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PFA-042A VOLUME II

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Abstract:

This data package consists of two volumes: Volume I is the technical information to support experimental planning for the analyses of test data from the five special tests performed by SSC on Sensor Subsystem S/N 012. Volume II is a package of detailed test plans and results of these tests.

ii

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TABLE OF CONTENTS

LIST OF TABLES

Hx ~~TOP SECRET~~ PFA-043 A

SECTION 1

TEST PLANS AND RESULTS, SPECIAL TESTS

Test plans and results, for analysis of the five S/N 012 Special Tests given in Volume I of PFA-043, are given in this volume (Volume II, PFA-043). Section 2 contains the test plans; Section 3 contains the test results. The S/N 012 Special Tests (Reference Volume I) are as follows:

Test No.	Test
1	Thru Focus
2	Thru Smear
3	Thru Focus and Thru Smear Combined
4	Variable Synch Flash
5	Variable Synch Flash, Smear Bias

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SECTION 2

TEST PLANS

2.1 THRU-FOCUS, TEST NO. 1

2.1.1 Film MTF/Diffusion Model (EKONIK, Test C)

2.1.1.1 Objective

The objective is twofold: to evaluate the effectiveness of linearization methods in estimating the MTF of the test film due to optical spreading and to produce a best estimate film MTF for future use.

2.1.1.2 Methods

A. Sensitometric integrity as measured by line areas.

B. Evaluation of linear smear at fixed OTF.

2.1.1.3 Tools

A. Microdensitometer: FSPPF "D" machine with focus servo.

B. Software: GNFLINES and PFALINES with latest diffusion model.

2.1.1.4 Film Samples

The film samples needed are listed in Table 2-1 with sample requirements specified as "Primary" or "Secondary". No action other than MACFACT analysis, however, should be carried out on secondary frames at this time. All measurements will be made at the 45° and/or 0° collimator position at two different contrasts, and two exposure levels will be analyzed at the 45° position.

The "Primary" frames include those at best focus as measured in Test 3 data reduction, with frames selected to accommodate measured astigmatism. Also included are five frames at 18μ platen position to provide transition to the Test 2 data. These latter data comprise the through smear data wherein only cross-track lines will be considered.

The "Secondary" frames are check cases that may be used for additional testing. They comprise the Aft Camera complement to the smeared frames of the Primary set plus selected zero smear, near best focus frames from Test 3.

A total of 272 candidate lines have been selected for primary consideration. Standard MACFACT limits should be used.

2.1.1.5 Problems

A. According to availabl data, the "mixe bag" reticle is oriented cross-track, thus limiting the amount of data that can be collected. Some effort is expected to be needed to qualify targets as not contaminated by random image motion and/or random focus perturbations. To accommodate this problem, certain data will be processed from the 45° collimator in-track line plates.

B. Since an appreciable amount of data is to be produced, scheduling will be affected by concurrent AFSPPF work load.

C. Exposure variation can only be accommodated in the 45° collimator position (line plate).

2.1.1.6 Procedure

A. Select from Primary frames (C-1 and C-2) those targets mechanically and photographically acceptable.

B. Qualify these targets by:

1. MACFACT data
2. Microdensitometer analysis
3. Exposure levels and density
4. Correct mean smear from sync-flash data

C. Scan lines

1. 1 x 80μ slit
2. 0.5μ sample spacing
3. 3 cuts
4. two contrasts (to be selected)
5. 20% replication

D. Calculate film MTF and its statistics.

E. Repeat above steps for C-3 frames of Primary group (Test 2 frames).

F. Using the film MTF derived above, calculate the smear and its dispersion attributable to uncertainty in film MTF.

G. Evaluate line areas as a function of smear to determine if target energy is conserved.

H. Evaluate results in terms of

1. effectiveness of the experiment
2. degree of linearization achieved
3. accuracy of motion estimation and effect thereon of error in the film MTF.

I. Perform additional measurement as indicated by experimental results.

J. Report results, including a statement as to the degree of sensitometric integrity achieved and recommendations as to additional action required.

2.1.1.7 Resources

A. MACFACT support from SETS.

B. Microdensitometric and computational support form AFSPPF under current arrangements.

C. Upon completion of tests, replication of selected samples at Bridgehead and completion of a mini-experiment of the same type.

D. Test planning, data reduction and analysis by EIKONIX.

E. Synch flash data from SSC.

2.1.2 Chamber D to Chamber A MTF Comparison (AFSPPF, Test D)

2.1.2.1 Objective

The objective is to evaluate the behavior of the lens MTFs determined from Chamber D interferometry when compared to MTF's derived from lines exposed in Chamber A. Emphasis is to be placed on the suspected understatement of the POLYMOD MTF's when the system is defocused.

2.1.2.2 Method

The line targets in the special reticles will be traced by a microdensitometer, and converted to MTF estimates by program PFALINES using the Non-Linear Diffusion Model to compensate for the Dual Gamma processing. These MTF's will be compared as a function of focus position to the MTF's derived by POLYMOD from the Chamber D data. Because of the random variability of camera performance as well as the statistical nature of the film, some line MTF's will be averaged together, and error bounds established.

2.1.2.3 Tools

AFSPPF PDS microdensitometer with Focus Control.

AFSPPF IBM 360/40 computer.

AFSPPF Line Analysis Software.

2.1.2.4 Problems

Lack of certainty of film MTF behavior (see paragraph 2.1.1).

Possible exposure or camera variability problems confounding the data.

2.1.2.5 Procedure

1. Determine actual system PSF from tribar and line focus data.

2. Obtain POLYMOD MTF's for SN-012 optical bars.

3. Trace all 2-micron wide lines in each reticle using AFSPPF PDS microdensitometer with focus servo.

4. Process data through program GNPLINES using the Non-Linear Diffusion Model for the modified Dual Gamma process.

5. Average line MTFs as a function of focus and field position.

6. Compare the average line MTFs with the appropriate POLYMOD MTFs.

2.1.2.6 Resources

AFSPPF line trace data.

SSC POLYMOD MTF data.

2.1.2.7 Schedule

The schedule depends on focus determination results from TM curve test (paragraph 2.3.1) and final answers to film MTF questions.

2.2 THRU SMEAR, TEST NO. 2 (SCC)

The thru smear test covers a range of -5 to +20 microns smear offset in approximate one micron steps. Focus for this test was held constant at 20 microns for the Forward and 74 microns for the Aft camera. The line and Synch Flash targets were scanned at each of these OOAA settings. Test results are given in Paragraph 3.2.

2.3 COMBINED THRU-FOCUS/THRU-SMEAR, TEST NO. 3

2.3.1 TM Curve* (BRIDGEHEAD)

2.3.1.1 Objective

The objective is to produce more reliable TM curves to support the Hexagon program. This can be accomplished by:

A. Examining how tri-bar threshold modulation requirements vary as a function of exposure and contrast with smear, defocus and combined smear-defocus as the degrading elements.

B. Comparing the results after necessary error analysis with currently-used TM curves.

C. Giving recommendations for future use.

2.3.1.2 Method

Several methods are available to produce the TM curves and all rely upon tri-bar readings of large arrays. In this experiment, five different contrasts of $\sqrt[12]{2}$ tri-bar were used at three exposure levels. To plot what the threshold modulation was for a given reading, the original contrast is converted to modulation and multiplied by the modulation transfer factor of the optics that apply at that spatial frequency and recording condition. The recording conditions can be varied in a number of ways (defocus, smear, etc.) and, therefore, the input array of points from which a TM curve is derived can be generated in a number of ways. However, it is strongly suggested (from past experience) that each way does not produce the same TM curve. These differences

*TM, or Threshold Modulation, is the term being standardized in the National Reconnaissance Program by the Image Resolution Acquisition and Recording Standardization Task Force in place of what was formerly referred to in Vol. I as AIM, i.e., Aerial Image Modulation.

as well as other ambiguities should be resolved with an adequate error analysis.

2.3.1.3 Tools

AFSPPF tri-bar reading microscopes and light tables.

Bridgehead computer (IBM 370).

2.3.1.4 Procedure (See Table 2.2)

1. Obtain test chamber imagery and preview. (Done)
2. Establish tri-bar reticle calibrations. (Done)
3. Sort imagery for scheduling. (Done)
4. Arrange for TM tri-bar reading at AFSPPF. (Done)
5. Obtain results of tri-bar reading.
6. Preliminary review and analysis for acceptability.
7. Arrange for re-do or additional reading as required.
8. Obtain optics MTF data. (Partial)
9. Compute and plot preliminary TM curves.
10. Use data to produce TM in other manners.
11. Analyze variations and differences.
12. Establish confidence limits.
13. Compare with currently used curves.
14. Make recommendations.

2.3.1.5 Schedule

As soon as possible.

2.3.1.6 Resources

AFSPPF (tri-bar readings)

HQS (optics MTF's)

TABLE 2-2

FRAMES TO BE ANALYZED

FORWARD CAMERA

SMEAR (MICRONS) \ DEFOCUS (MICRONS)	0	4	8	16	32	OCP	SEQUENCE
0	4-8	13-17	21-25	30-34	44-48	77	9030
1	4-8	13-17	21-25	30-34	44-48	100	9031
2	4-8	13-17	21-25	30-34	44-48	102	9032
4	4-8	13-17	21-25	30-34	44-48	104	9033
8	4-8	13-17	21-25	30-34	44-48	106	9034

AFT CAMERA

SMEAR (MICRONS) \ DEFOCUS (MICRONS)	0	4	8	16	32	OCP	SEQUENCE
0	3-7	10-14	18-22	27-31	41-45	77	9030
1	3-7	10-14	18-22	27-31	41-45	100	9031
2	3-7	10-14	18-22	27-31	41-45	102	9032
4	3-7	10-14	18-22	27-31	41-45q	104	9033
8	3-7	10-14	18-22	27-31	41-45	106	9034

2.3.2 Visual Edge Match (VEM) Matrix Calibration (SSC, Test 8)

2.3.2.1 Objective

To determine if VEM calibration varies as a function of contrast, smear or focus position.

2.3.2.2 Method

A VEM (INSCAL) matrix calibration will be done utilizing smeared as well as defocused imagery at two contrast levels as found in the nadir collimator VEM reticles for both cameras. Test 3 contains photography degraded by both smear and defocus.

The original negative VEM tribars from Test 3 will be read by three readers. Once the resolution levels for this test are known, an intelligent choice of frames to be Visual Edge Matched will be made. For an initial calibration, only one camera and one direction will be used.

2.3.2.3 Tools

AFSPPF tri-bar reading microscopes and light tables

SSC Visual Edge Matching Comparator and Matrix

2.3.2.4

None anticipated.

2.3.2.5 Procedures

1. Have Test 3 ON VEM tribars read by three AFSPPF personnel.

2. Choose frames to be Visual Edge Matched.

3. Have SO-192 Dupe made at optimum print level.

4. VEM one contrast level of frames chosen.

5. VEM second contrast level of frames chosen.

6. Determine VEM calibration as a function of the various parameters using resolving power as the common denominator.

7. Analyze calibration differences if any.

2.3.2.6 Schedule

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2.3.2.7 Resources

AFSPPF tribar readers.

SSC VEM readers.

SSC software.

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2.4 VARIABLE SYNCH FLASH (WITH & WITHOUT SMEAR BIAS), TESTS NO. 4&5 (EIKONIX, TEST G)

2.4.1 Thru-OB Synch Flash

2.4.1.1 Objectives

The objectives are as follows:

A. Measure the shape of the image displacement autocorrelation function in the vicinity of the origin by use of synch-flash data, FBS and MCRECON.

B. Evaluate the correspondence of these sources in terms of this second order statistic.

C. Examine sync flash (SF) data versus time to evaluate the impact of any particular set measuring interval upon the probable accuracy of data obtained.

2.4.1.2 Methods

A. Analysis of through OB synch-flash data as variance versus time.

B. Simulation of this function from the autocorrelation functions corresponding to the ensemble averaged FBS and MCRECON spectra.

C. Comparison of results.

2.4.1.3 Tools

A. Standard synch-flash procedures in use at SSC, (all frames).

B. Spectral analysis and computation of autocorrelation functions.

C. Data reduction by plotting, comparison and numerical analysis.

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2.4.1.4 Film Samples

The whole of Tests 4 and 5 comprises the set of candidate frames, and all synch-flash data from these frames will be required:

	SEQUENCE	FRAMES	CR COUNTS	SMEAR OFFSET
Forward Camera	9060	1-24	0	0
	9093	1-24	1	0
	9094	1-24	3	0
	9095	1-24	5	0
	9096	1-24	7	0
	9097	1-24	9	0
	9098	1-24	11	0
	9099	1-24	13	0
	9100	1-24	15	0
	9101	1-24	7	0
	9061	1-24	0	4.32
	9102	1-24	1	4.32
	9103	1-24	3	4.32
	9104	1-24	5	4.32
	9105	1-24	7	4.32
	9106	1-24	9	4.32
	9107	1-24	11	4.32
	9108	1-24	13	4.32
	9109	1-24	15	4.32
	9110	1-24	7	4.32
Aft Camera	9060	1-21	0	0
	9093	1-21	1	0
	9094	1-21	3	0
	9095	1-21	5	0
	9096	1-21	7	0
	9097	1-21	9	0
	9098	1-21	11	0
	9099	1-21	13	0

	SEQUENCE	FRAMES	OB COUNTS	OFFSET
Aft Camera	9100	1-21	15	0
	9101	1-21	7	0
	9061	1-21	0	4.4
	9102	1-21	1	4.4
	9103	1-21	3	4.4
	9104	1-21	5	4.4
	9105	1-21	7	4.4
	9106	1-21	9	4.4
	9107	1-21	11	4.4
	9108	1-21	13	4.4
	9109	1-21	15	4.4
	9110	1-21	7	4.4

Because this test comprises some 900 frames of photography, the EM data for analysis must be carefully selected. The form of this data will be as formatted (to be specified between EIKONIX and SETS) records of MCRECON displacement versus time (microns) and FAS output in IPS versus time, both from shutter open to shutter close. Since the data will be analyzed to an ensemble averaged spectrum, one for each camera, it is difficult to specify the exact amount of data required for convergence. Preliminary requirements for a total of 80 frames, subject to later review, are:

	SEQUENCE	FRAMES	OB COUNTS	OFFSET
Fwd	9095	5-14	5	0
	9097	5-14	9	0
	9104	5-14	5	4.32
	9106	5-14	9	4.32
Aft	9095	5-14	5	0
	9097	5-14	9	0
	9104	5-14	5	4.4
	9106	5-14	5	4.4

A request will be submitted to SETS at a later data to specify a limited set of this data for analysis. Possibly, convergence will allow a reduction in the number of frames to be processed.

2.4.1.5 Problems

The only problem is the stationarity of the sample data. It may be necessary to match EM data segments to the vicinity of the SF event. If so, the problem can be solved and be accommodated with software. If a wide deviation from statistical stationarity (second order) occurs, then the experiment may fail, at least with respect to the attempted correlation with EM data.

2.4.1.6 Procedure

A. Collect all synch-flash data from Tests 4 and 5. The required data are the mean and standard deviation versus OB count, calculated for each group of frames at each OB count.

B. Segregate the data by collimator location and plot, for each target, variance versus time delay.

C. For the designated sample frames, calculate MCRECON data (smear versus time), shutter open to close.

D. Compute average spectrum from (C) for each case.

E. Fourier transform the result of (D) to provide an autocorrelation function for each case.

F. Calculate from (E) the statistical equivalent of (B).

G. Compare results, particularly with respect to rate of ascent, and the possible occurrence of high frequency (short delay) turn around.

H. Repeat D, E, F and G for FBS.

I. Evaluate results.

J. Assess the result of (B) in terms of the deviation of results from a kT^2 type of behavior and evaluate the impact of particular OB delay selections.

K. Report results and describe implications of findings.

2.4.1.7 Resources

A. Synch-flash data to be supplied by SSC.

B. MCRECON and FBS data to be supplied by SETS. The form of the data will require some special additions to existing software, but these additions are not expected to be extensive.

C. A special spectrum calculation routine will be prepared by EIKONIX.

D. Computer support will be required from AFSPPF.

SECTION 3

TEST RESULTS

3.1 THRU-FOCUS, TEST NO. 1

3.1.1 EM Data Review, Focal Plane Position

At SPO request, a MACFACT run was made of Special Test No. 1, Sequence 0001. This sequence is a three-focus run with a specified number of frames at each focal plane position (See Table 3-1). Discrepancies found in the Volume I roadmap were frames representing transition from one position to the next; in Table 3-1, TR indicates the focal plane was stationary but at an intermediate position between two desired settings.

TABLE 3-1

FOCAL PLANE POSITION SEQUENCE 9001

Camera A		Camera B	
Focal Plane Position (microns)	Frame	Focal Plane Position (microns)	Frame
4.	1 - 10	55	1 - 7
TR	11, 12	TR	8, 9
7.	13 - 18	59	10 - 12
TR	19	TR	13 - 17
11.	20 - 25	65	17 - 22
TR	26	TR	23
17	27 - 33	68	24 - 28
TR	34	TR	29 - 31
18	35 - 40	70	32 - 37
TR	41	TR	38
24	42 - 47	76	39 - 46
26	48 - 53	76	47 - 50 (1)
28	54 - 59	79	51 - 52
TR	60	TR	53 - 60
30	61 - 66	81	61 - 63
31	67 - 72	83	64 - 69
33	73 - 78	85	70 - 75
35	79 - 84	87	76 - 81
TR	85	TR	82
39	86 - 91	89	83 - 88
39	92 - 97	90	89 - 94
41	98 - 103	92	95 - 100
44	104 - 1[illegible]	94	101- 106
TR	110	TR	107, 108
46	111 - 116	98	109 - 113

(1) Alternating between 75.5 & 77.3

TABLE 3-1 (Continued)

FOCAL PLANE POSITION SEQUENCE 90001

Camera A		Camera B	
Focal Plane Position (microns)	Frame	Focal Plane Position (microns)	Frame
48	117 - 122	98	114 - 119
50	123 - 128	100	120 - 125
52	129 - 134	103	126 - 131
TR	135 - 139	TR	132
54	140 - 141	105	133 - 138
55	142 - 147	107	139 149
59	148 - 153	TR	145, 146
61	154 - 160	109	147 - 150
61	161 - 165	111	151 - 156
TR	166	TR	157
63	167 - 172	113	158 - 162
65	173 - 178	TR	163
68	179 - 184	114	164 - 169
TR	185	116	170 - 175
68	186 - 187	120	176 - 180
TR	188 - 191	TR	181, 182
72	192 - 197	120	183 - 187
74	198 - 203	TR	188
76	204 - 209	122	189 - 194
TR	210	124	195 - 200
78	211 - 215	127	201 - 207
TR	216	127	208 - 212
79	217 - 222	TR	213
83	223 - 228	129	214 - 219
85	229 - 234	133	220 - 225
TR	235	135	226 - 231
		TR	232 - 235

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TABLE 3-2

THROUGH SHEAR TEST

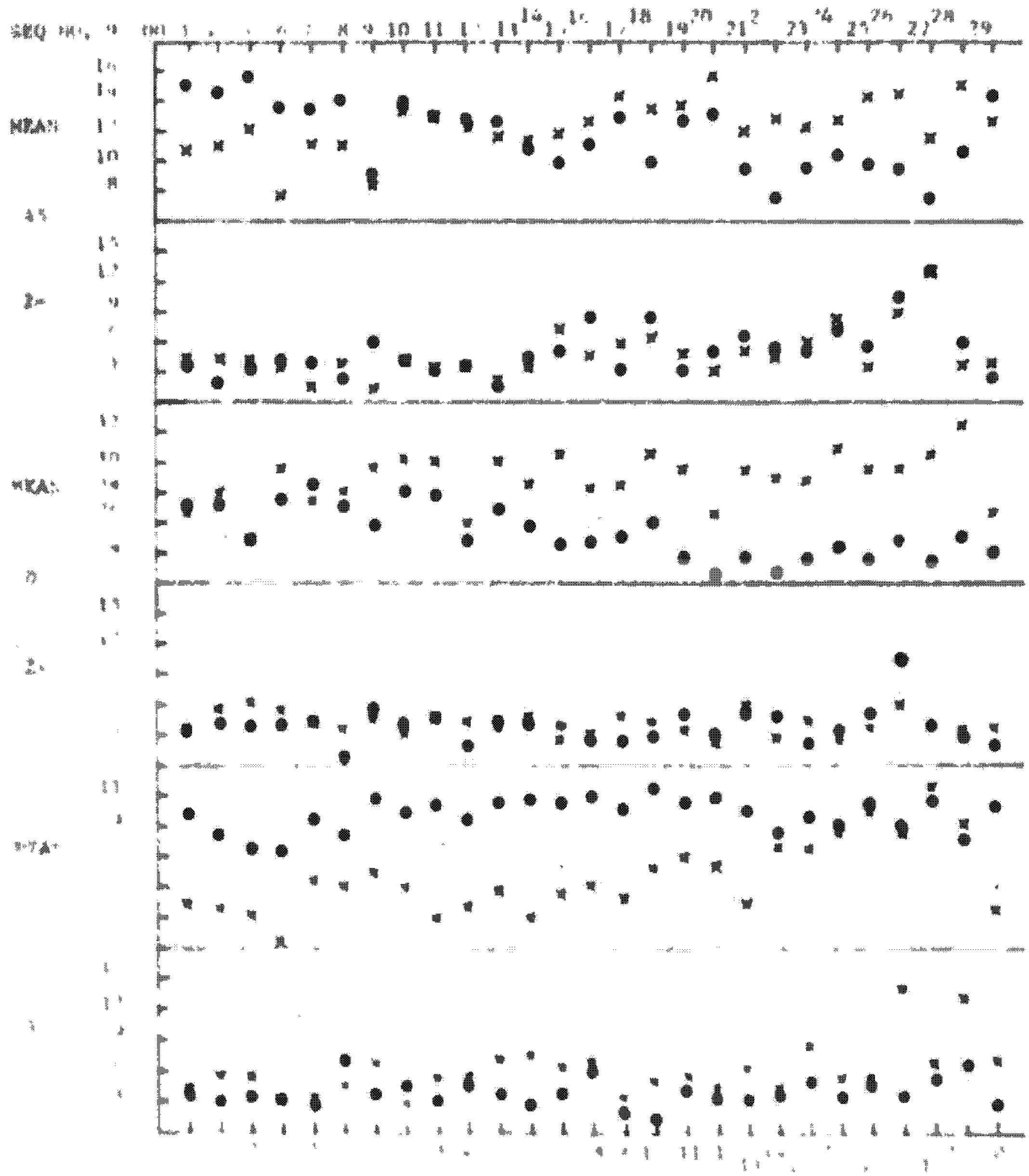
FOCUS IN MICRONS FROM LINE TARGETS

PLATES DIAGNOSTIC AT 20L (5 FRAMES OR LESS AT EACH SEQUENCE)

A-SIDE

● IN TRACK

✖ CROSS TRACK



PFA-043A

TABLE 3-2 (Continued)

FOCUS IN MICRONS FROM LINE TARGETS

PLATEN DIAGNOSTIC AT 74μ (6 FRAMES OR LESS AT EACH SEQUENCE)

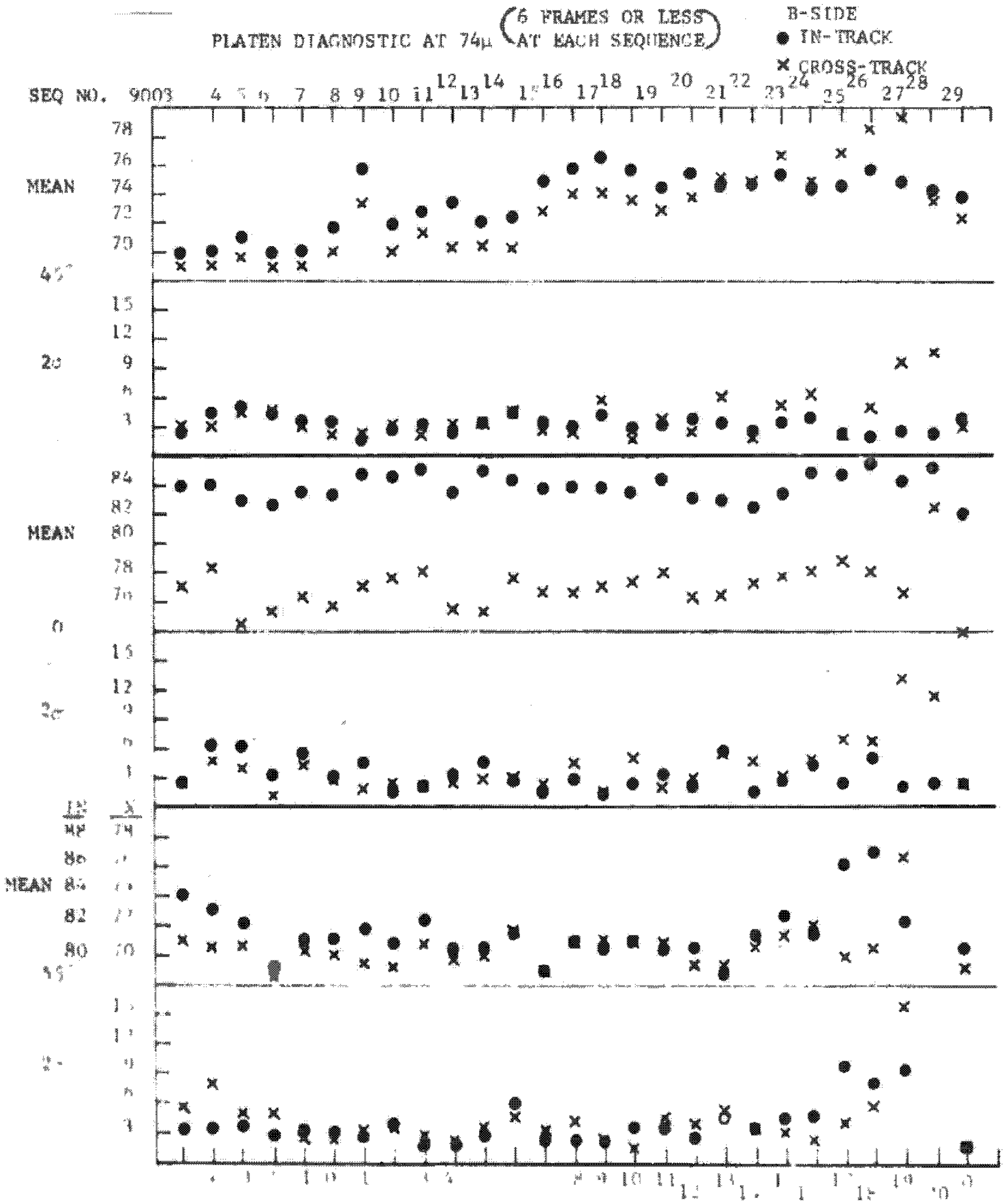


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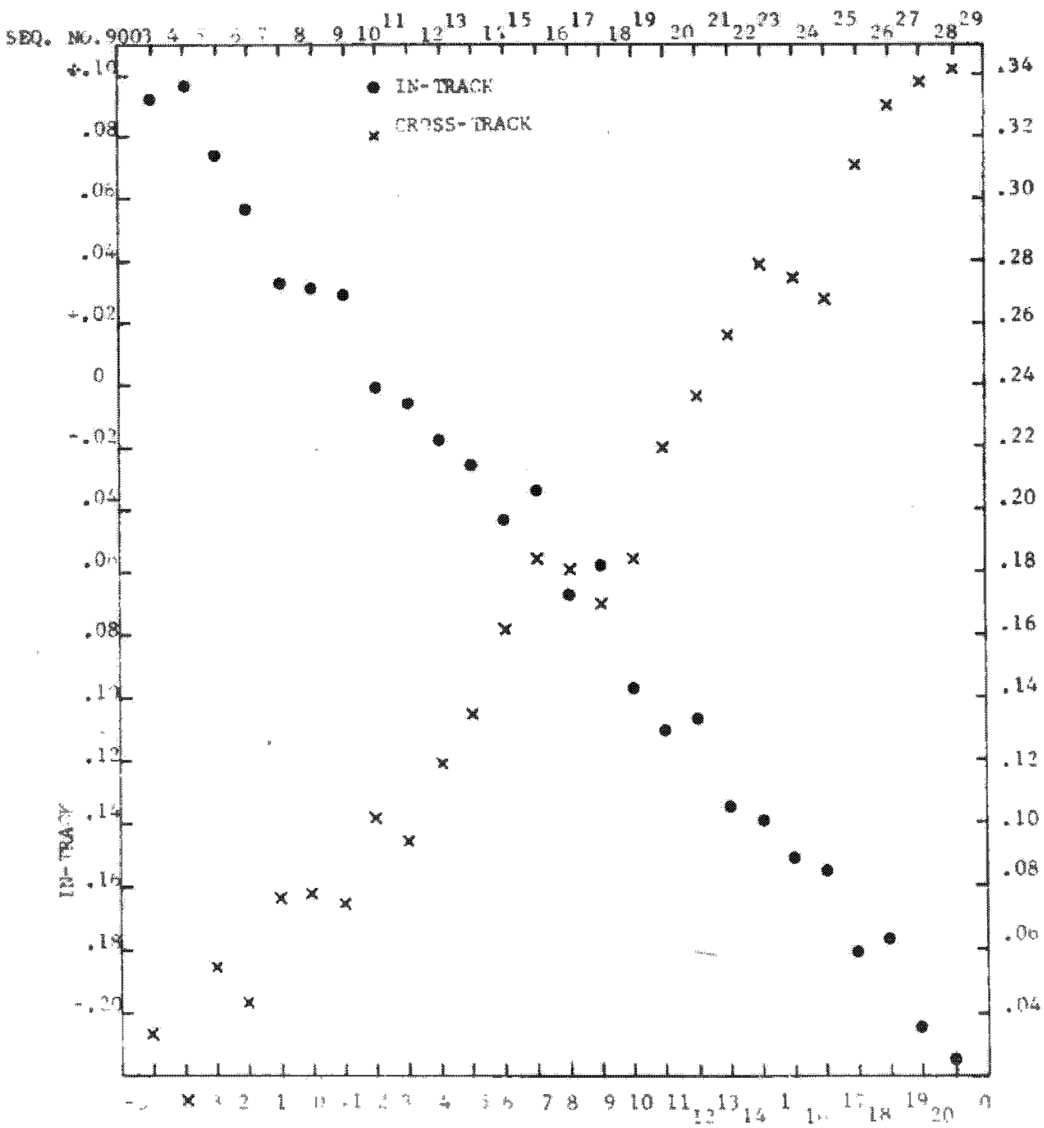
TABLE 3-2 (Continued)
MEAN IMAGE MOTION ERROR (IN./SEC.)
B-SIDE 45° COLL. POSITION (6 FRAMES AT EACH SEQUENCE)



MEAS OFF-SET POSITIONS

TABLE 3-2 (Continued) PFA-043A

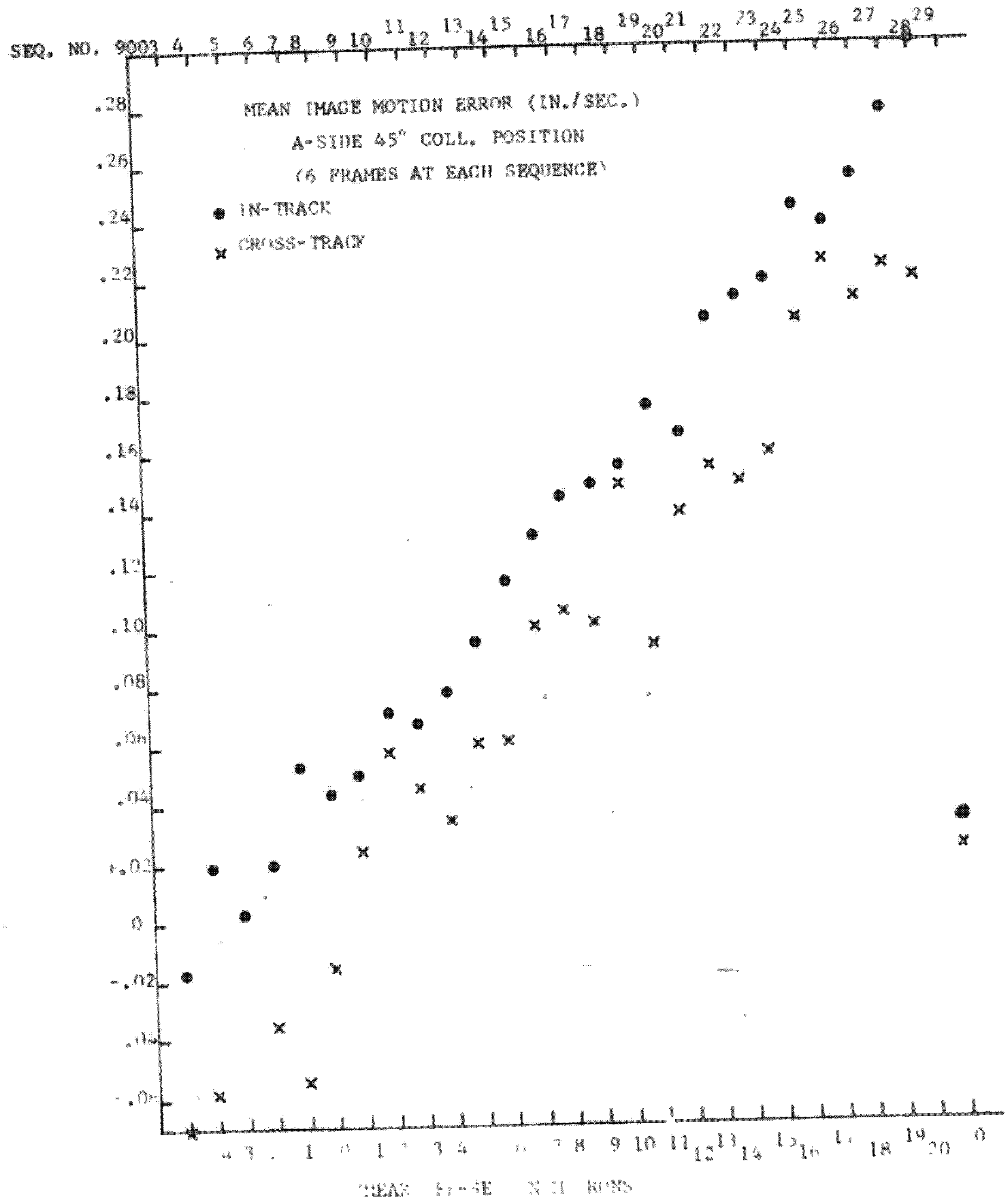


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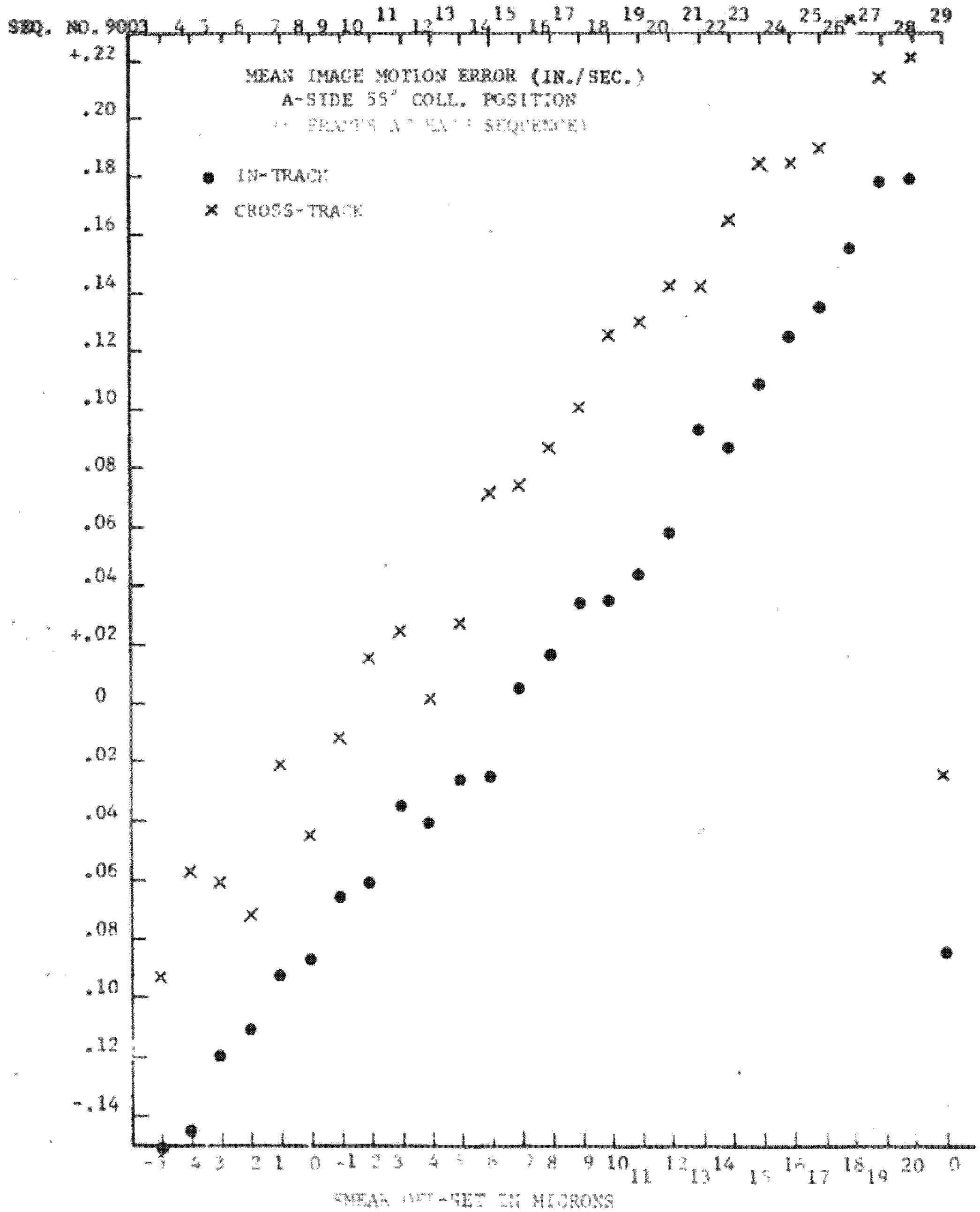
TABLE 3-2 (Continued)



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PFA-043A

TABLE 3-2 (Continued)

MEAN IMAGE MOTION ERROR (IN./SEC.)

B-SIDE 55° COLL. POSITION (6 FRAMES AT EACH SEQUENCE)

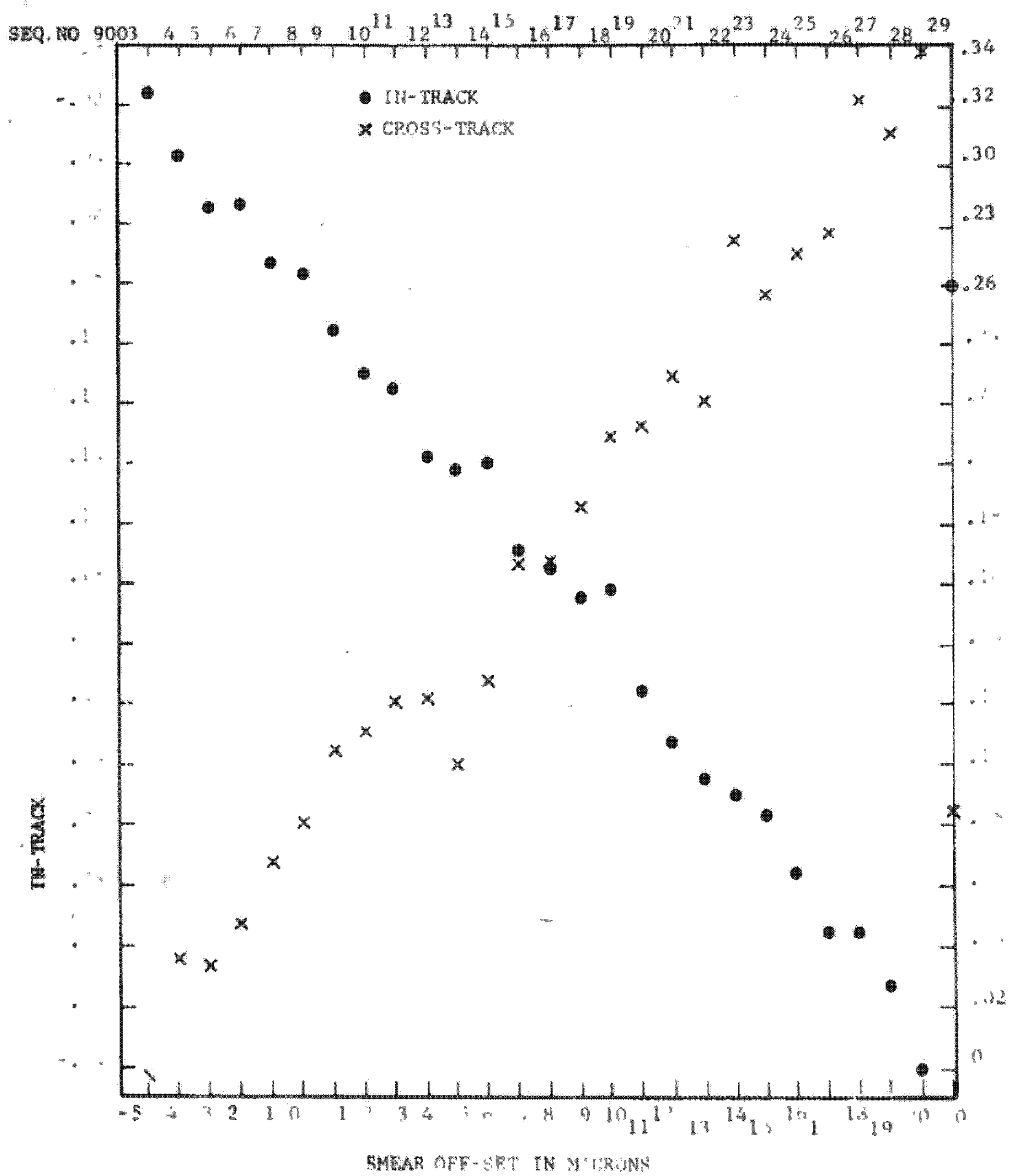

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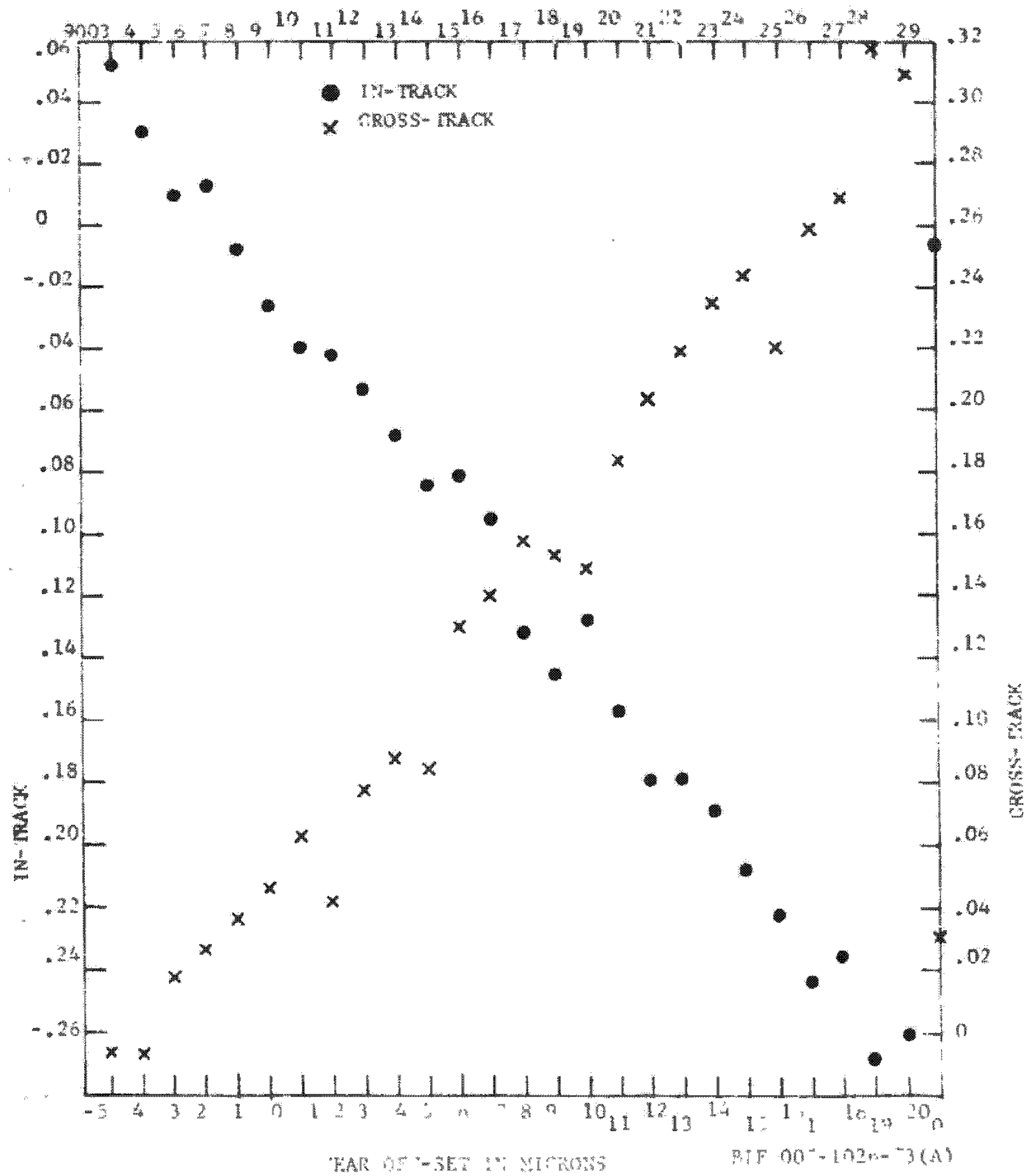
TABLE 3-2 (Continued) PFA-043A

MEAN IMAGE MOTION ERROR (IN./SEC.)

B-SIDE NADIR COLL. POSITION (6 FRAMES AT EA SEQUENCE)



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3.3 COMBINED THRU FOCUS/THRU SMEAR, TEST NO. 3

3.3.1 EM Data Review

3.3.1.1 Focal Plane Position

As a cross check of the road map in the S/N 012 special test data package, MACFACT runs were made on each of the test sequences in Test 3 (See Table 3-3, sequences 9030, 9031, 9033, and 9034). The parameters of primary interest were focal plane position and smear bias. Some discrepancies in the loaction of transition frames within the sequences and in the magnitude of smear bias were found. Each of the test sequences analyzed is a through focus run containing photography at specified focal plane position. The discrepancies noted were the frames representing transition from one position to the next. In Table 3-3, "TRANS" means that the focal plane was stationary but at an intermediate position between the two desired settings; "*" means the focal plane was actually moving during photography.

3.3.1.2 Smear Bias Commands

A confirmation of commanded vs actual smear bias was made by analyzing the mean of the film-to-Bar Sync (FBS) for cross-track smear and the mean of the platen recycle error at 55° for the in-track smear (See Table 3-4 for results of this comparison).

To convert the commanded cross-track and in-track smear in microns to equivalent inches per second, the following relationship was used:

$$\text{inches/second} = \frac{\text{smear}}{(25.4)\ (\text{exposure time})}$$

where smear is in microns and exposure time = $\frac{\text{slit width}}{(3770)\ (Vx/h)} * 10^3$ in milliseconds. The comparison of commanded inches-per-second cross -track was made with the mean FBS for the whole sequence. The effect of the normal FNOB bias is subtracted out in the MACFACT calculations.

In comparisons for the in-track bias, the MACFACT sampled the platen recycle mode error in telemetry volts at -55 degrees OB angle. The mean voltage for the zero smear command sequence (9030) was taken as the reference level.

TABLE 3-3

FOCAL PLANE POSITIONS

SEQUENCE 9030

Camera A		Camera B	
Focal Plane Position (microns)	Frame	Focal Plane Position (microns)	Frame
22	1-10	74	1-7
Trans	11	76	8-14
26	12-17	Trans	15-16*
Trans	18-19*		
30	20-24	84	17-21
Trans	25-28*	Trans	22-25*
38	29-35	89	26-31
Trans	36-41	Trans	32-38
34	42-46	108	39-44
Trans	47-48	Trans	45-48*

SEQUENCE 9031

Camera A		Camera B	
Focal Plane Position (microns)	Frame	Focal Plane Position (microns)	Frame
22	1-10		
Trans	11	74	1-7
26	12-17	76	8-14
Trans	18-19*	Trans	15-16*
30	20-24	81	17-21
Trans	25-26*	Trans	22-23*
Trans	27-28	Trans	24-25
38	29-35	89	26-32
Trans	36-42*	Trans	33-38
34	43-47	105	39*
Trans	48*	105	44-44
		Trans	45-48*

TABLE 3-3 (Continued)

FOCAL PLANE POSITION

SEQUENCE 9032

Camera A		Camera B	
Focal Plane Position (microns)	Frame	Focal Plane Position (microns)	Frame
22	1-10	74	1-7
Trans	11	Trans	8
26	12-17	76	9-14
Trans	18	Trans	15
30	19-24	79	16-21
Trans	25-28*	Trans	22-25*
39	29-35	89	26-31
55	36-47	Trans	32-38
Trans	48*	105	39-44
		Trans	45-48*

SEQUENCE 9033

Camera A		Camera B	
Focal Plane Position (microns)	Frame	Focal Plane Position (microns)	Frame
22	1-9	74	1-7
Trans	10	Trans	8
26	11-16	78	9-14
Trans	17-18*	Trans	15-16*
30	19-24	79	17-22
Trans	25-27	Trans	23-25
39	28-34	89	26-32
Trans	35-38	Trans	33-36
Trans	39-41*	Trans	37-39*
54	42-46	105	40-44
Trans	47	Trans	45-48*

TABLE 3-3 (Continued)

FOCAL PLANE POSITIONS

SEQUENCE 9034

Camera A		Camera B	
Focal Plane Position (microns)	Frame	Focal Plane Position (microns)	Frame
22	1-9	74	1-7
Trans	10	Trans	8
26	11-16	76	9-14
Trans	17-18*	Trans	15-16*
30	19-23	81	17-21
Trans	24-26*	Trans	22-24*
39	27-34	89	23-32
Trans	35-40	Trans	33-38
54	41-46	105	39-44
Trans	47	Trans	45-48*

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TABLE 3-4

COMPARISON OF COMMANDED AND ACTUAL SMEAR BIAS

IN-TRACK

			A			B		
Seq.	Command Bias (microns)	Command Bias ips	P1 Recycle Summ Error TM Volts	TM Quantiz. Levels	Actual Bias ips	P1 Recycle Sum Error TM Volts	TM Quantiz. Levels	Actual Bias ips
9030	0	0	0.87	0	0	3.56	0	0
9031	0.742	0.0093	0.90	1	0.0133	3.56	0	0
9032	2.22	0.0278	0.92	2	0.0266	3.52	2	0.0266
9033	3.71	0.046	0.94	3	0.040	3.50	3	0.040
9034	8.16	0.102	1.00	6	0.079	3.42	7	0.0931

CROSS-TRACK

			A		B	
Seq.	Command Bias (microns)	Command Bias ips	FBS Mean ips	Actual Bias ips	FBS Mean ips	Actual Bias ips
9030	0	0	0.007	0	0.006	0
9031	0.99	0.0124	0.019	0.012	0.018	0.012
9032	1.98	0.0248	0.031	0.024	0.027	0.021
9033	3.87	0.0486	0.053	0.046	0.052	0.046
9034	8.25	0.1035	0.108	0.101	0.111	0.105

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For the biased sequences, the mean voltage was compared to the reference level and the difference converted to 20 mv. quantization levels. The conversion to inches-per-second is 0.0133 inches/second per quantization level.

3.3.1.3 Conclusions

The smear actual vs commanded bias show no major differences except for the 8.16 micron (0.102 ips) in-track case resulting in only a 0.079 ips change. The cross-track bias are confirmed to be the magnitudes commanded. The review of the other film path diagnostics summarized by MACFACT indicates normal, in tolerance performance of the cameras during these sequences.

3.4 VARIABLE SYNCH FLASH (WITH AND WITHOUT SMEAR)BIAS,TESTS NO. 4 AND 5

3.4.1 Synch Flash Data, Thru-OB

Synch Flash (SF) data collected from Special Tests 4 and 5, show delays ranged from 0.25 to 3.82 ms, yielding samples of the differenced displacement function d(t):

$$\Delta d = d(t_2) - d(t_1)$$

The mean and variance of this quantity is calculated by SSC and the results have been supplied to EIKONIX. Historically, point-by-point correlation between SF and the EM sources (FBS, MCRECON) have not be impressive. Tests 4 and 5 of the Special test series seek to compare these results on a statistical basis. The mean $\overline{\Delta d}$ is removed, thereby eliminating any local systematic component. If we calculate the variance of Δd (assuming the zero mean case)

$$\begin{aligned} \langle(\Delta d)^2\rangle &= \langle[d(t_2) - d(t_1)]^2\rangle \\ &= \langle(d(t_1))^2 + (d(t_2))^2 - 2d(t_1)d(t_2)\rangle \\ &= 2(r(0) - R(t_2 - t_1)) \end{aligned}$$

assuming wide-sense stationarity, R( ) is the autocorrelation function of d(t).

Both the FBS and the processed MCSE (MCRECON) data give estimates of d(t), derived from measurements made in the film drive system. These signals are sampled at 2 ms intervals (generally conceded to be sufficient sampling);

they can be used as a basis for comparison with the SF data. A first comparison will be made by calculating the estimate

$$F(\tau) = 2\,(R)\,(0) - R\,(t_2 - t_1))$$

from the MCRECON and FBS data.

3.4.2 Processing Synch Flash Data

Synch flash measurements were supplied by SSC for all frames of Tests 4 and 5. The data was supplied by frame for each replication at OB counts of 0, 1, 3, 5, 7, 9, 11, 13 and 15. The number of replicated frames varied somewhat for each test but averaged about 18. The mean-squared displacement was calculated for each delay and several editing programs were written and processed to produce the final data. A plot program has been written to produce (CALCOMP) plots of σ^2 versus Δt.

3.4.3 Processing MCRECON and FBS Data

SETS has produced tapes (See Table 3-5) of displacement versus time from both MCRECON and FBS output. A test tape was supplied and successfully read prior to production of this data. The actual data tapes were received on 7 December 1973.* The data delivered consists of whole frame estimates of image displacement (μm) versus time. Separate estimates were derived from MCRECON and FBS data.

A computer program (EMTAPE) has been written and tested for the purpose of reducing the SETS data to the required form. The program accomplishes the following:

*Errors due to telemetry re-assignment by SSC has now required re-generation of about 1/4 of this data.

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TABLE 3-5

NCHK OUTPUT TAPES

Tape No.	File No.	Test/Sequence	Side
1	1	49/9103	A
	2	(Bade data)	A
	3	48/9095	A
	4	49/9102	A
	5	48/9094	A
	6	49/9104	A
	7	48/9096	A
2	1	49/9105	A
	2	49/9106	A
	3	49/9107	A
	4	49/9109	A
	5	48/9094	B
	6	48/9096	B
3	1	48/9098	A
	2	48/9099	A
	3	48/9100	A
	4	48/9098	B
	5	48/9099	B
	6	48/9100	B
4	1	48/9093	A
	2	48/9093	B
	3	48/9097	A
	4	48/9097	B
	5	49/9108	A
	6	48/9095	B

a. Interpolates the data to a finer time sampling by means of a four point LaGrangian method.

b. Accumulates and smooths spectra for the three replications using the MCRECON and FBS records (whole frame). Trends are removed via a second order least square fit routine.

c. Partitions the records into quarter-frame records centered (as nearly as possible) about the SF events.

d. Calculates and accumulates spectra for the partitions over the replications.

e. Calculates the four functions (2.0) $\left[R_i(0) - R_i(\tau)\right]$ by Fourier transforming the smoothed, averaged spectra. The smoothing is three-point triangular weight smoothing with weights 0.35, 0.50, 0.25.

f. Provides data interpolated to 0.01 ms in the vicinity of the SF events for later smear analysis to accomodate timing uncertainty.

g. Calculates means and standard deviations.

h. Calculates SF smear for all times for all data sets, using the nominal SF event location.

i. Provides tape output of original data, interpolated data and spectra.

Tests of the program were conducted by generating known data of the form:

$$\text{MCRECON}(t) = 10.0t + 10.0 \sin 120\pi t$$

$$\text{FBS}(t) = 10.0 \sin 120\pi t$$

The results obtained were satisfactory, being within about 2% of the results predicted from continuous theory ignoring the record length, sampling and smoothing. Trend removal was effective, with differences between the "FBS" and "MCRECON" cases reflected only in about the sixth significant figure. Partioning (quarter records) produced nearly identical data in all cases. Maximum differences on the order of a fraction of a percent were noted, and these are consistent with the arbitrary starting points (relative to the periodicity) of the data. A typical output for the "FBS" signal is shown in Figure 3-1;

Figure 3-2 shows the effect of interpolating the original data.

3.4.4 Data Comparison

The comparison of the synch-flash (SF) data with that derived from MCRECON and FBS will be based upon finding the similarity (or lack thereof) between the derived functions and those observed from SF data. Variances will also be compared. Particular interest lies in determining whether or not the spectral shapes predicted by MICRECON and FBS can give rise to the changes in variance observed with Δt in the SF data. A second objective is to determine if there is an "optimum" SF spacing that can be used to improve confidence in velocity error estimates. Data will be examined also for any evidence of scaling differences that might be significant. Following the first round analysis, a report will be issued and plans will be made for a second round analysis of the same data. Later processing will be addressed to the question of point-to-point correlation, and in particular to sorting out local trends in the vicinity of the SF event. All SF data exists on a frame-by-frame basis; the selection of frames for FBS and MCRECON analysis resulted in complete sequences available with three frames per [illegible]

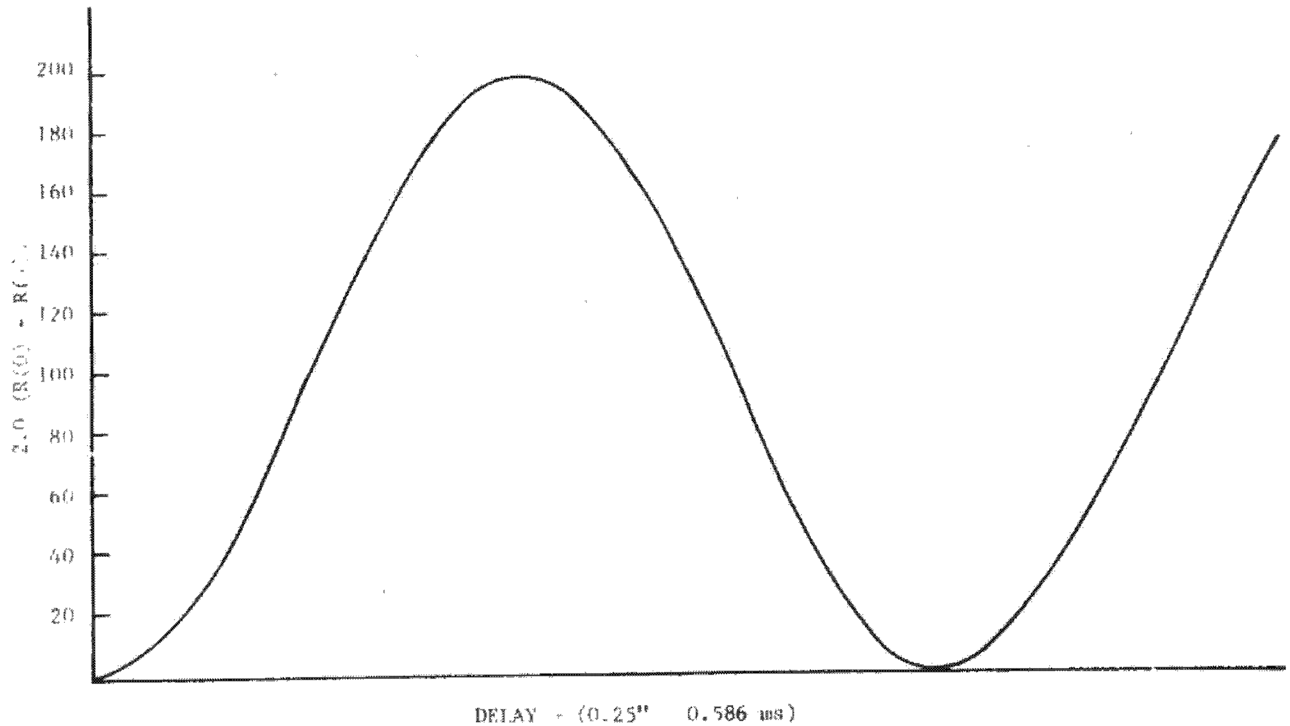

Figure 3-1. FBS Signal, Typical Output (2.0 (R(0) - R(τ)) For F(t) = 10.0 SIN 120 πt AS CALCULATED BY PROGRAM EMTAPE)

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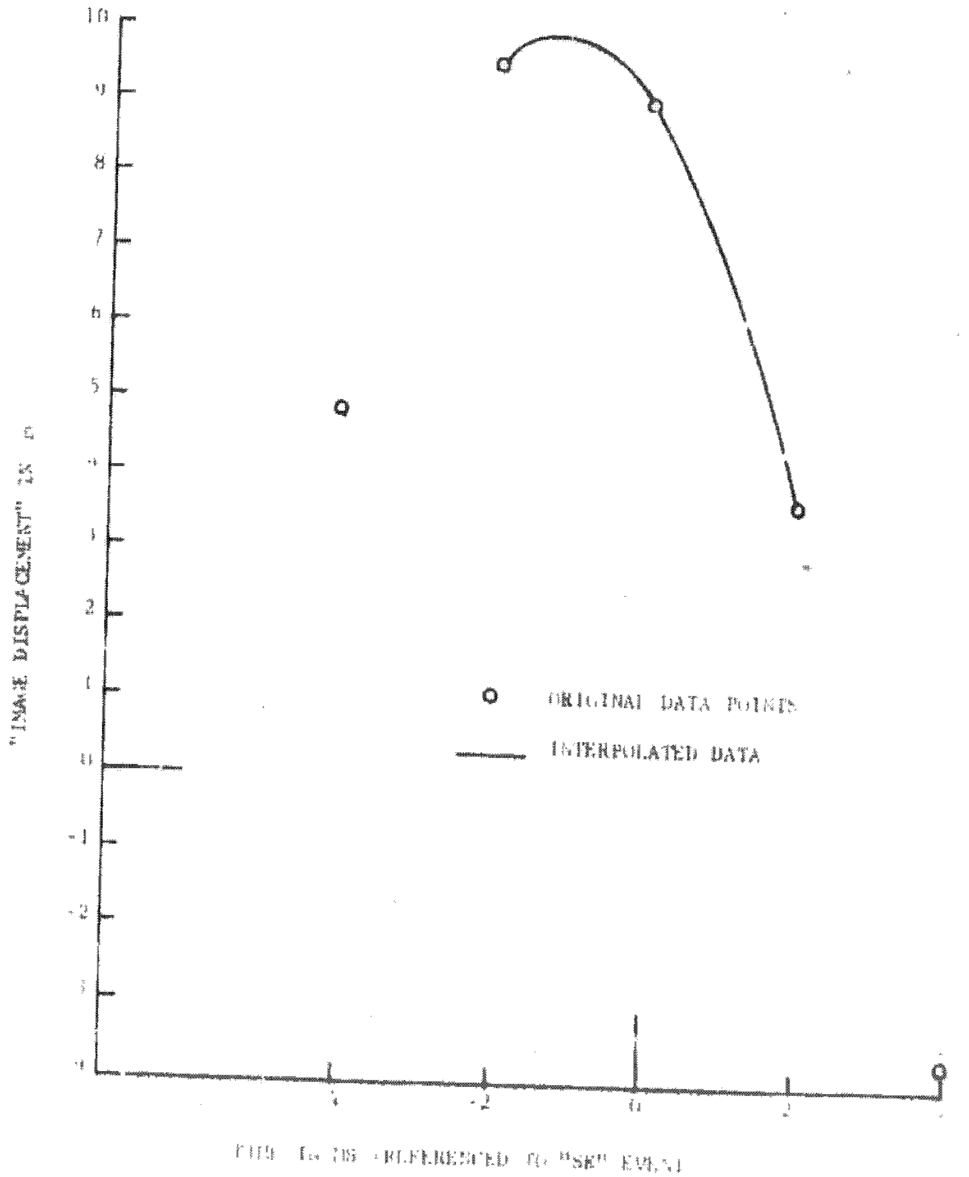

Figure [illegible]. Interpolated Displacement Function, 2 MS

[illegible] 007-10206-73(A)

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