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10 October 1969

TECHNICAL MEMORANDUM #39

SUBJECT : Sensitivity of KH-4 Ground Resolution and
Frame Area Coverage to Altitude

PREPARED BY. [REDACTED] and [REDACTED]

I. SUMMARY AND CONCLUSIONS

1. This paper examines the sensitivity of KH-4 ground resolved distance (GRD) to location in the ground frame and to variation in perigee altitude for two typical orbits having perigee altitudes of 85 and 100 n.m. and a latitude of perigee of 50 degrees North.

2. The increase in altitude of 15 n.m. causes a resolution degradation of about 18%.

3. This increase in altitude increases the area coverage of an individual frame of photography by approximately 40%.

II. RESOLUTION CONSIDERATIONS

1. The resolution performance of a panoramic system is influenced by such factors as:

- (a) Film Quality
- (b) Lens Performance
- (c) Film Focus Position
- (d) Image Smear
- (e) Atmosphere

2. Components of GRD are defined in the direction of image motion and in the direction of scan motion. In this paper GRD is expressed in feet as the geometric mean of these components.

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In Accordance with E. O. 12958

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3. Figures 1(a) and 1(b) display resolution contours of the KH-4 system at altitudes of 100 n.m. and 85 n.m. respectively. Data of the latter figure were obtained from dynamic testing of instrument #309, which had a third generation lens and a 20 mil offset from the node. This instrument was used as the forward camera in Mission 1104, and its performance was considered representative, as manifested in TABLE 3-S of "Performance Analysis of the J-3 Systems," [REDACTED]

4. To generate the resolution contours associated with an altitude of 100 n.m. from the contours of 85 n.m. two assumptions were made:

(a) Any changes in target illumination and contrast resulting from the increase in altitude are negligible,

(b) Image angular smear rate remains nearly constant.

5. The apparent asymmetry of contours in Figures 1(a) and 1(b) results from the 20 mil offset of the rear node of the lens from the mechanical axis of rotation. The purpose of this offset is to partially correct for cross-track smear at the center of format.

6. At an altitude of 100 n.m. the resolution varies from 6.8 feet near the center of the imaged area to a maximum of 19 feet at one edge. This represents a resolution degradation of about 18% when compared with the resolution at 85 n.m., which varies from 5.8 feet near the center to over 16 feet at one edge.

III. SYSTEM PERFORMANCE

1. The area imaged by the system operating at an altitude of 85 n.m. shown in Figure 1(b), increases by approximately 40% when the altitude is increased to 100 n.m., as shown in Figure 1(a).

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2. The increase in GRD for the KH-4 orbits as a function of latitude is shown in Figure 2. Figure 3 presents the altitude profiles which were utilized to calculate the resolution data.
3. For convenience, this change in ground resolution for each orbit is expressed relative to 85 n.m. which is perigee altitude for the lower orbit.
4. Over the Sino-Soviet area (70 degrees North to 20 degrees North), the average increase in GRD for the 100 n.m. orbit is seventeen percent. The minimum and maximum increase of fifteen and eighteen percent occur at 20 degrees North and 50 degrees North (latitude of perigee), respectively. This increase in GRD is the difference of the percent increase of the two orbits at a given latitude.
5. Figure 2 indicates an improvement of ground resolution South of the latitude of perigee for both orbits. An average improvement of three percent, relative to perigee, occurs from 35 degrees North to 20 degrees North for the 100 n.m. orbit. The 85 n.m. orbit exhibits an improvement of better than one and one-half percent from 40 degrees North to 25 degrees North. At the same time, the average degradation North of perigee to 70 degrees is two percent for the 100 n.m. orbit and three percent for the 85 n.m. orbit. A slight improvement in resolution for the more northern latitudes, 50 to 60 degrees North, is possible by moving the latitude of perigee to the North. For this reason, the latitude of perigee should be located as far North as possible within system constraints such as drag makeup capability to assure a high reliability of RV recovery.
6. The descriptions of the orbits considered in this paper are summarized in Table 1. Figure 4 presents the orbital geometry and definition of perigee altitude as well as latitude of perigee. Perigee is located along the semimajor axis and perigee altitude is defined as a normal to the earth's surface. The latitude of perigee is defined as the latitude at which this normal intersects the earth model. Minimum altitude is less than perigee altitude and occurs at a lower latitude due to the oblateness of the earth.

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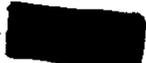
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7. Nominal parameters for a KH-4 orbit are considered to be a 7.5 day synchronous period, 85 n.m. perigee altitude at 50 degrees North, 80 degree inclination, and the LOW orbital period which satisfies the synchronous period condition. Only the first of six KH-4B systems utilized the HIGH orbital period which is considered atypical of the KH-4 missions. The GRD increase for HIGH vs. HIGH orbits with different perigee altitudes is essentially equivalent to that of the LOW vs. LOW orbits.

8. A second KH-4 orbit with a perigee of 100 n.m. was selected for comparison of GRD. This orbit has the same synchronous period and latitude of perigee as the nominal case. A point of interest is the latitude of complete coverage in one synchronous period for these orbits, 46.5 degrees North for the 85 n.m. case and 37.0 degrees North for the 100 n.m. case. The 100 n.m. orbit is nearly equivalent to a circular orbit of that altitude over the Sino-Soviet area as Figure 3 indicates.

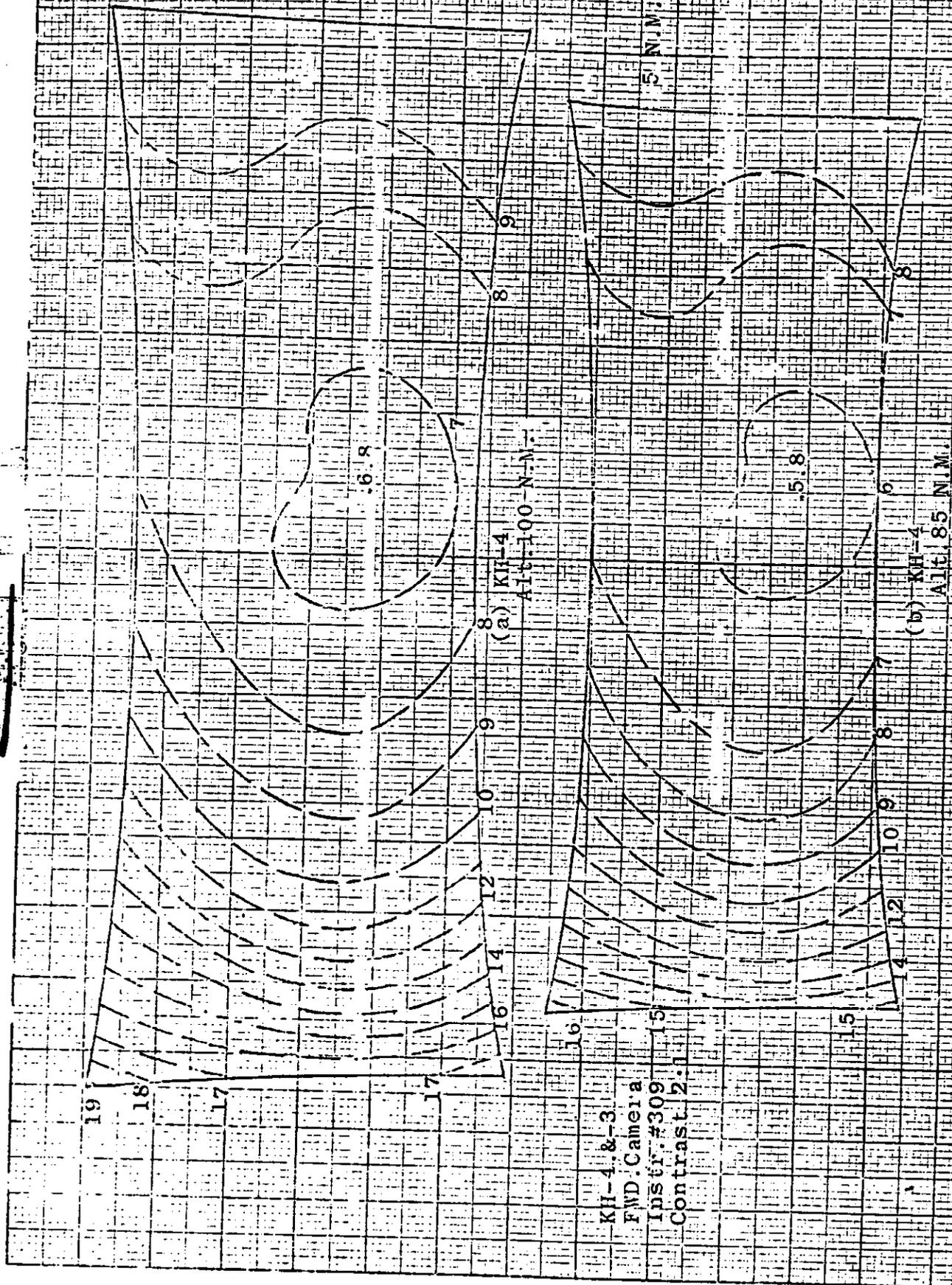

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(a) KH-4
Alt 100 N-N

(b) KH-4
Alt 85 N.N.

KH-4 & -3
FWD Camera
Instr. #309
Contrast 2.1

5 N.M. x 15 N.M.

Figure 1. RESOLUTION CONTOURS (Feet)

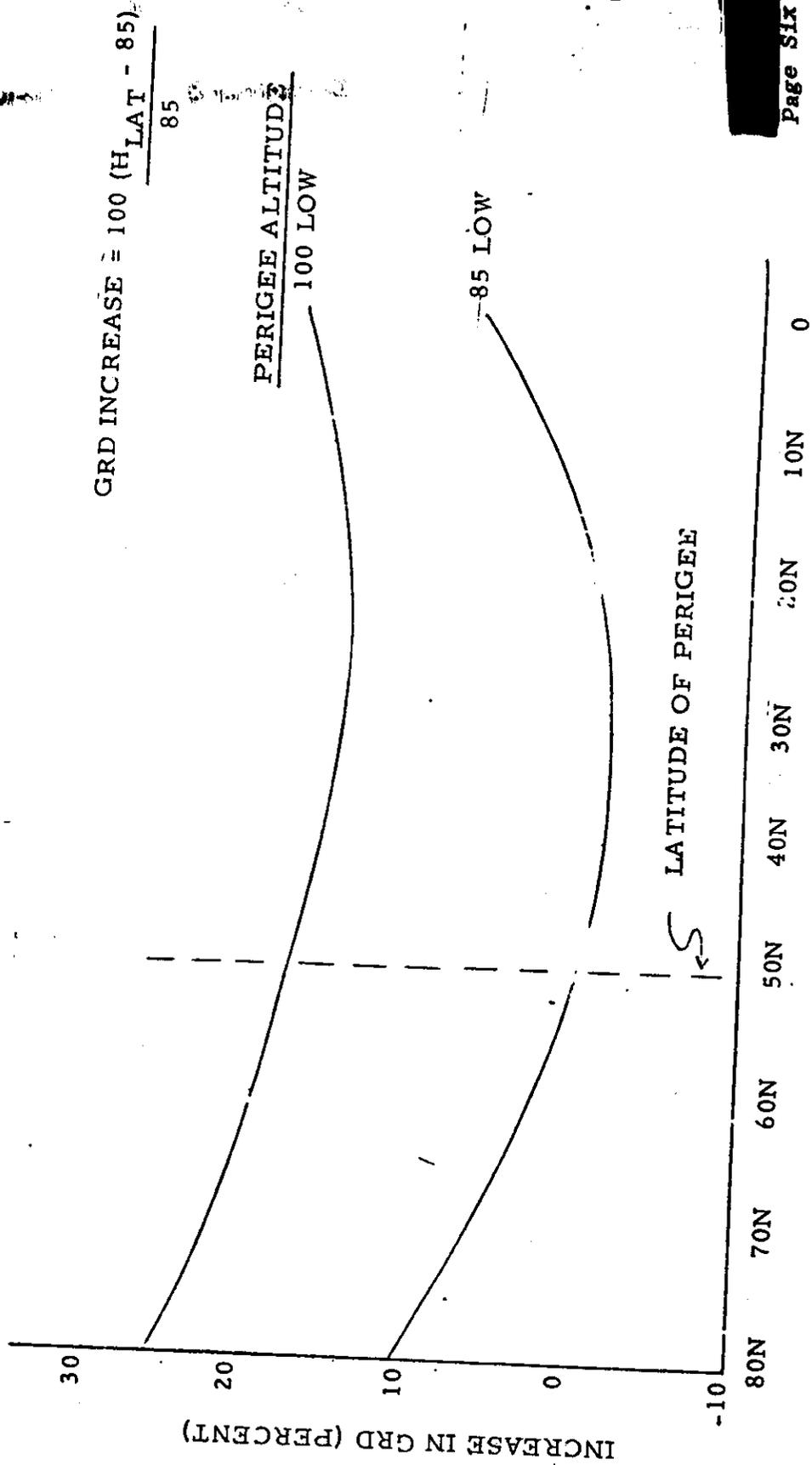
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FIGURE 2

INCREASE IN GRD VS. LATITUDE

(KH-4)



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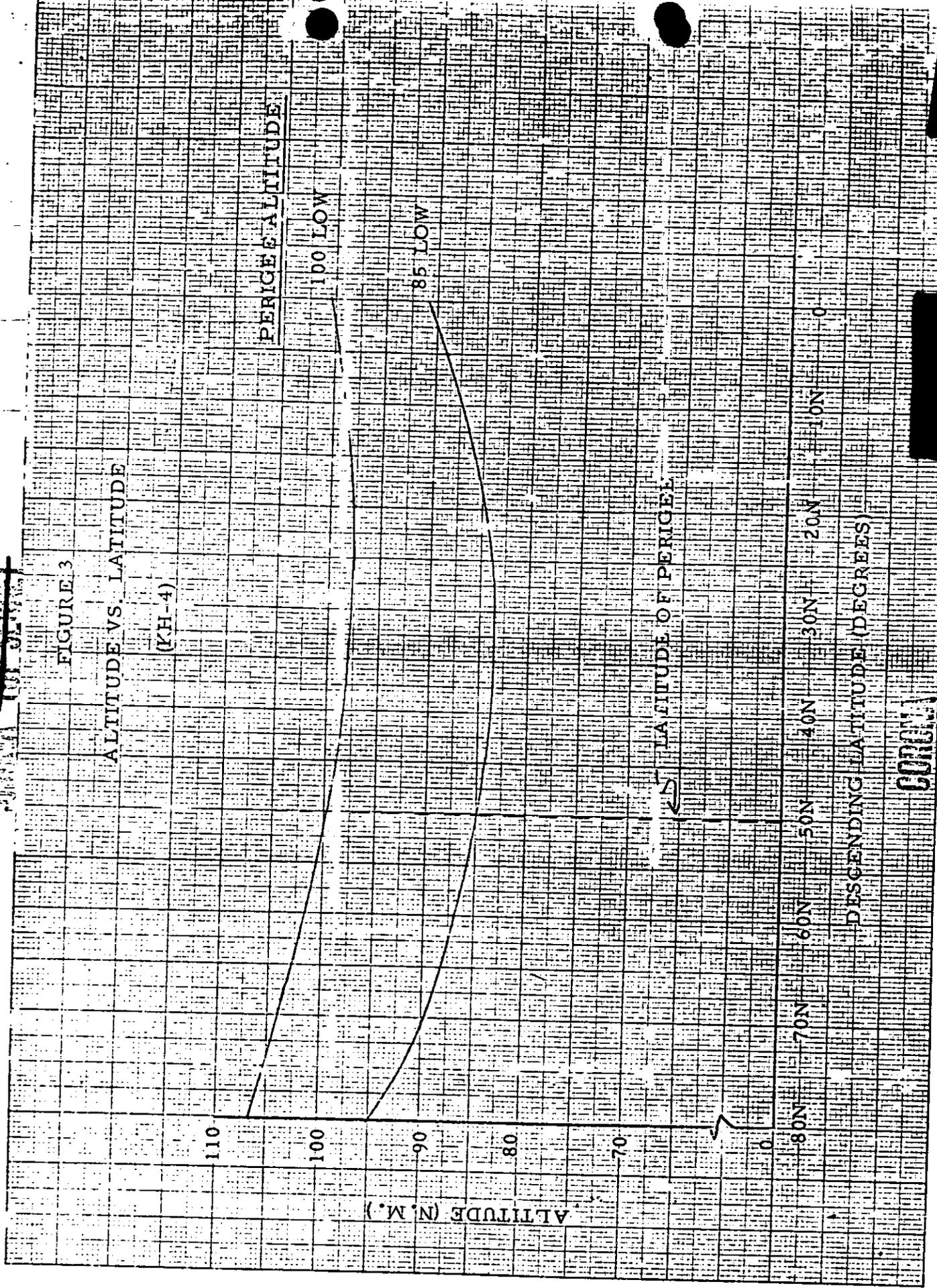


FIGURE 3

ALTITUDE VS. LATITUDE

(KH-4)

PERIGEE ALTITUDE

100 LOW

85 LOW

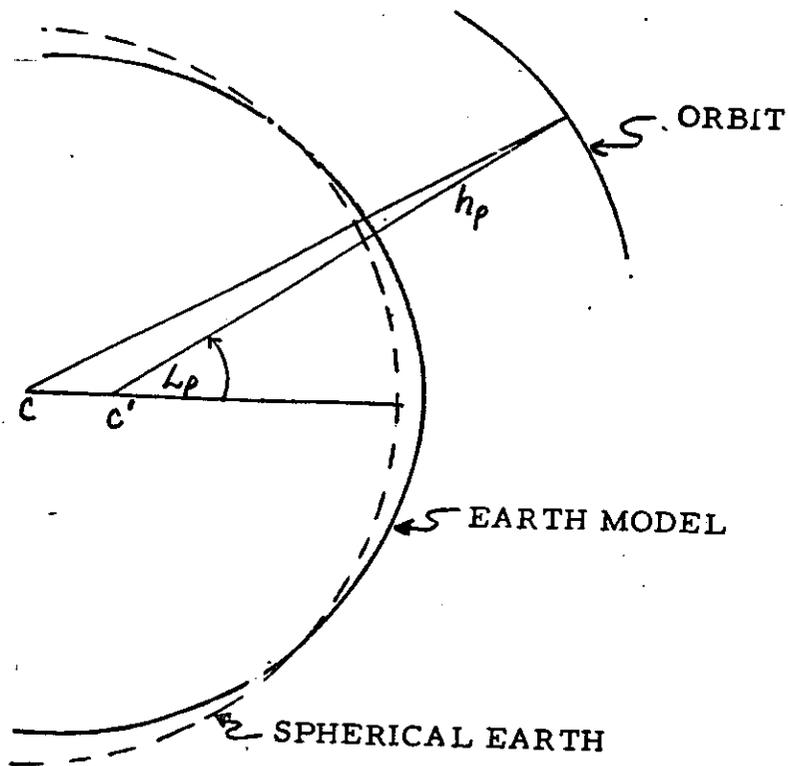
← LATITUDE OF PERIGEE

DESCENDING LATITUDE (DEGREES)

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FIGURE 4
ORBITAL GEOMETRY



- C Center of Spherical Earth
- C' Center of Earth (Geodetic)
- L_p Latitude of Perigee
- h_p Altitude of Perigee

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TABLE I
ORBITAL DESCRIPTIONS

KH-4		
	85 n.m.	100' n.m.
Perigee Altitude	85 n.m.	100 n.m.
Perigee Latitude	50 Degrees North	50 Degrees North
Apogee Altitude	150 n.m.	135 n.m.
Inclination	80 Degrees	80 Degrees
Synchronous Period	7.5 Days	7.5 Days
Orbital Period	88.63 Minutes	88.63 Minutes
Simulated Launch	WTR	WTR
Comments	LOW Period	LOW Period
Complete Coverage In Sync Period	46.5 Degrees North	37.0 Degrees North

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