

C05128017

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BIF003W/2-090278
Revision A
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HEXAGON

ATTITUDE DETERMINATION IMPROVEMENT (U)

25 OCTOBER 1973



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HANDLE VIA BYEMAN
CONTROL SYSTEM ONLY

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STUDY OBJECTIVES (U)

- DEFINE NON-PHOTOGRAPHIC ATTITUDE MEASUREMENT AND REPORTING SYSTEMS FOR PROVIDING ACCURATE, LESS THAN 30 SEC ERROR (1σ), POST-FLIGHT DETERMINATION OF SENSOR SUBSYSTEM ATTITUDE DURING STEREO OPERATION.
- FOR EACH SYSTEM DEFINED PROVIDE:
 - DESCRIPTION: EQUIPMENT AND LOCATIONS
 - SV IMPACTS: WEIGHT, POWER, INTERFACES, TEST
 - ESTIMATED PERFORMANCE AND ERROR ANALYSIS
 - PLANNING ROM COSTS AND SCHEDULES
 - DATA PROCESSING AND REPORTING

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GROUND RULES AND ASSUMPTIONS (U)

- ERROR IS BETWEEN TCA ALIGNMENT CUBE AND ORBIT PLANE COORDINATES IN ROLL, PITCH AND YAW
- ACCURACY GOAL IS $\pm 10 \text{ SEC } 1\sigma$
- SYSTEM IS AUXILIARY TO SV OPERATION - NO FULL REDUNDANCY
- EFFECTIVITY NO LATER THAN SV-19
- MEASUREMENTS NEEDED ON AT LEAST 15% OF TOTAL SS OPERATION WITH ANY OPERATION BEING AT LEAST 10 MINUTES OF STEREO PHOTOGRAPHY
- EQUIPMENT MAY BE LOCATED ON SS HARDWARE

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APPROACH (U)

PREVIOUS STUDIES CONCLUSIVELY SHOWED THAT METHODS MOST SUITABLE FOR P-95 APPLICATION AND ACCURACY GOAL ARE STELLAR SYSTEMS. THESE SYSTEMS COMBINE CELESTIAL REFERENCE, STAR SIGHTING INFORMATION, EPHEMERIS DATA, AND VEHICLE MOTION KNOWLEDGE TO PRODUCE AN EARTH REFERENCED ATTITUDE. NECESSARY EQUIPMENT ITEMS FOR THE SYSTEM ARE: A DATA PROCESSOR, A DATA LINK, STAR SENSORS, AND PRECISION RATE GYROS. OPTIONAL EQUIPMENT ITEMS FOR IMPROVED ACCURACY ARE A DOPPLER BEACON SYSTEM AND ON-ORBIT DEFORMATION MEASURING DEVICES.

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PROCESSING CONSIDERATIONS (U)

ONBOARD PROCESSING

- REQUIRES ADDITION OF COMPUTER TO SV
- CAN GIVE DIRECT READOUT
- REDUCES DOWNWARD DATA FLOW
- NEEDS EPHEMERIS INPUTS
- PROVIDES ALTERNATE/BACKUP FOR HORIZON SENSORS

GROUND PROCESSING

- RAW DATA REQUIRES HIGH DOWNWARD FLOW
- DATA FLOW DOWNWARD ONLY
- FEWER CONSTRAINTS ON COMPUTATIONAL TECHNIQUES
- MORE ACCURACY
- USES EXISTING GROUND COMPUTER(S)

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DATA LINK CONSIDERATIONS (U)

TELEMETRY

- NO ADDITIONAL ASSOCIATE INTERFACE REQUIRED
- FEW PHYSICAL LIMITATIONS ON AMOUNT OR TYPE OF DATA
- UTILIZES EXISTING P-95 TECHNIQUES
- RAW OR PROCESSED DATA EASILY ACCEPTED
- DATA PROCESSED AND ATTITUDES KNOWN WHEN FILM IS AVAILABLE
- USING PRESENT EQUIPMENT WOULD AVOID HIGH EXTRA COSTS

MATERIAL MARKING

- MINIMIZES TELEMETRY INCREASES
- LIMITS ON AMOUNT OF DATA AND TIMING OF DATA
- REQUIRES ADDITIONAL ASSOCIATE INTERFACE
- ATTITUDES NOT AVAILABLE UNTIL AFTER FILM IS RECOVERED AND PROCESSED

OTHER (E.G., RECOVERABLE DATA TAPE)

- NO FURTHER SENSOR SYSTEM IMPACT AND RELATIVELY SIMPLE RV INTERFACE
- ADDITIONAL HARDWARE REQUIRED
- POSSIBLE LIMITATION ON AMOUNT OF DATA
- ATTITUDE OR ATTITUDE DATA NOT AVAILABLE BEFORE RV IS RECOVERED

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STAR DETECTOR TYPE TRADE-OFFS (U)

WIDE ANGLE TRACKERS/SCANNERS

● TRACKERS

- WIDE FIELD OF VIEW: INSTALLATION DIFFICULT
- MECHANICALLY COMPLEX
- MODERATE DATA REQUIREMENTS
- SIMPLE PROCESSING

● SCANNERS

- WIDE FIELD-OF-VIEW: INSTALLATION DIFFICULT
- HIGH ACQUIRED/STORED DATA REQUIREMENTS
- COMPLEX PROCESSING
- MORE SOPHISTICATED DETECTORS

FIXED SENSORS

- ACCURATE DISPLACEMENT HISTORY BETWEEN SIGHTINGS NECESSARY
- STAR DATA ACQUISITION AND STORAGE LOW
- MECHANICALLY SIMPLE
- NARROW FIELD-OF-VIEW

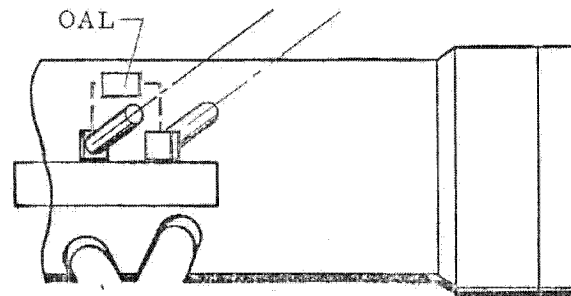
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EQUIPMENT LOCATION CONSIDERATIONS

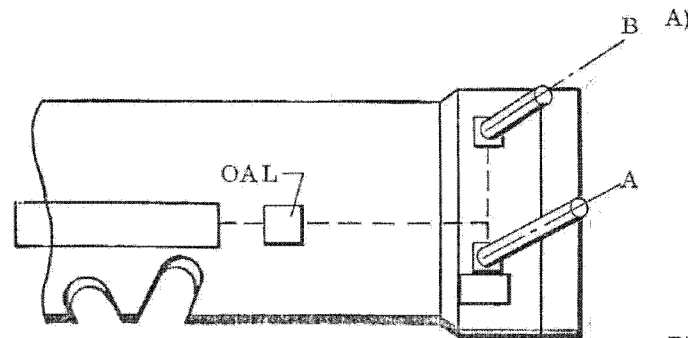
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SENSOR LOCATIONS



SENSORS ON TCA FRAME

- MINIMAL STRUCTURAL IMPACT
- ADEQUATE SPACE AND FIELD-OF-VIEW
- ASCENT PROTECTION PROVIDED BY PRESENT SHROUD
- CARE REQUIRED TO PRESERVE TCA THERMAL ENVIRONMENT
- MINIMAL STRUCTURAL DEFORMATIONS
- ADDITIONAL ASSOCIATE INTERFACE
- OAL BETWEEN SENSORS TO IMPROVE ACCURACY



SENSORS IN AFT SECTION

- A) ON ARM
- B) ELSEWHERE

- RCM PRIME STRUCTURAL MODS AND/OR SMALL DIAMETER DETECTORS
- ONLY MINOR ASSOCIATE IMPACT
- REQUIRES ASCENT CONTAMINATION PROTECTION
- OPTICAL ALIGNMENT LINK, OAL, TO TCA REQUIRED FOR DESIRED ACCURACY
- ARM ELEMENTS REPACKAGED BUT ALL SENSORS IN ONE MODULE

B)

- GOOD FIELD-OF-VIEW
- EQUIP SECTION AND RCM PRIME STRUCTURE MODS
- OAL TO TCA AND ARM GYROs
- REQUIRES ASCENT AERO AND CONTAMINATION PROTECTION

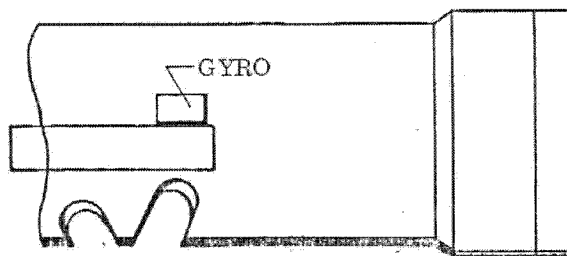
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EQUIPMENT LOCATION CONSIDERATIONS

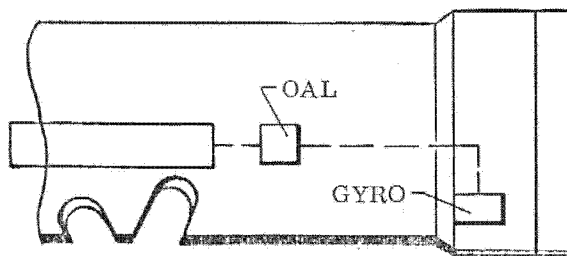
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GYRO LOCATIONS



ON TCA FRAME

- MINIMIZES STRUCTURE DEFORMATION EFFECTS
- EFFECTS TCA THERMAL ENVIRONMENT
- ADDITIONAL ASSOCIATE INTERFACE
- IF SUPPLEMENTAL GYRO PACKAGE
 - INCREASED HARDWARE COSTS
 - HIGHER DATA LOAD
- IF RELOCATED (FROM ARM) P-95 IRA
 - CUMBERSOME SV TEST FLOW
 - EXTENSIVE MODULE LEVEL TEST IMPACT



IN AFT SECTION

- PRESENT P-95 GYROs ARE USABLE
 - NO CHANGE OF ARM
 - NO INCREASE IN DATA LOAD
- OAL TO TCA REQUIRED TO MEET ACCURACY GOAL
- MINIMUM, IF ANY, ASSOCIATE IMPACT

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SELECTED APPROACHES (U)

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GROUND PROCESSING

- MINIMUM CHANGES TO EXISTING SV
- EXTRA FLEXIBILITY IN DEVELOPING SOFTWARE
- LATER ADAPTION TO ON-BOARD PROCESSING IS FEASIBLE

TELEMETERED DATA

- MINIMUM ASSOCIATE IMPACT
- BEST SUITED FOR RAW DATA
- COMPATIBILITY WITH EXISTING SYSTEM

FIXED SENSOR

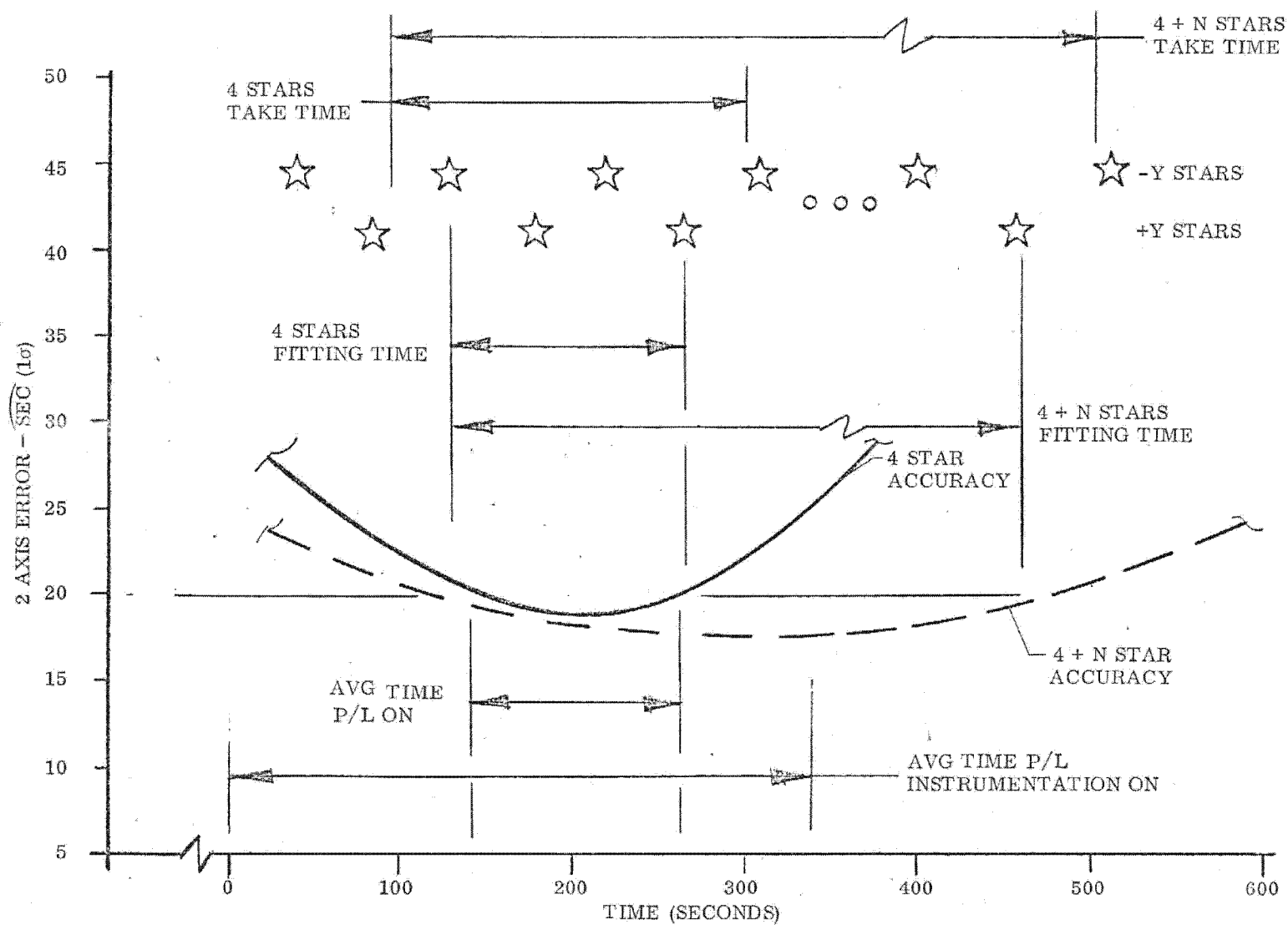
- LOW STORED/ACQUIRED DATA REQUIREMENTS
- MECHANICAL SIMPLICITY
- SUITABLE HARDWARE DEVELOPED AND/OR QUALIFIED
- RELATIVE EASE OF INSTALLATION

EQUIPMENT INSTALLATION

- SENSORS ON TCA FRAME: MINIMUM STRUCTURAL DEFORMATION AND EASE OF INSTALLATION
- PRESENT IRA, IN ARM, USED: MINIMUM SV IMPACT
- OPTICAL ALIGNMENT LINK, OAL, OPTIONAL TO IMPROVE ACCURACY

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SYSTEM OPERATION



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STAR SENSORS (2 PER VEHICLE)

SOLID STATE SENSOR

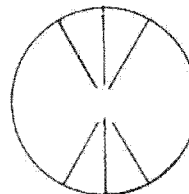


IMAGE DISSECTOR

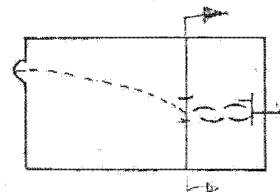
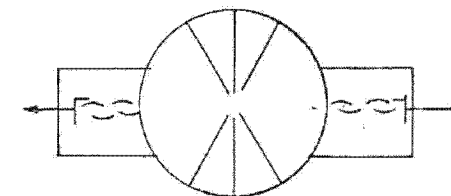


PHOTO MULTIPLIER



Detector	6 Silicon Detectors	1 Image Dissector	2 Photo Multipliers
Qualification Status	Just Now Completing Flight Qual.	Qualified	High Likelihood of Qual.
Accuracy (1σ)	Random 6 sec Systematic 6 sec	Random 10 sec Systematic 7 sec	Random 4 sec Systematic 4 sec
Field of view	10°	8° Square	6°
Aperture Dia.	2.75 in.	3.4 in.	
Star Magnitude	3.8	6	5.5
Telescope	3.8" Dia. x 7.8 long		6" Dia. x 10" long
Overall	4.8 " Dia. Flange	12" X 6" X 5.25"	10" Dia X 10" Long
Weight	6.6 pounds	18 pounds	30 pounds
Power	2 watts	10 watts	15 watts
Sun Shield Dimensions (est.)	Max. 8.6 in dia. 14 in. long	Max. 12 in dia. 15 long	Max. 11 in dia. 22 long
Cost	135K	75K	250K
Data Requirements	8ms accuracy time word + slit identification	13 bit digital word each axis	8 ms accuracy time word

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EQUIPMENT — OPTICAL ALIGNMENT LINK

COST ESTIMATES

<u>Supplier</u>	<u>Configuration/ Random Accuracy</u>	<u>Qual. Cost</u>	<u>Recurring (6 Units)</u>	<u>Total (6 Units)</u>
Barnes	2 axis/3 $\widehat{\text{sec}}$	\$ 120K	\$ 280K	\$ 400K
	Twist axis/5 $\widehat{\text{sec}}$	\$ 180K	\$ 400K	\$ 580K
Perkin Elmer	2 axis/3 $\widehat{\text{sec}}$	?		\$ 800K
	3 axis/3 $\widehat{\text{sec}}$	?		\$ 1.2 M
ITT (image dissector)	2 axis/3 $\widehat{\text{sec}}$	\$ 120K*	\$ 500K	\$ 620K

*Estimated no contact

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YAW ERRORS

(Sec 1σ)

ERROR SOURCE	T = 370 SEC SOLID STATE			T = 35 SEC IMAGE DISSECTOR			T = 90 SEC PHOTO MULTIPLIER		
	A**	B	C	A	B	C	A	B	C
Star Sensor Random	12	12	12	10	10	10	8	8	8
Star Sensor Systematic	6	6	6	7	7	7	5	5	5
OAL Random	---	3	3	---	3	3	---	3	3
OAL Systematic	---	---	3.5	---	---	3.5	---	---	3.5
*Attitude Solution Error (2 axis)	9	9.1	9.1	8.7	8.8	9.5	6.58	6.75	7.6
Vehicle + Structural Frame	13	—	—	.5	—	—	2	—	—
Fit	—	3	—	—	—	—	—	1	—
Frame Only	—	—	—	—	—	—	—	—	—
Undetectable Frame Shift	15	15	—	15	15	—	15	15	—
OAL Random	—	3	3	—	3	3	—	3	3
Ephemeris	2	2	2	2	2	2	2	2	2
Total RSS	22	18	10	17	17	10	17	17	9

$$* \text{Attitude Solution Error} = \left\{ \frac{1}{4} (E_{\text{Random}}^2 + QT) + E_{\text{Sys}}^2 \right\}^{1/2}$$

$$Q = .1 \frac{(\text{o/hr})^2}{\text{Hz}}$$

- **
A - No OAL
B - OAL TCA to Gyros
C - OAL'S SENSOR TO SENSOR AND TCA TO GYRO

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NADIR POINTING ERRORS

ERROR SOURCE	T = 370 SEC SOLID STATE			T = 35 SEC IMAGE DISSECTOR			T = 90 SEC PHOTO MULTIPLIER		
	A**	B	C	A	B	C	A	B	C
Star Sensor Random	6	6	6	10	10	10	4	4	4
Star Sensor Systematic (to reference cube)	6	6	6	7	7	7	5	5	5
OAL Random	---	3	3.7 5	---	3	3.7 5	---	3	3.7 5
OAL Systematic	---	---	---	---	---	---	---	---	---
*Attitude Solution Error (2 axis)	13.5	14.5	14.5	18.9	19.2	21	10	11	13.5
Vehicle + Structural Frame Fit	24	---	---	1	---	---	4	---	---
Frame Only	---	6	---	---	25	---	---	1	---
Undetectable Frame Shift	30	30	---	30	30	---	30	30	---
OAL Random	---	4.2	4.2	---	4.2	---	---	4.2	---
Ephemeris	4	4	4	4	4	4	4	4	4
Total RSS	41	35.	17	36	36	22	32	33	15

*Attitude Solution Error = $(2.6 \times E_{\text{Random}}^2 + 2 E_{\text{Sys}}^2 + 0.4 Q)^{1/2}$
 $Q = .1 \frac{(\text{°/hr})^2}{\text{Hz}}$ (Gyro Noise Power)

- **A - No OAL
B - OAL TCA to Gyros
C - OAL'S Sensor to Sensor and TCA to Gyros

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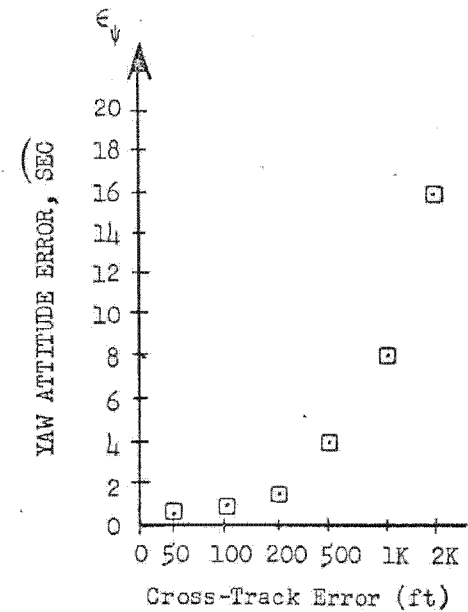
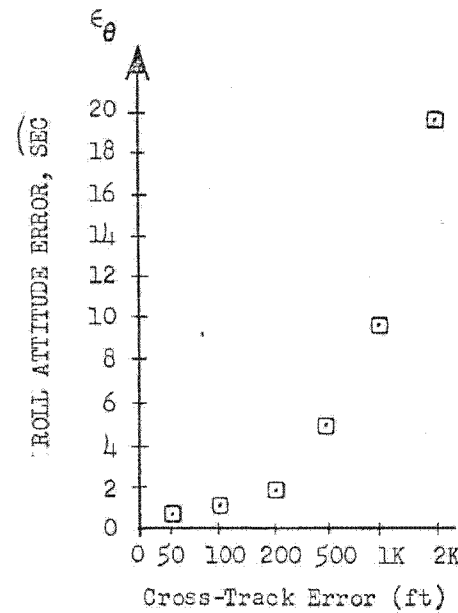
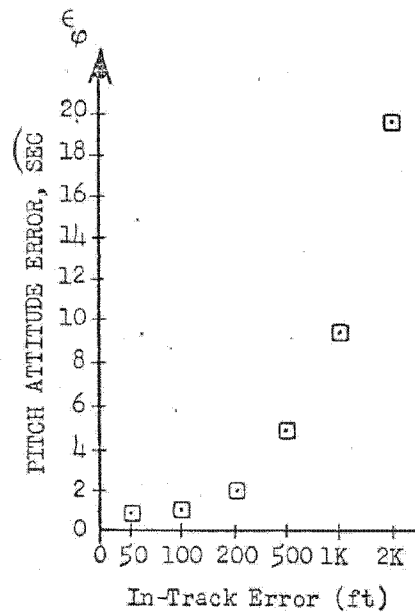
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EFFECT OF EPHEMERIS ERRORS ON ATTITUDE ERRORS

{ cross-track error maps into roll error
cross-track error maps into yaw error*
in-track error maps into pitch error
radial error has no first order effect

*via cross-track velocity error

Ephemeris Errors



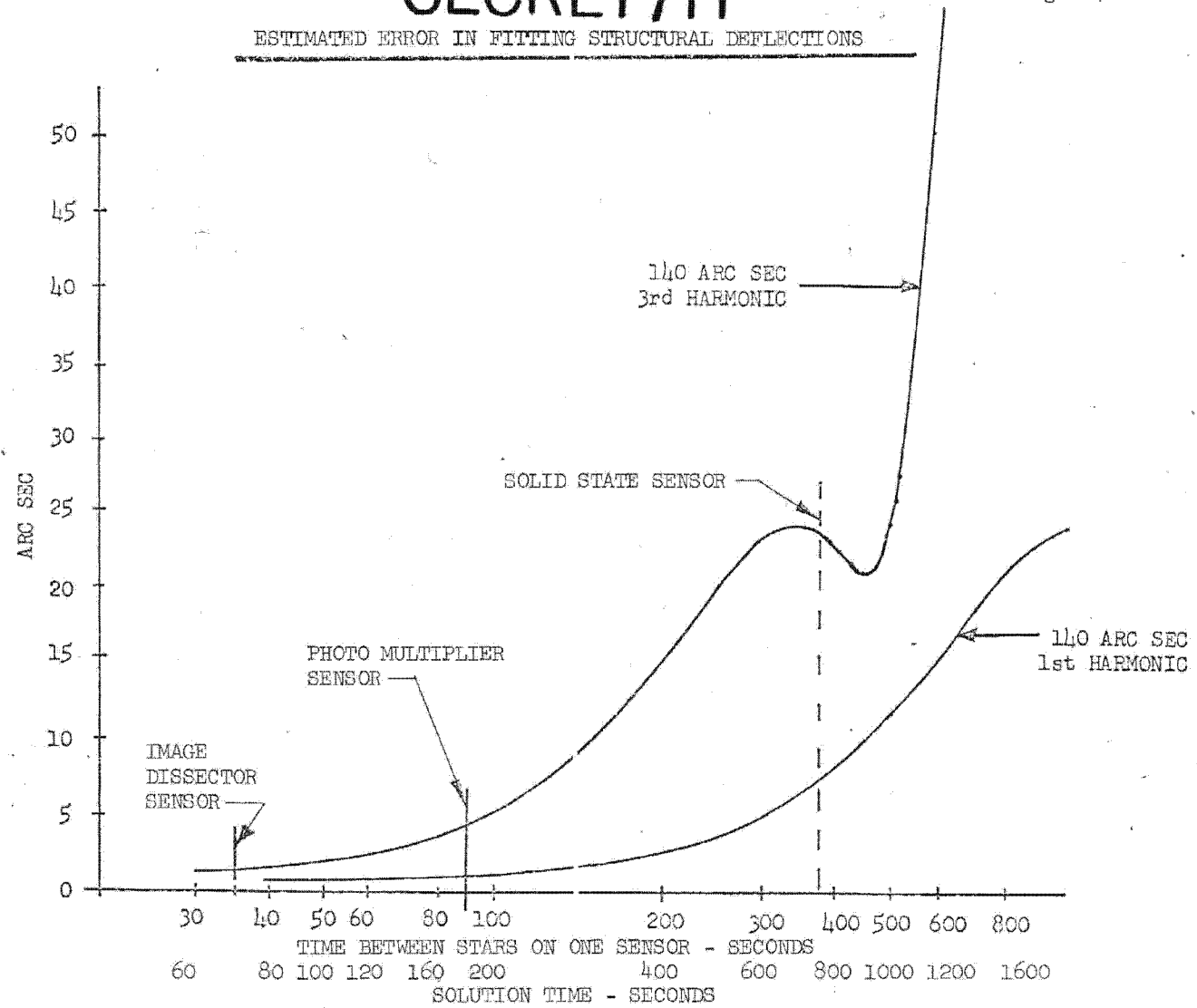
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ESTIMATED ERROR IN FITTING STRUCTURAL DEFLECTIONS



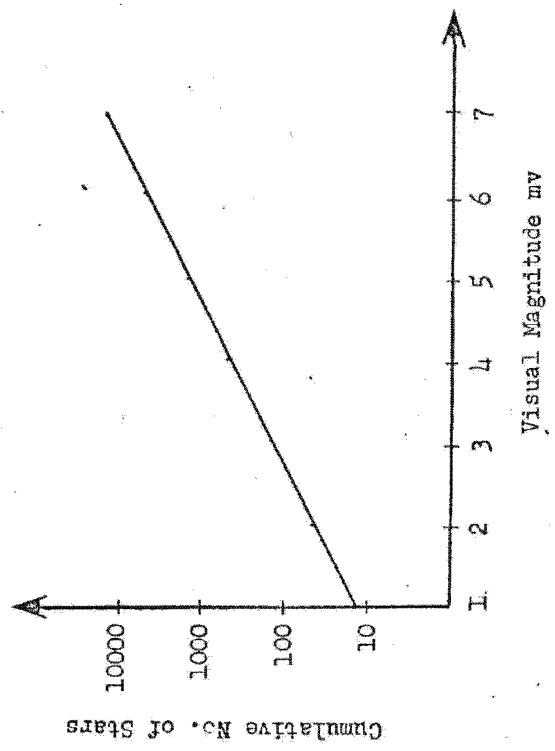
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STAR AVAILABILITY VS. SENSITIVITY



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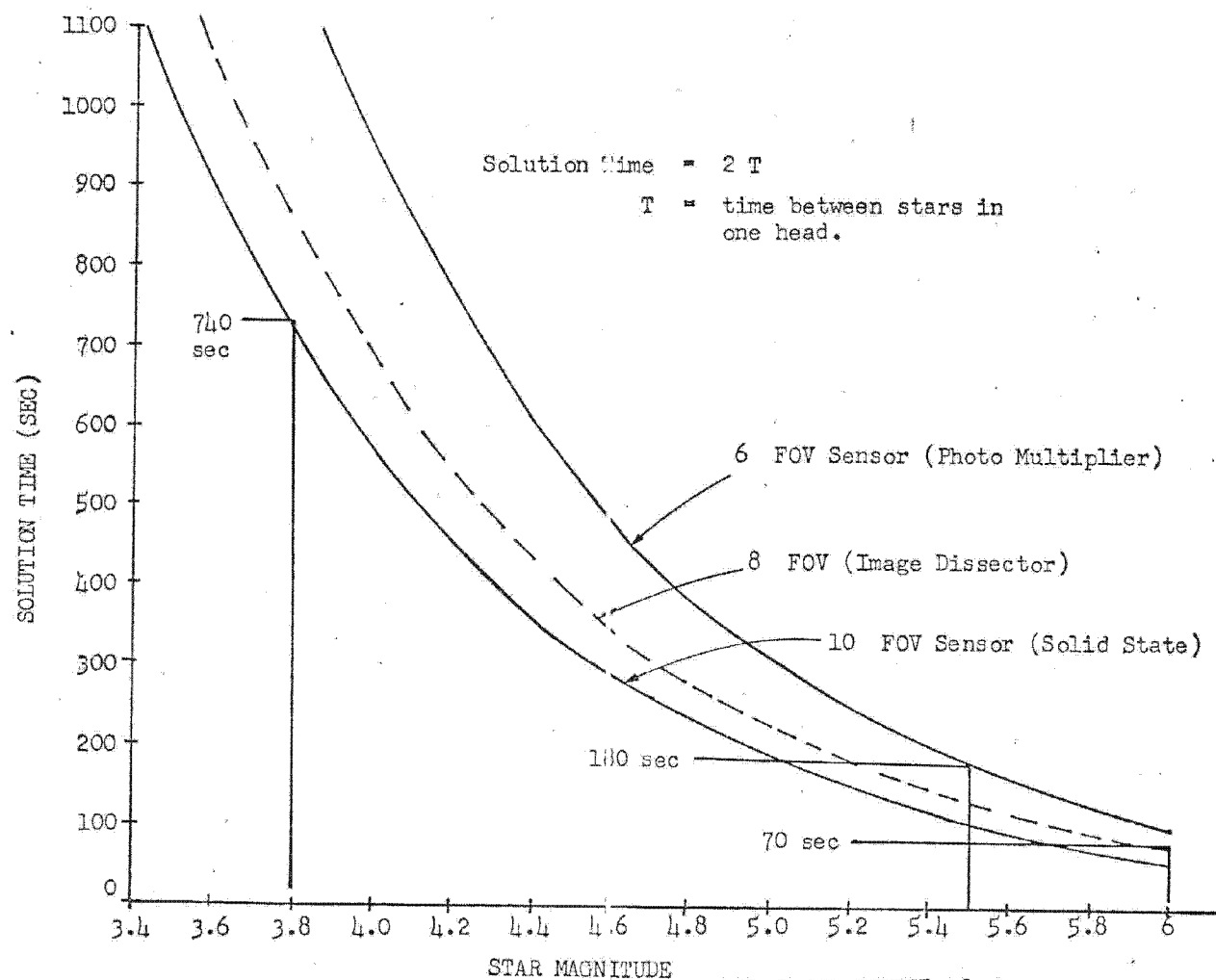
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ATTITUDE SOLUTION TIME VS STAR MAGNITUDE



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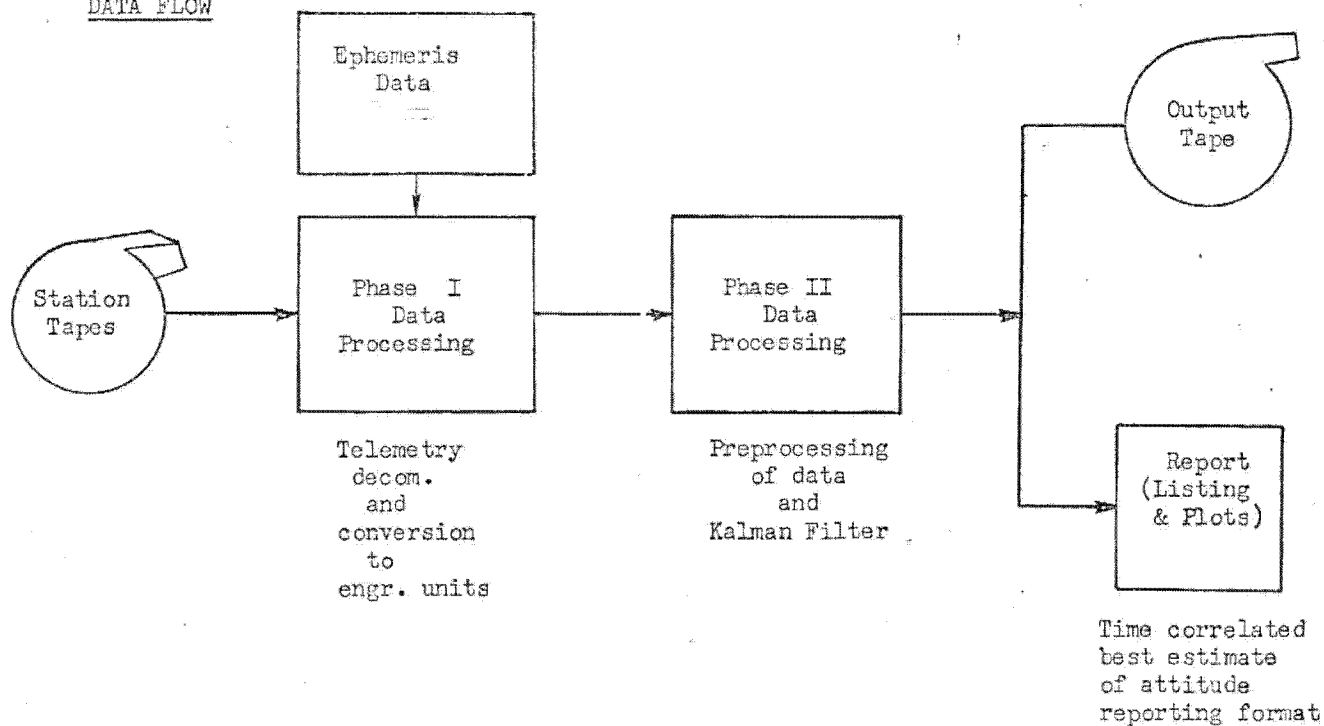
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GROUND DATA PROCESSING

DATA FLOW



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RECOMMENDED SYSTEMS (U)

THE RECOMMENDED SYSTEMS ARE A SERIES OF SYSTEMS IMBODYING THE SELECTED APPROACH FEATURES AND COVERING A RANGE OF PERFORMANCE AND COSTS. AT ONE END OF THE SERIES IS A SYSTEM WHICH ADDS ONLY IMAGE DISSECTOR SENSORS TO THE TCA FRAME FOR AN OVERALL ATTITUDE OF TCA REFERENCE CUBE ACCURACY OF APPROXIMATELY 30 SEC. AT THE OTHER END IS A SYSTEM USING PHOTOMULTIPLIER SENSORS AND OPTICAL ALIGNMENT LINKS BETWEEN THE SENSORS AND ARM GYROS WHICH MEETS THE ACCURACY GOAL OF 10 SEC. THE ADDITIONAL OPTICAL LINKS OF THE LATTER SCHEME SUGGEST REMOTE MOUNTING OF THE DETECTORS SINCE DEFORMATION IS NO LONGER A CONCERN, THEREBY REDUCING ASSOCIATE INTERFACE IMPACT AND FACILITATING INSFALLATION. SCHEMES USING SOLID STATE DETECTORS ARE NOT RECOMMENDED BECAUSE OF THEIR LONG SOLUTION TIME.

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SUMMARY OF CANDIDATE SYSTEMS (U)

SENSOR	PARAMETER	SGLS TRACKING			DOPPLER TRACKING
		NO OAL	OAL ARM/TCA	OALS ARM/SENSOR	OALS ARM/SENSOR
IMAGE DISSECTOR 70 SECONDS SOLUTION TIME	ACCURACY, $\overline{\text{SEC } 1\sigma}$ 2 AXIS NADIR/YAW	36/17	36/17	23/11	22/10
	Δ WEIGHT POUNDS	120	166	211	231
	Δ POWER WATTS	25	50	75	80
	COST*, \$1,000 TOTAL/NONRECURRING	5,240/1,980	7,243/2,003	8,585/2,945	8,837/3,125
PHOTO MULTIPLIER 180 SECONDS SOLUTION TIME	ACCURACY, $\overline{\text{SEC } 1\sigma}$ 2 AXIS NADIR/YAW	32/17	33/17	16/10	15/9
	Δ WEIGHT POUNDS	137	182	228	248
	Δ POWER WATTS	30	55	80	85
	COST*, \$1,000 TOTAL/NONRECURRING	6,770/1,562	9,068/2,360	10,130/2,522	10,382/2,702

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SV IMPACT

THE IMPACT OF ADDING ANY OF THE RECOMMENDED SYSTEMS TO THE SV IS SMALL. BY THE USE OF THE APPROPRIATE SIGNAL CONDITIONING DESCRIBED, THE EXISTING TELEMETRY SYSTEM CAN HANDLE THE ADDITIONAL DATA. COMMAND AND POWER INCREASES ARE SMALL AND CAN READILY BE ACCOMMODATED. STRUCTURAL CHANGES ARE EASILY MANAGED SINCE ADDED EQUIPMENT IS LIGHT WEIGHT AND LOCATIONS HAVE BEEN SELECTED TO AVOID REDESIGN OF PRIME STRUCTURE. EXTENSIVE ANALYSIS WILL BE REQUIRED TO INSURE THAT AN ACCEPTABLE SENSOR SUBSYSTEM THERMAL ENVIRONMENT IS RETAINED. ALTHOUGH IT APPEARS TO BE NO PROBLEM FOR EXISTING TECHNIQUES, AND TO ACCURATELY PREDICT STRUCTURAL MOTION AND STABILITY AFFECTING SYSTEM ACCURACY, SOME UNCERTAINTY EXISTS IN THE AREA OF SYSTEM CALIBRATION, WHICH CAN ONLY BE RESOLVED BY BETTER DEFINITION OF THE SYSTEM TO BE USED, MORE KNOWLEDGE OF THE EXISTING IN-FLIGHT ENGINEERING TEST CAPABILITIES, AND DESIRED LEVEL OF PERFORMANCE. DEVELOPMENT OF ATTITUDE SOLUTION ALGORITHMS AND IMPLEMENTING SOFTWARE IS BASICALLY THE SAME AS THAT DONE FOR THE QUANTIC EXPERIMENT; HOWEVER, PARTICULAR ATTENTION WILL HAVE TO BE GIVEN TO HANDLING AND REPORTING METHODS WHICH WILL ASSURE TIMELY DELIVERY OF THE ATTITUDE INFORMATION TO THE INTERESTED USER.

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STAR SENSOR (SS) DATA PROCESSING (U)

● PHOTO MULTIPLIER (2)

<u>SIGNALS</u>	<u>HARDWARE REQUIREMENT</u>	<u>REMARKS</u>
1 DISCRETE EVENT/SS	● MODIFY DIU TO ACCEPT (1) DISCRETES/SS AND RESOLVE TO ± 1 MILLISEC. UPDATE EVERY 100 MILLISEC. OUTPUTS TO PCM 8 DISCRETES SAMPLED AT 20 SPS.	ADDS 8-BIT DATA COUNTER FOR SS 1 AND 2
1 MAGNITUDE ANALOG/SS	● (1) ANALOG/SS DIRECT TO PCM SAMPLED AT 20 SPS	ADDS (2) 8-BIT STORAGE REGISTERS AND DRIVERS
REPETITION RATE - 10 SEC	● RECORD DATA FOR A MINIMUM OF 10 MINUTES AND UP TO 20 MINUTES/REV MAX	ADDS ONE ANALOG/DISCRETE SLICE TO PCM SYSTEM
	● 8 REDUNDANT ON/OFF COMMANDS	PRESENT SYSTEM CAN BE USED FOR DATA STORAGE, READOUT AND COMMANDING

STAR SENSOR (SS) DATA PROCESSING (CONT.)

● SOLID STATE (2)

<u>SIGNALS</u>	<u>HARDWARE REQUIREMENT</u>	<u>REMARKS</u>
6 DISCRETE EVENTS/SS	● MODIFY DIU TO ACCEPT (6) DISCRETES/SS; IDENTIFY ONE OF SIX AND RESOLVE TIME OF OCCURRENCE TO 8 MILLISEC. UPDATE EVERY 1.0 SEC. OUTPUTS TO PCM 8 DISCRETES SAMPLED AT 10 SPS.	ADDS INPUT AND DECODE CIRCUITRY, 8-BIT DATA WORDS FOR SS 1 AND 2
6 MAGNITUDE ANALOGS/SS	● MODIFY DIU TO ACCEPT (6) ANALOGS/SS MULTIPLEX TO A SINGLE OUTPUT TO PCM AT 10 SPS	ADDS INPUT AND MULTIPLEX CIRCUITRY, SINGLE ANALOG OUTPUT BUFFER
REPETITION RATE - 10/SEC	● RECORD DATA FOR 10 MINUTES MINIMUM, AND UP TO 20 MINUTES/REV MAX.	ADDS ONE ANALOG/DISCRETE SLICE TO PCM SYSTEM
	● 8 REDUNDANT ON/OFF COMMANDS	PRESENT SYSTEM CAN BE USED FOR DATA STORAGE READOUT, AND COMMANDING

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STAR SENSOR (SS) DATA PROCESSING (CONT.)

● IMAGE DISSECTOR (2)

<u>SIGNALS</u>	<u>HARDWARE REQUIREMENT</u>	<u>REMARKS</u>
1 - X POSITION ANALOG	● NEW DEVELOPMENT OF DUAL CHANNEL STAR SENSOR CONVERTER. RESOLVE X AND Y POSITION TO 3.5 SECONDS OF 8 DEGREES FULL SCALE (13 BITS).	STAR SENSOR CONVERTER WILL CONTAIN:
1 - Y POSITION ANALOG	UPDATE EVERY 0.2 SECONDS	2 - POWER SUPPLIES
1 - MAGNITUDE ANALOG	OUTPUT TO PCM 28 DISCRETES SAMPLED AT 5 SPS.	4 - ISOLATED INPUTS
REPETITION RATE - CONTINUOUS	● (1) MAGNITUDE ANALOG DIRECT TO PCM SAMPLED AT 5 SPS.	4 - SAMPLE AND HOLD AMPS
	● MODIFY DIU FOR (2) 5 PPS OUTPUTS TO DUAL SS CONVERTER.	4 - A TO D CONVERTERS (14-BIT)
	● RECORD DATA FOR 10 MINUTES MINIMUM AND UP TO 20 MINUTES/REV MAX	2 - OSCILLATORS AND CONTROL TIMING
	● 8 ON/OFF COMMANDS	4 - 14-BIT PARALLEL OUTPUTS
		ADD (2) OUTPUT BUFFERS TO DIU
		ADDS ONE ANALOG/DISCRETE SLICE TO PCM SYSTEM
		PRESENT SYSTEM CAN BE USED FOR DATA STORAGE, READOUT AND COMMANDING

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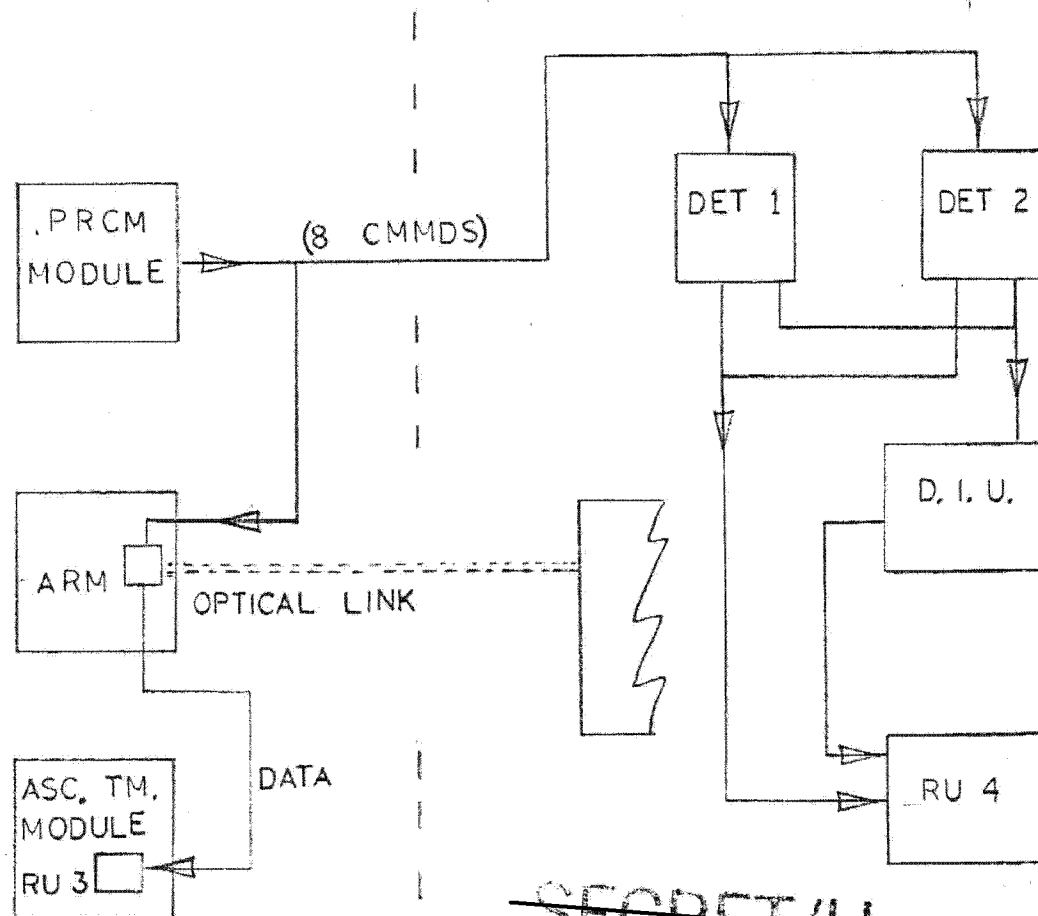
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BIF003W/2-090278-73 Rev A
Page 27

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BLOCK DIAGRAM - PHOTOMULTIPLIER AND SOLID STATE (U)



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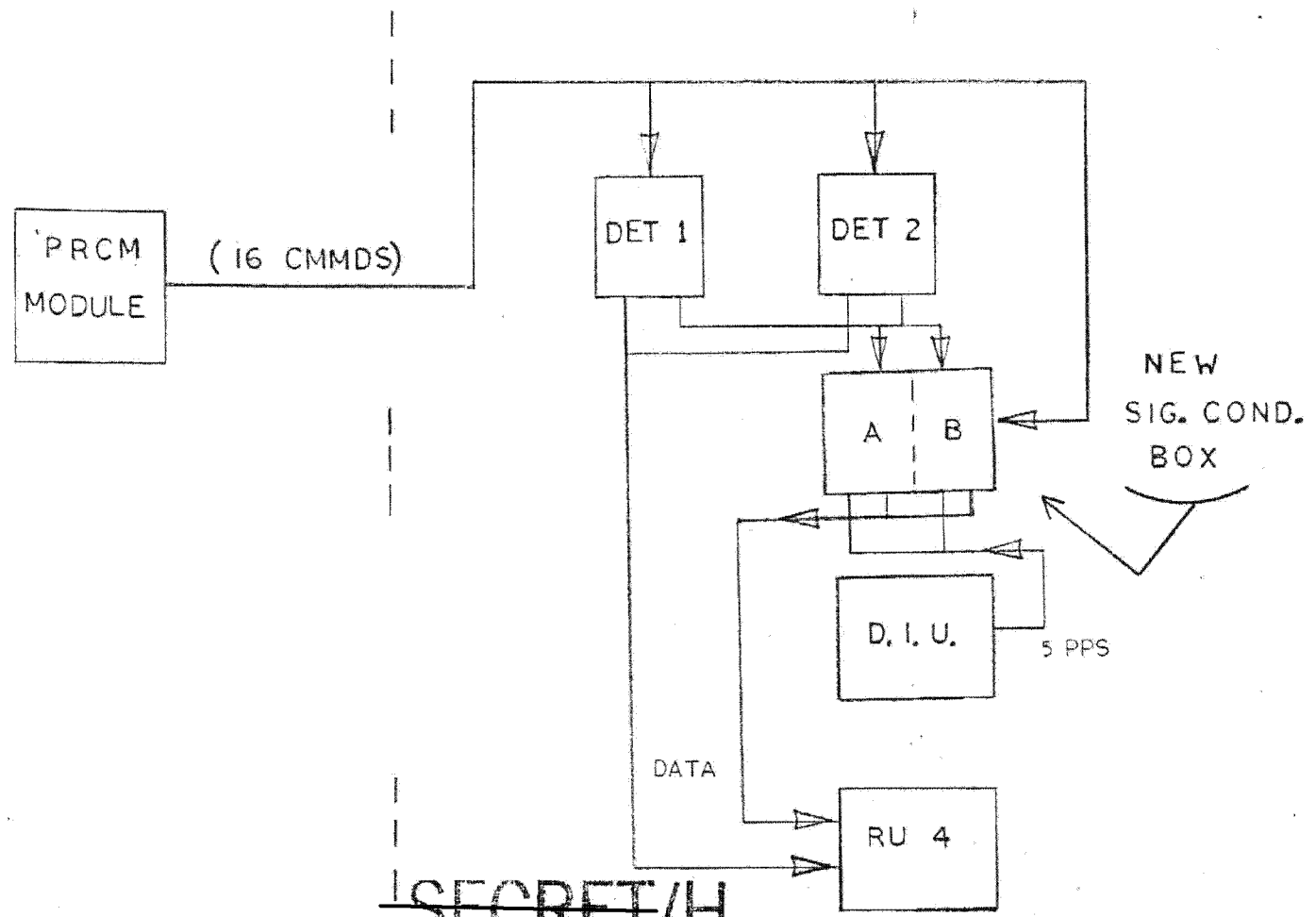


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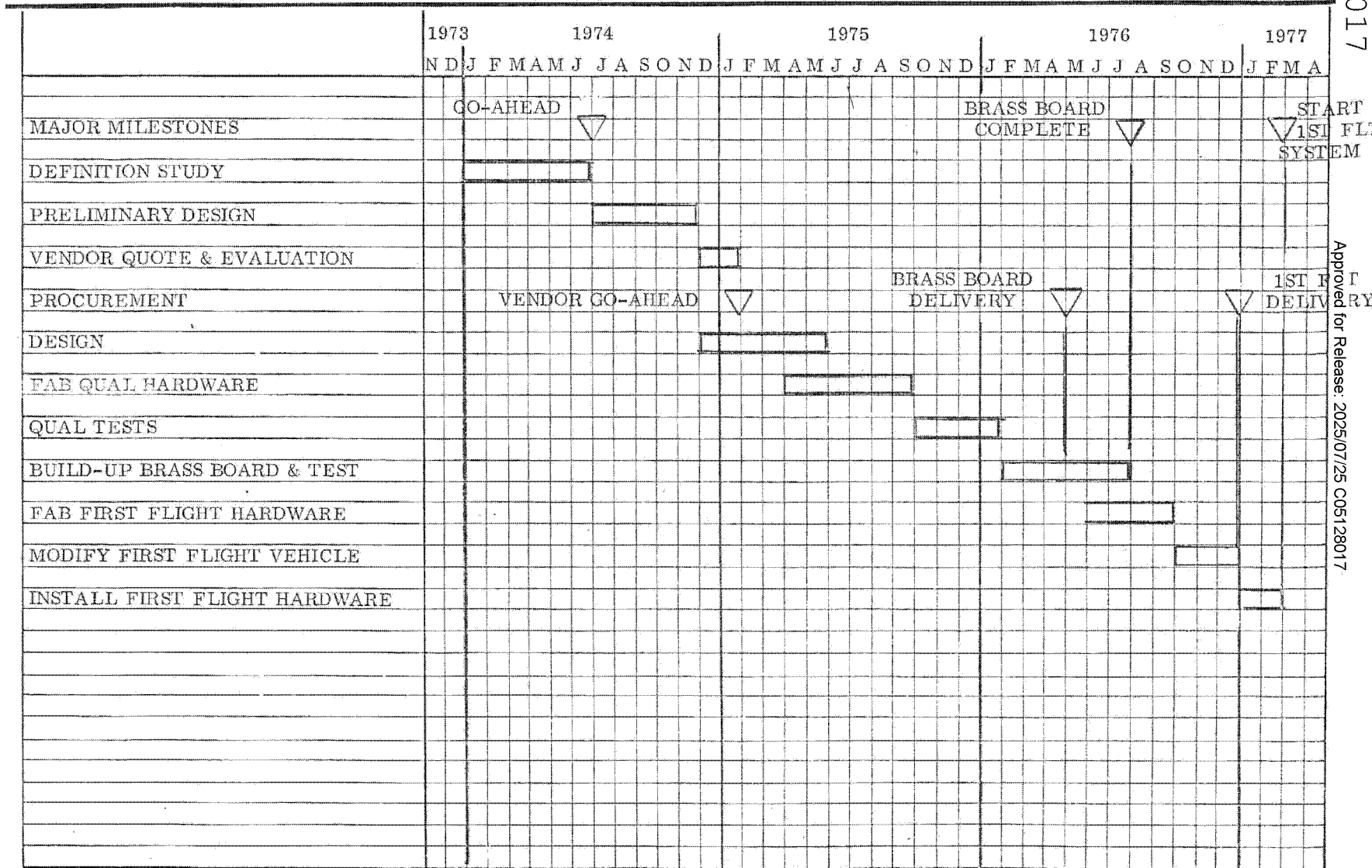
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BLOCK DIAGRAM - IMAGE DISSECTOR (U)



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TYPICAL SCHEDULE (U)



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Page 30

CONCLUSIONS (U)

THERE EXISTS FEASIBLE CONCEPTS TO ACHIEVE ACCURACIES AS LOW AS 10 SEC (1σ) AT THE TCA ALIGNMENT CUBE. SUITABLE SENSORS SHOULD BE AVAILABLE AND CAN BE ACCOMMODATED WITH LITTLE SV HARDWARE IMPACT. THE MAJOR OPEN PROBLEM AREAS OF THESE CONCEPTS ARE:

- STRUCTURAL DEFORMATION MODELING AND FITTING
- DEFINITION OF GROUND TEST PROGRAM
 - VERIFICATION OF ALIGNMENT STABILITY
 - BRASS BOARD PERFORMANCE VERIFICATION
 - VEHICLE ACCEPTANCE TEST REQUIREMENTS
- DEFINITION OF FLIGHT TEST PROGRAM
 - VERIFICATION OF ALIGNMENT STABILITY USING APSA
 - DETERMINATION OF ON-ORBIT CALIBRATION CAPABILITY WITHOUT APSA
- VERIFICATION OF GROUND PROCESSING PROCEDURE AND SOFTWARE

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CONTROL SYSTEM

Wheeler
Her Peake

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DE RUXQIA 286 1551900
ZNY XXXXX ZKZ ZNM
P 041900Z
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GUARD 035 CATOR 039
GUARD PASS WHIG WAHOO
CATOR PASS CHARGE

Metrie
Pan.

DISTRIBUTION		
SAPES	A	I
SAPUS		
DD		
SS-1		
SS-2		✓
SS-3		
SS-4		
SS-5		
SS-6		
SS-7		✓
COMP		
SS-TRF		✓
RF-11		
FILE		

~~TOP SECRET~~ 041900Z JUN 74 CITE ETHER 0286.
WHIG INFOR CHARGE WAHOO
SECUR HEXAGON TALENT KEYHOLE
WHIG FOR PEAKE, CHARGE FOR D. BERGANINI, WAHOO FOR G. SMITH.
SUBJECT: MEETING TO DISCUSS POSSIBLE APPROACHES FOR ATTITUDE
CAPABILITY FOR THE HEXAGON PAN CAMERA.

1. REFERENCES:

- A. MESSAGE, CITE WHIG 0073, 161845 Z JAN 74, SUBJECT: HEXAGON
PAN CAMERA-MAPPING APPLICATIONS STUDIES.
B. MEMORANDUM FOR THE CHAIRMAN, COMIREX, 16 APR 74, SUBJECT:
HEXAGON PAN MAPPING APPLICATIONS STUDIES, BYE-47539-74.
C. TELECON BETWEEN H. PEAKE AND J. WEBB, 3 JUN 74, SUBJECT:
MEETING REGARDING ATTITUDE CAPABILITY FOR THE HEXAGON PAN CAMERA.

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PAGE 2 ETHER 0286 ~~TOP SECRET~~

2. REFERENCE A. REQUESTED THAT ETHER PROVIDE REQUIREMENTS FOR
ATTITUDE ACCURACY. THIS WAS ACCOMPLISHED BY REFERENCE B. FOR THE
PURPOSE OF REVIEW THE FOLLOWING IS EXTRACTED FROM REFERENCE B.
ETHER HAS ANALYZED A PROJECTED ERROR BUDGET FOR A PAN STAND-ALONE
SUBSYSTEM INCORPORATING ALL THE RECOMMENDED IMPROVEMENTS. THE
TOTAL ERROR BUDGET COMPUTATIONS WERE MADE CONSIDERING ABSOLUTE
ATTITUDE AT 5, 6, 10 AND 15 ARC SECONDS AT THE OPTICAL AXIS. THESE
COMPUTATIONS MAKE IT POSSIBLE TO COMPARE POTENTIAL CAPABILITIES
VERSUS THE VALIDATED G AND G TECHNICAL OBJECTIVE FOR THE ADVANCED
ICBM WHICH STATES A RANGE OF 100 TO 165 FEET (CEP). THE FOLLOWING
TABLE PROVIDES THE SATISFACTION LEVEL IN TERMS OF APPLICABLE
PORTIONS OF THE SCAN FORMAT IN DEGREES RELATIVE TO ATTITUDE ACCURACY
CAPABILITY AND THE ADVANCED ICBM RANGE:

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SYSTEM ATTITUDE CAPABILITY	ADVANCED ICBM RANGE (FEET)		
	120	125	165
	0-30	0-45	0-60
	-	0-15	0-45
5-6 ARC SEC	0-30	0-45	0-60
10 ARC SEC	-	0-15	0-45
15 ARC SEC	-	-	0-30

AS CAN BE SEEN FROM THE ABOVE TABLE, TO SATISFY THE OBJECTIVE RANGE OF THE ADVANCED ICBM OVER THE FULL PAN FORMAT WOULD REQUIRE AS A

PAGE 3 ETHER 0286 ~~TOP SECRET~~

MINIMUM, ATTITUDE CAPABILITY OF 5-6 ARC SECONDS ON EACH AXIS. A LESSER CAPABILITY OF 10 OR 15 ARC SEC WOULD PERMIT SOME LIMITED APPLICATION AT THE MID AND UPPER OBJECTIVE RANGE: HOWEVER IT IS EMPHASIZED THAT SATISFACTION OF THE TOTAL OBJECTIVE RANGE WITH A PAN STAND-ALONE SYSTEM THROUGHOUT ITS FORMAT WOULD REQUIRE 5-6 ARC SEC OR BETTER ATTITUDE CAPABILITY.

3. DISCUSSIONS BETWEEN WHIG AND ETHER OVER THE PAST FOUR MONTHS, CULMINATING IN REFERENCE C., INDICATE THAT STUDIES HAVE PROGRESSED TO THE POINT WHERE A MEETING BETWEEN THE INTERESTED PARTIES TO DISCUSS POSSIBLE APPROACHES IS APPROPRIATE AND POSSIBLE, ETHER REQUESTS IF POSSIBLE THAT THIS MEETING BE HELD DURING THE WEEK OF 24 JUN 74. OUR SPECIFIC AREAS OF INTEREST FOR THE MEETING ARE A DISCUSSION OF THE VARIOUS TECHNICAL APPROACHES, ACCURACY OF EACH, INTERFACE REQUIREMENTS, TIME FRAME FOR IMPLEMENTATION, PROJECTED COST, AND THE POTENTIAL OF EACH FOR INCREASED ACCURACY BEYOND THE DISCUSSED 5-6 ARC SECONDS. THIS INFORMATION COULD BE VERY IMPORTANT IN ESTABLISHING POSITION RELATIVE TO ON-GOING STUDIES AND THEREFORE IS TIME CRITICAL. E-2 IMPDET

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~~(S)~~ NATIONAL RECONNAISSANCE OFFICE

WASHINGTON, D.C.



THE NRO STAFF

25 July 1974

MEMORANDUM FOR RECORD

SUBJECT: HEXAGON Metric Pan-Option Review Meeting

BACKGROUND

When, in 1972, it became obvious that the current buy of 12 HMC's would not acquire all the coverage DMA required, new collection options were developed. One scenario evolved around the HMC (mainly pushed by DMA-TC) another around a metric pan concept (mainly DMA-AC and some adherents from DMA-Hqs who had transferred from DMA-AC).

In August 1972, the NRO requested DMA-Hqs to perform a study (to be completed by May 1973) evaluating both approaches from a requirements point of view. The study was undertaken but was not completed until August 1973. Its principal result was a preference for a metric pan system if accuracies could be met and enough film was available.

The July 1973 ExCom decided that no further NRO funds would be spent on DMA cameras after the exhaustion of the current buy of 12 HMC's. The ExCom did agree to perform pertinent studies in cooperation with DMA to determine which approach (pan or frame) would be best technically for the future.

Two NRO studies were subsequently performed. One by Lt Col Al Taylor, SS-4, investigated the coverage mix options, over time, as a function of DMA requirements by priority. This study was completed in May 1974. The second study was initiated by SS-7 and involved the technical capability of the HEXAGON pan system to be modified to accomplish the MC&G mission. The item at issue was attitude accuracy and precision of the focal plane during exposure. This was

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completed in May 1974 and briefed at Sunnyvale on 26 June 1974 to LMSC, SP-7 (Berganini), NRO (Peake), DMA (Joe Webb, Dr. Mahoney, [redacted]) and PE [redacted]. Copies of the briefing aides are attached. A formal report won't be written at this time due to time and cost problems.

CURRENT SITUATION

Of the four alternatives at the 26 June meeting, the so-called solid state stellar (S³) camera was recommended. PE later estimated total costs including LMSC integration at less than \$20M. This was much lower than the \$30-50M estimated with other techniques considered earlier. The S³ also involved a relatively high risk because it had not been done before, and it involved an in-flight calibration of the pan camera using stars with the bird rolled over on its back. While the latter had been attempted with the HMC it hasn't been successful yet.

Peake
The second most likely alternative involved attaching stellar indexing cameras with their own film path; with the pan camera, ~~their risk due to technical capability~~ is much lower here ~~all components exist; however, bucket take-up and additional film paths are required. This means greater risk to the existing systems over all and more total cost (\$20-30M).~~ The final conclusion at the meeting (26 June 1974) was that a metric pan was possible at the accuracies desired by DMA. This was contrary to previous predictions, but it ~~is~~ a unanimous judgement of all present.

At the July 74 ExCom the decision not to fund future MC&G camera requirements out of NRO resources was reaffirmed and the decision on a fourth block of HEXAGON systems was left open.

DISCUSSION

At this point in time the issue of a metric pan is academic, unless another buy of HEXAGON systems is made. If it is, DOD can fund either hardware system they choose.

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Assumming DMA can demonstrate enough advantage for the metric
pan to warrant the risk to the pan system primary mission,
the route is feasible. Chinese copies of the HMC is the
back-up option. In either case they pay.


HAYDEN B. PEAKE
Lt Colonel, USAHANDLE VIA
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AA 8592 JA

~~SECRET~~ 132000Z SEP 74 CITE CHARGE 7073.

WHIG INFO WAHOO, ETHER.

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HEXAGON

FOR: GEN KULPA [REDACTED] MR. MURPHY

FM: GEN BRADBURN/ COL ANDERSON/ LT COL POWELL/

LT COL HOFMANN

REF: A. WHIG 1121 261348Z AUG 74

B. CHARGE 5616, 231700Z JUL 74

1. THE FOLLOWING COMMENTS ARE OFFERED IN RESPONSE TO PARAGRAPH 4 OF REF A:

A. BECAUSE OF THE GREATER RISKS (BOTH TECHNICAL AND FINANCIAL), CHARGE DOES NOT RECOMMEND PURSUING THE METRIC PAN IN LEIU OF PROCUREMENT OF ADDITIONAL

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SS-2		✓
SS-3		✓
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SS-6	✓	
SS-7		2
COMAP		✓
SS-TRF		
RF-11		
FILE		

PAGE 2 CHARGE 7073 ~~SECRET~~

MAPPING CAMERAS FOR MISSIONS 1217 AND 1218.

B. IF IT IS DECIDED TO PURSUE THE METRIC PAN, CHARGE WOULD RECOMMEND THE SOLID STATE STELLAR CAMERA ASSEMBLY FOR ATTITUDE DETERMINATION COMBINED WITH A DOPPLER BEACON SYSTEM OR GEODETIC PACKAGE FOR ORBIT DETERMINATION. THE SOLID STATE STELLAR CAMERA ASSEMBLY CONCEPT WAS DESCRIBED DURING THE CHARGE/ WHIG/ ETHER MEETING AT MAHDI, 27 JUN 74. (COPIES OF THE VIEWGRAPHS PRESENTED WERE FORWARDED AS BIF-007-0639-74.) THIS CONCEPT WILL REQUIRE DEVELOPMENT AND QUALIFICATION BEFORE IT IS READY FOR USE. IT MUST BE CONSIDERED NEW TECHNOLOGY WITH ATTENDANT HIGH RISK ESPECIALLY WHEN CONSIDERED FOR ACCELERATED IMPLEMENTATION.

C. THE ACCURACY OF THE ORBIT DETERMINATION WILL REMAIN THE SAME AS CURRENTLY EXISTS UNLESS THE GEODETIC PACKAGE EXPERIMENTS CURRENTLY PLANNED FOR MISSIONS 1213, 1214, AND 1215 ARE SUCCESSFUL.

D. BASED UPON A 2 ARC SEC (ONE SIGMA) ON-ORBIT CALIBRATION OF THE ORIENTATION OF THE SOLID STATE STELLAR

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PAGE 3 CHARGE 7073 ~~SECRET~~

CAMERAS TO THE PAN CAMERAS, THE ATTITUDE ACCURACY IS PREDICTED TO BE 5 ARC SEC (ONE SIGMA). THE ABILITY TO PERFORM AN ON-ORBIT CALIBRATION TO 2 ARC SEC HAS NOT BEEN DEMONSTRATED. INITIAL ANALYSIS BY PERCH INDICATES THAT THE PAN CAMERA HAS THE CAPABILITY TO IMAGE 4.7 MAGNITUDE STARS ON 1414 FILM BUT EITHER HAS NOT DETERMINED THAT THIS IS ADEQUATE TO PERMIT A 2 ARC SEC CALIBRATION. AN ENGINEERING EXPERIMENT IS PLANNED FOR THE LAST PART OF THE 1209 MISSION TO ANSWER THIS CALIBRATION QUESTION.

E. NO CHANGES IN THE TIMING ACCURACY THAT CURRENTLY EXISTS ARE CONTEMPLATED.

F. APPROXIMATELY FOUR YEARS WILL BE REQUIRED AFTER GO AHEAD UNTIL FIRST FLIGHT OF THE METRIC PAN WITH THE SOLID STATE STELLAR CAMERA ASSEMBLY. ASSUMING AN OCTOBER 1975 GO AHEAD AND A 100 PERCENT SUCCESS SCHEDULE, THIS WILL MEET THE CURRENT PLANNED LAUNCH DATE FOR MISSION 1217. GREATER CONFIDENCE COULD BE ACHIEVED WITH AN EARLIER GO AHEAD.

G. A VERY ROUGH ESTIMATE OF THE FUNDING REQUIRED

PAGE 4 CHARGE 7073 ~~SECRET~~

BY FISCAL YEAR IS GIVEN BELOW. THIS IS AN IN-HOUSE ESTIMATE AND IS NOT, REPEAT NOT, BASED ON CONTRACTOR PROPOSALS. THE DOLLARS ARE GIVEN IN MILLIONS.

FY75 FY76 FY77 FY78 FY79 TOTAL
(TRANS)

START OCT 74 4.25 9.10 1.00 5.50 2.25 0 22.10

START OCT 75 0 4.65 2.50 8.50 6.00 2.50 24.15

(THE ESTIMATE FOR OCTOBER 75 START IS APPROXIMATELY 10 PERCENT HIGHER DUE TO INFLATION AND UNKNOWN.)

2. IF DECISION TO PURCHASE TWO ADDITIONAL MAPPING CAMERAS IS DELAYED PAST JAN 75, THERE IS NO GUARANTEE THAT THESE TWO CAMERA SYSTEMS CAN BE OBTAINED TO FLY ON MISSIONS 1217 AND 1218. THIS IS EXPLAINED MORE FULLY IN REFERENCE B.

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~~(S)~~ NATIONAL RECONNAISSANCE OFFICE

WASHINGTON, D.C.

THE NRO STAFF

18 September 1974

MEMORANDUM FOR THE RECORD

SUBJECT: Metric Pan

Colonel Anderson called and said we did not need a meeting in Los Angeles because DMA (Joe Webb) stated in a meeting with Bill Powell today that he has enough data to make a decision. I agreed to talk to Joe Webb and get back to Anderson on Friday.

Colonel Anderson's position is that we can direct them to press with this metric pan in spite of their recommendation; they're "good engineers" and will get the job done; we may have to get more money to bail them out down stream. I called [] at home and related the above; he's going to touch bases with Webb and get back to me Friday morning.

Anderson also said that his recommendation is based on gut feel rather than ~~the~~ hard analysis; that we could work further questions such as risk to the primary mission (he said there isn't any) by TWX.

[] stated that Gen Breedlove wants to go to the LA meeting.



DANIEL B. HUTCHISON
Lt Colonel, USAF

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HEXAGON METRIC PAN ISSUE

STATUS BRIEFING TO THE

DEFENSE MAPPING AGENCY

17 OCTOBER 1974

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Lt Col Daniel B. Hutchison
National Reconnaissance Office

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SYSTEM ONLYBACKGROUND

- 73-74: *74 74* REQUIREMENTS VS CAPABILITY BEYOND 12 HMC
- JAN *73*-JUN *73*: METRIC PAN OPTIONS
- JUL *73*: *74* EXCOM REAFFIRMED NO NRP FUNDING FOR HMC PAST SV-16
- 26 AUG 74: NRO REQUIREMENT FOR METRIC PAN EVALUATION
- 13 SEP 74: SAFSP MESSAGE TO DMA, DNRO
- 27 SEP 74: SAFSP BRIEF DNRO
- 17 OCT 74: NRO BRIEF DMA

----- DEADLINE 15 DEC 1974 -----

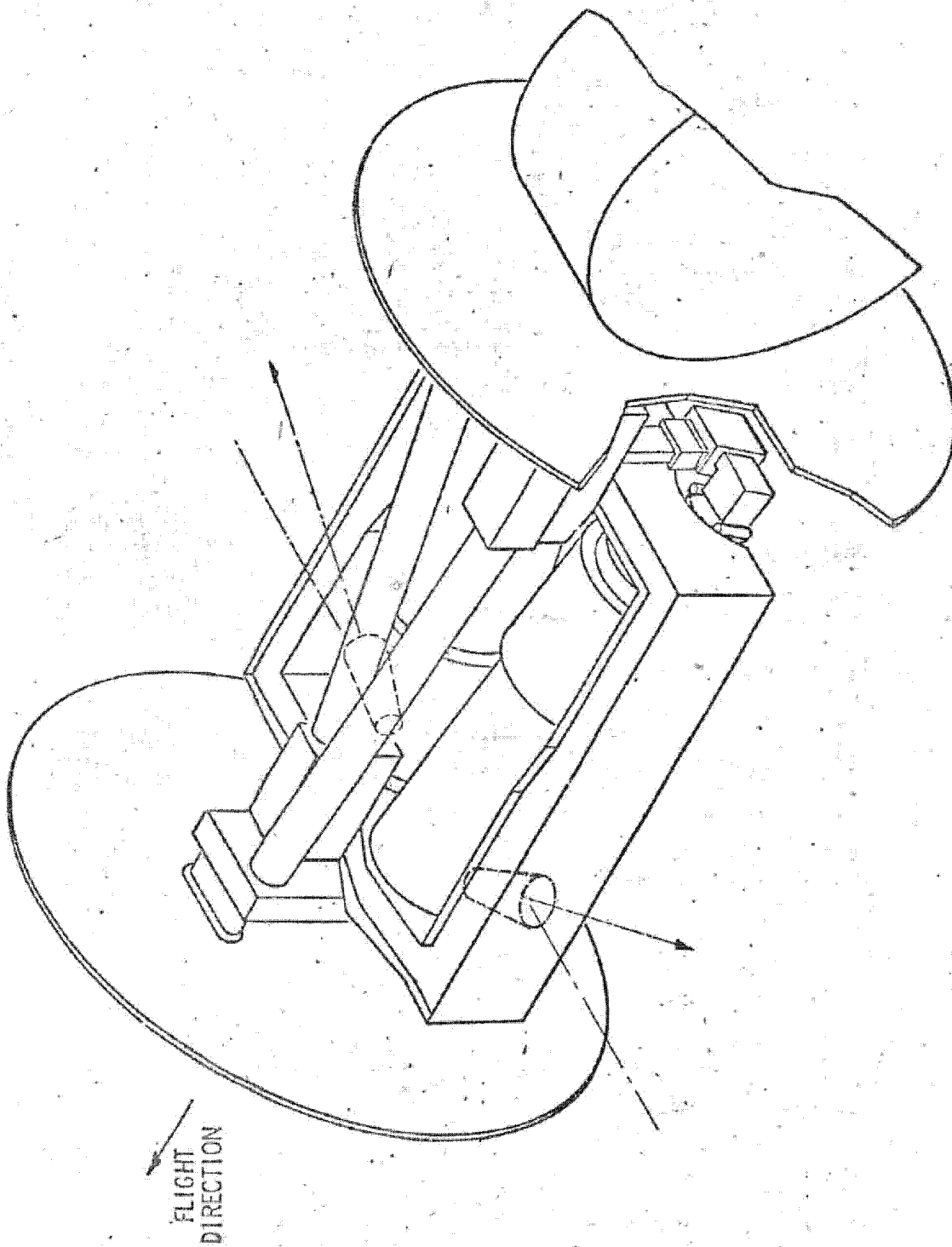
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METRIC - PAN PRELIMINARY INVESTIGATIONS

- * G ARRAY SILICON DETECTOR
- * SOLID STATE STELLAR DETECTOR - CCD
- * IMAGE DISSECTOR
- * PHOTOMULTIPLIER PAIR
- * INDEPENDENT FILM PATH STELLAR CAMERA
- * INTER-OP IMAGING STELLAR CAMERA

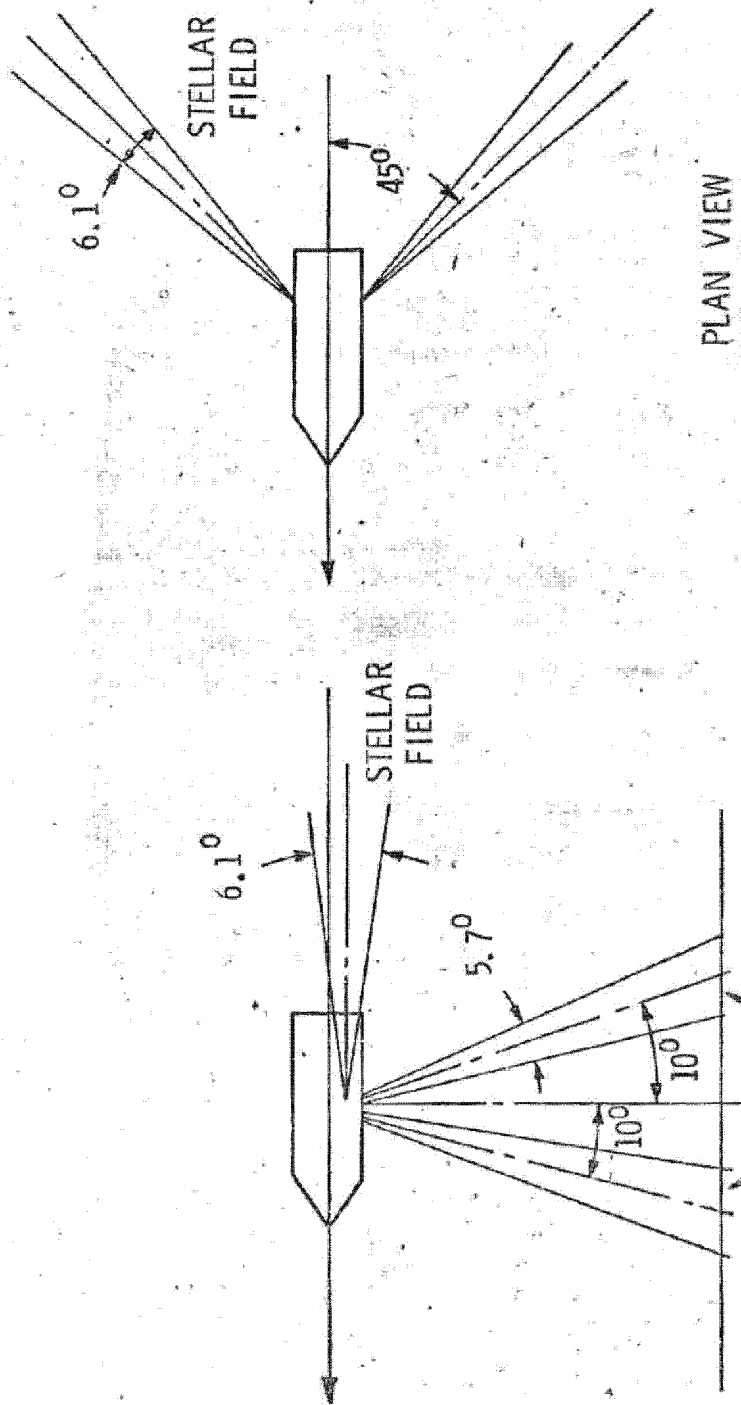
S³ ATTITUDE CAMERA ARRANGEMENT

28361



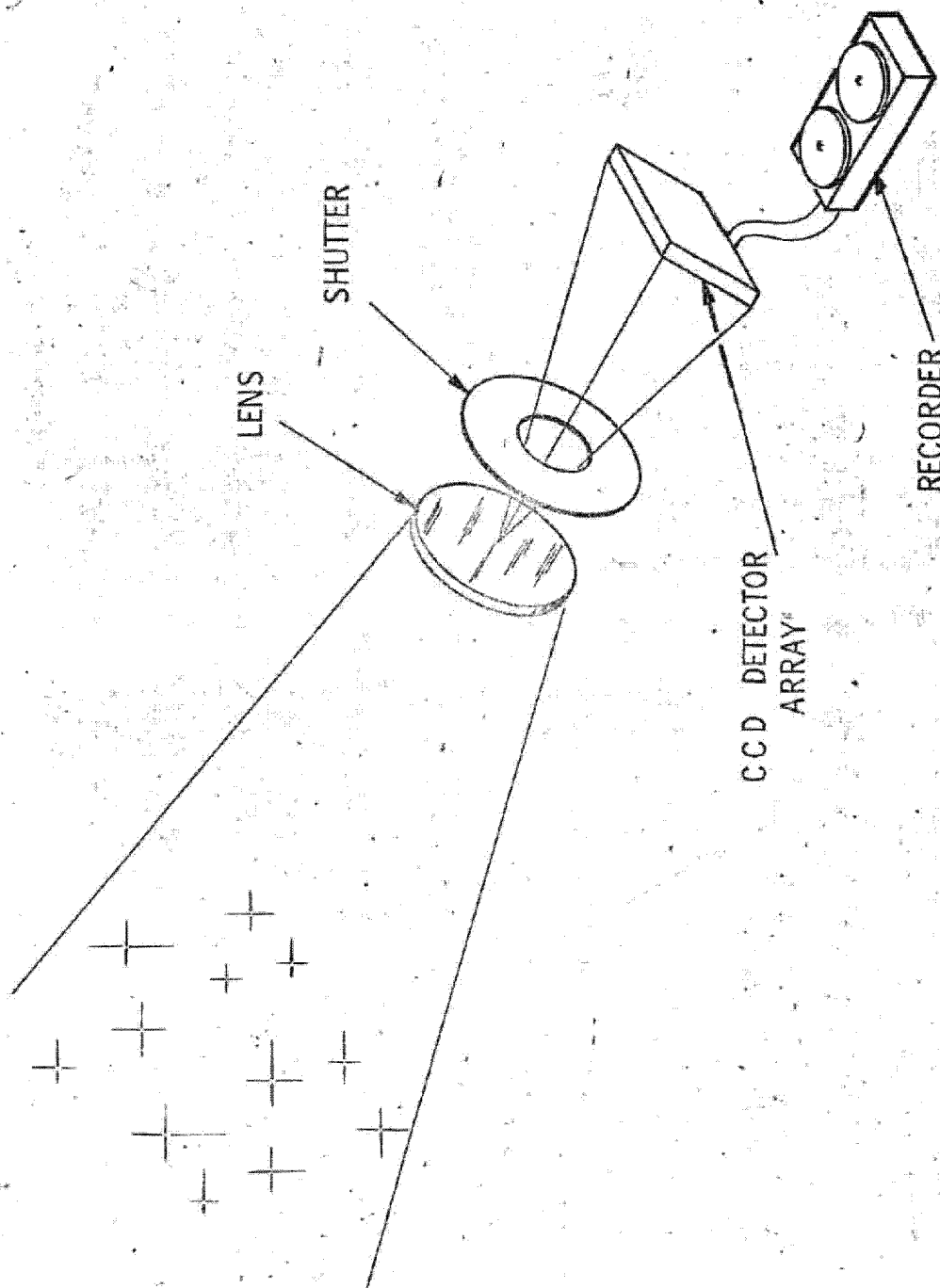
6/26/74 TJC

P-E SOLID STATE STELLAR ATTITUDE SYSTEM



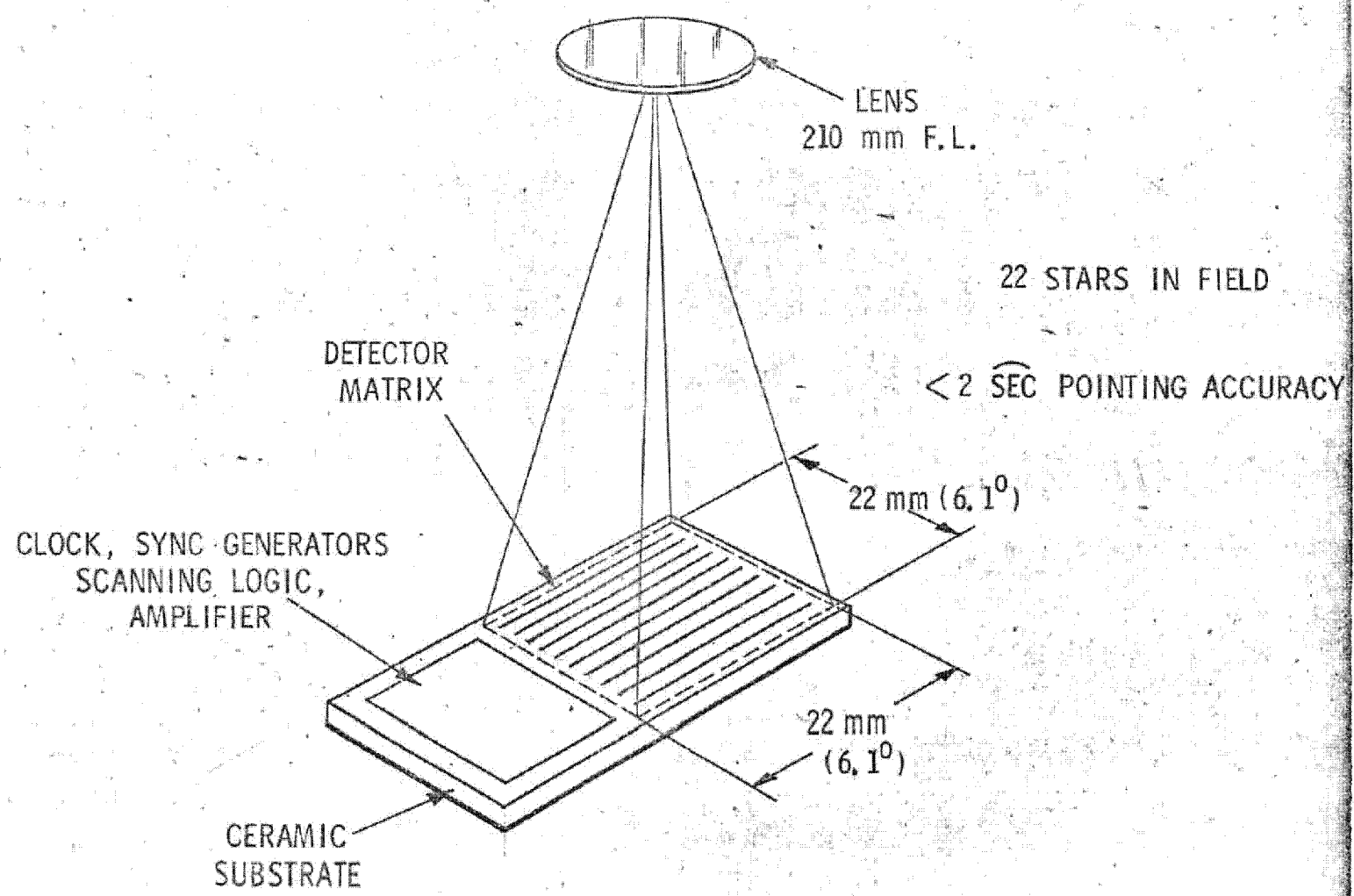
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S³ ATTITUDE SYSTEM



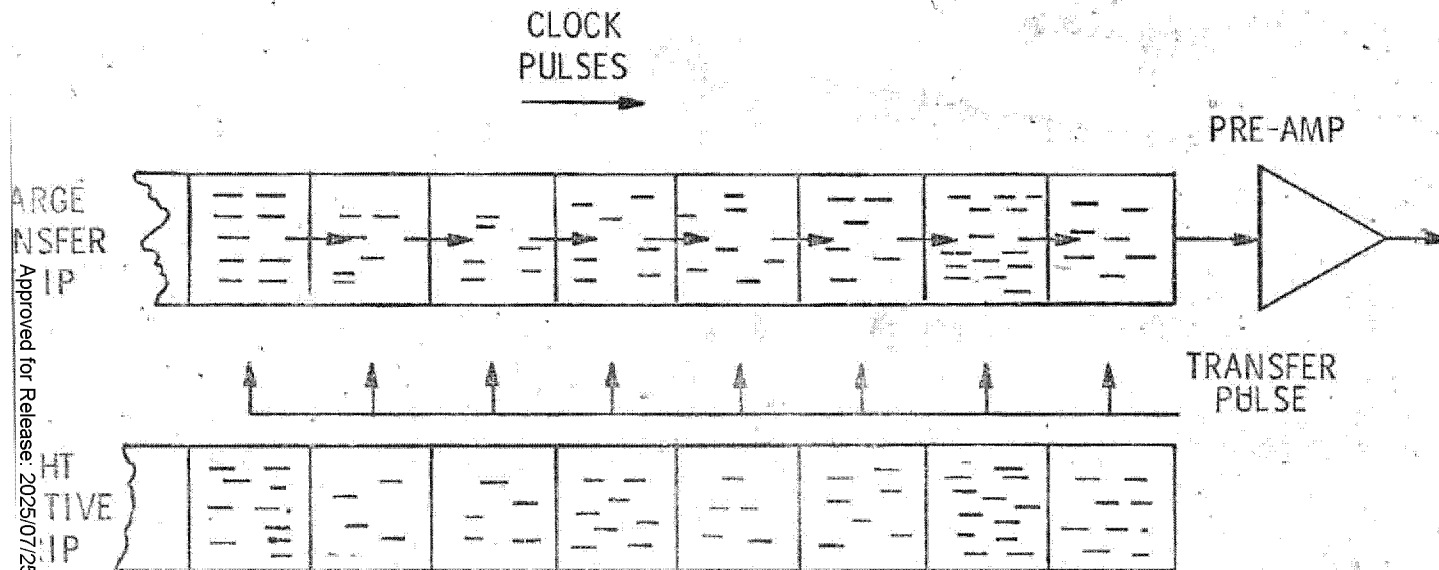
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SOLID STATE CAMERA SCHEMATIC



9/23/74 TJG

CHARGE COUPLED DEVICE (CCD)



CHARACTERISTICS

ELEMENT SIZE 13 x 16 μ m (1 x 1728)

SENSITIVITY 1.2×10^{-14} W/ELEMENT @ S/N 10:1
IN 0.5 TO 1 μ BAND FOR
INTEGRATION TIME OF 50 MSEC

9/23/74 TJC

RISK AREAS

CHIP DEV/QUAL/PROD

SIGNAL TO NOISE RATIO

CALIBRATION/STABILITY

TCA QUAL & VIB MODES

SUMMARY - RISK ASSESSMENT				
	COST	SCHEDULE	PERFORMANCE	SYSTEM IMPACT
	TOTAL	RISK		
PRESENT SYSTEM	\$19.4M	LOW	NONE	NONE
	(6.0M)			
METRIC-PAN	22.1M	MODERATE TO HIGH	HIGH	LOW

RECOMMENDATIONS

- * BUY TWO ADDITIONAL MCS FOR I7 & I8
UNLESS CURRENT PERFORMANCE IS CONSIDERED INADEQUATE - THEN
- * DEFINE REQUIREMENTS
- * PERFORM 6 MONTH CONFIGURATION STUDY FOR METRIC PAN SYSTEM

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HEXAGON MAPPING MISSION

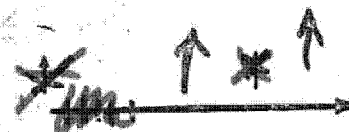
HEXAGON SV-	9	10	11	12	13	14	15	16	17	18
1/YR '78	OCT'74	APR'75	OCT'75	APR'76	OCT'76	APR'77	OCT'77	OCT'78	OCT'79	OCT'80
1/YR '76	OCT'74	APR'75	OCT'75	OCT'76	OCT'77	OCT'78	OCT'79	OCT'80	OCT'81	OCT'82
			75	76	77	78	79	80	81	82
MAPPING CAMERAS	*	*	*	*	*	*	*	*		
M1/205' H (1)										
95' V										

GEODETIC PACKAGE
MX (2) 85' H
75' V

OPTION A: 2 MORE MAPPING CAMERAS \$20M
OPTION B: METRIC PAN CAPABILITY \$24M

NOTE:

- (1) VALUES ARE 90% CEP FOR HORIZONTAL; 90% LINEAR FOR VERTICAL.
(2) GEODETIC PACKAGE REDUCES ORBIT ERRORS TO 30' INTRACK, 30' ACROSSTRACK
AND 30' VERTICAL (1σ) VS CURRENT 90, 60, 30 WITH DOPPLER BEACON SYSTEM



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OPTIONS

1. NO MORE MAPPING CAPABILITY *after SV-16*
SATISFY 97% CAT I TARGETS AT 205'
50% CAT I TARGETS AT 85'
70% AREA REQUIREMENT (PRI 1-4)
49% AREA REQUIREMENT (PRI 1-5)
2. TWO MORE MAPPING CAMERAS *(17 and 18)*
SATISFY 97% CAT I TARGETS AT 205'
65% CAT I TARGETS AT 85'
76% AREA REQUIREMENT (PRI 1-4)
60% AREA REQUIREMENT (PRI 1-5)
3. METRIC PAN *(17 and 18)*
SATISFY 100% CAT I TARGETS AT 205'
100% CAT I TARGETS AT 85'
APPROACH 98% AREA REQUIREMENT (PRI 1-5)
4. MAPPING-DEDICATED SATELLITE
5. MAPPING CAMERAS
HIGH (\$10M/FLIGHT) RECURRING COST
6. METRIC PAN
RELATIVELY LOW RECURRING COST; BECOMES PART
OF BASELINE PAN CAMERA

CANCEL HEXAGON

AFTER SV-18

CONTINUE HEXAGON

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HEXAGON

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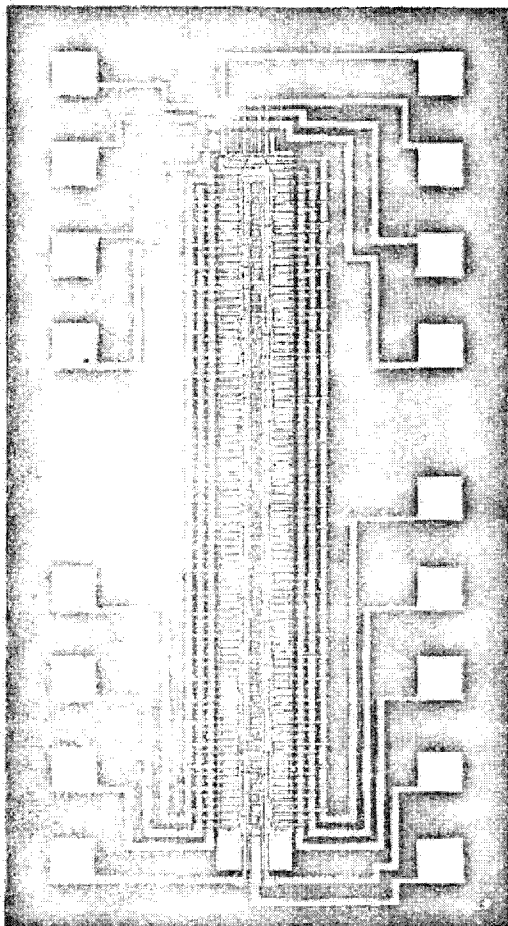
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CONCLUSION

- DMA HAS OPTIONS UNTIL 15 DECEMBER 1974
- NRO STAFF IS AVAILABLE FOR ANY HELP REQUESTED
- (OPINION) REQUIREMENTS IS THE REAL ISSUE (ORIGINAL BUY OF
12 WAS WELL CONSIDERED)

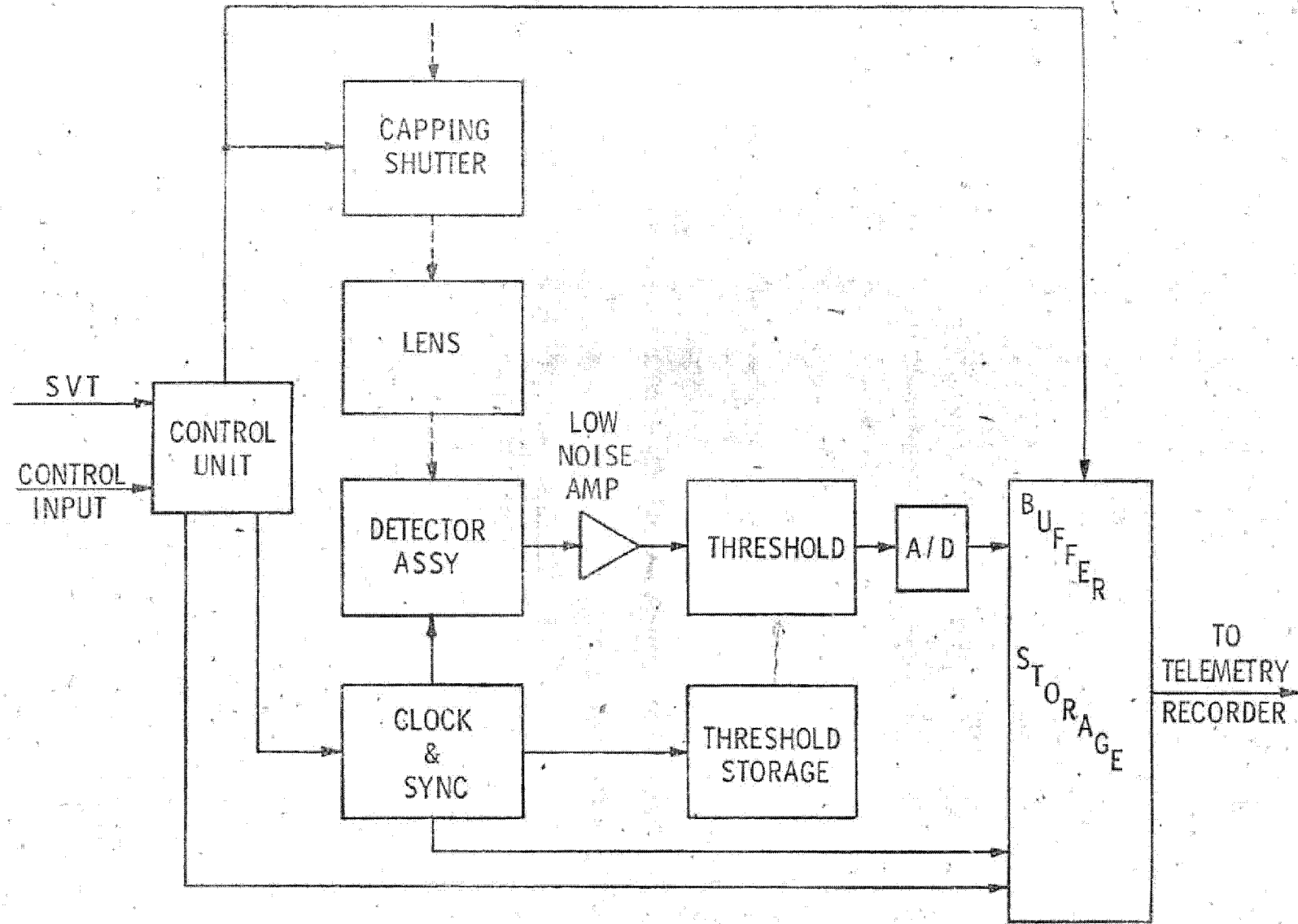
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CCD ARRAY



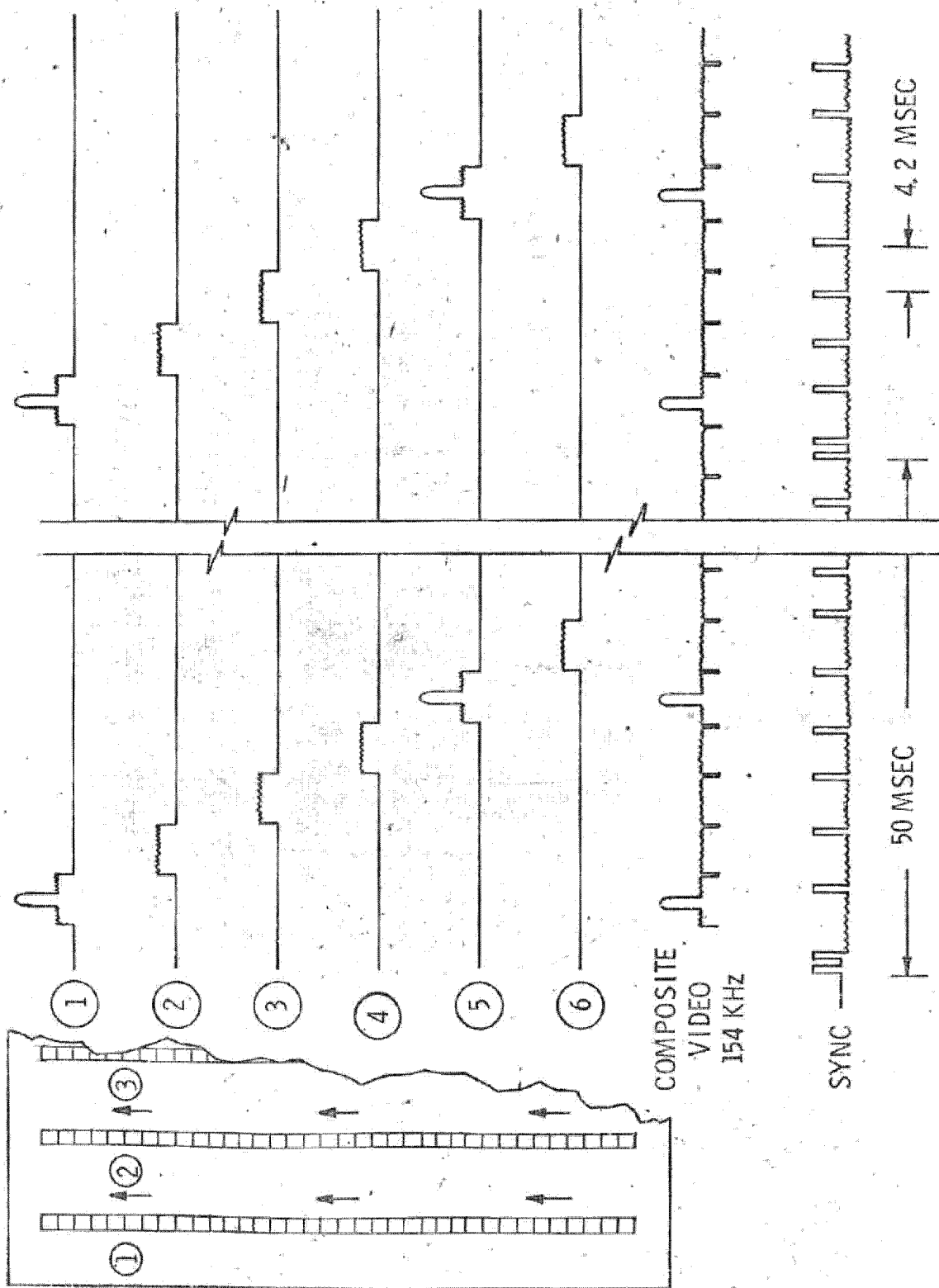
6/26/74 TJG

S³ CAMERA BLOCK DIAGRAM



9/23/74

SCANNING SEQUENCE AND WAVEFORMS



9/23/74 TJG



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 DE RUKQIA 547 295 1531
 ZNY XXXXX KKK ZNM
 P 22 153Z
 BT
 XXXXX
 GUARD 153
 GUARD PASS WHIG

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PRIORITY WHIG

OPS HEXAGON

WHIG FOR HUTCHISON, [REDACTED]

SUBJECT: STAND ALONE PAN

1. RECENT NRO SIMULATIONS RELATIVE TO COVERAGE CAPABILITIES FOR THE HEXAGON PROGRAM AND THE HEXAGON SYSTEM PERFORMANCE ON MISSIONS 1206 AND 1207 PROVIDE EXPECTED ACQUISITIONS THROUGH MISSION 1218 AS FOLLOWS, ASSUMING NO CHANGE IN CURRENT COLLECTION STRATEGIES:

A. CURRENT WGS PROGRAM.

(1) THROUGH MISSION 1216

96.9 PERCENT OF CAT 1 TARGETS (25/75 ACCURACY).

57 PERCENT OF PRI 1-5 AREA REQUIREMENTS.

(2) THROUGH MISSION 1218

97.1 PERCENT OF CAT 1 TARGETS (25/75 ACCURACY).

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64 PERCENT OF PRI 1-5 AREA REQUIREMENTS.

B. IMPROVED WGS PROGRAM (FOUR TO SIX MISSIONS WITH GEOPAC).

(1) THROUGH MISSION 1216 (FOUR MISSIONS)

50 PERCENT OF CAT 1 TARGETS (25/75 ACCURACY)

57 PERCENT PRI 1-5 AREA REQUIREMENTS

(2) THROUGH MISSION 1218 (SIX MISSIONS).

64 PERCENT OF CAT 1 TARGETS (25/75 ACCURACY)

64 PERCENT OF PRI 1-5 AREA REQUIREMENTS.

C. PROBABLE ACQUISITION WITH TWO PAN-ONLY MISSIONS, BASED ON MISSIONS 1206 AND 1207 EFFICIENCIES.

99.8 PERCENT OF CAT 1 TARGETS.

64 PERCENT OF PRI 1-5 AREA REQUIREMENTS, ASSUMING NO ADDITIONAL FILM ALLOCATION FOR WGS.

2. INCREASED COVERAGE AT HIGH ACCURACY IS REQUIRED FOR SUPPORT OF BOTH STRATEGIC AND TACTICAL FORCES. WITH RESPECT TO THE STRATEGIC, AS INDICATED ABOVE, THE PROCUREMENT OF TWO ADDITIONAL MAPPING CAMERA SYSTEMS WOULD PROVIDE AN INCREASE IN COVERAGE OF CAT 1 TARGETS AT 25/75 ACCURACY LEVEL OF ONLY 16 PERCENT WHILE TWO STAND ALONE PAN (SAP) SYSTEMS COULD PROVIDE AN INCREASE OF 50 PERCENT.

WORKING COPY

DEPARTMENT OF THE AIR FORCE
OFFICE OF THE SECRETARY

MEMORANDUM

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\$1.5M. ADDITIONALLY, THIS DELAY WILL NECESSITATE AN EQUIVALENT NUMBER OF MONTHS OF TWO SHIFT OPERATION AFTER COMMENCEMENT OF WORK IN ORDER TO INSURE MEETING SCHEDULE FOR SV-17. THIS PREMIUM OPERATION WILL COST APPROXIMATELY \$150K PER MONTH OR APPROXIMATELY \$1.2M. THESE COSTS ARE IN ADDITION TO PREVIOUS ESTIMATES SUBMITTED FOR TWO ADDITIONAL MAPPING CAMERA SYSTEMS. * UNQUOTE. 2. IN THE EVENT YOU DESIRE TO FUND A HEXAGON MAPPING CAPABILITY FOR SV-17 AND 18, ACTION IS REQUIRED BY 15 DEC 74 IN ORDER TO OBTAIN DNRO APPROVAL BY JAN 1975. LT COL HUTCHISON WILL BE AVAILABLE TO WORK WITH YOU TO PREPARE A BRIEFING OR MEMORANDUM, AS YOU MAY DESIRE. E-2 IMPDET. <i>Go to next page</i>						
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FOR [REDACTED] HUTCHISON FROM ANDERSON HOPMANN
SUBJECT: STUDY PLAN FOR S-CUBED CAMERA.
REFERENCE WHIG 1474.

1. IN RESPONSE TO PARAGRAPH 2A OF REFERENCE, WE SUGGEST THE FOLLOWING STUDY EFFORT BE IMPLEMENTED:
 - A. CCD RELIABILITY EVALUATION - EVALUATES CHIP DEVELOPMENT, QUALIFICATION AND PRODUCTION RISKS.
 - B. SENSOR DEMONSTRATION MODEL - EVALUATES THE RISK OF SIGNAL TO NOISE PARAMETERS AND THE STABILITY OF THE CALIBRATION OF THE FOCAL PLANE ASSEMBLY.
 - C. PAN CAMERA AND VEHICLE ERRORS - EVALUATES THE RISK OF

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PAGE 2 CHARGE 8992 ~~SECRET~~

SYSTEM CALIBRATION AND TWO CAMERA ASSEMBLY VIBRATION MODES.

D. CONCEPT ANALYSIS - ESTABLISHES DESIGN PARAMETERS FOR THE SYSTEM COMPONENTS AND EXAMINES THE CONCEPT FOR OTHER RISK AREAS. ESTIMATED COST OF THIS STUDY EFFORT IS 500K FOR MATERIALS AND SUBCONTRACTS. THE LABOR REQUIRED IS WITHIN EXISTING SUSTAINING ENGINEERING. THESE 3600 FUNDS COULD BE OBTAINED USING THE 650K PREVIOUSLY ESTABLISHED (BUT RETURNED) FOR SENSOR SUBSYSTEM DESIGN STUDY, OR FROM OMA.

2. IN RESPONSE TO PARAGRAPH 2B OF REFERENCE, THIS STUDY EFFORT WILL BE COMPLETED BY 1 SEP 75. AT THIS TIME THE CONTRACTOR WILL PREPARE A PROPOSAL FOR INCORPORATION OF THE S-CUBED CAMERA ON CURRENTLY SCHEDULED SV-17.
3. IN RESPONSE TO PARA 2D OF REFERENCE, REDUCTION OF MAPPING

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CONTROL SYSTEM

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CENTRAL SYSTEM

AMERA PRODUCTION LINE AT ITEX WILL BEGIN IN JAN 75 AND IT IS SCHEDULED TO BE CLOSED DOWN ENTIRELY IN MAR 75, THUS ELIMINATING THE OPTION FOR MAPPING CAMERAS FROM ITEX FOR SV-17. APPROXIMATELY \$175K PER MONTH WILL BE REQUIRED AFTER JAN 75 TO SUSTAIN THE ASSEMBLY LINES. ASSUMING 45 DAYS BEYOND THE STUDY END DATE OF 1 SEP, THIS OPTION WILL COST APPROXIMATELY \$1.5M. ADDITIONALLY, THIS DELAY WILL NECESSITATE AN EQUIVALENT NUMBER OF MONTHS OF TWO SHIFT OPERATION

PAGE 3 CHARGE 8992 ~~SECRET~~

AFTER COMMENCEMENT OF WORK IN ORDER TO INSURE MEETING SCHEDULE FOR SV-17. THIS PREMIUM OPERATION WILL COST APPROXIMATELY \$150K PER MONTH OR APPROXIMATELY \$1.2M. THESE COSTS ARE IN ADDITION TO PREVIOUS ESTIMATES SUBMITTED FOR TWO ADDITIONAL MAPPING CAMERA SYSTEMS.

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PRIORITY CHARGE.

HEXAGON

CHARGE FOR F. HOFMAN/W/ANDERSON FROM HUTCHISON

SUBJECT: METRIC PAN/S-CUBED CAMERA

ONE OF THE FACTORS BEARING ON THE DECISION TO PURSUE THE S-CUBED CAMERA IS THE POSSIBLE IMPACT ON THE BASIC HEXAGON PROGRAM IF THE DMA LINE ITEM WERE CUT AFTER THE PROJECT HAD STARTED. REQUEST YOU ANALYZE THE TECHNICAL AND COST IMPACT ON THE BASIC HEXAGON PROGRAM OF TERMINATING THE S-CUBED PROJECT ONE OR MORE YEARS AFTER APPROVAL. FOR EXAMPLE, IF YOU WERE TWO YEARS INTO THE PROJECT AND HAD MODIFIED FLIGHT HARDWARE, WOULD IT BE LIKELY THAT A CANCELLATION OF THE DMA FUNDING WOULD REQUIRE SIGNIFICANT NRP FUNDS TO MAKE THE HARDWARE FLYABLE? REQUEST YOU REPLY BY 9 DC 74.

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HEXAGON

ETHER FOR [REDACTED] MARTIN FROM H. WHEELER [REDACTED]

SUBJECT: METRIC PAN

1. THE FOLLOWING MESSAGE IS QUOTED IN PART FOR YOUR
 REVIEW: CHARGE 8992

QUOTE

FOR [REDACTED] HUTCHISON FROM ANDERSON/HOFMANN

SUBJECT: STUDY PLAN FOR S-CUBED CAMERA.

REFERENCE: WHIG 1414

1. IN RESPONSE TO PARAGRAPH 2A OF REFERENCE, WE
 SUGGEST THE FOLLOWING STUDY EFFORT BE IMPLEMENTED:

A. CCD RELIABILITY EVALUATION - EVALUATES CHIP
 DEVELOPMENT, QUALIFICATION AND PRODUCTION RISKS.

PAGE 2 WHIG 1600 ~~TOP SECRET~~

B. SENSOR DEMONSTRATION MODEL - EVALUATES THE
 RISK OF SIGNAL TO NOISE PARAMETERS AND THE STABILITY
 OF THE CALIBRATION OF THE FOCAL PLANE ASSEMBLY.

C. PAN CAMERA AND VEHICLE ERRORS - EVALUATES THE
 RISK OF SYSTEM CALIBRATION AND TWO CAMERA ASSEMBLY VIBRATION
 MODES.

D. CONCEPT ANALYSIS - ESTABLISHES DESIGN PARAMETERS
 FOR THE SYSTEM COMPONENTS AND EXAMINES THE CONCEPT FOR
 OTHER RISK AREAS. ESTIMATED COST OF THIS STUDY EFFORT
 IS 500K FOR MATERIALS AND SUBCONTRACTS. THE LABOR
 REQUIRED IS WITHIN EXISTING SUSTAINING ENGINEERING.

2. IN RESPONSE TO PARAGRAPH 2 B OF REFERENCE, THIS
 STUDY EFFORT WILL BE COMPLETED BY 1 SEP 75. AT THIS
 TIME THE CONTRACTOR WILL PREPARE A PROPOSAL FOR
 INCORPORATION OF THE S-CUBED CAMERA ON CURRENTLY
 SCHEDULED SV-17.

3. IN RESPONSE TO PARA 2D OF REFERENCE, REDUCTION
 OF MAPPING CAMERA PRODUCTION LINE AT ITEK WILL BEGIN
 IN JAN 75 AND IT IS SCHEDULED TO BE CLOSED DOWN
 ENTIRELY IN MAR 75, THUS ELIMINATING THE OPTION

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PAGE 3 WHIG 1600 ~~TOP SECRET~~
FOR MAPPING CAMERAS FROM ITEK FOR SV-17. APPROXIMATELY
\$175K PER MONTH WILL BE REQUIRED AFTER JAN 75 TO SUSTAIN
THE ASSEMBLY LINES. ASSUMING 45 DAYS BEYOND THE STUDY
END DATE OF 1 SEP, THIS OPTION WILL COST APPROXIMATELY
\$1.5M. ADDITIONALLY, THIS DELAY WILL NECESSITATE
AN EQUIVALENT NUMBER OF MONTHS OF TWO SHIFT
OPERATION AFTER COMMENCEMENT OF WORK IN ORDER TO
INSURE MEETING SCHEDULE FOR SV-17. THIS PREMIUM
OPERATION WILL COST APPROXIMATELY \$150K PER MONTH
OR APPROXIMATELY \$1.2M. THESE COSTS ARE IN
ADDITION TO PREVIOUS ESTIMATES SUBMITTED FOR TWO
ADDITIONAL MAPPING CAMERA SYSTEMS. UNQUOTE.

2. IN LIGHT OF CHARGE'S RESPONSE QUOTED ABOVE, THE
FOLLOWING OPTIONS ARE AVAILABLE.

A. OPTION I: CHOOSE METRIC PAN OPTION NOW.

ETHER PROVIDE \$500K BY JAN 75; CHARGE CONDUCT METRIC
PAN STUDY TO BE COMPLETE BY 1 SEP 75, INCLUDING A
CAMERA CONTRACTOR PROPOSAL FOR METRIC PAN ON SV-17 (OR
EARLIER IF POSSIBLE); ETHER PROVIDE IMPLEMENTATION FUNDS
FOR METRIC PAN STARTING IN OCT 75. ETHER DECIDE NOW WITH ASD(D)

PAGE 4 WHIG 1600 ~~TOP SECRET~~
CONCURRENCE THAT THERE WILL BE NO HEXAGON MAPPING CAMERA
FOR SV-17 AND ON, AND PROVIDE NO FUNDS TO KEEP THE MAPPING
CAMERA OPTION OPEN.

B. OPTION II: KEEP BOTH METRIC PAN AND MAPPING
CAMERA OPTIONS OPEN UNTIL OCT 75. ETHER PROVIDE \$500K
PLUS \$1.5M TO NRP BY JAN 75; CHARGE CONDUCT METRIC PAN
STUDY TO BE COMPLETE BY 1 SEP 75, INCLUDING A CAMERA
CONTRACTOR PROPOSAL ON SV-17 (OR EARLIER IF POSSIBLE);
CHARGE START PRODUCTION OF SV-17 AND 18 MAPPING CAMERAS
NOW AT THE LOWEST LEVELS POSSIBLE TO KEEP THE LINE OPEN;
ETHER PROVIDE NRP WITH IMPLEMENTATION FUNDS FOR METRIC
PAN OR MAPPING CAMERAS IN OCT 75, BASED ON CONTRACTOR
METRIC PAN STUDY RESULTS. IMPLEMENTATION COSTS FOR
MAPPING CAMERA WOULD EXCEED PREVIOUS ESTIMATE (WHIG 1121)
BY \$1.2M BECAUSE OF ACCELERATED SCHEDULE REQUIRED.

C. OPTION III: CHOOSE MAPPING CAMERA OPTION NOW.
ETHER PROVIDE \$1.5M TO NRP BY JAN 75; CHARGE START
PRODUCTION ON SV-17 AND 18 MAPPING CAMERAS NOW. ETHER
PROVIDE NRP WITH FULL IMPLEMENTATION FUNDS FOR MAPPING
CAMERA IN OCT 75.

D. OPTION IV: DECIDE THAT THERE WILL BE NO MAPPING

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PAGE 5 WHIG 1600 ~~TOP SECRET~~
CAPABILITY FOR HEXAGON AFTER SV-16.

3. COST SUMMARY (MILLIONS OF DOLLARS)

	FY-75	FY-76	FY-77	FY-78	FY-79	FY-80
OPTION I	0.5	9.7##	9.7	2	2	2
OPTION II	2.0	9.7	9.7	2	2	2
		(10.9)#				
OPTION III	0	9.7##	9.7	2	2	2
OPTION IV	0	0	0	0	0	0

#IF MAPPING CAMERA IS SELECTED.

#TO BE REVISED DEPENDING ON WORK ACCOMPLISHED IN FY-75.

4. REQUEST EITHER NOTIFY WHIG OF THE OPTION DESIRED NOT
LATER THAN 15 DECEMBER 1974, SO THAT DNRO CONCURRENCE CAN
BE OBTAINED BY 1 JAN 75. LT COL HUTCHISON WILL BE AVAILABLE
TO HELP PREPARE A BRIEFING OR MEMORANDUM FOR
THE DNRO, AS YOU MAY DESIRE. E-2 IMPDET
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HEXAGON

WHIG FOR HUTCHISON FROM F. HOFMANN ANDERSON.

REFERENCE WHIG 1595.

THE CURRENT S-CUBED CAMERA DESIGN IS INDEPENDENT OF THE HEXAGON
 SEARCH AND SURVEILLANCE MISSION. A DECISION TO CANCEL THE S-CUBED
 PROJECT IN THE FUTURE, AFTER INITIAL APPROVAL, WOULD HAVE NO
 SIGNIFICANT IMPACT ON THE BASIC HEXAGON PROGRAM COSTS OR SCHEDULE.

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ETHER.
HEXAGON.
FOR [REDACTED]

SUBJECT: S-CUBED CAMERA IMPACT.
REFERENCE: CHANGE MSG 9555, 11 DEC 74.
THE REFERENCED MESSAGE STATES THAT (QUOTE) THE CURRENT S-CUBED CAMERA DESIGN IS INDEPENDENT OF THE BASIC HEXAGON PROGRAM MISSION. A DECISION TO CANCEL THE S-CUBED PROJECT IN THE FUTURE, AFTER INITIAL APPROVAL, WOULD HAVE NO SIGNIFICANT IMPACT ON THE BASIC HEXAGON PROGRAM COSTS OR SCHEDULE (UNQUOTE).

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PRIORITY WHIG.

OPNS HEXAGON

FOR H. WHEELER FM

SUBJ: SELECTION OF OPTION FOR CONTINUED METRIC CAPABILITY FOR HEXAGON

REF: A. WHIG BRIEFING TO ETHER ON METRIC PAN RISK, 17 OCT 74.

B. MESSAGE 291417Z NOV 74 CITE WHIG 1600.

C. MESSAGE 021706Z DEC 74 CITE WHIG 1605.

1. ETHER HAS JUST COMPLETED AN ANALYSIS OF THE ADVANTAGES/ DISADVANTAGES OF THE OPTIONS PRESENTED IN REFERENCE B. THE RESULTS OF THE ETHER ANALYSIS IN COMBINATION WITH RECENT DISCUSSIONS WITH YOUR ORGANIZATION, INDICATING DIMINISHING TECHNICAL RISK SINCE YOUR BRIEFING (REF.A), HAVE LED US TO SELECT

PAGE 2 ETHER 0655 ~~TOP SECRET~~

OPTION 1: METRIC PAN OPTION AS THE MOST VIABLE APPROACH FOR ETHER.

2. STUDIES PERFORMED WITH RESPECT TO THE HEXAGON MAPPING CAMERA (HMC) FOR INPUT TO THE OPTION ANALYSIS SHOWED THAT MUCH COULD BE ACCOMPLISHED TO COMPLEMENT THE PAN MATERIAL THROUGH OPTIMIZED COLLECTION AND UTILIZATION OF THE HMC THROUGH SV-16. WE ARE THEREFORE INTERESTED IN THE HMC MODIFICATIONS DISCUSSED IN REF.

C. OF IMMEDIATE INTEREST IS THE MODIFICATION OF SUPPLY AND TAKEUPS. IN ADDITION, UTB OFFERS CONSIDERABLE PROMISE BUT ETHER MUST FIRST INVESTIGATE WHETHER UTB WILL REQUIRE AN INCREASED INTERNAL RESEAU IN ORDER TO CONTROL DEFORMATIONS. REQUEST PROVISION OF COST, SCHEDULE, AND EFFECTIVITY DATA ON BOTH PROPOSED CHANGES.

3. WE ARE CURRENTLY WORKING THE PROBLEM OF FUNDING, AS DESCRIBED PER REFERENCES, TO BE AVAILABLE TO YOU BY JANUARY 75.

4. DIRECTOR, ETHER PLANS TO BRIEF DNRO RELATIVE TO THIS DECISION FOR CONTINUED HEXAGON METRIC CAPABILITY AT THE EARLIEST MUTUALLY ACCEPTABLE DATE. IN ADDITION,

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PAGE 3 ETHER 0655 ~~TOP SECRET~~
ETHER WILL BRIEF ASD (1) ON THE DECISION. WE WOULD
LIKE TO EXERCISE YOUR OFFER OF LT COL HUTCHISON TO
ASSIST IN THE PREPARATION OF THE BRIEFING TO DNRD.
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FOR D. HUTCHINSON FROM BERGANINI.
THE PERKIN ELMER CORP IS CURRENTLY EVALUATING DESIGN TRADEOFFS FOR
VARIOUS PIXEL-TYPE IMAGING SENSORS FOR USE IN THE S-CUBED ATTITUDE
REFERENCE CAMERA. THIS STUDY IS A PORTION OF THE S-CUBED TECH-
NOLOGY DEMONSTRATION PLAN. REQUEST THAT PERKIN ELMER BE GIVEN

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HEXAGON

CHARGE FOR MAJ GEN BRADBURN, COL ANDERSON: Wahoo FOR
LI COL TAYLOR FROM COL WHEELER

SUBJECT: HEXAGON MAPPING CAPABILITY

1. BASED ON THEIR EVALUATION OF THE COST/RISK/
EFFECTIVENESS TRADE, ETHER HAS DECIDED THAT THEIR
RESOURCES CAN BE BEST USED BY DECIDING NOW THAT NO MORE
WACORN MAPPING CAMERAS WILL BE PROCURED AFTER THE
CURRENT 12. THEY WOULD PROPOSE THAT YOU CONDUCT A
STUDY WITH \$520K PROVIDED BY THEM, STARTING NOW AND
LASTING UNTIL OCTOBER 1975 OR UNTIL A BEST APPROACH
HAD BEEN DEFINED, WHICHEVER CAME FIRST. THE OBJECTIVE
OF THE STUDY WOULD BE TO DEFINE A MODIFICATION TO THE

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HEXAGON SYSTEM WHICH WOULD ALLOW GEOPositionING
ACCURACIES WITH THE PAN SYSTEM EQUAL TO OR BETTER THAN
THAT POSSIBLE WITH THE PRESENT MAPPING CAMERA. THE STUDY
WOULD BE DETAILED ENOUGH TO ALLOW EVALUATION OF THE
TECHNICAL, SCHEDULE AND FINANCIAL REQUIREMENTS AND
RISKS, AND WOULD CULMINATE IN A COST PROPOSAL FOR
INCORPORATING THE METRIC PAN MODIFICATION AS EARLY AS
POSSIBLE BUT NO LATER THAN SV-17.

2. SINCE ETHER'S PLAN REQUIRES A DECISION TO NOT HAVE
MCS'S ON SV-17 AND 18, WE HAVE INFORMED THEM THAT AS
THERE IS A FINITE POSSIBILITY THAT THE STUDY WILL SHOW
THAT A METRIC PAN OF THE REQUIRED ACCURACY IS INFEASIBLE
FOR SV-17 AND 18, THOSE UNITS MIGHT BE WITHOUT ANY METRIC
MAPPING CAPABILITY. SINCE THE SUCCESS OF THE ETHER
PLAN DEPENDS ON THE ASSUMPTION THAT THE STUDY WILL
DEFINE A FEASIBLE DESIGN APPROACH, REQUEST YOU ASSESS
THE RISK OF FAILURE OF THE STUDY TO DEFINE A FEASIBLE
METRIC PAN APPROACH.

3. REQUEST YOU PROVIDE THIS RISK ASSESSMENT BY MESSAGE
NLT 26 DECEMBER 1975, SO THAT MR. PLUMMER CAN HAVE IT
IN HAND WHEN HE IS BRIEFED BY ETHER.

E-2 IMPDET

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BT

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PLUMMER
WHEELER
CHIEF

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 HANDLE VIA BYEMAN CONTROL SYSTEM

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HANDLE VIA BYEMAN CONTROL SYSTEM

HEXAGON

WHIG FOR COL WHEELER [REDACTED] WAHOO FOR LT COL TAYLOR,

FROM GEN BRADBURN/ COL ANDERSON.

SUBJECT: HEXAGON MAPPING CAPABILITY

REFERENCE WHIG 1688; CHARGE 8992

OUR RECOMMENDATION FOR A STUDY WAS BASED ON OUR CONSIDERATION OF THE FEASIBILITY OF THE CONTRACTOR PROPOSED STELLAR SUBSYSTEM FOR THE HEXAGON PAN SYSTEM. THE STUDY IS REQUIRED TO ALLOW A RISK ASSESSMENT OF THE VARIOUS ASPECTS OF THE APPROACH (CHARGE 8992). THE PRINCIPAL AREAS OF CONCERN ARE THE APPLICATION OF THE CHARGE COUPLED DEVICE ARRAY IN THE STELLAR CAMERA AND THE VALIDITY OF THE CONTRACTOR'S PRELIMINARY ERROR BUDGET. ASSUMING POSITIVE

PAGE 2 CHARGE 9875 ~~SECRET~~

RESULTS FROM THE STUDY, WE ARE CONFIDENT THE INITIAL UNIT COULD BE INCORPORATED ON SV-17. THIS CONFIDENCE IS BASED ON AN ASSUMED SUCCESS SCHEDULE AND ADEQUATE FUNDING.

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 HANDLE VIA BYEMAN CONTROL SYSTEM

TOP SECRET
 DEPARTMENT OF THE AIR FORCE
 HEADQUARTERS UNITED STATES AIR FORCE
 WASHINGTON, D.C.



REPLY TO
 ATTN OF: IN

SUBJECT: KH-9 Metric Capability

Mr. Plummer has seen.

27 DEC 1974

3AF/US (Mr. Plummer)

1. As the Air Force Office of Primary Responsibility (OPR) for Mapping, Charting and Geodesy (MC&G) I continue to be concerned for the satisfaction of very exacting target positioning requirements to support tactical and strategic operations. To this end I maintain a continuous dialogue with the Defense Mapping Agency (DMA) whose task it is to satisfy these Air Force requirements.
2. I have followed with great interest the various studies and proposals to provide the DMA with satellite photographic source material of sufficient metric quality and resolution to meet these requirements. I have recently asked for and received a series of briefings on the best approach to optimize satellite MC&G collection to meet these stringent Air Force requirements.
3. The prospects of a system that could provide rapid, high resolution, and metrically accurate coverage with a single camera is a very exciting concept to me. A Stand Alone Pan (SAP) System not only could satisfy all present MC&G requirements but also would provide necessary support to advanced tactical and strategic weapon systems now in development, both in target positioning and in various forms of operational point positioning data bases.
4. I know you will receive detailed technical briefings on the advantages and benefits of the Stand Alone Pan. However, I wish to express my interest and urge the immediate implementation of this approach.

Copy to: DMA
 DIA

George J. Keegan, Jr.
 GEORGE J. KEEGAN, JR.
 Major General, USAF
 Asst Chief of Staff, Intelligence

by: *BYE 1*
 FROM CENTRAL
 SION SCHEDULE

BYE-06009 1274

HANDLE VIA
 BY MAIL/KEYHOLE
 CONTROL ONLY AS LOCALLY

OF EXECUTIVE ORDER 11652
 EXEMPTION CATEGORY DATA 5.6(1)(3)
 DECLASSIFY ON *IMDET* Underwrite Your Country's Might - Buy U.S. Savings Bonds

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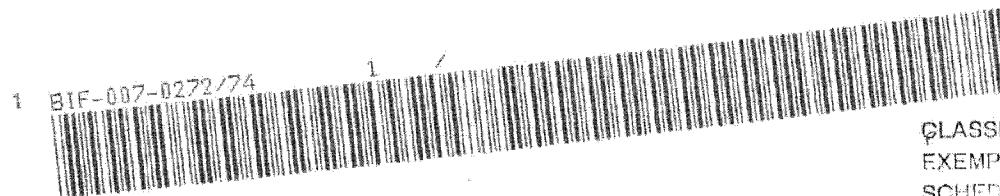
MENSURATION IMPROVEMENTS

1. CALIBRATE OB ENCODER TO REDUCE THE ERROR IN DETERMINING RELATIVE SCAN ANGLE FROM THE SCAN ANGLE DOTS.
2. PROVIDE A HIGH RESOLUTION FIDUCIAL MARK TO IMPROVE ACCURACY IN MEASUREMENT TO THE MARK.
3. PROVIDE SCAN ANGLE DOTS AT ONE DEGREE INTERVALS TO FACILITATE MEASUREMENT AND ORIENTATION ON COMPARATOR TABLES AND ALSO REDUCE FILM DISTORTION AND VELOCITY ERRORS.
4. CALIBRATE THE DIMENSION BETWEEN SCAN ANGLE DOTS ACROSS THE FILM WIDTH AND LOCATE THE PRINCIPAL POINT WITH RESPECT TO THE SCAN ANGLE MARKS.

This is what is being
done to SU 14 for
for pan calibration
see Taylor or
Capt. ~~Colman~~
Dave Bingham
for details.
HBR

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CLASSIFIED BY eman 1
EXEMPT FROM GENERAL DECLASSIFICATION
SCHEDULE BY EXECUTIVE ORDER 11652
EXEMPTION CODES BY (1), (2), (3), OR (4)
AUTOMATICALLY DECLASSIFIED ON: _____
IMPOSSIBLE TO DETERMINE

WARNING NOTICE - SENSITIVE INTELLIGENCE
SOURCES AND METHODS INVOLVED.

WINDLE VIA BYEMAN
CONTROL SYSTEM ONLY

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COPY 1 OF 5 COPIES

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PRO-A-14

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MENSURATION IMPROVEMENTS

<u>ERROR SOURCE</u>	<u>MENSURATION ERROR - MICRONS (1 - SIGMA)</u>			
	<u>In-Track</u>		<u>Cross-Track</u>	
	<u>Present</u>	<u>Improved</u>	<u>Present</u>	<u>Improved</u>
1. SCAN ANGLE ACCURACY	--	--	10.0	5.0
2. FIDUCIAL DOT COORDINATE MEASUREMENT	11.0	2.0	11.0	2.0
3. FILM DISTORTION AND VELOCITY ERROR	2.9	1.6	4.2	1.1
4. SCALE FACTOR	19.0	3.0	--	--

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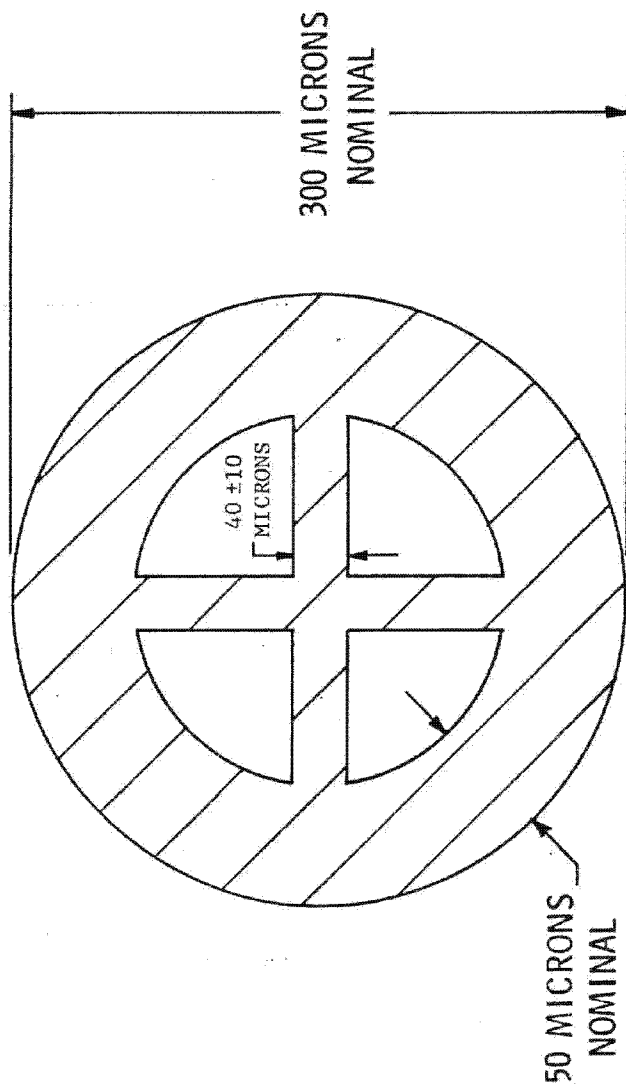
CONTROL POINT MENSURATION ERROR BUDGET SUMMARY

<u>ERROR SOURCE</u>	<u>ALLOCATED MENSURATION ERROR</u> (1-sigma)	
	<u>In-Track</u> (microns)	<u>Cross-Track</u> (microns)
Optical Distortion	1.0	-
Principal Point Location*	1.0	-
Scan Angle Accuracy Relative to 0° Scan Dot	-	5.0
Location of Fiducial Dot Coordinate	2.0	2.0
Control Point Measurement	2.0	2.0
Skew Angle Error	-	7.0
Nonuniform Film Distortion	1.5	0.5
Focal Length and Scale Factor Error	5.0	-
Uncompensated Thermal Error in the Platen	1.5	-
Film Velocity Error	0.5	1.0
Platen Bearing Runout and Spin Axis Offset	1.5	1.5
Optical Bar Wobble and Vibration of Optical Elements	4.0	-
Attitude Rate Transient Error	1.5	1.5
Total RSS	7.8	9.5

* Assuming 0.02 inch, 1-sigma error in location of principal point.

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FIDUCIAL MARK

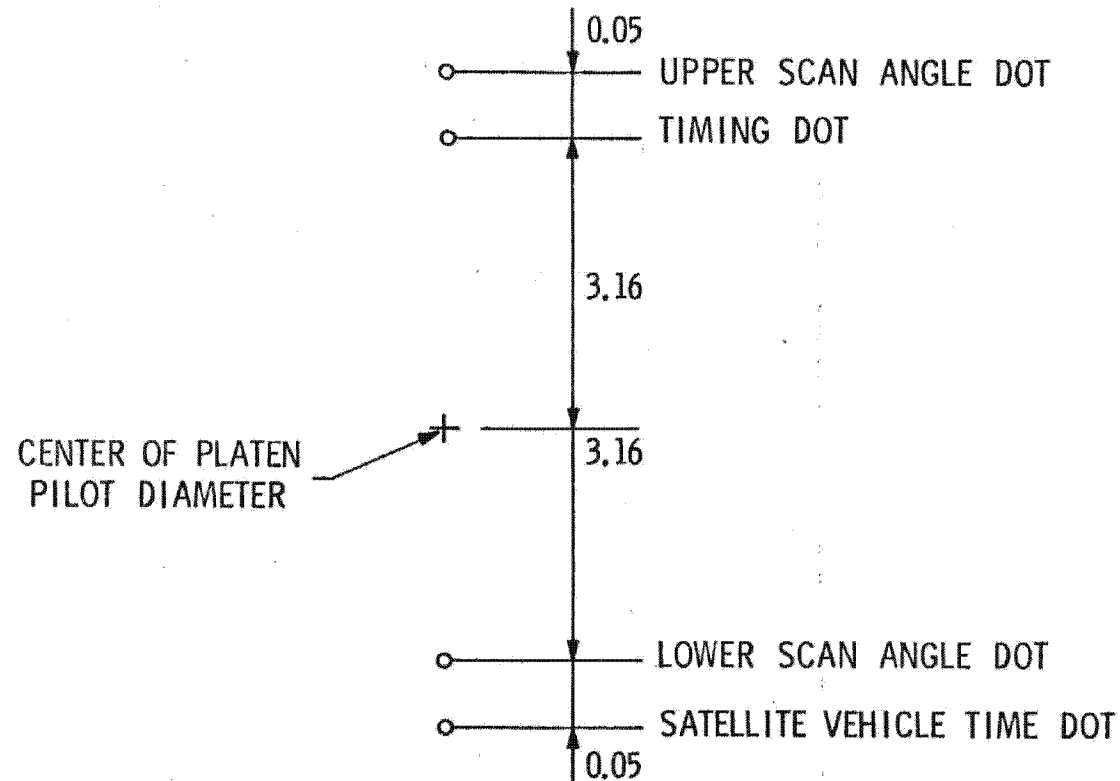


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FIDUCIAL DOT LOCATION IN IN-TRACK DIRECTION



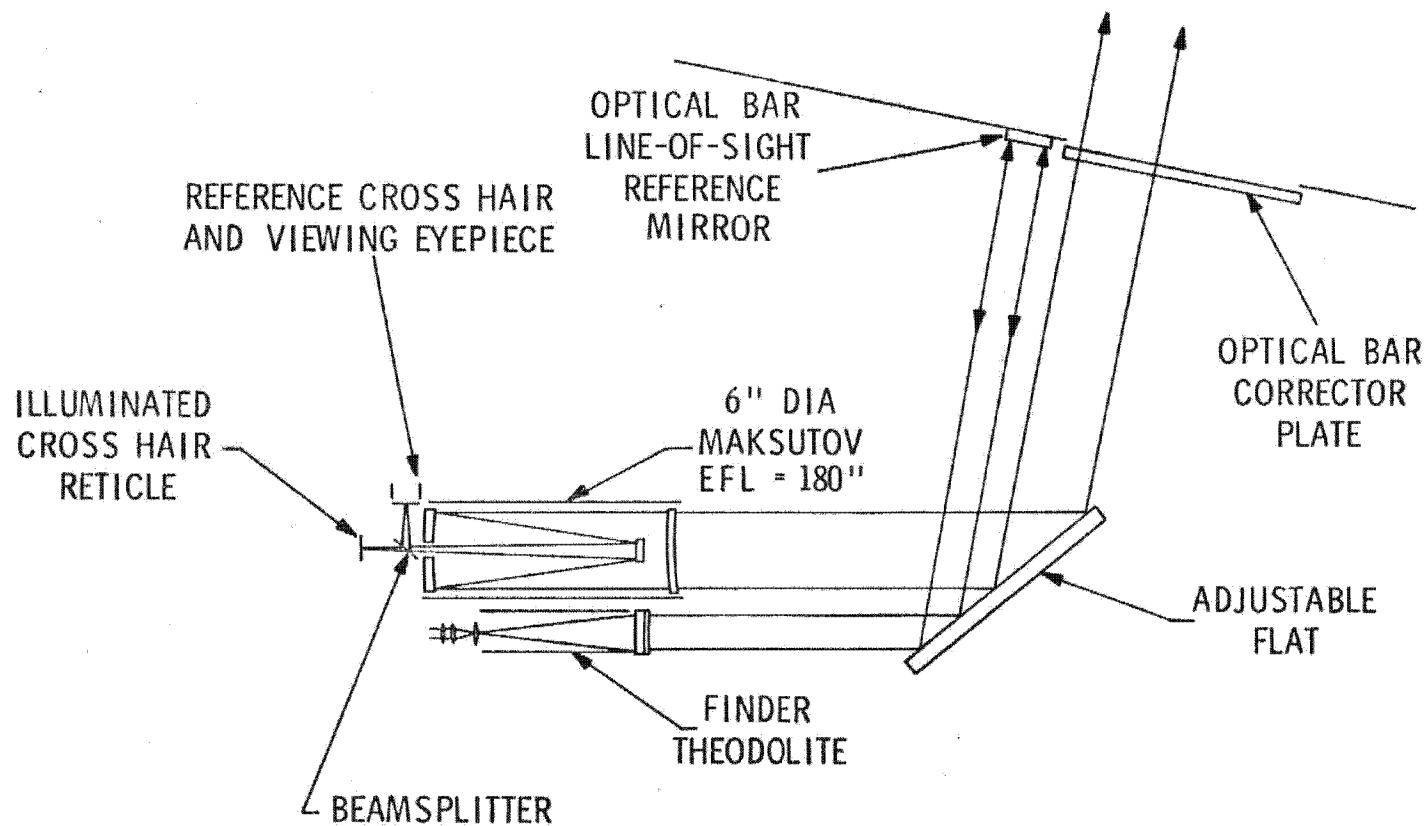
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PROPOSED ARRANGEMENT FOR PRINCIPAL POINT CALIBRATION



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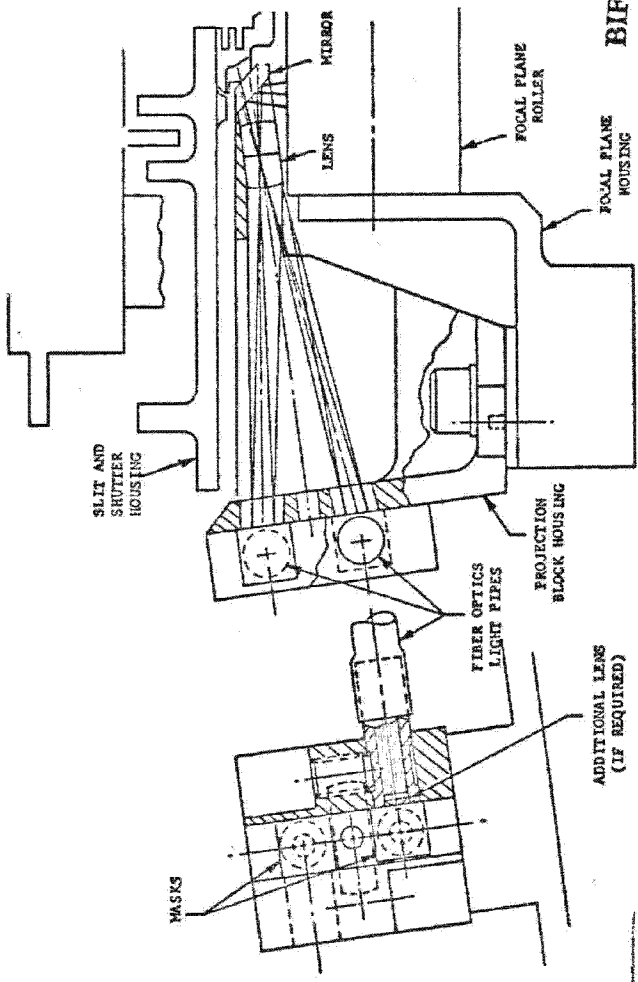
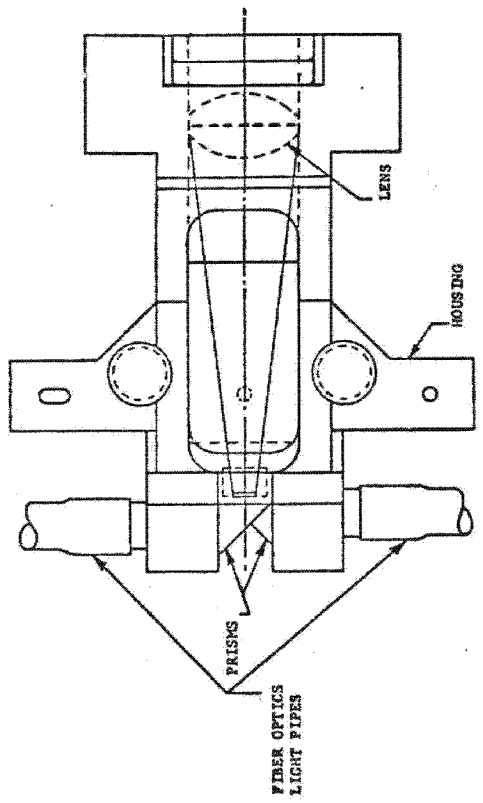
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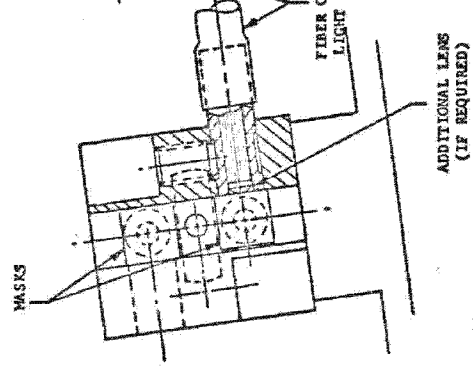
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TOP VIEW



LONGITUDINAL SECTION



END VIEW

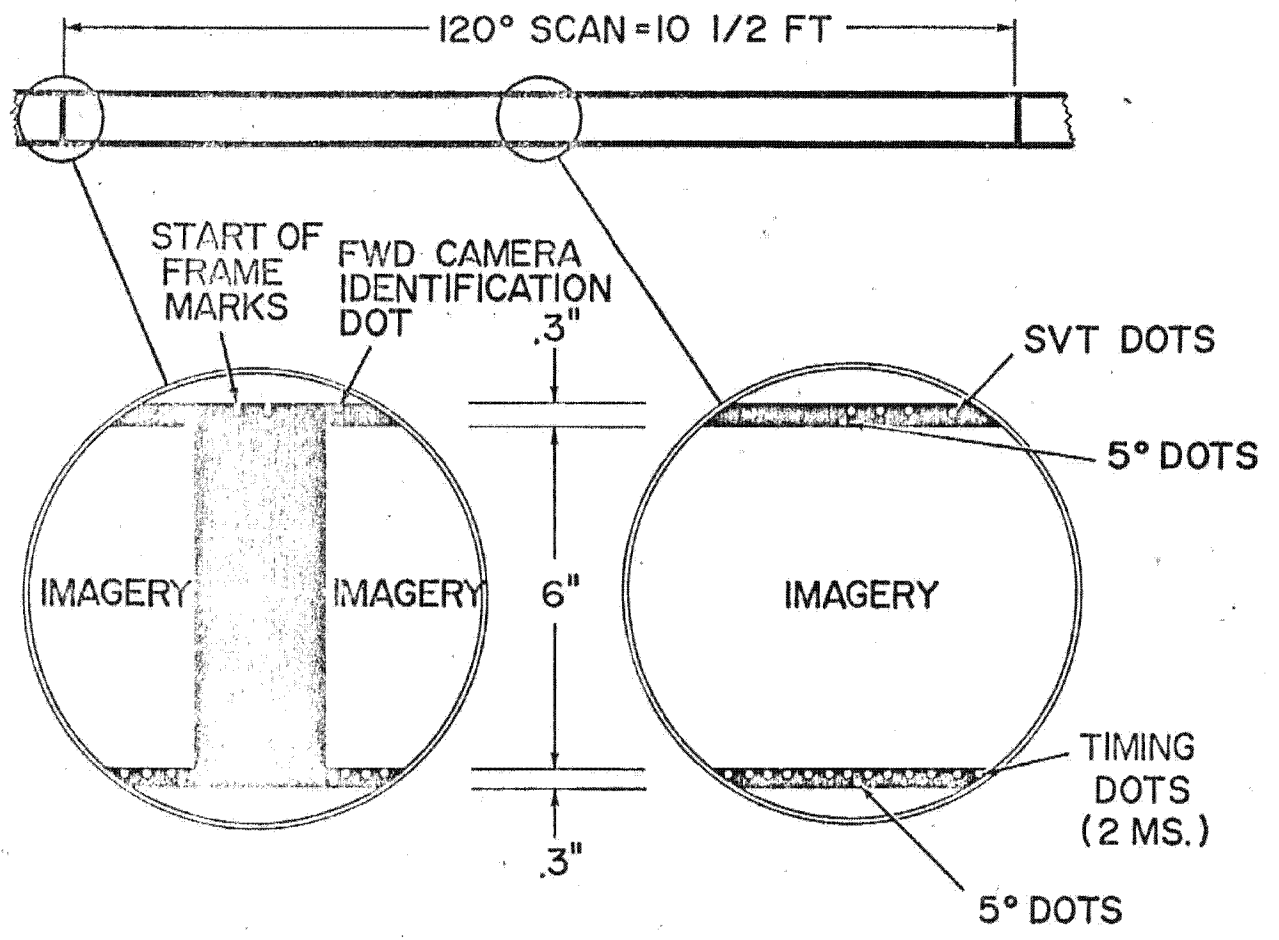
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FILM FORMAT DETAILS (DUPLICATE POSITIVE)



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1974

1975

M A M J J A S O N D J

1. IMPROVED FIDUCIAL MARKS

a. DESIGN, BUILD AND TEST
PROTOTYPES.



b. BUILD AND INSTALL ON
P-14 (TCA).



2. CALIBRATION OF OB ENCODERS

a. DEVELOP CALIBRATION
PROCEDURE, TEST EQUIP-
MENT AND SOFTWARE.



b. CALIBRATE P-14 ENCODERS.



c. INSTALL ON P-14 (OB's)

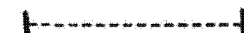


IN-TRACK CALIBRATION OF SCAN
ANGLE DOTS

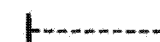
a. DESIGN AND FABRICATE TEST
EQUIPMENT.



b. TEST PL ASSEMBLIES.



c. MS TEST.



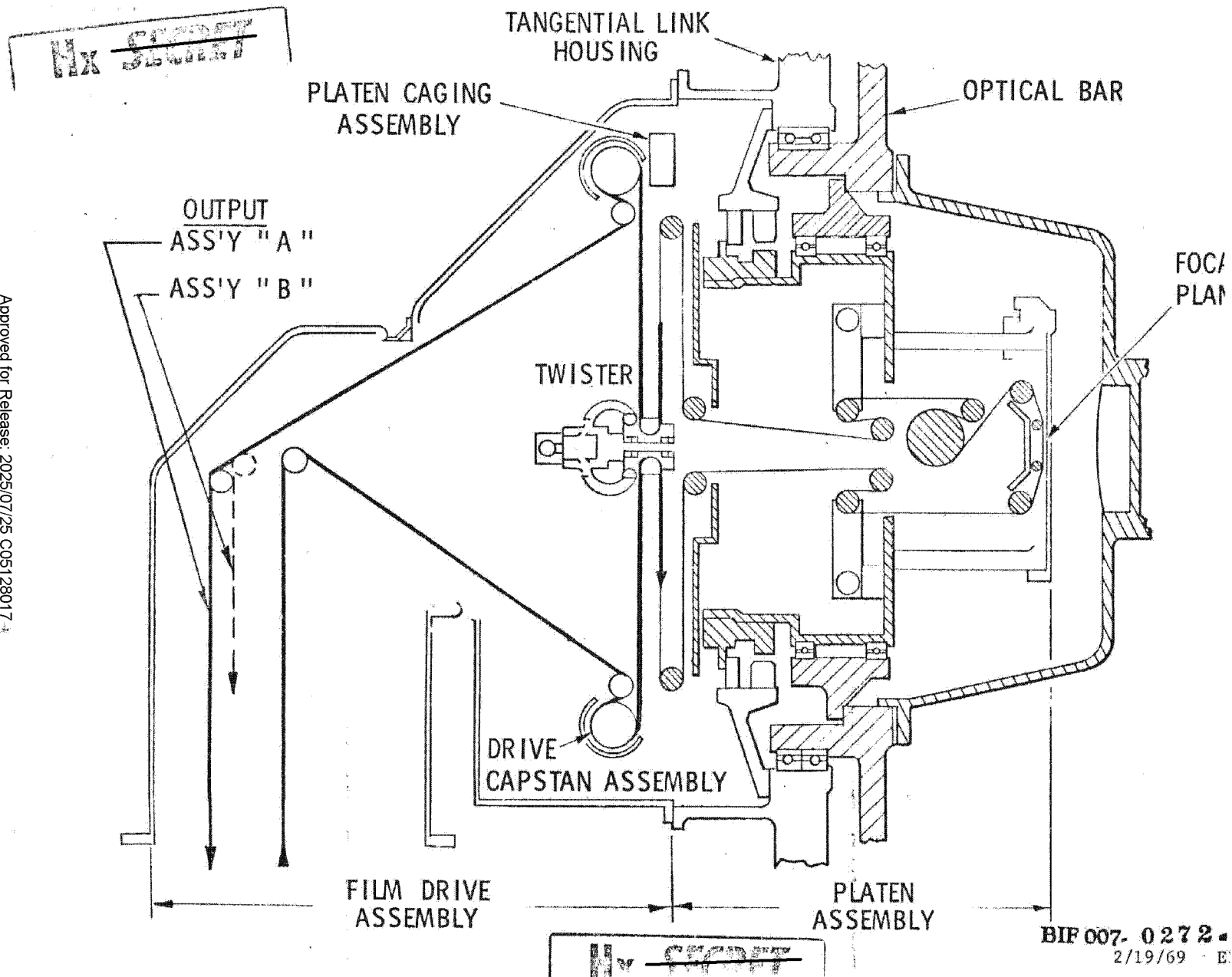
4. 1° SCAN DOT INTERVAL



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SCHEMATIC OF FILM DRIVE, PLATEN AND OPTICAL BAR INSTALLATION



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DMA's

5 Dec 74.

(\$ in millions)

<u>PRICES</u>	'75	'76	'77	'78	'79	'80
Keep line open	.9	.7				
SAP Study	.5					
MCS Mod. Capacity	.9	.9	.1			
MCS UTBF						
Geo. Pac. 3 more veh integration		1.0	1.25	.25	.25	.25
Studies (P)		2.0	2.0			
+ Procurement				?	?	?
MCS Option		9.7	9.7	2.0	2.0	2.0
MCS 2 shift makeup		1.2				
SAP Option		6.0 4.65	6.0 2.5 8.5	5.0 6.0	2.0 2.5	2.0 —

<u>OPTIONS</u>						
MCS only + MOO	.9	13.6	13.1	2.25	2.25	2.25
SAP only + MOO	1.4	9.9	9.35	5.25	2.25	2.25
Both	1.4	19.6	19.05	7.25	4.25	4.25
Optional no decision row						
- MCS	2.3	15.5	13.1	2.25	2.25	2.25
- SAP	2.3	10.6	9.35	5.25	2.25	2.25