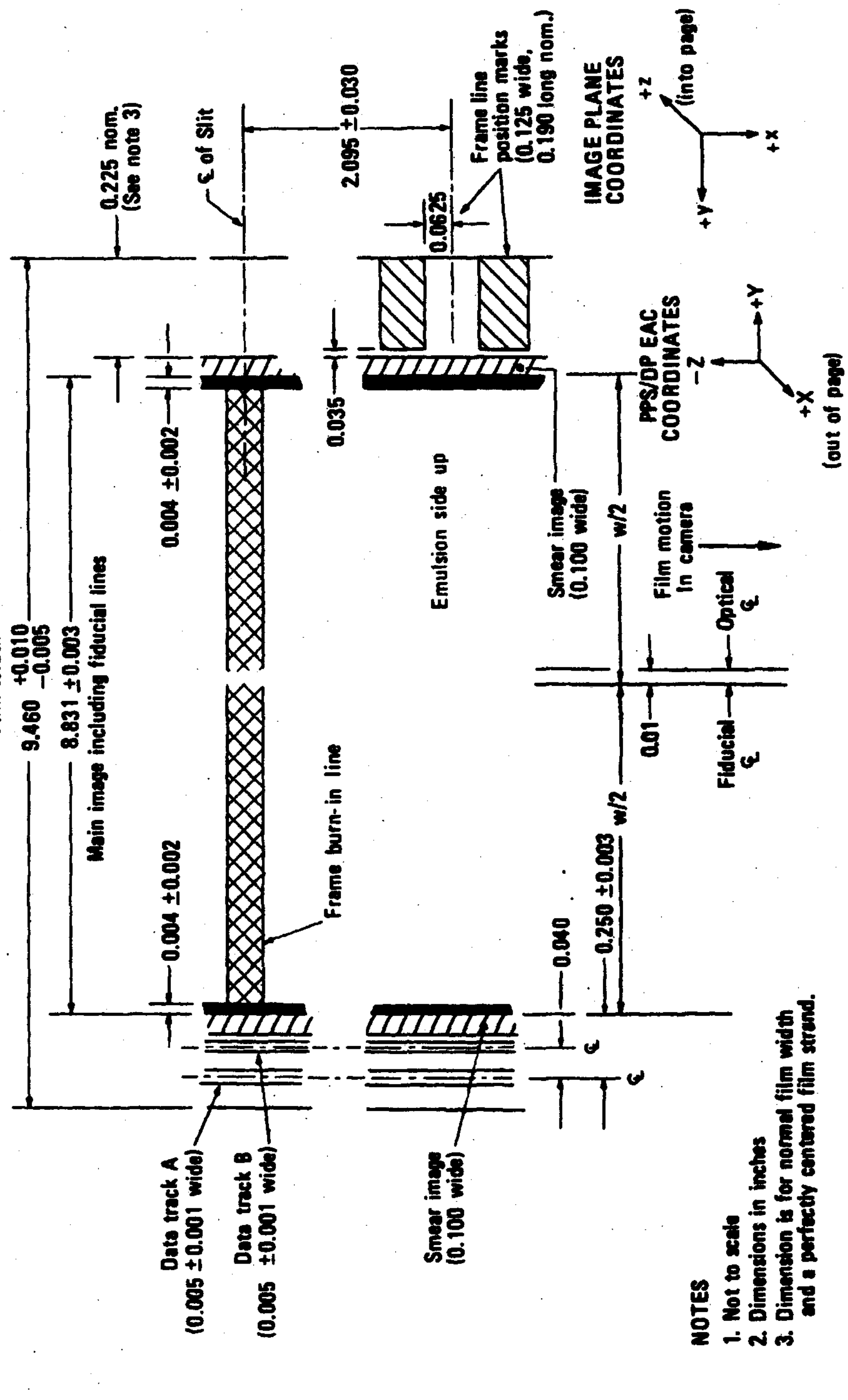

FIGURE 3. NINE-INCH FILM FORMAT

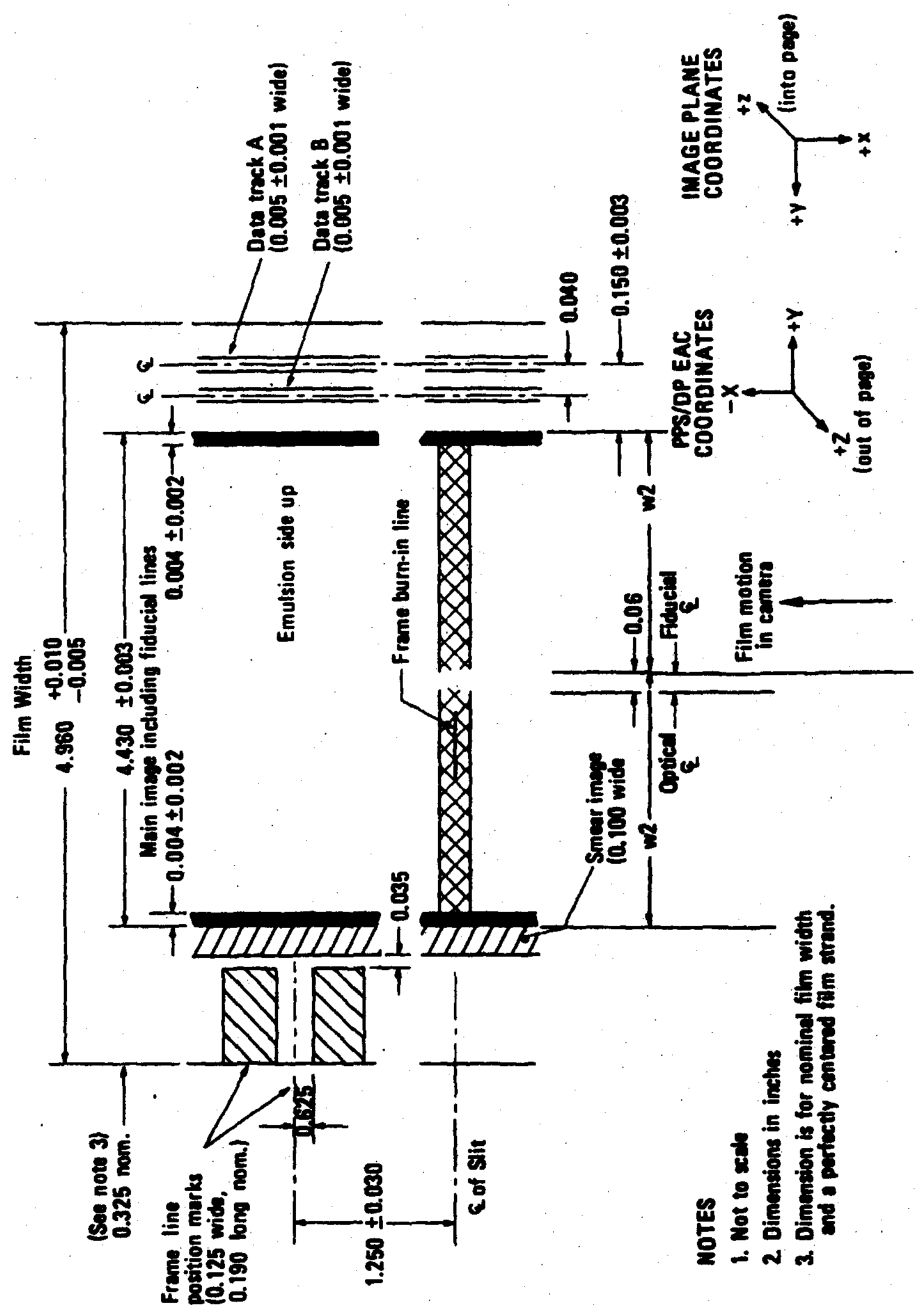

FIGURE 4. FIVE-INCH FILM FORMAT

Film Can Labeling

The control number on the shipping labels will be similar to those previously used. Typical examples follow:

M481001	-	"M" for main record (9 inch)
	-	"481" for Mission 4348-1
	-	"001" for can number
C481001	-	"C" for 5-inch record

Color coding on the label will be the same as previously used:

Original negative (ON)	-	Green
Duplicate negative (DN)	-	Yellow
Duplicate positive (DP)	-	Blue
DP File Copy	-	Red
Color original positive (OP)	-	Orange
Color DP	-	Green

MODES OF OPERATION

The KH-8 system is capable of performing three basic modes of photography; monoscopic, stereoscopic, and lateral coverage. These three modes, with the variations described below, are available for almost every photographic opportunity. The mode required for a particular acquisition may be specified by the user. Each of the modes and how to state the requirement for them is discussed below.

MONOSCOPIC PHOTOGRAPHY

As stated earlier, there are three stereo mirror pointing positions; forward 8.65°, vertical, and aft 8.65°. Monoscopic photography is obtained by imaging a target from only one of these mirror positions on a given pass (Fig. 5). The resulting frame can vary in length from only a few inches up to several feet.

STEREOSCOPIC PHOTOGRAPHY

Single-pass stereo photography can be obtained in three ways. The full stereo pair consists of one photo taken with the stereo mirror in the forward position and one with the mirror aft (Fig. 6). The convergence angle is approximately 17.3 degrees. A stereo triplet consists of a series of three frames, one from each of the mirror positions (Fig. 7). The stereo half pair is made up of a vertical acquisition and either a forward or aft frame (Fig. 8). The stereo angle in these latter two modes is 8.65 degrees.

LATERAL COVERAGE PHOTOGRAPHY

Lateral coverage photography is a combination of the mono and stereo modes and is used to provide greater area coverage around a point on the ground. Two options are available. A lateral pair consists of two frames taken in the forward and aft mirror positions with a vehicle roll between acquisitions. The resultant pair overlap approximately 15 percent cross-track, and the target is centered in the overlap (within system limits). A lateral triplet consists of three frames laid cross-track, one from each mirror position with a vehicle roll between each acquisition. Examples of lateral pairs and triplets are shown in Figures 9 and 10.

REQUEST FOR A SPECIFIC MODE

The user may request a mandatory mode or a set of acceptable modes and their preferred order. Table IV shows the mode options that will be available for operations.

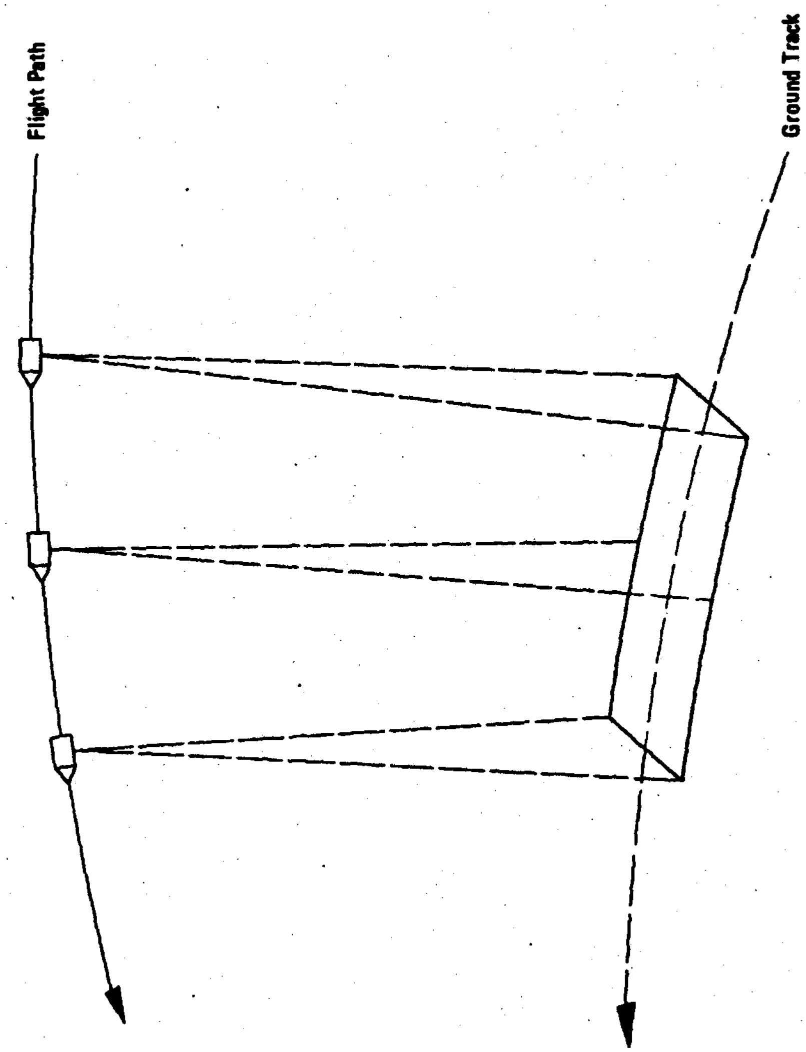

FIGURE 5. MONO PHOTOGRAPHY (Example with mirror vertical)

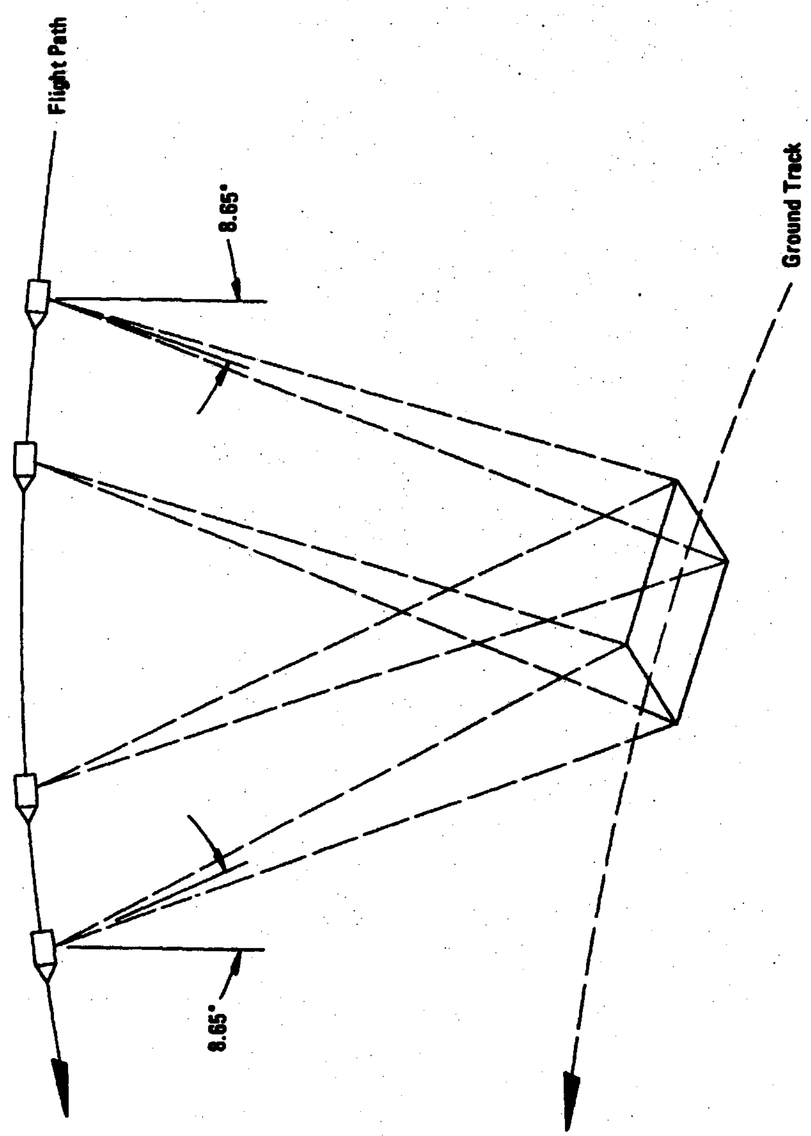

FIGURE 6. FULL STEREO PAIR

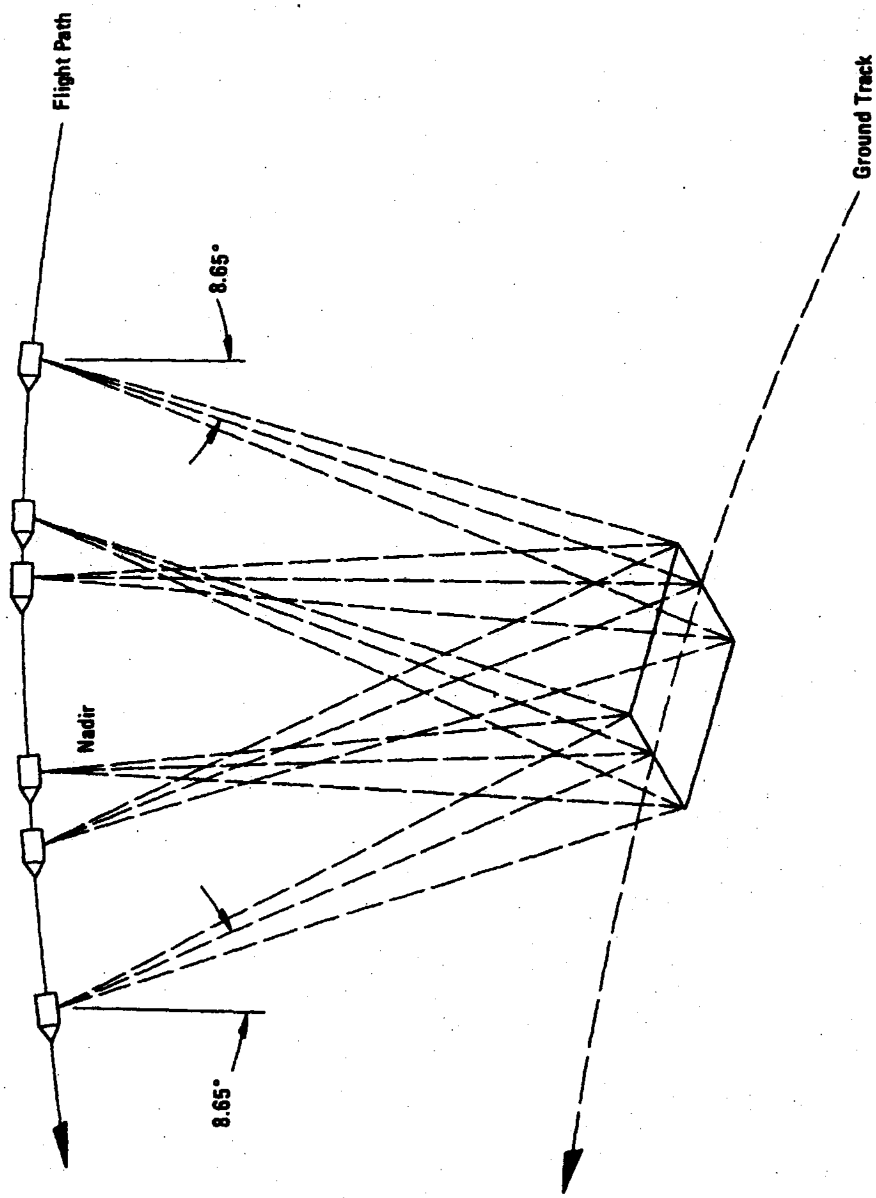

FIGURE 7. STEREO TRIPLET

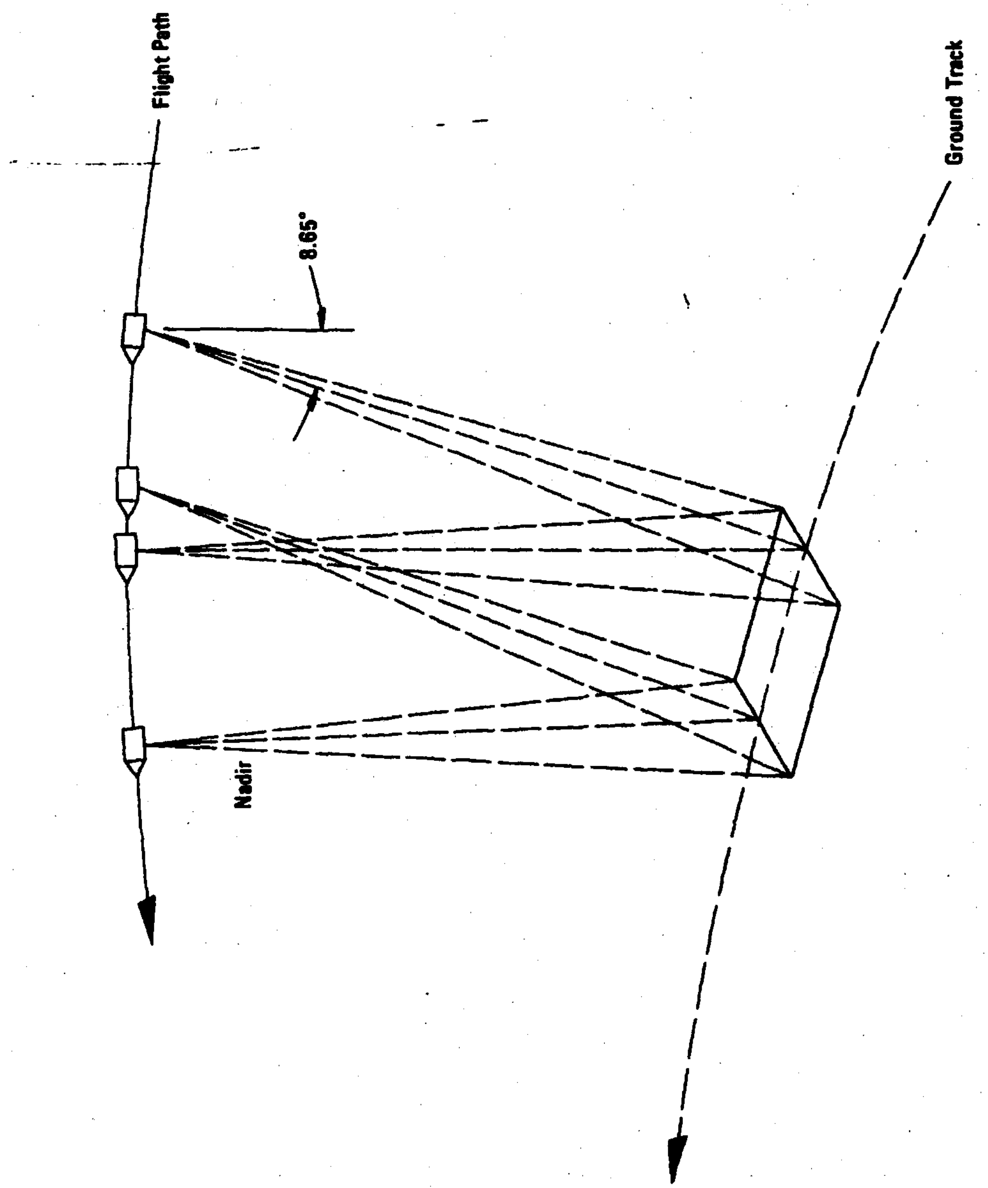

FIGURE 8. HALF STEREO PAIR

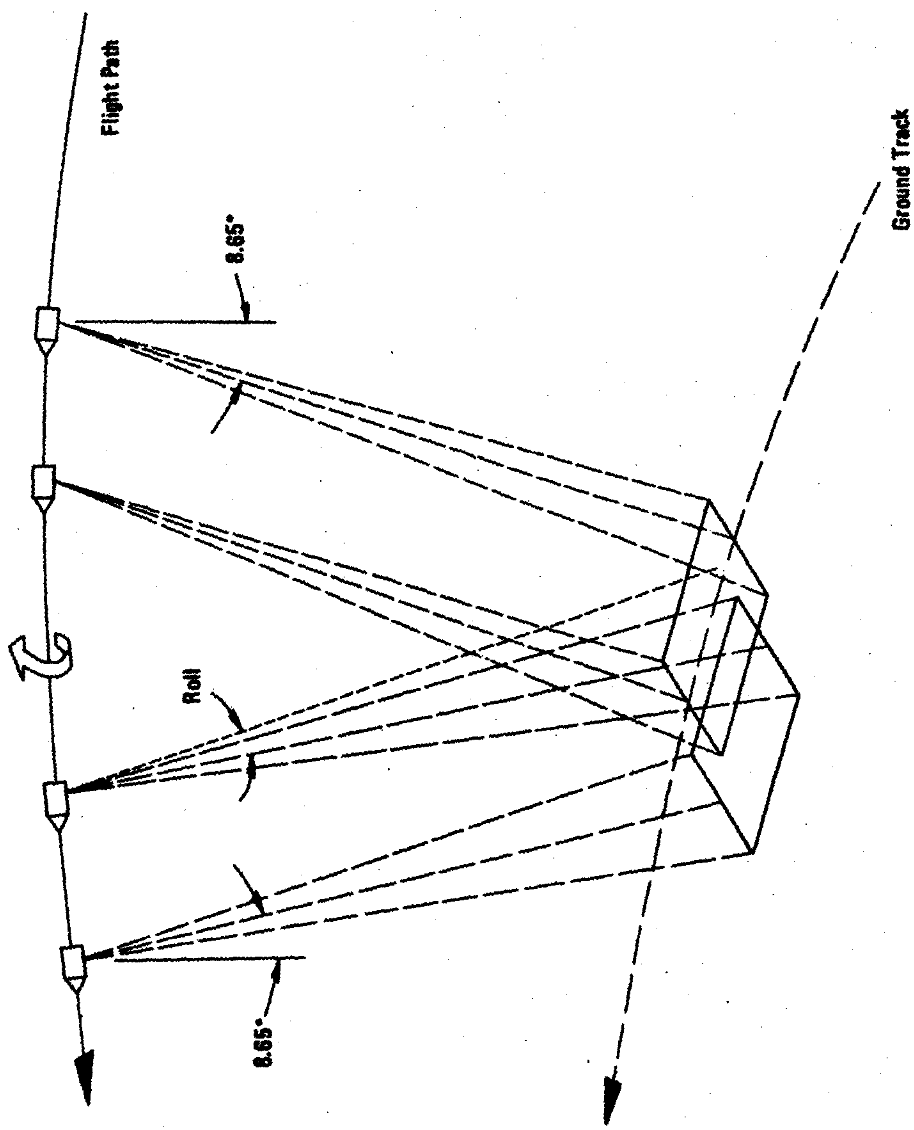

FIGURE 9. LATERAL PAIR

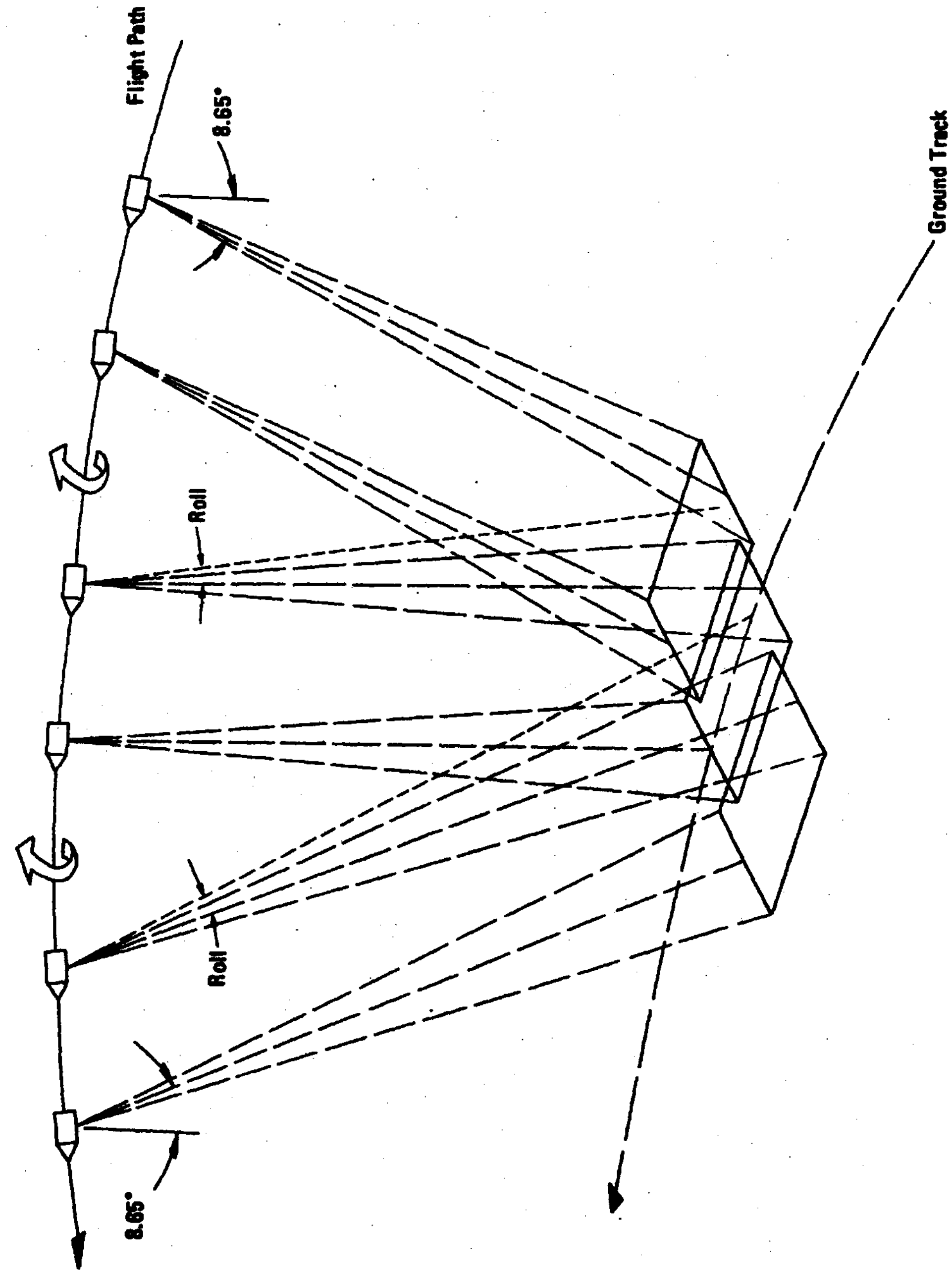

FIGURE 10. LATERAL TRIPLET

TABLE IV

AVAILABLE MODE OPTIONS

Any mono
Forward mono mandatory
Vertical mono mandatory
Aft mono mandatory
Stereo triplet mandatory
Stereo pair mandatory
Stereo pair (preferred over) any mono
Half stereo mandatory
Half stereo (preferred over) any mono
Stereo pair (preferred over) half stereo
Stereo pair (over) half stereo (over) any mono
Stereo triplet (over) stereo pair (over) half stereo
Stereo triplet (over) stereo pair (over) half stereo (over) any mono
Lateral triplet mandatory
Lateral pair mandatory

A typical example of how the mode preference logic operates is shown in Figure 11. The example is intended to show how fixed parameters of the camera system affect requested modes. In this example the limiting parameter is the time required to flip the stereo mirror from one position to another.

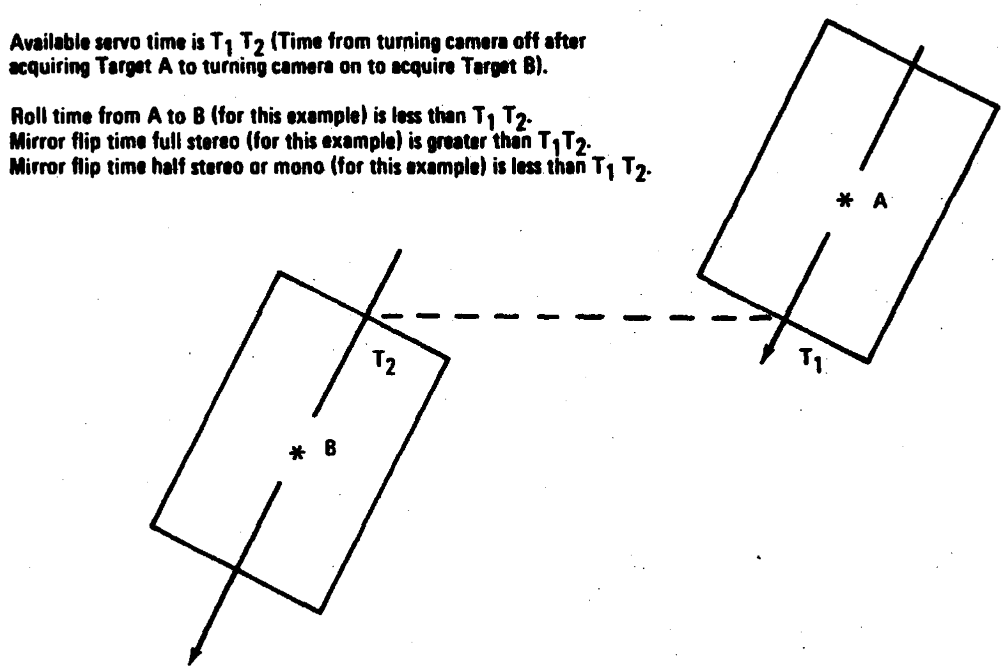

FIGURE 11. EXAMPLE OF CONFLICTING MODE

As shown, the time to alter the vehicle pointing in roll is within the servo time available between the off-time of the frame of Target A to the on-time of the frame of Target B. The time to flip the stereo mirror between extreme positions (aft to forward) is greater than the available time. The time to flip between adjacent positions (aft to vertical), however, is less than the available time, T1 T2. This conflict in timing means that a request that includes both an aft frame of Target A and a forward frame of Target B cannot be achieved. Hence, if both targets are specified "stereo mandatory," only one would be photographed in a single pass. If either was "stereo mandatory" and the other was "stereo preferred but mono acceptable," then the photography would consist of a stereo pair of the first and a mono strip of the other.

OPERATIONS SCHEDULE

Pre-Flight

The KH-8 dual-mode reconnaissance system is maintained in a launch-on-demand status and does not have preestablished launch dates as did most previous KH-8 vehicles. Preflight activities of importance to users remain essentially the same, however.

Normally, the launch processing timelines are as follows:

L-80: Deadline for users to submit any requirements to ICRS that necessitate the use of "exotic"films or multiple coverage requirements for different films.

L-60: ICRS submits final film load requirements for film spool design.

L-35: ICRS submits final mission profile (altitude selection). Users should submit any requirements for coverage that may affect orbit selection well before this date.

On-Orbit

The KH-8 satellite is loaded with a set of commands just prior to each revolution of photography. This is to take maximum advantage of the latest available predicted weather. New target requirements, or changes to existing ones, can be accepted at the KH-8 operations center as late as 90 minutes prior to the start of imaging operations on a given revolution.

MISSION FILM INDEX (MFI)

The MFI, a sample copy of which is shown as Table V, is a computer listing of mission coverage by rev, and identifies specifically how the frames from each system correlate. A sample format of the MFI is explained below:

TABLE V.

MISSION FILM INDEX FORMAT (Sample)

M Cont No	Printing DP DN	C Cont No.	Printing DP DN	Date-DDMMYY	Area	Rev	M Frames From-To	C Frames From-To	Code ED-NF-CC	M Footage Photo	M Footage Ship	C Footage Photo	C Footage Ship	Changes *
M481001	LD-LD	C481001	LD-LD	010276	A	0001	9001-9001	5001-5001		XXX.XX	XXX.XX	XXX.XX	XXX.XX	
M481001				010276	A	0001	9001-9002		NF	23.01				
M481001		C481001		010276	A	0001		5001-5001	NFCC			10.00		
M481002		C481001		010276	A	0001	9003-9004	5002-5003		11.68	34.69	4.72	14.72	

Table Heading or Entry	Explanation
M Cont #	Main control number
M481001	"M" for main record (9-inch), "481" for Mission 4348-1, "001" for can number. If the control number is followed by a "C" or "I", the associated frames ("M Frames" column) are color or IR film.
Printing DP/DN	Printing level for the 9-inch DP and DN. A medium copy will always be shipped. If any additional print levels are produced, they will be reflected in this column. L - Light D - Dark
C Cont #	Companion control number.
C481001	"C" for companion record (5-inch), "481" for Mission 4348-1, "001" for can number. If the control number is followed by a "C" or "I", the associated frames ("C Frames" column) are color or IR film.
Printing DP/DN	Printing level for the 5-inch DP and DN.

Table Heading or Entry	Explanation
Date	GMT date of photography
Area	Geographic area
Rev	Revolution number
M frames From - To	Frame numbers for the 9-inch film. Frame numbers are sequential within a rev and cycle back to 9001 at the beginning of each rev.
C Frames From - To	Same for the 5-inch film.
Code ED-NF-CC	ED - Edited; NF - Noforn; CC - Cloud Cover.
M Footage Photo Ship	Film footage for the 9-inch film for each set of frames and the cumulative film footage by rev.
C Footage Photo Ship	Same for the 5-inch film.
Changes	Two versions of the MFI are produced - preliminary, and final. This column flags any changes between these two editions.

MISSION CORRELATION DATA (MCD)

The MCD is a computer listing of the parameters associated with each photograph. A sample MCD entry is shown on the pages that follow, accompanyed by a description of each entry. Note that KEY numbers (first column) in the 40's are heading or title lines, and KEY numbers in the 60's are data lines. Note also that not all title lines are described here; the reader is directed to the MCD glossary for a complete description.

Typic

```
41  REV    ACC T T1T2 MR M  ROLL  CMD-CRAB-COMP  S F SR  CONE A
61   53D 9007 8    5.2 V 0  24.85  1.672  1.709  3 0  .0 26.521
43  REV   ACC     LAT*U*LONG       LAT*Z*LONG       LAT*W*LONG
63   53 9007  55.93N  39.85E  55.46N  40.46E  55.75N  40.68E
44       ADAPT BIASES-YAW  PITCH  ROLL        THERM BEND ERROR-
64                    .0000   .0135   .0000                    .1
45                                             NPA        VEL-X
65                                             1.1       -3.584506
66     PROGRAMMED ID    07Z016601  *
47  IN FRAME ID M    LAT     LONG   D T-ALT    VFC     RES  FW AW
67    08Z016601  0 55.70N  40.57E     1000.  1.2053   41.6 90 40
67    02Z016601  0 55.90N  39.67E     1000.  1.2445   53.2 80 35
67    07Z016601  0 55.70N  40.12E     1000.  1.2223   34.1 85 40
67    12Z016601  0 55.50N  40.57E     1000.  1.1992   50.5 85 45
67    06Z016601  0 55.70N  39.67E     1000.  1.2389   43.6 80 40
67    11Z016601  0 55.50N  40.12E     1000.  1.2164   34.9 85 45
67    03Z016601  N 55.90N  40.12E     1000.  1.2281   35.1 80 35
42     SYSTIME   CLK TIME    LAT-NADIR-LONG     HEIGHT  INER VEL
62     31774.26 005727231 57 5.17N  3344.24E  452.046 24331.19
62     31774.86 005727234 57 3.14N  3343.00E  452.049 24331.14
62     31775.46 005727237 57 1.10N  3341.77E  452.053 24331.10
62     31776.06 005727242 5659.07N  3340.54E  452.056 24331.05
62     31776.66 005727245 5657.03N  3339.31E  452.060 24331.01
62     31777.26 005727250 5654.99N  3338.08E  452.064 24330.96
62     31777.86 005727253 5652.96N  3336.85E  452.067 24330.92
62     31778.46 005727256 5650.92N  3335.63E  452.071 24330.87
62     31779.06 005727261 5649.89N  3334.40E  452.074 24330.83
62     31779.46 005727263 5647.53N  3333.59E  452.077 24330.80
```

MCD Entry

```
G   VF       SS    F-USED  INTRK-SC-XTRK    ALPHA-90-BETA  213-FRAME-ID
 1.2220    .0051     .53 214174. 248050.      .627     .541 5223MAY809096
LAT*X*LONG      *V**Y*   *V**U*   *V**W*   *Y**X*   *Y**Z*   F-AREA FLMRS
5.65N  39.64E    21.10    14.72    15.31    14.72    15.31    611.3 00000
AW  PITCH                    ORB DEP ERROR-YAW  PITCH  ROLL
12   .0465                              .0000  -.0125   .0000
 VEL-Y          VEL-Z          SLR
 -.126590       .014356        513.500

VTK-D-XTK CLN TNT MAR CMD-SLIT-COMP HR  GM  LR  P2 P3 P4 P5 P6 P7 P8
13.0  1.5 59.  FFF600 .00620 .00540 14. 11.  8. 99 99 99 99 99 99 99
12.2 26.1 16.  000017 .00620 .00540 14. 11.  8. 99 99 99 99 99 99 99
 7.8 11.8 99.  FFFFFF .00620 .00540 14. 11.  8. 99 99 99 99 99 99 99
 3.4 -2.1 25.  CEA000 .00620 .00490 14. 11.  8. 99 99 99 99 99 99 99
 2.6 22.4 41.  0006FF .00620 .00540 14. 11.  8. 99 99 99 99 99 99 99
-1.8  8.2 28.  088ACC .00620 .00540 14. 11.  8. 99 99 99 99 99 99 99
17.3 15.4 37.  333111 .00620 .00540 14. 11.  8. 99 99 99 99 99 99 99
 V/H  VEH AZM  FLTPTH    LAT-PR RAY-LONG    AZM-PR RAY-SLR   EL-SUN-AZM
.0089 196.209    .2358 5550.56N  4015.55E 291.709   513.55   54.5 169.4
.0089 196.194    .2356 5548.60N  4014.02E 291.686   513.56   54.5 169.4
.0089 196.179    .2354 5546.64N  4012.49E 291.664   513.56   54.5 169.3
.0089 196.164    .2352 5544.67N  4010.96E 291.642   513.56   54.6 169.3
.0089 196.149    .2350 5542.70N  40 9.44E 291.621   513.57   54.6 169.2
.0089 196.133    .2349 5540.74N  40 7.91E 291.599   513.57   54.6 169.2
.0089 196.118    .2347 5538.77N  40 6.39E 291.578   513.58   54.6 169.2
.0089 196.104    .2345 5536.80N  40 4.88E 291.556   513.58   54.7 169.1
.0089 196.089    .2343 5534.84N  40 3.36E 291.535   513.58   54.7 169.1
.0089 196.079    .2342 5533.52N  40 2.35E 291.520   513.59   54.7 169.0
```

[redacted]

[redacted]

KEY	HEADER	DESCRIPTION
61	41	CAMERA EVENT DATA LINE
	REV	REV NUMBER
	(NO HEADER)	ASCENDING OR DESCENDING FLAG IDENTIFIED BY A OR D
	(NO HEADER)	STRAND OF FILM USED (9 OR 5)
	ACC	FRAME ACCESSION NUMBER, STARTS AT 1 AT EACH REV FOR BOTH OPERATIONAL AND H AND D FRAMES
	T	FILM TYPE USED FOR THIS FRAME - IDENTIFIED IN VEHICLE CONSTANTS DISPLAY
	T1T2	BURST TIME
	MR	MIRROR POSITION
	M	OVERLAP FRAME INDICATOR IF ANY PART IS COVERED BY OTHER FRAME - 0 = OVERLAPPED, 1 = NOT OVERLAPPED
	ROLL	ROLL ANGLE, QUANTIZED
	CMD-CRAB	COMMANDED CRAB ANGLE
	-COMP	COMPUTED CRAB ANGLE
	S	SLIT NUMBER, COMMANDED
	F	FLAG OF SLIT BIAS TYPE
	SB	PLANNED SLIT BIAS OF FRAME
	CONE ANG	CONE ANGLE, QUANTIZED
	VF	FILM SPEED, QUANTIZED
	SS	EFFECTIVE SHUTTER SPEED
	F-USED	LENGTH OF FRAME, COMPUTED
	INTRK-SC	SCALE FACTOR AT INTRACK AZIMUTH = 0 DEG
	-XTRK	SCALE FACTOR AT CROSSTRACK AZIMUTH = 90 DEG
	ALPHA-90	SKEW ANGLE WHEN ALPHA = 90 DEG.
	-BETA	SKEW ANGLE WHEN BETA = 90 DEG.
	213-FRAME-ID	213 DEFINED FRAME ID FLIGHT NUMBER DAY MONTH YEAR STRAND INDICATOR (5 OR 9) FRAME NUMBER - RECYCLES TO 1 AT 0001 GMT EACH DAY

[redacted]

COLUMN	FORMAT	UNITS
2-3	NN	N.D.
5-8	NNNN.	N.D.
9	A	N.D.
11	N	N.D.
12-14	NNN	N.D.
16	N	N.D.
18-22	NNN.N	SEC.
24	A	N.D.
26	A	N.D.
28-33	NNN.NN	DEG.
35-40	NN.NNN	DEG.
42-47	NN.NNN	DEG.
49-50	NN	N.D.
52	N	N.D.
53-56	NN.N	LOG BASE 10
58-64	NN.NNNN	DEG.
66-72	NN.NNNN	IN/SEC.
74-80	NN.NNNN	SEC.
82-86	NN.NN	FT.
88-94	NNNNNN.	N.D.
96-102	NNNNNN.	N.D.
104-110	NNN.NNN	DEG.
112-118	NNN.NNN	DEG.
120-132		
120-121	NN	N.D.
122-123	NN	N.D.
124-126	AAA	N.D.
127-128	NN	N.D.
129	N	N.D.
130-132	NNN	N.D.

42	SYSTIME	CLK TIME	LAT-NADIR-LONG		HEIGHT	INER V
62	31788.66	005727341	5616.28N	3315.10E	452.129	24330.
62	31789.26	005727344	5614.25N	3313.91E	452.133	24330.
62	31789.86	005727347	5612.21N	3312.73E	452.136	24330.
62	31790.46	005727352	5610.17N	3311.54E	452.139	24329.
62	31791.06	005727355	56 8.13N	3310.35E	452.143	24329.
62	31791.66	005727360	56 6.09N	33 9.17E	452.146	24329.
62	31792.26	005727363	56 4.05N	33 7.99E	452.149	24329.
62	31792.86	005727366	56 2.01N	33 6.81E	452.153	24329.
62	31793.46	005727371	5559.97N	33 5.63E	452.156	24329.
62	31794.06	005727374	5557.93N	33 4.46E	452.159	24329.
62	31794.26	005727375	5557.25N	33 4.07E	452.160	24329.

SNO	KEY	HEADER	DESCRIPTION
365	62	42	CAMERA EPHEMERIS AND PO
370		SYSTIME	SYSTEM TIME AT START OF
371			IN INCREMENTS OF 0.6 SE
372		CLK TIME	VEHICLE CLOCK TIME IN O
373			IN INCREMENTS OF 3 OCTA
374		LAT-NADIR	GEODETIC LATITUDE OF VE
375		-LONG	GEODETIC LONGITUDE OF V
376		HEIGHT	ALTITUDE OF VEHICLE
377		INER VEL	INERTIAL VELOCITY OF VE
378		V/H	VEHICLE INERTIAL VELOCI
379		VEH AZM	FLIGHT PATH AZIMUTH OF
380		FLTPTH	VEHICLE FLIGHT PATH ANG
381		LAT-PR RAY	GEODETIC LATITUDE OF PR
382		-LONG	GEODETIC LONGITUDE OF P
383		AZM-PR RAY	INSTANTANEOUS AZIMUTH O
384			ON THE LOCAL HORIZONTAL
385		-SLR	SLANT RANGE OF PRINCIPA
386		EL-SUN	SUN ELEVATION AT PRINCI
387		-AZM	SUN AZIMUTH AT PRINCIPA

ion of Entries-Line 42/62

L	V/H	VEH AZM	FLTPTH	LAT-PR	RAY-LONG	AZM-PR	RAY-SLR	EL-SUN-AZM	
2	.0089	195.854	.2314	5615.40N	4033.61E	273.247	521.36	54.1	170.1
8	.0089	195.840	.2312	5613.44N	4032.04E	273.224	521.36	54.1	170.1
3	.0089	195.825	.2310	5611.48N	4030.48E	273.202	521.37	54.1	170.0
9	.0089	195.811	.2308	56 9.53N	4028.92E	273.179	521.37	54.2	170.0
5	.0089	195.797	.2306	56 7.56N	4027.36E	273.157	521.37	54.2	169.9
0	.0089	195.782	.2304	56 5.60N	4025.80E	273.135	521.38	54.2	169.9
6	.0089	195.768	.2303	56 3.64N	4024.25E	273.112	521.38	54.3	169.8
2	.0089	195.754	.2301	56 1.68N	4022.70E	273.090	521.39	54.3	169.8
7	.0089	195.740	.2299	5559.72N	4021.15E	273.068	521.39	54.3	169.7
3	.0089	195.725	.2297	5557.76N	4019.60E	273.046	521.40	54.4	169.7
1	.0089	195.721	.2296	5557.11N	4019.09E	273.038	521.40	54.4	169.7

	COLUMN	FORMAT	UNITS
ITIONING DATA	2-3	NN	N.D.
HIGH RES. ONDS	9-16	NNNNN.NNN	SEC.
TAL AT START OF HIGH RES. CLOCK STEPS	18-26	NNNNNNNN	.2 SEC.
ICLE NADIR	28-35	NNNN.NND	DEG. MIN
HICLE NADIR	37-45	NNNNN.NND	DEG. MIN
	48-54	NNN.NNN	N.MI.
ICLE	56-63	NNNNN.NN	FT./SEC.
Y DIVIDED BY HEIGHT	65-69	.NNNN	RAD/SEC.
EHICLE	71-77	NNN.NNN	DEG.
E	79-85	NN.NNNN	DEG.
NCIPAL RAY	87-94	NNNN.NND	DEG., MIN.
INCIPAL RAY	96-104	NNNNN.NND	DEG., MIN
PROJECTION OF THE PRINCIPAL RAY	106-112	NNN.NNN	DEG.
RAY	114-120	NNNN.NN	N.MI.
AL RAY INTERSECTION WITH THE GEOID	122-126	NNN.N	DEG.
RAY INTERSECTION WITH THE GEOID	128-132	NNN.N	DEG.

[redacted]

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Explanation of Entries-Line 43/63

[redacted]

KEY	HEADER	DESCRIPTION
63	43	CAMERA FRAME CORNERS, DIMENSIONS, AND ANOMALIES
	REV	REV NUMBER
	(NO HEADER)	STRAND OF FILM USED (5 OR 9)
	ACC	FRAME ACCESSION NUMBER, STARTS AT 1 EACH REV FOR EAC
	LAT*U*	LATITUDE OF CORNER U
	LONG	LONGITUDE OF CORNER U
	LAT*Z*	LATITUDE OF CORNER Z
	LONG	LONGITUDE OF CORNER Z
	LAT*W*	LATITUDE OF CORNER W
	LONG	LONGITUDE OF CORNER W
	LAT*X*	LATITUDE OF CORNER X
	LONG	LONGITUDE OF CORNER X
	*V**Y*	DISTANCE FROM V TO Y
	*V**U*	DISTANCE FROM V TO U
	*V**W*	DISTANCE FROM V TO W
	*Y**X*	DISTANCE FROM Y TO X
	*Y**Z*	DISTANCE FROM Y TO Z
	F-AREA	FRAME AREA ENCLOSED BY U-W-Z-X
	F	FILM DRIVE SPEED REQUIRED NOT WITHIN HARDWARE CAPABI
	L	TAKE-UP MOVEMENT DURING HIGH RESOLUTION PHOTOGRAPHY
	M	STEREO MIRROR MOVEMENT DURING HIGH RESOLUTION PHOTOG
	R	CRAB ERROR REQUIRED BY ROLL JOINT LOCK-UP
	S	SLIT DID NOT ACHIEVE REQUIRED WIDTH

[redacted]

COLUMN	FORMAT	UNITS
2-3	NN	N.D.
5-8	NNNN	N.D.
10	N	N.D.
11-13	NNN	N.D.
16-21	NN.NND	DEG.
23-29	NNN.NND	DEG.
32-37	NN.NND	DEG.
39-45	NNN.NND	DEG.
48-53	NN.NND	DEG.
55-61	NNN.NND	DEG.
64-69	NN.NND	DEG.
71-77	NNN.NND	DEG.
80-85	NNN.NN	N.MI.
89-93	NN.NN	N.MI.
97-101	NN.NN	N.MI.
105-109	NN.NN	N.MI.
113-117	NN.NN	N.MI.
120-125	NNNNN.N	(N.MI.)2
127	N	1/0
128	N	1/0
129	N	1/0
130	N	1/0
131	N	1/0

[redacted]

47	IN FRAME ID	M	LAT	LONG	D	T-ALT	VFC	RES	FW	AW	INT
67	092016815	0	53.90N	28.42E		1000.	1.2890	40.4	90	30	2[illegible]
67	122016814	0	53.90N	27.97E		1000.	1.2753	33.1	95	35	1[illegible]
67	112016814	0	53.90N	27.52E		1000.	1.2604	52.4	99	35	1[illegible]
67	132016815	0	53.70N	28.42E		1000.	1.2915	45.7	90	30	1[illegible]
67	162016814	0	53.70N	27.97E		1000.	1.2779	32.3	95	30	[illegible]
67	152016814	0	53.70N	27.52E		1000.	1.2631	45.6	95	25	[illegible]
67	012016820	0	53.50N	28.42E		1000.	1.2939	53.1	90	30	
67	042016819	0	53.50N	27.97E		1000.	1.2804	32.8	95	35	-[illegible]
67	052016815	0	54.10N	28.42E		1000.	1.2865	36.8	90	30	3[illegible]
67	082016814	0	54.10N	27.97E		1000.	1.2726	34.1	95	35	3[illegible]

KEY	HEADER	DESCRIPTION
450 67	47	TARGETS IN FRAME DATA
451		* FOR INTERSECTING TARGET, OTHER
452	IN FRAME ID	TARGET IN FRAME IDENTIFIER
453	M	PHOTOGRAPHIC COVERAGE OF TARGET
454		O = OVERLAP N = NO OVER
455	LAT	GEODETIC LATITUDE OF TARGET (N O
456	LONG	LONGITUDE OF TARGET (E OR W IN C
457	D	TARGET DIAMETER CODE
458	T ALT	TARGET ALTITUDE
459	VFC	COMPUTED FILM SPEED
460	RES	COMPUTED RESOLUTION - BASED ON C
461	FW	FORECASTED WEATHER
462	AW	ASSESSED WEATHER
463	INTK-D	INTRACK DISTANCE ON FILM FROM FR
464		TIME, TO CENTER OF TARGET
465	-XTK	CROSSTRACK DISTANCE ON FILM FROM
466		OF TARGET
467	CLN	FOR POINT TARGETS PERCENTAGE PRO
468		FOR CELL TARGETS THE PERCENT ARE
469	INT	PERCENTAGE PROBABILITY POINT TAR
470	MAR	PERCENTAGE PROBABILITY POINT TAR
471	INT MAR	HEXA-DECIMAL MASK OF THOSE 3X3 P
472		SEEN. ONE CHARACTER PER COLUMN O
473	CMD-SLIT	COMMANDED SLIT WIDTH
474	-COMP	COMPUTED SLIT WIDTH - DOES NOT I
475		SNOW OR REQUIREMENT BIASES
476	HR	HIGHEST REFLECTANCE OF TARGET -
477	GM	GEOMETRIC MEAN REFLECTANCE OF TA
478	LR	LOWEST REFLECTANCE OF TARGET - P
479	P2	PROBABILITY OF ACHIEVING REQUIRE
480	P3	PROBABILITY OF ACHIEVING REQUIRE
481	P4	PROBABILITY OF ACHIEVING REQUIRE
482	P5	PROBABILITY OF ACHIEVING REQUIRE
483	P6	PROBABILITY OF ACHIEVING REQUIRE
484	P7	PROBABILITY OF ACHIEVING REQUIRE
485	P8	PROBABILITY OF ACHIEVING REQUIRE

ntries-Line 47/67

K-D-XTK		CLN	INT MAR	CMD-SLIT-COMP		HR	GM	LR	P2	P3	P4	P5	P6	P7	P8
.3	-.0	50.	FFF000	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.5	13.6	99.	FFFFFF	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.8	27.0	12.	000007	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.6	-2.7	29.	FF0000	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.8	11.1	99.	FFFFFF	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.1	24.6	33.	0000FF	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.8	-5.3	8.	C00000	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.0	8.6	29.	88888C	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.0	2.6	12.	111000	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99
.2	16.1	33.	331111	.00620	.00540	14.	11.	8.	99	99	99	99	99	99	99

	COLUMN	FORMAT	UNITS
	2-3	NN	N.D.
WISE BLANK	6	A	N.D.
	7-16	AAAAAAAAAA	N.D.
	18	A	N.D.
LAP			
S IN COLUMN 25	20-25	NN.NNA	N.D.
OLUMN 33	27-33	NNN.NNA	N.D.
	35	N	N.D.
	37-42	NNNNN.	FT.
	44-50	NN.NNNN	IN/SEC.
OMMANDED PARAMETERS	52-56	NNN.N	IN.
	58-59	NN	N.D.
	61-62	NN	N.D.
AME END, I.E., CAMERA OFF	64-68	NNN.N	CM.
FIDUCIAL LINE TO CENTER	70-73	NN.N	CM.
BABILITY OF CLEAN COVERAGE. A COVERED	75-77	NN.	N.D.
GET IS INTERSECTING	79-81	NN.	N.D.
GET IS MARGINAL	83-85	NN.	N.D.
ORTIONS OF THE CELL TARGET F FOUR 3X3S	80-85	NNNNNN	N.D.
	87-92	.NNNNN	IN.
NCLUDE EITHER	94-99	.NNNNN	IN.
PERCENT	101-103	NN.	N.D.
RGET - PERCENT	105-107	NN.	N.D.
ERCENT	109-111	NN.	N.D.
D NIIRS-P2	113-114	NN	N.D.
D NIIRS-P3	116-117	NN	N.D.
D NIIRS-P4	119-120	NN	N.D.
D NIIRS-P5	122-123	NN	N.D.
D NIIRS-P6	125-126	NN	N.D.
D NIIRS-P7	128-129	NN	N.D.
D NIIRS-P8	131-132	NN	N.D.

Explanation of Entries-Line 48/68

```
48          MARGINAL ID M   LAT     LONG   D T-ALT     VFC    RES     FW AW INTK-D-X
68           07A4713A   0 20.41N 104.23E 0  2800.  7.6318  [redacted] 85 85  12.6 10
```

SNO	KEY	HEADER	DESCRIPTION
487			
488	68	48	MARGINAL TARGET DATA
489		MARGINAL ID	MARGINAL TARGET IDENTIFIER
490		M	PHOTOGRAPHIC COVERAGE OF TARGET
491			O = OVERLAP N = NO OVERLAP
492		LAT	GEODETIC LATITUDE OF TARGET =N OR S IN COLUMN 2
493		LONG	LONGITUDE OF TARGET =E OR W IN COLUMN 33
494		D	TARGET DIAMETER CODE
495		T ALT	TARGET ALTITUDE
496		VFC	COMPUTED FILM SPEED
497		RES	COMPUTED RESOLUTION - BASED ON COMMANDED PARAME
498		FW	FORECASTED WEATHER
499		AW	ASSESSED WEATHER
500		INTK-D	INTRACK DISTANCE ON FILM FROM FRAME END, I.E., (
501			TIME, TO CENTER OF TARGET
502		-XTK	CROSSTRACK DISTANCE ON FILM FROM FIDUCIAL LINE
503			OF TARGET
504		CLN	PERCENTAGE PROBABILITY TARGET IS CLEAN
505		INT	PERCENTAGE PROBABILITY TARGET IS INTERSECTING
506		MAR	PERCENTAGE PROBABILITY TARGET IS MARGINAL
507		CMD-SLIT	COMMANDED SLIT WIDTH
508		-COMP	COMPUTED SLIT WIDTH - DOES NOT INCLUDE EITHER
509			SNOW OR REQUIREMENT BIASES
510		HR	HIGHEST REFLECTANCE OF TARGET - PERCENT
511		GM	GEOMETRIC MEAN REFLECTANCE OF TARGET - PERCENT
512		LR	LOWEST REFLECTANCE OF TARGET - PERCENT
513			

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```
D=XTK CLN INT MAR CMD=SLIT=COMP HR  GM  LR
 10.7 15.  6. 21. .03120 .03220 14. 11.  8.
```

	COLUMN	FORMAT	UNITS
	2-3	NN	N.D.
	7-16	AAAAAAAAAA	N.D.
	18	A	N.D.
N 25	20-25	NN.NNA	N.D.
	27-33	NNN.NNA	N.D.
	35	N	N.D.
	37-42	NNNNN.	FT.
	44-50	NN.NNNN	IN/SEC.
AMETERS	52-56	NNN.N	IN.
	58-59	NN	N.D.
	61-62	NN	N.D.
. CAMERA OFF	64-68	NNN.N	CM.
NE TO CENTER	70-73	NN.N	CM.
	75-77	NN.	N.D.
S	79-81	NNN	N.D.
	83-85	NN.	N.D.
	87-92	.NNNNN	IN.
I	94-99	.NNNNN	IN.
	101-103	NN.	N.D.
IT	105-107	NN.	N.D.
	109-111	NN.	N.D.

PART II: TARGETING

MISSION TARGET FILE

The target file for KH-8 missions is made up of target entries, which describe the physical properties of the targets, and requirement entries, which describe the reason for photography, the required conditions of photography, and the worth of the target image under those conditions. Each target is limited to a maximum of 10 requirements; the total file is constrained to 32,767 targets and 65,535 requirements.

TARGET ENTRIES

The target entry consists of its COMIREX identification (ID) and seven descriptors:

- o Target location (latitude, longitude)
- o Country code
- o Diameter
- o Target location uncertainty
- o Elevation above mean sea level
- o High, mean, low reflectance
- o National Tasking Plan code.

The ID and country code are used for bookkeeping and reporting; location and elevation are used to calculate vehicle pointing; diameter and location uncertainty are used to determine frame length; and, finally, reflectance data are required in determining the resolution values used in the target weighting and selection process. National Tasking Plan (NTP) code and country code (CC) are used to determine National Imagery Interpretability Rating Scale (NIIRS) set.

Although the community (ICRS) assigns the target parameters, it is worth the time of the individual user to evaluate them in terms of his or her needs. If repeated coverage of a target demonstrates a consistent bias or error, it is probably due to a problem in one or more of the target parameters. A typical example is where the target complex is centered in the frame but the object of interest is consistently in the camera start-up transient. This situation indicates a problem with the target diameter or may indicate that a change in the aiming point coordinates or establishment of a new target is required to ensure desired coverage is obtained.

REQUIREMENT ENTRIES

Requirement entries are supplied by both the ICRS and the individual user. Although the user is obviously most concerned with the photographic conditions that must be specified, the effects of the ICRS-specified items cannot be ignored.

ICRS-Specified Requirement Parameters

The dominant property of a requirement is its value. ICRS specifies this value on the basis of its worth to the entire user community. The parameters used are priority and shade. The priority range is from zero (highest) to nine. After priority is set, shade provides a means of discriminating between requirements of the same priority.

Another ICRS-specified term that can significantly affect photographic collection is the probability objective. This is the probability that a target will be imaged to a certain level of satisfaction.

The remaining ICRS-specified items are: date of last confirmed coverage that satisfied requirement, requirement type, and problem set identifier.

User-Specified Requirement Parameters

The individual user may specify a number of conditions required of the imagery, so as to maximize its utility with respect to such factors as look angle (both vertical and horizontal), sun elevation and azimuth, etc. With the exceptions of mode and resolution, these parameters are optional, and if not specified, no restrictions are imposed. The mode and resolution limits will be set by ICRS if not supplied by the user.

Target-to-Vehicle Elevation

Target-to-vehicle elevation is the vehicle's location as seen from the target and is the vertical angle measured in degrees from the target's horizon to the vehicle. Two limits must be specified: an upper elevation and a lower elevation. These limits describe two concentric cones with their common vertexes at the target. If imagery is to satisfy the specified requirement, the vehicle must be in the volume between the two cones at the time of the photography.

Target-to-Vehicle Azimuth

This requirement is the horizontal angle in degrees measured at the target from true north to the vehicle. The azimuth constraint consists of an initial and a final limit which together define a sector of a circle centered on the target (Figure 12). The sector is the area clockwise from the initial to final limit. By specifying such limits, the user is stating that photography collected only from within this sector will meet viewing requirements.

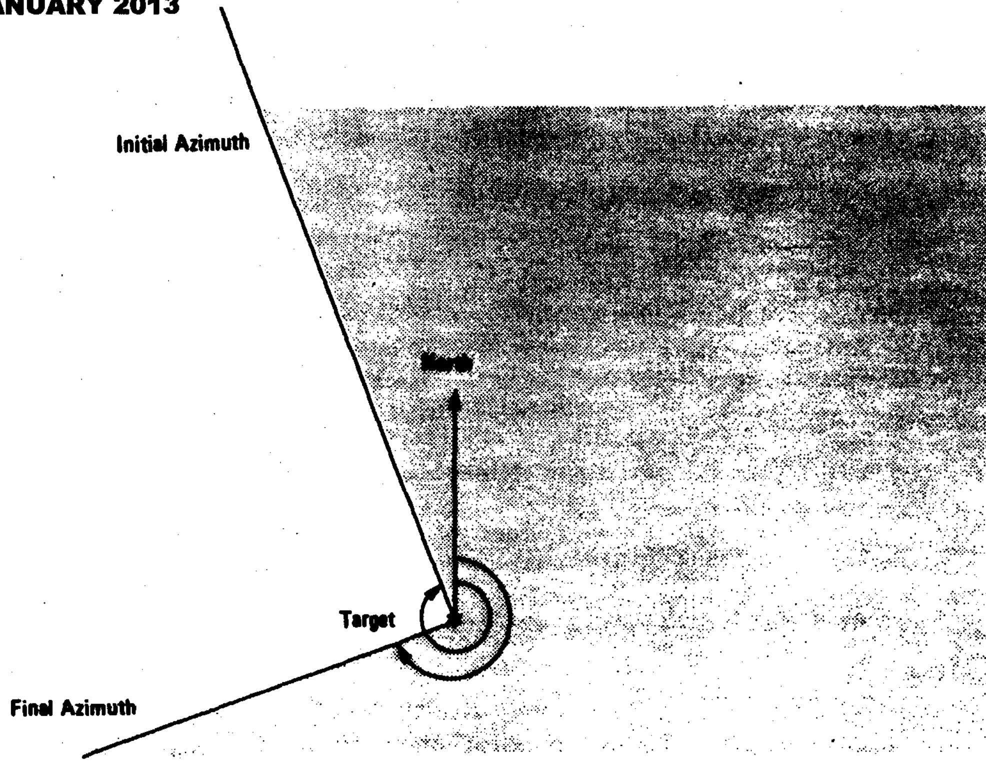


FIGURE 12. TARGET-TO-VEHICLE AZIMUTHS

Solar Elevation

Solar elevation limits are specified the same way target-to-vehicle elevations are specified - an upper and lower limit, measured in degrees above the target's horizon, specifying the highest and lowest solar elevation acceptable.

Solar Azimuth

Solar azimuth limits are specified the same way target-to-vehicle azimuths are specified and define a sector that the sun must be in if acceptable photography is to be obtained.

Exposure Modification

The nominal exposure may be altered by specifying an amount of over or underexposure through an entry on the requirement specification. If nominal exposure is required, this entry should be ignored or set to zero.

If the exposure is to be modified, the value and sign of the entry will indicate the amount and direction. The value of the entry can be calculated using either of the two following equations:

$$MOD = 1.2385\ \Delta S$$

or

$$MOD = 3.0\ \Delta f,$$

where MOD = exposure modification entry, integer with range -99 to +99,

ΔS = number of slits over or underexposure required,

Δf = number of f-stops over or underexposure required.

The MOD entry will modify the exposure only of the acquisitions specified.

Snow Inhibit Flag

Typically, the presence of snow cover that meets certain criteria, because of its higher reflectance, will result in a calculated underexposure. The snow inhibit flag, if set, will prevent this underexposure from occurring.

Film Requirement

The user may specify a particular film by keying in a coded entry with a value range of 0 to 15. These codes vary from mission to mission depending on specific film loads. Typically, codes will be provided for such film requirements as

- o No preference
- o Any black-and-white
- o Any color
- o Any true color
- o Any IR color
- o Any specific black-and-white
- o Any specific color

Since the film load for a specific mission is based on requirements for specific films or generic film types, these requirements should be provided to ICRS in accordance with established time lines.

Mode

Mode options, discussed in Part I, will be specified to the software via a mode designator, or code. The exact codes will be published by ICRS prior to each mission.

Resolution

~~Each requirement must have a stated resolution. If this is not~~ supplied by the user, it will be added by ICRS. The required resolution is extremely important, as it operates as the upper limit for attempted photography. For example, if a requirement calls for [redacted] resolution (GRD) and the expected resolution on a given target [redacted] then no attempt will be made. The predicted resolution is a [redacted] based on a model that uses folded means of the distribution of the quality degraders (smear, defocus, exposure error, etc.) along with geometry of the access and target reflectance data.

APPLICATION OF THE REQUIREMENT CONSTRAINTS

The requirement parameters just defined can be applied by the user in virtually any combination. The only limitations typically imposed on a requirement are resolution and mode. As more constraints are applied, the probability of attaining the required conditions decreases. In fact, it is quite common to have requirements with conditions that are impossible to meet. This does not mean that the use of limits should be avoided but that the requester should use care in setting them.

The purpose of the discussion that follows is to provide the user with some basic information that will aid him in specifying the requirements just described. It is aimed primarily at the interpreter or analyst who has a specific need or problem and desires imagery tailored to meeting that need.

Requirement parameters can be divided into three broad classes and are discussed below in that order:

- Geometric
  - Vehicle azimuth
  - Vehicle elevation
  - Mode
- Solar
  - Sun azimuth
  - Sun elevation
- Quality
  - Resolution
  - Exposure modification
  - Snow inhibit flag
  - Film

Geometric Constraints

The target-to-vehicle azimuth and elevation constraints define a volume in space that the vehicle must occupy at the time of photography. For photography to occur, however, the vehicle must be able to point the optics at the target from its position within this volume. This is not always possible.

The KH-8 vehicle is a pointing system that uses a strip camera. At any instant of time, the point on the earth's surface that can be imaged by the vehicle is defined by the pointing parameters pitch and obliquity. Pitch is the in-track position of the stereo mirror; obliquity (the algebraic sum of mirror crab and vehicle roll) is the cross-track position of the principal ray. The angles, shown in Figure 13, do not change during photography (i.e., a given frame has constant pitch and obliquity angles). This means that at a given obliquity there are only three times when the vehicle can image a single point on the ground, corresponding to the three positions of the stereo mirror.

All these factors are combined in Figure 14, which shows the visibility limits to a target and the forward, vertical, and aft mirror position view lines over the full obliquity. This illustration will serve as background for discussing the geometric constraints.

The vehicle elevation constraint is target centered and, essentially, the complement of the obliquity. Since the maximum obliquity is approximately 48.85° the minimum possible elevation is, therefore, about 41.2°. Any requirement with a maximum elevation less than 41.2° is impossible and will never be attempted.

Figure 15 illustrates two methods of visualizing the elevation constraints. In the vertical plane the limits form two fans radiating from the target. If the maximum elevation were 90°, there would be only a single fan formed by the two minimum elevation radii. In the horizontal plane the limits define two concentric circles about the target's local vertical. Since this is the same projection used for the background illustration, we can overlay a set of example elevation limits onto the background and create Figure 16. Here the required limits are superimposed onto the vehicle capabilities, thus showing where the vehicle must be to satisfy the requirement.

When viewed in the horizontal plane, the target-to-vehicle azimuth limits describe a sector, as was shown in Figure 12. As mentioned previously, the useful sector is measured clockwise from the initial to the final limit. A sample azimuth limit is shown on the background chart in Figure 17.

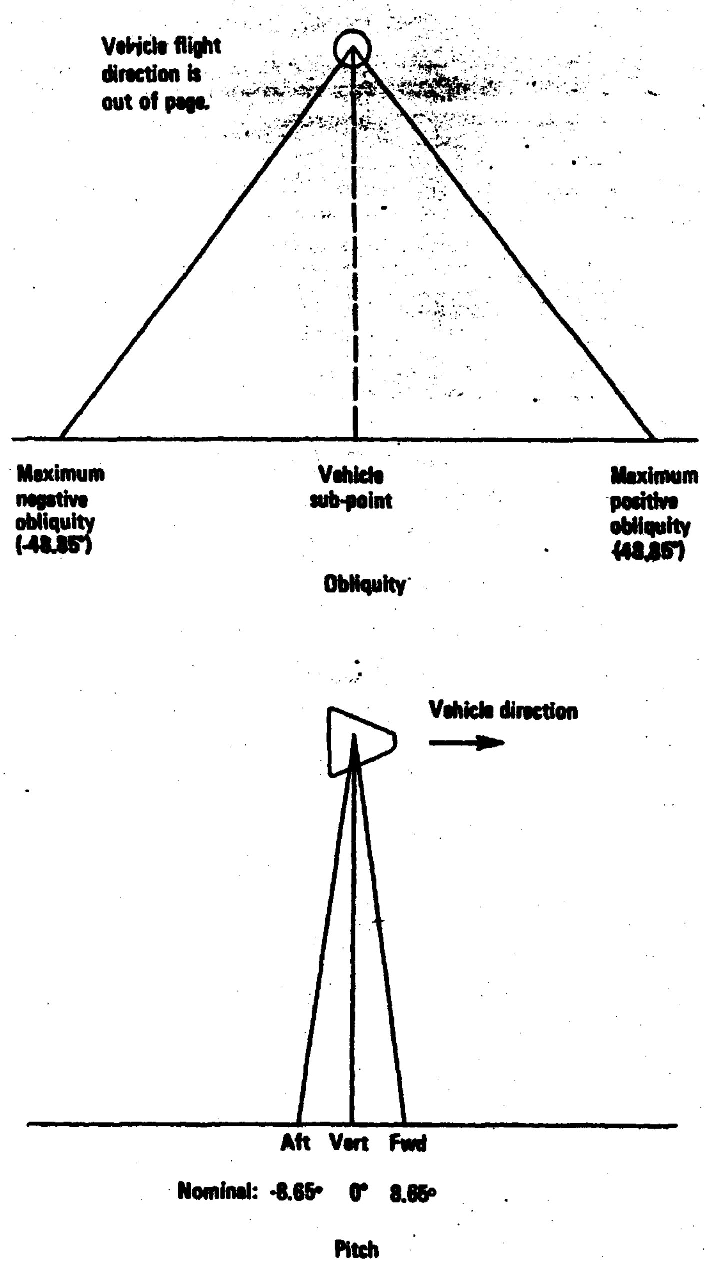
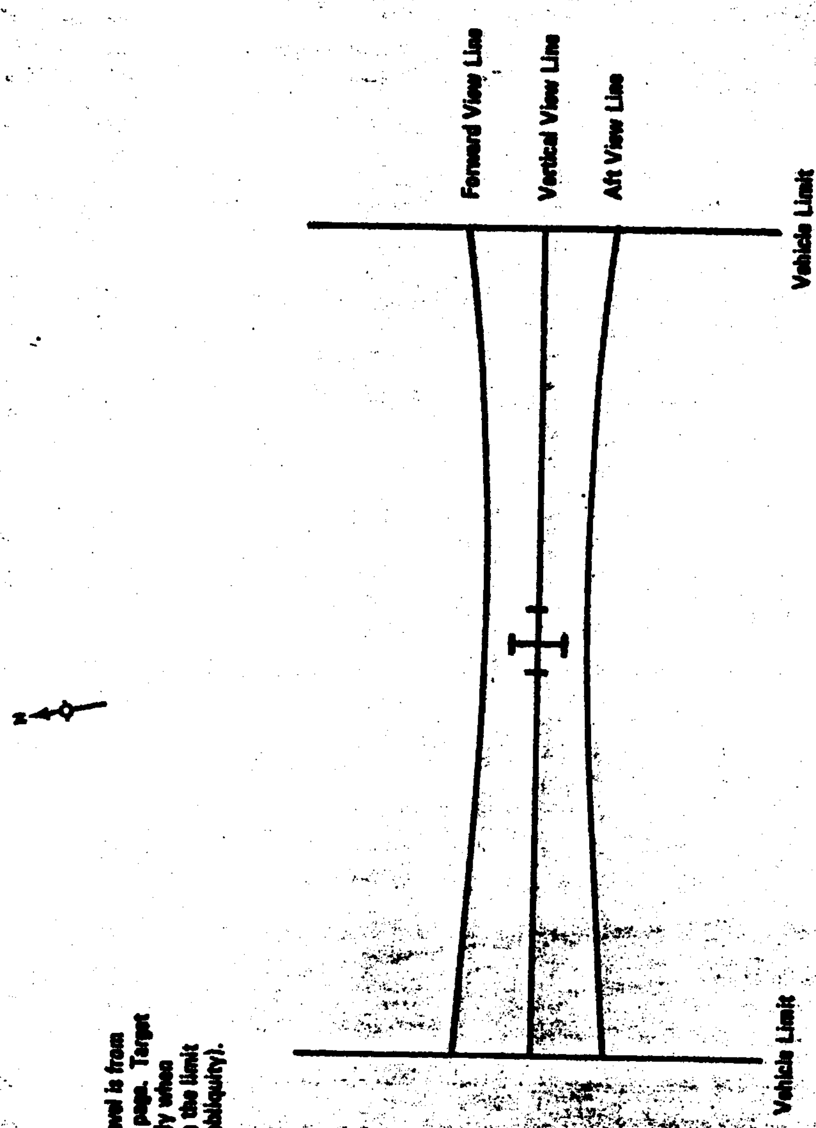


FIGURE 13. VEHICLE POINTING



Note: Vehicle travel is from top to bottom of page. Target can be imaged only when vehicle is between the limit lines (maximum obliquity).

FIGURE 14. VEHICLE VIEWING LIMITS

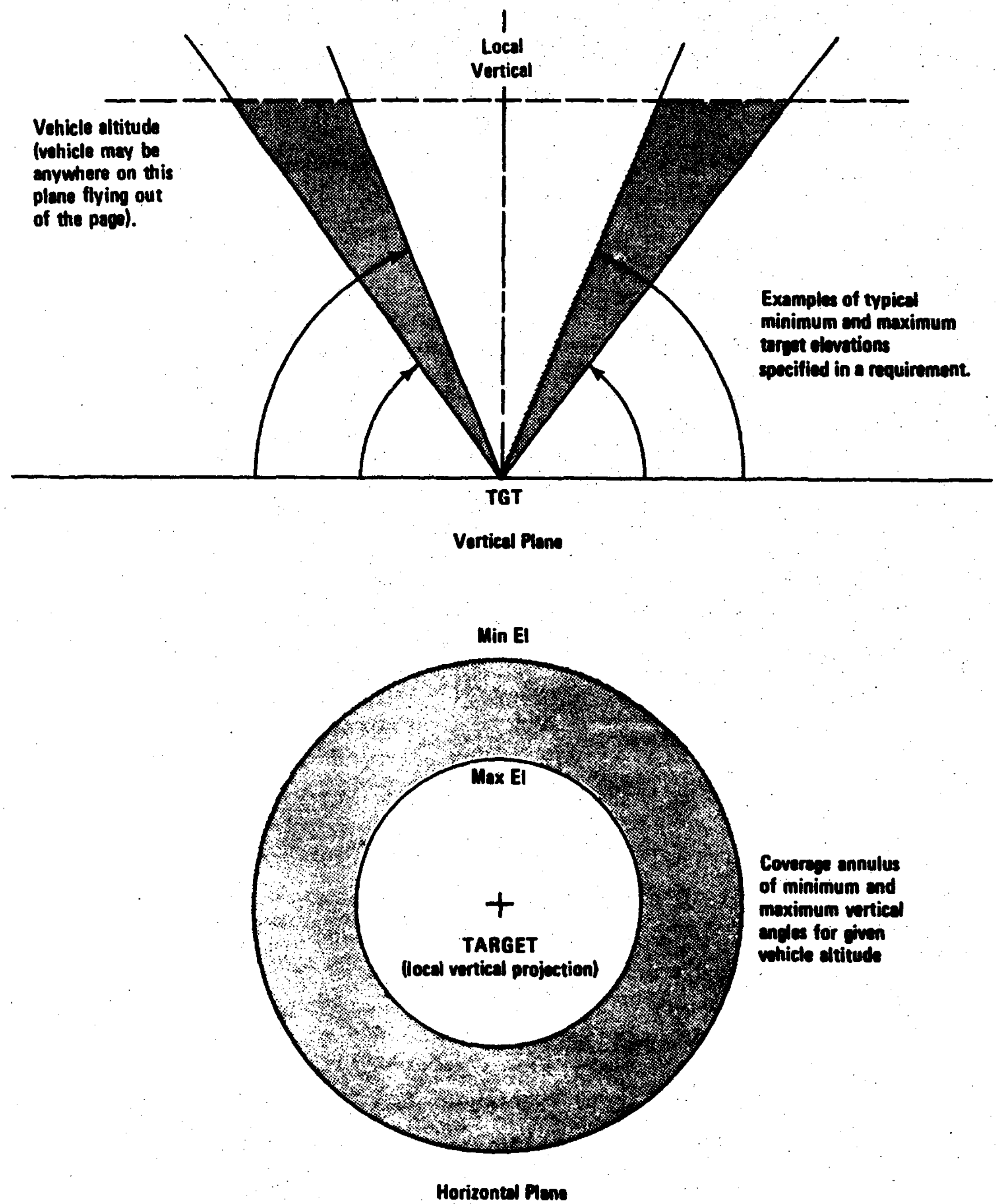


FIGURE 15. TARGET-TO-VEHICLE ELEVATION BANDS

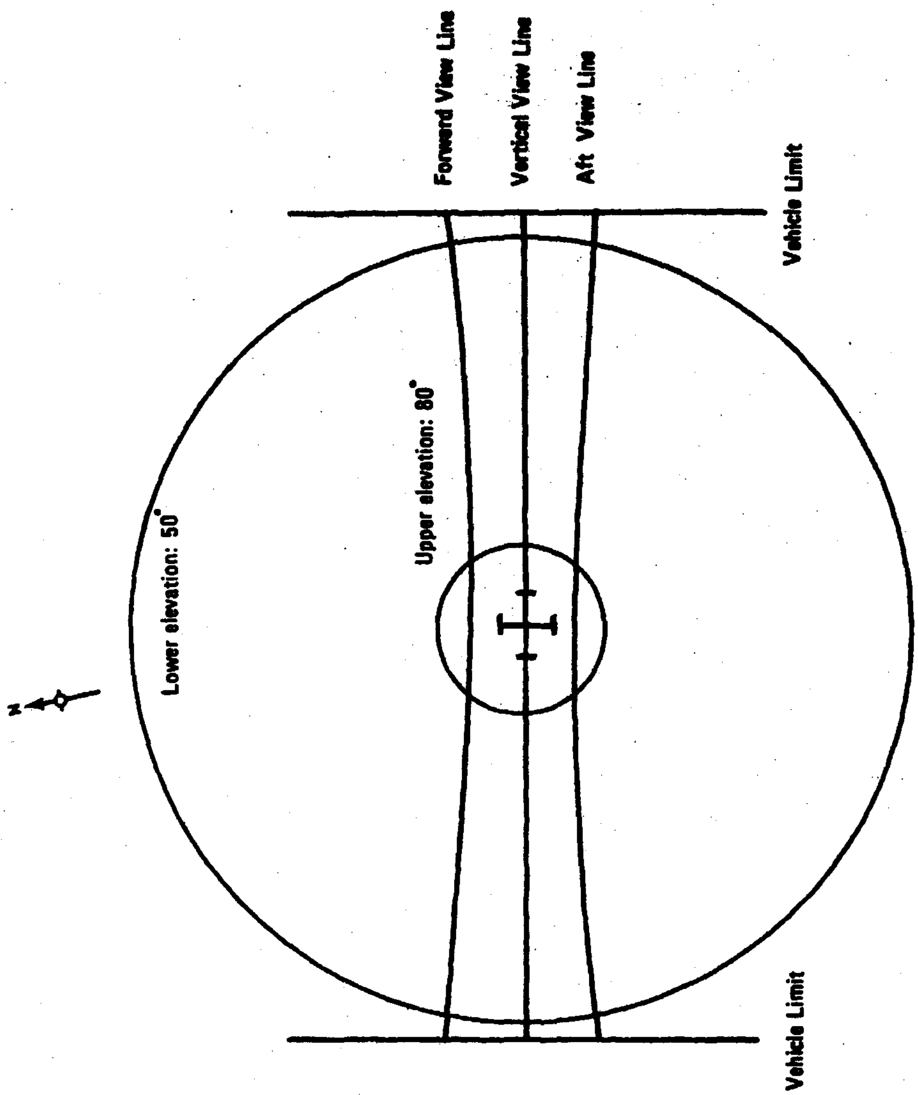


FIGURE 16. ELEVATION VIEWING LIMITS

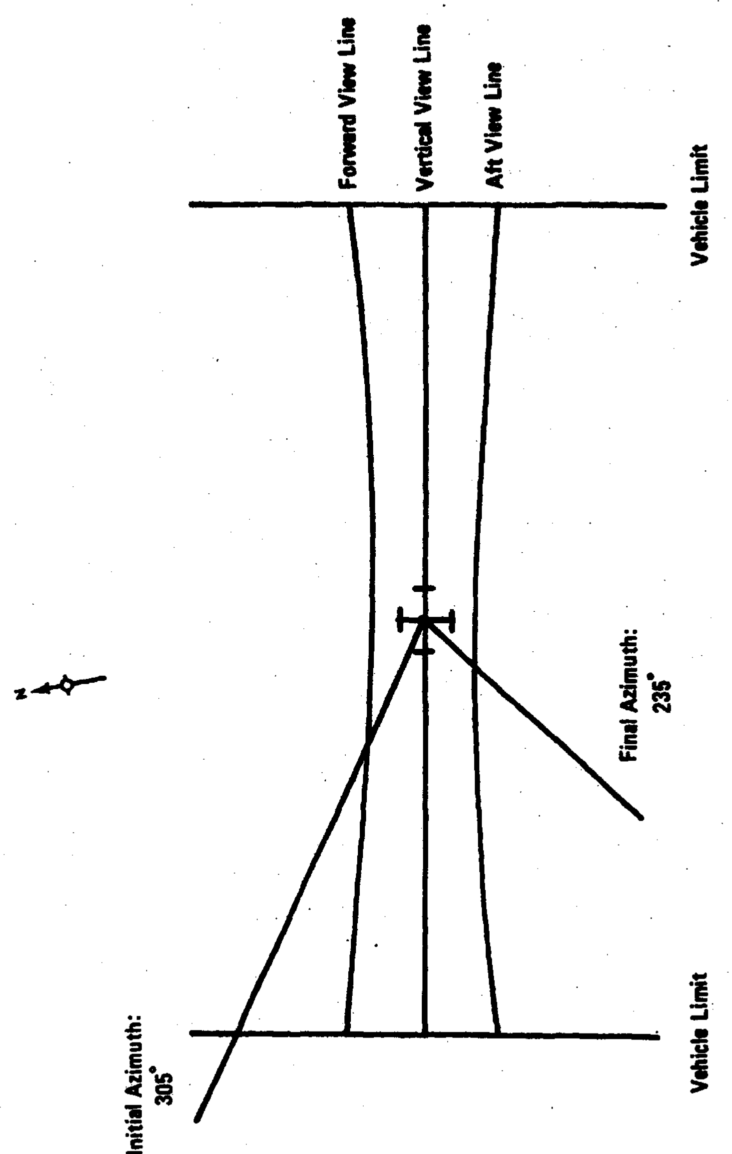


FIGURE 17. AZIMUTH VIEWING LIMITS

Figures 18 through 23 illustrate the interaction of azimuth and elevation limits with required mode. Figure 18 shows some example limits of 50° and 80° elevation and 290° to 260° azimuth. The shaded area between both the two azimuth limit lines and the elevation rings is, by definition, the only area where the vehicle can be for suitable photography to be attempted. In addition, it has been shown how the vehicle can photograph the target only when it is at a point on one of the three view lines. The bold lines inside the shaded area therefore represent the points where photography is both possible and required. Subsequent illustrations will provide sample vehicle traces and assess their impact on the photographic mode.

In Figure 19 the vehicle is passing vertically down the page to the east of the target. Since the vehicle never passes through the shaded area, no photography will be attempted.

The sample pass has moved inboard toward the target in Figure 20. Here the trace passes through the shaded area and crosses each of the usable view lines. This means that each of the mirror positions, and therefore every possible mode, is possible.

An almost direct overhead pass is shown in the next example. The vehicle trace in Figure 21 passes through the shaded area twice but does not cross the view lines inside the required viewing geometry. In this case the requirement would not be a candidate for photography.

The fourth example is shown in Figure 22. This pass crosses the view lines inside the shaded area for both the forward and aft mirror positions. As a result, any mode except vertical mono, stereo or laterial triplets, or half stereo can be accomplished. If, for example, the requirement were for a stereo triplet mandatory mode, it would not be a candidate. On the other hand, if the mode were stereo triplet preferred/stereo pair acceptable, the requirement would be an active candidate for photography.

Figure 23 shows the last example. Here the vehicle cuts only the forward view line while inside the shaded segment. As a result the only modes that would allow photography would be those that allow monoscopic coverage with the mirror in the forward position.

As this discussion has shown, obtaining a normal stereo pair, because of the characteristics of the KH-8, require that one frame must be collected prior to the closest approach to the target and one frame after that point. When the user has specific azimuth requirements, he must assess the impact of the azimuth limits on mode. To do this he must know the direction of the vehicle when it is at his target latitude. This data is provided in Tables VI and VII. Data in these tables is for northern hemisphere descending passes. Table VI is for the usual 96.4° (sun-synchronous) inclination; Table VII is for the 110.5° inclination used for some previous KH-8 missions. Azimuth data for the entire orbits are shown in Figures 24 and 25 for the two inclinations. Use of the vehicle azimuth data is illustrated in Figure 26. Given this, the user can determine the effect of the azimuth limits.

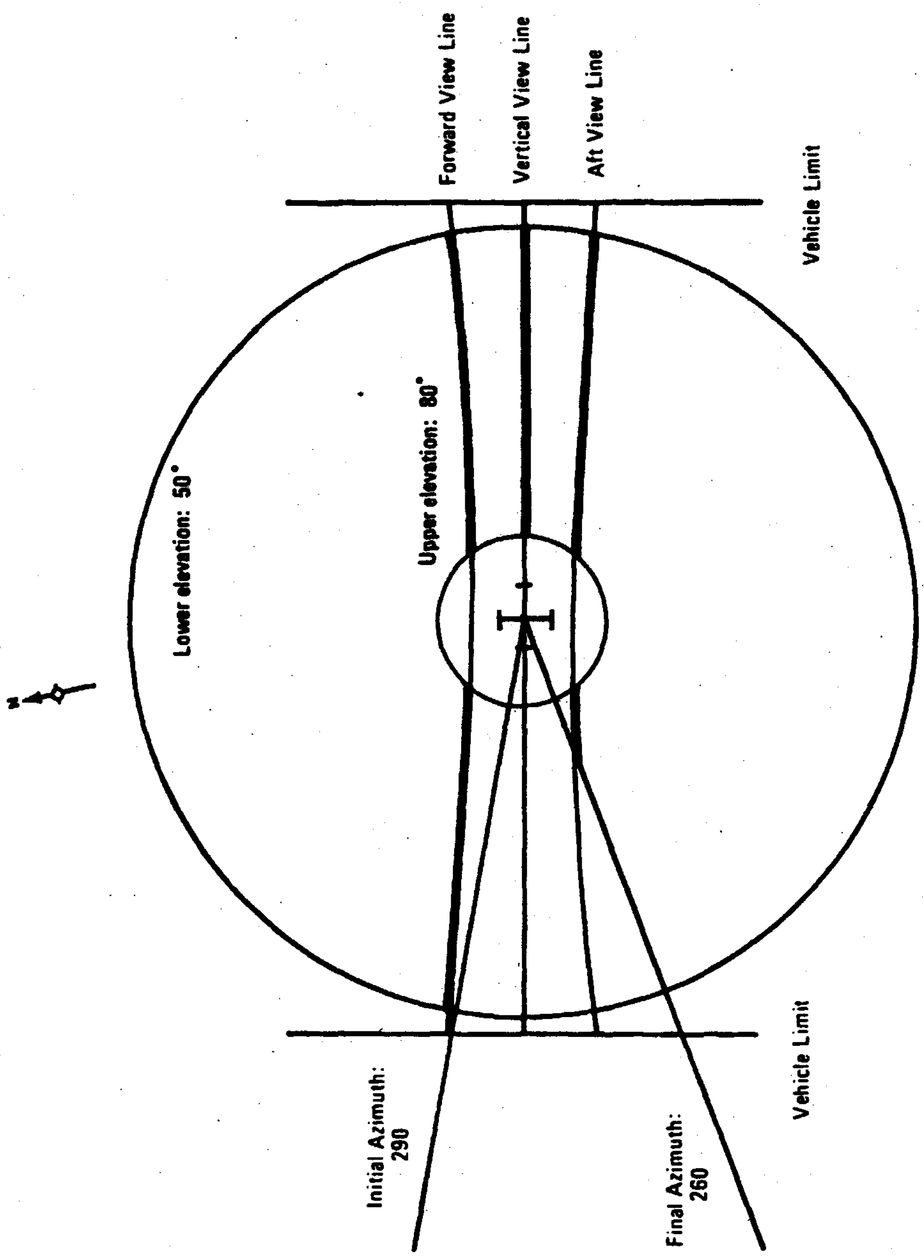


FIGURE 18. AZIMUTH AND ELEVATION VIEWING LIMITS

Handle via
TALENT-KEYHOLE
Channels
TCS-27601/81

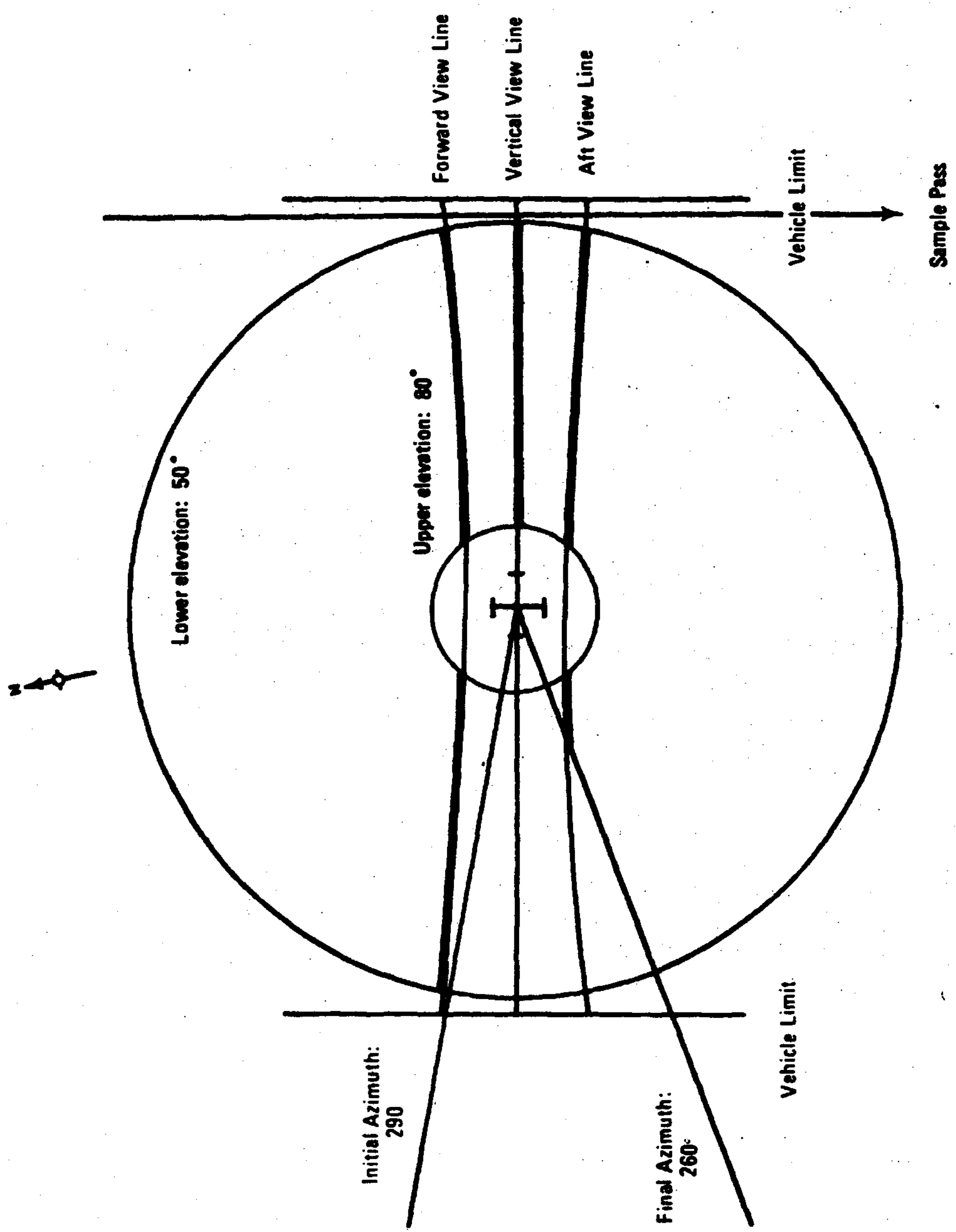


FIGURE 19. VEHICLE/TARGET GEOMETRY - Sample Pass 1

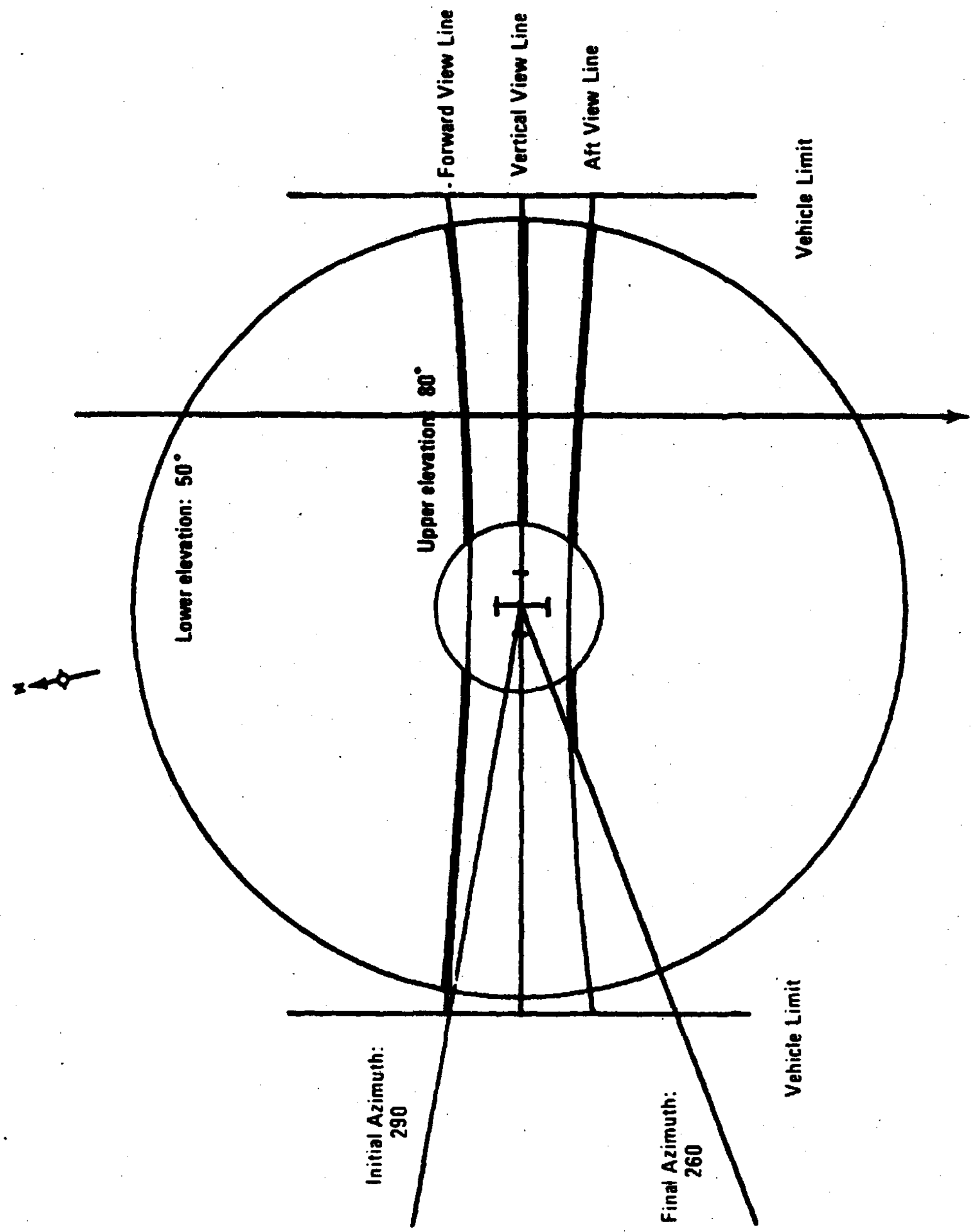


FIGURE 20. VEHICLE/TARGET GEOMETRY - Sample Pass 2

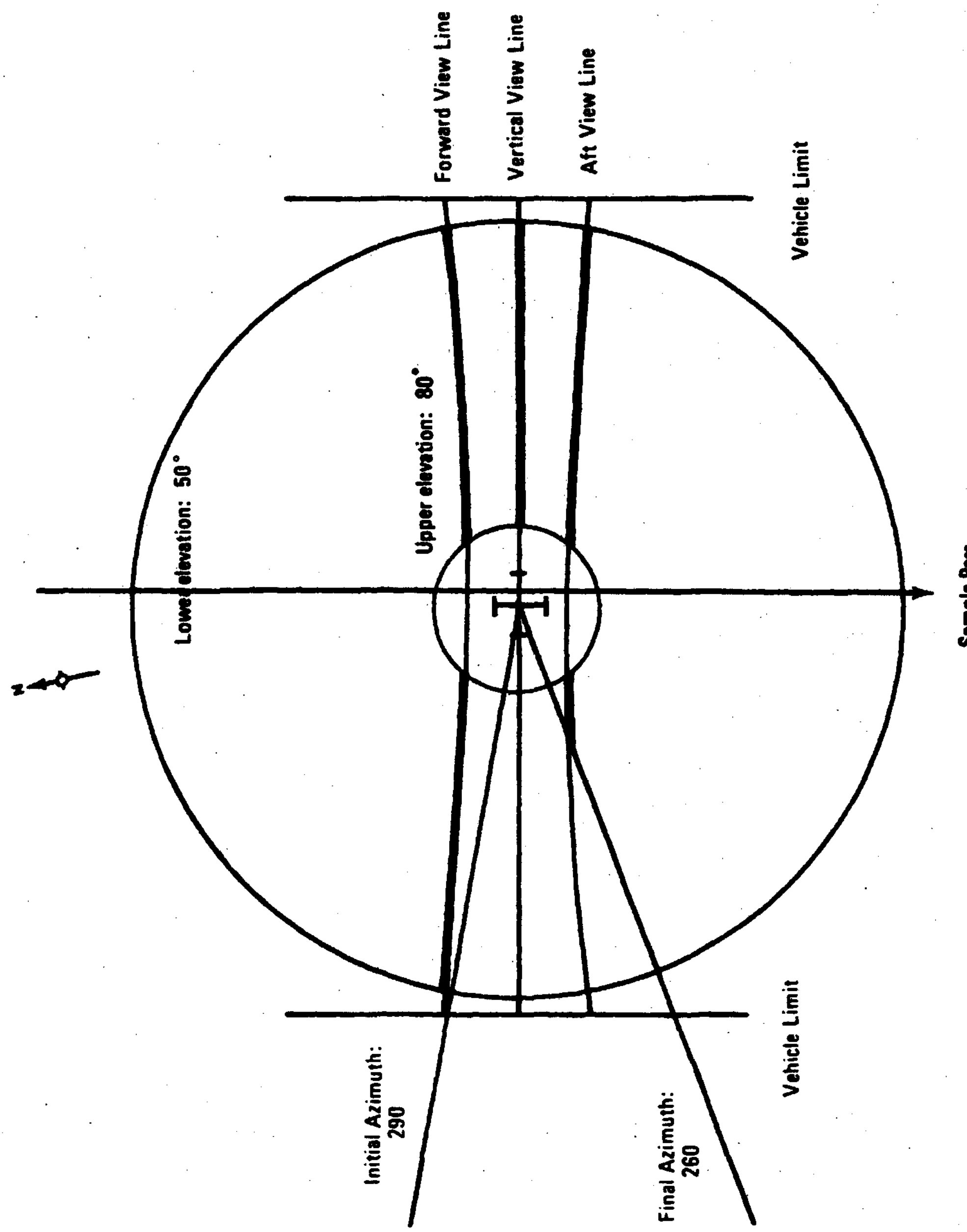


FIGURE 21. VEHICLE/TARGET GEOMETRY - Sample Pass 3

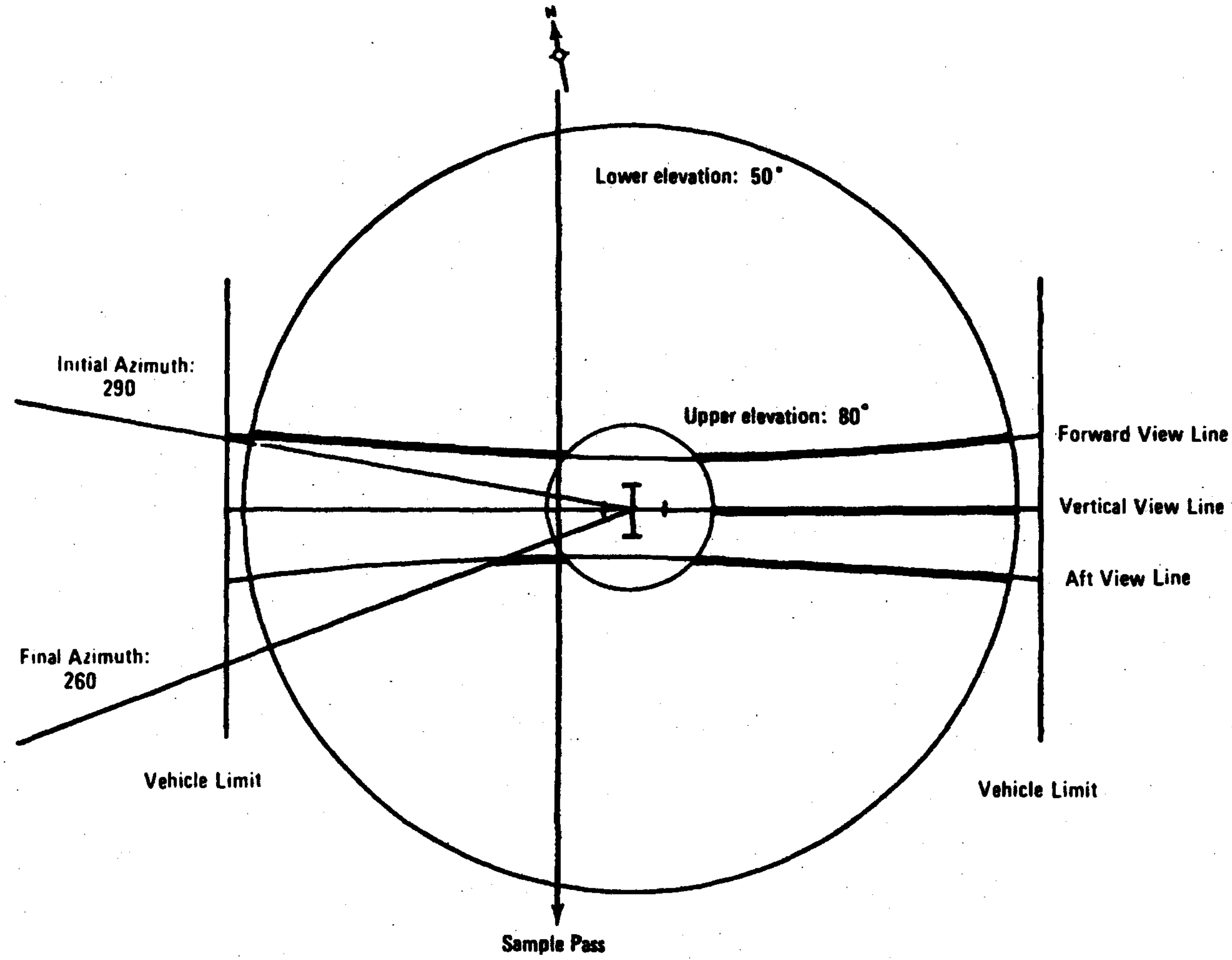


FIGURE 22. VEHICLE/TARGET GEOMETRY - Sample Pass 4

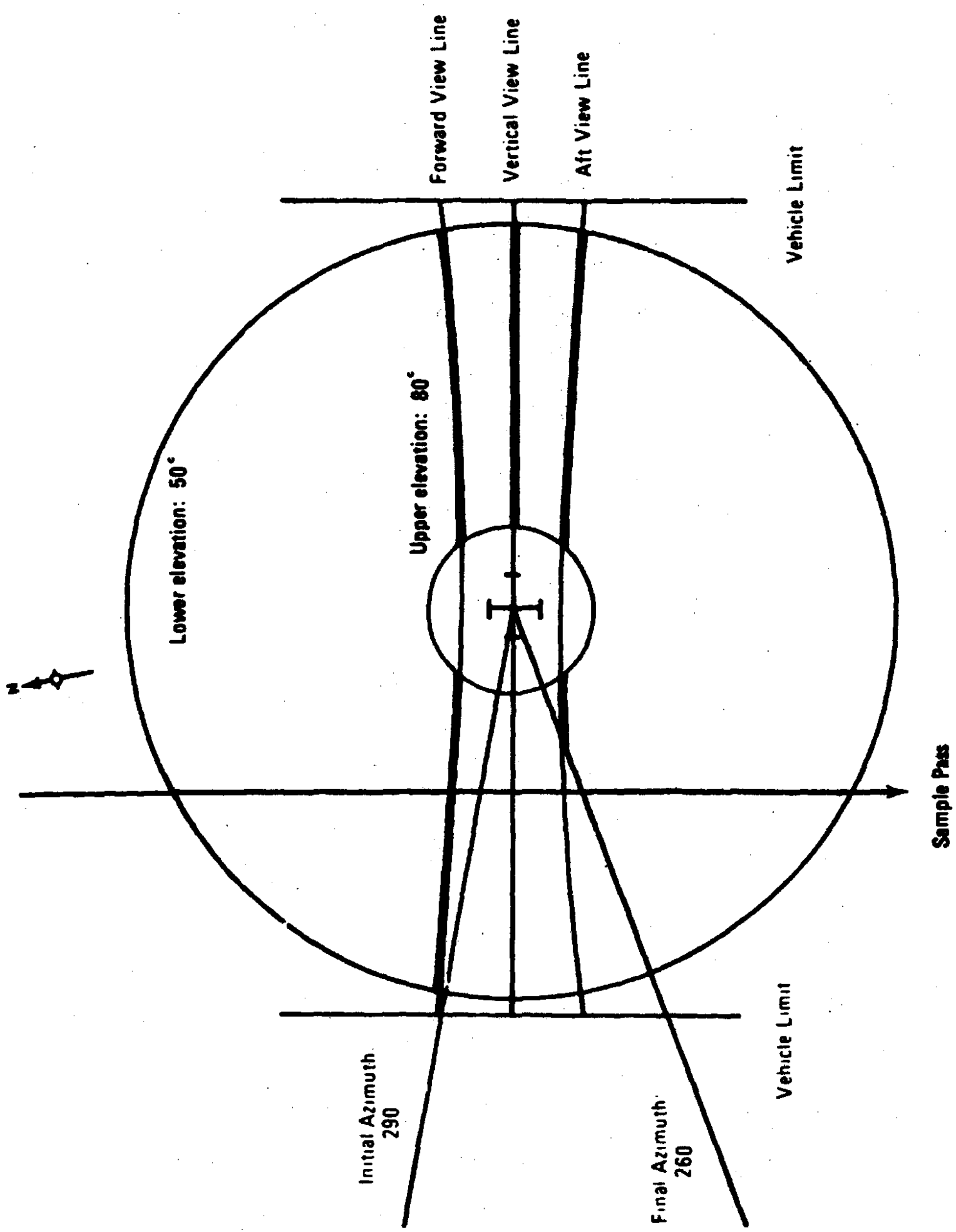


FIGURE 23. VEHICLE/TARGET GEOMETRY - Sample Pass 5

TABLE VI

VEHICLE AZIMUTH vs. TARGET LATITUDE: INCLINATION 96.4°

Latitude (deg. N)	Azimuth (deg.)
80	219.9
75	205.5
70	199.0
65	195.3
60	192.9
55	191.2
50	189.9
45	189.1
40	188.4
30	187.4
20	186.8
10	186.5
0	186.4

TABLE VII

VEHICLE AZIMUTH vs. TARGET LATITUDE: INCLINATION 110.5°

Latitude (deg. N)	Azimuth (deg.)
65	236.0
60	224.5
55	217.6
50	213.0
45	209.7
40	207.2
35	205.3
30	203.8
25	202.7
20	201.9
10	200.8
0	200.5

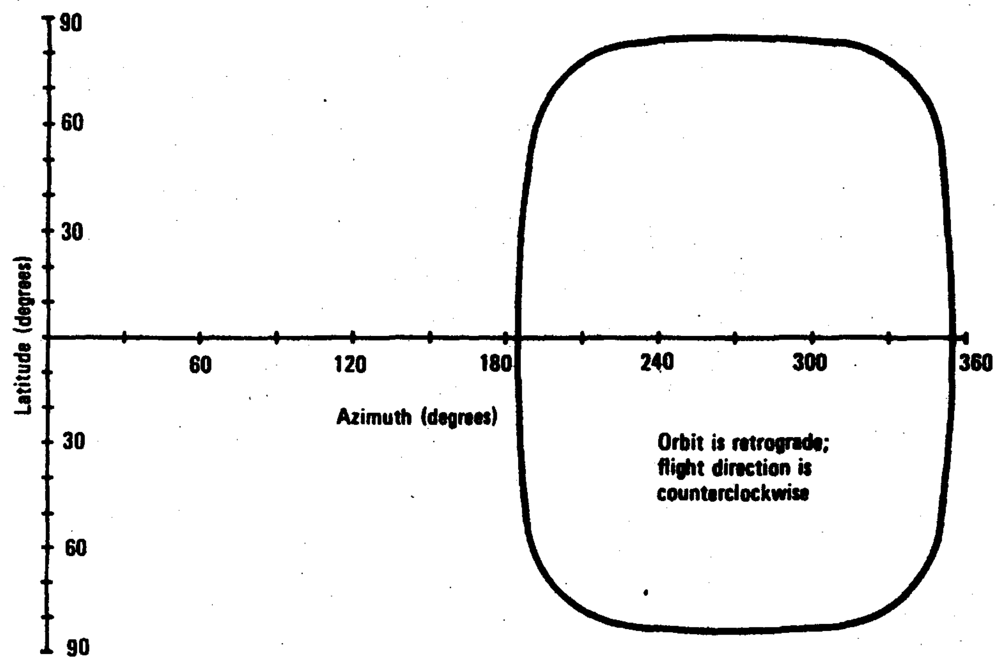


FIGURE 24. VEHICLE AZIMUTH VS. TARGET LATITUDE - *Inclination = 96.4°*

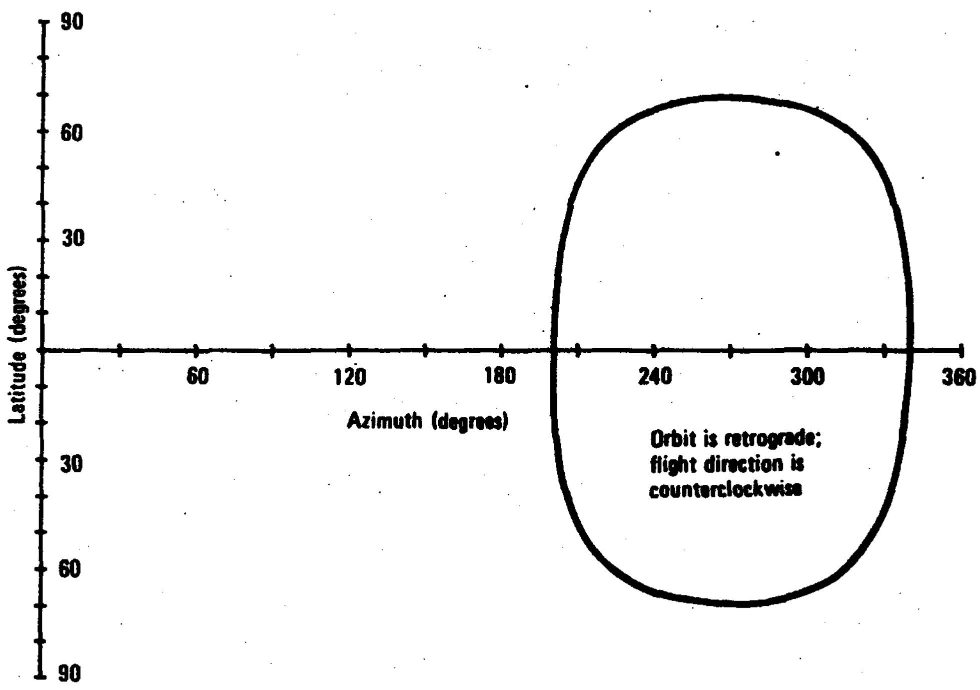


FIGURE 25. VEHICLE AZIMUTH VS. TARGET LATITUDE - *Inclination = 110.5°*

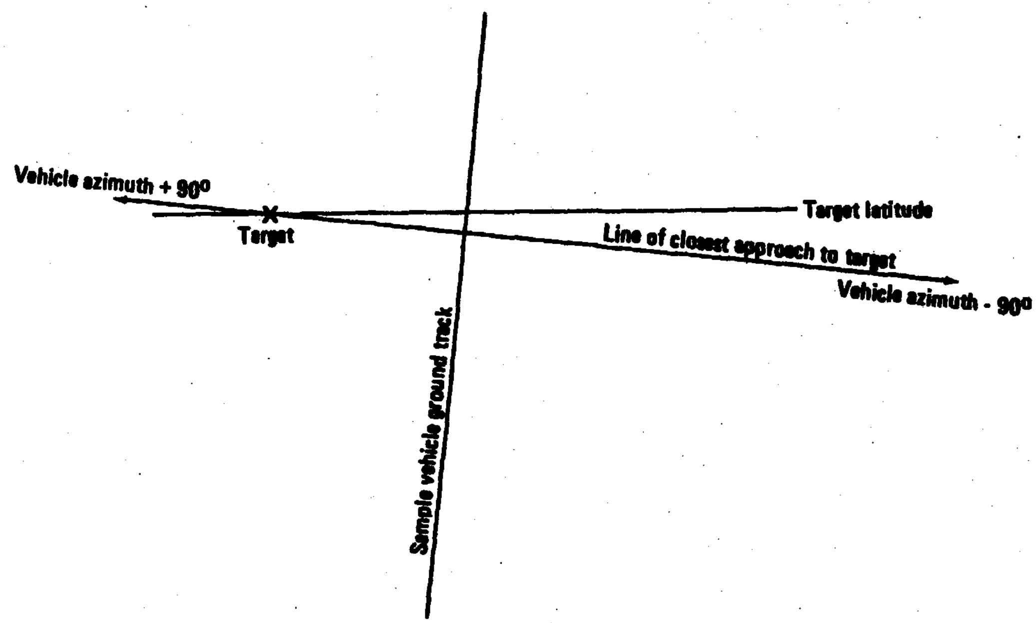


FIGURE 26. LINE OF CLOSEST APPROACH FROM VEHICLE AZIMUTH

Solar Constraints

Limits on the sun's elevation or azimuth should not be imposed without a basic knowledge of the target/sun geometry. Once the orbit and the launch date and time are determined, there is no further control of this geometry. Even if the orbital and launch parameters are based on a specified target's solar constraints, there is little or no manipulation possible. The target/sun geometry is predetermined for each instant of time, and the sole control is over the time at which the vehicle is present. If the desired geometry never exists, the arrival time of the vehicle is of no consequence.

The first step in knowing the target/sun geometry is to determine the location of the sun. The equatorial plane is inclined to the ecliptic plane by an angle of roughly 23.5°. This means that the solar sub-point will fall somewhere between 23.5° North and 23.5° South, depending upon the day of the year. The sun's latitude, or declination, is plotted in Figure 27. The other coordinate, longitude, is based on time of day. For a target at longitude X, the sun is at that same longitude at local noon, X+45° at 1500 local, X+180° at 0000 local, etc. Thus, given a date and time, the position of the sun can be easily approximated.

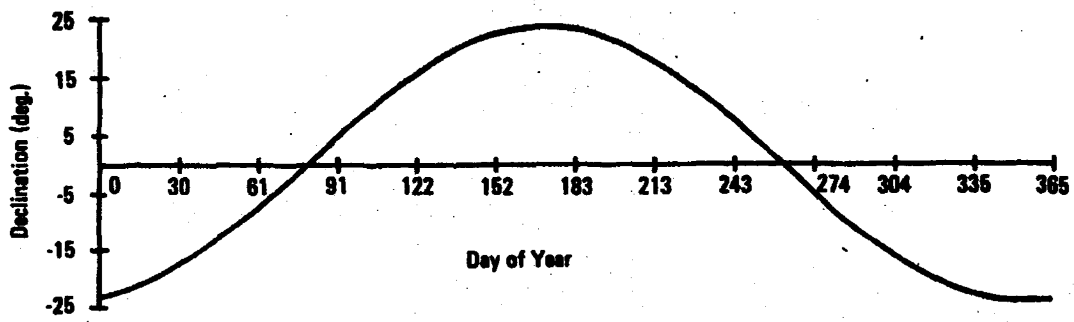


FIGURE 27. SUN DECLINATION (Latitude of solar sub-point by day)

Most dual-mode missions will be launched to provide target overflight in the region of local noon. There will be some deviation but probably not beyond the 1000-to-1300 local range. The result is that the sun will be 30° of the longitude of most targets at the time they are visible to the KH-8 system. Also, since the great preponderence of KH-8 targets are between 35° and 65° North, this means that the solar azimuth will usually be between 90° and 180° (i.e., generally south).

The use of orbits near local noon also confines the range of solar elevations at a given target. The maximum solar elevation occurs at local noon and can be obtained using the equation

$$\eta_{max} = 90 - |\delta_S - \phi_T|,$$

where η_{max} = maximum sun elevation, deg

δ_S = solar declination, deg

ϕ_T = target latitude, deg.

This is a maximum for a given date; if the target overflight time is not local noon, the solar elevation will be lower. Figure 28 shows the maximum

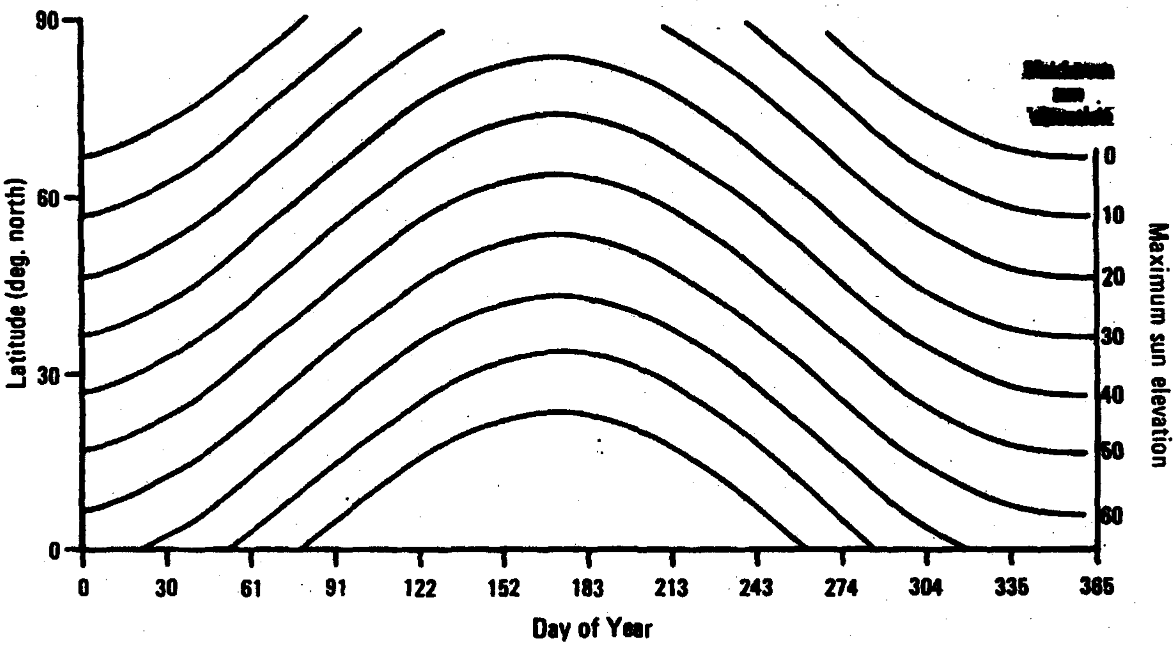


FIGURE 28. NORTHERN HEMISPHERE SUN ANGLES (Lines of maximum sun elevation for latitude and day)

sun elevations by date and latitude. The approximate sun elevations at two hours before or after local noon are shown in Figure 29. These two illustrations can be used to provide the requestor with an approximation of the expected solar elevation during a mission.

Quality Constraints

The user has relatively firm control over the photographic quality of his requested imagery by specifying film type and levels of acceptable resolution and exposure. These are interdependent factors, however, and the user must weigh them and specify requirement constraints that provide imagery pertinent to the need.

The required resolution is a limit beyond which photography will not be attempted. It defines the lowest resolution acceptable to the requestor, not a specific value. Predicted resolution is based on such parameters as vehicle altitude, roll, stereo mirror position, sun elevation, camera-target-sun geometry, and so on. Resolution is also based on the film in use and the exposure.

The relationship between resolution and film is obvious. Typically, the best resolutions are available from the slow speed, fine grain, black-and-white films. Color emulsions, either true color or the false color

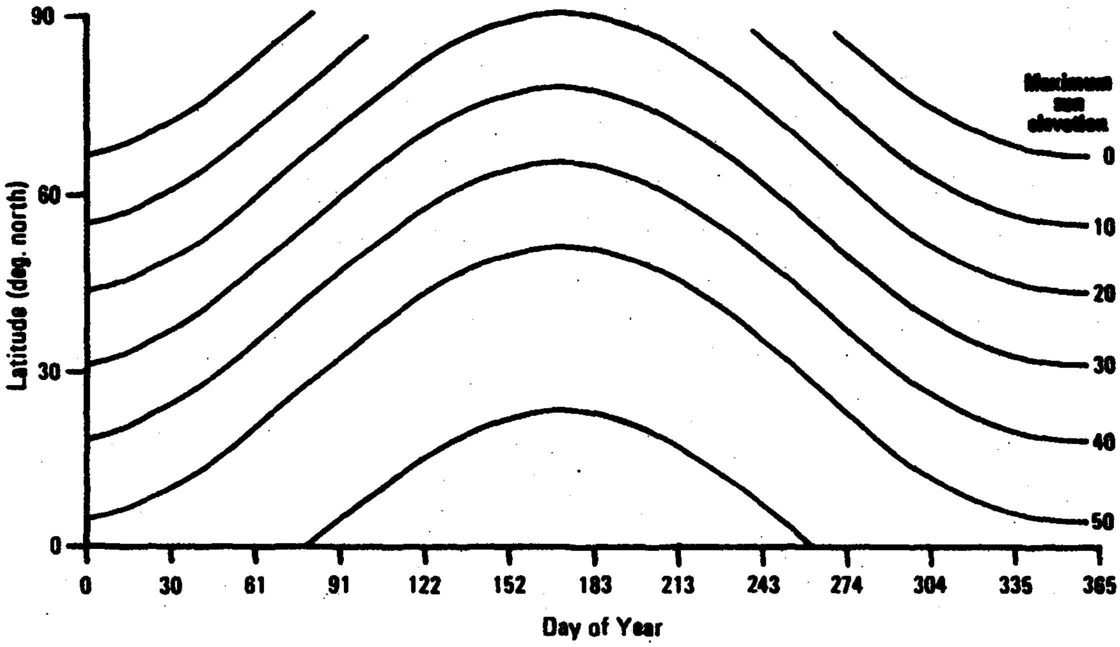


FIGURE 29. NORTHERN HEMISPHERE SUN ANGLES (Lines of constant sun elevations by latitude and day at 2 hours away from local noon)

camouflage detection material, cannot yet return the high quality imagery available from the best black-and-white films. Since the user specifies both the film and the required resolution, he should beware of setting up combinations that give a less than desirable result.

One such result would be lack of coverage. If a requirement, for example, calls for color film and a GRD of no worse than [redacted] then it is extremely unlikely that any imagery would be collected. There is currently no color film that would return [redacted] photography under normal KH-8 operating conditions. If the requirement had been written for 60-inch resolution or any available film, it is probable that imagery would have been obtained. The image quality, however, could possibly be lower than that needed by the user.

The target selection process is too complex to include a "look-ahead" feature; instead, decisions are made on a pass-by-pass basis. If a 60-inch requirement is available at 59 inches today and [redacted] tomorrow, the selection software cannot make a decision to wait. The only method of imposing patience is to specify more stringent constraints. A user may also box himself in by the interaction between resolution and exposure modification. The operational software recognizes that the resolution will be degraded through mis-exposure whether it is an error or a deliberate choice. A stringent resolution requirement can be undermined by including an over or underexposure constraint. Even if the predicted resolution originally meets the required quality, a small exposure change can cause the prediction to exceed the quality limit.

The individual requester must keep the combined constraints logical. If a particular analyst had a need to see into the doors on the north face of a building located at 50° North, he might specify an azimuth range of 330° to 30° and an elevation range of 40° to 50°. Since the north face would be in shadow, he might also require a two-stop overexposure. All this is logical. Adding a resolution limit of [redacted] would not be logical.

These factors are under his control, and he should use them to his advantage by careful application of the constraints.

SPECIAL OPERATIONS

AREA REQUIREMENTS

Capability

The KH-8 has some capability to obtain high-resolution (low altitude) area coverage. This can range from simply increasing the length of frames around known point targets to mosaicking a geographic area from coverage is the only practical mode. Examples of the various types of coverage are shown in Figure 30.

Specification

Specifying requirements for any type of area coverage is accomplished by clear text messages from the ICRS through the NRO Satellite Operations Center.

For lengthening frames around point targets, the information needed is:

(1) The COMIREX target identifier
(2) Requirement priority
(3) Mode required: mono, stereo, lateral pair, etc.
(4) Length of extension in nautical miles.
(5) Preference for direction, if any (i.e., if conflicts exist, would extending photography south of the target be preferred to extending north?)
(6) Preference for resolution or area. If the preference is for area, extensions can take advantage of high obliquity angles, thus maximizing area coverage. If the preference is for quality, they must be limited to lower obliquity angles.

For area coverage, the information needed is:

(1) Coordinates of the corner points defining the area.
(2) Priority of the requirement relative to point targets in or near the area.
(3) Preference for point target coverage in the area prior to beginning of stripping operations.
(4) Preference for high resolution or maximum area.

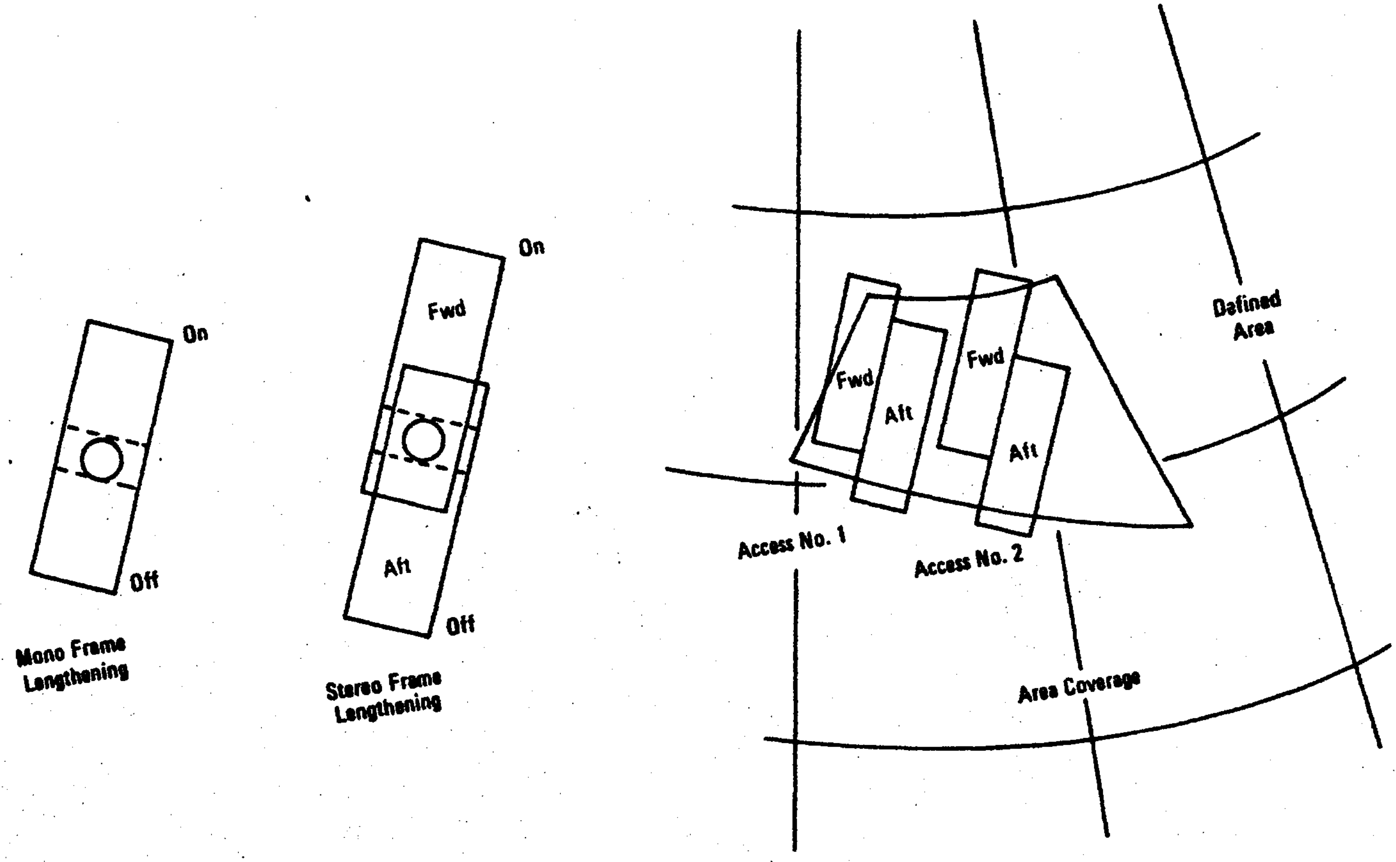


FIGURE 30. AREA COVERAGE CAPABILITY

Special Viewing Conditions

Capability

Users may request special viewing requirements through the requirements specification format, which varies among users, or in clear text.

Specification

When expressing special viewing requirements in clear text, the following information is required:

(1) Brief general description of the problem to be solved.
(2) Orientation of the object or objects of interest with respect to true north.
(3) Parts of the object to be seen.
(4) Mode required or desired.
(5) Exposure considerations, if needed (i.e., if the object is always in shadow or if the requirement is to look into a tunnel or hanger, an exposure adjustment may be needed).

Exposure Bracketing

Requirements for exposure adjustments in employing both camera subsystems which cannot be expressed easily in the requirements specification format may be requested in clear text. The information needed is:

(1) COMIREX target identifiers
(2) Range of exposure and increments around nominal exposure.

Mixed Stereo

The normal or routine operation for multiple stereo would be a stereo pair with each camera subsystem, since at any given time each camera would normally contain a different film type. These routine operations can be specified by a combination of clear text and the requirements specification format. Requirements for other combinations of coverage are best stated in clear text; for example, "two stereo pairs with one pair in black-and-white and the other in color." The information needed is:

(1) COMIREX target identifier
(2) Film types to be used and the modes required (film type, not camera, should be specified.)

Linked Coverage

"Linked coverage" is coverage of two or more targets within some specified period, i.e., one pass or one day. This must be requested in clear text. The information required is:

(1) COMIREX identifiers of the targets.
(2) Period of coverage (pass or day).

OPERATIONS PROCESS

Target Selection Functional Flow

The target selection functional flow consists of six basic segments, as illustrated in Figure 31: the target/requirements file, the acquisition module, the target selection module, the vehicle commanding module, and the Mission Correlation Data/Countdown module.

The target/requirements file contains the physical description and the specific collection requirements against each target. This file also contains the results of previous imaging operations against this target during a given mission. As images are accumulated against a target/requirement, its value for future collection is diminished.

The target acquisition module determines which targets the vehicle will pass over on each revolution and which requirements against each target can potentially be satisfied. Those target/requirement pairs that can be satisfied are then considered as candidates for photography on each rev.

The target selection module is the critical module in the selection process. Based on the candidate targets passed by the acquisition module and the relative worth of the target/requirement pairs and predicted weather, the selection module determines the best series of targets to image over the entire revolution. This process is described in more detail in the following section on the target selection process.

After a best set of targets is selected for imaging, the module determines the on and off times for each frame of photography.

The vehicle commanding module uses the list of photographic frames determined by the selection module to assemble the proper sequence of satellite vehicle commands necessary to collect the imagery operations.

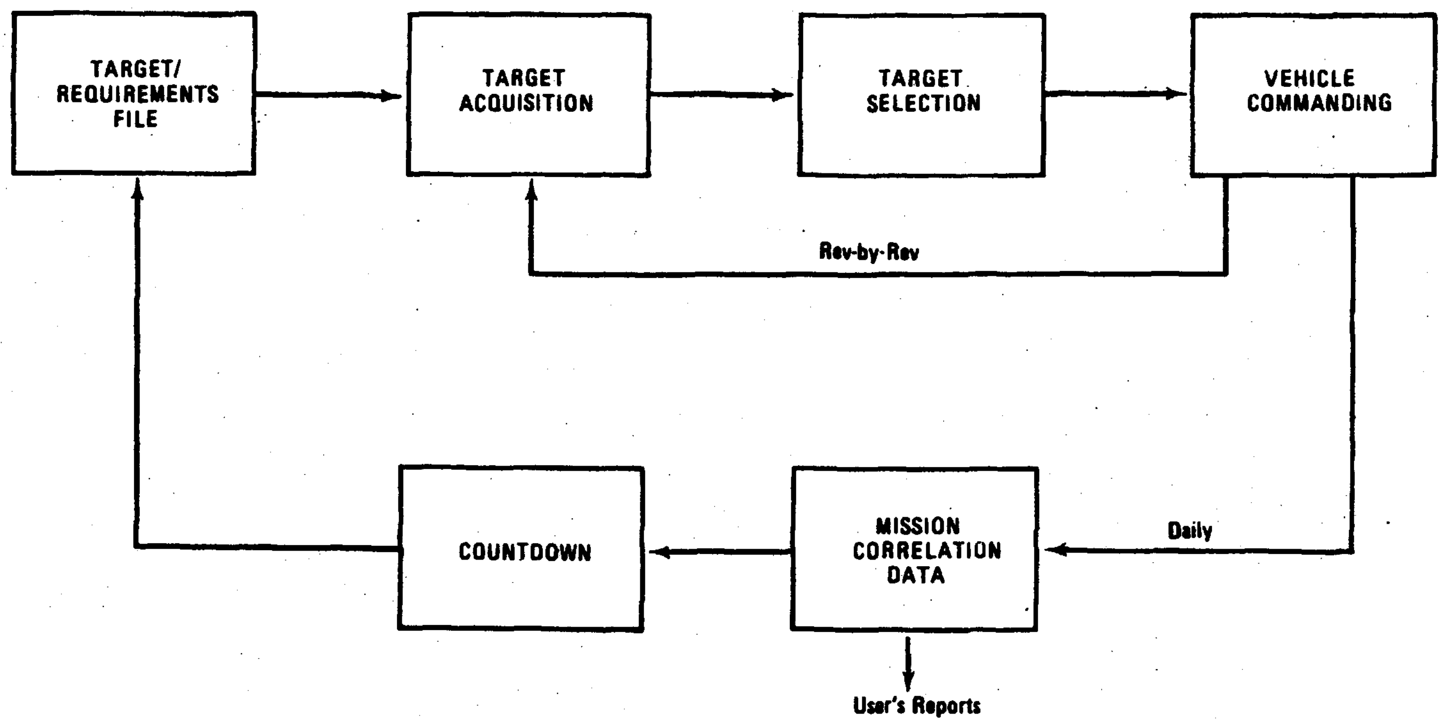


FIGURE 31. TARGET SELECTION: FUNCTIONAL FLOW

The Mission Correlation Data (MCD) module determines the actual geographical area and targets imaged. This is done based on the actual execution time of each camera on/off and the best estimate of the vehicle's location at the time of photography. The best estimate of the vehicle's location is obtained from tracking data acquired before and after the photographic revolution.

The countdown module updates the coverage status in the target/requirements file. It examines each target identified by the MCD to determine which requirements were satisfied. Requirement satisfaction requires meeting resolution, mode, and any geometric constraints. For those requirements which were satisfied, the weather assessment is combined with the assessments from past attempts to determine the cumulative probability of having completely satisfied the requirement at this point in the mission. If the requirement has been satisfied, no further photography will be attempted against that requirement. If it has not been satisfied, further attempts may be made. A target with more than one requirement will be a candidate for photography until all its requirements are satisfied.

As can be seen from Figure 31, there are two feedback loops in the target selection process. The first is rev-by-rev, in which the selection module is informed of which targets have already been attempted at any point during a day. This is important at high latitudes, where targets may be accessible on 2 or 3 successive resolutions. The second is a daily loop, which updates the target/requirement file and incorporates assessed weather and after-the-fact tracking data. It is also the point at which user reports are generated.

Target Selection Factors

Whether a target is selected for imaging and is successfully photographed is determined by several factors, the two most important of which, from a user's viewpoint, are a target's worth relative to other targets and how a photographic frame is constructed.

A target's worth, or weight, is the sum of the weights of each individual requirement levied against it. The weight of an individual requirement is a function of its priority and shade, the mode required, the predicted-versus-required resolution, the predicted weather, the cumulative probability of having already satisfied the requirement during the mission, and the probability of being able to completely frame the target with a given operation. The higher the total weight of a target, the higher the probability of its being imaged. This is especially true in areas of high target density, such as Moscow.

A frame of photogaphy is constructed based on the diameter of the target or targets that are to be imaged plus the target's location uncertainty, ephemeris uncertainties, vehicle pointing uncertainties, and the vehicle clock granularity (the camera can only be turned on or off in increments of 0.2 sec). This total process is depicted by the error ellipsoids in Figure 32.

In the case where two or more targets are so close that their required "camera on" times overlap, the camera would be left on to cover both targets with one frame (see Figure 33).

The target diameter is an important parameter. The larger the diameter, the longer the camera must be turned on, and therefore the less time there is available to operate against other targets close by. However, if the diameter specified does not represent the total area desired, the user will not obtain the coverage desired.

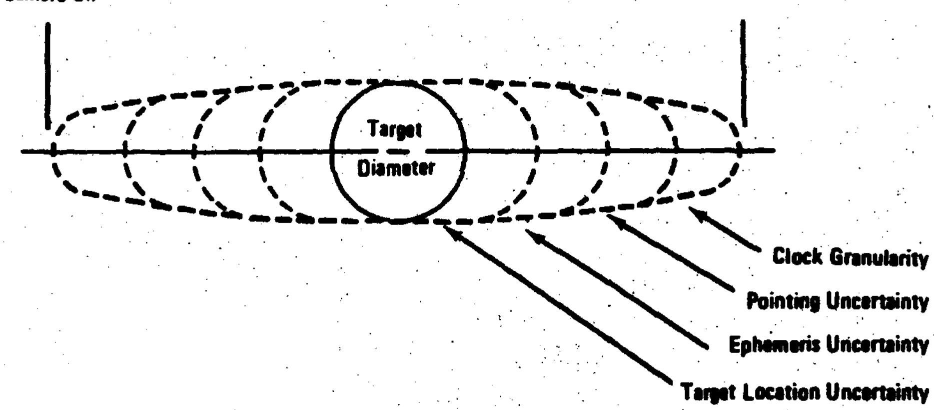


FIGURE 32. TARGET COVERAGE (Figure is not to scale but for illustration)

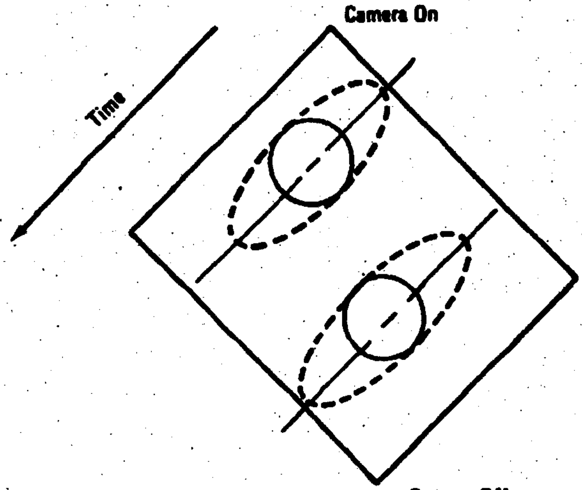


FIGURE 33. MULTIPLE TARGET FRAMING

GLOSSARY

Aspheric reflector -A concave spherical mirror, formed from the inner surface of a portion of a sphere. Called the "primary mirror" in the KH-8 system.

Companion camera -Camera subsystem using the 5-inch wide film.

Companion coverage -Term used to indicate that a target was photographed simultaneously by both the 9- and 5-inch cameras.

Crab -Rotation of the stereo mirror about the roll axis of the vehicle to compensate for the earth's rotation.

Cross-track -Perpendicular to the direction the vehicle is moving.

Ground-resolved distance -The minimum test target element distance resolved on the ground (the sum of one bar and one space on a tribar test targe[redacted] with a system that produces a GRD o[redacted] the smallest bar of the tes[redacted]istinguishable has a width of [redacted]

In-track -Parallel with the direction the vehicle is moving.

Main camera -Camera subsystem using the 9.5-inch wide film.

Mode -Manner in which the imagery is acquired: monoscopic, stereoscopic, lateral pair, etc.

Nadir -Point on the earth directly beneath the vehicle.

Obliquity -Angle between vehicle nadir vector and the principal ray.

Pitch -Apparent rotation of the vehicle about the horizontal axis perpendicular to vehicle motion, accomplished by movement of the stereo mirror (displaces the optical line of sight in track).

Principal ray	-Projection of the optical line of sight to the ground. Manipulated by ±45° vehicle roll capability and stereo mirror pitch (3 positions) and crab (+3.85°) capability. Its ground trace in strip camera imagery is a line through the center of a photograph along the axis of the film.
Requirement priority	-Ranking of a requirement relative to other requirements on a ten-point scale, 0 being the highest and 9 the lowest.
Roll	-Rotation of the vehicle about the longitudinal axis of the vehicle (displaces the optical line of sight cross-track).
Semi-field angle	-One-half the optical field of view.
Slant range	-Line-of-sight distance from image plane to target.
Start-up transient	-Time and film used to accelerate the film velocity from zero to the proper speed for high resolution photography.
Strip camera	-A camera which acquires imagery by moving film past a stationary slit at the same speed that the image moves past the slit.
Swath width	-Cross-track distance on the ground subtended by the optical field of view.
Sun-synchronous	-Orbit whose parameters are such that the nodal regression rate is equal in magnitude and sense to the earth's mean rate of revolution about the sun. An imaging satellite in such on orbit will pass over a given target at approximately the same local time each time this event occurs.
Target worth	-Sum of the weights of all requirements assigned to a target. For each requirement this includes factors for priority, mode, quality, forecast weather, and past coverage.