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25 July 1969

MEMORANDUM FOR THE RECORD

SUBJECT: Expected Ground Resolved Distance, 85 vs. 100 nm Perigee on Mission 1108

At the 3 July 1969 COMIREX meeting, the question of flying the J-3 vehicle at 100 vs. 85 nm perigee was discussed. It was stated that flying at 100 nm provided "significant" increase in coverage with "minimal" loss in resolution. This statement was immediately questioned as to what was meant by "minimal." While it is obvious that one answer is that the difference is a straight linear 15%, this answer is misleading in that it is a qualitative rather than quantitative answer. Subsequent discussion with DD/OSP indicated the desirability of attempting to provide a quantitative answer for Mission 1108. Such an analysis was done, and this memo summarizes that work.

1.0 BASIC PURPOSE

The basic purpose of the analysis was to calculate realistic GRD values for some limited set of "typical" conditions for Mission 1108. For this purpose, then, both FWD- and AFT-looking camera performances were calculated under the following conditions:

A. For 1 November 1969 photography.

B. 85 nm perigee case, perigee being at an average of 30° N.L. GRD vs. scan angle being calculated for both this case and for a 60° N.L. case, assuming altitude at this latitude to be approximately 95 nm.

C. 100 nm perigee case, perigee being at an average of 30° N.L. GRD vs. scan angle being calculated for both this case and for a 60° N.L. case, assuming altitude at this latitude to be approximately 110 nm.

D. Local afternoon photography was assumed since this is normal for this time of year.

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E. The inclination of the orbit was assumed to be 80°, again since this is fairly standard.

2.0 BASIC COMPUTATIONAL PROCEDURE

The basic computational procedure used was as follows:

1. The parameters above were input to the Crystal Ball Atmospheric Program to compute

A. Contrast (C) Factors and mean scene brightness as a function of scan angle and altitude. This was done assuming typical haze conditions for the USSR.

B. The Contrast Factors were used to determine the modulation apparent at the camera aperture for a 5:1 contrast target. That is, it was assumed that a constant 5:1 contrast target was on the ground and the change in its contrast due to atmospherics was calculated. The use of 5:1 seems reasonable since (1) it does not vary greatly from contrasts determined from Project Sunny and (2) it relates to the 51/51 CORN T-Bar target. The new contrast (above the atmosphere) is calculated from the equation:

$$C_A = \frac{R_H + CF}{R_L + CF}$$

where C = apparent contrast above atmosphere
CF = Contrast Factor from Crystal Ball
R_H = Highlight reflectance, in this case 33% (CORN target)
R_L = Lowlight reflectance, in this case 7% (CORN target)

C. Using the mean brightness data from Crystal Ball, the proper exposure time was calculated* and this was used to determine the amount of smear that would exist across the format.

*NOTE: This is not necessarily the exposure time achievable with an actual J-3 because of the discrete 4-position exposure control.

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D. The expected smear was assumed to be of a

$$\frac{\sin x}{x}$$

nature and the appropriate smear MTF was multiplied by the appropriate lens (second or third generation) MTF to obtain a predicted MTF as a function of scan angle. This MTF was then crossed with the AIM curve, the AIM curve being adjusted to the proper apparent modulation as a function of scan angle derived from B above, the subsequent intersection yielding expected camera resolving power (in two directions). Average resolving power was then calculated.

E. The altitude as a function of scan angle was determined and the expected resolution values converted to expected GRD.

3.0 RESULTS

The results of this analysis are discussed below.

A. The Contrast Factor vs. scan angle data from Crystal Ball is shown in Figure 1. The total effect of altitude, camera angle to the sun, solar altitude and declination, latitude, etc., on contrast attenuation is readily seen in this plot. The increased haze attenuation at 60° N.L. is to be expected due to the very low sun angle at this time of year.

B. The apparent modulation of a 5:1 targetas a function of scan angle is then shown in Figure 2. Since the C Factors are not significantly different between the 85/100 and 95/110 cases, the single set of modulation is used.

C. The MTF;s of the lenses employed are shown in Figure 3, while the expected smear (in microns/ms) is shown in Table 1. The smear values in Table 1 were adjusted to reflect the actual smear for the actual exposure time required.

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D. The final results are shown in Figures 4 and 5 where ground resolved distance is plotted vs. scan angle, Figure 4 being for the 85 nm perigee case and Figure 5 for the 100 nm perigee case. All the factors, now, of atmospheric attenuation, smear and scale are included in these plots and combine to cause the dramatic departure from best GRD.

E. A more meaningful presentation of the data, however, is given in Figures 6 and 7 where GRD is plotted against the percentage of the format expected to be better than any given GRD, Figure 6 being for the FWD-looking camera and Figure 7 for the AFT-looking camera. For example, at 30° N.L., 92% of the format of the FWD camera is expected to be better than 8 feet GRD for the 85 nm case; while only 55% of the format is expected to be better than 8 feet for the 100 nm case. In like manner, at 60° N.L., 42% of the FWD camera format is expected to be better than 10 feet, while in the 100 nm case 0% of the format is expected to be better than 10 feet.

[redacted]
Staff Scientist
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Distribution:
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C SECRET
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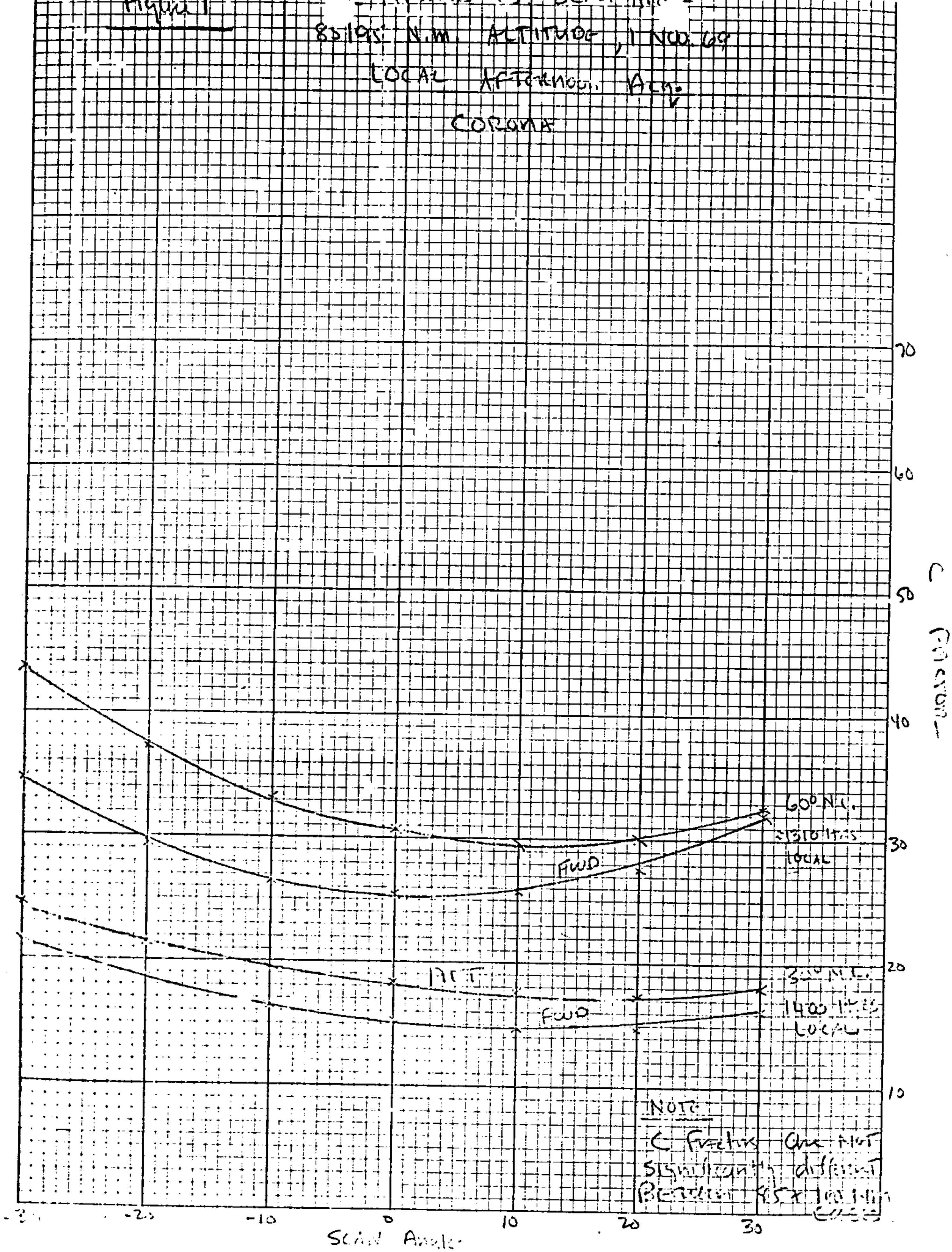
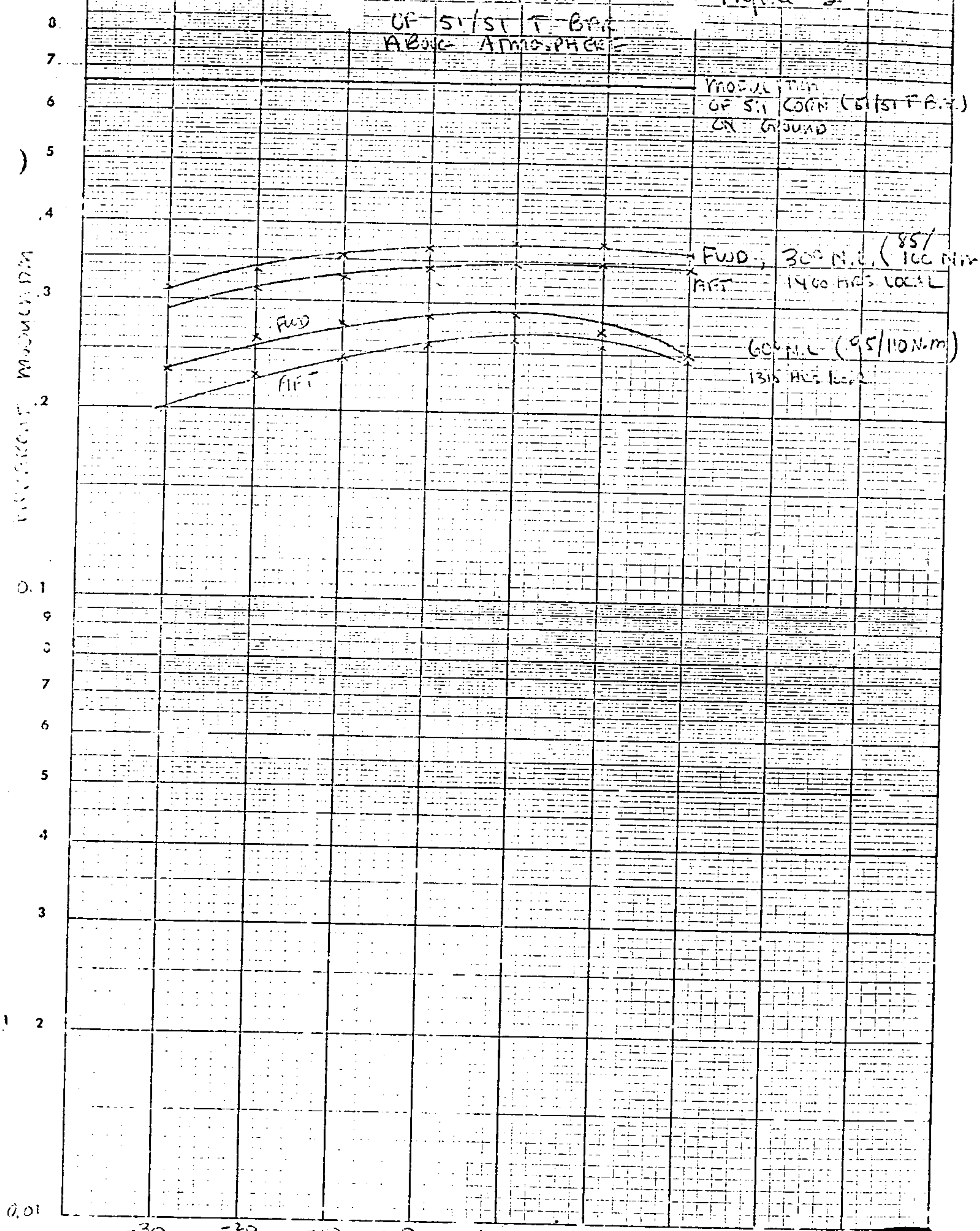

85195' N.M. ALTITUDE, 1 NOV. 69
LOCAL AFTERNOON AVG.
CORONA
FWD
AFT
FWD
60° N.L.
LOCAL
LOCAL
NOTE
C Factors are NOT
significantly different
Between 85 & 100 NM
70
60
50
40
30
20
10
-10
0
10
20
30
Scan Angle
C Factor



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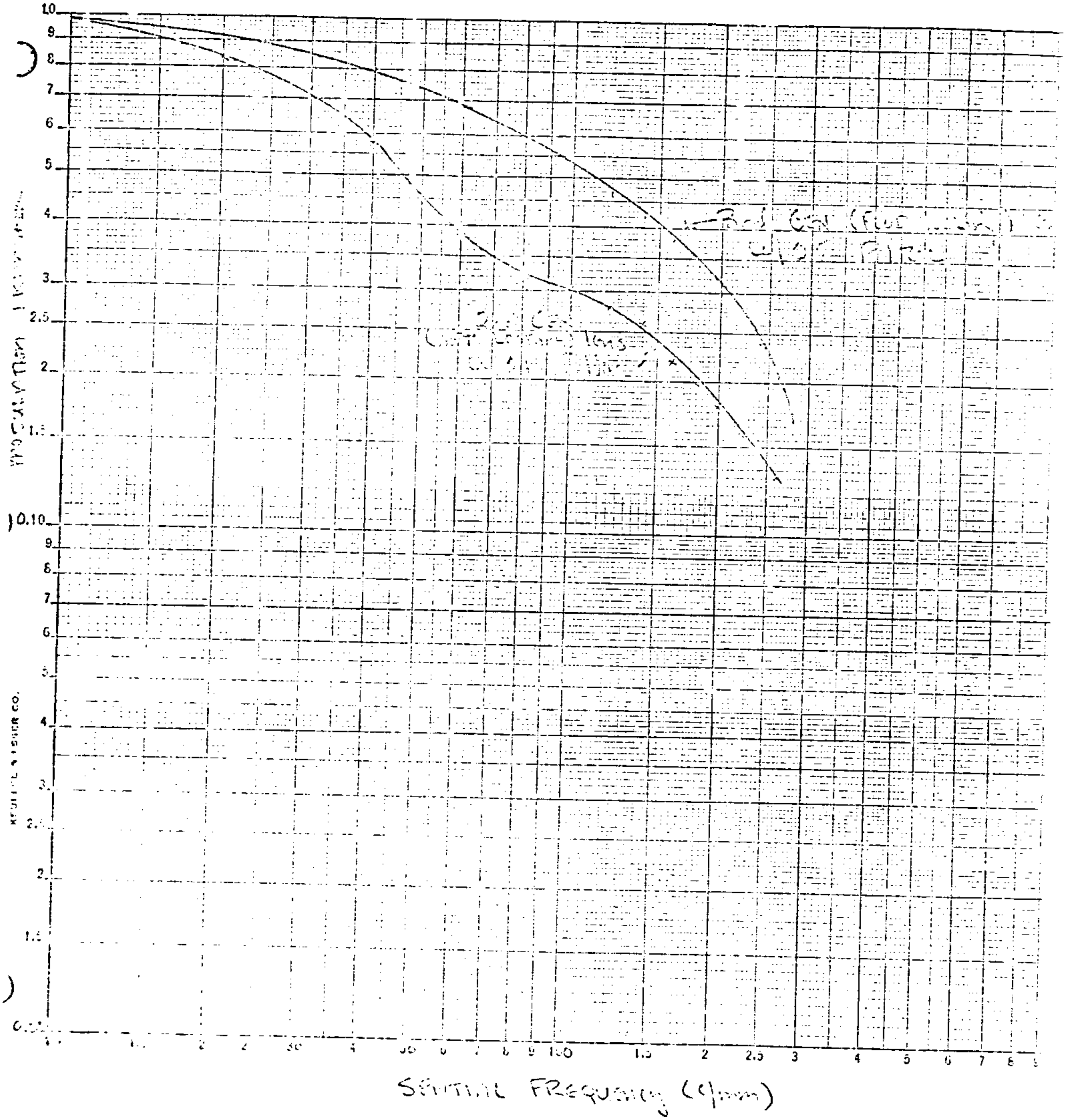
Polychromatic MTF's of 2nd and 3rd Generation Petzvals

Figure 3



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SMEAR IN MICRONS PER MILLISECOND OF EXPOSURE TIME

(FWD CAMERA)

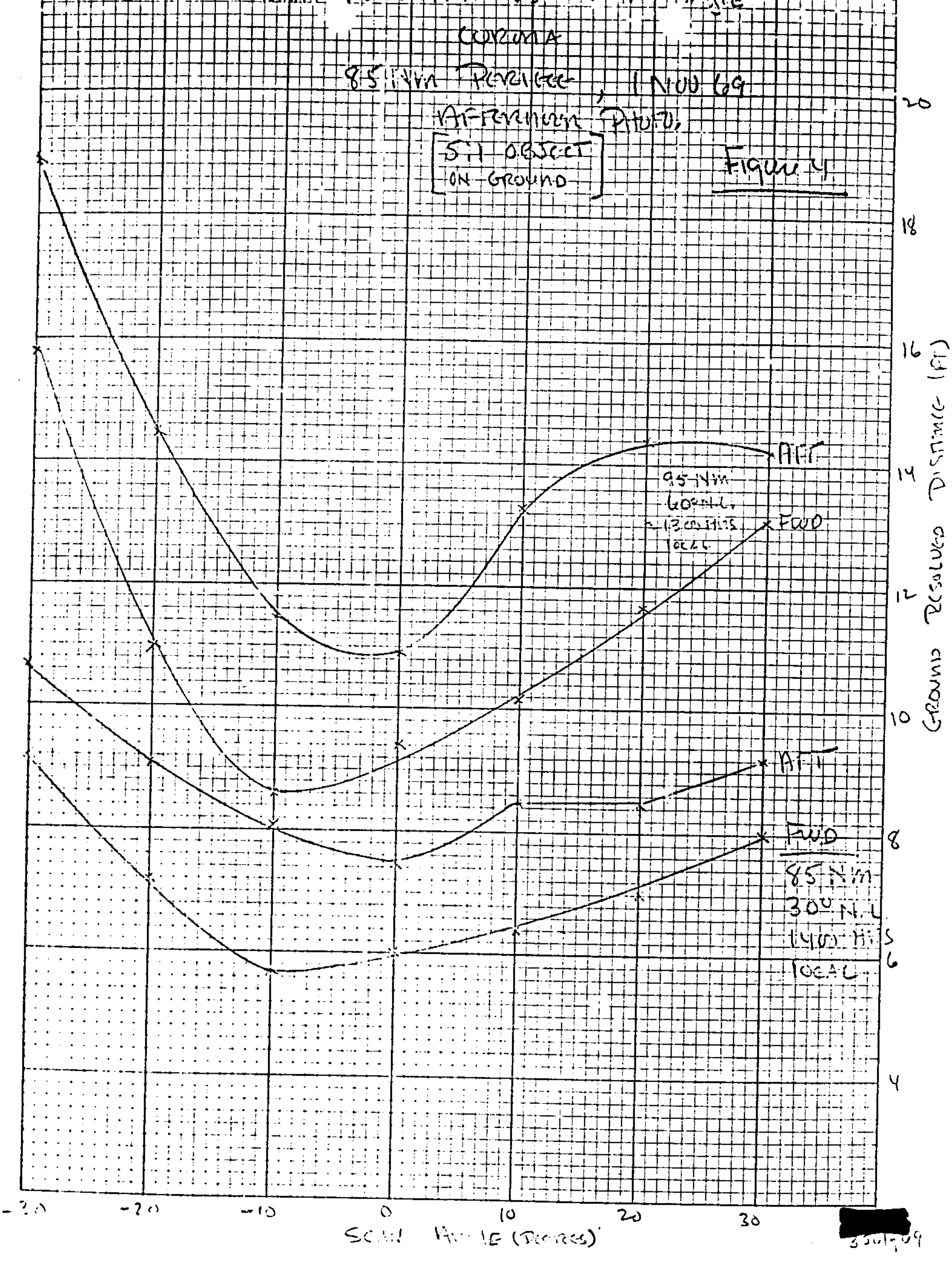
Altitude	Format Position -30	-20	-10	0	10	20	30	
85 nm	1.462	1.584	1.659	1.684	1.659	1.584	1.462	(1)
	4.332	2.028	.554	.894	1.555	2.080	2.562	(2)
95 nm	1.305	1.413	1.480	1.502	1.480	1.413	1.305	(1)
	3.860	1.644	.292	.964	1.487	1.891	2.285	(2)
100 nm	1.236	1.338	1.402	1.423	1.402	1.338	1.236	(1)
	3.660	1.481	.234	.994	1.458	1.811	2.167	(2)
110 nm	1.121	1.213	1.271	1.290	1.271	1.213	1.121	(1)
	3.314	1.200	.388	1.406	1.409	1.672	1.963	(2)

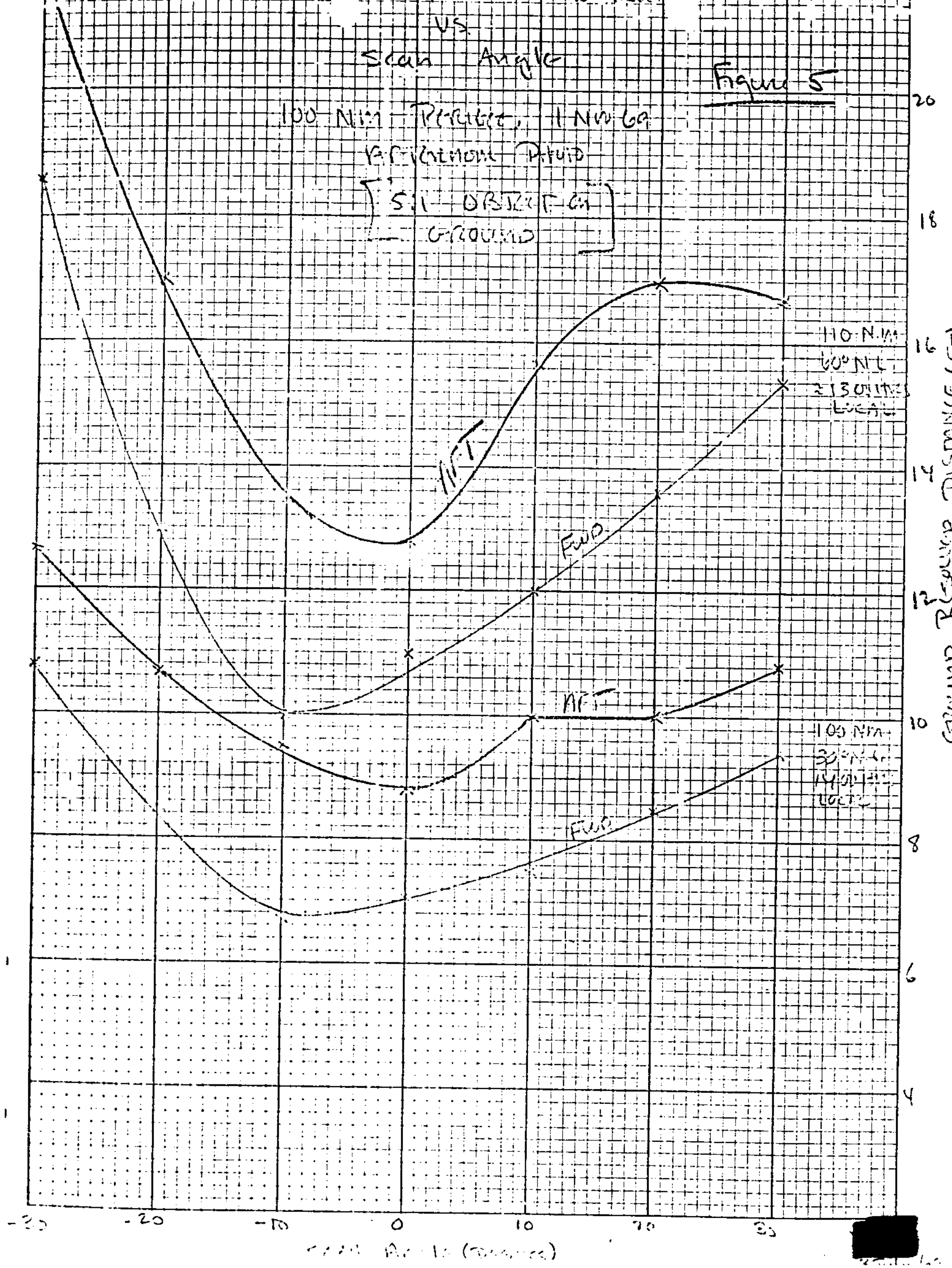
(AFT CAMERA)

Altitude	Format Position 30	20	10	0	-10	-20	-30	
85 nm	1.462	1.584	1.659	1.684	1.659	1.584	1.462	(1)
	2.548	3.238	2.482	.894	1.481	3.186	4.318	(2)
95 nm	1.305	1.413	1.480	1.502	1.480	1.413	1.305	(1)
	2.271	3.048	2.414	.964	1.219	2.802	3.846	(2)
100 nm	1.236	1.338	1.402	1.423	1.402	1.338	1.236	(1)
	2.153	2.968	2.386	.994	1.107	2.638	3.646	(2)
110 nm	1.121	1.213	1.271	1.290	1.271	1.213	1.121	(1)
	1.949	2.829	2.336	1.046	.915	2.357	3.300	(2)

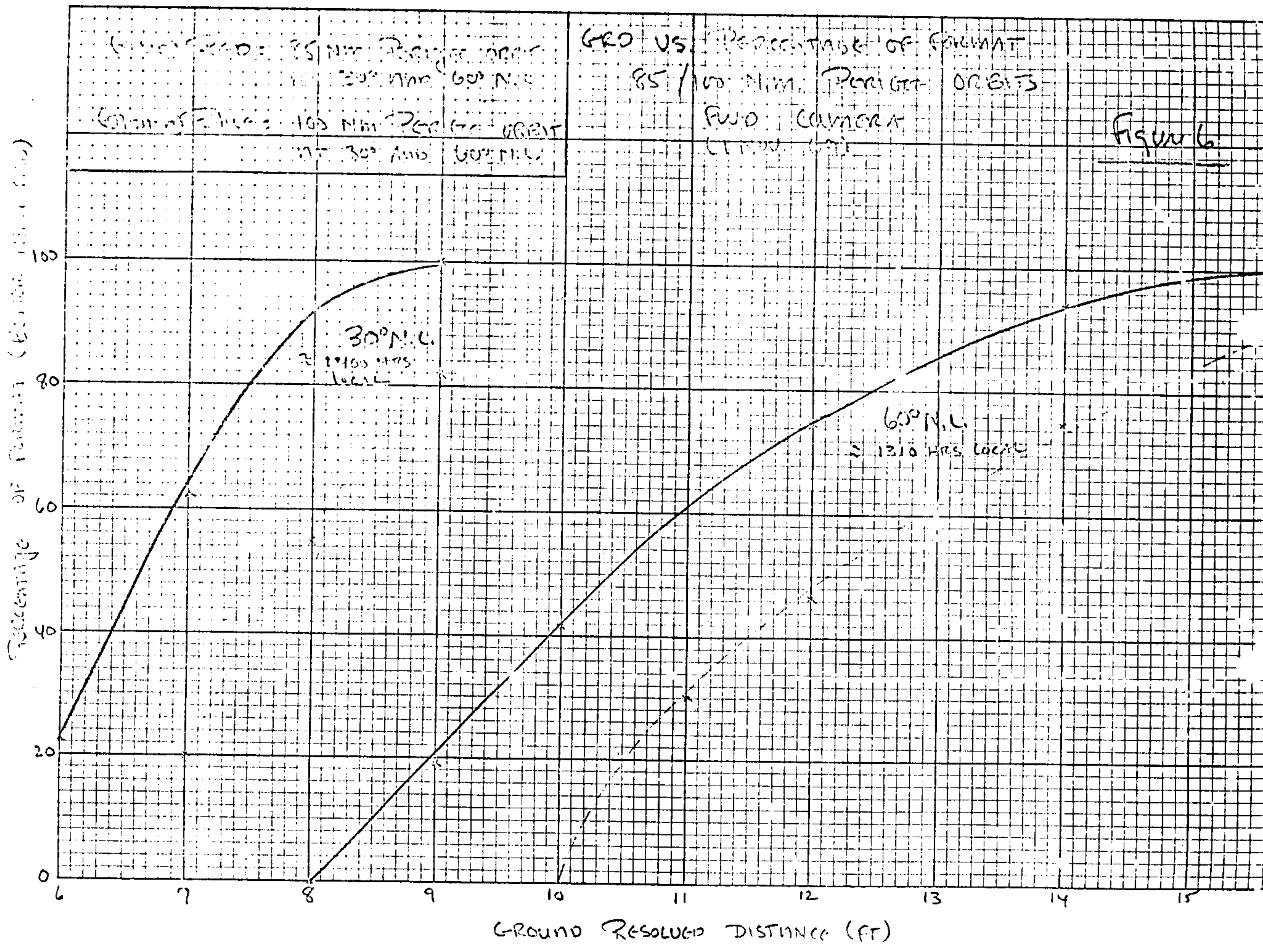
(1) Along Track
(2) Cross Track

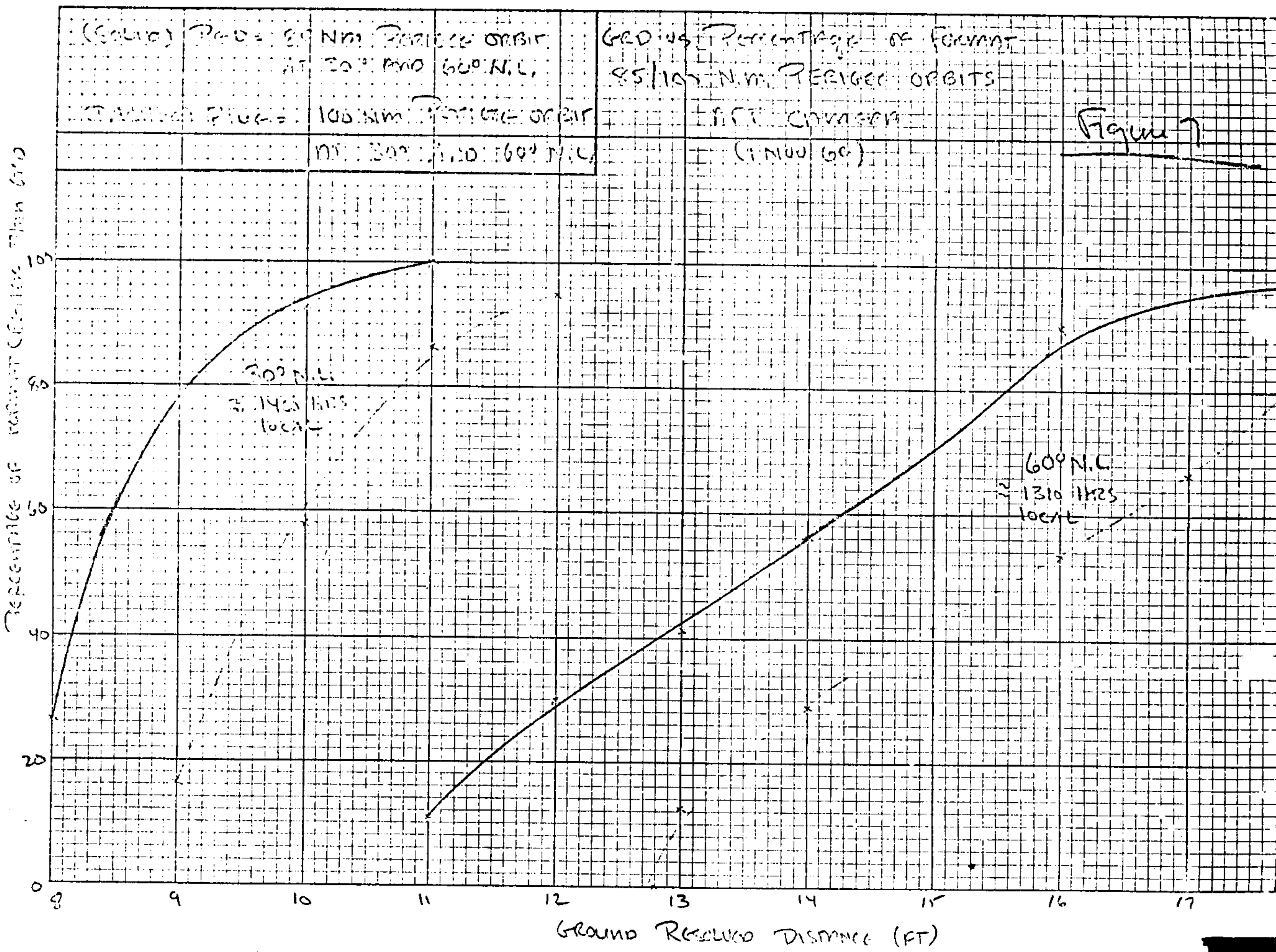
TABLE 1


CORONA
85 NM PERIGEE, 1 NOV 69
AFTERNOON PHOTO,
[5 FT OBJECT ON GROUND]
Figure 4
AFT
95 NM
40° N.L.
1300 HRS
LOCAL
FWD
AFT
FWD
85 NM
30° N.L.
1400 HRS
LOCAL
20
18
16
14
12
10
8
6
4
GROUND RESOLVED DISTANCE (FT)
-30
-20
-10
0
10
20
30
SCAN ANGLE (DEGREES)
[redacted]


VS
Scan Angle
Figure 5
AFT
FWD
AFT
FWD
110 NM
100 NM
20
18
16
14
12
10
8
6
4
-20
-10
0
10
GROUND RESOLVE DISTANCE (FT)

[redacted]


GRD VS. PERCENTAGE OF FORMAT
85/100 NM. PERIGEE ORBITS
FWD. CAMERA
Figure 6
30°N.L.
60°N.L.
≈ 1310 HRS LOCAL
0
20
40
60
80
100
6
7
8
9
10
11
12
13
14
15
GROUND RESOLVED DISTANCE (FT)


GRD vs Percentage of Format
85/100 N.M. Perigee Orbits
(1 Nov 66)
Figure 7
30° N.L.
≈ 1425 hrs
local
60° N.L.
≈ 1310 hrs
local
0
20
40
60
80
100
8
9
10
11
12
13
14
15
16
17
Ground Resolved Distance (FT)