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BYE-7385-69

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16 December 1969

## TECHNICAL MEMORANDUM #28-A

SUBJECT : Sensitivity of Ground Resolution to Altitude and  
Location in the Ground Frame

PREPARED BY: I. INTRODUCTION

1. This paper examines the sensitivity of KH-4 and KH-9 ground resolved distance (GRD) to location in the ground frame and variation in perigee altitude for a typical orbit. In particular, GRD variation for two KH-4 orbits with perigee altitudes of 85 n.m. and 100 n.m. is discussed. The latitude of perigee is 50 degrees North for each KH-4 orbit. A KH-9 orbit with a perigee altitude of 82 n.m. at 45 degrees North is also presented.

2. Examples of KH-4 and KH-9 resolution data are included. These plots are presented with resolution contours expressed in feet.

II. RESOLUTION CONTOURS

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 as the geometric mean of these components.

3. Figures 1(a) and 1(b) display resolution contours of

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the KH-4 system at altitudes of 100 n.m. and 85 n.m. respectively. Data of the latter figure were derived from an instrument used on one of the KH-4 Missions, and its performance was considered representative of good photography.

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

- (a) Target illumination and contrast are independent of altitude,
- (b) Image angular smear rate remains constant as altitude varies.

5. The apparent asymmetry of contours in Figures 1(a) and 1(b) results from a 20 mil offset from the optical node. The purpose of this offset is to partially correct for cross-track smear.

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.

7. Figure 1(c) displays resolution contours of KH-9 at 82 n.m., based on performance prediction results of line pairs per millimeter plotted as a function of scan angle and slit position. These contours are nearly symmetrical and indicate a resolution of from 2.3 feet near the center to over 9 feet at the edges. Because of overlap, however, the extreme edges of any frame will contain area covered close to the cross-track centerline of an adjacent frame. Therefore, all targets can be acquired with a resolution of about six feet or better. These values are based on engineering studies and are 96% reliable, as indicated in Figure 1.

### III. KH-4 SYSTEM

1. 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.

2. 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.

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3. 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.

4. 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.

5. The descriptions of the KH-9 and KH-4 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.

6. 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.

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7. 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, 46.3 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.

#### IV. KH-9 SYSTEM

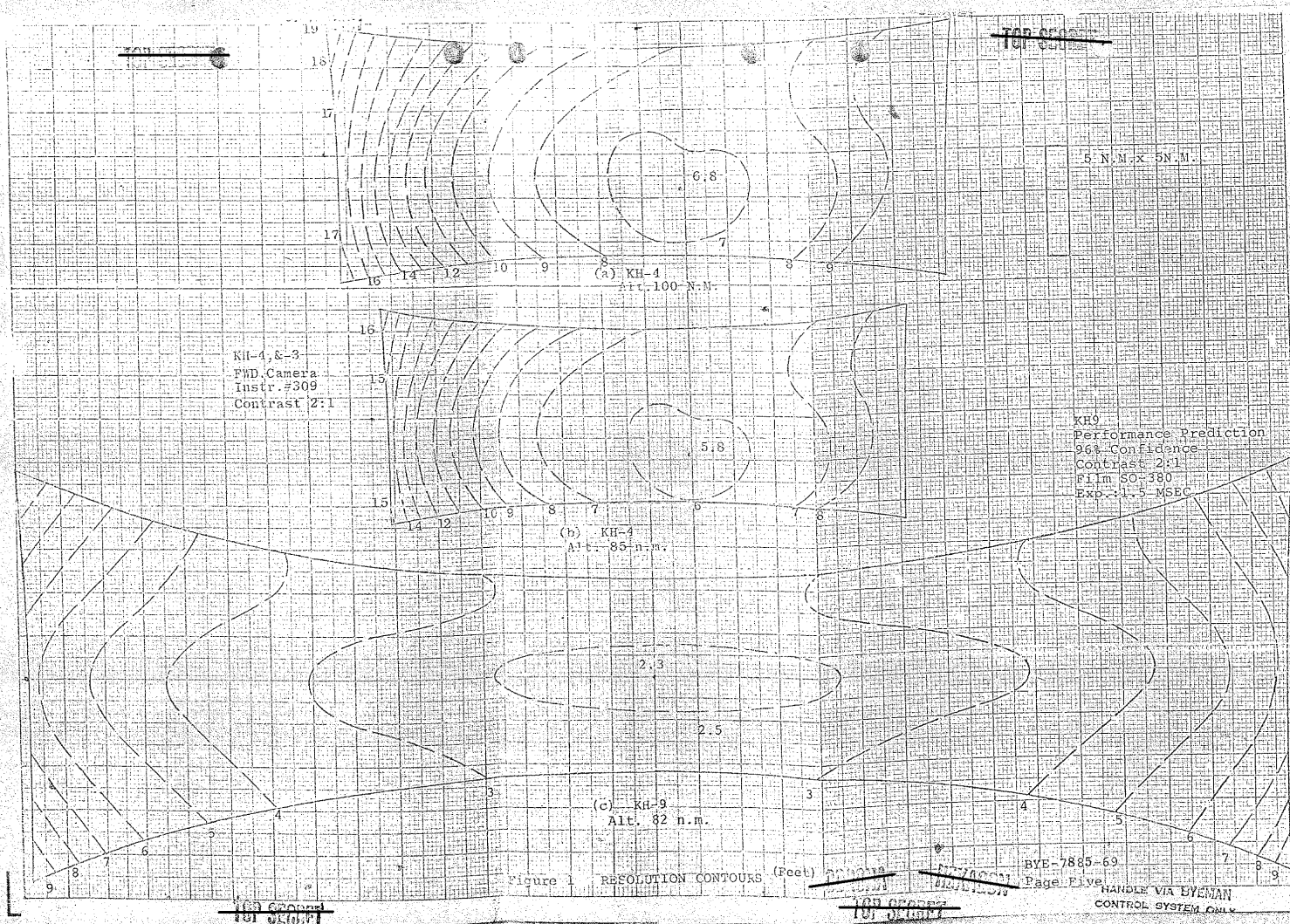
1. An altitude profile and the corresponding percent increase in GRD for a KH-9 orbit are included in Figure 5 and 6. Over the Sino-Soviet area the average increase in ground resolution is one and one-half percent greater than that at perigee, 45 degrees North. An average degradation of four percent occurs North of 45 degrees (latitude of perigee) and an average improvement of one and one-half percent is apparent South of perigee. A more northern location of perigee will improve the overall resolution for the Sino-Soviet area.

2. The KH-9 orbital parameters are a perigee altitude of 82 n.m. at 45 degrees North and a 3.5 day synchronous period with a sun synchronous inclination. The 100 orbital period is assumed nominal for the KH-9. In 1.5 days, earth coverage is complete North of 41.5 degrees North or South of 41.5 South.

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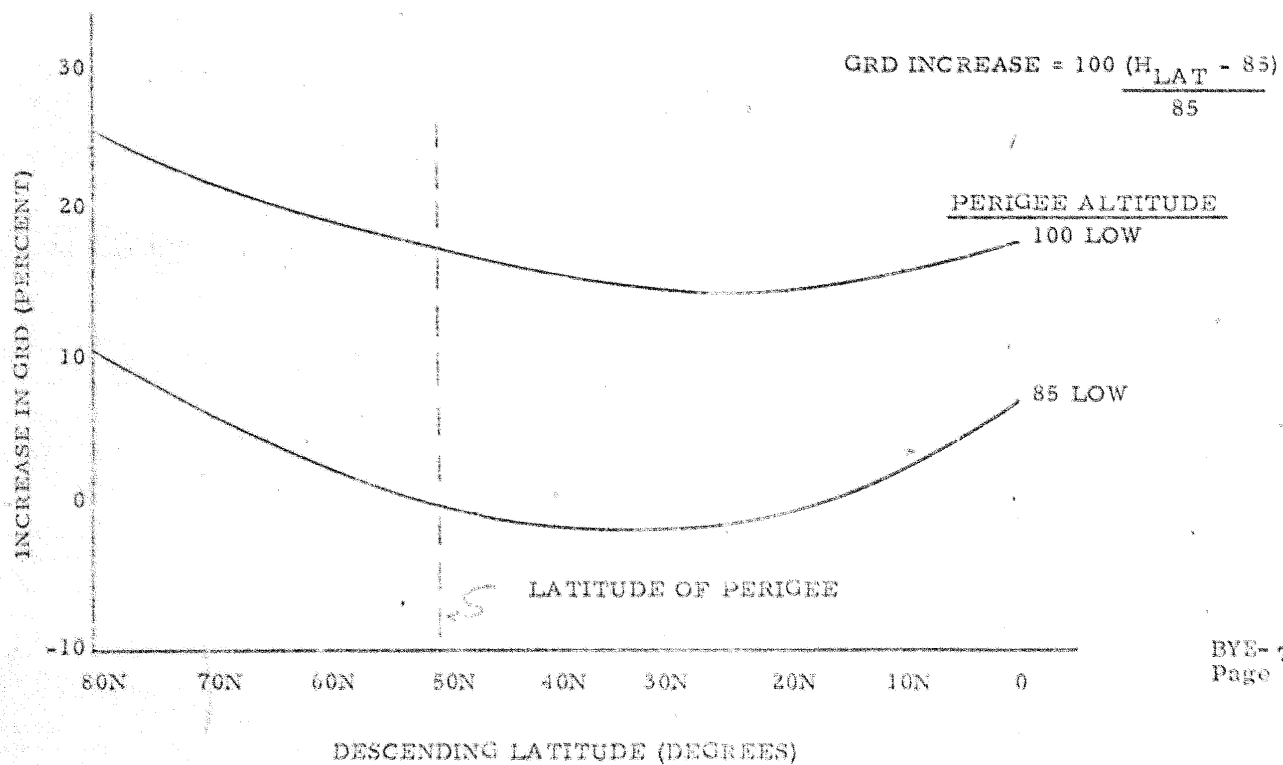
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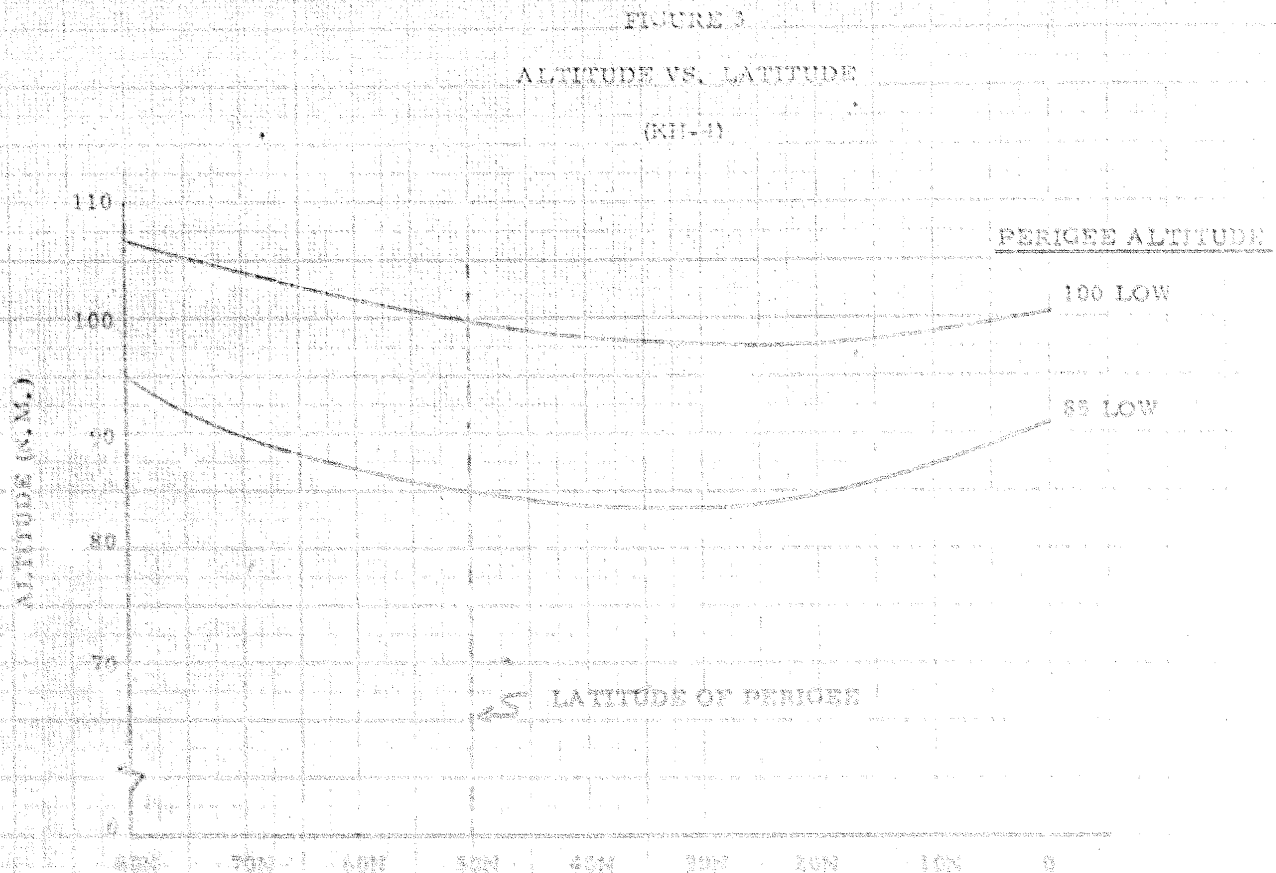


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FIGURE 2  
INCREASE IN GRD VS. LATITUDE  
(KH-4)



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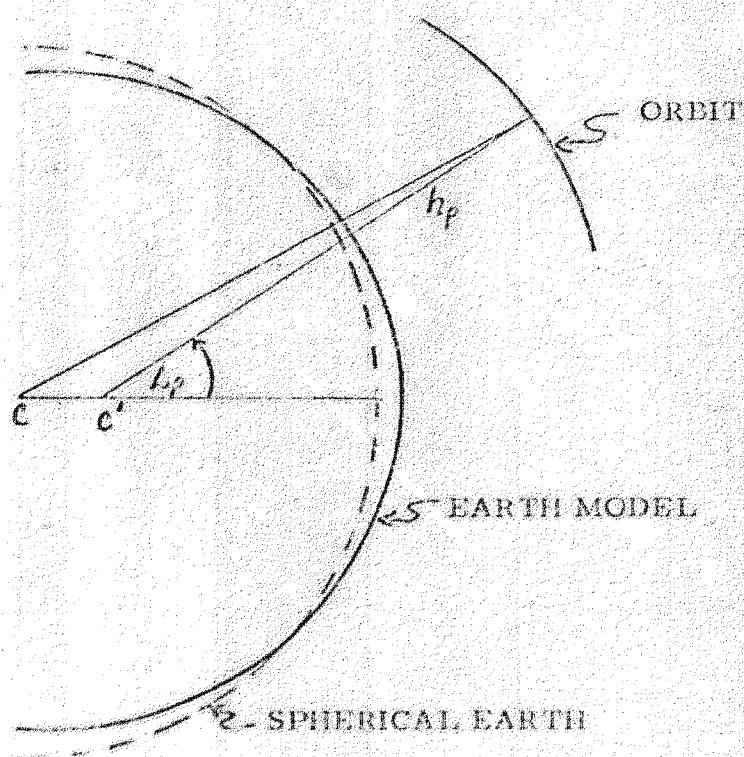
DESCENDING LATITUDE (DEGREES)

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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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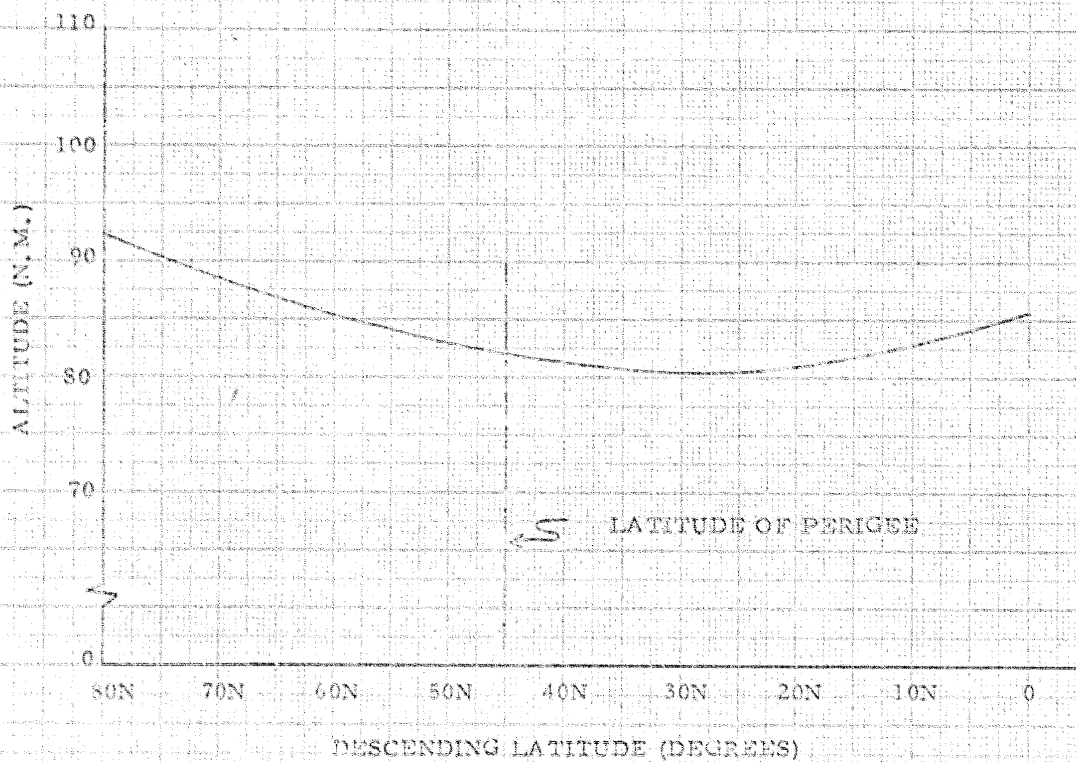
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FIGURE 5

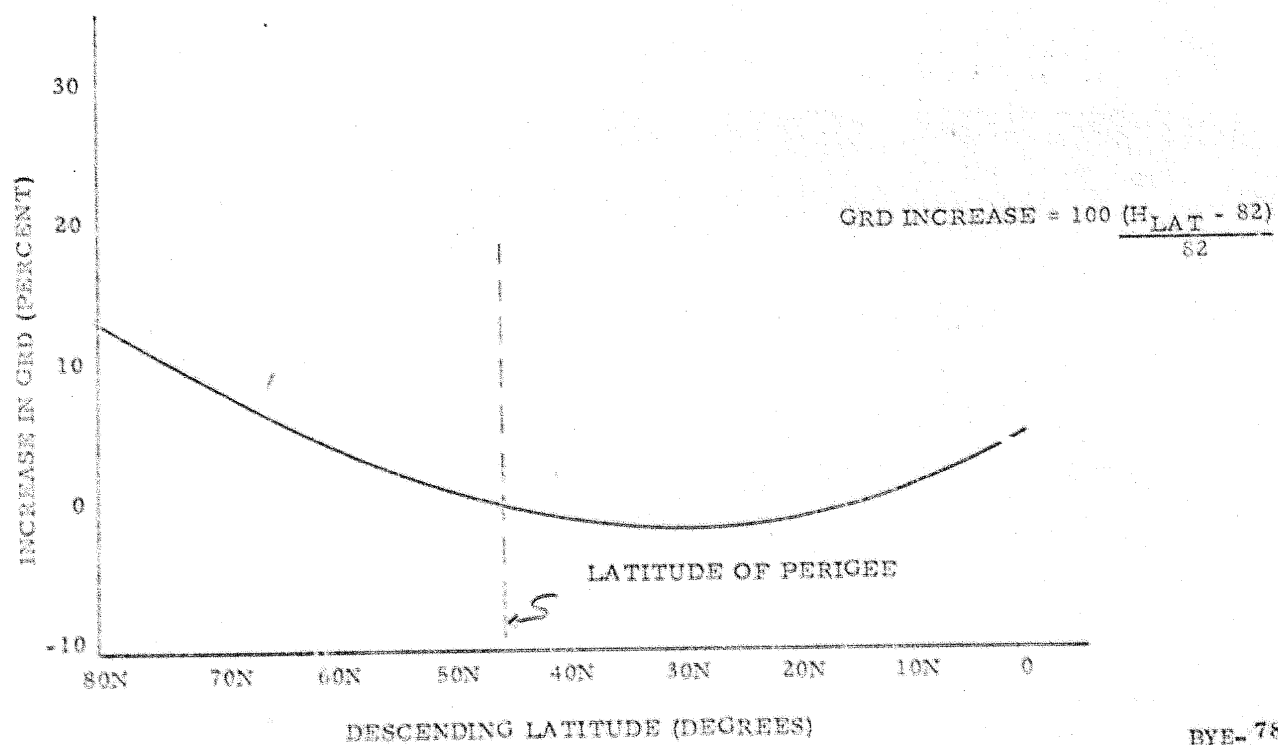
ALTITUDE VS. LATITUDE  
(KH-9, 82 N.M. PERIGEE)

DESCENDING LATITUDE (DEGREES)

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FIGURE 6  
INCREASE IN GRD VS. LATITUDE  
(KH-9, 82 N.M. PERIGEE)



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ORBITAL DESCRIPTIONS

|                                     | KH-4               |                    | KH-9                          |
|-------------------------------------|--------------------|--------------------|-------------------------------|
|                                     | 85 n. m.           | 100 n. m.          |                               |
| Perigee Altitude                    | 85 n. m.           | 100 n. m.          | 92 n. m.                      |
| Perigee Latitude                    | 50 Degrees North   | 50 Degrees North   | 45 Degrees North              |
| Apogee Altitude                     | 180 n. m.          | 135 n. m.          | 134 n. m.                     |
| Inclination                         | 50 Degrees         | 50 Degrees         | 95.3 Degrees                  |
| Synchronous Period                  | 7.5 Days           | 7.5 Days           | 3.5 Days                      |
| Orbital Period                      | 88.63 Minutes      | 88.63 Minutes      | 88.62 Minutes                 |
| Simulated Launch                    | WTR                | WTR                | WTR                           |
| Comments                            | LOW Period         | LOW Period         | See Synchronous<br>LOW Period |
| Complete Coverage<br>in Sync Period | 46.5 Degrees North | 37.0 Degrees North | 41.5 Degrees North            |

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