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1 April 1968

Dear Pat:

We are forwarding herewith one (1) copy of the following report for your review:

Contract [redacted]

Classified Supplement to Quarterly Report - Third Quarter FY-68 (2 December 1967 through 8 March 1968) [redacted]

[redacted]

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Classified Supplement to
QUARTERLY REPORT
Third Quarter FY-68

(2 December 1967 through 8 March 1968)

8 March 1968

Prepared by:

[redacted]

Approved by:

E. L. Green

Date: 28 March 1968

Prepared at Contractor's Facility
as Specified by
Contract [redacted]

[redacted]

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8 Mar 68

INTRODUCTION

The higher classification of the PAR 24-8-5S, 24-7-6S/R2, 24-7-7S/R1, 143S and 144S/M quarterly reports requires that they be bound separately from the other PAR reports making up the Quarterly Report, Contract [redacted] Third Quarter FY-68 dated 8 March 1968 [redacted].

8 Mar 68

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Contract [redacted] Task 3

Third Quarter FY-68

PAR 24-8-5S

8 Mar 68

SUBJECT: Exposure Criteria for Acquisition Films

TASK/PROBLEM

1. Modify and refine the criteria for exposure of black-and-white and color acquisition films through analysis of data from orbital missions and scientific literature. As significant results are obtained, publish updated exposure recommendations for the reconnaissance community.

DISCUSSION

2. <u>Mission Exposure Analysis</u>

a. <u>Routine Data Collection and Processing</u>

(1) Data collection of the main camera record for routine orbital missions continues. Data collection of the terrain (index) camera record was started and will be reported on a regular basis along with the main camera record.

(2) Routine analysis of main and terrain camera density data for the Scene Luminance Study was completed for 4 of the 6 missions listed in Table 1. Density/luminance profiles were also completed for these 6 missions, and are shown in Figures 9 through 32 at the end of this report.

<u>Table 1</u>

Number	Mission	Density Data Collected	Data Processing Completed	Analysis Complete (Percent
	1000 Series			
1	1044-1	11/13/67	11/21/67	100
	1044-2	11/20/67	11/30/67	100
2	1045-1	2/05/68	--	90
	1045-2	2/12/68	--	90
	1100 Series			
3	1101-1	10/11/67	10/25/67	100
	1101-2	10/18/67	11/02/67	100
4	1102-1	12/28/67	--	90
	1102-2	1/11/68	--	90
5	[redacted]	[redacted]	[redacted]	[redacted]
6				

b. Routine Mission Evaluation. Main camera density analysis for completed 1000- and [redacted] missions is summarized in Figures 1 and 2. (A similar summary graph for the 1100 series will be compiled when three two-part missions have been processed.) These figures are based on a criterion of 1.2 gradient for both upper and lower density extremes.* Included in Figures 3 and 4, for comparison purposes, are similar results from earlier missions which use two different criteria for the tolerance limit of the lower density extreme, 0.5 and 0.4; in both of those cases 2.0 has been used as the upper density limit. For frames which had density values below or above the desired limits, the graphs indicate whether this condition could have been corrected or improved by different levels of processing or exposure.

(1) Summary Evaluation for 1000 Series. Analysis for one mission of this Type (1044) was completed during the period since the last quarterly report was issued (1 December 1967). [redacted] The data in Table 2 compares the degree of underexposure between Missions 1042, 1043, and 1044.

Table 2

Mission	Dmin Tolerance Criteria	Percentage of Frames Considered Underexposed (Three-Condition Process Data Only) -1 FWD	-1 AFT	-2 FWD	-2 AFT	Overall
1044	0.4	23.2	23.8	25.8	20.3	23.3
	0.45**	--	43.0	--	28.2	35.6
	0.49**	46.6	--	43.9	--	45.3
1043	0.4	18.0	14.9	35.2	14.2	20.6
	0.47**	39.3	34.0	52.6	36.2	40.6
1042	0.4	2.2	8.6	2.5	0.0	3.3
	0.56**	50.6	50.4	48.2	38.9	47.0

* i.e., densities which plot on the density vs log exposure curve where that curve has a slope greater than 1.2, are within the extremes.

**1.2 Gradient Density Level

[redacted]

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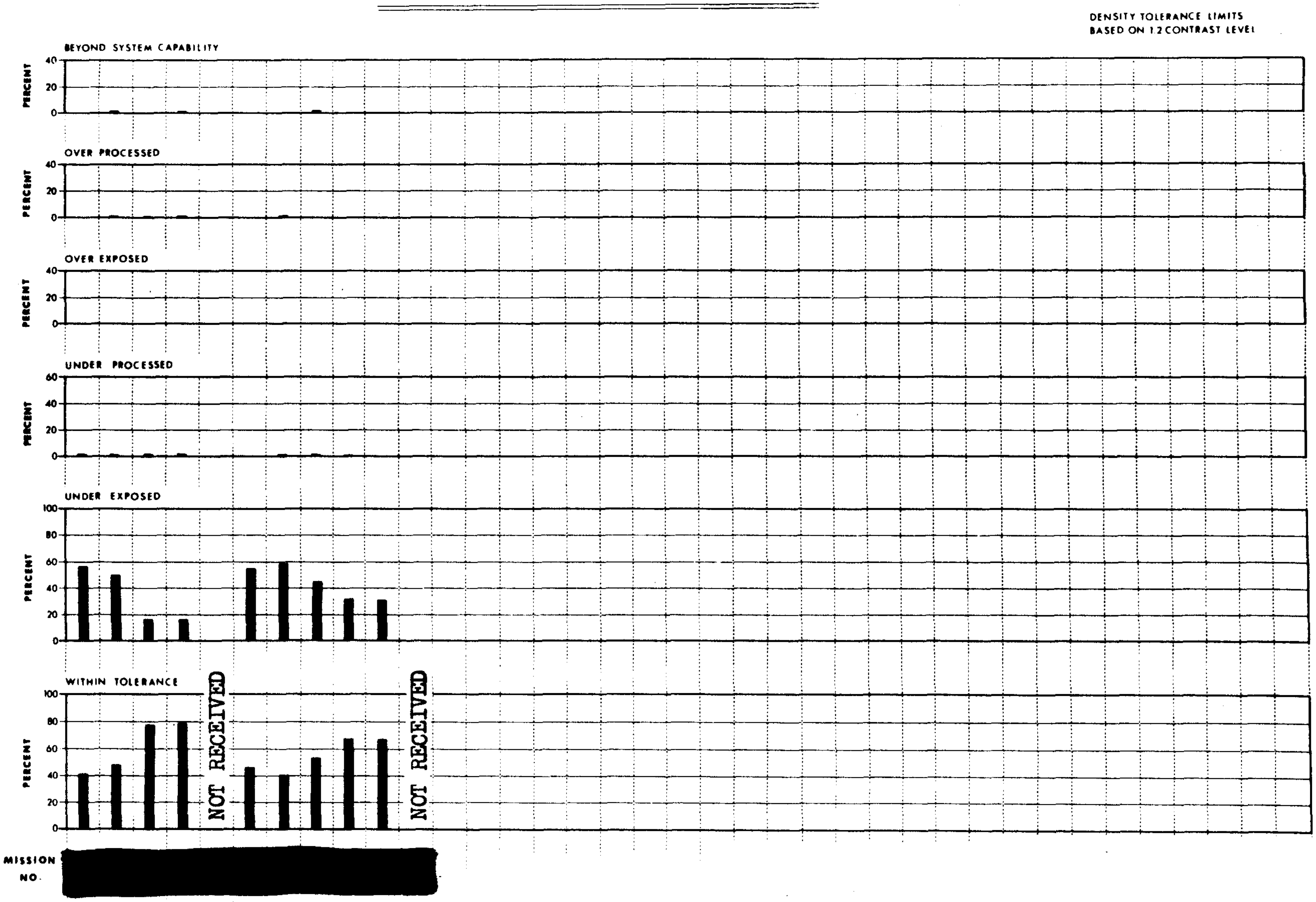
Figure 1

MAIN CAMERA

Cumulative DENSITY TOLERANCE ANALYSIS



[redacted]

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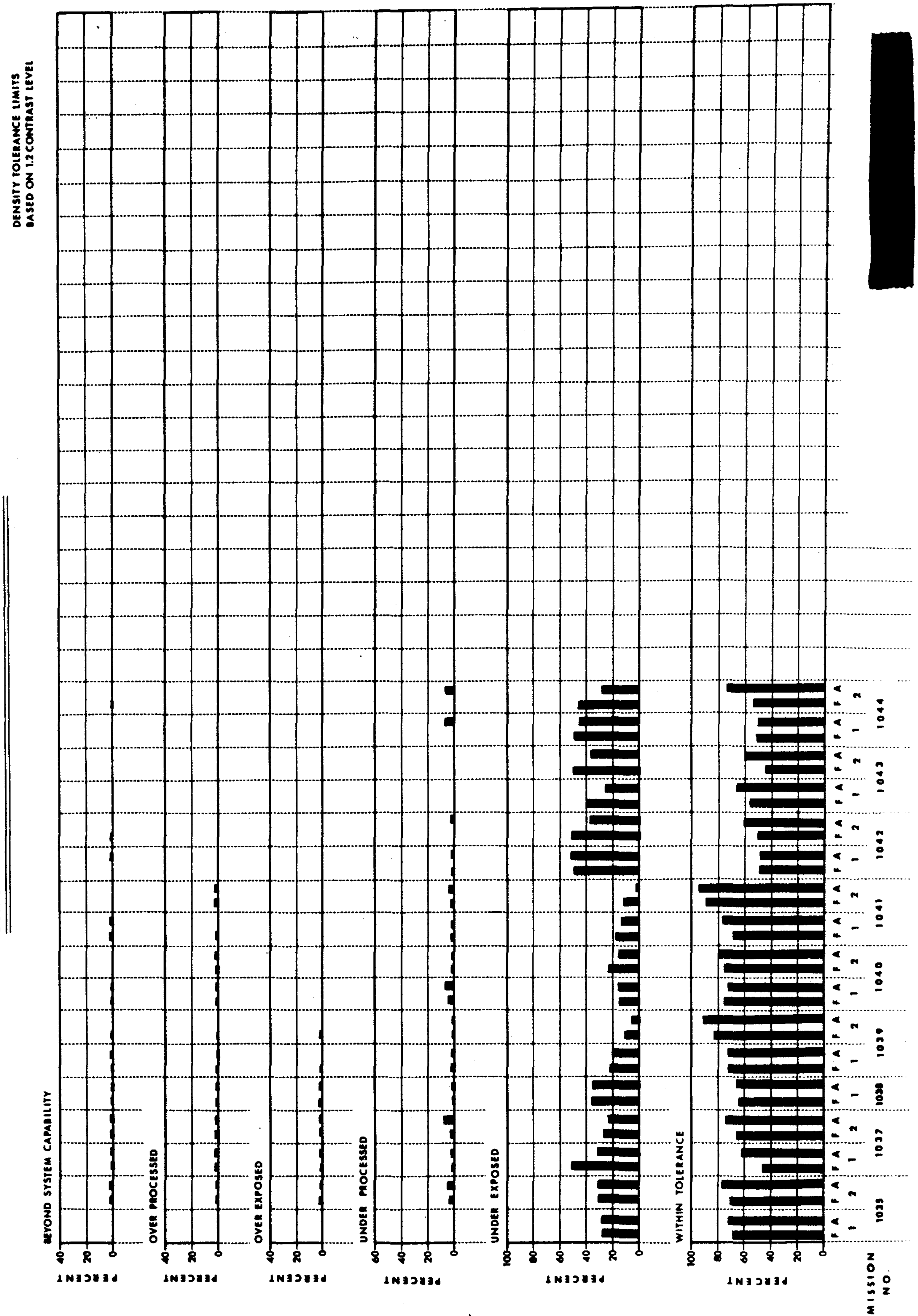
Figure 2

MAIN CAMERA

Cumulative DENSITY TOLERANCE ANALYSIS



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[redacted]

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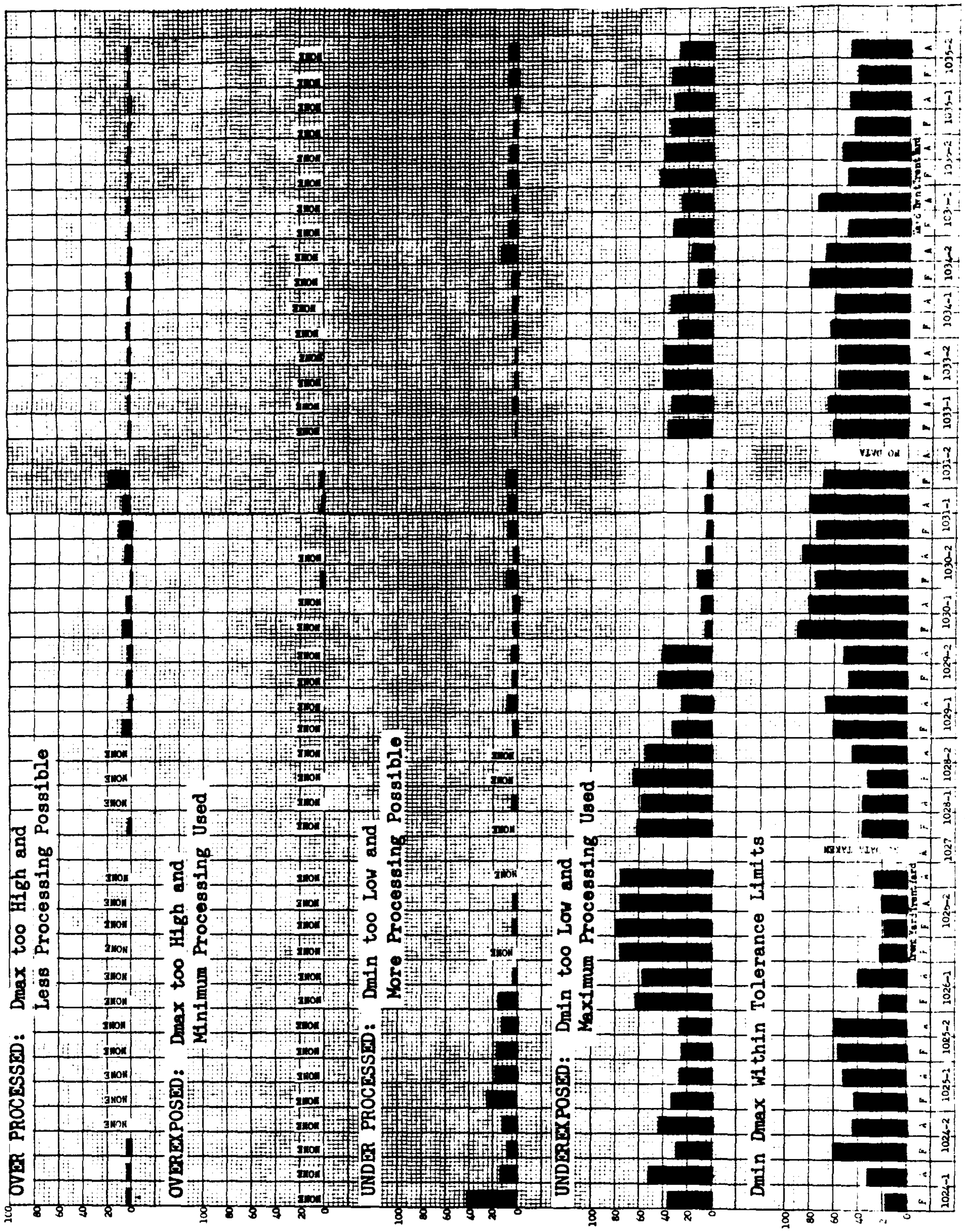
Figure 3

Analysis of Frames Out of Tolerance Using Two Criteria (1000-Series Missions)



Density Tolerance Limits: 0.5 to 2.0

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[redacted]

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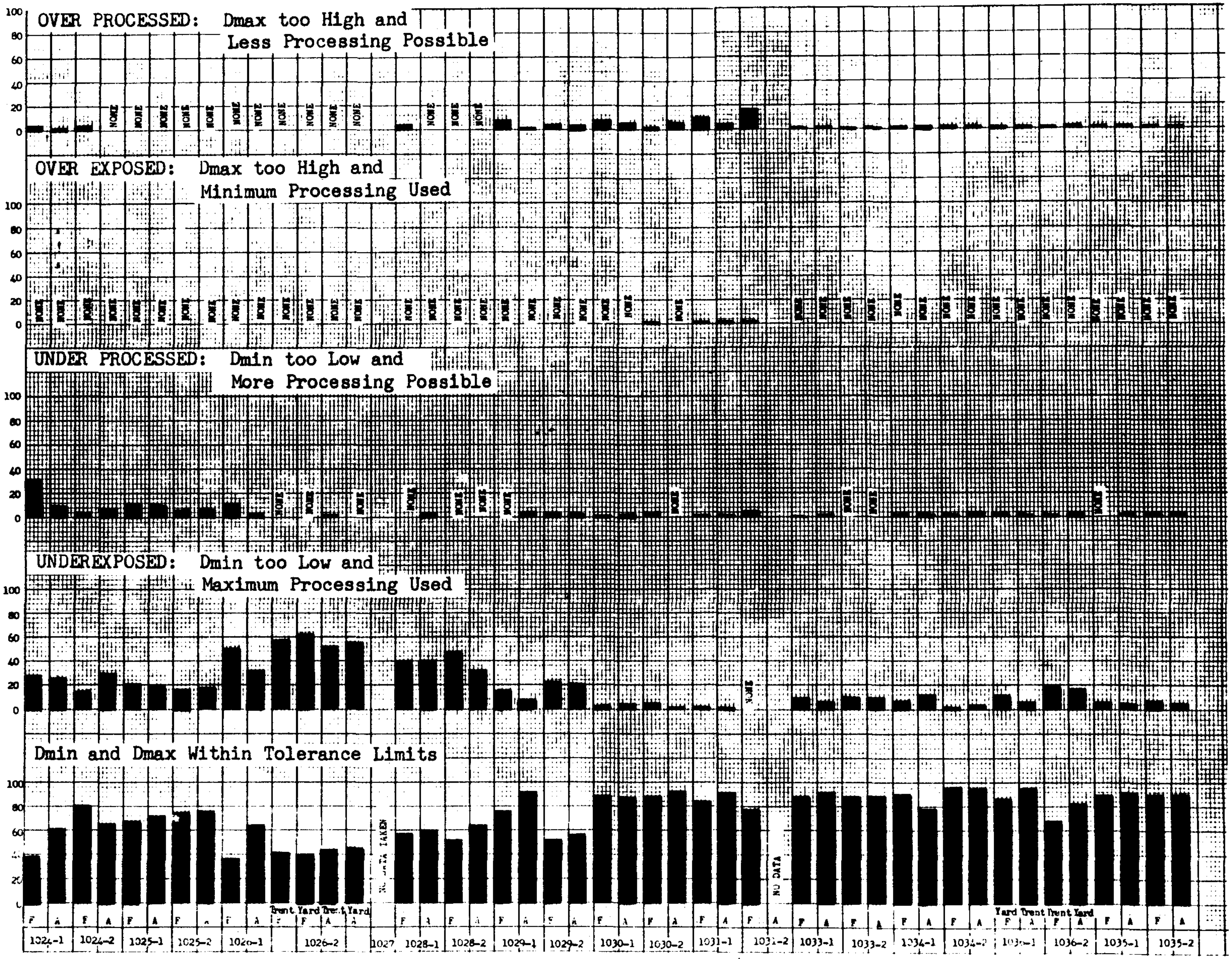
Figure 4

Analysis of Frames Out of Tolerance Using Two Criteria (1000-Series Missions)



Density Tolerance Limits: 0.4 to 2.0

[redacted]

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Two criteria are tabulated: The 1.2 gradient method currently being used, and the 0.4 minimum density method historically used by some members of the community. The percentage of underexposure determined when using the 0.4 minimum density criteria can be misleading if the fog level is high. Such is the case with Mission 1042. The fog level was higher than that of Missions 1043 and 1044; the 0.4 data would indicate that Mission 1042 was much less underexposed. This is in disagreement with the 1.2 gradient method used here, which indicates all three missions are substantially underexposed, with 1042 being slightly worse in this regard than either 1043 or 1044.

(2) Summary Evaluation for 1100 Series

(a) Mission 1102 was processed during the period since the last quarterly report (see again Table 1). Analysis was completed on Mission 1101. As noted earlier, the density data for completed 1100-series missions will be compiled into cumulative bar charts similar to Figures 1 and 2 when a total of three two-part missions have been processed.

(b) Mission 1101 had luminance values which were slightly lower than the normal distribution found for a September launch. A majority (56.4%) of the frames was underexposed. Table 3 compares the percentage of frames judged to be underexposed by the current 1.2 gradient method and the 0.4 minimum density criterion used previously.

Table 3

	Percentage of Frames Considered Underexposed				
	1101-1		1101-2		
Minimum Density Judgment Level	Fwd	Aft	Fwd	Aft	Overall
0.4	40.5	17.0	33.2	30.3	30.1
0.50 (1.2 Gradient)	65.6	42.9	59.3	57.7	56.4

(c) Exposure experiments carried out in these missions are reported in detail later in paragraph 2.f.(3).

(3) Summary Evaluation for [redacted] Series

(a) One mission of this type was processed [redacted] during the period since the last quarterly report (see again Table 1). Analysis was completed on two missions [redacted]. Density analysis for completed [redacted] series missions is summarized by the bar charts of Figure 1.

(b) Based on the 1.2 contrast level, Missions [redacted] and [redacted] were similarly underexposed (approximately 31%). The average luminances of both missions very closely approximated the normal distributions previously reported for their respective launch months, October and December.

c. <u>Computer Programs and Reporting Procedures</u>

(1) Input message in machine readable form.

(a) The IBM 047 tape-to-card converter is adequately servicing present requirements.

(b) As yet there has been no action on the magnetic tape communication system suggested by some customer personnel.

(2) Two approaches for possible replacement of the current density tolerance criteria will be analyzed.

(a) Base the lower density tolerance limit upon a fixed density above fog.

(b) Evaluate exposure/processing by utilizing the resolution/exposure relationships.

(3) General improvements in mission reporting have been achieved in 1000- and [redacted]-series missions by the use of the new cumulative comparison graphs (see example Figures 1 and 2). When data for these missions have been collected, a similar type graph will be constructed for 1100-series missions.

d. <u>Scene Luminance Curves and Exposure Recommendations</u>

(1) Exposure time recommendations have been made for DISIC terrain camera in each 1100-series flight as summarized in Table 4.

Table 4

Mission	Film Type	Exposure Time (sec)	Solar Altitude Range (Degrees)
1101	3400	1/250	0 - 50
	3400	1/500	51 - 90
1102	3400	1/250	0 - 17
	3400	1/500	18 - 90

(2) Because of an equipment anomoly, all DISIC terrain photography in Mission 1101 was taken at 1/250 second. All Mission 1102 DISIC terrain photography was taken at 1/500 second by customer direction.

(3) It has been observed that when the monthly seasonal luminance curves* for the forward camera of 1000-series missions are subjectively tempered by experience from recent terrain camera data, an approximation regarding the terrain luminances by month can be made. In the range of approximately 300 to 400 ft-L, the observed terrain luminances have been about 100 ft-L lower than the observed main forward camera luminances. Utilizing this data, it is possible to recommend exposures for 1100-series terrain records based upon the date of launch; i.e., seasonally.

(a) Specific recommendations based upon the above approach have been transmitted by message to the customer and interested vendor for Missions CR-3 and CR-4.

(b) In addition to the normal recommendations, which were given based upon the lens and f/4.5 aperture used in the two initial missions in this series (CR-1 and CR-2), recommendations were made in the event the lens is stopped down to an aperture of f/6.3 as planned.

(4) Information has been received that the exposure times can be changed over a certain range but the ratio between them must remain a factor of two. More specific recommendations based upon this data have been prepared for Missions CR-3 and CR-4 and transmitted to the interested vendor in the same message mentioned in paragraph (3)(a) above.

e. <u>Effects of Masking Donut on Analysis of [redacted]-Series Terrain Photography</u>

(1) The optical system of the [redacted] series terrain camera is not capable of producing uniform image-forming light at the focal plane of the camera. The result is some vignetting at the corners of the square format (a falling off of illumination, and hence less density on the negative) and a minor "hot spot" in the center of the format (producing higher than normal densities). This effect is greatly enhanced when the terrain record

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*PAR 24-7-5S Interim Report, "Seasonal Exposure Recommendations for Satellite Systems," Contract [redacted] Task 1, 22 June 1967.

is processed in a high-gamma chemistry; i.e.. 2.60 gamma, and is minimized to insignificant proportions when processed to a lower gamma; i.e.. 1.5 to 1.8.

(2) Analysis of comparative data taken from Mission [redacted] indicated that a given material is considered better exposed and processed when measurements are made within the limitations of the masking donut, than for the same material measured without the mask. The mask probably gives a better indication of the system performance when the high gamma process is used. When the terrain record is processed to a gamma significantly lower than formerly used (1.5 to 1.8 vs 2.60) the use of the masking donut is not particularly effective; i.e., the results are not significantly different. It is recommended that any future [redacted]-series terrain records processed to a gamma of 2.60 be analyzed with the masking donut. The masking donut is not recommended for use with 1.5 - 1.8 gamma terrain records.

f. Analysis of Exposure Experiments

(1) Stereo Slit-Change Experiments [redacted] Series). Analysis of the slit-change stereo exposure experiments in the [redacted]-series was completed, and a report written and approved for publication. A special feature of this report is an objective evaluation of the trade-off between smear and exposure. Publication should occur with or shortly after this quarterly report.

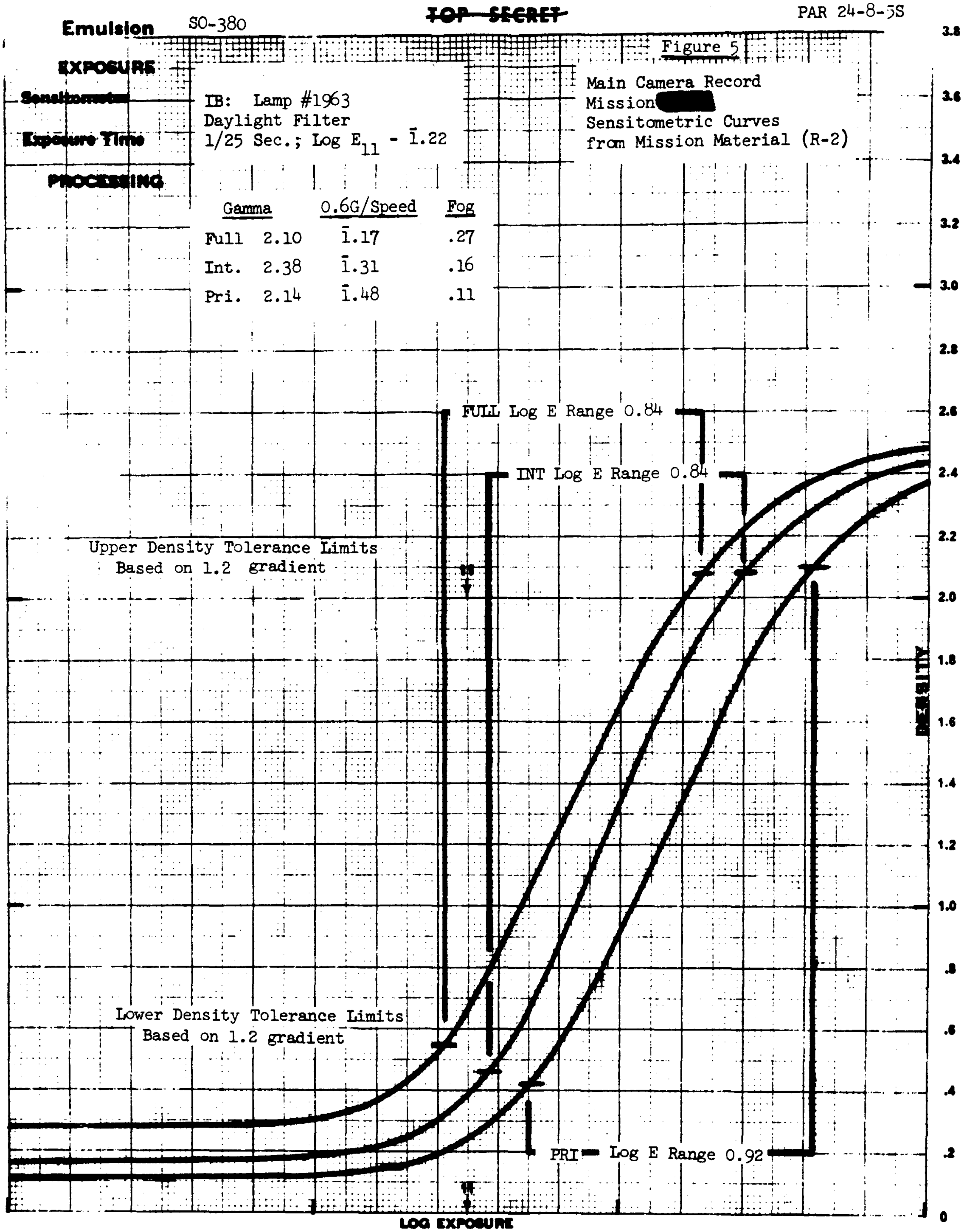
(2) Analysis of Exposure When Material is Processed in Dual-Gamma Process

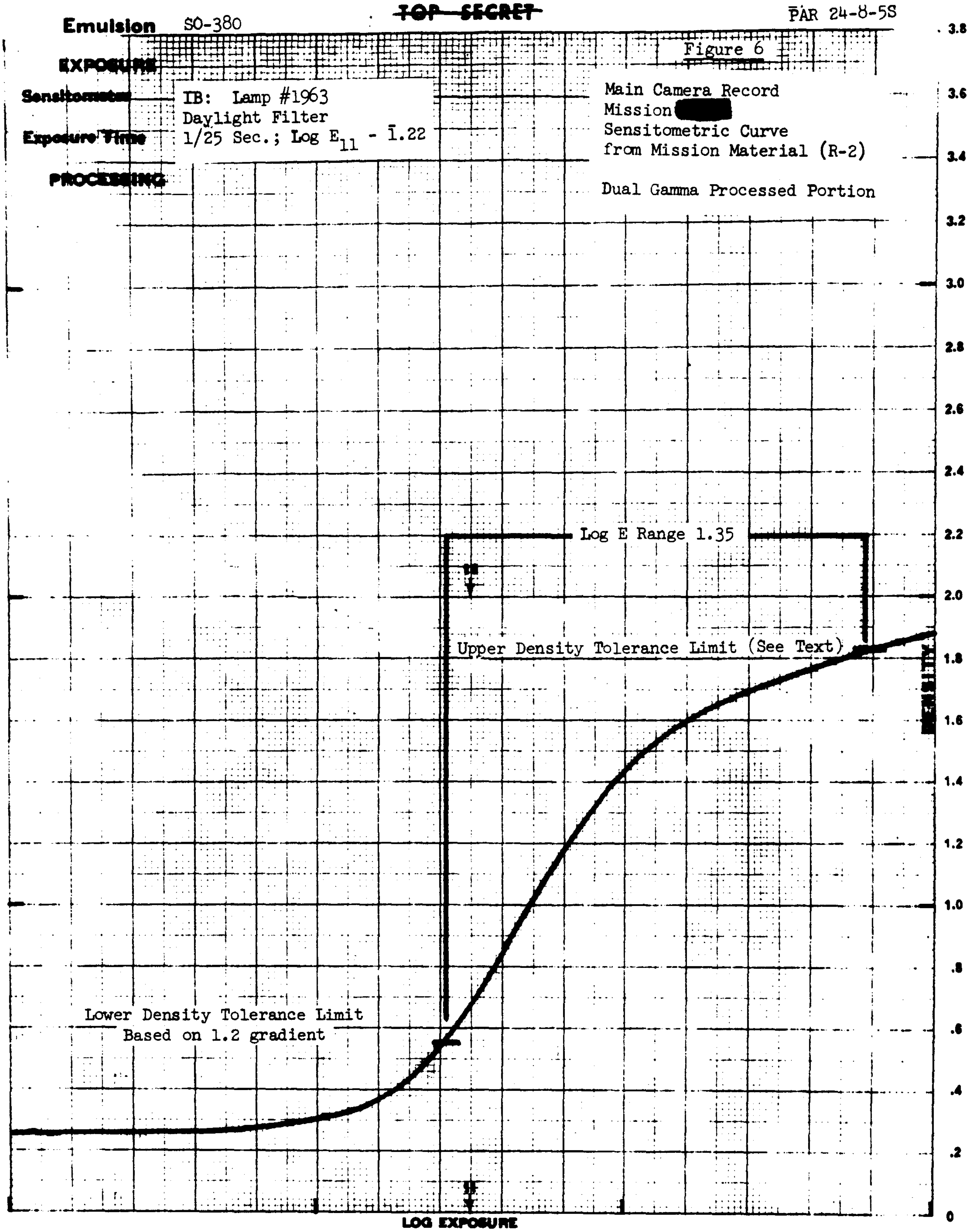
(a) Portions of the main camera records of missions 1044 and [redacted] were given a single-level, dual-gamma process. Historically, there have been two schools of thought regarding the gamma to which an aerial negative should be developed. The normal high gamma process supplied the necessary shadow detail but at the same time led to "blooming" of highlights. Developing to a lower gamma improved the highlights, but resulted in excessive loss of shadow detail. A study was made on PAR 24-7-2S which indicated that what was needed was a process which would provide, in effect, two gammas. A theoretical sensitometric curve which would supply the desired contrast characteristics was derived from this analysis and a developer formulation was obtained which produced results closely approximating the theoretical curve.

(b) Sensitometrically, the dual-gamma curve is designed to have the same toe speed as the Yardleigh/Trenton "Full" level (see Figures 5 and 6). At a density of approximately 1.0 the dual-gamma curve starts to shoulder off; while the Yardleigh/Trenton "Full" curve continues to climb until an approximate density of 1.9, when it then starts to shoulder. The gamma of the standard process approaches zero near a log E of 0.4, while on the dual-gamma curve there is still enough slope to distinguish exposure differences even beyond this point. Exposures are recorded on the shoulder of the dual-gamma processed material at densities substantially lower than those on the standard process curve which results in, among other things, less blooming of the image.

(c) The overexposure density tolerance limit for the single-level, dual-gamma process is determined as follows: The 1.2 shoulder gradient log E is taken from the <u>Primary</u> curve for the three-level process (0.34). The single-level, dual-gamma sensitometric curve is entered at this log E and the resultant density noted. If this density were used as the upper density tolerance limit, any object considered overexposed at the Primary level of the three-condition process would also be considered overexposed in the dual-gamma system. Inasmuch as one advantage of the single-level, dual-gamma process is that objects having somewhat higher luminances can be recorded without resulting in overexposure, a one-half stop shift (0.15 log E) to the right (to 0.49 log E from 0.34) is arbitrarily made. This, in effect, results in an exposure latitude of approximately 1.35 log E vs the total three-level process range of approximately 1.25. Using this approach, the resultant over-exposure tolerance limit for the single-level, dual-gamma of Mission [redacted] material is a density of 1.83.

(d) An analysis of the dual-gamma processed portions of Missions 1044 and [redacted] indicated a slightly greater degree of underexposure than the three-level processed portions. As the toe shape and placement of both the standard "Full" curve and the dual-gamma curve are virtually identical; i.e., they superimpose on the sensitometric plot, this difference between the amounts of underexposure can be attributed to the fact that the photography


Emulsion SO-380
Figure 5
EXPOSURE
Sensitometer
Exposure Time
PROCESSING
IB: Lamp #1963
Daylight Filter
1/25 Sec.; Log E11 - 1̄.22
Main Camera Record
Mission[redacted]
Sensitometric Curves
from Mission Material (R-2)
Gamma 0.6G/Speed Fog
Full 2.10 1̄.17 .27
Int. 2.38 1̄.31 .16
Pri. 2.14 1̄.48 .11
FULL Log E Range 0.84
INT Log E Range 0.84
Upper Density Tolerance Limits
Based on 1.2 gradient
Lower Density Tolerance Limits
Based on 1.2 gradient
PRI Log E Range 0.92
DENSITY
LOG EXPOSURE
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0


Emulsion SO-380
EXPOSURE
Sensitometer
Exposure Time
PROCESSING
IB: Lamp #1963
Daylight Filter
1/25 Sec.; Log E_{11} - $\bar{1}$.22
Figure 6
Main Camera Record
Mission [redacted]
Sensitometric Curve
from Mission Material (R-2)
Dual Gamma Processed Portion
Log E Range 1.35
Upper Density Tolerance Limit (See Text)
Lower Density Tolerance Limit
Based on 1.2 gradient
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
LOG EXPOSURE

which received the single-level, dual-gamma process was acquired under different solar altitude conditions than the remainder of the photography, which received the three-level process. In other words, the brightness of the subjects between differently processed portions was dissimilar enough to result in the percentage underexposure differences observed. Based upon the data collected thus far, it is felt that no basic change in exposure criteria is warranted for material which is to be dual-gamma processed.

(3) Analysis of Experiments in Mission 1101

(a) Special Exposure Experiment - Main Camera

1. During Mission 1101-2, a slit-changing experiment was performed. The nature of the experiment was not spelled out in the incoming messages; i.e., whether it was a mechanical slit-changing test or an effort to determine which slit resulted in the best exposure.

2. Because the test conditions did offer an opportunity to evaluate camera exposure for this system, an exposure analysis of the frames involved in the experiment was made.

3. As the aft camera record was "soft" (e.g., slightly out of focus),* only the forward camera frames of interest were analyzed. To determine the brightness of these frames, the exposures were calculated from their densities using the R-2** sensitometric curves (see Figure 7).

4. Targets were selected for analysis from photography acquired by each of the five slit changes included in the experiment. Each target chosen was recorded in adjacent frames by two different slit widths; i.e., at two different exposure times. For each slit change, two targets were selected for analysis; a high and a low brightness subject. Table 5 is a compilation of the exposure/brightness data for the frames and targets analyzed.

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* Diagnosis stated by PEIR preliminary report dated 17 October 1967.

**R-2 material is sensitized product removed from the roll shortly before launch.

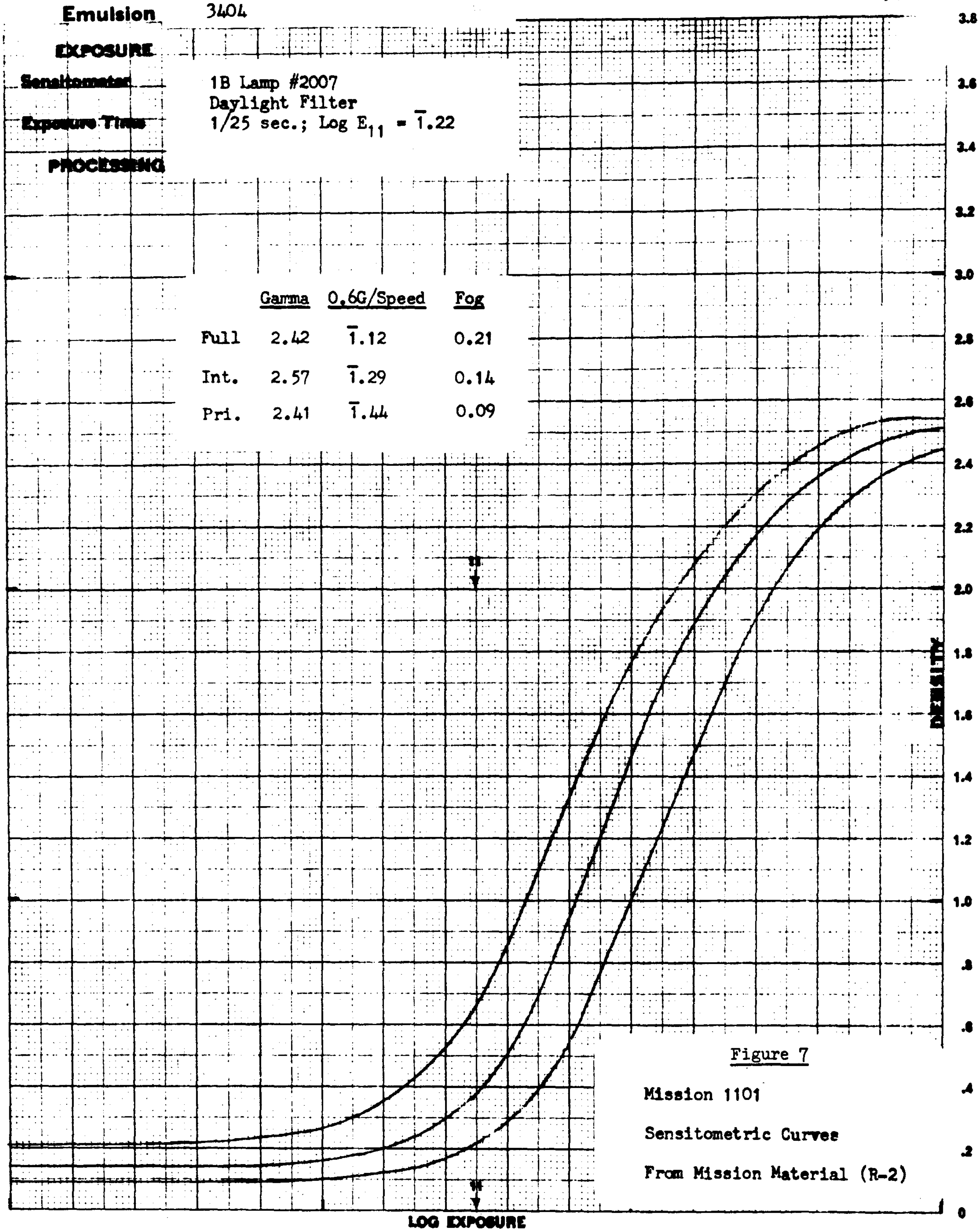

Figure 7

Mission 1101

Sensitometric Curves

From Mission Material (R-2)

Table 5

Exposure/Brightness Data for Frames and Targets Analyzed

Mission 1101
Pass 159 Forward Record

			High Brightness Target					Low Brightness Target				
Frame	Slit (inches)	Process	Target Description	Density	Log E	Exposure (Meter Candle Seconds)	Brightness (foot-Lamberts)	Target Description	Density	Log E	Exposure (Meter Candle Seconds)	Brightness (foot-Lamberts)
10	0.218	Full	Bldg. roof	1.42	$\bar{1}.54$	0.347	1640	Foliage	0.89	$\bar{1}.32$	0.209	985
11	0.150	Full	Bldg. roof	1.14	$\bar{1}.43$	0.269	1810	"	0.47*	$\bar{1}.06$	0.115	773
12	0.150	Full	Storage tank	1.54	$\bar{1}.58$	0.381	2607	Bldg. near airport runway	0.48*	$\bar{1}.07$	0.118	807
13	0.171	Full	Storage tank	1.54	$\bar{1}.58$	0.381	2287	" "	0.40*	$\bar{2}.98$	0.096	576
16	0.171	Full	Cultivated field	1.08	$\bar{1}.40$	0.252	1513	Cultivated field	0.66	$\bar{1}.21$	0.162	972
17	0.218	Full	"	1.50	$\bar{1}.56$	0.364	1720	"	1.00	$\bar{1}.36$	0.229	1082
19	0.218	Full	Bldg. roof	1.78	$\bar{1}.72$	0.526	2486	Field	0.46*	$\bar{1}.05$	0.112	529
20	0.272	Full	Bldg. roof	1.84	$\bar{1}.74$	0.551	2077	Field	0.66	$\bar{1}.21$	0.163	614
30	0.250	Full	Storage tank	2.00	$\bar{1}.85$	0.709	2914	Field	0.86	$\bar{1}.30$	0.200	822
31	0.218	Full	Storage tank	1.78	$\bar{1}.72$	0.526	2486	Field	0.64	$\bar{1}.20$	0.159	751

* Out-of-tolerance when judged by the
1.2 gradient density tolerance limits
0.50 and 2.16

PAR 24-8-5S

5. The exposure time was analyzed in relation to two different exposure planning criteria; the customer's A/P Exposure Criteria, and the September Exposure Curve for the forward camera.*** These criteria are illustrated by Figure 8. The recommended exposure times for the solar altitudes involved are:

Recommendation	Exposure Time (Seconds)
A/P	1/350
Seasonal	1/240

6. Correctness of exposure was judged by two different criteria methods: 0.4-2.0 density tolerance limit system, and the 1.2 gradient density tolerance limit system.

7. When judged by the 0.4-2.0 density tolerance criterion, all of the frames and targets within the frames were considered satisfactorily exposed, regardless of slit width; i.e., the narrowest slit (0.150 inches) did not result in underexposure and the widest slit (0.272 inches) did not result in overexposure.

8. Applying the 1.2 gradient density tolerance limits of 0.50 and 2.16 (as calculated from the R-2 Full process sensitometric curve of Figure 7) six frames were judged correctly exposed and four (Frames 11, 12, 13, and 19) underexposed. None was considered overexposed when judged by this method.

9. As there were no experimental frames which were found to be under or overexposed when judged by the 0.4-2.0 density tolerance criterion, any of the five slits (exposure duration range of 1/554 through 1/305 seconds) would have been satisfactory for photographing the particular solar altitudes studied.

10. When applying the 1.2 gradient density tolerance criterion to the same frames, those exposed at 1/333 seconds and longer were found to be within tolerance (no under or overexposure) and those exposed at 1/383 seconds and shorter were found to be underexposed.

***PAR 24-7-5S Interim Report, "Seasonal Exposure Recommendations for Satellite Systems," Contract [redacted] Task 1, 22 June 1967.

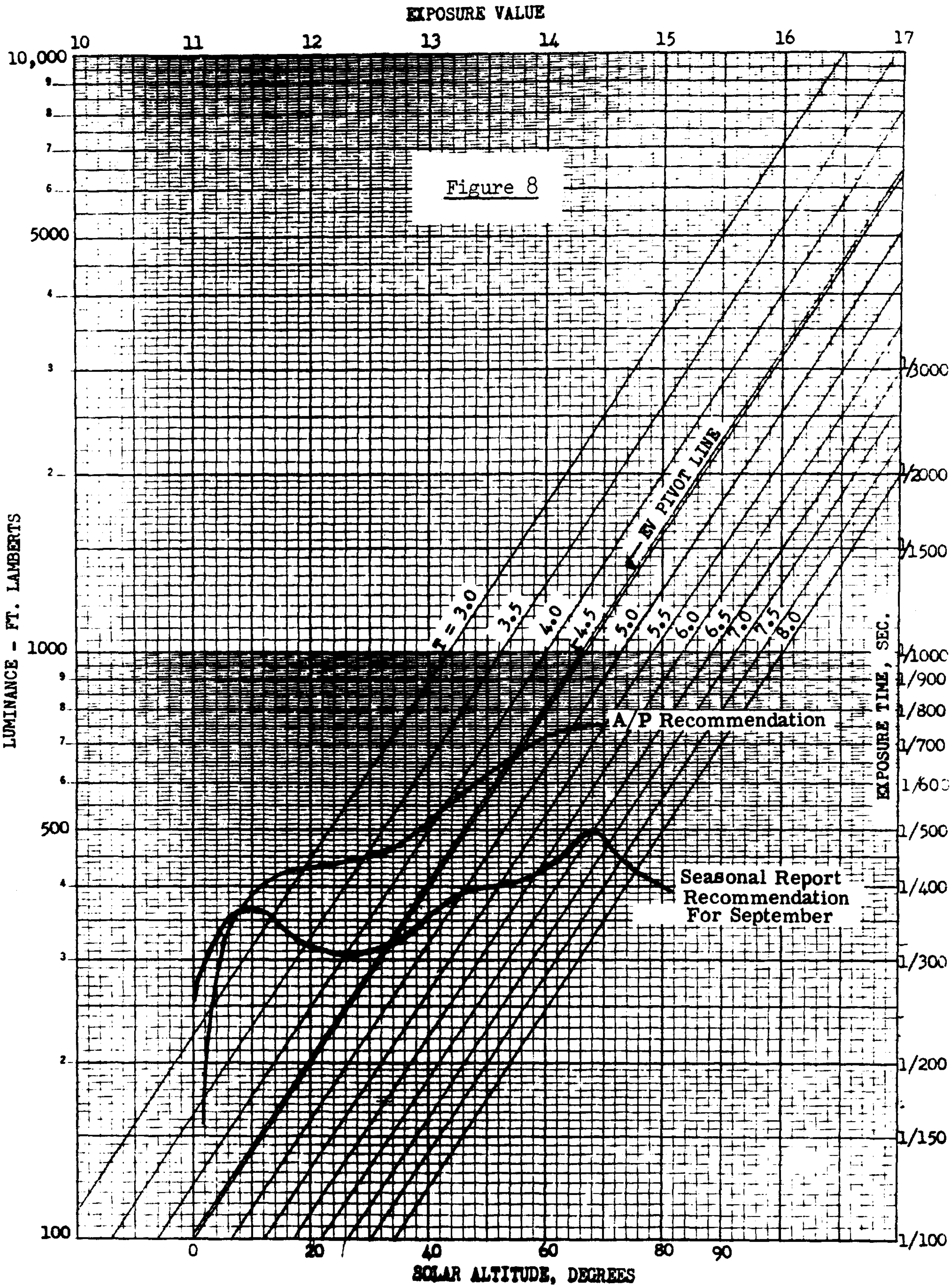
EXPOSURE VALUE
10
11
12
13
14
15
16
17
10,000
5000
1000
500
100
LUMINANCE - FT. LAMBERTS
1/3000
1/2000
1/1500
1/1000
1/900
1/800
1/700
1/600
1/500
1/400
1/300
1/200
1/150
1/100
EXPOSURE TIME, SEC.
EV PIVOT LINE
T = 3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
A/P Recommendation
Seasonal Report
Recommendation
For September
0
20
40
60
80
90
SOLAR ALTITUDE, DEGREES

Figure 8

11. It is desirable to expose mission photography for the shortest possible time in order to minimize smear. This experiment showed a two-third stop difference between the shortest acceptable exposure time when judged by the 0.4-2.0 density tolerance criterion (1/554 seconds) and the shortest acceptable exposure time when judged by the 1.2 gradient density tolerance criterion (1/333 seconds). The latter exposure time more closely approaches the recommended exposure time of 1/240 second when based on seasonal data, and also the A/P recommendation of 1/350 second, than does the former.

12. The choice of which exposure time is "best" was found to be dependent largely upon the judgment criteria used. The 0.4-2.0 density tolerance criterion indicated the shortest acceptable exposure was 1/554 seconds while the 1.2 gradient density tolerance criterion indicated the shortest acceptable exposure was 1/333 seconds. In this experiment the difference in these exposure times is less than one photographic stop, as noted above.

13. For 1100-series missions flown in the month of September, we recommend that exposures made within the solar altitude range of 43.0° to 48.2° be photographed with a slit which will give a resultant exposure time to the film of at least 1/333 second.

14. As a result of this exposure experiment, analyzed with reference to accumulated historical exposure data as well as analysis of the main camera record of Mission 1101 as a whole, we recommend future 1000- and 1100-series missions be exposed at the exposure time recommended in the seasonal report mentioned earlier. Had longer exposures been programmed, the rather high percentage of underexposure for this initial 1101-series mission would have been reduced. Naturally, a trade-off between smear and exposure will be necessitated at the longer exposure times and this must be taken into account by the mission programmers.

(b) Special Filter Experiment - Main Camera

1. During the second half of Mission 1101, a filter changing experiment was performed. A special analysis was made of this experiment in terms of exposure only.

2. The exposure used with the W23A filter in the aft-looking camera experiment was about the same as that used with the W23A filter in normal forward-looking camera photography. The results were almost identical amounts of underexposure (65.5% vs 65.8%).

3. No attempt was made to evaluate the difference in the various filters and their effect on image contrast or information content.

3. Exposure Research

a. Haze Studies and CORN Program. Routine data collection was accomplished for CORN displays in orbital missions.

b. Figure of Merit. This tool was used in the slit-change stereo exposure experiment analysis. The technique has been developed sufficiently to be applied to other pertinent exposure research studies.

c. Luminance distribution and exposure simulation studies are being postponed till anticipated pertinent results and techniques from PARs 24-7-6S/R2 and 27-7-7S/R1 become available.

PLANNED ACTIVITIES

4. Mission Exposure Analysis

a. Continue density data collection, processing, and publication of Density/Luminance Analysis Reports for each routine operational mission.

b. Continue work to prepare cumulative graphs for mission-by-mission comparison of density/luminance data for 1100-series missions.

c. Refine Procedures for Routine Reports:

(1) Be prepared to continue working with the customer to review data communication as needed.

(2) Postpone, for the present time, efforts to refine computer programs for preparing the Density/Luminance Profile.

(3) Continue efforts to develop a universally acceptable criteria for Density Tolerance Analysis.

5. Exposure Research

a. Haze Studies and CORN Program. Continue routine collection of CORN data from orbital missions.

b. Figure of Merit Studies. Develop procedures to determine smear in [redacted] and [redacted] series missions.

c. Luminance Distribution Studies. These studies will make use of the PAR 70 Scanner and Project Sunny data.

d. CATS Angle. Study in connection with haze and luminance distribution studies.

e. Exposure Simulation Studies. Use data from Target Brightness Studies, PAR 24-7-6S/R2, when it becomes available.

6. Exposure Recommendations. Work on updating seasonal exposure data and on refining recommendations for snow scenes will utilize results from PAR 24-7-6S/R2.

7. Orbital Color Mission Analysis. Computer programs will be converted to System/360 only when there is a definite requirement.

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Figure 9

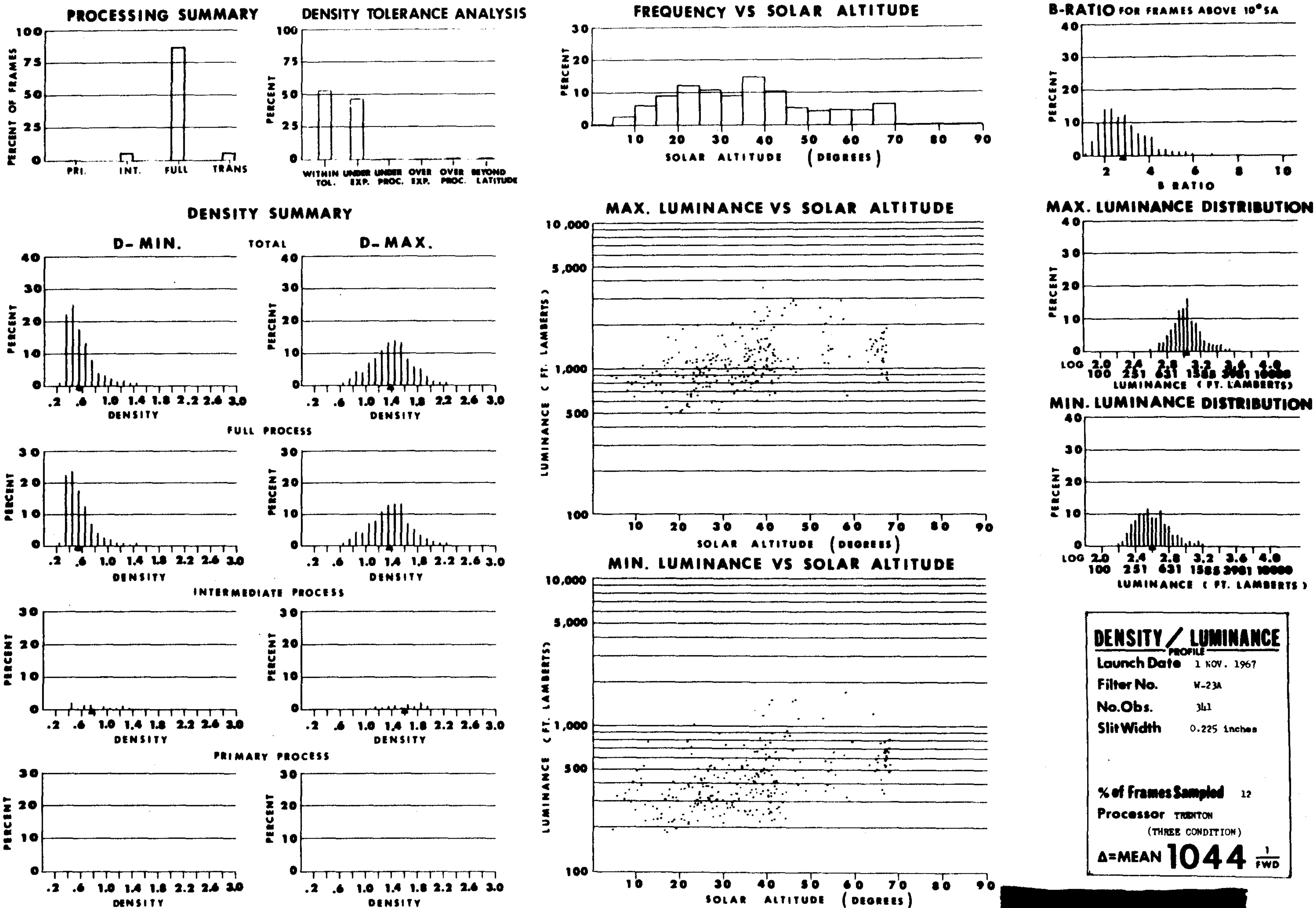

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Figure 10

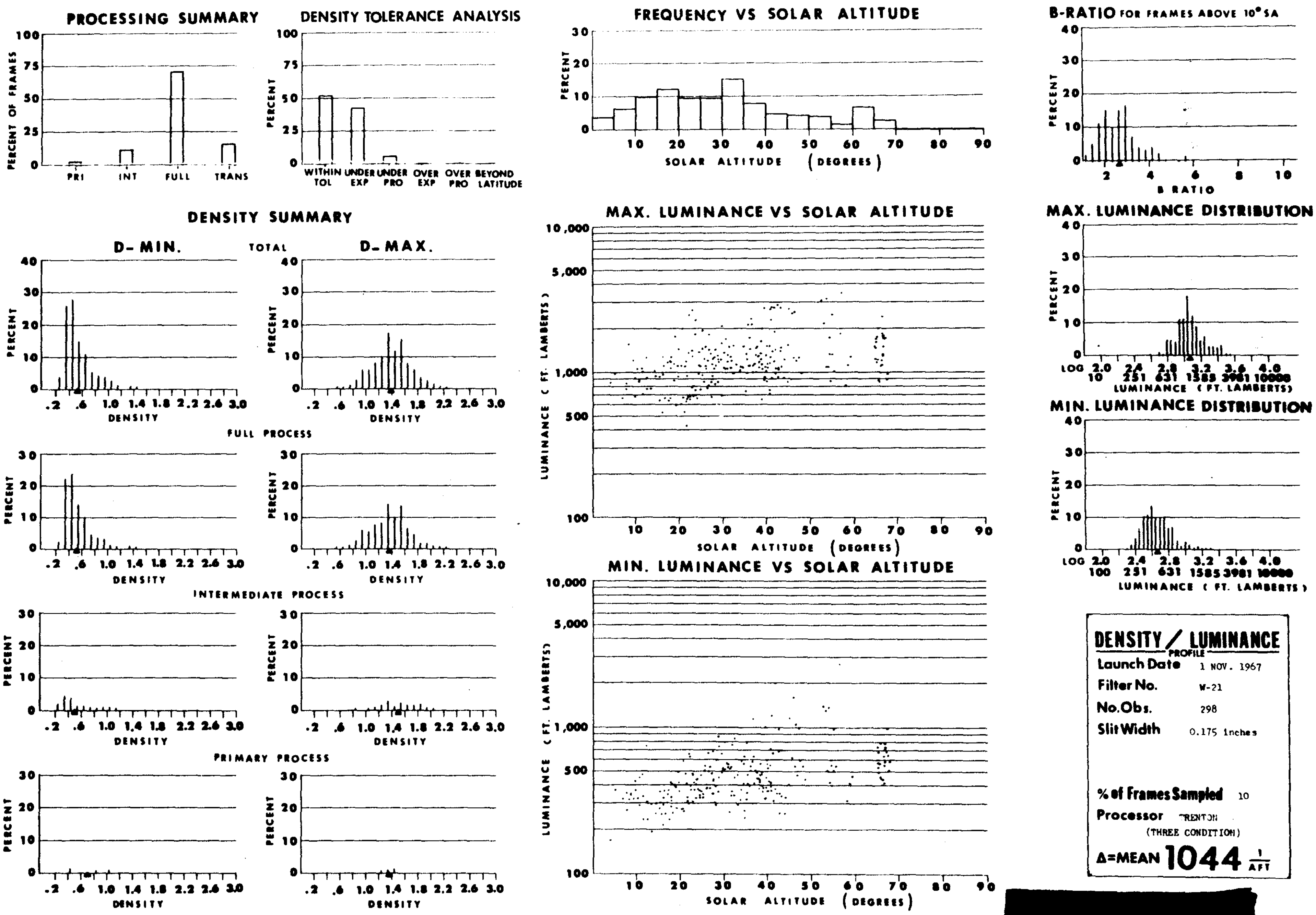

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Figure 11

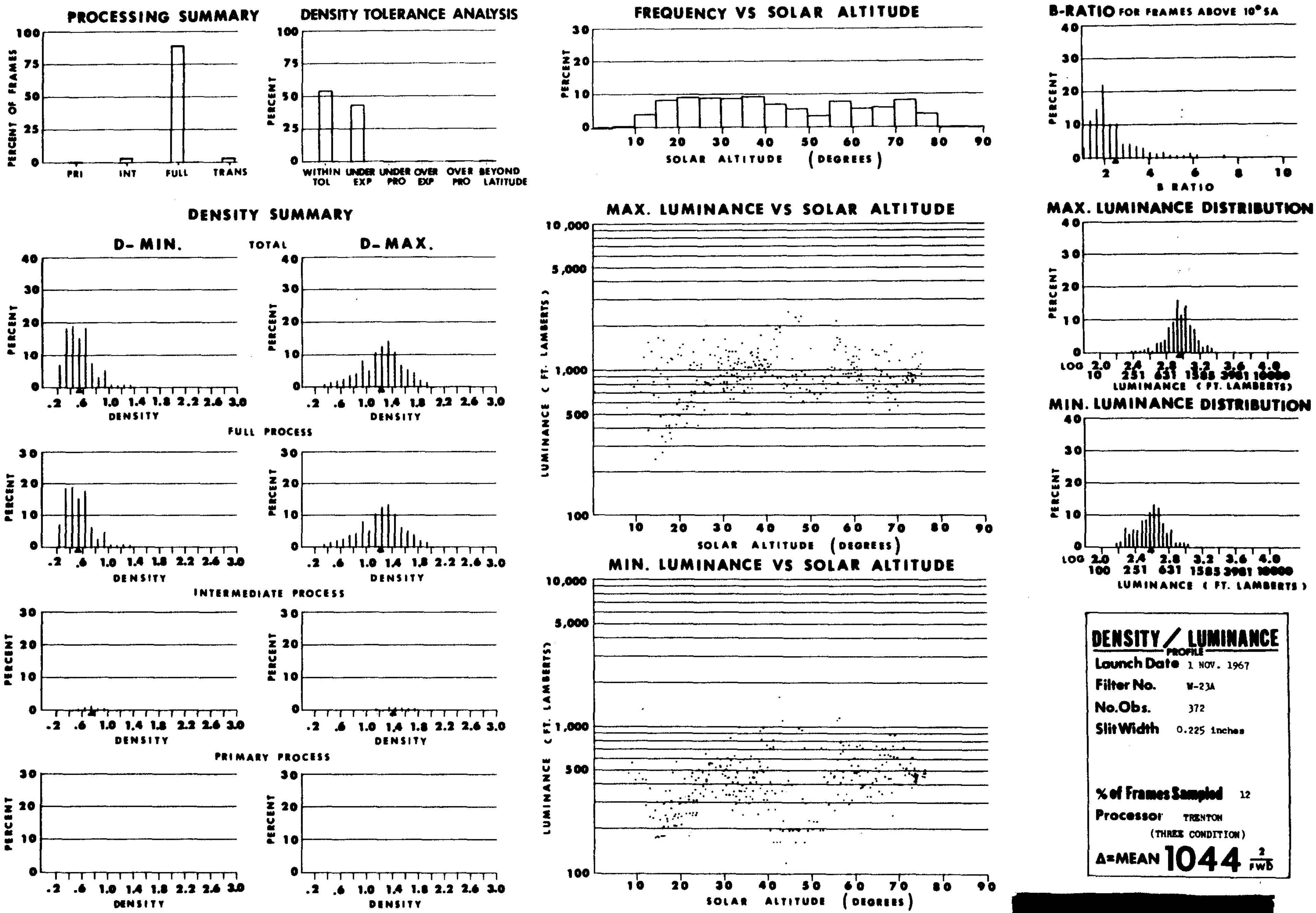

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Figure 12

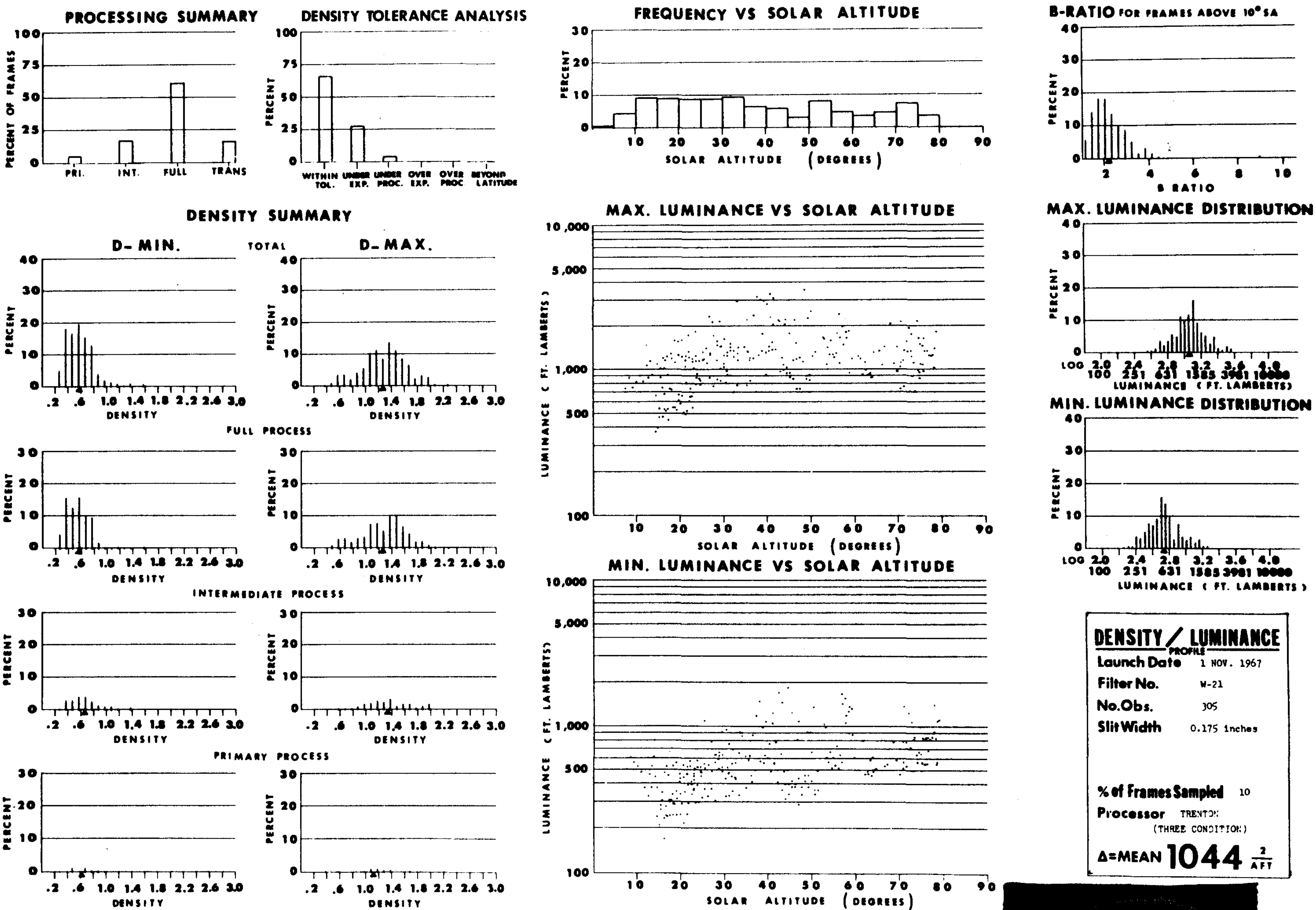

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Figure 13

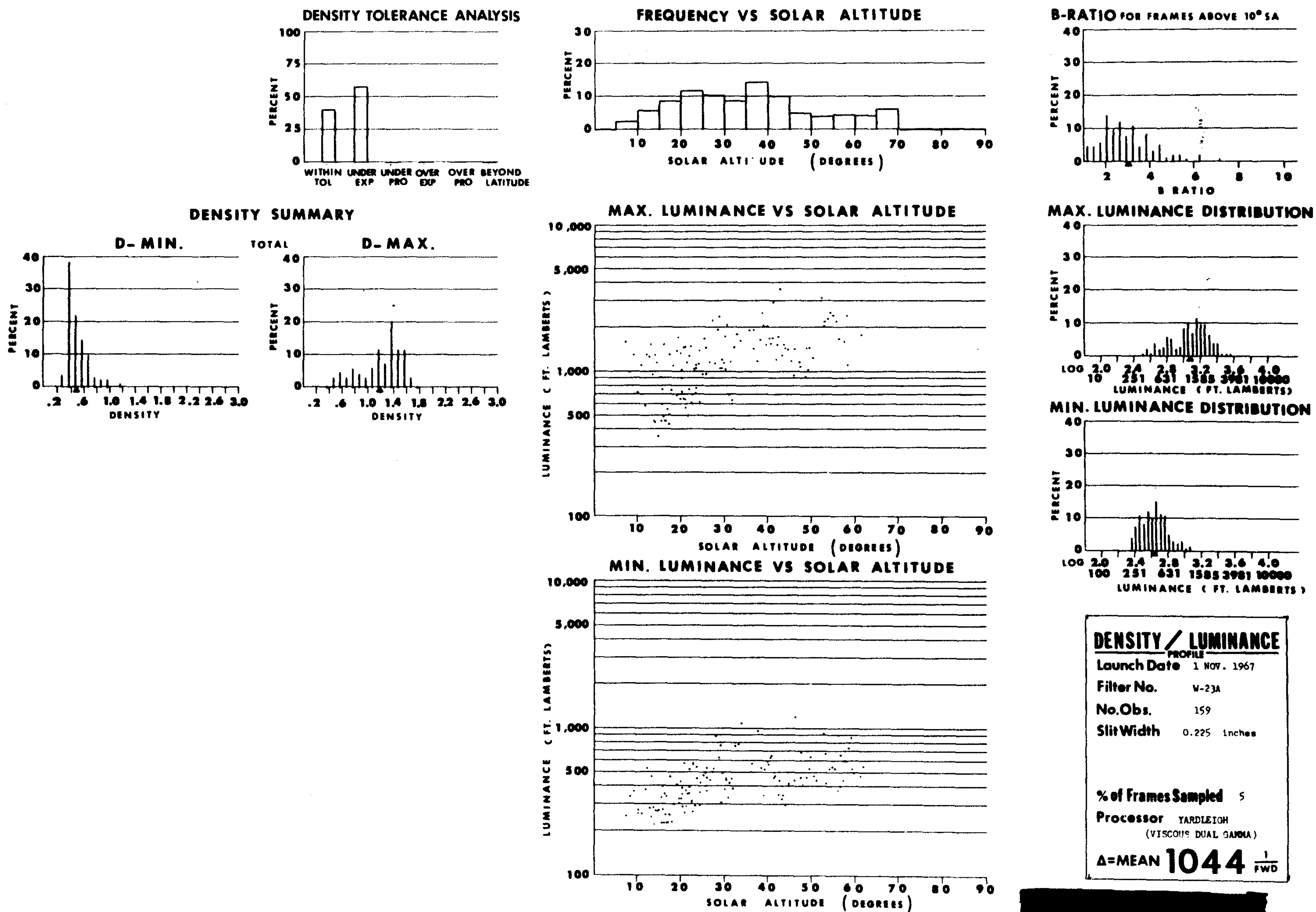

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Figure 14

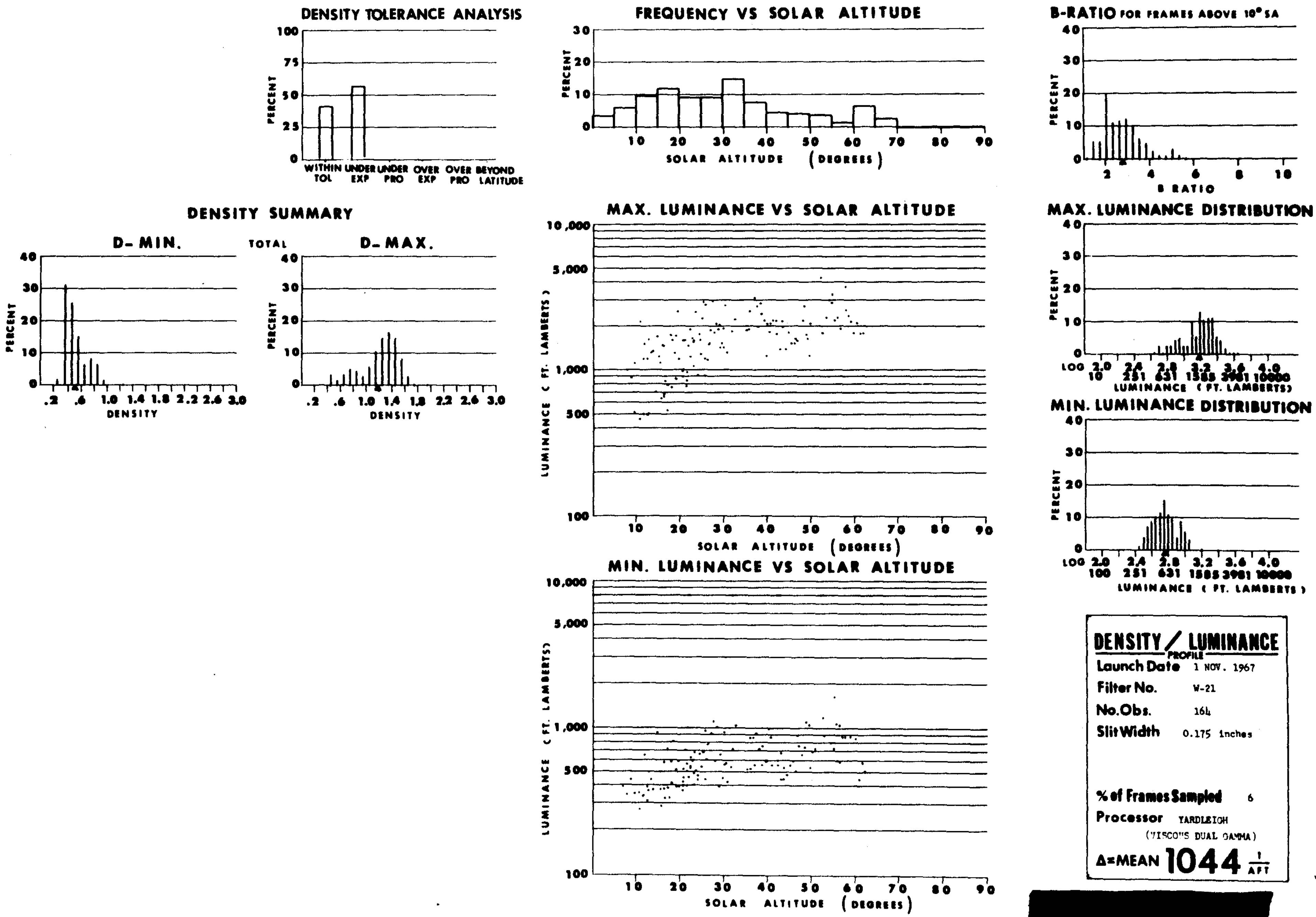

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Figure 15

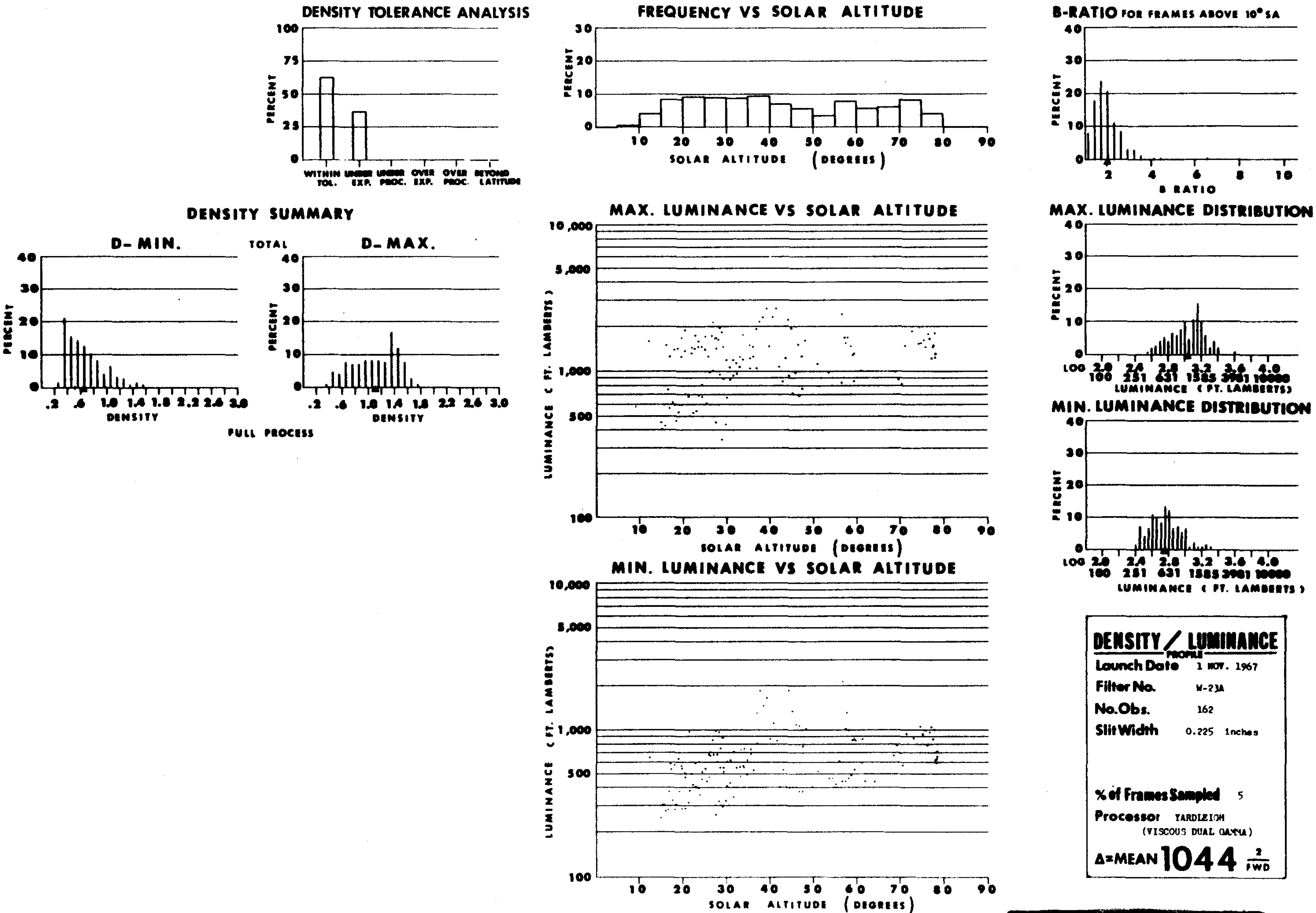

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Figure 16

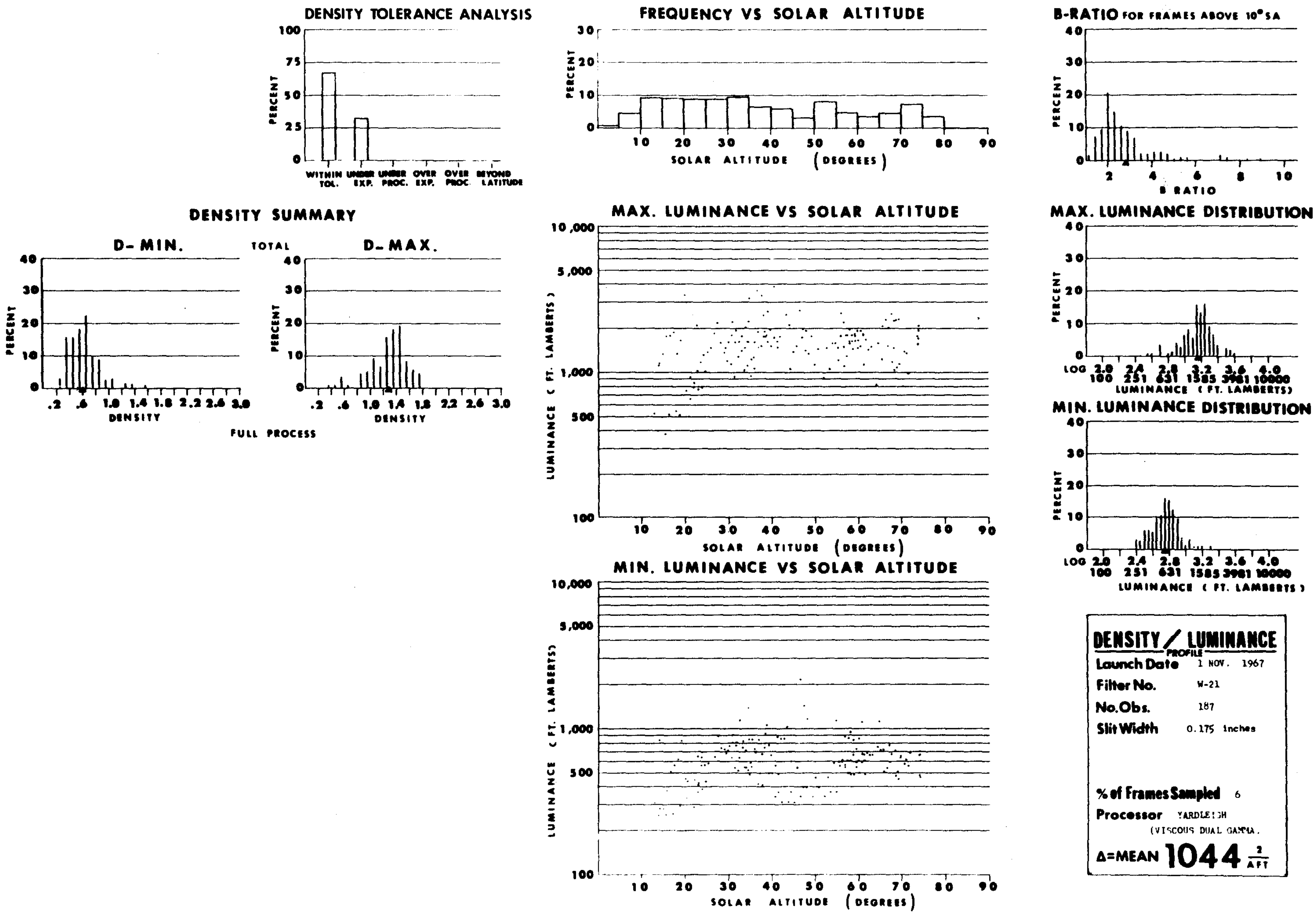

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Figure 17

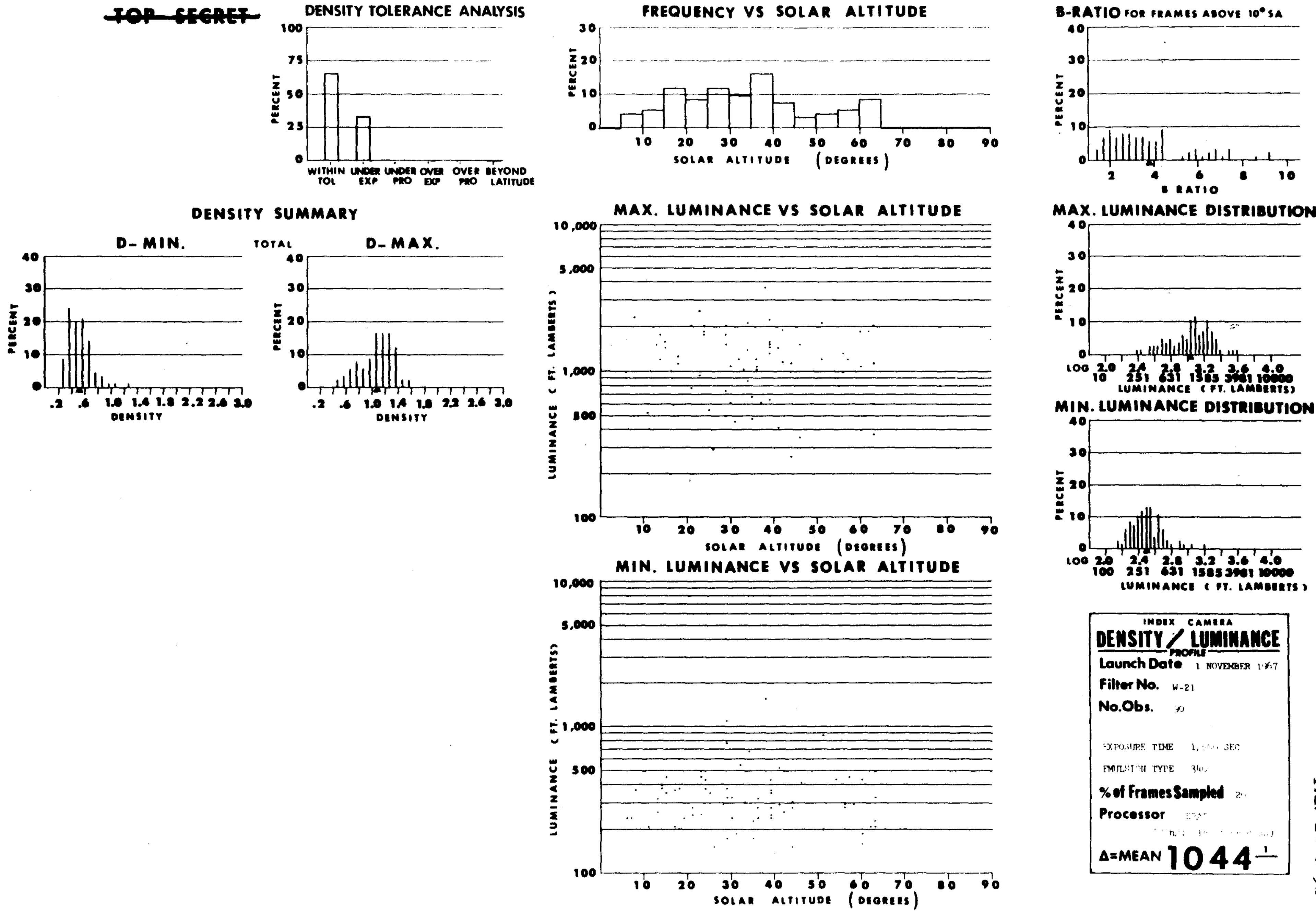

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Figure 18

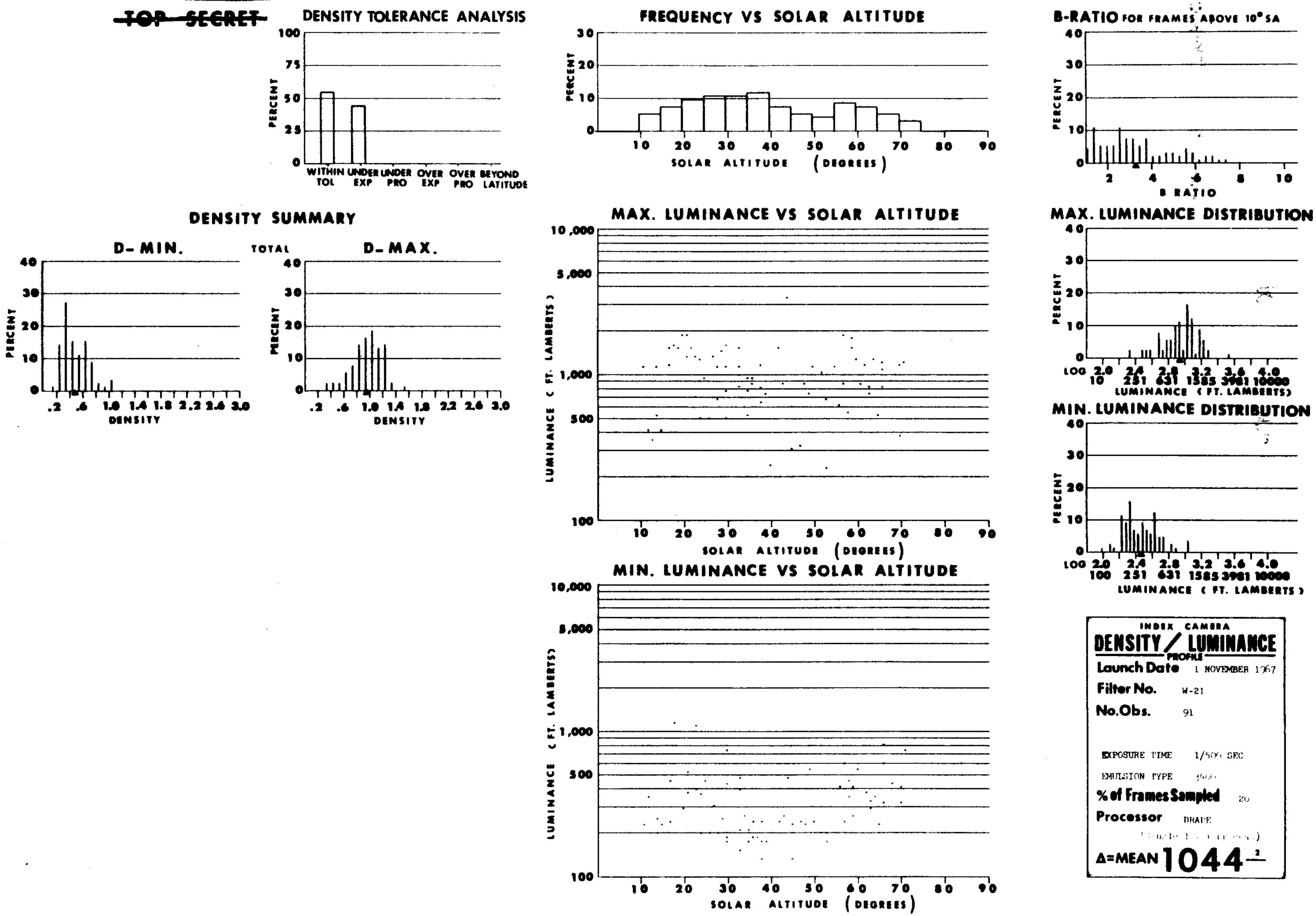

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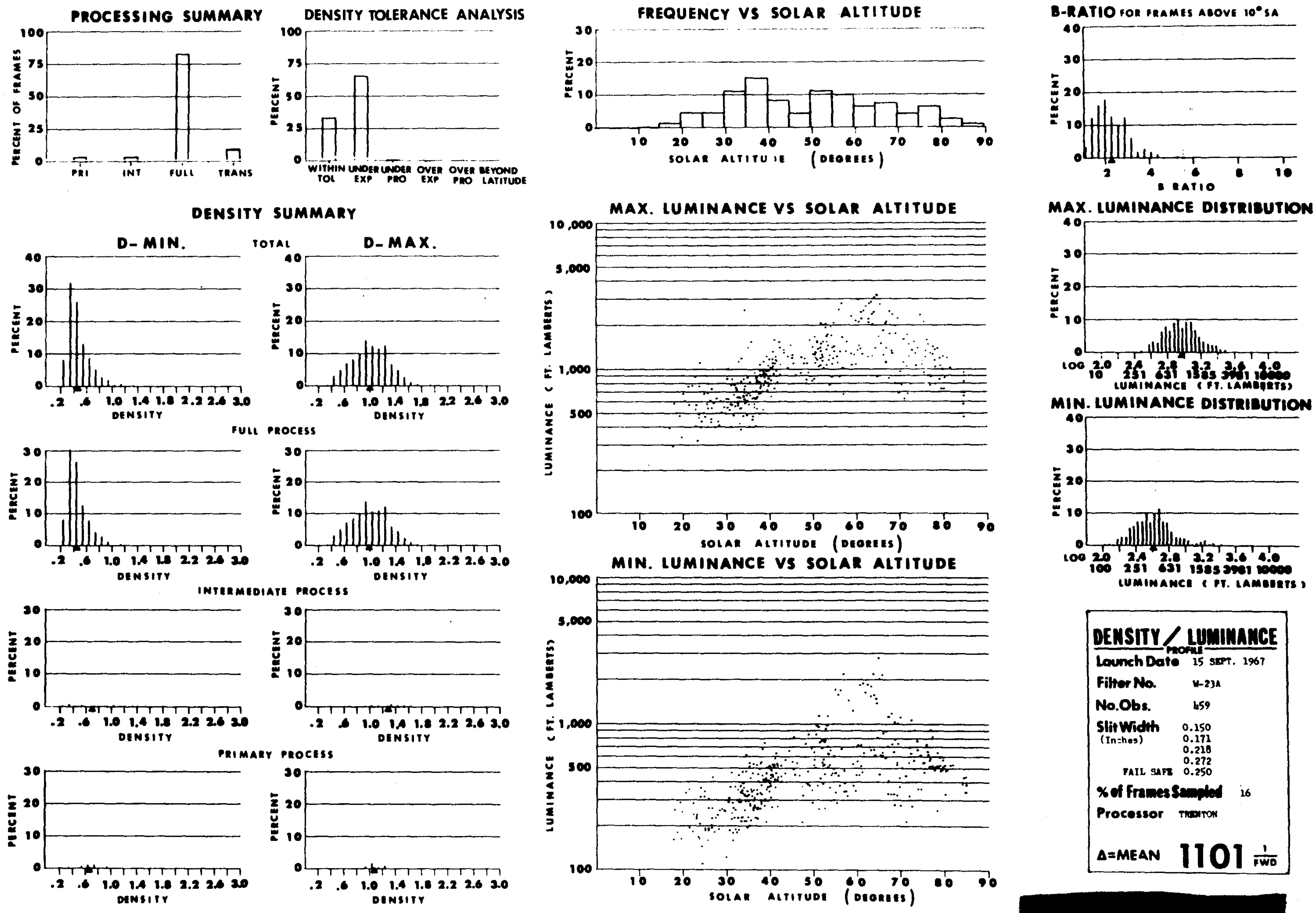
Figure 19



DENSITY / LUMINANCE PROFILE

Launch Date 15 SEPT. 1967

Filter No. W-23A

No.Obs. 459

Slit Width (Inches) 0.150 0.171 0.218 0.272 FAIL SAFE 0.250

% of Frames Sampled 16

Processor TRENTON

Δ=MEAN 1101 $\frac{1}{FWD}$

PAR 24-8-5S

[redacted]

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[redacted]

TOP SECRET

Figure 20

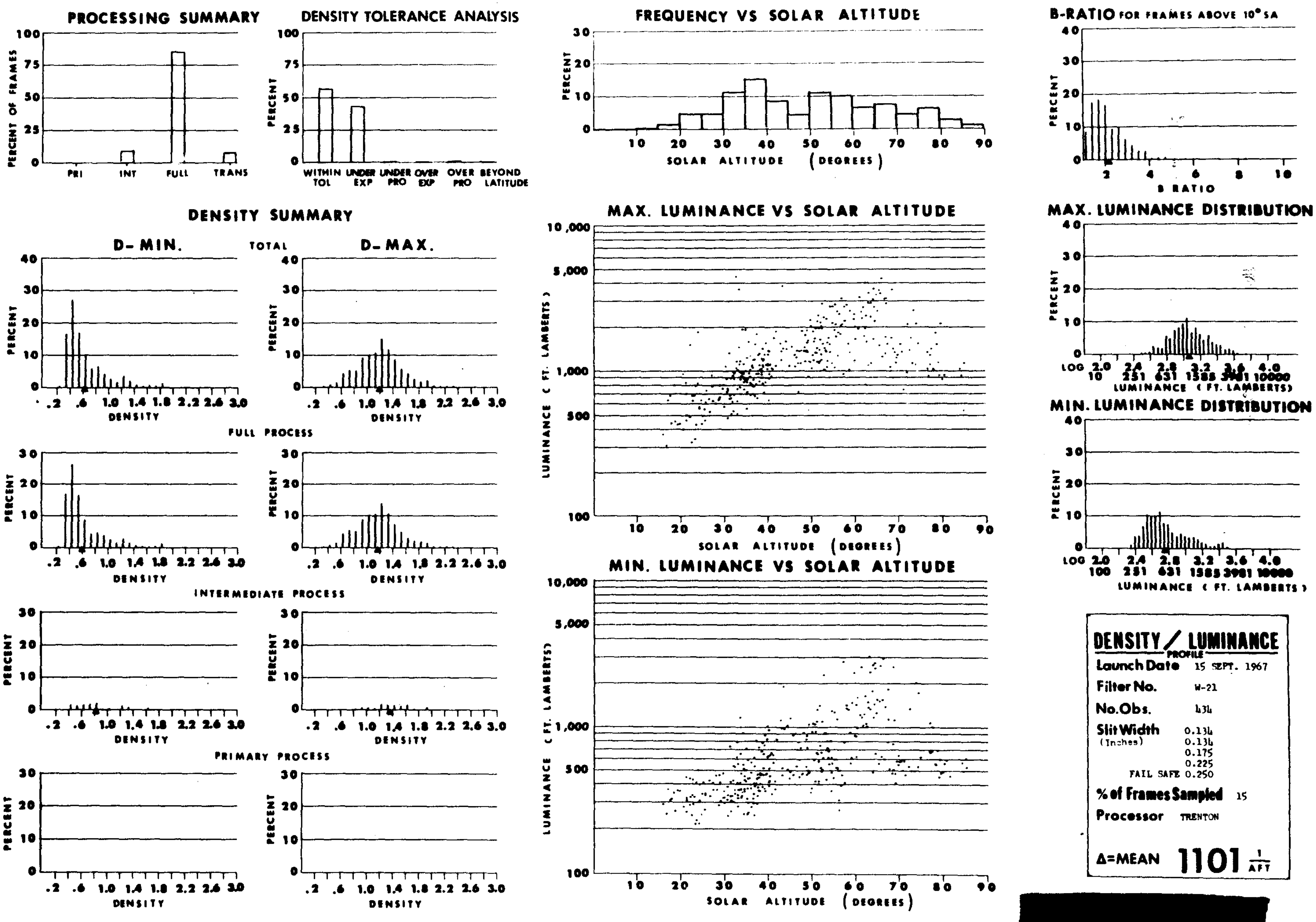

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Figure 21

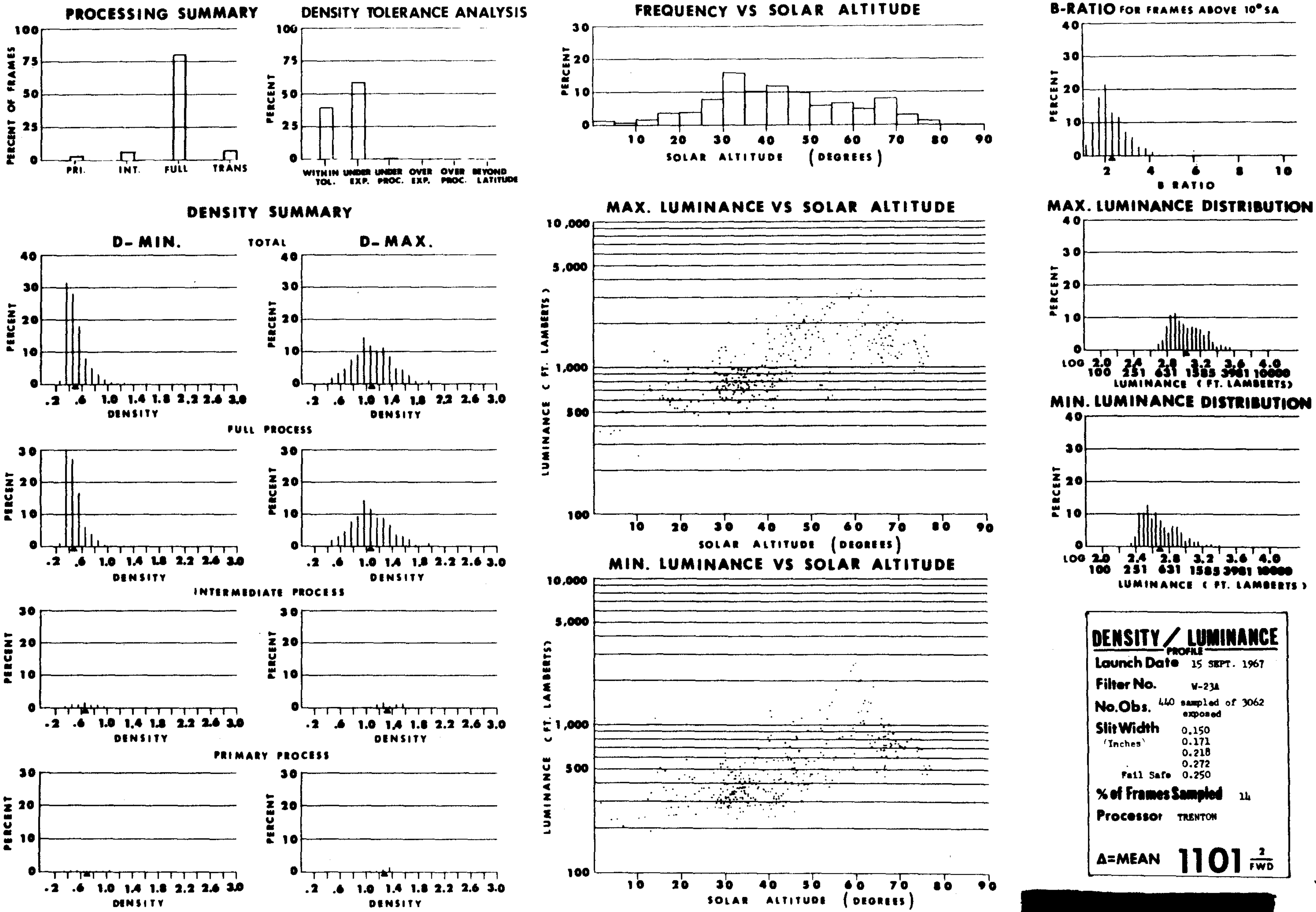

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Figure 22

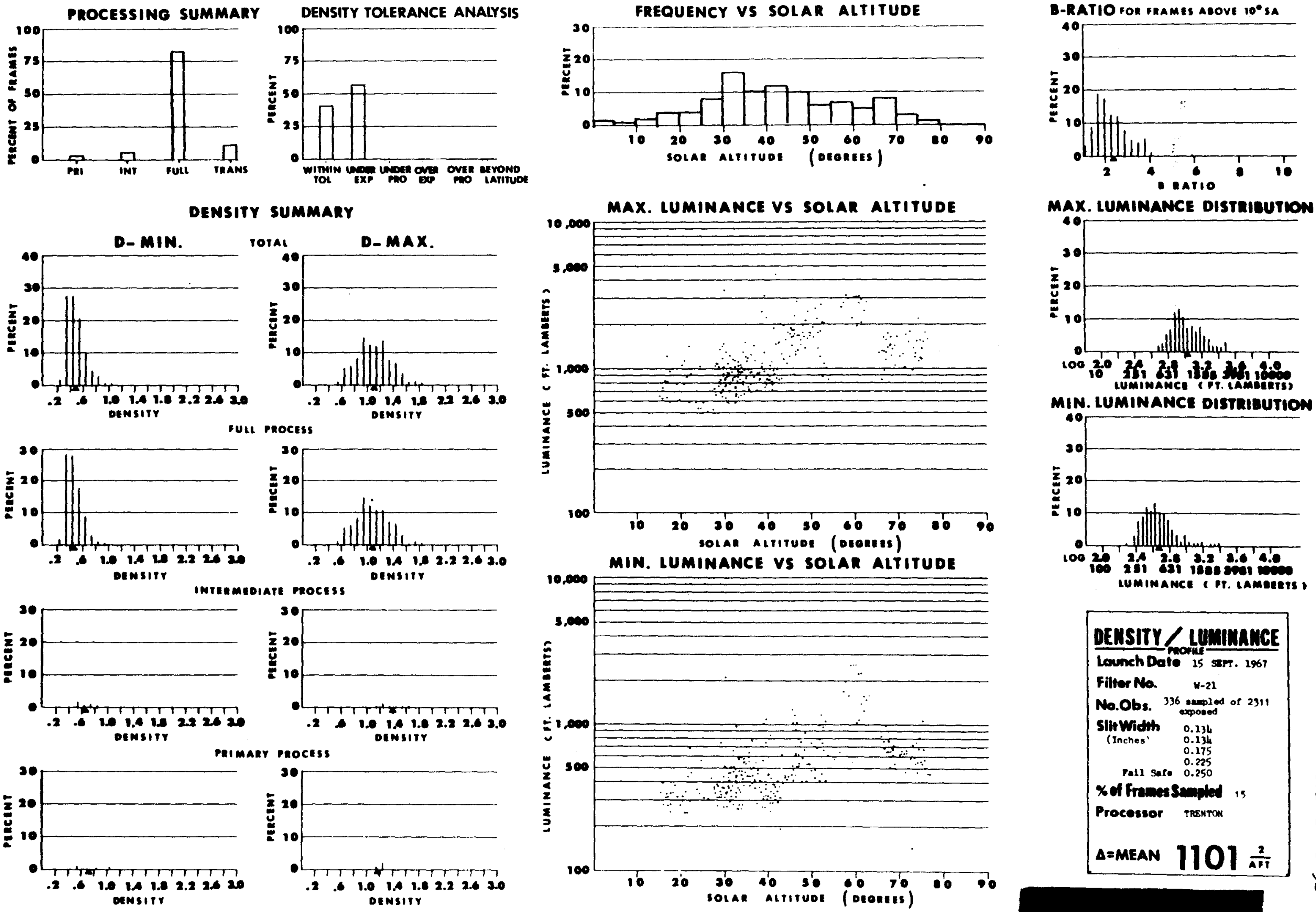

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Figure 23

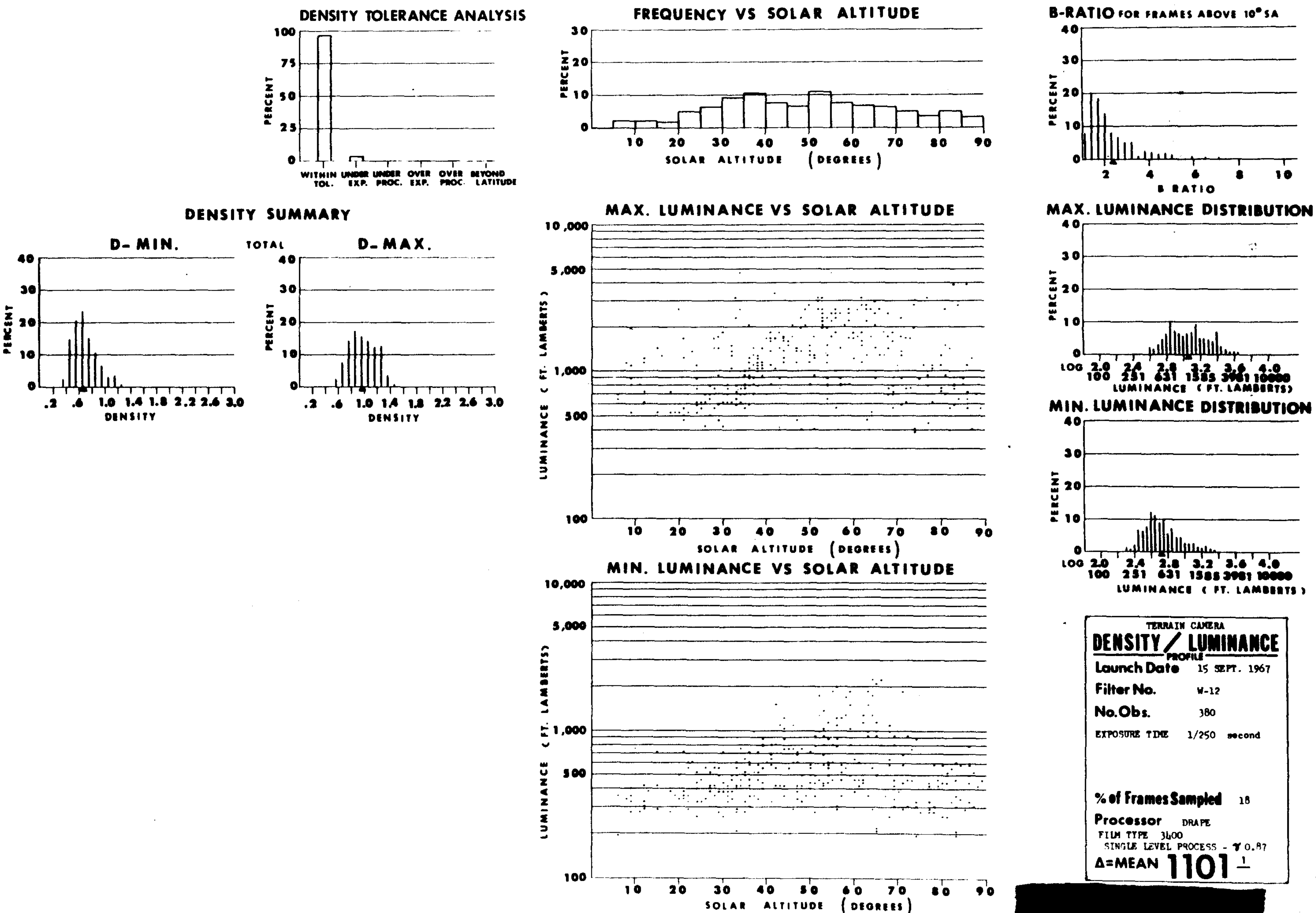

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Figure 24

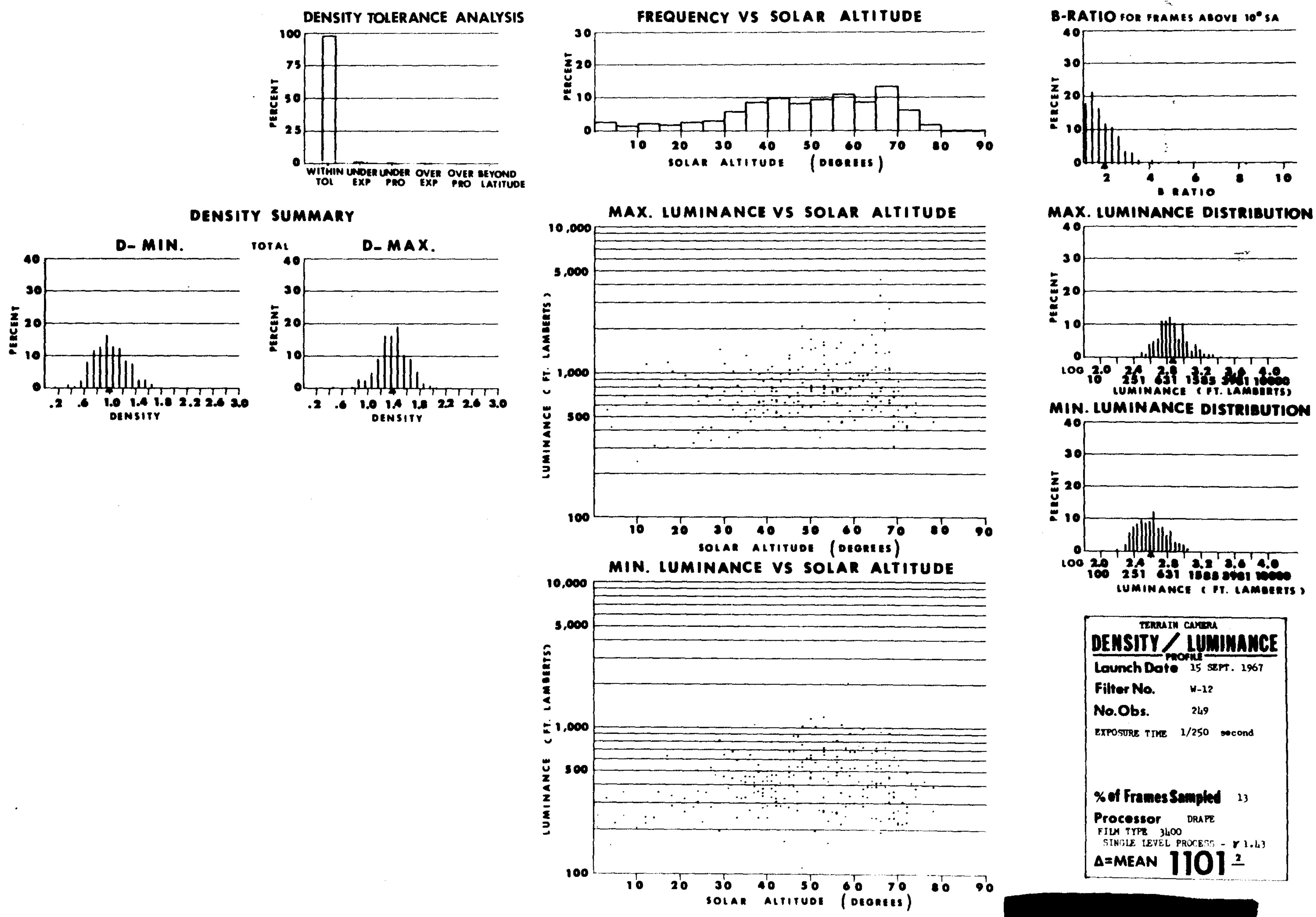

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Figure 25

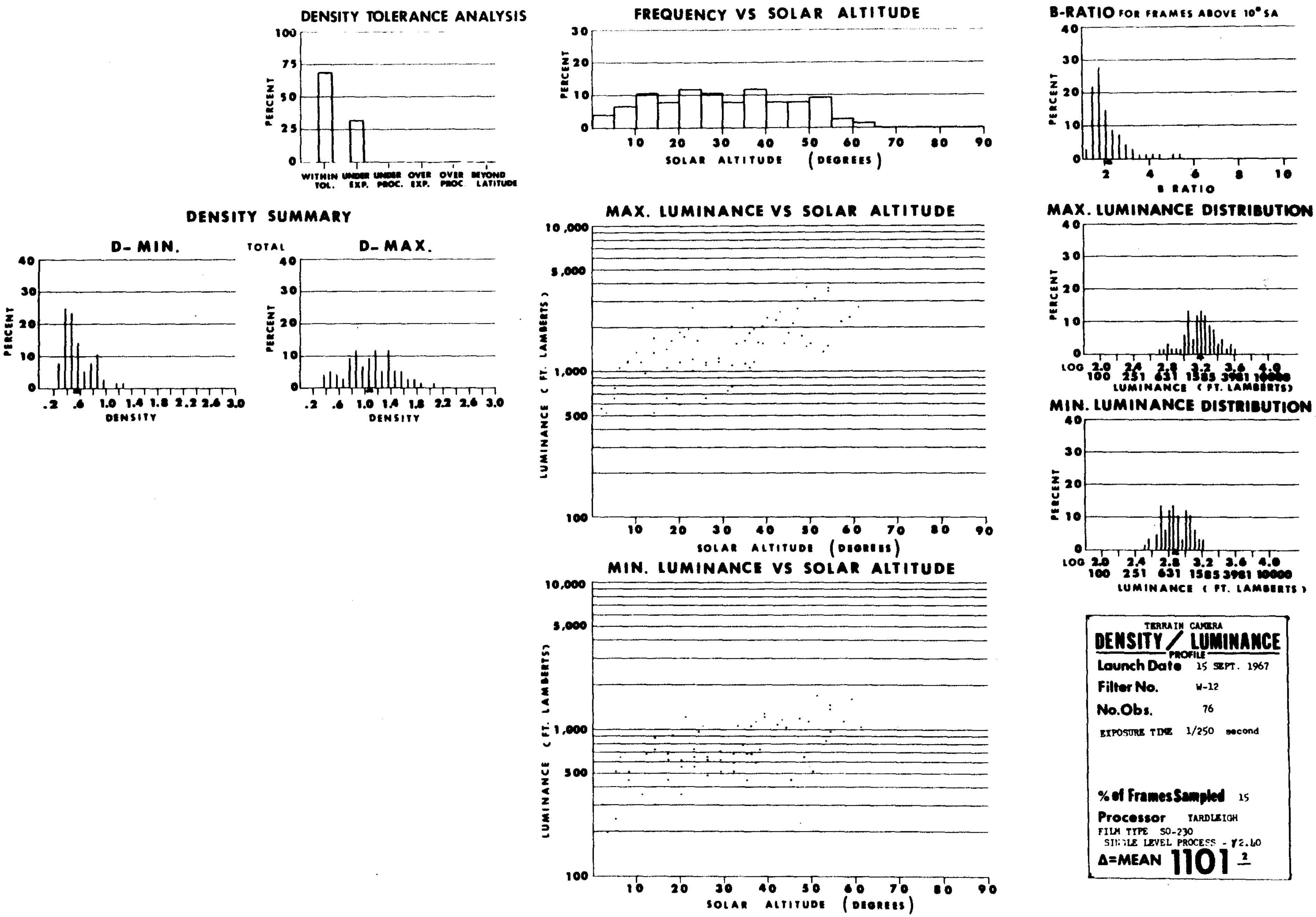

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Figure 26

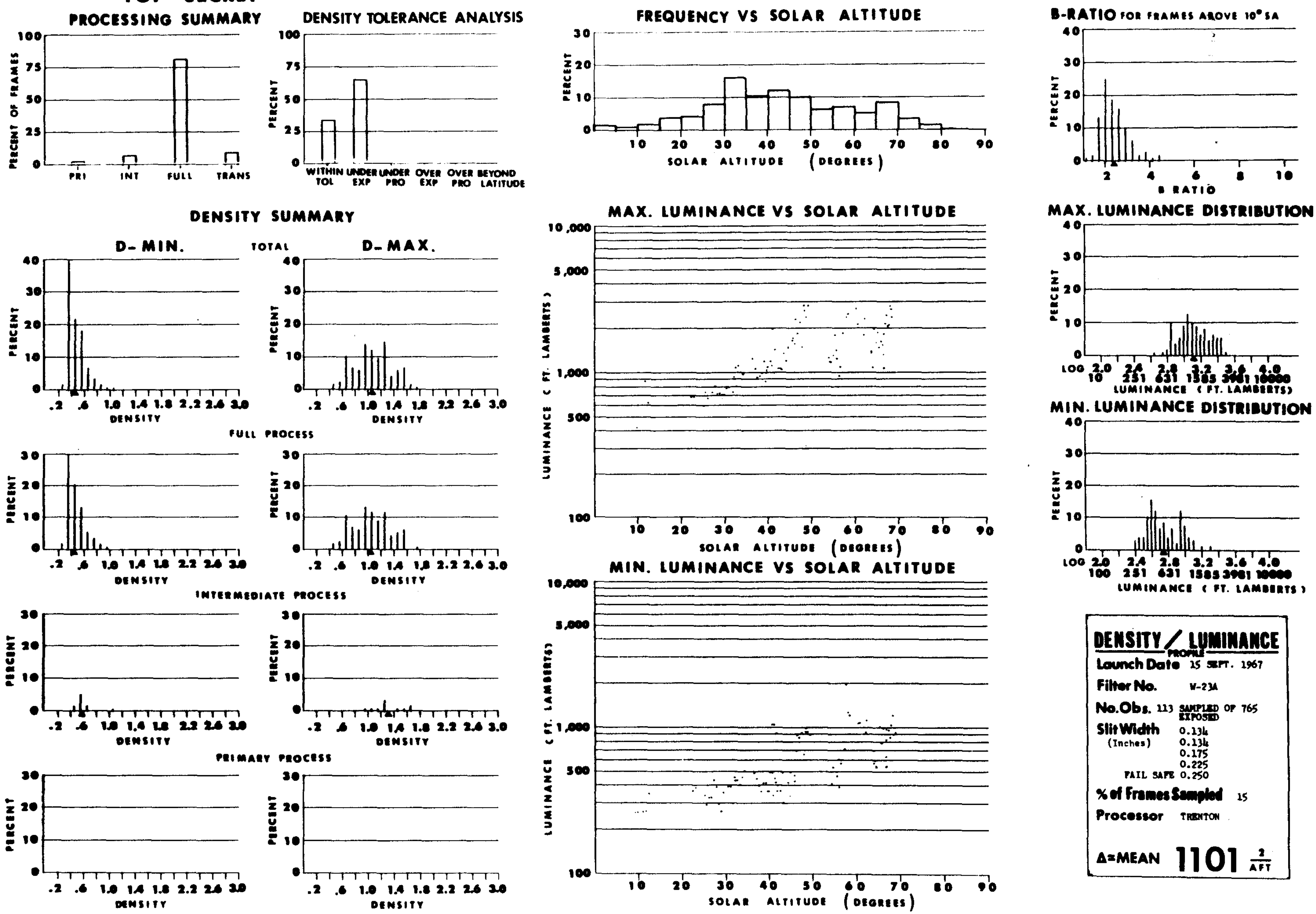

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Figure 27

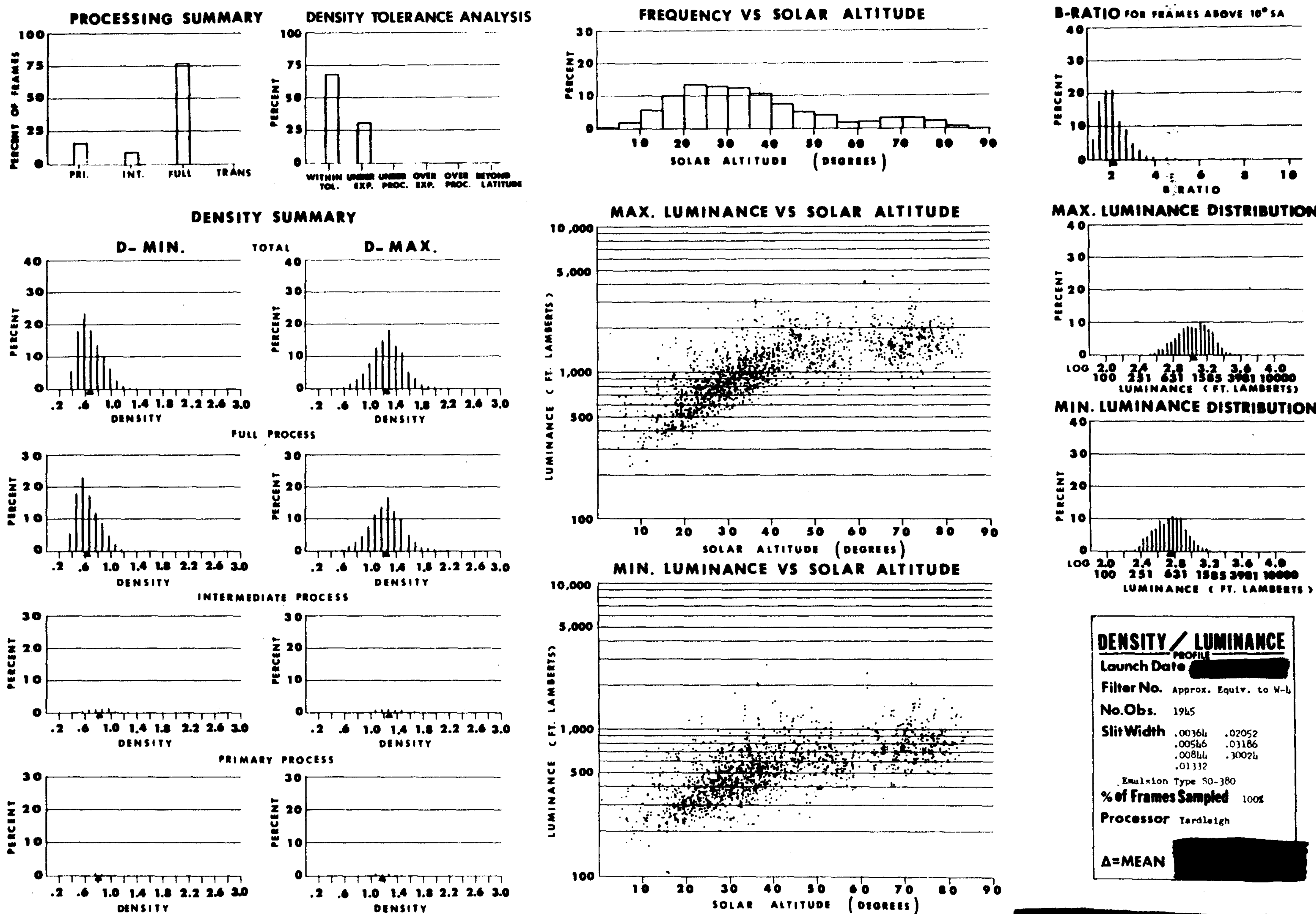

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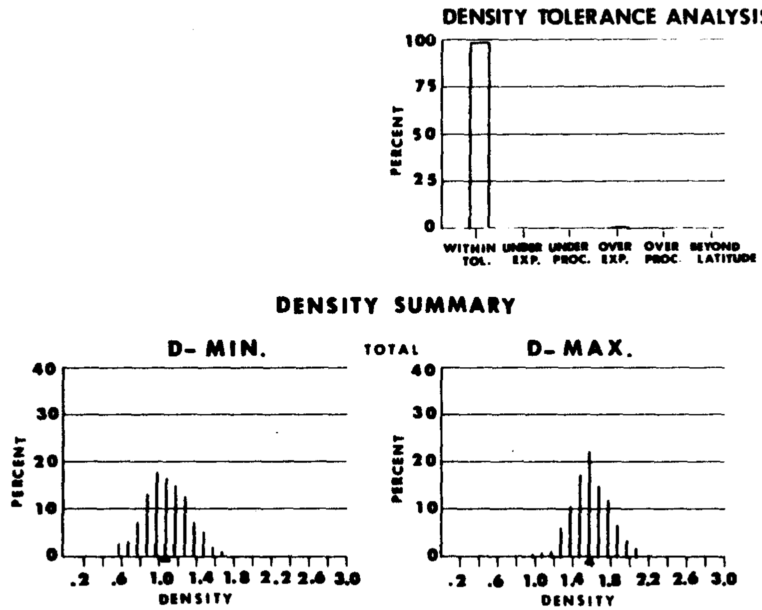
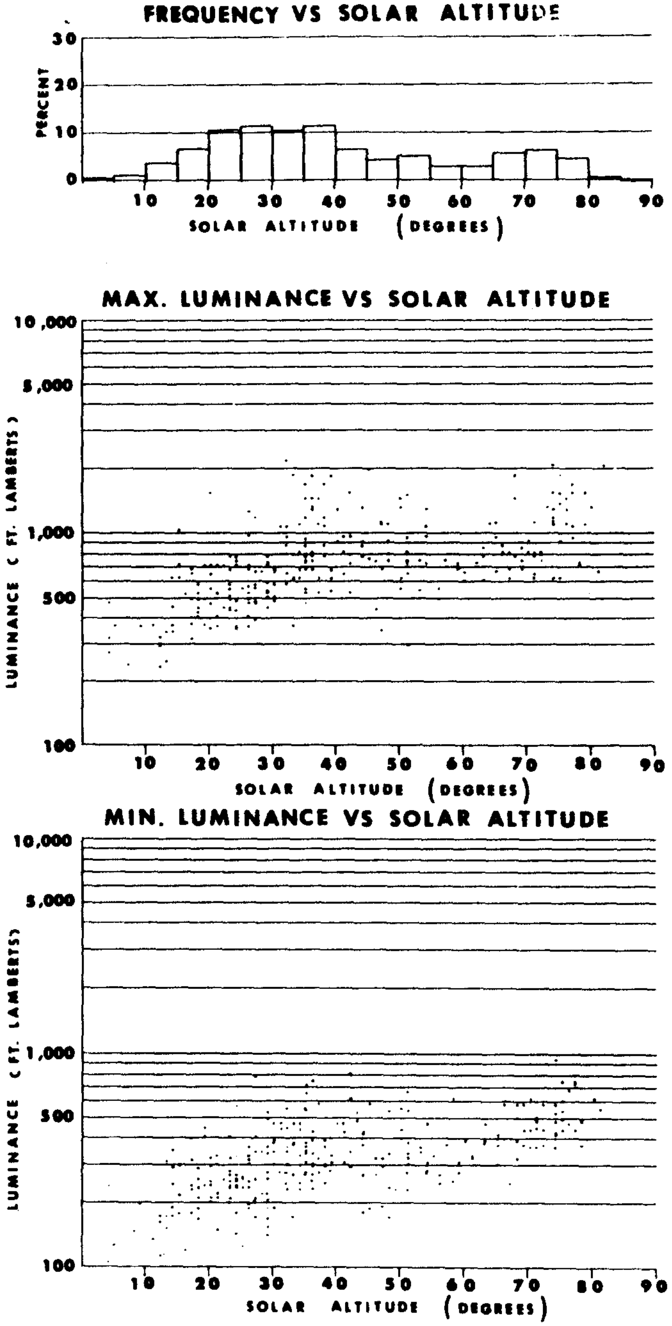
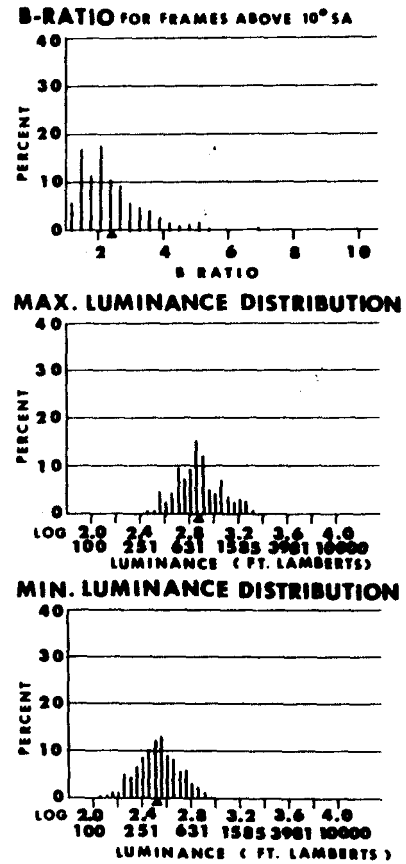
Figure 28







TERRAIN RECORD
WITHOUT MASKING DONUT

DENSITY / LUMINANCE PROFILE

Launch Date [redacted]

Filter No. APPROX. EQUIV. TO W-4

No.Obs. 353

EXPOSURE TIMES SECONDS
1/200
1/300
1/500

EMULSION TYPE 3400

% of Frames Sampled 16

Processor DRAPE
(Single level process)

Δ=MEAN [redacted]

[redacted]

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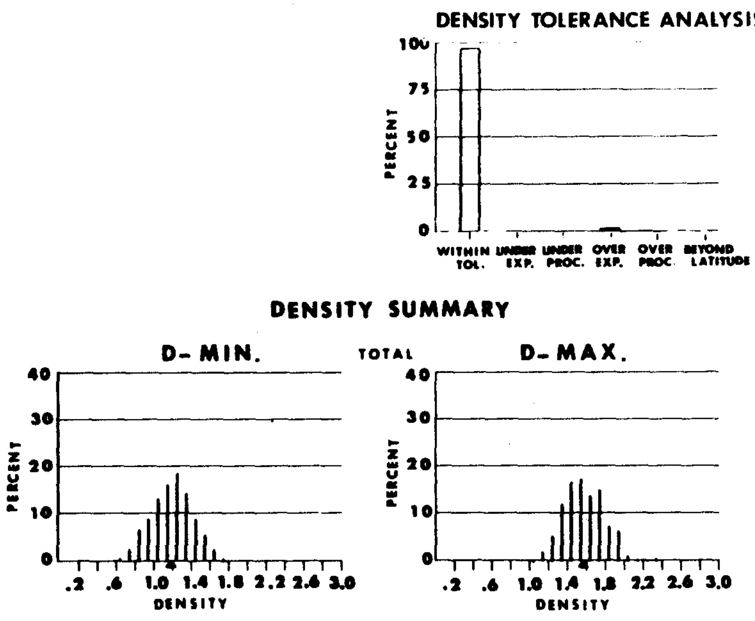
Figure 29



TERRAIN RECORD
WITH MASKING DONUT

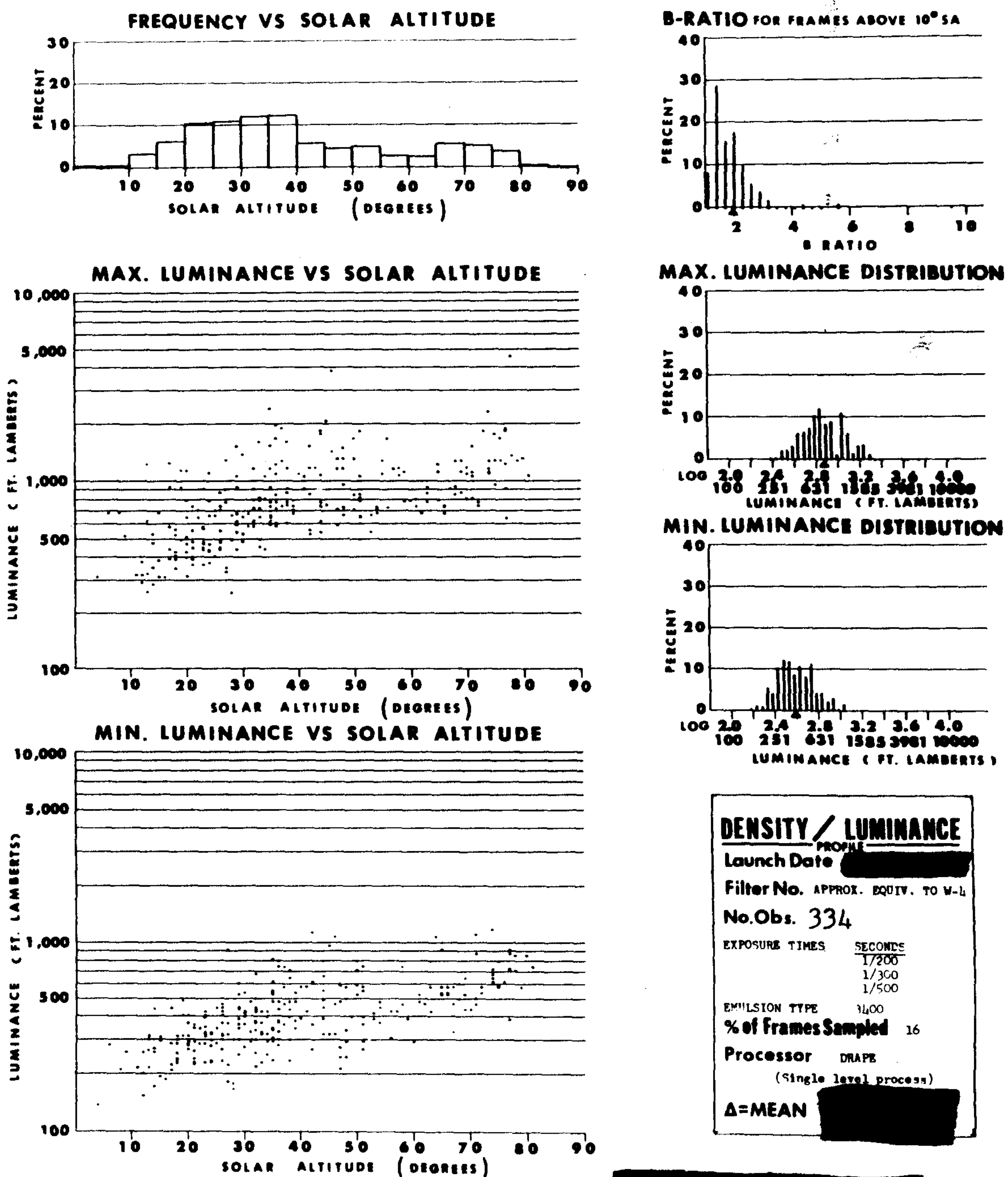


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Figure 30

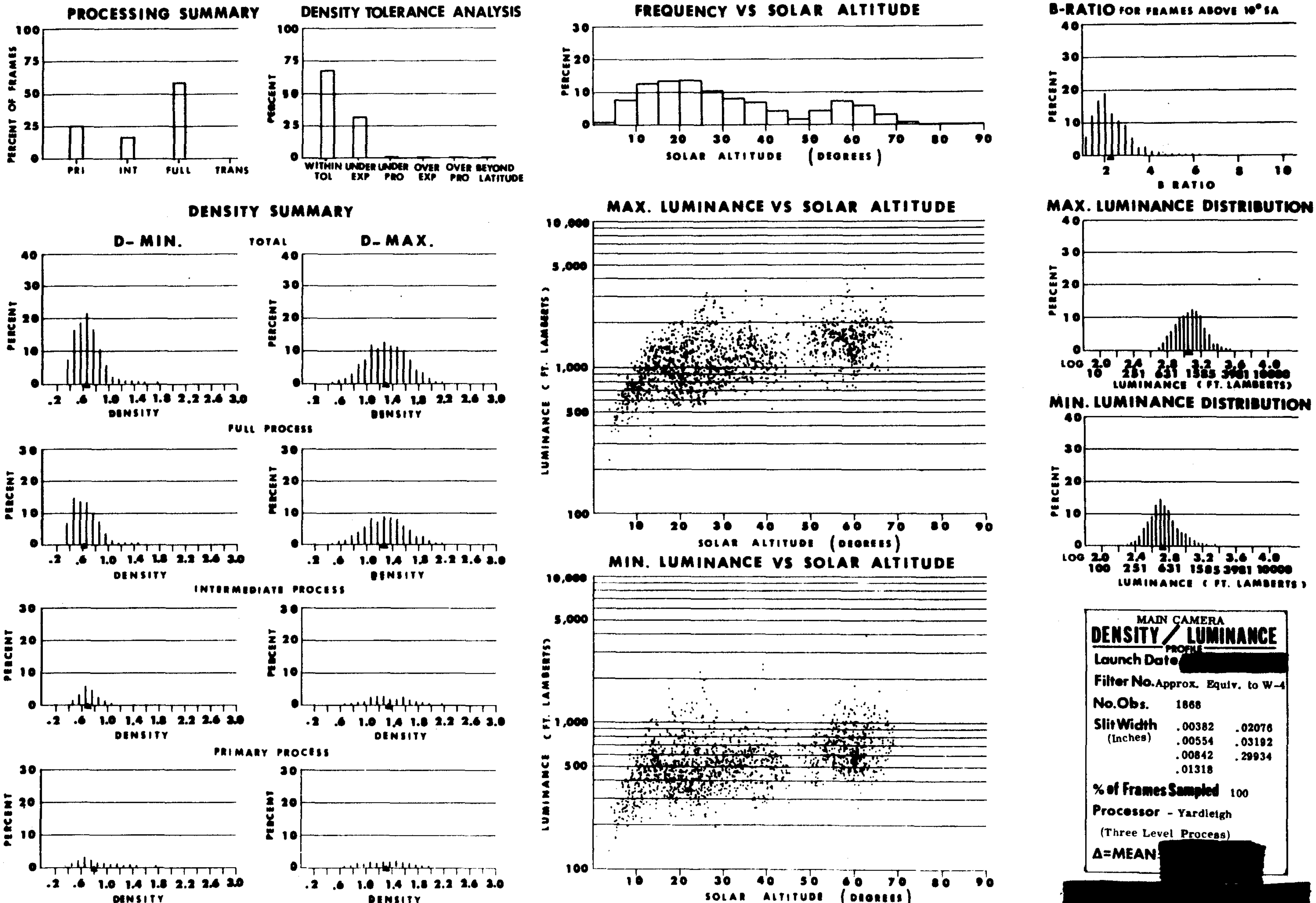

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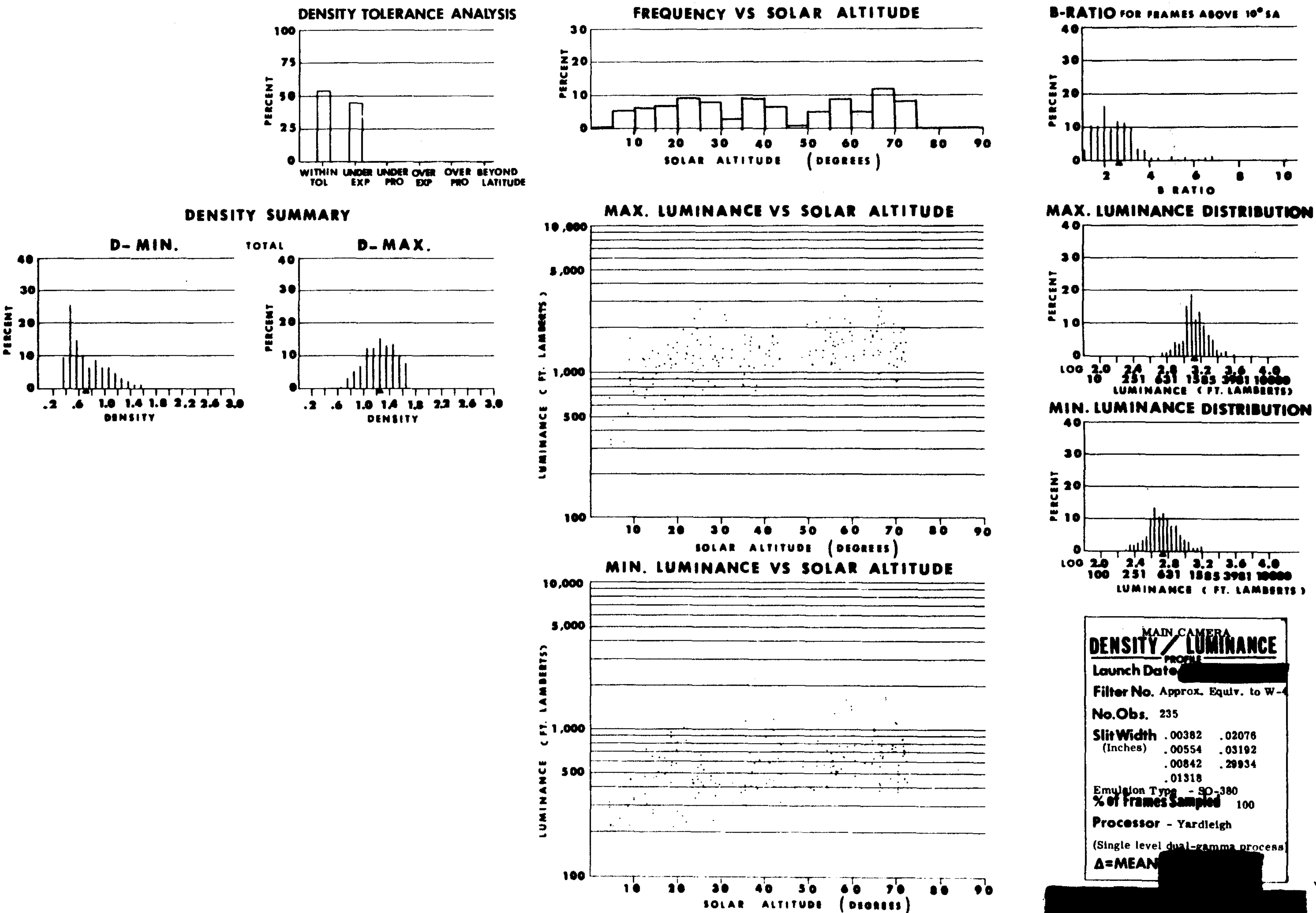
Figure 31



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PAR 24-8-5S

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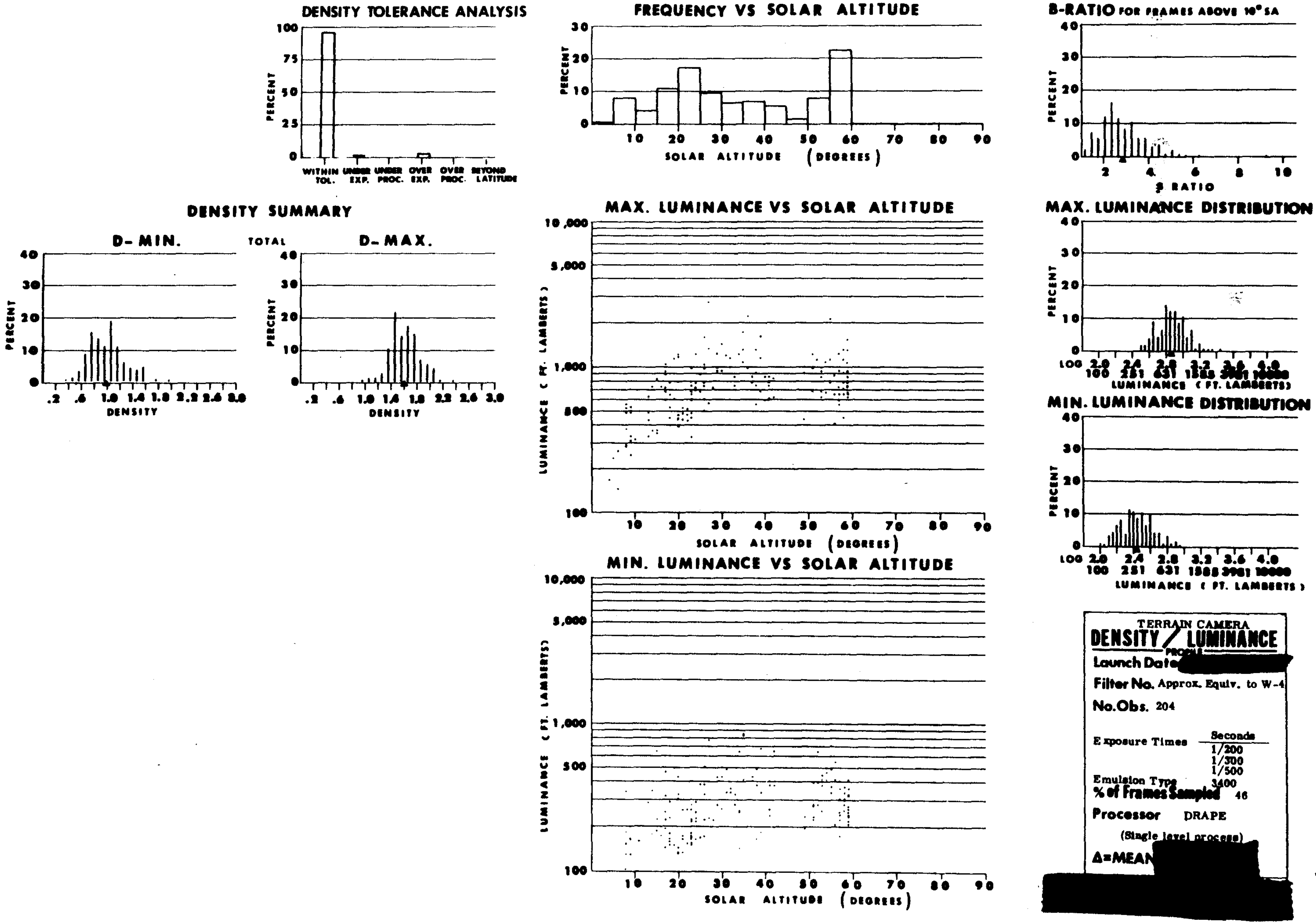
Figure 32



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Third Quarter FY-68

[redacted]

8 Mar 68

SUBJECT: Target Brightness Studies

TASK/PROBLEM

1. Evaluate the feasibility of selecting exposure for operation of very high altitude photography on the basis of the individual brightness history of each specific target.

DISCUSSION

2. Data collection for Project Sunny was completed during the first week of January, and the last Weekly Progress Report was sent on 19 January 1968. We analyzed a total of 1400 acquisitions of 31 targets, reporting the results at an average rate of 66.9 acquisitions per week. This data forms the basis for the extensive correlation and summary analyses for the final report.

3. During the data collection phase of this PAR, 22 Weekly TWX Reports were transmitted -- one every week from 26 August 1967 to 19 January 1968.

4. Four interim monthly summary reports (dated 4 October 1967, 6 November 1967, 6 December 1967, and 10 January 1968) were published as scheduled. These reports documented the status of recalled material and acquisition reporting, presented a cumulative tabulation of specific target acquisition data, and gave preliminary results of the correlation analyses as they were made, concurrently with data collection.

5. A progress report was presented to the January CCB meeting.

6. A special customer request for frame and target density data on 1000-series acquisitions was satisfied on schedule.

7. Correlation and summary analyses are nearing completion and the final report is now in preparation. This report will include a tabulation of specific target acquisition data for all acquisitions analyzed during the course of this project, as well as the results of the summary analyses.

PLANNED ACTIVITIES

8. Complete the final report in time for the tentatively scheduled delivery in May 1968.

Contract [redacted], Task 3

Third Quarter FY-68

PAR 24-7-7S/R1

8 Mar 68

SUBJECT: Study of Scanning Techniques

TASK/PROBLEM

1. Establish criteria for improving acquisition, processing, and reproduction based on scan data obtained from black-and-white reconnaissance films.

DISCUSSION

2. Section I: Scanning as Related to Exposure Criteria

a. Single-Frame Scanning Mode. A computer program has been written and placed in operation which enables any number of long or short runs to be made on the PAR 70 Scanner Recorder without the need to re-calibrate before and after each run. In other words, a calibration run is made; any number of runs on imagery are performed (with up to four minutes allowable between runs for winding to frames of interest, changing of rolls, etc); and finally the second calibration run is made. This program provides a convenient single-frame scanning mode.

b. Blockout. We have completed the computer program BLOCKOUT which removes from consideration those areas not considered representative (frame lines and optically distorted imagery near frame lines). The last signal at the end of each PAR 70 scan is normally about 600 millivolts. By pressing a button, the end of scan signal is increased to approximately 800 millivolts. If the button is depressed when framelines are encountered (as above), the BLOCKOUT program will automatically disregard the unwanted signals, and the frequency distribution bar graphs constructed will not use these values. The program has been checked on a limited number of frames and appears to perform satisfactorily. Further tests are planned before the BLOCKOUT program is released for general use. This program, along with the one described above for a single-frame scanning mode, will enable efficient scanning of the type needed for initial studies.

c. Density distribution. The method previously used for data compilation within the density cells of the frequency distribution bar charts resulted in certain unreal frequency "peaks." These peaks were distortions caused when certain density values were truncated and others rounded off. By normalizing the data this problem has been resolved. A program to produce a continuous line graph on the Calcomp Incremental Plotter was written. As there is no density cell size which necessitates rounding off or truncation, the data need not be normalized. This program has not as yet been fully tested, but initial results are good.

d. Brightness distribution. A computer program, BRIGHT, which will compute brightness bar graphs, has been written and is now being debugged. Tests will be performed prior to releasing this program for general use. Associated with this are statistical analysis and a Calcomp plot capability.

e. Tension and Speed Settings. Seventy millimeter flashed and processed Type SO-380 film was run on the PAR 70 Scanner at different speeds and tensions in an effort to determine the proper settings for the 70mm width. The recommended tension and speed settings based upon these test results are: both torque control settings at "20" and film travel speeds up to 45 fpm. At lower torque settings, severe fluttering and uneven tracking were encountered; at higher torque settings, the film was abraded on the emulsion side. At speeds higher than recommended, film oscillation was observed. A label containing the recommended settings has been attached to the PAR 70 Scanner.

f. Illuminator. To assist in the visual detection of frame lines on [redacted] series original negative materials, a portable illuminator has been installed on the PAR 70 Scanner. This illuminator has been found to be especially valuable for the successful depressing of the end-of-scan push button (see paragraph 2.b. above).

g. Scan Format. The reliability evaluation effort has been intensified. This effort includes the scanning of a limited number of frames using different scan pitches and film transport rates. It is anticipated that these tests will provide information necessary for specifying efficient, yet reliable, scan formats.

h. Calibration. A computer program to analyze the calibration data cell-by-cell has been written and tested. This program will indicate which individual scanner cells are reading consistently high or low, and should be recalibrated. Further testing to determine tolerance limits is underway.

i. Safety of Material. As a matter of good practice and safety, original negative material should not be run in a reverse direction on the PAR 70 Scanner. That is, we will not use it as a power rewind. As original negatives should be returned to customers wound on the same spool as received, and as the PAR 70 should not be used as a rewind device, a set of hand re-winders have been placed in the PAR 70 Scanner location. Compliance with the recommended procedures will protect the original negative from damage caused by taking unnecessary risks.

3. Section II: Scanning as Related to Optimum Processing

a. Data collection from the PAR 61 Improved IR Scanner as a breadboard has been completed. All of the tests, scheduled to be conducted on this scanner prior to its installation on the Yardleigh 6 processor, have been performed. (Installation will be made under another contract.)

(1) Various negative film types, 3404, SO-230, 3400 and 3401 were tested for effects on scanner response. These films have been examined under three different conditions, fixed-out, stabilized-wet and stabilized-dry. The effects of these material variations at the scanning station have been evaluated.

(a) IR transmission characteristics under these various conditions have been established for each of the negative film types scanned.

(b) The relationship between the effective infrared density and the subsequent visual density of the processed product will be used to establish trigger point settings for the scanner when operating on the Y-6 processor.

(2) Test samples of known density distributions scanned on both the PAR 61 Improved IR Scanner and the PAR 70B Scanner have been used to establish basic data handling techniques. These techniques will be helpful

in determining the effects of original negative imagery distributions as related to the level of development.

b. An attempt to correlate PAR 70B data with data collected with the PAR 61 IR Scanner has been a major effort during the quarter. Output from these two units will constitute the bulk of the data to be used in this section of the study.

c. Image distribution data generated by scanning the same imagery on the PAR 70 and the PAR 61 IR Scanner offers a means of relating the output from the two scanners.

(1) Usually image density distribution data is described in terms of relative frequency distributions. This same data, however, can be presented in another manner, namely as a cumulative distribution. Cumulative distributions frequently have an "S" shaped form with the lower limit cumulative frequency equal to zero, and the upper limit cumulative frequency equal to 1.00. Distribution data in one form can be easily converted and presented in the other form.

(2) Either form of the density distribution data is readily available from the PAR 70B Film Scanner Recorder output. The output signals from this scanner are recorded on magnetic tape and converted to calibrated density readings with the aid of a 360 computer program. From these calibrated density readings (covering the entire density range of the black-and-white positive or negative aerial reconnaissance films), a density frequency distribution (bar graph) is constructed. The relative frequencies can then be summed to produce the complete cumulative frequency distribution.

(3) The cumulative form of the frequency distribution is more suited for the data output from the PAR 61 Improved IR Scanner. This scanner has three comparator circuits with trigger-point settings. The trigger points can be adjusted to a certain level and a pulse will be generated each time the signal exceeds that level. Therefore, with the proper adjustment of trigger-point settings in conjunction with 6-digit frequency counters, it is possible to obtain the cumulative relative frequency of occurrence for all densities below that density which corresponds to the trigger-point setting.

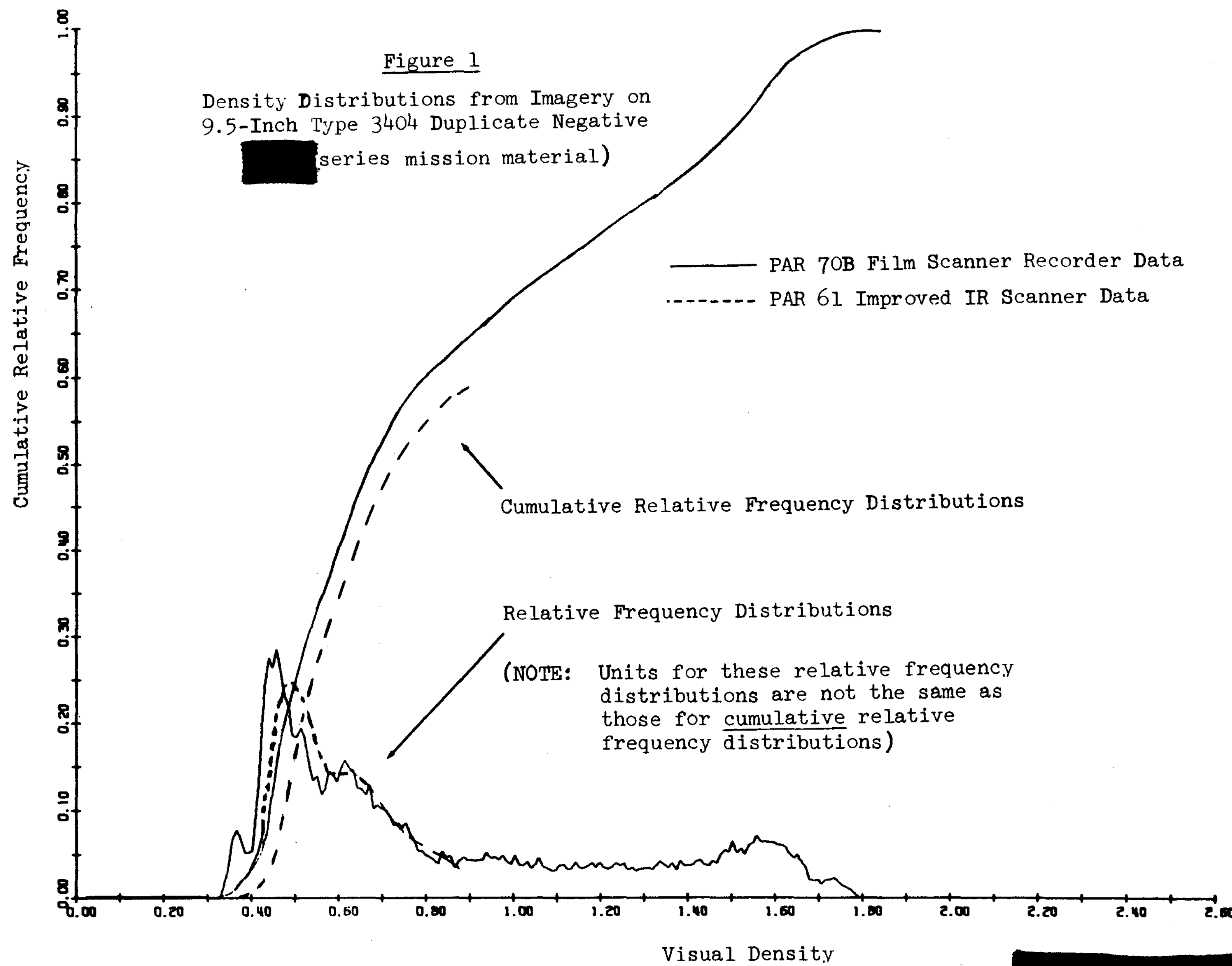
With film Type 3404, reliable cumulative frequencies up to a level of 0.9 density have been obtained. Although only three points on the cumulative frequency distribution curve can be obtained with each scan of the imagery on the PAR 61 Scanner, repeated runs with new trigger-point settings are used to construct a more complete cumulative frequency distribution curve. These cumulative frequency distribution data, generated by scanning film Type 3404 imagery on the PAR 61 Scanner, are limited to densities below 0.9; but the cumulative relative frequencies can be determined if the total scan time on the total area of the imagery scanned is known.

d. Figure 1 shows an example of the two ways of presenting the density distribution data (example was obtained scanning Type 3404 duplicate negative imagery from a 9.5-inch, [redacted] series mission). The solid lines represent the imagery density distribution data as obtained with the PAR 70B Scanner. These data are presented in the cumulative form as well as in the form of a relative frequency distribution. (Note that the relative frequency curve measures the slope of the cumulative curve.) For comparison, the density distribution data as obtained with repetitive scanning on the PAR 61 IR Scanner breadboard is represented by the dashed line. The cumulative curve depicts the image density distribution data as it is obtained with the frequency counters on the PAR 61 Scanner. The relative frequency distribution is then derived from the cumulative curve. Note that approximately 60% of the imagery in the example frame does not exceed a density of 0.90. Therefore, for this region of the scale, the relative frequency distribution as derived from the PAR 61 scanner is fairly well defined.

e. Image distribution data from a wide cross-section of imagery distributions will be examined in an attempt to determine the relation between density distributions and process level. This can be done using data from recalled mission material scanned on the PAR 70 Scanner, now that confidence has been gained in the ability to relate the output from this scanner and the output from the PAR 61 IR Scanner.

Figure 1

Density Distributions from Imagery on 9.5-Inch Type 3404 Duplicate Negative ([redacted] series mission material)



f. Meanwhile, the PAR 61 Scanner is being prepared for testing on the Yardleigh 6 processor where it will function in a relatively passive monitoring role as a data-collection station.

g. The time during which the PAR 61 Scanner is not available for testing will be needed to complete the analysis of the data collected from the breadboard.

4. <u>Section III: Scanning as Related to Reproduction Operations</u>

a. Work is continuing on examination of two- and three-dimensional density frequency bar distributions of 184 [redacted] series mission original negatives and their acceptably printed duplicate positive frames. The determination of the correct printing level is made from the conventional Dmin/Dmax system and the subjective examination of several D.P.'s made at different printing levels.

b. Four computer programs are now operational for the analysis of printing parameters:

(1) Printing Dmin and Dmax, and density mean, mode, and range are printed adjacent to each density frequency bar distribution to identify the conventional parameters associated with each plot.

(2) Three-dimensional density vs delta density vs frequency plots indicate the extent of density modulation indicative of different types of scenery, and indicate the range of problem area modulation.

(3) A calibrated density mapping of each frame is used to ascertain which peaks within the frequency bar distributions indicate specific scenery.

(4) The HISTO computer program has the ability to discriminate against low density modulation and to plot two-dimensional density distributions with the remaining densities. This procedure is beneficial in excluding unwanted low modulation densities in problem areas while not being overly severe against acceptance of modulation characteristic for "flat" targets.

c. Additional original negative frames and their subjective acceptable D.P.'s pertinent to Project Sunny are being examined.

PLANNED ACTIVITIES

5. Section I (Exposure Criteria)

a. Perform additional reliability and format checks on the scanner, using several types of imagery, and various scan pitches.

b. Postpone plans to develop programs to calibrate and edit the raw data tape as it now exists to produce a condensed, calibrated summary tape. The form required must first be more clearly identified.

c. Continue work on calibration and error analysis to determine degree of accuracy necessary in calibration of data, in order to accomplish scan objectives.

d. Write additional bar-graph plot programs as needed.

e. Collect and evaluate initial data on about 100 frames of original negative using crude techniques (this includes scans needed for both Sections II and III). The data collected will include:

(1) Plotting density and brightness bar graphs.

(2) Analyze results relative to exposure, processing, and printing.

(3) Evaluate the significance of the effects of clouds and water on the density distribution.

(4) Make a recommendation as to whether discrimination for clouds and water is or is not needed. (This recommendation will be drawn from data collected and will not be the subject of a separate investigation.)

6. Section II (Processing). Continue that part of the investigation which can be accomplished concurrent with testing of the PAR 61 Scanner on the Yardleigh processor.

a. Attempt to determine the relation between imagery density distributions and the level of development. Much of the data needed for this purpose is available from Section III (Reproduction Operations).

b. Complete analysis of the data collected from the PAR 61 breadboard scanner.

c. Assist where needed in the preparation of the PAR 61 scanner for installation on the Yardleigh Processor (this is being accomplished under a separate contract).

7. Section III (Reproduction Operations)

a. The total transmission of each frame will be computed based on the density frequency bar distributions and will be analyzed with reference to its assigned printing level.

b. Data from the conventional printing parameters and from the new transmission data will be analyzed statistically (analysis of variance) to determine similarities of frequency distribution and assigned printing level with different types of scenery.

c. Tone reproduction methods will be employed, using computer methods, to try to obtain the density frequency bar distribution of the correctly printed D.P. from scan data taken from the O. Neg. Selection of lower or higher exposure printer curves for printing the O Neg. would indicate the corresponding shift in latitude densities of the D.P. plot.

PAR 143S
8 Mar 68

SUBJECT: Study Detailed Production Systems Requirements

TASK/PROBLEM

1. Study the detailed operations and production control requirements for the processing and reproduction of large-roll mission material.

DISCUSSION

2. Introduction:

a. Intermediate and long-range goals for improvement of the present production system were defined in PAR 121S, Define Objectives for a Systems-Improvement Program. The purpose of the subject PAR (143S) is to translate those goals into detailed specifications for improving major components of the production system. These improvements will enable the system to handle production loads that will result from the large-roll missions anticipated in 1970. Five areas were designated for study, which can be divided into two groups.

(1) Define system requirements to:

(a) Provide effective production control, including the monitoring of product flow and machine control, where applicable.

(b) Provide effective material flow throughout the system.

(2) Define equipment performance specifications for effective:

(a) Printing

(b) Dupe inspection

(c) Labeling, packing, and shipping

b. Effort prior to this quarter included detailed studies of present procedures in each of the five areas of this project. These studies pinpointed desirable improvements and provided a basis for evaluating alternate proposals.

3. Progress and Current Status:

a. Production Control. A number of alternate systems were analyzed and reviewed with a committee from production. From this analysis, two alternate systems were selected for additional evaluation. Both systems are based on the assumption that an on-line central computer will be available for continuous monitoring of data input stations. One of the systems uses a punched card to identify the product; the other uses a self-contained code that is exposed in the "ident" to identify the product. An evaluation is now being made of the cost and reliability of these two alternate systems.

b. Material Flow. As alternate systems are being defined, tentative solutions to material flow problems are being developed. In this connection, product flow in the dupe inspection operation and through shipping operations is a major area of attention. Math model refinements, the need for which was reported last quarter, have not yet been made because of conflict with other effort on this project having a higher priority.

c. Printing Requirements. After PAR 153P, Advanced Step-and-Repeat Drum Printer for UTB Film, was approved by the CCB, effort in this area was redirected from defining equipment requirements for selective copy printing to estimating what the future customer requirements may be for both full and selective copies. This information will be needed in estimating production control system requirements.

d. Dupe Inspection. Six plans for improving the dupe inspection, breakdown, rewind, canning, and labeling operations were evaluated and reviewed with a committee from production. From these six a preferred method was selected. Essentially, the plan provides for specialization of some functions and combination of others. Dupe inspection would be performed at a separate workplace, without breakdown of the rolls coming to it from dupe processing. Breakdown, rewinding, canning, and labeling would be done at a second workplace. Improvements in quality and efficiency will result from (1) more critical inspection, (2) reduction in the handling of individual rolls, (3) automatic rewinding while other work is performed, and (4) on-the-spot preparation of labels. Preparation of final specifications is being delayed pending the effect that decisions on the production control system have on the dupe inspection interfaces.

e. Labeling. An analysis was made of several alternate possibilities for automatic preparation of labels; the analysis was based on commercially available systems. These were reviewed with a committee from production who indicated their system preferences. Final selections will be made as part of the production control system study.

PLANNED ACTIVITY

4. Production Control. Select a system and recommend it for installation. Review the recommendation in-house with department management, and make presentation of the recommended system to the April meeting of the CCB. Following this, develop detailed performance specifications to use in soliciting bids from vendors on the hardware. This hardware will be designed and installed under a later PAR.

5. Material Flow. After the general production control system has been determined, make recommendations with respect to material flow.

6. Printing Requirements. After the production control system has been selected, evaluate the effect of different mixes of full versus selective copy requirements on the overall production system. Review these with the customer and indicate the possible trade-offs that may be useful in establishing future production requirements.

7. Dupe Inspection. Prepare and present final recommendations for dupe inspection, breakdown, canning, and labeling at the April meeting of the CCB. Propose equipment design PARs to implement these recommendations.

8. Labeling. Incorporate final recommendations for labeling in the recommendations for dupe inspection.

PAR 144S/M

8 Mar 68

SUBJECT: Primary/Secondary Breakdown Station Study

TASK/PROBLEM

1. Conduct a study to determine the hardware required to facilitate inspection, breakdown, densitometry, and handling of UTB original negative.

DISCUSSION

2. Introduction:

a. Studies on PAR 121S, Define Objectives for a Systems Improvement Program, indicated that the original negative primary and secondary breakdown functions——inspection, mission-profile breakdown, densitometry, and printing breakdown——must be analyzed in detail to integrate these operations into the proposed new system. Since these functions interface with the processors and printers and affect many subsequent operations, the stations must be optimized in terms of overall system performance.

b. It is the intent of this PAR to investigate (1) material flow, (2) the information that is available and that will be required for decisions and subsequent operations, (3) operator's tasks, and (4) equipment performance requirements to provide detailed parameters for the required breakdown and densitometry work centers.

c. Prior to this quarter, functional operation (production) relationships and interrelationships with internal (technology) and external (camera, customer) influences were analyzed. Numerical summary-type data pertaining to film format was being developed, as well as requirements for data media storage and flow rates. Workplace layouts were proposed and reviewed.