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PERFORMANCE ANALYSIS FOR THE 1104 SYSTEM

2 APRIL 1969

CONTRIBUTORS: [redacted]

Itek OPTICAL SYSTEMS DIVISION

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1. SUMMARY

The performance of the 1104 system was better than the performance of any previous system of the KH-4 series. It is significant to note that the 1104 mission has been assigned an MIP rating of 115, the highest ever given.

A good description of the 1104 system's performance, as evidenced in the photographic record, appears in the performance estimate of the PEIR Report* for mission 1104.

"The overall image quality of mission 1104 is the best yet obtained from the CORONA system. The photointerpreters reported: 'The photointerpretability of mission 1104 is generally good when not degraded by atmospherics. The best of the FWD camera record is rated as being very good. The best of the AFT camera photography is also good but not as good as that of the FWD.' The PET† concurs in this observation. This is attributable to the fact that the FWD-looking camera used, for the first time, a third generation lens. The best resolution read from a mobile CORN‡ target was 5 feet in the flight direction."

A very interesting question that one may ask is how does mission 1104 compare with mission 1103 which did not receive a very favorable rating. The ground resolved distances from the CORN and fixed targets provide part of the answer. On the other hand, a visual image quality comparison between the two missions should be very helpful in placing the differences between missions 1103 and 1104 into proper perspective. The contractor's photointerpreter made such a visual comparison on photography obtained during domestic passes of both missions over populated areas of the West Coast. Primarily he compared imagery from the FWD-looking cameras of both systems and found that there was an obvious difference in the contrast of the photography. The 1103 system's imagery appeared to be of lower contrast and grainier (which is another indication of low contrast). The low contrast in the 1103 system's imagery may be due primarily to either the lens being out of focus or heavier haze conditions. The contractor's photointerpreter also observed subtle differences in the imageries of the two systems with respect to small detail, and he made the following comments:

1. Automobiles appear rather oval in shape in 1103 and more rectangular in 1104.

2. Piggyback trailer cargo on railroad flat cars is discernible in 1104.

3. Railroad cars are well defined and quite rectangular in 1104.

4. Commercial airliners are more identifiable as to their type in 1104. Their engine nacelles are quite prominent and aircraft with fuselage mounted engines are readily distinguished from other types. Other structural details of the aircraft, including tail booms and high horizontal stabilizers, are also in evidence.

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* [redacted]
† Performance evaluation team (PET).
‡ Controlled range network (CORN).

5. Pedestrian crosswalks and traffic lane stripes are resolved and easily identified in 1104; also, edges of buildings are better defined in 1104.

The performance evaluation which is described in this report has produced the following information which appears to be significant:

1. The optimum focusing of the panoramic cameras is still an unresolved ambiguity (see Section 2 of this report). The 1104 system appears to have been better focused than any of the previous systems of the 1100 series. However, this analysis shows the CORN and fixed target readings indicate a 0.001-inch focusing error for the FWD-looking camera and a 0.0015-inch focusing error for the AFT-looking camera.

2. The apparent air-to-vacuum focus shift* (utilizing the CORN and fixed target readings) seems to be 0.013 inch for the AFT-looking camera and 0.014 inch for the FWD-looking camera.

3. In Section 3.3 of this report, GRD predictions were made for the CORN and fixed targets that were photographed with the primary filters (W-21 for the AFT-looking camera and W-25 for the FWD-looking camera). There was a total of 18 GRD numbers predicted. Of these, 7 are within 1/2 foot of their respective average target readings, 10 are within 1 foot and 17 are within 2 feet. The accuracy of the predictions would increase further if the predictions could be made for the actual contrast of the targets at the lens aperture.

4. In Section 3.4 of this report it was established that the rms V/h programming error for the first priority targets was indeed very small and therefore does not affect the panoramic camera performance. The average altitude of photography for these targets was about 88.6 nm primarily because the perigee latitude of the orbit was much further south than the average latitude of the first priority targets. It should be pointed out that the 1104 mission orbit was very similar to the orbits of previous missions.

5. The first priority targets were found to be approximately uniformly distributed along the length of the format. Since the large scan angles are associated with appreciable cross-track smear and smaller scale photography, if possible, missions should be planned in such a way that the first priority targets would tend to fall in the center of the format.

6. A study was carried out to determine possible ways of improving the resolution performance of the 1104 panoramic system with respect to the first priority targets. This study showed that a 29 percent improvement in resolution performance would have been achieved if the following conditions had prevailed:

a. Both lenses were focused to maximize tri-bar resolution.

b. The average altitude of photography was 80 nm.

c. SO-230 film was used instead of 3404 (assuming the SO-230 film is of equal quality to the 3404 film).

7. It appears that the combination of the third generation lens, the panoramic cameras in their present configuration, and the exposure times required for the 3404 film is such that the image quality of which the third generation lenses are capable will not be fully realized. The systems are image smear limited, therefore, a film faster than 3404 and of at least equal quality to 3404 would be more suitable for the panoramic cameras equipped with third generation lenses.

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* The apparent air-to-vacuum focus shift includes the actual air-to-vacuum focus shift plus all the focus shifts that occur between the ambient conditions in the laboratory and the actual environmental conditions of a mission.

2. CAMERA FOCUS EVALUATION

The difficulties experienced with the focus adjustments of the panoramic cameras have been discussed in detail in the performance reports for missions 1101, 1102, and 1103.*

The uncertainties in the focus conditions of the panoramic cameras during the mission is a problem of prime concern to the contractor and one which has not been satisfactorily solved. A careful review of Section 2 of these reports should be highly pertinent to the discussion of the present section.

Fundamentally, the focusing difficulties arise from two sources:

1. The air-to-vacuum focus shift of the Petzval lenses is not known to better than 0.001 inch.
2. The thermal and vacuum environment of the lenses during a mission induces focus shifts (probably less than 0.001 inch) which have not been accurately determined.

Of course, the focusing difficulties could be eliminated by utilizing a chamber in which the mission environment could be simulated and which in addition has photographic capabilities. This idea has already been suggested in the performance reports for missions 1102 and 1103.

Some experience on focusing the panoramic cameras has been gained from the results of missions 1101, 1102, 1103, and 1104. Specifically, the cameras for missions 1102 and 1104 appeared to be properly focused as evidenced from the photographic record. However, there is no certainty that they were optimally focused, since only relatively large focusing errors can be detected in the photographic record. In addition, there has been a continuous improvement in the lens quality between systems 1101 and 1104. Significantly, the FWD-looking camera of system 1104 carried the first third-generation Petzval lens to be used in a photographic mission. In the absence of previous experience with third generation lenses, one cannot conclude that this lens was precisely focused by observing its photographic record. As long as it performed better than a second generation lens, it would appear as if it was properly focused. It is also worth mentioning that the focusing adjustment is more critical for a third generation lens because its depth of focus is smaller than the depth of focus of a second generation lens.

In Section 2.2 of the performance analysis report for system 1103 it was stated that a theoretical investigation was conducted on a third generation lens with a W-25 filter and on a second generation lens with a W-21 filter. This investigation showed that for the third generation lens, the minimum rms wavefront distortion lies 0.0004 inch further away from the field flattener than the low contrast (2:1) resolution peak; while for the second generation lens, the corresponding displacement is 0.0005 inch. These results imply that the optimum focus position for general photography lies about 0.0005 inch beyond the low contrast resolution peak.

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*1101 report no. [redacted] 1102 report no. [redacted] 1103 report no. [redacted]

A similar but more accurate theoretical investigation on the same two lenses showed that the rms wavefront distortion should reach a minimum about 0.0005 inch beyond the low contrast resolution peak for the second generation lens and between 0.0000 and 0.0002 inch beyond the low contrast resolution peak for the third generation lens. This difference between second and third generation lenses can be explained by the fact that the third generation lenses are better approximations to the diffraction limited lens for which the optimum focus position for general photography coincides with the low contrast resolution peak. In fact, in terms of rms wavefront distortion, a properly focused third generation lens represents an improvement of about 50 percent over a second generation lens.

Some special tests were performed on the panoramic cameras of the 1105 system (see Appendix E of the 1103 Performance Report) which effectively showed that the third generation lens (FWD-looking camera) reached its optimum MTF* at the focus position which produced the low contrast resolution peak, while for the second generation lens (AFT-looking camera) the optimum MTF appeared to lie 0.0005 inch beyond the low contrast resolution peak. In any case, the optimum focus position for general photography should be determined by performing through focus resolution tests with various amounts of IMC mismatch, as has already been recommended in the 1101 and 1103 system performance reports.

Figs. 3-1 through 3-4 show the final through focus resolution tests performed on the panoramic cameras of the 1104 system. The 0 focus position indicates the position occupied by the film for an air-to-vacuum focus shift of 0.014 inch. Examination of Figs. 3-1 through 3-4 suggests that, with respect to the optimum lens MTF discussed above, the lenses were focused as if the air-to-vacuum focus shift was expected to be 0.0145 inch for the AFT-looking camera and 0.0131 inch for the FWD-looking camera.

Some indications of the apparent air-to-vacuum focus shifts for mission 1104 have been obtained from the CORN target readings. The apparent air-to-vacuum focus shift includes the actual air-to-vacuum focus shift plus all the focus shifts that occur between the ambient conditions in the laboratory and the actual environmental conditions that exist during the mission. Predictions were made for the CORN targets photographed in mission 1104, and in order to obtain a favorable correlation between the predictions and the actual readings (see Table 3-4 and Section 3.3), it was necessary to assume that the apparent air-to-vacuum focus shifts were 0.013 inch for the AFT-looking camera and 0.014 inch for the FWD-looking camera. So, it appears that the 1104 system was not optimally focused, even though the photographic record showed no obvious focusing errors.

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*Modulation transfer function (MTF).

3. SYSTEM PERFORMANCE

3.1 CORN TARGET RESOLUTION

Each CORN target deployed consisted of the 51/51 tri-bar resolving power target, a Gray scale target, and a 100-foot edge target. These targets have already been described in the mission 1101 performance analysis report, so their description will not be repeated here. A more thorough description of these targets is also available in the CORN Target Manual.

Table 3-1 — CORN Target Coverage

Pass	Frame	x, centimeters	y, centimeters	Location
14	6 FWD	36.4	1.3	Steward AFB, New York, CORN target, 41° 30' N, 74° 5' W
	12 AFT	39.0	4.4	
16	6 AFT	43.1	2.2	Edwards AFB, California, fixed target, 34° 51' N, 117° 45' W
16	6 FWD	44.5	3.1	San Bernardino, California, CORN target, 34° 6' N, 117° 15' W
	12 AFT	30.8	2.6	
129	10 FWD	50.9	3.5	Indian Springs, Nevada, fixed target, 36° 42' N, 115° 29' W
	16 AFT	24.5	1.7	
129	12 FWD	30.5	0.1	Pahrump, Nevada, fixed target, 36° 19' N, 116° 2' W
	18 AFT	44.9	5.2	
129	13 FWD	30.3	5.2	
	19 AFT	44.7	0.2	
145	32 FWD	30.1	1.7	Phoenix, Arizona, CORN target 33° 30' N, 112° 0' W
	38 AFT	45.1	3.6	

Table 3-1 lists the geographic distribution of the CORN targets which were deployed and photographed. In addition, three of the targets listed in Table 3-1 were fixed (not mobile) installations. The first two columns labeled Pass and Frame uniquely identify the frame on which the image of a specific target display appears. The x and y coordinates listed in Table 3-1 pinpoint the position of the target image on the respective panoramic frame according to the universal grid system.

The images of the CORN and fixed targets were examined by two observers who determined the corresponding ground resolved distances. The average readings are shown in Table 3-2. The readings were taken from the original negative unless marked otherwise. As in the previous missions, an insufficient number of CORN targets has been photographed. A minimum of six CORN targets should be photographed in each mission, in addition to any fixed targets that may be covered. A small number of CORN targets (less than six) could conceivably create erroneous impressions about a system's actual performance.

Table 3-2 — Resolution Target Readings, Average of Two Contractor Readers, feet

Pass	Frame	Along Track	Cross Track	Filters	Weather Estimate
14	6 FWD	8.0	7.1	W-25	Clear with scattered
	12 AFT	8.0	8.0	W-21	cumulus clouds
16	6 AFT	8.0	8.0	W-21	Clear
16	6 FWD	5.7	8.0	W-25	Clear
	12 AFT	12	>16	SF-05	Clear
129	10 FWD	6.1	6.8	W-25	Clear
	16 AFT	>13.6	>13.6	SF-05	Clear
129	12 FWD	5.5	6.8	W-25	Clear
	18 AFT	>13.6	10.9	SF-05	Clear
129	13 FWD	4.8	6.8	W-25	Clear
	19 AFT	9.7	9.7	SF-05	Clear
145	32 FWD	8.0	7.0	W-25	Clear
	38 AFT	8.0	8.0	W-21	Clear

Table 3-2 also shows that four of the targets were photographed by the AFT-looking camera with an SF-05 filter. Consequently, only the remaining three targets were photographed with a W-21 filter. It is hardly worthwhile to attempt any serious performance analysis and evaluation with such a meager sample of resolution targets.

As far as the SF-05 filter is concerned, it is obvious from Table 3-2 that the resolution performance of the AFT-looking camera with this filter is poor as expected. This is due to the reduced contrast photography associated with the SF-05 filter as well as to the reduced resolution performance of the AFT-looking camera lens with the specific SF-05 filter that was utilized.

3.2 DETERMINATION OF OPERATIONAL RESOLUTION

The method for determining the operational resolution is discussed more extensively in Section 3.2 of the 1101 performance analysis report. This technique is described only briefly in the present section.

The dynamic camera resolution, image smear, and static lens-film resolution for any image point are related by the expression:

$$R_d = \frac{R_s}{[1 + (bR_s)^{E_1}]^{E_2}} \qquad (3.1)$$

where R_d = dynamic camera resolution
b = image smear
R_s = static lens-film resolution
E_1 and E_2 = experimentally determined exponents

Exponents E_1 and E_2 were determined from resolution versus image smear tests performed at the contractor's laboratory. Table 3-3 shows the exponents that were determined for the 1104 FWD- and AFT-looking cameras. The static resolution, R_s, at a specific point of the panoramic format is dependent on the performance of the Petzval lens at the corresponding field angle, the focus position occupied by the film, and the film characteristics. Thus, for all practical purposes, R_s varies over the panoramic format of a camera, but is not a function of time (does not vary between successive frames). In fact, one could construct a contour map of R_s over the panoramic format.

Table 3-3 — Mission 1104 Exponents

AFT		Contrast	FWD	
E_1	E_2		E_1	E_2
2.00	0.64	High	1.90	0.70
2.00	0.63	Low (2:1)	2.20	0.70

In the resolution predictions, the values of R_s are determined individually for each target. To accomplish this, the static resolution of the lens as a function of field angle and focus position (from laboratory data) are utilized. For a specific target image, its y coordinate gives immediately the field angle the image occupies. In order to determine the focus position the same target image occupies, it is necessary to review the film flatness tests which provide the relative focus position of the target image with respect to the center of format. Finally, the operational focus position at the center of the format can be obtained from the final dynamic resolution versus focus tests performed at the contractor's laboratory. The results of these tests have been plotted in Figs. 3-1 through 3-4. The anticipated focus position at the center of format during the mission is also shown in these figures. Having determined the field angle and focus position of a specific target, the associated R_s values are readily obtained.

The computation of image smear is also described in detail in Section 3.2 of the 1101 performance analysis report. Since it is not possible to compute the image smear exactly, a systematic image smear component, b_s, and a random component, b_r, are separately computed for each target image. Then the total image smear, b_t, is determined by the equation

$$b_t = b_r + |b_s| \qquad (3.2)$$

Factor b_t is introduced into Equation (3.1) and utilized in the computation of the dynamic camera resolution, R_d. In turn, the ground resolved distance is related to R_d by a scale factor affected by vehicle altitude, camera focal length, and location on the panoramic format of the target image. The ground resolved distance which is computed in this fashion is a probabilistic quantity. Thus, the predicted ground resolved distance is not equal to the actual ground resolved distance. Instead, the predicted ground resolved distance implies that the probability that the actual ground resolved distance is smaller than the predicted value is between 64 and 84 percent. Therefore, the average predicted ground resolved distance is larger than the average actual ground resolved distance.

Resolution predictions were computed for the CORN targets of Table 3-1 and the first priority targets of Appendix B.

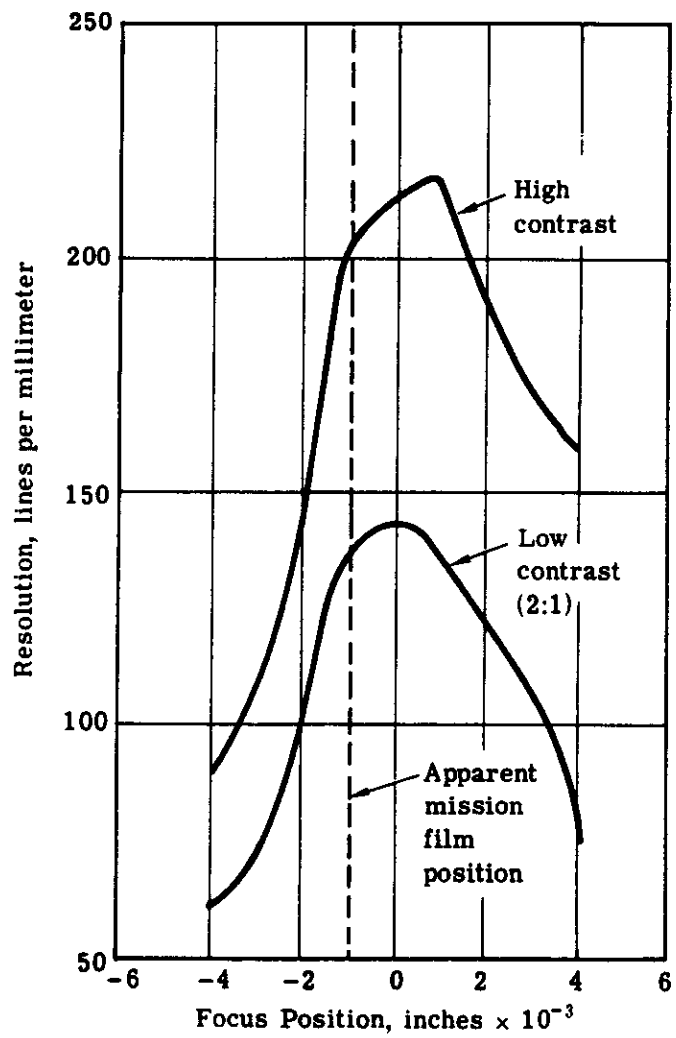

Fig. 3-1 — Dynamic resolution versus focus position, AFT-looking camera no. 308, along track, Wratten no. 21 filter

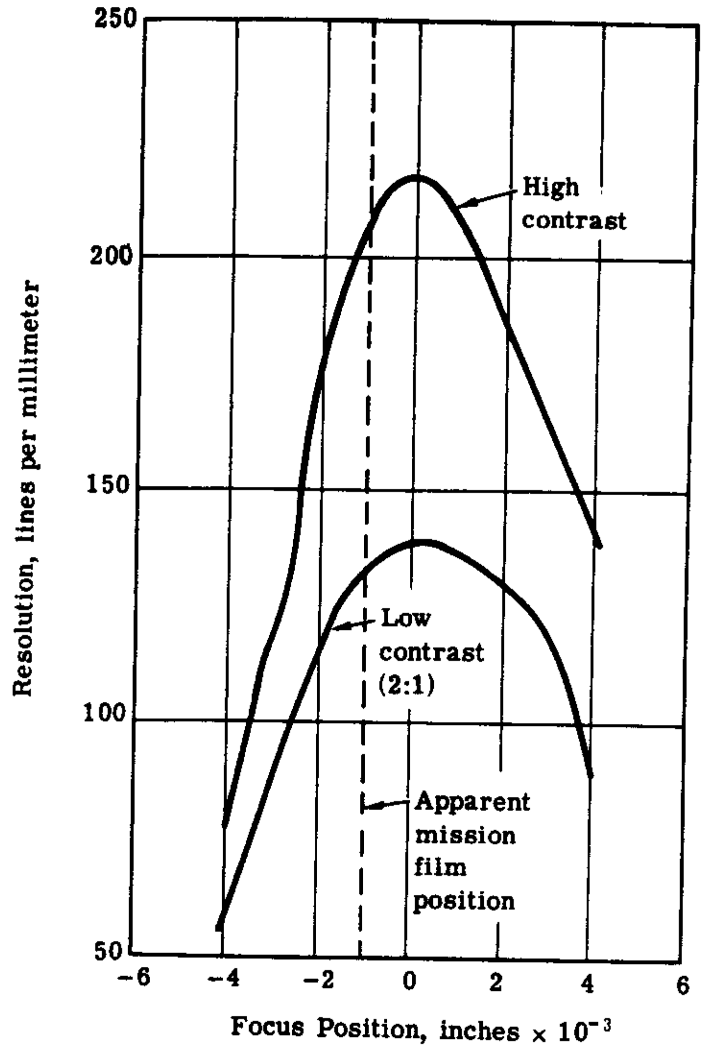

Fig. 3-2 — Dynamic resolution versus focus position, AFT-looking camera no. 308, cross track, Wratten no. 21 filter

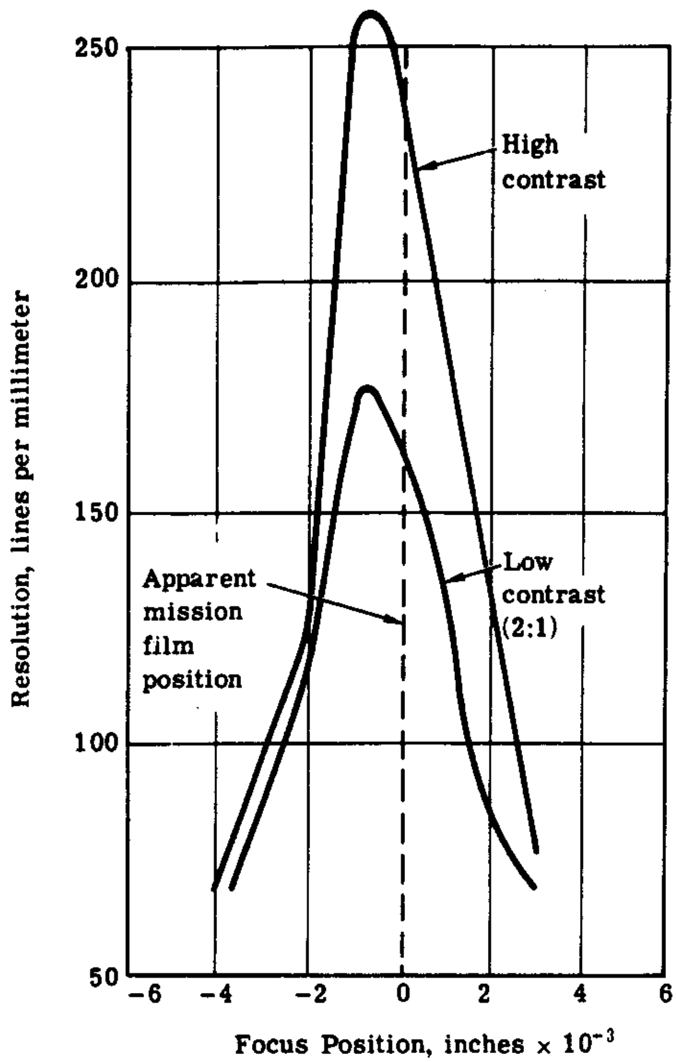

Fig. 3-3 — Dynamic resolution versus focus position, FWD-looking camera no. 309, along track, Wratten no. 25 filter

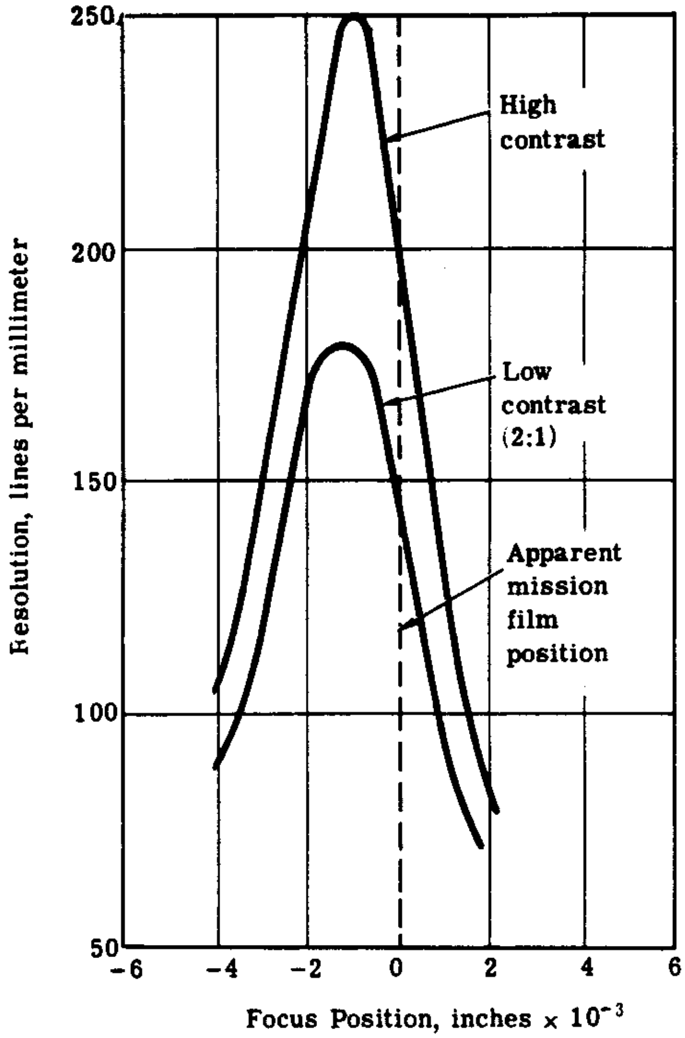

Fig. 3-4 — Dynamic resolution versus focus position, FWD-looking camera no. 309, cross track, Wratten no. 25 filter

3.3 COMPARISON OF CORN TARGET AND PREDICTED RESOLUTIONS

A fair comparison between a CORN target reading and the corresponding predicted ground resolved distance cannot be conducted without a knowledge of the apparent contrast of the target at the lens aperture. Resolution predictions have been computed for very high contrast and low contrast (2:1) tri-bar targets. On the ground, the contrast of the CORN targets is a nominal 4.7:1. The fixed targets are usually of higher contrast, approximately 10:1, but their real contrast at the lens aperture is unknown.

On the other hand, during the photographic mission, the contrast of all ground objects including resolution targets is reduced by the atmosphere. The loss in contrast is affected by weather conditions as well as by solar elevation and azimuth. In Section 3.1 of the 1101 performance analysis report, the relationships between contrast and modulation are described. In the same section, a method for determining the apparent CORN target contrast at the lens aperture is also described. This method requires that microdensitometer traces be obtained on the original negative of the edge target which is part of the CORN target display. The fixed target displays have no edge targets. Thus, for the fixed targets, the apparent target contrast or modulation cannot be computed.

For mission 1104, the apparent contrast of the CORN targets was computed by the method discussed in the 1101 performance report. However, the apparent contrast numbers obtained were much larger than those obtained from the previous three missions. It was assumed that they were erroneous and were not included in this report. An investigation of the data and the computations leads one to believe that the errors are either in the density measurements or the D-log E curve. The density measurements are similar to those obtained in previous missions. However, the D-log E curve is different because of the dual gamma processing which was carried out for the first time on mission 1104. If the D-log E curve is in error, it will produce errors in other evaluation work that is being carried out. Therefore, it would be worthwhile to resolve this apparent discrepancy.

Table 3-4 provides a means of comparing the CORN and fixed target readings with the predicted ground resolved distances. The columns identified as Average Reading have entries which are the corresponding average readings taken from Table 3-2. A direct comparison is not possible because the predictions were made for targets of 2:1 contrast, and the apparent contrast of the actual targets is variable and unknown. Despite this limitation, the following definite statements can be made for the 18 GRD numbers predicted:

1. 7 predicted GRD numbers are within 1/2 foot of the actual readings.
2. 10 predicted GRD numbers are within 1 foot of the actual readings.
3. 17 predicted GRD numbers are within 2 feet of the actual readings.

3.4 EVALUATION OF SYSTEM OPERATION

3.4.1 Altitude of Photography

For the first priority targets for which resolution predictions were computed, the average altitude of photography turned out to be 88.6 nm. It should be obvious that the average ground resolved distance and more significantly, the scale of the photography could be increased approximately 10 percent by photographing the first priority targets from an average altitude of 80 nm. Fig. 3-5 shows the altitude distribution of the first priority targets. Each point in this chart

Table 3-4 — CORN Target Readings and Predictions,* feet

Pass	Frame	Along Track: Average Reading	Along Track: Predicted GRD	Cross Track: Average Reading	Cross Track: Predicted GRD
FWD-Looking Camera					
14	6	8.0	7.3	7.1	6.9
16	6	5.7	5.9	8.0	6.1
129	10	6.1	6.0	6.8	5.7
129	12	5.5	6.3	6.8	8.2
129	13	4.8	7.1	6.8	7.8
145	32	8.0	6.4	7.0	7.0
AFT-Looking Camera					
14	12	8.0	7.8	8.0	7.7
16	6	8.0	7.7	8.0	6.7
145	38	8.0	6.8	8.0	6.4

* Predictions applicable to targets of 2:1 contrast.

represents one or more targets. There are also two targets photographed on revolution nos. 201 and 203 which are not shown in Fig. 3-5. The first priority targets fall in the following categories according to their respective altitudes of photography:

1. 8 targets between 95 and 100 nm
2. 11 targets between 90 and 95 nm
3. 18 targets between 85 and 90 nm
4. 12 targets between 82 and 85 nm.

Fig. 3-5 shows that the altitude of photography for the first priority targets is somewhat reduced as the mission progresses. The average geographic latitude for the first priority targets is approximately 48.5°N with a standard deviation of about 7.4 degrees. However, for system 1104, the perigee of the orbit was maintained throughout the mission at latitudes between 5.3°N and 50°N, while the altitude at perigee varied between 84.7 and 81.5 nm. Therefore, it is evident that the first priority targets were photographed at an average altitude of 88.6 nm mainly because the perigee latitude was considerably farther south than the average latitude of the first priority targets. This is particularly true for the first priority targets that were photographed during the first half of the mission because the perigee latitude started at 5.3°N and progressed to 50°N. The most desirable solution to this problem would be to maintain the perigee altitude to 80 nm and the perigee latitude to 48°N throughout the mission.

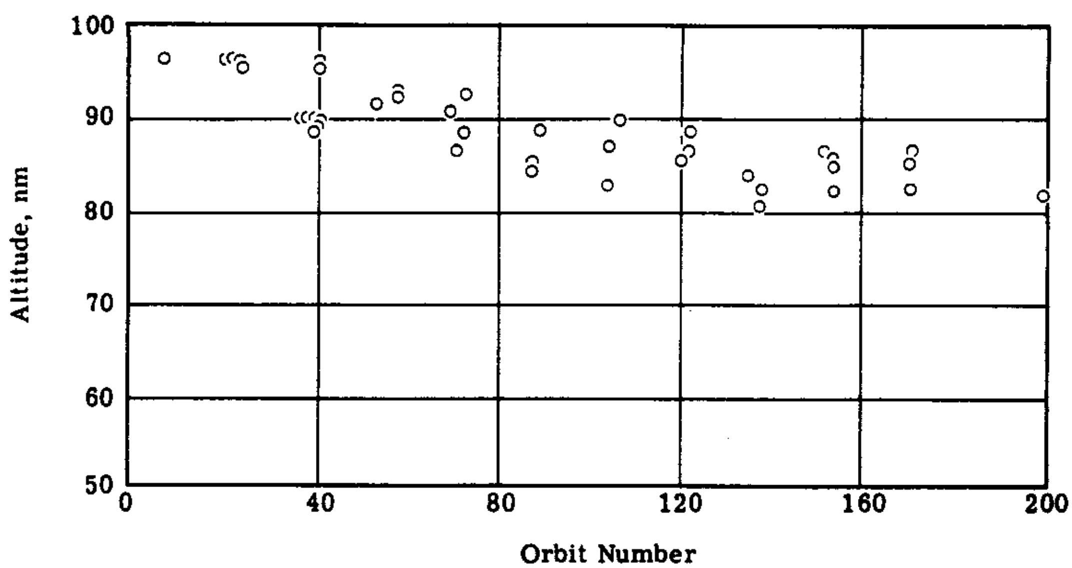

Fig. 3-5 — Altitude distribution of first priority targets

3.4.2 V/h Errors

The FMC rates of the panoramic cameras were checked against the required V/h rates computed from ephemeris data. This was done for the frames of both panoramic cameras which contained first priority targets. For these frames the average V/h error was 0.14 percent while the standard deviation of the V/h errors from this mean was computed to be 0.67 percent. Therefore, the V/h errors for the frames checked are well within the allowable rms error of 1.41 percent.

3.4.3 Distribution of First Priority Targets Over the Format

It was observed that approximately 50 percent of the first priority targets had fairly large (larger than 5 microns) image smears associated with them in the cross-track direction (see Appendix B). It was felt that perhaps the first priority targets happened to lie far away from the center of format (large scan angles) where cross-track image smear is usually large. This possibility was investigated by determining the location of the first priority target images in the panoramic format in terms of scan angle. The following distribution of the first priority targets was obtained.

1. 16 targets between 0 and 5 degrees of scan angle
2. 5 targets between 5 and 10 degrees
3. 17 targets between 10 and 15 degrees
4. 12 targets between 15 and 20 degrees
5. 16 targets between 20 and 25 degrees
6. 18 targets between 25 and 30 degrees
7. 10 targets between 30 and 35 degrees.

The average scan angle was computed to be 17.5 degrees, with a standard deviation of 9.5 degrees. It appears that the distribution of first priority targets over the format in terms of scan angle is fairly uniform. A similar investigation was conducted for the first priority targets of mission 1103 andgave similar results (an average scan angle of 15.1 degrees and a standard deviation of 9.4 degrees). It would be highly desirable in every mission to photograph the first priority targets at small scan angles because image smear is greatly reduced at small scan angles and the scale of photography is also reduced. All the constraints in planning a mission are not known to the contractor, but it seems that it might be possible to photograph the same number of first priority targets at small scan angles.

3.4.4 Ultimate Resolution Performance

Ways by which the performance of the 1104 panoramic cameras could have been optimized will now be considered. All possibilities that were considered fall under one of the following categories:

1. Reduction of image smear
2. Reduction of altitude of photography
3. Improvement of lens focusing techniques.

In Table 3-5, various steps which would have improved the 1104 system performance with various degrees of success have been listed. In Table 3-6, the average expected ground resolved distances for the cases described in Table 3-5 have been entered. In Table 3-6, an attempt has been made to use identical values for all parameters which should be invariant between any two cases. This is essential in order to make a valid comparison. At the same time, data from mission 1104 have been used in order to make the comparison directly applicable to this mission. The data utilized were obtained by averaging the respective data from the first priority targets. Thus, average image smear, average static lens resolutions, and average scale factors were determined for the first priority targets.

Case H shows the optimum performance level of which the 1104 system was capable. For this case, the following assumptions have been made:

1. Both lenses have been focused to maximize tri-bar resolution.
2. The average altitude of photography is 80 nm.
3. Type SO-230 film replaces Type 3404.

Comparing Cases H and A in Table 3-6 shows that Case H represents a 29 percent improvement in performance over Case A. Approximately 15 percent of the improvement would result by replacing Type 3404 film with SO-230 and approximately 10 percent would result by reducing the average altitude of photography (for the first priority targets) to 80 nm.

Table 3-5 — List of System Configurations

Case	Description
A	Actual mission 1104 configuration
B	Identical to A except the average altitude of photography reduced to 80 nm
C	Identical to A except the cameras focused for maximum resolution
D	Identical to C except the average altitude of photography reduced to 80 nm
E	Identical to A except that Type 3404 film replaced by Type SO-230
F	Identical to E except that the average altitude of photography reduced to 80 nm
G	Identical to C except that Type 3404 film replaced by Type SO-230
H	Identical to G except the average altitude of photography reduced to 80 nm

Table 3-6 — Comparative Chart of Average System Performance, Low Contrast GRD, feet

Case	FWD-Looking Camera		AFT-Looking Camera	
	Along Track	Cross Track	Along Track	Cross Track
A	6.8	10.6	8.0	9.8
B	6.2	9.5	7.2	8.8
C	6.4	10.3	7.5	9.4
D	5.8	9.3	6.8	8.5
E	6.2	7.6	7.7	8.2
F	5.6	6.9	7.0	7.4
G	5.7	6.9	7.2	7.7
H (Goal)	5.2	6.2	6.5	7.0

In the performance analysis report for mission 1103, it was stated that the corresponding improvement in performance if a similar optimization of parameters was introduced would be only 19 percent. This difference between systems 1103 and 1104 can be explained by the superior optical quality (compared with a second generation lens) of the third generation lens in the FWD-looking camera of the 1104 system. Stated in another way, the third generation lenses allow the panoramic cameras to reach a much higher level of performance. However, this higher level of performance is attainable only when the focus error and image smear are further reduced below their respective levels which were allowable for a second generation lens. The use of the Type SO-230 film should effectively reduce image smear by a factor of 2 and should make it possible to more fully realize the image quality of which the third generation lenses are capable. Hence, an important conclusion is that the Type SO-230 film is the most suitable for the third generation lenses.

4. A-TAKEUP EXPERIMENT

The A-takeup experiment was undertaken to quantitatively define the image quality characteristics of the particular emulsion batch of film used on each successive 1100 mission. The primary film samples that are evaluated are obtained from the first 100 to 150 feet of preflight cycling. This material is run through the camera before launch and is recovered from the A bucket. There is, as might be suspected, a chance that this film sample would become fogged during this operation, since this preflight cycling procedure is not for the purpose of obtaining this film but to check out the camera system prior to flight. The samples from mission 1104 were, in fact, fogged, thus making the A-takeup analysis impossible on this mission.

5. DENSITY

5.1 OBJECTIVE

This section is concerned with an assessment of the quality of exposure given the frames containing Priority I targets. The assessment was made by analyzing the maximum and minimum densities from microdensitometer traces of the image of these targets. If the densities fell beyond certain limiting values, the image was judged to be over- or underexposed. One significant factor associated with this mission was different from previous missions. This was the first 1100 series mission to be processed in the dual gamma process.* This process is unlike the normal Trenton full process in that the slope of the curve in the upper density region is much lower. The dual gamma characteristic curve shape is virtually identical to that of the Trenton Full process in the toe region.

5.2 PROCEDURE

Forty-seven Priority I targets from mission 1104 were examined. Since each target was covered with both cameras, there were 94 target acquisitions. A microdensitometer with a 10-micron aperture is used to scan the target images.† At the scales of photography involved in this mission, the equivalent ground coverage by these measurements is an area 9 to 10 feet in diameter. Calibration was maintained by periodically scanning the R-2 control sensitometric strip. The maximum and minimum densities are then picked off the microdensitometer trace for evaluation. The criterion for evaluating exposure is that a target is underexposed if the minimum density is below 0.4. The target is considered overexposed if the minimum density is greater than 0.8 or if the maximum density is greater than 2.0. The value of 0.8 was chosen since the photography could have received a full stop less exposure and still have had a minimum density greater than 0.4. The limiting values of 0.4 and 0.8 are still suitable criterion points with the dual gamma process; however, 2.0 is not. Since the dual gamma characteristic curve barely reaches a density of 2.0, this is not a useful criterion and has been dropped in this analysis.

5.3 RESULTS

Table 5-1 lists the specific frames and target numbers‡ as well as the minimum and maximum densities. As would be expected with the dual gamma process, there are no densities above 2.0. However, there are 23 targets out of the 94 (24 percent) with a minimum density below 0.4.

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*For a derivation of this process, see Final Report, Study the Characteristics and Uses of Suitable Materials for High Altitude Acquisition, [redacted] 14 October 1968.

†All scanning is performed by NPIC.

‡An arbitrary number assigned by NPIC.

However, this estimate of underexposure is more a function of the criteria employed in this analysis on this mission than previous missions. The criteria of a constant minimum density (i.e., 0.4) assumes that the sensitometric fog level is nearly the same from one mission to the next. However, as can be seen in Fig. 5-1, the fog levels are not the same. There is a difference in base plus fog density of 0.06, with the 1104 dual gamma characteristic curve lower than the standard Trenton Full curve. It appears from Fig. 5-1 that there is actually a speed difference of 0.12 log E between these curves. However, there is no speed loss since the curve is shifted downward, not to the right. By raising the dual gamma curve up vertically, the toe shape would be very nearly the same as the Trenton Full curve. This would be the same as using a 0.06 ND filter in the printer, which does not affect the contrast. However, this lowered fog level distorts the estimations of underexposure with this fixed minimum density criteria. If the difference in fog level were to be taken into account, the estimate of underexposure would decrease from 24 to 16 percent.

Work is presently being undertaken to re-evaluate the density criteria employed in this analysis on the 1100 series missions.

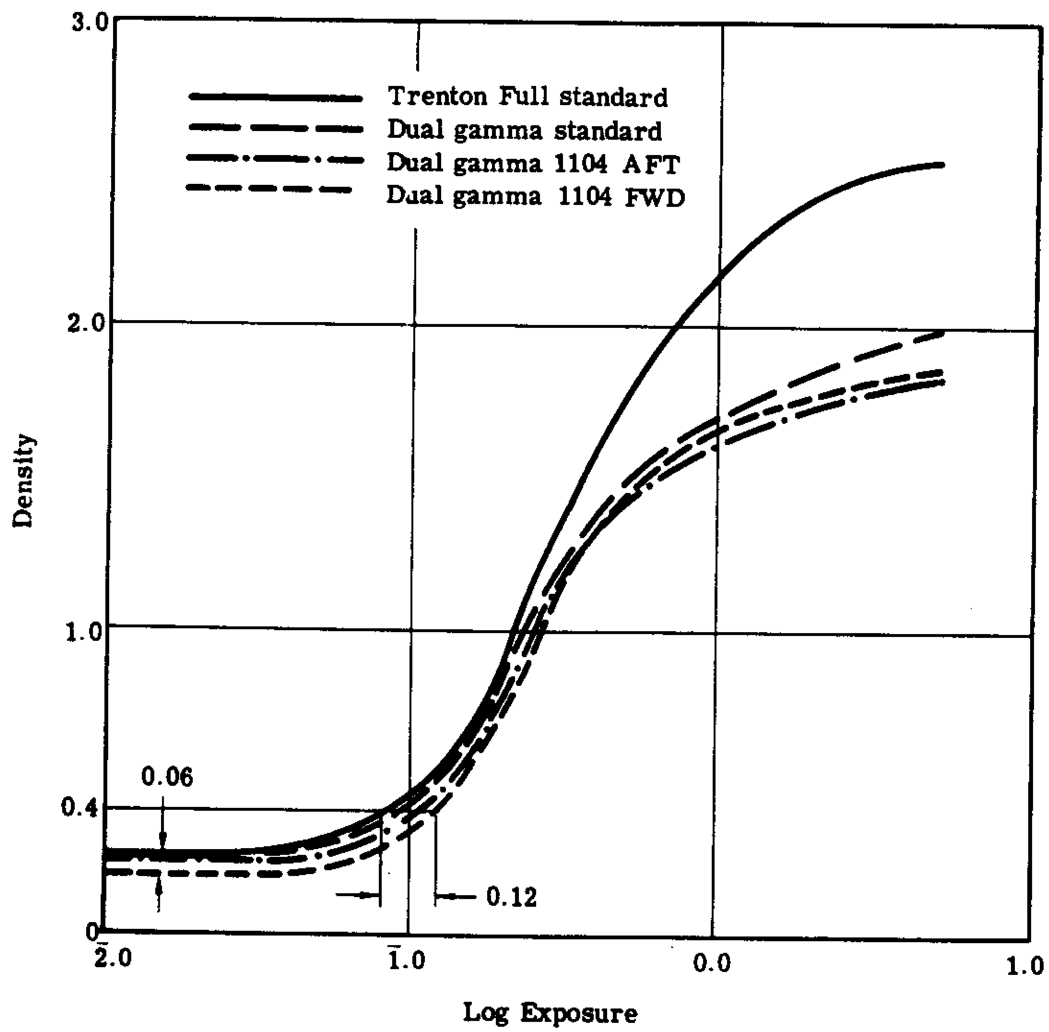

Fig. 5-1 — 3404 processing characteristic curves

Table 5-1 — Mission 1104 Density Analysis

Pass	Frame	Camera	Target Number	Slit	Filter	D_{min}	D_{max}
D-008	090	F	305	0.199	W-25	1.05	1.37
D-008	096	A	305	0.151	W-21	0.97	1.32
D-021	007	F	106	0.199	W-25	0.43	1.56
D-021	013	A	106	0.151	W-21	0.60	1.50
D-022	008	F	40	0.199	W-25	0.28	1.20
D-022	015	A	40	0.151	W-21	0.32	1.36
D-023	101	F	122	0.199	W-25	0.30	1.55
D-023	016	A	122	0.151	W-21	0.45	1.47
D-024	023	F	121	0.199	W-25	0.75	1.50
D-024	029	A	121	0.151	W-21	0.94	1.54
D-037	042	F	79	0.199	W-25	0.37	1.56
D-037	048	A	79	0.151	W-21	0.52	1.85
D-037	044	F	270	0.199	W-25	0.34	1.45
D-037	050	A	270	0.151	W-21	0.65	1.60
D-037	046	F	77	0.199	W-25	0.45	1.74
D-037	052	A	77	0.151	W-21	0.77	1.82
D-037	052	F	710	0.199	W-25	0.47	1.80
D-037	058	A	710	0.151	W-21	0.62	1.85
D-037	052	F	714	0.199	W-25	0.30	1.80
D-037	058	A	714	0.151	W-21	0.64	1.85
D-038	017	F	318	0.199	W-25	0.28	1.72
D-038	023	A	318	0.151	W-21	0.42	1.54
D-039	037	F	34	0.199	W-25	0.45	1.85
D-039	043	A	34	0.151	W-21	0.65	1.66
D-039	050	F	31	0.199	W-25	1.32	1.64
D-039	056	A	31	0.151	W-21	1.26	1.74
D-041	007	F	108	0.199	W-25	0.43	0.70
D-041	013	A	108	0.151	W-21	0.45	0.92

Table 5-1 — Mission 1104 Density Analysis (Cont.)

Pass	Frame	Camera	Target Number	Slit	Filter	D_{min}	D_{max}
D-041	011	F	113	0.199	W-25	0.45	1.32
D-041	017	A	113	0.151	W-21	0.38	1.40
D-041	014	F	801	0.199	W-25	0.50	1.70
D-041	020	A	801	0.151	W-21	0.49	1.78
D-041	030	F	209	0.199	W-25	0.48	1.05
D-041	036	A	209	0.151	W-21	0.45	1.50
D-054	026	F	107	0.199	W-25	0.22	1.20
D-054	032	A	107	0.151	W-21	0.38	1.50
D-058	022	F	277	0.199	W-25	0.23	1.36
D-058	028	A	277	0.151	W-21	0.43	1.41
D-058	034	F	260	0.199	W-25	0.26	1.41
D-058	040	A	260	0.151	W-21	0.55	1.41
D-070	037	F	119	0.199	W-25	0.26	1.41
D-070	043	A	119	0.151	W-21	0.45	1.46
D-071	041	F	36	0.199	W-25	0.38	1.64
D-071	047	A	36	0.151	W-21	0.70	1.54
D-072	061	F	302	0.199	W-25	0.59	1.60
D-072	066	A	302	0.151	W-21	0.54	1.64
D-073	014	F	105	0.232	W-25	0.70	1.55
D-073	020	A	105	0.163	W-21	0.87	1.62
D-087	015	F	303	0.199	W-25	0.50	1.80
D-087	021	A	303	0.151	W-21	0.90	1.70
D-087	048	F	824	0.199	W-25	0.57	1.55
D-087	054	A	824	0.151	W-21	1.10	1.65
D-089	025	F	22	0.199	W-25	0.38	1.22
D-089	031	A	22	0.151	W-21	0.63	1.50
D-103	059	F	500	0.199	W-25	0.68	1.76
D-103	065	A	500	0.151	W-21	0.95	1.83

Table 5-1 — Mission 1104 Density Analysis (Cont.)

Pass	Frame	Camera	Target Number	Slit	Filter	D_{min}	D_{max}
D-104	055	F	33	0.232	W-25	0.74	1.25
D-104	061	A	33	0.163	W-21	0.94	1.41
D-106	009	F	802	0.298	W-25	0.43	1.79
D-106	015	A	802	0.256	W-21	0.58	1.80
D-120	065	F	120	0.232	W-25	0.92	1.80
D-120	071	A	120	0.163	W-21	0.85	1.85
D-121	036	F	112	0.232	W-25	0.55	1.10
D-121	042	A	112	0.163	W-21	0.68	1.26
D-121	073	F	123	0.232	W-25	0.60	1.85
D-121	079	A	123	0.163	W-21	0.76	1.85
D-134	021	F	50	0.232	W-25	0.36	1.35
D-134	027	A	50	0.163	W-21	0.66	1.79
D-137	027	F	104	0.199	W-25	0.32	1.50
D-137	033	A	104	0.151	W-21	0.42	1.72
D-137	081	F	274	0.199	W-25	0.66	1.50
D-137	087	A	274	0.151	W-21	0.91	1.54
D-137	088	F	60	0.199	W-25	0.60	1.45
D-137	094	A	60	0.151	W-21	0.46	1.50
D-152	006	F	109	0.232	W-25	0.22	0.98
D-152	012	A	109	0.163	W-21	0.24	1.20
D-153	067	F	114	0.232	W-25	0.23	1.56
D-153	073	A	114	0.163	W-21	0.28	1.50
D-153	070	F	110	0.232	W-25	0.43	1.45
D-153	076	A	110	0.163	W-21	0.45	1.30
D-153	107	F	124	0.232	W-25	0.70	1.48
D-153	113	A	124	0.163	W-21	0.90	1.35
D-153	191	F	24	0.199	W-25	0.24	1.75
D-153	197	A	24	0.151	W-21	0.53	1.74

Table 5-1 — Mission 1104 Density Analysis (Concl.)

Pass	Frame	Camera	Target Number	Slit	Filter	D_{min}	D_{max}
D-170	006	F	16	0.298	W-25	0.50	1.82
D-170	012	A	16	0.205	W-21	0.66	1.42
D-170	007	F	701	0.298	W-25	0.78	1.18
D-170	013	A	701	0.205	W-21	0.97	1.41
D-170	020	F	101	0.298	W-25	0.86	1.52
D-170	026	A	101	0.205	W-21	0.66	1.79
D-170	041	F	125	0.232	W-25	0.42	1.10
D-170	047	A	125	0.163	W-21	0.56	1.05
D-199	006	F	28	0.199	W-25	0.38	0.97
D-199	013	A	28	0.151	W-21	0.49	1.20

Table 5-2 — Percent Under/Overexposure for the Priority I Targets From Mission 1101 Using the Fixed Minimum Density Criteria

Rating	Number of Targets	Percent
Underexposure	23	24
Overexposure	16	17
Satisfactory	55	59
Total	94	100

6. RECOMMENDATION

The following recommendation is offered concerning future missions of the 1100 series panoramic camera systems:

The average altitude of photography for the first priority targets should be reduced to 80 nm. This could be achieved either by reducing the altitude at perigee or by maintaining the perigee latitude of the orbit at 48 °N.

Appendix A

RESOLUTION PREDICTIONS FOR CORN TARGETS

This appendix is a listing of the image smear and resolution data which have been computed for the CORN targets (see Tables A-1 and A-2).

Notations

BALTR	Image smear along track, random, microns
BALTS	Image smear along track, systematic, microns
TBAT	Total blur along track, mircons
RESL	Dynamic film resolution along track, low contrast (2:1), lines per millimeter
RESH	Dynamic film resolution along track, high contrast, lines per millimeter
GDRL	Ground resolution along track, low contrast, feet
GDRH	Ground resolution along track, high contrast, feet
BCTR	Image smear cross track, random, microns
BCTS	Image smear cross track, systematic, microns
TBCT	Total image smear cross track, microns
CRESL	Dynamic film resolution cross track, low contrast, lines per millimeter
CRESH	Dynamic film resolution cross track, high contrast, lines per millimeter
CGDRL	Ground resolution cross track, low contrast, feet
CGDRH	Ground resolution cross track, high contrast, feet

Table A-1 — Resolution Predictions for CORN Targets,
FWD-Looking Camera, Unit No. 309

Pass	14	16	129	129	129	145
Frame	6	6	10	12	13	32
Along Track						
BALTR	2.03	2.01	2.00	2.03	2.03	2.03
BALTS	0.64	−0.23	−1.26	0.75	−2.35	−0.09
TBAT	2.67	2.24	3.26	2.78	4.39	2.12
RESL	140	165	147	143	121	140
RESH	196	228	185	188	147	221
GDRL	7.3	5.9	6.0	6.3	7.1	6.4
GDRH	5.2	4.2	4.8	4.8	5.9	4.1
Cross Track						
BCTR	0.61	0.60	0.60	0.61	0.61	0.61
BCTS	−1.67	0.60	1.30	−5.13	−4.70	−2.98
TBCT	2.28	1.21	1.90	5.74	5.31	3.59
CRESL	140	155	156	106	109	124
CRESH	199	253	234	117	125	162
CGDRL	6.9	6.1	5.7	8.2	7.8	7.0
CGDRH	4.9	3.7	3.8	7.4	6.8	5.4

Table A-2 — Resolution Predictions for CORN Targets, AFT-Looking Camera, Unit No. 308

Pass	14	16	145
Frame	12	6	38
Along Track			
BALTR	1.45	2.13	1.54
BALTS	−0.79	0.35	−0.95
TBAT	2.33	2.48	2.49
RESL	126	126	129
RESH	188	190	197
GDRL	7.8	7.7	6.8
GDRH	5.2	5.1	4.5
Cross Track			
BCTR	0.46	0.64	0.46
BCTS	0.55	−0.18	−1.13
TBCT	1.02	0.82	1.59
CRESL	125	140	134
CRESH	211	224	208
CGDRL	7.7	6.7	6.4
CGDRH	4.5	4.2	4.1

Appendix B

RESOLUTION PREDICTIONS

This appendix presents resolution predictions for first priority targets for the FWD- and AFT-looking cameras (Tables B-1 and B-2) and average low contrast ground resolved distance readings versus photointerpreter ratings (Table B-3).

Table B-1 — Resolution Predictions for First Priority Targets, FWD-Looking Camera, Unit No. 309

Target No.	305	106	40	122	121	79	270
Pass	8	21	22	23	24	37	37
Frame	10	7	8	10	23	42	44
Along Track							
BALTR	2.00	2.01	1.92	2.03	2.03	1.99	2.03
BALTS	1.84	−0.17	1.11	−0.04	−0.11	−0.08	0.48
TBAT	3.84	2.19	3.03	2.07	2.15	2.06	2.52
RESL	130	165	137	162	161	141	145
RESH	157	230	178	235	231	220	192
GDRL	8.2	6.4	8.3	6.4	6.4	7.2	6.9
GDRH	6.8	4.6	6.4	4.5	4.5	4.6	5.2
Cross Track							
BCTR	0.60	0.60	0.56	0.61	0.61	0.59	0.61
BCTS	−2.95	1.14	−8.19	−0.50	−0.53	−4.88	−3.58
TBCT	3.55	1.74	8.75	1.11	1.14	5.47	4.19
CRESL	136	144	73	150	150	103	125
CRESH	165	231	77	253	252	120	144
CGDRL	7.5	7.1	15.8	6.7	6.7	9.8	7.7
CGDRH	6.2	4.4	15.0	4.0	4.0	8.4	6.7

Table B-1 — Resolution Predictions for First Priority Targets, FWD-Looking Camera, Unit No. 309 (Cont.)

Target No.	77	710	714	318	34	31	108
Pass	37	37	37	38	39	39	41
Frame	46	52	52	17	37	50	7
Along Track							
BALTR	1.90	1.83	1.97	1.75	1.74	1.86	1.78
BALTS	−0.62	−1.45	−0.65	−0.11	1.05	0.02	−1.24
TBAT	2.52	3.28	2.62	1.86	2.79	1.87	3.01
RESL	161	147	159	169	131	166	133
RESH	216	184	212	246	188	240	187
GDRL	6.5	7.3	6.4	6.5	8.7	6.2	8.8
GDRH	4.9	5.8	4.8	4.5	6.1	4.3	6.3
Cross Track							
BCTR	0.55	0.53	0.58	0.50	0.49	0.54	0.51
BCTS	−7.14	−10.47	−4.66	−12.18	−12.57	2.73	3.63
TBCT	7.70	11.00	5.24	12.68	13.06	3.27	4.14
CRESL	82	55	108	46	47	135	119
CRESH	87	58	127	49	50	181	151
CGDRL	13.3	21.1	9.4	26.5	27.0	8.1	11.0
CGDRH	12.5	20.2	8.0	25.3	25.6	6.0	8.7

Table B-1 — Resolution Predictions for First Priority Targets, FWD-Looking Camera, Unit No. 309 (Cont.)

Target No.	113	801	209	107	277	260	119
Pass	41	41	41	54	58	58	70
Frame	11	14	30	26	22	34	37
Along Track							
BALTR	2.03	1.80	1.83	1.96	2.02	1.93	2.00
BALTS	−0.97	0.16	0.18	−0.71	−0.33	−0.06	−0.52
TBAT	3.00	1.96	2.01	2.67	2.34	1.99	2.52
RESL	151	163	164	154	161	168	146
RESH	194	238	238	206	222	239	208
GDRL	6.8	7.2	6.6	6.5	6.2	6.2	6.5
GDRH	5.3	4.9	4.5	4.9	4.5	4.4	4.6
Cross Track							
BCTR	0.61	0.52	0.53	0.53	0.61	0.57	0.60
BCTS	0.14	−10.81	3.15	1.47	−0.90	−4.95	−2.70
TBCT	0.75	11.32	3.67	2.06	1.50	5.53	3.30
CRESL	166	55	131	157	163	107	137
CRESH	276	56	169	230	256	121	178
CGDRL	6.0	23.4	8.8	6.4	5.9	9.8	6.8
CGDRH	3.6	22.7	6.8	4.4	3.8	8.7	5.2

Table B-1 — Resolution Predictions for First Priority Targets, FWD-Looking Camera, Unit No. 309 (Cont.)

Target No.	36	302	105	303	824	22	500
Pass	71	72	73	87	87	89	103
Frame	41	61	14	15	48	25	59
Along Track							
BALTR	1.69	2.00	2.13	1.82	1.84	1.81	1.96
BALTS	0.40	−0.35	−0.68	0.64	0.70	−1.28	1.68
TBAT	2.09	2.35	2.81	2.46	2.55	3.09	3.64
RESL	160	152	145	147	146	148	132
RESH	228	216	198	205	202	190	162
GDRL	6.9	6.2	7.5	7.1	7.0	7.2	7.1
GDRH	4.9	4.3	5.5	5.1	5.0	5.6	5.7
Cross Track							
BCTR	0.47	0.60	0.62	0.52	0.53	0.52	0.58
BCTS	3.92	−2.13	3.40	3.20	2.94	−10.93	5.46
TBCT	4.39	2.73	4.02	3.72	3.47	11.44	6.04
CRESL	119	146	128	130	133	53	104
CRESH	146	199	158	162	169	55	111
CGDRL	10.7	6.2	9.1	8.6	8.1	22.1	9.1
CGDRH	8.7	4.6	7.4	6.9	6.4	21.1	8.3

Table B-1 — Resolution Predictions for First Priority Targets, FWD-Looking Camera, Unit No. 309 (Cont.)

Target No.	33	802	120	112	123	50	104
Pass	104	106	120	121	121	134	137
Frame	55	9	65	36	73	21	27
Along Track							
BALTR	2.28	3.00	2.26	2.33	2.08	2.31	1.72
BALTS	−0.22	−0.90	−0.91	−0.27	1.17	−0.16	0.72
TBAT	2.50	3.90	3.17	2.59	3.25	2.47	2.43
RESL	158	138	149	153	150	161	158
RESH	216	164	190	212	176	219	216
GDRL	6.0	7.1	6.4	6.4	7.3	5.7	6.6
GDRH	4.4	6.0	5.1	4.6	6.2	4.2	4.9
Cross Track							
BCTR	0.68	0.90	0.66	0.69	0.59	0.69	0.48
BCTS	−5.29	1.75	−6.82	−4.22	4.26	−4.10	−13.37
TBCT	5.96	2.65	7.49	4.91	4.85	4.79	13.85
CRESL	103	145	85	113	123	115	42
CRESH	113	203	90	135	136	137	44
CGDRL	9.2	6.6	11.6	8.5	9.8	7.9	28.3
CGDRH	8.4	4.7	10.9	7.2	8.8	6.6	27.1

Table B-1 — Resolution Predictions for First Priority Targets, FWD-Looking Camera, Unit No. 309 (Cont.)

Target No.	274	60	109	114	110	124	24
Pass	137	137	152	153	153	153	153
Frame	81	88	6	67	70	107	191
Along Track							
BALTR	1.92	1.92	2.23	2.21	2.33	2.33	1.91
BALTS	0.11	1.63	−1.14	−2.55	0.11	0.28	−0.60
TBAT	2.03	3.54	3.37	4.76	2.44	2.61	2.51
RESL	163	131	147	108	137	137	155
RESH	234	164	182	135	205	196	218
GDRL	5.6	7.2	6.7	9.0	7.0	6.9	6.1
GDRH	3.9	5.7	5.4	7.2	4.7	4.8	4.4
Cross Track							
BCTR	0.57	0.56	0.65	0.64	0.69	0.69	0.56
BCTS	1.98	−7.96	−8.12	2.92	−5.12	−5.72	2.62
TBCT	2.55	8.52	8.77	3.56	5.81	6.41	3.17
CRESL	141	75	72	120	100	94	136
CRESH	205	79	75	162	114	104	183
CGDRL	6.5	12.7	14.1	8.6	9.4	9.8	7.2
CGDRH	4.5	12.0	13.5	6.4	8.2	8.9	5.4

Table B-1 — Resolution Predictions for First Priority Targets, FWD-Looking Camera, Unit No. 309 (Concl.)

Target No.	16	701	101	125	28
Pass	170	170	170	170	199
Frame	6	7	20	41	6
Along Track					
BALTR	2.71	2.86	2.83	2.06	2.01
BALTS	−0.20	0.59	−0.57	−0.37	1.77
TBAT	2.91	3.45	3.40	2.43	3.78
RESL	155	128	142	162	135
RESH	202	175	183	221	162
GDRL	6.8	7.8	7.0	6.4	6.7
GDRH	5.2	5.7	5.4	4.7	5.6
Cross Track					
BCTR	0.77	0.84	0.82	0.58	0.60
BCTS	−15.89	−10.73	−10.92	−14.47	−1.83
TBCT	16.66	11.56	11.75	15.05	2.43
CRESL	32	54	52	38	156
CRESH	35	56	54	40	208
CGDRL	34.6	18.9	19.7	30.6	5.5
CGDRH	32.6	18.1	19.1	29.1	4.2

Table B-2 — Resolution Predictions for First Priority Targets, AFT-Looking Camera, Unit No. 308

Target No.	305	106	40	122	121	79	270
Pass	8	21	22	23	24	37	37
Frame	96	13	15	16	29	48	50
Along Track							
BALTR	1.52	1.52	1.46	1.54	1.54	1.51	1.55
BALTS	−0.70	−0.26	0.84	−0.41	−0.47	−1.04	−1.49
TBAT	2.22	1.79	2.30	1.95	2.01	2.55	3.04
RESL	115	128	121	133	133	132	110
RESH	185	198	200	202	200	199	173
GDRL	8.9	8.1	9.3	7.8	7.7	7.5	8.7
GDRH	5.5	5.3	5.6	5.1	5.1	5.0	5.6
Cross Track							
BCTR	0.46	0.46	0.43	0.46	0.46	0.45	0.46
BCTS	−0.60	4.55	−5.05	1.46	1.33	−3.38	−1.12
TBCT	1.06	5.00	5.48	1.92	1.80	3.83	1.59
CRESL	113	108	104	137	138	118	112
CRESH	197	132	126	204	207	157	190
CGDRL	8.8	9.4	10.9	7.3	7.2	8.4	8.4
CGDRH	5.0	7.7	9.0	4.9	4.8	6.3	4.9

Table B-2 — Resolution Predictions for First Priority Targets, AFT-Looking Camera, Unit No. 308 (Cont.)

Target No.	77	710	714	318	34	31	108
Pass	37	37	37	38	39	39	41
Frame	52	58	58	23	43	56	13
Along Track							
BALTR	1.45	1.40	1.50	1.33	1.32	1.41	1.35
BALTS	−0.36	0.01	−0.63	0.34	−0.61	0.32	0.34
TBAT	1.81	1.41	2.12	1.67	1.93	1.73	1.69
RESL	120	125	130	128	133	135	117
RESH	186	210	188	196	215	205	196
GDRL	8.7	8.8	7.7	8.6	8.3	7.7	10.3
GDRH	5.6	5.2	5.3	5.6	5.1	5.1	6.1
Cross Track							
BCTR	0.42	0.40	0.44	0.38	0.37	0.41	0.38
BCTS	−5.44	−6.65	−3.76	−7.09	−7.26	5.95	4.86
TBCT	5.86	7.05	4.21	7.47	7.64	6.36	5.24
CRESL	98	90	120	88	86	99	104
CRESH	116	100	150	95	94	102	128
CGDRL	11.0	13.0	8.4	13.9	14.5	11.0	12.7
CGDRH	9.4	11.7	6.7	12.8	13.3	10.7	10.4

Table B-2 — Resolution Predictions for First Priority Targets, AFT-Looking Camera, Unit No. 308 (Cont.)

Target No.	113	801	209	107	277	260	119
Pass	41	41	41	54	58	58	70
Frame	17	20	36	32	28	40	43
Along Track							
BALTR	1.54	1.37	1.38	1.49	1.53	1.47	1.52
BALTS	0.04	−0.77	−0.42	0.42	0.36	0.13	1.25
TBAT	1.58	2.13	1.80	1.91	1.90	1.59	2.77
RESL	131	136	136	124	127	133	117
RESH	209	209	216	202	201	198	184
GDRL	7.9	8.4	7.8	8.3	7.9	7.8	8.4
GDRH	5.0	5.5	4.9	5.1	5.0	5.3	5.4
Cross Track							
BCTR	0.46	0.39	0.40	0.44	0.46	0.43	0.46
BCTS	3.29	−6.91	5.45	5.17	1.42	−4.02	0.25
TBCT	3.75	7.30	5.85	5.61	1.88	4.46	0.70
CRESL	122	89	100	101	132	117	136
CRESH	161	98	118	122	204	145	225
CGDRL	8.2	14.2	11.5	10.0	7.3	9.0	6.9
CGDRH	6.2	12.9	9.7	8.4	4.8	7.2	4.2

Table B-2 — Resolution Predictions for First Priority Targets, AFT-Looking Camera, Unit No. 308 (Cont.)

Target No.	36	302	105	303	824	22	500
Pass	71	72	73	87	87	89	103
Frame	47	66	20	21	54	31	65
Along Track							
BALTR	1.28	1.52	1.50	1.38	1.39	1.38	1.49
BALTS	0.63	1.10	0.83	−0.86	−0.53	0.46	1.39
TBAT	1.91	2.62	2.33	2.24	1.92	1.85	2.88
RESL	137	120	122	131	133	124	116
RESH	206	187	193	202	212	205	181
GDRL	8.2	3.0	9.0	7.7	7.5	8.8	8.0
GDRH	5.4	5.1	5.7	5.0	4.7	5.3	5.2
Cross Track							
BCTR	0.36	0.46	0.43	0.39	0.40	0.40	0.44
BCTS	3.57	0.61	5.98	5.14	5.52	−6.73	−3.24
TBCT	3.93	1.07	6.41	5.53	5.92	7.12	3.68
CRESL	123	134	95	101	100	90	119
CRESH	159	125	109	125	117	100	164
CGDRL	10.5	6.9	12.3	11.0	10.7	13.0	7.7
CGDRH	8.1	7.5	10.7	8.9	9.1	11.7	5.5

Table B-2 — Resolution Predictions for First Priority Targets, AFT-Looking Camera, Unit No. 308 (Cont.)

Target No.	33	802	120	112	123	50	104
Pass	104	106	120	121	121	134	137
Frame	61	15	71	42	79	27	33
Along Track							
BALTR	1.60	2.57	1.59	1.63	1.45	1.63	1.31
BALTS	0.70	−0.11	0.17	−0.68	−1.39	−0.34	−0.30
TBAT	2.30	2.69	1.76	2.32	2.83	1.97	1.61
RESL	127	126	125	131	116	133	139
RESH	195	181	205	194	189	201	223
GDRL	7.6	7.8	7.8	7.4	9.1	6.9	7.4
GDRH	5.0	5.4	4.8	5.0	5.6	4.6	4.6
Cross Track							
BCTR	0.48	0.77	0.47	0.49	0.41	0.48	0.37
BCTS	−3.41	8.00	−4.87	−2.87	5.05	−2.84	−7.42
TBCT	3.89	8.77	5.34	3.35	5.46	3.33	7.79
CRESL	119	79	104	126	95	126	85
CRESH	158	81	126	170	123	171	92
CGDRL	8.0	12.2	9.5	7.6	12.6	7.2	13.8
CGDRH	6.1	11.8	7.8	5.6	9.7	5.3	12.8

Table B-2 — Resolution Predictions for First Priority Targets, AFT-Looking Camera, Unit No. 308 (Cont.)

Target No.	274	60	109	114	110	124	24
Pass	137	137	152	153	153	153	153
Frame	87	94	12	73	76	113	197
Along Track							
BALTR	1.46	1.45	1.57	1.55	1.64	1.64	1.45
BALTS	0.36	−0.80	−0.24	0.79	−1.10	−1.09	0.04
TBAT	1.82	2.25	1.81	2.35	2.74	2.73	1.48
RESL	134	117	130	120	131	131	125
RESH	204	188	203	187	194	194	209
GDRL	6.9	7.7	7.6	8.5	7.1	7.0	7.7
GDRH	4.5	4.8	4.9	5.5	4.8	4.7	4.6
Cross Track							
BCTR	0.43	0.43	0.46	0.45	0.49	0.49	0.42
BCTS	5.49	−5.13	−5.70	4.64	−3.02	−3.26	5.48
TBCT	5.92	5.56	6.16	5.10	3.50	3.75	5.90
CRESL	102	93	100	108	120	118	99
CRESH	118	120	114	133	167	161	117
CGDRL	9.0	10.0	10.2	9.8	7.7	7.7	10.0
CGDRH	7.9	7.7	9.0	7.9	5.5	5.7	8.5

Table B-2 — Resolution Predictions for First Priority Targets, AFT-Looking Camera, Unit No. 308 (Concl.)

Target No.	16	701	101	125	28
Pass	170	170	170	170	199
Frame	12	13	26	47	13
Along Track					
BALTR	1.86	1.96	1.95	1.45	1.52
BALTS	−0.60	−1.16	−0.24	−0.62	1.39
TBAT	2.46	3.11	2.19	2.08	2.90
RESL	122	123	125	123	116
RESH	191	181	182	187	180
GDRL	8.5	8.0	7.9	8.3	7.8
GDRH	5.4	5.4	5.4	5.5	5.0
Cross Track					
BCTR	0.53	0.57	0.57	0.41	0.46
BCTS	−9.37	−7.53	−7.44	−7.87	1.08
TBCT	9.90	8.10	8.01	8.28	1.53
CRESL	70	81	84	81	133
CRESH	72	88	89	86	219
CGDRL	16.1	12.5	12.2	14.1	6.5
CGDRH	15.7	11.5	11.5	13.2	3.9

Table B-3 — Average Low Contrast Ground Resolved Distance Versus Photointerpreter Ratings

The average low contrast ground resolved distance is obtained by averaging the ground resolved distances for the FWD- and AFT-looking cameras in both the along- and cross-track directions. In other words, it is the average of four numbers. The photointerpreter ratings include weather effects which have been eliminated by necessity from the predicted average ground distance.

Target	Pass	Average GRD, feet	Photointerpreter Rating
305	8	8.4	Poor
106	21	7.8	Fair
40	22	11.1	Fair
122	23	7.1	Good
121	24	7.0	Fair
79	37	8.2	Fair
270	37	7.9	Fair
77	37	9.9	Fair
710	37	12.6	Good
714	37	8.0	Good
318	38	13.9	Fair

Table B-3 — Average Low Contrast Ground Resolved Distance Versus Photointerpreter Ratings (Cont.)

Target	Pass	Average GRD, feet	Photointerpreter Rating
34	39	14.6	Fair
31	39	8.3	Fair
108	41	10.7	Fair
113	41	7.2	Fair
801	41	13.3	Poor
209	41	8.7	Fair
107	54	7.8	Fair
277	58	6.8	Fair
260	58	8.2	Fair
119	70	7.2	Fair
36	71	9.1	Poor
302	72	6.8	Fair
105	73	9.5	Fair
303	87	8.6	Good
824	87	8.3	Fair
22	89	12.8	Good
500	103	8.0	Good
33	104	7.7	Good
802	106	8.4	Fair

Table B-3 — Average Low Contrast Ground Resolved Distance Versus Photointerpreter Ratings (Cont.)

Target	Pass	Average GRD, feet	Photointerpreter Rating
120	120	8.8	Good
112	121	7.5	Fair
123	121	9.7	Fair
50	134	6.9	Fair
104	137	14.0	Good
274	137	7.0	Fair
60	137	9.4	Fair
109	152	9.7	Fair
114	153	9.0	Fair
110	153	7.8	Poor
124	153	7.9	Fair
24	153	7.8	Good
16	170	16.5	Poor
701	170	11.8	Poor
101	170	11.7	Fair
125	170	14.9	Poor
28	199	6.6	Good

Table B-3 — Average Low Contrast Ground Resolved Distance Versus Photointerpreter Ratings (Concl.)

The following cumulative statistics have been computed for the various photointerpreter ratings. These statistics include the photointerpreter ratings and predicted average GRD's of missions 1101, 1102, 1103, and 1104.

Photointerpreter Rating	Mean GRD, feet	Standard Deviation, feet
Good	9.5	2.5
Fair	10.1	2.9
Poor	13.9	4.4