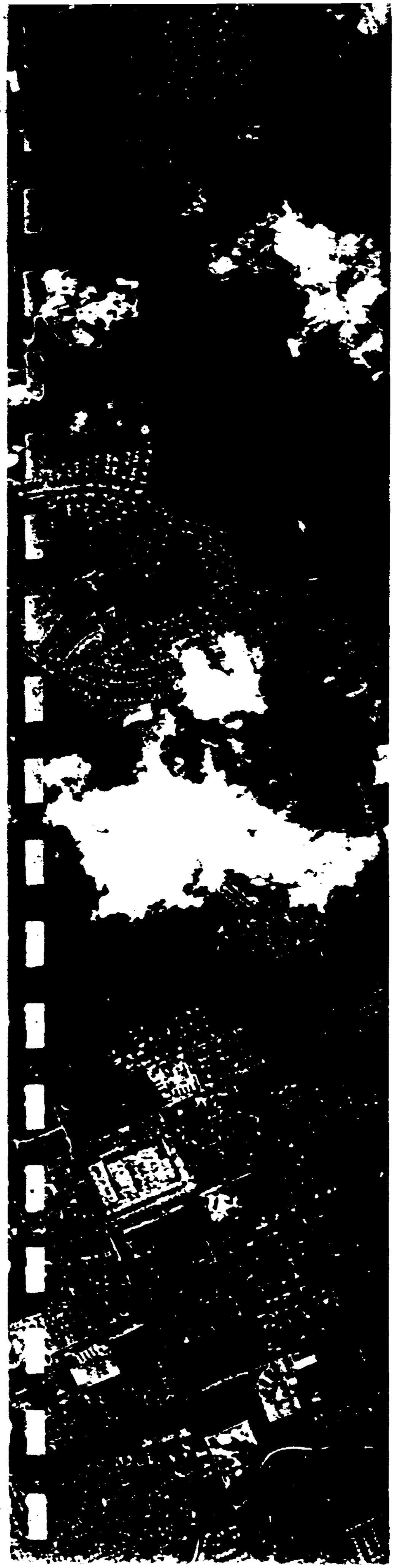

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EKIT REPORT NO. 8

EVALUATION OF LOW GAMMA PROCESSING

4 JULY 1967

CONTRIBUTORS:

[redacted]

APPROVED BY

[redacted]

GROUP 1

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1. INTRODUCTION AND SUMMARY

This report is the eighth in the EKIT series and contains a summary of the work done to date on low gamma processing. Discussions have been carried on for the last 2 years on low gamma processing, and as a result, a limited number of aircraft and satellite tests have been run. This report by no means provides a final answer to the question "Is low gamma processing desirable?" But sufficient evidence is now available to draw the conclusion that further operational testing is desirable.

1.1 PHILOSOPHY OF LOW GAMMA PROCESSING

Low gamma processing was first discussed relative to the KH-4 program in the spring of 1965. It is unfortunate that the approach to film processing discussed in this report got the nomenclature of "low gamma" processing, for it is not, in any real sense, low gamma processing. At worst, it is medium gamma processing. In reality, however, this work has been carried out in the attempt to define the optimum process gamma for KH-4 photography.

Current processing procedures involve a three-level "controlled" process that produces three levels of film speed. This processing is an attempt to correct for exposure variations encountered by the orbiting camera (i.e., solar altitude ground reflectance changes, etc.). At all these levels there is an attempt to maintain the same gamma. The gamma of the normal process ranges from 2.0 to 2.2 depending on the level, the specific emulsion, etc.

With type 3404 emulsion, a gamma of 2.0 to 2.2 produces a useful exposure latitude of approximately 10:1 (log exposure latitude of 1.0). This means, of course, that the camera/film combination cannot record information of greater contrast range, since the information greater than 10:1 will fall on either the toe or shoulder of the D-log E curve. Hence, the current processing procedures must make the assumption that the camera sees contrast ranges of 10:1 or greater in insignificant percentages of the time. This assumption, and its validity, is the heart of the low gamma argument.

Personnel who have been on the KH-4 photographic evaluation team (PET) for many years have commented on the overexposure of certain type targets. Such normally high reflectance objects as air fields, metal roofed buildings, military complexes, and urban areas (concrete) seem in subjective evaluation to be "burned out" a significant percentage of the time. This subjective evaluation would indicate there are contrast ranges of greater than 10:1 and that these occur in many areas of interest. This subjective analysis does not agree with the terrain density analysis done as part of the mission analysis. Density readings from "typical terrain" areas indicate that the current processing procedure is more than adequate to meet mission requirements. This analysis indicates that in very few cases does the terrain D_{max} exceed 1.8, which certainly is an acceptable density. However, one must challenge the validity of this kind of gross area analysis (spot sizes of 0.5 millimeter are used which correlate to approximately 600 feet on the ground at KH-4 scale).

EKIT Report No. 7 (exposure) evaluated the validity of this kind of analysis and showed that the possibility exists that gross area "terrain" density analysis does not necessarily correlate with the density of target areas. Table 1-1 shows the results for one mission on this kind of comparison. This table is from EKIT Report No. 7, and illustrates that average D_{max} and D_{min} values of targets are higher than their respective values from "typical terrain" areas. If this target versus terrain density analysis is valid in general, and if the subjective evaluation of the PET team is correct, then one can come to the conclusion that important information is being lost with current processing procedures. Low gamma processing, of course, extends the exposure latitude of the film, and can be made to extend the latitude to as much as 200:1. This greater latitude will allow the retention of considerably greater highlight information and will substantially reduce the amount of highlight information that is "burned out."

All this discussion is fine from a theoretical point of view. There is a very practical question, however, as to whether or not the low gamma processing provides sufficient contrast to overcome atmospheric attenuation. The current high gamma processing technique came about, in part, due to a recognition of the fact that the atmosphere significantly reduces ground contrast and some attempt to overcome this attenuation is necessary. This assumption has not really been questioned. As of this writing, there still is no firm answer on what gamma is required to compensate adequately for haze. It can be stated, however, that from the results discussed herein, that gammas as low as 1.0 are quite usable and produce (under the conditions tested) reconnaissance photography as good, or better than, normal gamma processing.

If the above is true, then there is a second reason for using low gamma processing that relates to the duplication process. Current duplication procedures very often require the frequent use of "density cuts." These are dupes made at different density levels for the same frame (or roll) of photography. Thus, density cuts are often required because all the information on the original negative cannot be placed on the dupe D-log E curve. That is, if the frame has information on it which covers the full density range of the 3404 (2.4), this cannot be usefully placed on the dupe material D-log E curve, since its useful exposure latitude is considerably less than 2.4. Low gamma processing not only extends the exposure latitude, but reduces the D_{max} to 1.9 - 2.0, which means that a greater amount of information can be duplicated at one printing level. Low gamma processing then offers the secondary advantage of reducing the number of density cuts required. This can be a significant practical advantage to the photointerpreter.

It is realized that lower gamma processing is a radical concept in light of what has been done, and the assumption on which current procedures have been based for the last several years. However, at this point, low gamma processing appears to offer the possibility of real increases in recorded information and definitely warrants operational testing with the KH-4 System.

1.2 SCOPE OF THE TESTS

This EKIT report discusses two quite separate tests. The first was run on the 112B Camera System in a high flying aircraft, and the second was a test on the KH-4 System (mission 1036).

The 112B test was EKIT flight test no. 13. It consisted of one flight over the Fresno-Bakersfield-Los Angeles area on 23 August 1966. The flight number was [redacted] The film used on both FWD (I6) and AFT (I5) looking cameras was type 3404. Normal slits and filters were used (0.049-inch slit, 1/385th second, and W/21 filter) on both units. The film was broken into thirds for the processing tests. The first third from one camera was processed to the normal gamma (2.2), while the first third from the other camera was processed to a lower gamma (1.6)

Table 1-1 — Density Analysis for Mission 1034

Mission 1034-1 D_{min} Density Analysis

Camera	Measurement	D_{min} Range	Average D_{min}	Standard Deviation D_{min} (σ)	Number of Samples
FWD	EK—Terrain	0.25 - 1.45	0.53	*	
	NPIC—Target	0.43 - 1.19	0.69	0.23	12
AFT	EK—Terrain	0.38 - 1.35	0.50	*	
	NPIC—Target	0.36 - 0.71	0.48	0.14	6

Mission 1034-1 D_{max} Density Analysis

Camera	Measurement	D_{max} Range	Average D_{max}	Standard Deviation D_{max} (σ)	Number of Samples
FWD	EK—Terrain	0.55 - 2.20	1.20	*	
	NPIC—Target	1.23 - 2.38	2.14	0.41	12
AFT	EK—Terrain	0.52 - 2.25	1.30	*	
	NPIC—Target	0.65 - 1.45	1.15	0.37	6

Mission 1034-2 D_{min} Density Analysis

Camera	Measurement	D_{min} Range	Average D_{min}	Standard Deviation D_{min} (σ)	Number of Samples
FWD	EK—Terrain	0.38 - 1.25	0.50	*	
	NPIC—Target	0.65 - 1.64	1.12	0.26	34
AFT	EK—Terrain	0.35 - 1.55	0.50	*	
	NPIC—Target	0.31 - 1.23	0.82	0.28	8

Mission 1034-2 D_{max} Density Analysis

Camera	Measurement	D_{max} Range	Average D_{max}	Standard Deviation D_{max} (σ)	Number of Samples
FWD	EK—Terrain	0.60 - 2.0	1.4	*	
	NPIC—Target	1.58 - 2.38	1.90	0.19	34
AFT	EK—Terrain	0.55 - 2.30	1.30	*	
	NPIC—Target	1.35 - 2.38	1.62	0.34	8

*Data estimated from histograms. σ and number of samples not available.

by the processing contractor. For the second third, the processing of each camera take was reversed. The remaining third of the take from both cameras was processed at Itek to a gamma of approximately 1.0.

On the KH-4 (mission 1036) test, approximately 120 feet from both cameras was cut off the end of the "A" bucket. This material was domestic take (over southwestern U. S.) and in no way interfered with the operational use of the system. Both 120-foot pieces were split into two 35-millimeter halves. One half from each side (FWD and AFT looking) was normally processed by the processing contractor. The remaining two halves were sent to Itek where they were processed to a gamma of approximately 1.0. After processing, all material was duplicated by the processing contractor at three conditions. Both low and normal gamma original negatives were duplicated to low, medium, and high gamma.

1.3 CONCLUSIONS

The following are the conclusions from the low gamma testing done to date:

1. There is no evidence of any degradation to either satellite or high flying aircraft photography from low gamma processing.
2. There is a definite improvement in highlight information with low gamma processing.
3. There appears to be an increase in shadow information with the low gamma process.
4. There appears to be a real increase in resolution and edge sharpness with low gamma processing.
5. There is no evidence of significant loss in contrast due to atmospherics with low gamma processing.
6. The KH-4 (mission 1036) experiment indicates that NPIC photointerpreters prefer the low gamma original negative/high gamma dupe positive system over the others tested.
7. Low gamma developer formulations can be generated that produce toe speed equal to the normal "full" processing.
8. Further operational testing of low gamma processing is recommended with the KH-4 System.

2. LOW GAMMA FORMULATIONS

Lower than normal gamma formulas have been developed at Itek to meet processing requirements of various aerial films to: (1) increase exposure latitude, and (2) achieve increased information in the duplicating process. In high altitude reconnaissance photography, ground object contrast is reduced by the effect of atmospheric haze and turbulance. To compensate for this degradation, aerial films are normally processed to high gamma in hopes that the ground object contrast recorded will be improved. This means that aerial films must normally maintain a relatively high gamma over a wide range of processing conditions. But what happens on a clear day when contrast degradation by the atmosphere is less, and the atmosphere is relatively free of haze? Under these conditions the average ground contrast is too high for conventional high gamma development. Normal high gamma processing would yield original negatives characterized by blocked highlights, distorted midtones and a density range that the duplicating material could not faithfully reproduce. A low gamma developer reduces the contrast range to a density range that the duplicating process can accept. The resulting reproduction is considerably improved and there is consequently a significant retention of tonal values of minute detail through the duplication stage.

Recent tone reproduction studies indicate that low gamma development of original negatives is tolerant of many system failures such as overexposure, extreme object brightness ranges, and other factors which tend to degrade photographic response and ultimately the intelligence value of original reconnaissance negatives. Through these low gamma formulas, the system can be set for the worst possible exposure condition that might be encountered and still be processed to yield a high degree of information content.

The usual approach to lower than normal gamma processing is to take an existing formula and modify it to effect changes in gamma and density. This can be done by manipulating the various constituents along with changes in pH and temperature. At times this is not always the right approach, since the result of variation of one constituent is very often dependent upon another. The motion picture industry, for example, relies heavily upon low gamma processing of negatives from which to make high contrast positives; they require gammas of 0.65 to 0.76. For the formulations developed in these laboratories, a rather elementary set of constituents were used. Many types of exotic components could have been used, but in general they were not really needed. Table 2-1 indicates the effect that these basic constituents have on the sensitometry.

The effects listed in Table 2-1 are very general and would not necessarily apply if unusual concentrations of any of these or other constituents were used.

The guides in this table are valid when development time remains constant; otherwise, if development time is increased, the slope of the straight line will be increased. At this point it might be of importance to state that the exact shape of the D-log E curve depends upon many factors: the particular photographic material, the spectral quality and intensity of the exposing source,

Table 2-1 — General Effects of Basic Constituents of a Developer

Change in Formulation	Resultant Effect on Sensitometer Properties		
	Gamma	Speed	Fog
Increase bromide	Decrease	Decrease	Decrease
Increase phenidone	Increase	Increase	Increase
Increase hydroquinone	Increase	Slight increase	Slight increase
Increase alkali	Increase	Slight increase	Slight increase
Increase sulfite	None	None	None
Increase bisulfite	None	None	None

time of exposure, the developer composition, and development time. Therefore, in formulating a lower gamma developer, it must be remembered that each emulsion may require a different formula or modification. When various emulsions are similar, then any required alteration would be slight.

The special gamma developers formulated in these laboratories have worked successfully for aerial films, duplicating films, microfilms, and spectroscopic films and plates. These formulas were developed for machine processes (liquid monobath and viscous processing techniques) depending upon the final application. In the development of these various low gamma processes, many problems were encountered. At first, lower than normal gammas were achieved through the manipulation of existing formulas such as D-19, D-76, and MX-577 (12 DX 90). A marked loss of film speed and maximum density, loss of shadow density in the toe region of the D-log E curve, and at times curves with no apparent straight line were encountered. Realizing that existing formulas could not meet the requirements desired, this approach was dropped. The requirements were to obtain lower gammas, i.e., gamma range of 1.0 to 1.5, while nearly maintaining the film speed usually associated with high activity developers, such as MX-577. The initial investigation led to a series of formulas (M-series) that could maintain the film speed presently obtainable with the control developer. Nevertheless, the formula was not in the desired gamma range. Changes were then made in the concentration of hydroquinone and Kodalk. There was a slight change in the gammas but not sufficient to warrant further investigation. Nevertheless, the formulas were useful in the development of new formulations. The G-series was then designed to increase the sodium sulfite concentration, and with careful evaluation of the sodium bisulfite concentration, a well buffered formulation was designed that did produce satisfactory gamma levels. Final adjustment of the potassium bromide level brought about the G-4 formula that would repeatedly produce gammas of 1.0 to 1.5 and speeds adequate for processing of the film from an aerial reconnaissance system. Table 2-2 presents the original formulation with a partial list of those formulas that led to G-4. A refinement of G-4 for machine processing is listed in Table 2-3.

2.1 DEVELOPER CONSTITUENT FUNCTIONS

The following is a discussion of the function that each constituent of the G-4 developer performs.

Reducing Agent

Phenidone (or 1-phenyl 3-pyrazolidone) is a colorless crystalline compound which is moderately soluble in hot water and slightly soluble in cold water. It is, however, readily soluble in both aqueous acids and alkalis, including solutions of alkali bisulfite and carbonates. Like most organic developing agents, its development properties are dependent on the pH of the solution, with developer activity increasing with pH although its dependence upon pH is less than most other developers. When used alone in carbonate solutions, it gives rapid development with extremely soft working capabilities. Phenidone works primarily in the toe region of the characteristic curve, and therefore has a great influence on the speed of the material. It also causes fog when excess amounts are used. Phenidone has the ability to develop the silver image evenly and rapidly at low density levels, regardless of development time. When used with hydroquinone it exhibits super-additivity, which means that an extremely small quantity of hydroquinone is capable of increasing the film speed, with a slight increase in maximum density, without blocking out highlight detail. Hydroquinone by itself requires long induction time and builds up contrast rapidly once development is initiated. When used with phenidone, the induction time is zero. Therefore, development is immediate and even throughout all densities.

Table 2-2 — Original Low Gamma Formulations

Developer	Developer Formula Tested						
	M3	M4	G2	G3	G3A	G4	G4A
Metol	3.0	3.0					
Phenidone			1.25	1.25	1.25	1.25	1.25
Sodium sulfite	35	35	50	50	50	50	50
Hydroquinone	0.5	0.25	0.25	0.25	0.25	0.25	0.25
Kodalk	20	10	20	20	20	20	20
Sodium bisulfite			7.5	7.5	7.5	7.5	7.5
Potassium bromide	0.375	1.0			0.25	0.375	0.375
Benzotriazole			0.25	0.25			

NOTE: Values listed indicate grams per liter.

Table 2-3 — G-4 Formula for Machine
Processing to Make 1 Liter
(pH 9.15 ± 0.10)

Constituent	Quantity, grams
Phenidone	1.3
Sodium sulfite	53.0
Hydroquinone	53.0
Kodalk	21.0
Sodium bisulfite	8.0
Potassium bromide	0.4

Preservative

Since all organic developing agents have a strong affinity for oxygen, sodium sulfite is usually added to protect against aerial oxidation and to prevent the formation of development by-products. Sodium sulfite cannot bring a developer "back to life" once it has been exhausted, though it can retain oxidation of the developer if it is in the solution when the developer is mixed. It does this by forming an inert by-product with the oxidizing developing agent before the oxygen has a chance to form an active molecule that inhibits development. Sodium sulfite also acts as a silver halide solvent and, therefore, helps reduce granularity of the processed film. Most developers have as much or more sulfite in them as G-4; the G-4, therefore, has no distinct advantage on this point.

Alkali

Alkali is the activating agent used to control the relative acidity or alkalinity of the solution. The degree of alkalinity must be varied with the developing agent used. Carbonates, borates, and hydroxides are commonly used as the activating alkali, depending upon the pH range required. The G-4 formula makes use of Kodalk (Kodak proprietary alkali of the sodium metaborate family). Kodalk is freely soluble in water, and when used with sodium bisulfite, teams up to increase the buffering capacity of the solution. Buffering capacity is the ability of a developer to withstand the neutralizing effects of an acid and to maintain the proper pH range necessary for development.

Restrainer

A restrainer is used to prevent the formation of fog during development. It lowers the speed of a material by the restraining action. The developing agents are generally positively charged. When the restrainer is used, a negative charge is set up around the silver halide grain. Therefore, it repells the positively charged developing agent. The most commonly used restrainers are potassium bromide and the benzotriazole. Potassium bromide would react similarly with a developing agent like metol. Phenidone, due to its particular charge, resists the effects of bromide as it enters into development. Therefore, a very small quantity of bromide is all that is required to control the growth of fog during development. The antifoggant benzotriazole was discontinued, and the proper concentration of bromide was determined to just control the fog level without impairing speed.

2.2 SENSITOMETRIC CHARACTERISTICS

Fig. 2-1 is a family of curves for 3404 film processed in Itek G-4 developer. The dotted line represents the control developer, MX-577. In formulating Itek G-4 developer, a requirement was to match the speed of the control developer. The family of curves in Fig. 2-1 shows the speed increase for development in G-4 at the three gamma levels. The increase is in the toe region, in the region of low exposure where it is needed. The gradual slope in the toe region and the moderate gamma permits an increase in the useful exposure latitude (UEL) of the film. The UEL of 3404 processed in G-4 has been expanded to almost 100:1. The control developer has a useful exposure latitude of only 6:1. This means that development of 3404 in G-4 formulation permits a greater brightness range acceptance. The upper portion of the D-log E curve and the shoulder portion slopes gradually. This indicates a loss of speed in this area, but when extremely bright highlights are recorded, the chance of blocking up highlight detail is not as great as that which would result from processing in a higher gamma developer such as MX-577.

The results indicate that a reduction of gamma, or lower gamma processing of original aerial negatives, can help extend the brightness range that a film must accept without losing detail in the highlights, while maintaining toe speed and increasing shadow information.

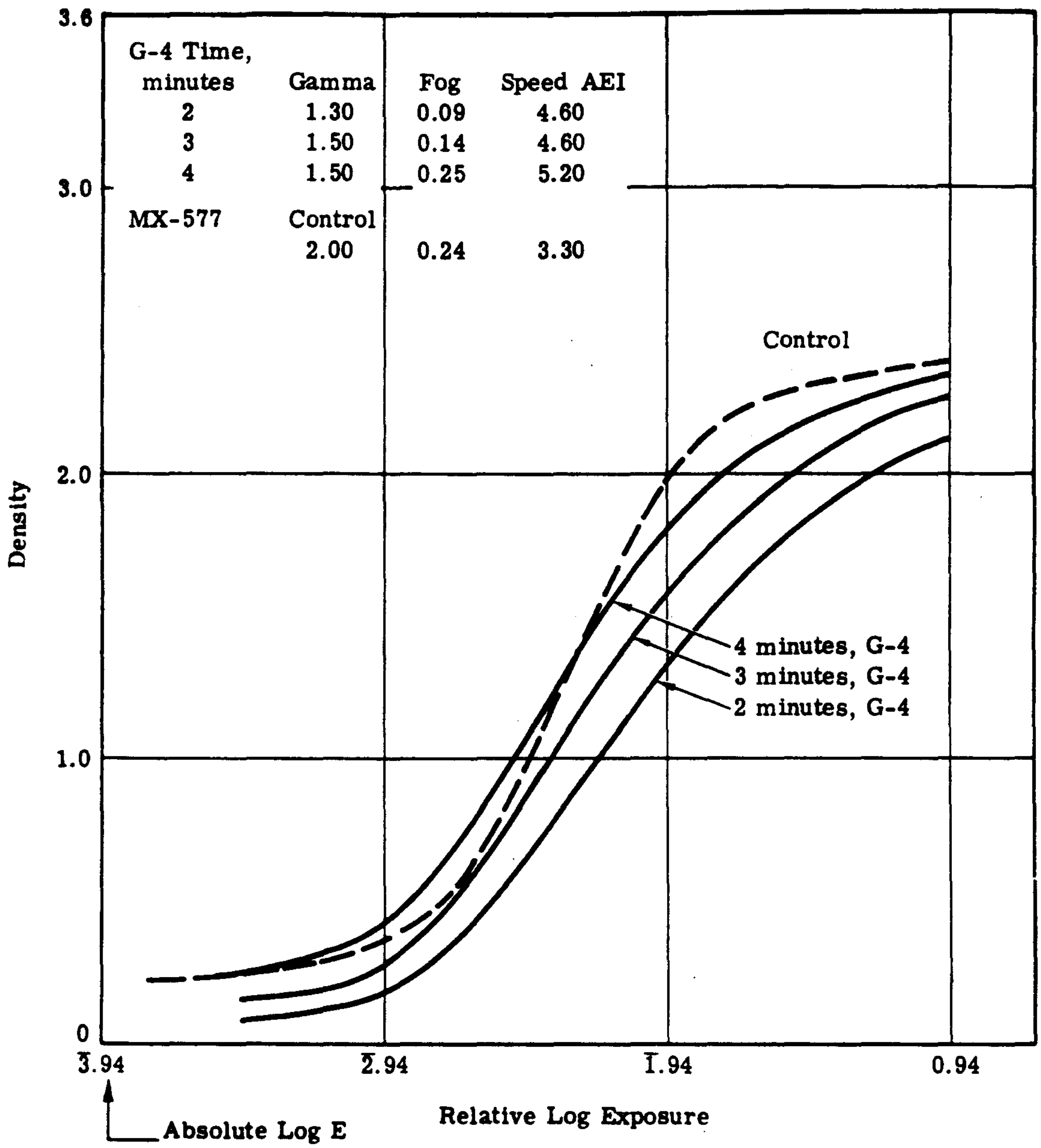


Fig. 2-1 — Sensitometric evaluation of 3404 film processed in G-4 formulation (Dotted line represents the control developer MX-577.)

3. TEST PLAN

EKIT test flight no. 13 consisted of one flight over Fresno-Bakersfield-Los Angeles. The 112B Camera System was used in a high flying aircraft to obtain the required imagery. Although it has been discussed in previous EKIT reports, a brief description of the system is warranted to introduce the new reader to the system.

3.1 112B CAMERA SYSTEM

The camera, a pan scanning type, has been designed around a diffraction-limited Petzval type lens of 24-inch focal length, with an f/3.5 aperture that covers a 6-degree field angle. To obtain stereo, a pair of these cameras is tilted from the nadir at 13 degrees each, and set face to face so that each camera scans in opposing directions. The lens is continuously rotated about its operational nodal point and scans across the line of flight and is translated against the flight direction for image motion compensation.

During approximately 70 degrees of the lens rotation, a capping shutter is opened to permit the aerial image to expose the 70-millimeter film through a slit. This slit controls the exposure time, e.g., at a 20-inch per second scan rate, a 0.040-inch slit produces an effective exposure of 1/500 second. At the completion of the photographic scan, the capping shutter is closed.

The film is continuously being transported in from the supply spool and out to the takeup spool. A frame-metering roller controls the frame length, the correct amount of film is placed in the format area, and clamps at each end of the format hold the film stable and in the approximate focus position. The excess film is accounted for by a shuttle assembly that gives or takes according to demand.

The focal position is determined by a scan head assembly mounted on a precise arm from the nodal point to the focus. This scan head gently lifts the film from the rails to the image plane during exposure and returns it to the rails after exposure. The rails are required only to hold the film at the approximate focus and to guide the film during transport.

Recorded on the film edge outside of the format area on each frame are frame number, binary time, and timing pips of 125 cycles per second. These timing pips are scanned on the film across the 70-degree format length with one pip blanked out to indicate when the binary time data block is printing out. Three scanning rates are built to match the V/h requirements while maintaining approximately 10 percent overlap at the format center. Increased overlap is acquired on both sides of nadir as the off vertical scan angle increases.

The exposure slit and filter are preselected for the V/h requirement and subject illumination and consistently produce the correct exposure.

3.2 FLIGHT TEST PLAN SPECIFIC DETAILS

No modifications to the camera were required for this test. The normal slit width and filter were, in fact, a necessary part of the test so that any effect introduced by the low gamma processing would be observed.

The specific details of the camera setting are listed in Table 3-1.

The unique feature of this test was not found in the operation of the camera, but in the processing that was used. The film from each camera was cut into thirds, resulting in six lengths of photographic coverage. The first third from one camera was processed to the normal (high) gamma and the corresponding first third from the other camera was processed to a lower gamma by the processing contractor. The same pattern was used for the second camera, but this time the first camera received the lower gamma processing. The remaining third was held in storage until an initial analysis was performed. Since the initial processing gammas were approximated (2.2 and 1.6), it was decided to process the remaining third at Itek to a very low gamma (i.e., approximately 1.0) in order to encompass a wider range of gammas in the test. Fig. 3-1 indicates the areas covered and the processing used for the films from each camera. It should be pointed out that the toe speeds are the same for the high and low gamma processing though the AEI speed values are 2.2 and 1.0, respectfully. When such wide ranges of gammas are used the AEI speed value becomes very inaccurate; it tends to give a higher (and unreal) measure of the lower gamma curve.

Table 3-1 — Camera Data for EKIT Flight Test
[redacted] Photographic coverage
1850z to 2145z; date 23 August 1966)

	Master Unit (I5) Aft-Looking	Slave Unit (I6) Fwd-Looking
Film	3404	3404
Slit width	0.049 inch (1/385 second)	0.049 inch (1/385 second)
Haze filter	Wratten no. 21	Wratten no. 21
Scan mode	II (8 seconds per cycle)	II (8 seconds per cycle)
f/no.	3.5	3.5

Camera

	Aft-Looking (I5) Master Unit	Fwd-Looking (I6) Slave Unit	Area Covered
Processed by [redacted]	High Gamma $\gamma = 2.13$ FOG = 0.22 AEI = 2.1	Medium Gamma $\gamma = 1.69$ FOG = 0.13 AEI = 2.2	Desert Fresno Fresno Fresno Fresno Bakersfield
Processed by [redacted]	Medium Gamma $\gamma = 1.32$ FOG = 0.15 AEI = 2.1	High Gamma $\gamma = 2.17$ FOG = 0.21 AEI = 2.1	Bakersfield Bakersfield Bakersfield Bakersfield Bakersfield Bakersfield
Processed by Itek	Low Gamma $\gamma = 1.06$ FOG = 0.16 AEI = 3.6	Low Gamma $\gamma = 1.04$ FOG = 0.16 AEI = 3.6	Bakersfield Los Angeles Los Angeles Los Angeles Los Angeles

Fig. 3-1 — Processing data for the three segments of film for this EKIT test

4. SUBJECTIVE PHOTOINTERPRETER EVALUATION OF 112B LOW GAMMA TEST

The sample negative materials supplied for printing were of three processing conditions. Type 3404 film, normally exposed, was processed as follows:

1. To the normal condition (by [redacted] to a gamma of 2.2
2. To a medium gamma (by [redacted] of 1.6
3. To a low gamma (by Itek) of 1.0

Contact film positives (and 10× enlargements) were made (on type 8430 print stock) of selected target areas that appeared in all three processing conditions. The relationships of the different steps are shown in Table 4-1.

These duplicating conditions were used to produce transparencies that were similar in contrast for all three original targets, though the negative gammas were different. Resolution comparisons were taken from the best target appearing for each processing condition. The test object was a CORN 51/51 bar target array with a 5:1 contrast (33 and 7 percent reflectance).

The resolution readings are shown in Table 4-2. In order for these readings to apply to practice, the positive images were represented, not the original negatives (even though the results were almost the same).

Resolution recording capability is demonstrated to change with the processing condition; the lower gamma sample showing a considerable increase in three bar resolution (63 percent) in the scan direction.

4.1 SPECIFIC EVALUATION

Two areas of interest were chosen for direct point-by-point evaluation and comparison, a thermal electric generating plant and a railroad yard with a turntable and round house. Contact duplicate positives and 10-diameter positives were made for evaluation. The enlargements present a general visual comparison of the sample, however, all comparisons were made using the contact duplicate positives at magnifications from 7 to 100 diameters.

4.1.1 Thermal Electric Generating Plant (Fig. 4-1)

4.1.1.1 Negatives

The negative materials are very different in appearance. The high gamma processing condition produces a negative which is quite dense in appearance; the medium gamma processing produces a thin, brown hued negative; and the low gamma processing produces a neutral hued result of more density than the medium gamma but considerably less density than the high gamma. One of the reasons for the medium gamma negative being somewhat thin is that the particular processing used (spray at [redacted] does not quite produce the speed that similar lower gamma developers obtain in an immersion process.

The high gamma processed negative exhibited very dense highlight areas with details being obscured by the blooming of images beyond their normal geometric limits. Edges are good and resolution is average for this condition.

The medium gamma sample holds the highlight detail very well, though low reflectance and shadow areas suffer from underprocessing. Edge acuity and resolution are considerably improved.

The low gamma negative exhibits a very good dynamic range from low reflectance target areas with good detail in highlight areas that show detail with no blooming.

In all cases, care must be taken to distinguish between specular reflection and dense highlights that detract from objective evaluation.

4.1.1.2 Positives

The high gamma condition produces a print that is striking to the eye but comparatively deficient in regard to information content. The very dense highlights of the original negative print as open areas. The shadow details at the boiler building, present in the negative, have blocked up somewhat as a result of having to print for a more dense area. Fine line detail in the transformer areas, the transmission towers, and cooling towers are quite good in relation to past missions over the same area.

The medium gamma sample has a good tonal distinction; highlight areas retain detail, and shadows do not block up appreciably when printing for high reflectance items. Edges of buildings, particularly those with parapets, are very well defined. Areas of low contrast are better defined than in the normal condition, and there is more detail and resolution in the transformer yards and transmitter towers, bearing out the indicated resolution improvement of the CORN targets.

The low gamma sample far exceeds the high gamma sample in tonal rendition, shadow details, resolution, and edge acuity. Only specular reflection areas are burned out. Compared to the medium gamma sample, it is about equal in edge sharpness and resolution capability, but the low gamma sample has a slight advantage in the reproduction of tonal values particularly in the low reflectance region.

For this target area, the low gamma sample shows a superiority in information content, and when compared to the high gamma sample, there is no real advantage to the latter except for visual impact.

4.1.2 Railroad Yards and Facilities (Fig. 4-2)

4.1.2.1 Negative

Overall density is apparent in the high gamma processing sample of this subject area as it was in the previous one. The rails are well located by specular reflections, as are several other structural items, but they should be disregarded as an item for evaluation in that they are a function of attitude at the time of exposure rather than a sensitometric feature for evaluation. Blooming of the specular images occurs to a very noticeable degree.

Table 4-1 — Duplicating Conditions for Photointerpreter Evaluation

Film Processing Condition	Gamma of Negative	Developer/Development Time for 8430, minutes	Gamma of Print Stock	System Contrast for Print
[redacted]ormal processing	2.2	Albert FG/2	1.1	2.4
[redacted]edium gamma processing	1.6	Albert FG/6	1.3	2.1
Itek low gamma processing	1.0	D-19/15	1.7	1.7

Table 4-2 — Resolution Readings for Duplicate Positives From Three Negative Gammas

Film Processing Condition	IMC		Scan		Note
	Target	Film Resolution, lines per millimeter	Target	Film Resolution, lines per millimeter	
High gamma	16	50	16	50	
Medium gamma	16	50	18	63	20th target is resolved but 19th is not
Low gamma	17	56	20	80	

The medium gamma sample exhibits the same characteristic as the previous area evaluated but the shadows are thin and the normally low reflectance character of this type of subject makes detail in the toe-end of the characteristic curve sparce. There is a slight brown cast to the negative, likely from processing.

The low gamma processing produced a negative of about the same total density but it has more detail in the low exposure region. The lower contrast of the sample is apparent and resolution and acuity are similar to the medium gamma negative.

4.1.2.2 Positives

The duplicate positives of the high gamma negative have a high visual contrast, owing in part to the contribution of the specular imagery. It compares well with other mission photography, is well resolved, and has adequate tonal coverage for the normal case. The subject area lends itself well to this mode of processing, the high gamma helping in low contrast areas.

The medium gamma processing exhibits a decided increase in detail, particularly fine lines (the roof of the round house, telephone poles, etc.). The edge acuity is well enhanced, and details in railraod cars, autos, trucks, and engineering appendages on buildings are more distinct.

The low gamma improves on the recording of edges and fine detail shown in the medium gamma case. Shadows are more luminous and, generally speaking, the total information content, noticeably in the low reflectance region, is greatly increased.

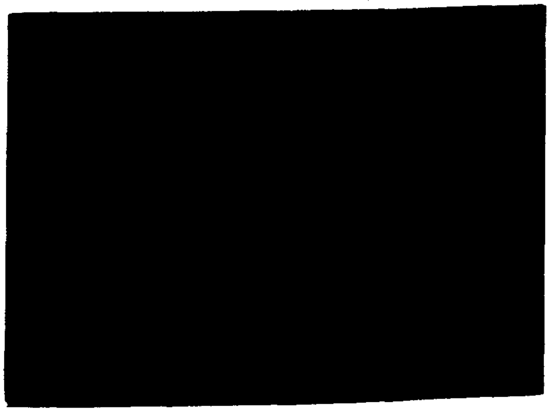
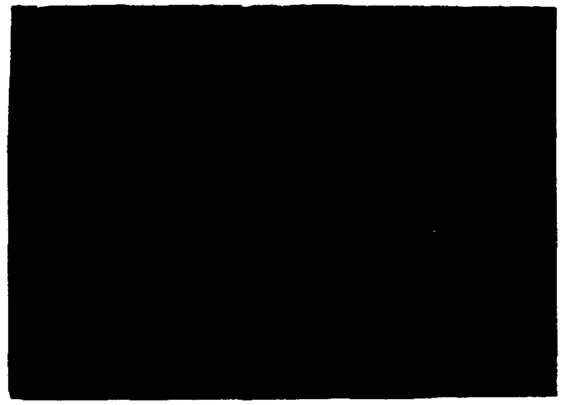
4.2 CONCLUSIONS

Comparison of the CORN targets, the thermal power plant, and the railraod yard provided a reasonably wide subject range to show the capabilities of each of the processing methods.

Unaided visual examinations, or examinations at relatively low magnification (7 × 30) show distinct advantages to using low gamma processing for extension of the range for information contained in an aerial exposure. Both the extended dynamic range imparted to the film and its capability to resolve detail and delineate edges beyond what is currently accepted as standard are good arguments for its use.

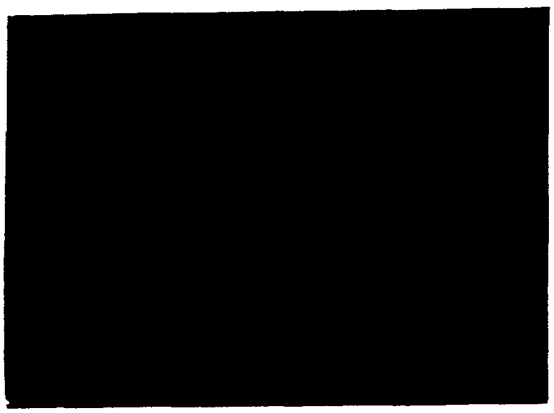
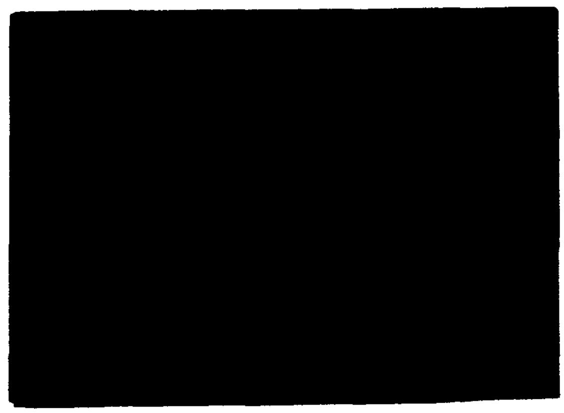
To fully explore the increases mentioned in the specific example preceding this conclusion, examination of the contact duplicate positive at a magnification of about 100× should be employed. The differences are very apparent, more apparent when comparing either low gamma method to the normal; however, quite noticeable advantages can be attributed to the low gamma method.

The low gamma negative allows a wide range of end products to suit a multitude of situations simply by increasing the printing gamma. Its sensitivity to low reflectance items extends the useful dynamic range of the film into a region, until recently ignored, containing a wealth of a new information.

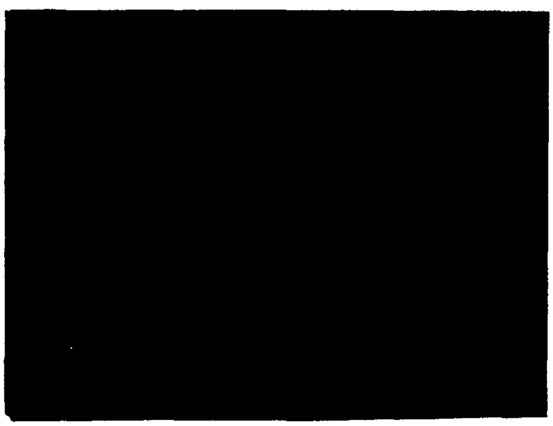
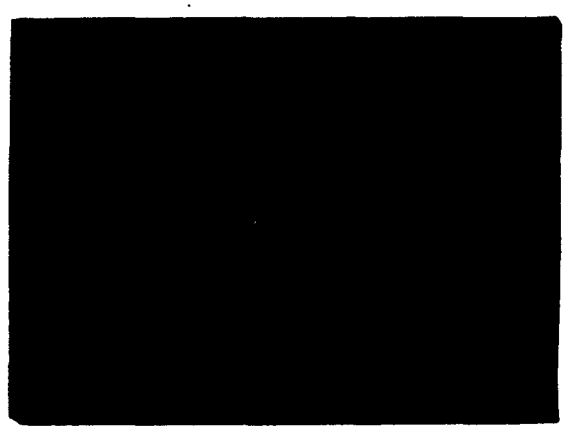
Contact D.P. 10× Enlargement

Normal Processing

Contact D.P. 10× Enlargement

Medium Gamma Processing

Contact D.P. 10× Enlargement

Low Gamma Processing

HANDLE VIA
TALENT-KEYHOLE
CONTROL SYSTEM O

Fig. 4-1 — Contact and 10× enlargement of thermal electric generating plant at three negative gamma levels [redacted] [redacted]

Contact D.P. 10× Enlargement

Normal Processing

[redacted] [redacted]

Contact D.P. 10× Enlargement

Medium Gamma Processing

[redacted] [redacted]

Contact D.P. 10× Enlargement

Low Gamma Processing

Fig. 4-2 — Contact and 10× enlargement of railroad yards and facilities at three negative gamma levels

5. SENSITOMETRY AND TONE REPRODUCTION

This section deals with the sensitometric properties of both the EKIT and KH-4 materials used in the low gamma experiments. In both tests, the low gamma negatives were processed at Itek with an immersion processor using the G-4 chemistry.

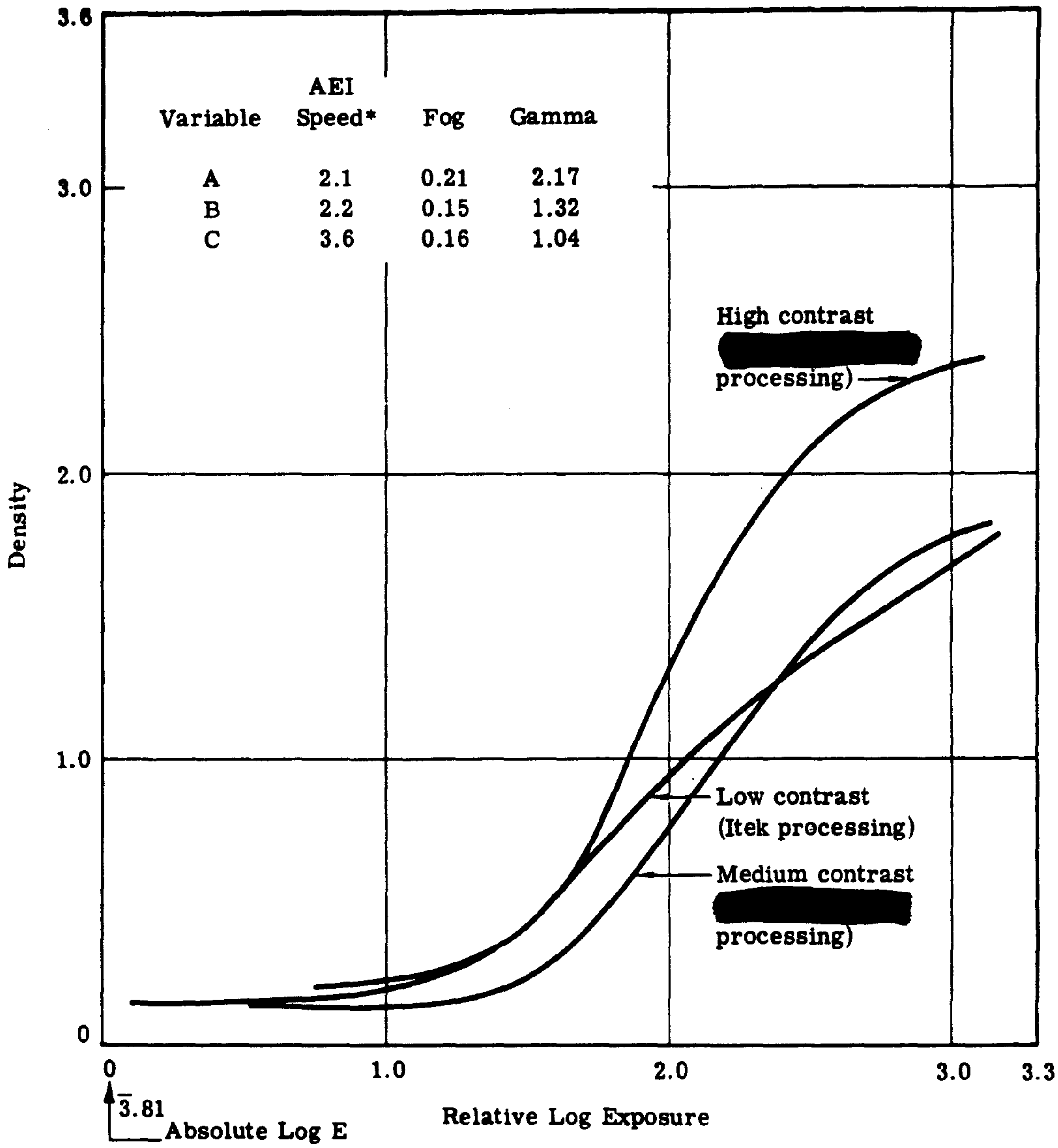
EKIT TEST SENSITOMETRY

The material from EKIT flight 13 was cut into three segments from each camera before processing. Two of these were processed to a high contrast at [redacted] in the Trenton Processor (the high and medium gamma samples), the other was processed to a low gamma at Itek. The sensitometric curves for each of these three processors has been plotted on the same graph in Fig. 5-1. The high and low gamma samples have essentially the same toe speed, though there is a significant departure above a density of 0.7. The medium contrast has approximately 2/3 of a stop less toe speed. This is because the spray processor used apparently does not lend itself to this particular low gamma processing.

Fig. 5-2 is the tone reproduction characteristics for the high and low contrast system in the EKIT test. Also plotted on this tone reproduction graph are the microdensitometer scans of the CORN T-bar target that was in the EKIT photography. The smooth bars on this graph represent the contrast (versus a relative distance) of the largest bars in the T-bar pattern. The final reproduction of these targets indicates that the original subject contrast range was reproduced slightly different for the high and low case.

However, this is how the photointerpreters "liked" the samples when they selected these from among a series of various duplication contrasts and exposure times. These curves indicate that the reproduction is not theoretically ideal and are in fact somewhat dark in the shadow areas. This is probably because the prints were on a transparent base which allows the eye to see better into the dense areas.

Although the final tone reproduction curves are almost symmetrical in shape, the photographs that they represent are significantly different in their visual appearance. The subject matter (the T-bar) in the pictures was not reproduced over the entire range on the low contrast reproduction in comparison to the high. The maximum density of the two are about equal, with the minimum density somewhat different. Thus, there is room for expansion in the low gamma system allowing a greater subject luminance range to be reproduced.



*It should be pointed out that the toe speeds are the same for the high and low gamma processing though the AEI speed values are 2.2 and 1.0, respectfully. When such wide ranges of gammas are used the AEI speed value becomes very inaccurate; it tends to give a higher (and unreal) measure of the lower gamma curve.

Fig. 5-1 — Sensitometric curves for all of the processes used in the EKIT tests for type 3404 film

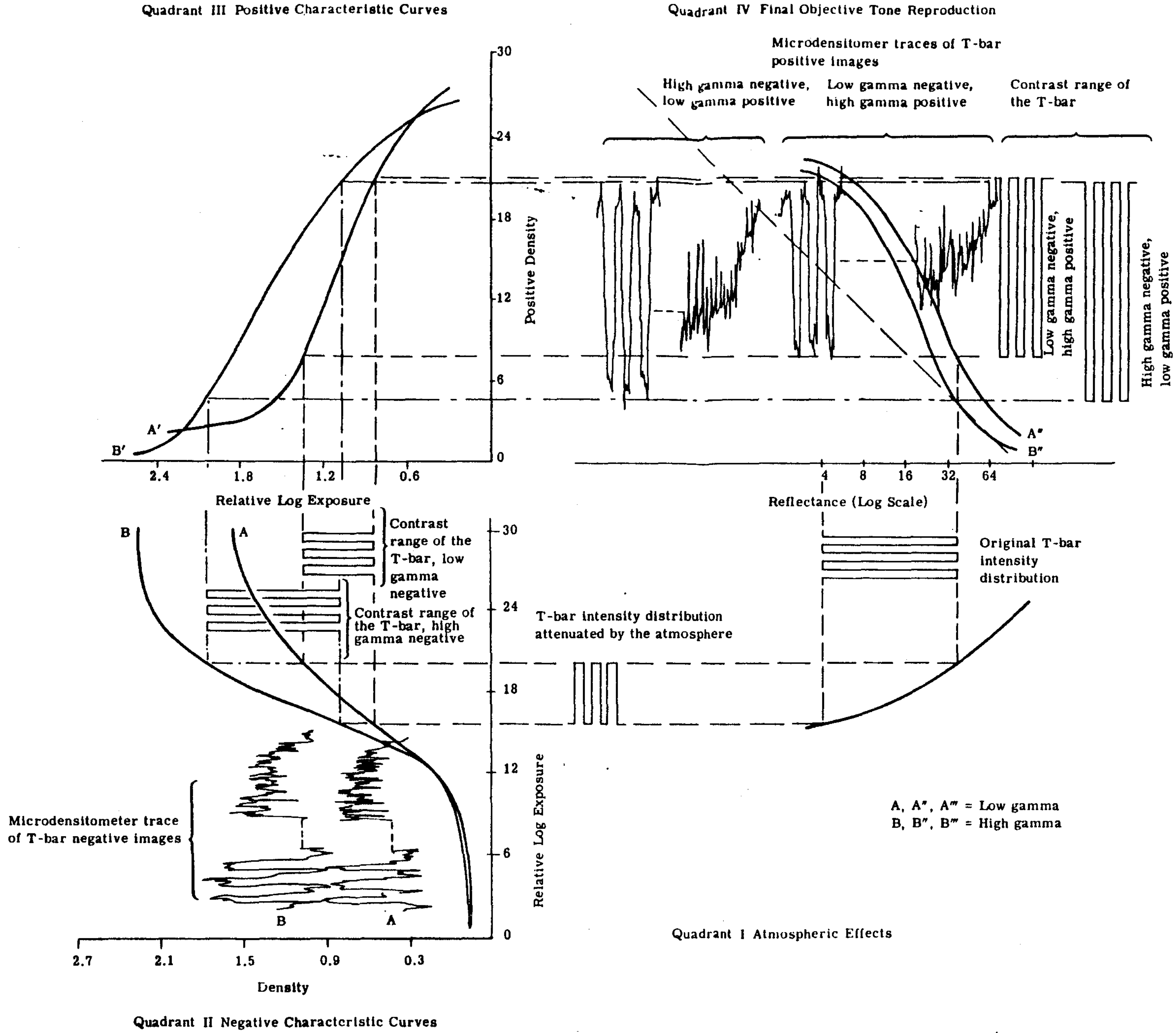


Fig. 5-2 — Tone reproduction graph for the high and low gamma negatives when duplicated on type 8430 film (Superimposed on the plot is the microdensitometer scans of the CORN T-bar target.)

6. KH-4 LOW GAMMA EXPERIMENT

One test of low gamma processing has been carried out on an operational KH-4 flight, mission 1036. The last 120 feet, which covered southern California on three passes, was removed from the spool before the main portion of the mission was processed. The material from both cameras was slit into two 35-millimeter lengths and used for this test. Half was processed normally (one camera at the full and the other at the intermediate level) by the processing contractor and half was processed to a low gamma (≈1.04) at Itek. The original negatives were then duplicated by the processing contractor to three levels of gamma—high, medium, and low. Figs. 6-1 and 6-2 are the characteristic curves for these negatives and positives. The medium contrast duplicate is very nearly the same as that ordinarily used for mission photography.

6.1 EXPERIMENTAL WORK

The experiment was conducted by NPIC personnel. The data were analyzed by photointerpreters at both NPIC and Itek. From this photography, 28 scenes were chosen to be examined. Since this was domestic photography, there were no insurgency areas or armored car movements; however, scenes that covered areas of possible military activity were chosen. For example, one scene was a mountain area partially in the shadow of a cloud. This was an ordinary part of southern California; however, not knowing this, an interpreter could be asked questions concerning the manner in which the images compared for assessing road damage. A group of 27 NPIC photointerpreters was used; each photointerpreter had four scenes to study. Each of the scenes had the six images—high, medium, and low contrast positives from the high and low gamma negatives. In 12 of the scenes, the target areas were identical (stereo pairs), obtained from the overlap region of the imagery. The remaining 14 scenes were similar in that the target was cut in half. One example of this would be a fairly large city that was on both halves of the 35-millimeter format when the film was slit.

The scenes were presented to the photointerpreters with the following instructions. First, they were to rank the images for their overall appearance. No specific points were to be noted. When this was done, they were to take the four best samples of the particular scene being examined and rate these according to how the images satisfied several questions. Each scene had from three to four specific questions that related to that particular scene. It was unfortunate that only the four best were chosen for the specific examination since the photointerpreters did not all choose the same four "best" ones. This attempt to save time caused difficulty in the analysis of the data.

The results are summarized in Table 6-1. This table shows the average rank of the six chips. The lowest number indicates that the photointerpreters ranked the chip first in quality. The higher value therefore represents the least preferred chip. One can conclude from this table, therefore, that over the average of all three duplicating conditions, the high gamma negative processing is best. One can also conclude that if the high gamma (either full or intermediate)

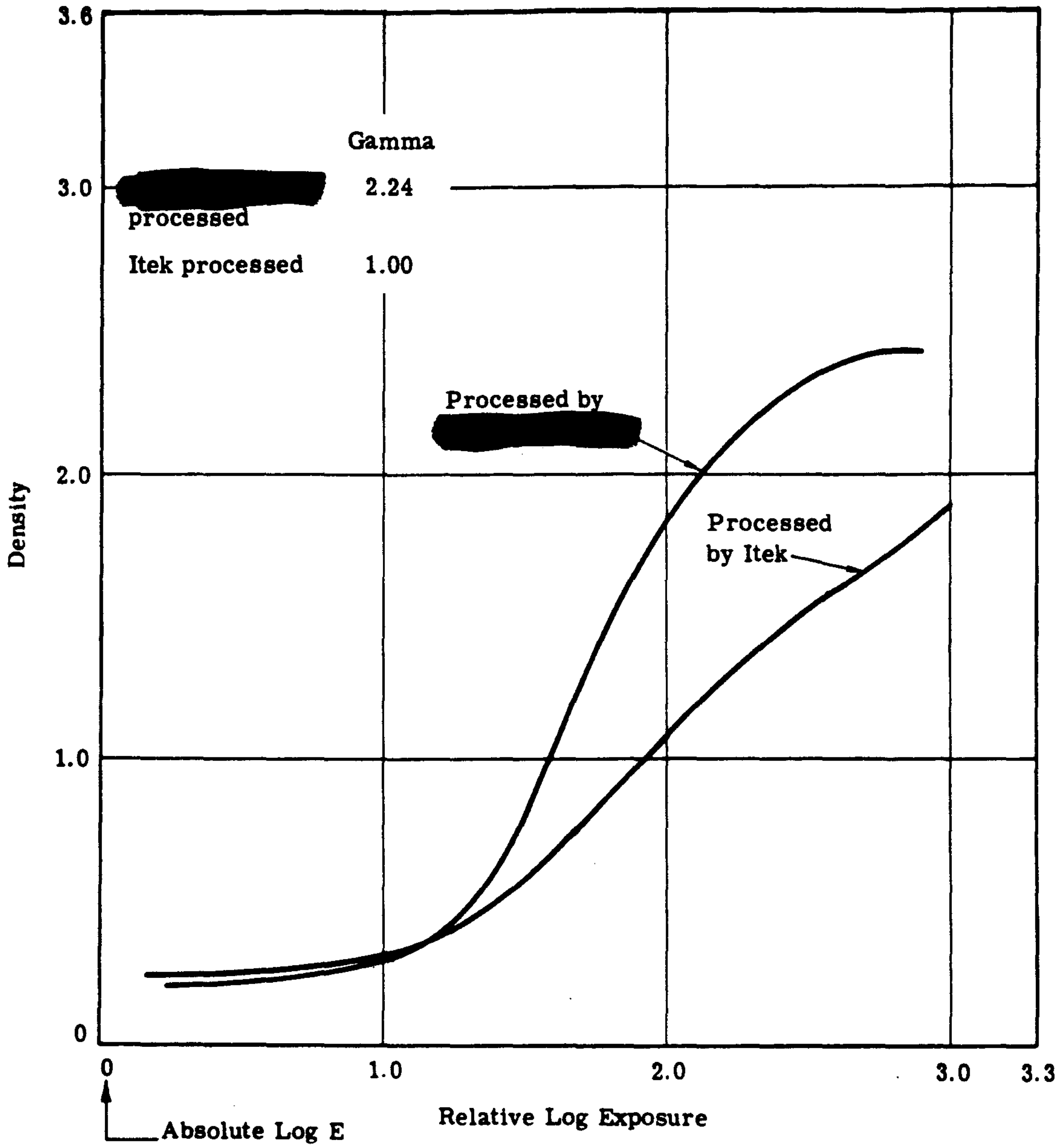


Fig. 6-1 — Sensitometric curves for 3404 processed at high and low gamma in the mission 1036 experiment

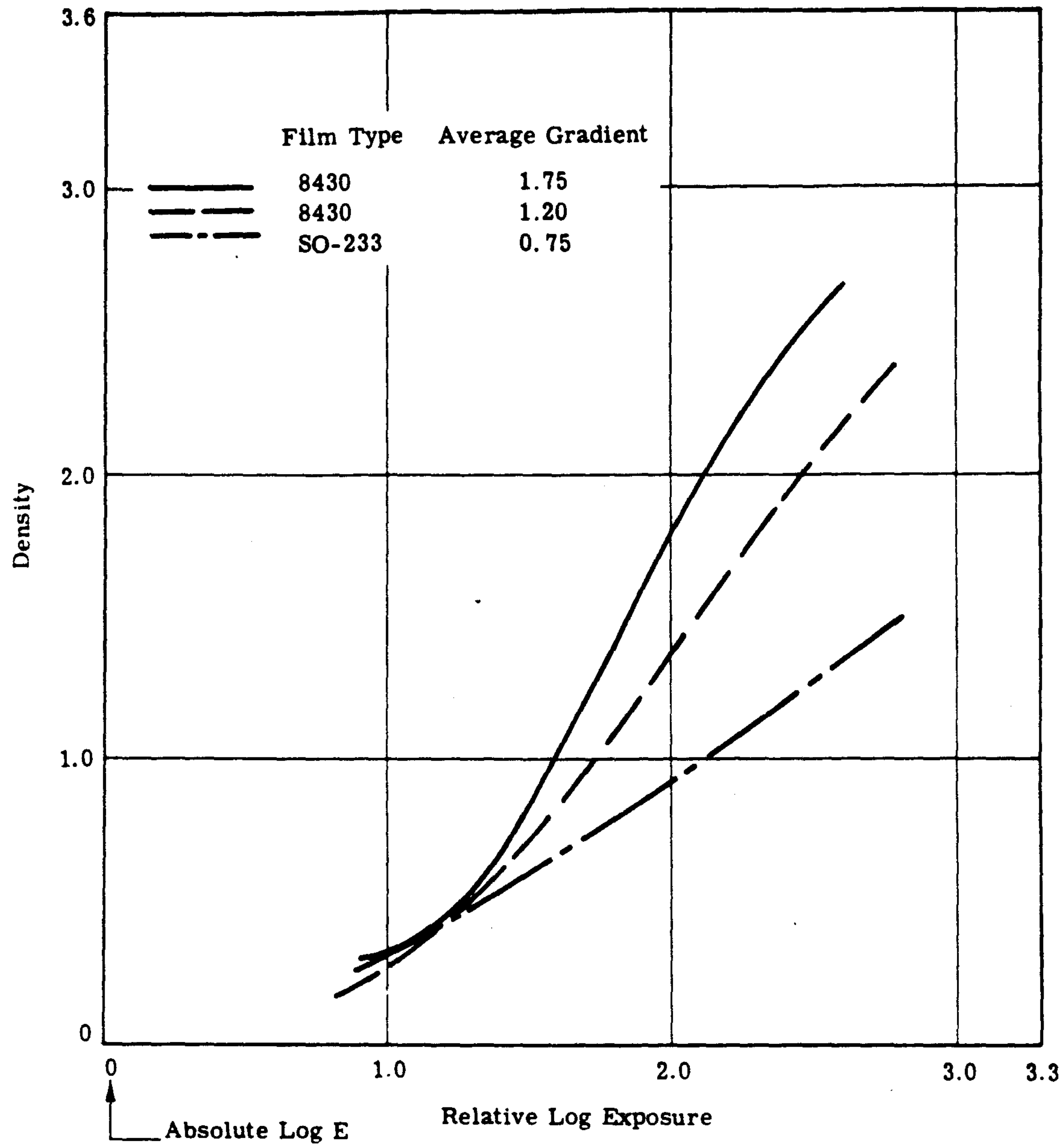


Fig. 6-2 — Sensitometric curves for the duplicate materials used in the mission 1036 experiment

Table 6-1 — Data Analysis Summary

	High	Medium	Low	Average
Overall Preference				
Low gamma	2.14	3.00	5.75	3.63
High gamma (both full and intermediate)	3.53	2.32	4.27	3.37
	2.83	2.66	5.00	3.50
Individual Examination				
Low gamma	2.23	3.03	5.80	3.68
Intermediate	2.96	2.43	4.55	3.32
	2.59	2.74	5.17	3.50
Low gamma	2.07	2.97	5.70	3.58
Full	4.03	2.22	4.00	3.42
	3.06	2.60	4.86	3.50

negatives were to be used, medium contrast printing is preferred. This is a satisfying conclusion since it is the current method of processing and duplicating mission photography. However, when stating that the high gamma negative is the best over the average of all three duplicate contrasts, an assumption is made that the three contrasts have an equal effect on both the high and low gamma negative. This assumption is not valid since the low gamma negative is severely treated when duplicated to a low gamma in comparison with the high gamma negative duplicated on a high gamma positive. In each individual case (the six values in the boxes of Table 6-1), the lowest number, or the chip most preferred, is the low gamma negative. It is also convenient that each of these occurs under the high gamma positive duplicating conditions. The conclusions, therefore, showed that at its optimum duplicating contrast (high gamma), the low gamma negative is most preferred. It should be noted, however, that this is preference and does not necessarily mean that the difference between the first and second preference is significant.

In order to determine the significance of this ranking, a Scheffel's test of significance for multiple means was used. This test indicates that there is no significant difference between the four combinations of:

Low gamma negative, high and medium gamma dupe
High gamma negative, high and medium gamma dupe

This test also indicates that either negative duplicated on the low gamma positive material gives very poor results, the low gamma negative/low gamma positive being the poorest combination of all.

6.2 DISCUSSION OF THE EXPERIMENT

Several factors that were uncovered during the experiment interfered with the analysis work. Normally, a better way to run an experiment is discovered after many mistakes have been made. Much has been learned from this experiment that will be useful in this type of analysis in the future. The following is a list of suggestions for the next low gamma experiment.

1. All photointerpreters should look at all of the scenes. This is perhaps the most costly suggestion in view of the fact that it consumed from 3 to 4 hours to thoroughly examine one set of six chips (one scene). With only four judgments of each scene (from four photointerpreters), the result could easily be swayed by only one person when a ranking method is used.

2. If the same two-stage experiment is used, all six chips should be used in the second part. By eliminating the two least preferred samples, the analysis was severely limited since not all photointerpreters eliminated the same two.

3. Only stereo scenes should be used. Selection of most preferred chips is very difficult when examining two images that are not identical (except for the factor under investigation). It is believed that the selection consumed a significant portion of the photointerpreter's examination time.

4. Several "density cuts" should be available to the photointerpreter for his evaluation. With only one print, there were areas that could have been improved and the photointerpreters judged these to be of lower quality for the wrong reason, thus favoring the high gamma negative, which was perhaps treated unfairly in this test.

5. Enough samples of each combination must be taken so that each element under test is compared for its characteristics alone. For example, the intermediate processing negative was

obtained from one camera and the full from the other. If a significant difference had been present, it would have been difficult to assign the proper cause.

6. Operational mission photography or engineering passes over other parts of the U. S. should be used. The results from these tests are applicable only to areas of the world similar to the southwestern part of California during the summer months.

7. There is a need to select several categories of scenes and to have several samples of each scene included in the test. The processing conditions for best results from one scene are not necessarily the best for another.

6.3 CONCLUSIONS

Many conclusions concerning differences in scenes, cameras, etc., can be drawn from this experiment. The following conclusions drawn from this experiment apply to the problem at hand, i.e., the problem of determining how low gamma processing affects the photointerpreter's judgment.

1. There is agreement among the photointerpreters as to the two poorest combinations—either the high or the low gamma negative duplicated on the low contrast positive.

2. There is considerable disagreement among the photointerpreters as to the best combination. Although there was a preference for the low gamma negative processing, there was in actuality, not a statistically significant preference. If the experiment were to be run again, with the same photointerpreters and their associated experimental error, there would be no guarantee that the preference would again be for the low gamma negative.

3. Another test should be run taking into account the suggestions discussed in Section 6.2. Since this test indicates that no harm is done by processing the original negatives to low gamma, it is suggested that a full scale test be undertaken with mission photography.

7. SUBJECTIVE EVALUATION, KH-4 TEST

In addition to the statistical experiment, a subjective analysis was performed at Itek in order to describe, in a photointerpreter's own words, what he saw in the images. For this analysis, the photointerpreter was asked only to view the stereo scenes. He performed this task with an A.O. split beam (ballistic type) microscope. Two of the scenes are included in this test for the benefit of the reader. The photointerpreter's evaluation is included below.

SPECIFIC EVALUATION OF KH-4 STEREO IMAGES

Table 7-1 indicates that acceptable duplicates can be generated from the high gamma as well as from the low gamma original negatives. In most cases, the low contrast duplicate from either original was poor and not acceptable. The low gamma duplicate lacked density and tonal range. With this lack of local contrast, it was difficult to detect information.

In many cases it was observed that the high contrast duplicate produced from the high gamma original negative lacked information in the highlight areas. These areas lacked detail and/or displayed blooming, making it difficult to make any precise measurements or to determine the location of an edge of an object. The prints of the tank farm in Fig. 7-1, scene 16, display the general tendency of the very high contrast duplicates to lose detail in the highlight areas. Notice also the lack of detail in the low contrast dupes.

Fig. 7-2, scene 2, displays tonal differences from the six duplicates. The loss of information in both low contrast duplicates is apparent.

In some cases, a scene was not downgraded due to lack of detail in the highlight areas where a sufficient increase in exposure would not affect the detail in the shadow areas.

Table 7-1 — Photointerpreter Rating of Stereo High-Low Gamma Scenes

Scene Number	High Gamma Negative Duplicates			Low Gamma Negative Duplicates			Comment
	Low Contrast	Medium Contrast	High Contrast	Low Contrast	Medium Contrast	High Contrast	
2 Tank farm	Poor	Good	Accep	Poor	Accep	Good	Low gamma, high contrast dupe had best tonal range and information content
8 Liquid storage	Accep	Good	Poor, washed out	Poor, no detail	Good	Accep, washed out	No significant difference
9 Buildings	Poor	Good	Good	Poor	Accep - Good	Good	No significant difference
10 Cloverleaf airfield	Poor	Good, high-lights	Accep - Good, blooming	Poor	Good	Accep - Good	No significant difference
11 Earth, Dam	Poor	Good	Accep - Good	Poor	Accep	Good	No significant difference
12 Farm	Poor	Good	Good	Poor	Good	Good	No significant difference
13 Buildings	Poor	Accep	Good	Poor	Good	Accep	High gamma, high contrast dupe had best tonal range and information content
16 Boats, Dam	Accep	Good	Accep, loss of detail in highlights	Accep, loss of detail in shadows	Good	Accep	Low gamma, medium contrast dupe contained better detail in highlight and shadow areas
17 RR yard	Accep	Good	Good - Accep	Poor	Good	Good	No significant difference
18 Town	Accep	Good	Accep - Poor	Accep	Accep - Good	Good	Low gamma, high contrast selected due to better definition in low density area. High gamma, medium contrast may be equal if given more exposure
22 Tank ferry	Accep	Good	Accep	Poor	Good	Good	No significant difference

Good = Good tonal differences; detail in highlights and shadows.
Accep = Acceptable tonal differences; may lack detail in shadow or highlight area but not both.
Poor = Poor tonal differences; hard to distinguish information beyond gross details; general lack of information.

[redacted]

High Contrast O.N.
High Contrast D.P.

[redacted]

Low Contrast O.N.
High Contrast D.P.

[redacted]

High Contrast O.N.
Medium Contrast D.P.

[redacted]

Low Contrast O.N.
Medium Contrast D.P.

[redacted]

High Contrast O.N.
Low Contrast D.P.

[redacted]

Low Contrast O.N.
Low Contrast D.P.

Fig. 7-1 — Contact duplicates from KH-4 mission 1036 EKIT 8

[redacted]

High Contrast O.N.
High Contrast D.P.

[redacted]

Low Contrast O.N.
High Contrast D.P.

[redacted]

High Contrast O.N.
Medium Contrast D.P.

[redacted]

Low Contrast O.N.
Medium Contrast D.P.

[redacted]

High Contrast O.N.
Low Contrast D.P.

[redacted]

Low Contrast O.N.
Low Contrast D.P.

Fig. 7-2 — Contact duplicates from KH-4 mission 1036 EKIT 8

8. CONCLUSIONS

The following conclusions have been drawn from the work involved in these tests.

1. There is no evidence that any harm results from low gamma processing of the original negatives. It is realized that the sampling is rather limited, being acquired over the southern part of California during the summer months.

2. There is a definite improvement in highlight information with low gamma processing. The main reason for this improvement is that the shoulder of the negative characteristic curve is brought down low enough so that its information can be properly transferred to the positive material.

3. There appears to be an increase in shadow detail with low gamma processing. The longer sloping toe of the low gamma negative material gives a better rendition of the shadow information (provided there is adequate speed) than does the rather abrupt toe of the high gamma negative material.

4. There appears to be a real increase in resolution and edge sharpness with low gamma processing. It is believed that the high activity developers required for high gamma processing have a harmful effect on the edges. The low gamma formulations obtain the speed through another mechanism, the phenidone, which does not have to operate at such high pH.

5. There is no evidence of a significant loss in contrast due to atmospherics with low gamma processing. Since all worldwide weather patterns are not the same, the full effect of low gamma processing will not be known until these formulations have been used on an operational mission.

6. The KH-4 (mission 1036) experiment indicates that NPIC photointerpreters prefer the low gamma original negative duplicated on the high gamma printing system. The preference has not been shown to be statistically significant over that of the high gamma negative duplicated on the medium gamma positives.

7. Low gamma formulas that produce emulsion speeds equal to the normal "full" processing can be generated. These formulations work well with immersion processing and some work has been carried out with viscous techniques. It is difficult, though not impossible, to implement low gamma processing on operational material when using spray processing in the Trenton Processor. The low gamma formulations use phenidone which is oxidized rapidly in the spray processor.

8. Further operational testing of low gamma processing with the KH-4 System is recommended. Further research on both viscous and spray formulations should be concurrently pursued.

Appendix

STATISTICAL EXPERIMENT BRIEFING GIVEN BY NPIC

The charts in this appendix summarize the results of the statistical experiment performed by NPIC statisticians on KH-4 mission 1036. The essential points of this experiment have been explained in Section 6. The charts have been included as a supplement to EKIT report no. 8.

TERMINOLOGY

MATERIAL DESCRIBERS

- GAMMA *(NEGATIVE)*
  - LOW GAMMA
  - STANDARD/INTERMEDIATE
  - STANDARD/FULL
- CONTRAST *(POSITIVE)*
  - HIGH
  - MEDIUM
  - LOW

TESTS

- RANKING *(INITIAL)*
- RATING *(SECOND)*

THE PROBLEM

LOW GAMMA – *Should we use it or not?*

THE STATISTICAL PROBLEM

- ASSUMPTIONS
- OBSERVATIONS
  - *RANKING*
  - *RATING*
- STATISTICAL DECISIONS

AVERAGES OF RANKS

	GAMMA	CONTRAST HIGH	CONTRAST MED	CONTRAST LOW	
OVERALL: LOW VS STANDARD PROCESSING	LOW	2.14	3.00	5.75	3.62
	STD.	3.53	2.32	4.27	3.37
		2.83	2.66	5.00	3.50
LOW VS STANDARD/ INTERMEDIATE PROCESSING	LOW	2.23	3.03	5.80	3.68
	STD.	2.96	2.43	4.55	3.32
		2.59	2.74	5.17	3.50
LOW VS STANDARD/ FULL PROCESSING	LOW	2.07	2.97	5.70	3.58
	STD.	4.03	2.22	4.00	3.42
		3.06	2.60	4.86	3.50

DIFFERENT VS SAME SCENES AND FWD VS AFT CAMERA POSITIONS

	GAMMA	CONTRAST					GAMMA	CONTRAST			
		HIGH	MED	LOW				HIGH	MED	LOW	
DIFFERENT SCENES *ANY CAMERA*	LOW	2.22	3.27	5.74	3.73	SAME SCENES *ANY CAMERA*	LOW	2.05	2.60	5.76	3.47
	STD.	3.39	2.19	4.20	3.24		STD.	3.73	2.50	4.36	3.53
		2.81	2.73	4.86	3.50			2.89	2.55	5.07	3.50
DIFFERENT SCENES *FWD CAMERA*	LOW	2.48	3.42	5.84	3.92	SAME SCENES *FWD CAMERA*	LOW	2.01	2.82	5.76	4.02
	STD.	2.58	2.27	4.42	3.09		STD.	3.34	2.56	4.56	3.97
		2.53	2.58	5.17	3.50			2.48	2.50	3.30	3.50
DIFFERENT SCENES *AFT CAMERA*	LOW	2.09	3.22	5.71	3.67	SAME SCENES *AFT CAMERA*	LOW	2.14	2.20	5.80	3.38
	STD.	3.26	2.16	4.10	3.33		STD.	4.47	2.40	4.00	3.62
		2.92	2.68	4.90	3.50			3.30	2.30	4.90	3.50
ALL SCENES *FWD CAMERA*	LOW	2.20	3.07	5.78	3.68	ALL SCENES *AFT CAMERA*	LOW	2.11	2.95	5.79	3.60
	STD.	3.09	2.44	4.50	3.32		STD.	3.58	2.22	4.07	3.42
		2.62	2.75	5.14	3.50			3.02	2.59	4.90	3.50

SUMMARY

GROUP	PREFERENCE			
	FIRST	SECOND	GAMMA	CONTRAST
ALL	LH	SM	STD	M
STD/INTER	LH	IM	INT	H
STD/FULL	LH	FM	FULL	M
DIF SCENE	LH	SM	STD	M
SAME SCENE	LH	SM	LOW	M
FWD CAMERA	LH	SM	STD	H
AFT CAMERA	LH	SM	STD	M

SUB-SAMPLES

	GAMMA	CONTRAST HIGH	CONTRAST MED	CONTRAST BOTH
RATINGS FOR 44 CASES	LOW	2.34	2.62	2.48
	STD.	2.70	2.35	2.53
		2.52	2.49	2.50
RANKS FOR 44 CASES	LOW	1.98	3.30	2.63
	STD.	2.66	2.07	2.36
		2.32	2.68	2.50
RANKS FOR 59 CASES	LOW	1.95	3.31	2.63
	STD.	2.64	2.11	2.37
		2.29	2.71	2.50

CONCLUSIONS

1. DEGREE OF PREFERENCE - NOT KNOWN
2. CONTRAST - APPEARS AS SIGNIFICANT AS GAMMA
3. STANDARD GAMMA - PREFERRED TO LOW GAMMA
4. LOW GAMMA/HIGH CONTRAST - FIRST PREFERENCE
5. STANDARD GAMMA/MEDIUM CONTRAST - SECOND PREFERENCE
6. NO CLEAR PROOF THAT THE FOLLOWING HAVE MUCH EFFECT
   - SAME VS DIFFERENT SCENES
   - FORWARD VS AFT SCENES
7. A BETTER TEST IS REQUIRED

INITIAL RANKING PREFERENCES

NEGATIVE	CONTRAST	PREFERENCE FIRST		PREFERENCE SECOND	
INTERMEDIATE VS LOW	HIGH	10	16	10	15
	MED.	12	10	13	6
	LOW	1	0	5	0
FULL VS LOW	HIGH	3	15	6	28
	MED	24	11	10	6
	LOW	2	0	4	1
STANDARD VS LOW	HIGH	13	31	16	43
	MED	36	21	23	12
	LOW	3	0	9	1
TOTAL		52	52	48	66

RANKED RATING PREFERENCES

NEGATIVE	CONTRAST	PREFERENCE FIRST		PREFERENCE SECOND	
INTERMEDIATE VS LOW	HIGH	14	19	(9)	(14)
	MED	(15)	(21)	(9)	7
	LOW	3	0	1	0
FULL VS LOW	HIGH	6	(26)	6	(15)
	MED	(22)	14	(12)	8
	LOW	5	0	6	1
STANDARD VS LOW	HIGH	20	(45)	15	(29)
	MED	(37)	35	(21)	15
	LOW	8	0	7	1
TOTAL		65	80	43	45