

~~TOP SECRET~~BYEMAN
CONTROL SYSTEM~~(S)~~ NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

THE NRO STAFF

27 February 1975

MEMORANDUM FOR COLONEL ANDERSON, SP-7

SUBJECT: DMA Accuracy Requirements for Metric Panoramic Materials

The attached memorandum from the Defense Mapping Agency, outlining the accuracy requirements a successful Metric Pan System must meet, is forwarded for your use in the HEXAGON Metric Pan System Study.

Daniel B. Hutchison
DANIEL B. HUTCHISON
Lt Colonel, USAF

Atch
BYE-47518-75, Cy 1A

WORKING PAPER

HEXAGON

HANDLE VIA
BYEMAN
CONTROL SYSTEMCLASSIFIED BY BYEMAN - 1 EXEMPT FROM
GENERAL DECLASSIFICATION SCHEDULE OF
EXECUTIVE ORDER 11652 EXEMPTION CATE-
GORY 582 DECLASSIFY ON IMP DET.~~TOP SECRET~~CONTROL NO. TAB B
COPY 1 OF 2 COPIES
PAGE 1 OF 1 PAGES



PR

25 FEB 1975

MEMORANDUM FOR NATIONAL RECONNAISSANCE OFFICE

ATTENTION: Lt Col. Hutchison

SUBJECT: Capability Requirements for a Metric Panoramic System

1. Reference WHIG 0203, 072320Z Feb 75, subject: Metric Pan Study.
2. In accordance with your request, the following data represents the MC&G metric requirements for an MPS:
 - a. Panoramic camera calibration to reduce orthogonal film distortions to less than 10 micrometers (one sigma).
 - b. Time readout for panoramic exposures to 0.10 milli-seconds (one sigma).
 - c. Attitude readout of each panoramic camera to a precision of 1 (one) arc second accurate to 5-6 arc seconds (one sigma) on each axis throughout limits of scan.
 - d. Continuous attitude rate readout to less than 1.5 arc seconds/second (one sigma).
 - e. Continuous tracking and post-mission determination of the HEXAGON orbit and its ephemeris to within 30 feet (one sigma) in all components.
3. Of the above requirements all, with the exception of item c., are either currently available in HEXAGON or being addressed for incorporation by a specific point in time. The data used in the 17 January 1975 briefing to Dr. Hall (briefing materials attached) assumed errors consistent with the design specifications and projected these errors to the ground in order to define attitude requirements in keeping with the total error budget.

Page 1 of 2 pages
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Classified by BYEMAN-1
EXEMPT FROM GENERAL DECLASSIFICATION
SCHEDULE OF EXECUTIVE ORDER 11652
EXEMPTION CATEGORY para 5B (2) &
DECLASSIFY ON impossible to determine

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4. We concur with your desire to determine the best approach for development of the MPS as opposed to just the solid state stellar camera but emphasize the need to initiate and complete the MPS study at the earliest possible date in order to work the funding problem for system incorporation. In keeping with this, we are available to discuss the requirement statement and Study Plan as soon as possible.

FOR THE DIRECTOR:

Enclosure a/s
(6 paper copies)


Acting Deputy Director
Plans, Requirements
and Technology

Page 2 of 2 pages
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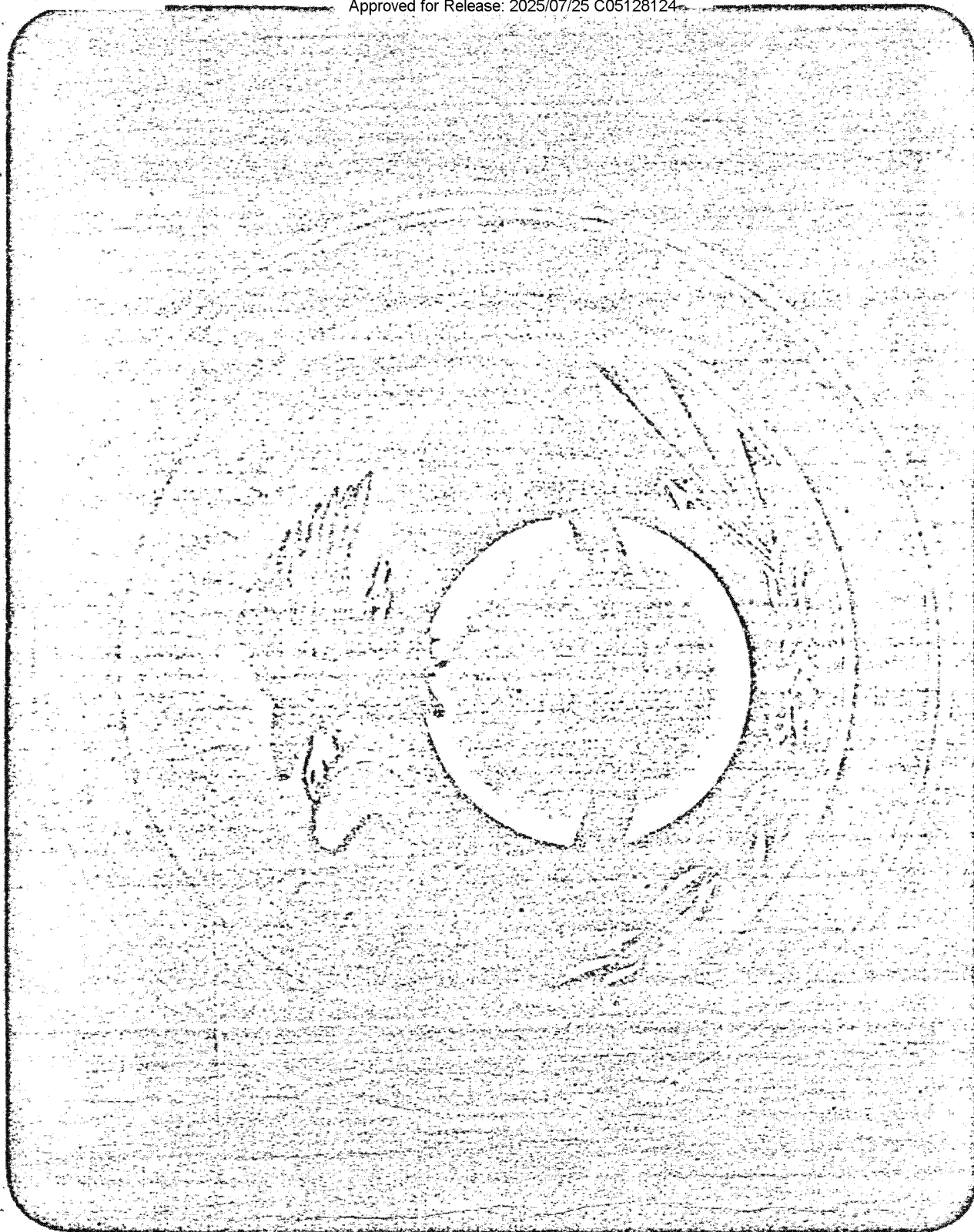
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2

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SATISFACTION

● HORIZONTAL

	UPPER	MIDDLE	LOWER
WITH 5 ARC SEC.	0-60°	0-45°	0-30°
6 ARC SEC.	0-60°	0-45°	0-30°
10 ARC SEC.	0-60°	0-15°	---
15 ARC SEC.	0-45°	---	---

● VERTICAL

WITH 5 ARC SEC.	0-60°	0-60°	0-45°
6 ARC SEC.	0-60°	0-60°	0-45°
10 ARC SEC.	0-45°	0-45°	0-30°
15 ARC SEC.	0-30°	0-30°	0-30°

HANDLE VIA
TALLET KEYHOLE
CHANNELS ONLY

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BY 7K.../.....

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OBJECTIVE

HORIZONTAL

VERTICAL

METERS @ 90%

FT 15

UPPER

128.6 39.2

18.3

22.6

FT 13.74

MIDDLE

86 26.2

12.2

22.6

FT 13.74

LOWER

75 22.9

10.7

17.5

FT 10.64

GROUP 2-2
TH 1
CLASSIFIED BY 2000
EXEMPT FROM AUTOMATIC
DOWNGRADING AND
DECLASSIFICATION
EXCEPT BY THE
AUTHORITY OF THE
SECRETARY OF DEFENSE

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ERROR BUDGET TOTALS

(MEIERS @ 90%)

○ HORIZONTAL

WITH 5 ARC SEC.
6 ARC SEC.
10 ARC SEC.
15 ARC SEC.

	0°	15°	30°	45°	60°
WITH 5 ARC SEC.	21.4 10	22.1 14	23.1 11	25.1 12	33.7 16
6 ARC SEC.	22.1	22.4	23.2	25.4	31.8
10 ARC SEC.	26.2	26.5	27.4	30.8	40.5
15 ARC SEC.	32.6	33.2	34.7	38.0	49.5

○ VERTICAL

WITH 5 ARC SEC.
6 ARC SEC.
10 ARC SEC.
15 ARC SEC.

	0°	15°	30°	45°	60°
WITH 5 ARC SEC.	11.2 6.8	11.8 7.1	12.7 7.2	14.5 8.1	20.1 11
6 ARC SEC.	11.2	11.9	12.9	14.7	21.4
10 ARC SEC.	11.2	12.0	14.3	19.2	23.1
15 ARC SEC.	11.2	12.4	16.8	24.8	37.4



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**ATTITUDE ERROR
PREDICTION**

alone

(MEYERS @ 90%)

● HORIZONTAL	0°	15°	30°	45°	60°
5 ARC SEC.	8.4	9.8	11.3	13.4	16.7
6 ARC SEC.	10.0	10.3	11.3	12.7	19.0
10 ARC SEC.	17.3	17.6	18.5	22.2	28.1
15 ARC SEC.	26.0	26.7	28.2	31.5	40.0
● VERTICAL	0°	15°	30°	45°	60°
5 ARC SEC.	3.3	4.1	5.6	8.6	12.7
6 ARC SEC.	3.3	4.4	6.1	9.0	14.8
10 ARC SEC.	3.3	4.7	8.7	15.2	23.4
15 ARC SEC.	3.3	5.6	12.3	21.9	34.0

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ALL INFORMATION CONTAINED
HEREIN IS UNCLASSIFIED
DATE 11-19-2008 BY 60322 UCBAW/STP

BY 7K-1.....

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ERROR BUDGET

FOR ITEMS UNDERWAY

*ie, Antennal
P.W.M.*

(METERS @ 90%)

HORIZONTAL	0° 15° 30° 45° 60°				
	0°	15°	30°	45°	60°
CALIBRATION	1.7	2.5	4.3	7.6	20.9
TIMING	.6	1.4	2.3	3.6	5.7
ORBIT POSITION	19.6	19.6	19.6	19.6	19.6
TOTAL	19.7	19.8	20.2	21.3	29.2

VERTICAL

CALIBRATION	6.3	6.9	7.4	7.8	12.9
TIMING	2.8	2.8	2.8	2.8	2.8
ORBIT POSITION	8.2	8.2	8.2	8.2	8.2
TOTAL	10.7	11.1	11.4	11.7	15.5

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COMPOSITE SATISFACTION

SYSTEM WITH

UPPER

MIDDLE

LOWER

5 ARC SEC.

0-60°

0-45°

0-30°

6 ARC SEC.

0-60°

0-45°

0-30°

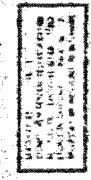
10 ARC SEC.

0-45°

0-15°

15 ARC SEC.

0-30°



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BT
XXXXX
GLAND 360, SATOR 133
GLAND PASS WHIS
SATOR PASS CHARGE

1. S-0000 PRELIMINARY SCHEDULE MAJOR BUDGET IS AS FOLLOWS (MAJOR BUDGET UNITS ARE IN DOLLARS):

	ROLL	PITCH	YAW
STELLAR SENSOR POINTING ERROR	1.4	1.8	1.3
INTERLOCK CALIBRATION ERROR	1.9	2.2	1.9
ENVIRONMENTAL STABILITY	3.3	4.3	4.4
	---	---	---
RES ID	4.1	4.9	4.9

2. THE STELLAR SENSOR POINTING ERROR IS MADE UP OF THE FOLLOWING ERROR SOURCES:

ERROR SOURCE	POINTING ERROR (S-CUBED CAMERA COORDINATES)	
	Y	Z
CENTROIDING ERROR	2.3	2.3
DETECTOR LOCATION ERROR	1.6	1.6
RESIDUAL OPTICAL DISTORTION	1.6	1.6
FOCAL PLANE RESIDUAL THERMAL ERROR	1.3	1.3
STAR CATALOG UNCERTAINTY	0.5	0.5
	Y	Z
POINTING ERROR/STAR R S S	3.2	3.2
FOR 9 DEFINITIONS/FIELD	1.1	1.1
ATTITUDE CONTROL SYSTEM	1.2	1.2
---	---	---
S-CUBED POINTING ERROR R S S	1.6	1.6

POINTING ERROR TRANSFERRED TO TCA COORD. SYSTEM

ROLL	1.4
PITCH	1.3
YAW	1.3

DISTRIBUTION		
SAFSS	A	I
SAFUS		
ED		
SS-1		
SS-2		X
SS-3		
SS-4		
SS-5		
SS-6		
SS-7	X	
CONF	X	X
SS-8		X
REF-1		
FILE		

SECRET

GROUP 1
EXCLUDED FROM AUTOMATIC
DOWNGRADING AND
DECLASSIFICATION

708 C

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3. THE INTERLOCK CALIBRATION ERROR IS MADE UP OF THE FOLLOWING ERROR SOURCES:

ERROR SOURCE	POINTING ERROR		
	ROLL	PITCH	YAW
STELLAR SENSOR POINTING ERROR	1.4	1.3	1.3
PAN PHOTO MEASUREMENT ERROR	0.3	0.9	1.0
ANGULAR VIBRATION OF TCA	1.0	1.0	1.0
SVT CORRELATION		0.3	
	---	---	---
R S S	1.9	2.2	1.9

4. THE PAN PHOTO MEASUREMENT ERROR, WHICH IS ONE OF THE ERROR SOURCES OF THE INTERLOCK CALIBRATION ERROR SHOWN ABOVE, IS MADE UP OF THE FOLLOWING ERROR SOURCES. (MEASUREMENT ERRORS ARE IN MICRONS AND CONVERTED TO ARC SECONDS).

ERROR SOURCE	ERROR - MICRONS	
	CROSS TRACK	IN-TRACK
1. OB WOBBLE DUE TO BEARING RUNOUT PLUS VIBRATION OF OPTICAL ELEMENTS	5	12
2. FOCAL LENGTH CALIBRATION ERROR AND SCAN ANGLE MARK CALIBRATION		

PAGE 4 PERCH 6519 ~~SECRET~~

ERRORS (WITH P14 IMPROVEMENTS)	5	4
3. ERRORS IN MEASUREMENT OF IMAGE COORDINATES AND FIDUCIAL MARK COORDINATES (WITH P14 IMPROVEMENTS)	3.5	3.5
4. PLATEN SKEW ANGLE ERROR (DEPARTURE FROM PROGRAMMED IMC)	9	
5. PLATEN THERMAL EXPANSION AND UNCALIBRATED OPTICAL DISTORTION	5	5
	---	---
TOTAL R S S	13 MICRONS	14 MICRONS
ASSUMING 4 STARS	6.5 MICRONS	7 MICRONS
ERROR (ARC-SECONDS)	0.9	0.9

5. ENVIRONMENTAL STABILITY ERRORS ARE MADE UP OF THE FOLLOWING ERROR SOURCES:

ERROR SOURCE	POINTING ERROR		
	ROLL	PITCH	YAW
ALIGNMENT CHANGE OF PAN CAMERA LOS TO S-CUBED SENSOR MTS. DUE TO THERMAL ENVIRONMENT SIDE TO SIDE GRADIENT IN TCA (2 DEGREES F.)	1.7	2.0	3.5

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~~SECRET~~HANDLE VIA ~~SECRET~~

CONTROL SYSTEM

PAGE 5 PERCH 6519 ~~SECRET~~FRONT TO REAR GRADIENT IN TCA
(3 DEGREES F.)

0.5 0.3 1.2

TOP TO BOTTOM GRADIENT IN TCA
(0.2 DEGREES F.)

0.6 1.9

DEFORMATION IN TCA DUE TO VEHICLE
DISTORTION

1.5 1.5

PRIMARY MIRROR TILT (0.5 DEGREES F.
METERING RODS)

0.4 0.4

FOLD FLAT TILT (2.0 DEGREES F IN
TEMP. LEVEL)

--- 0.7 0.5

R S S 1

2.5 3.1 3.7

ALIGNMENT CHANGE OF S-CUBED SENSOR
LOS TO SENSOR MOUNT ON TCA THERMAL
GRADIENTS IN SENSOR HOUSING (0.5
DEGREES F.)

1.6 1.6 1.6

THERMAL SHIFT OF FOCAL PLANE DETECTOR
ARRAY

1.9 1.9 1.9

R S S 2

1.9 1.9 1.9

ANGULAR VIBRATION OF TCA RELATIVE TO
THE AM FOLD FLAT STABILITY WITH DBPAGE 6 PERCH 6519 ~~SECRET~~
VELOCITY VARIATION

1.5 1.0

R S S 3

1.4 1.8 1.4

TOTAL R S S

3.3 4.8 4.4

6. THIS DATA IS A SUMMARY OF THE S-CUBED ERROR BUDGET ANALYSIS
AND TEST PROGRAM PRESENTATION MADE ON OCTOBER 18, 1975. THE
ANALYSIS IS BASED ON THE S-CUBED CONFIGURATION PRESENTED AT THE
CONCEPT DESIGN REVIEW ON JUNE 19, 1975.

E-2 IMPDET

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