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PRELIMINARY
Working Material

FINAL REPORT

OF

MANAGEMENT AND CONTRACTING EVALUATION GROUP
FOR PROCURING A STAR SENSOR SUB-SYSTEM

INTRODUCTION

This report is a supplement to "Final Report of Star Sensor Assembly Evaluation Group" dated 15 March 1976. This report consists of six parts. The first part is a brief summary of facts gathered and conclusions drawn by the SSA Evaluation Group. Parts II through V contain background, management concerns, various contract approaches and conclusions drawn by the Management and Contracting Evaluation Group. The sixth part is a copy of the briefing charts used by this group to brief Major General Kulpa on the results of the evaluation.

PART I

The Star Sensor Assembly Evaluation Group was formed at the request of Major General Kulpa to evaluate the capability of "off-the-shelf" Star Sensor Assembly (SSA) to fulfill the Hexagon Program's mapping requirements for Vehicle 17 and up. Based upon the group's evaluation, it was concluded that the SSA could not be eliminated as a possible contender to fulfill the DMA requirements for the Hexagon metric pan camera system. However, it was also recognized that time and lack of data left many significant areas only superficially reviewed and should a decision be made to pursue a more definitive proposal for the SSA use, the following areas required additional attention:

1. Adequacy of vehicle [redacted] (b)(1) (b)(3)

2. Impact of [redacted] on vehicle power budget.

3. The method, accuracy and mission impact of calibration of the overall system.

4. Signal/noise analysis of SSA operating at 6.5 MV.

5. Possibility of reducing SSA detection capability below the 6.5 MV thereby increasing star acquisition rate and lowering dependence on gyros.

6. Capability of any proposed system to fulfill the overall system requirements with special emphasis on the 3 arc sec relative accuracy.

In the process of performing the technical evaluation of the SSA, it became apparent that certain management and contractual factors also required attention. Some of the concerns were verbally addressed

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during the preliminary briefing on 11 March 1976. As a result of this briefing, General Kulpa requested another group be formed to evaluate the management and contracting factors associated with contracting for a star sensor sub-system on a competitive basis, i.e., Solid State Stellar (S^3) and SSA systems.

PART II

The Management and Contracting Evaluation Group was formed to evaluate:

1. Reasons S^3 was originally considered to be a selected source.

2. Various contract approaches that could be taken to effect a competition for the procurement of the systems from PE or Bendix-Itek.

3. Opening the competition for the procurement of a system to all qualified sources.

4. In conjunction with the above, procurement lead times and development/production schedules of the total Hexagon system.

PART III

A. BACKGROUND

1. In the summer of 1974, SAFSP, DMA, Aerospace and SAFSS personnel reviewed a number of proposed methods of determining Hexagon vehicle attitude to meet DMA mapping requirements. Basic conclusions made from this review were:

a. Slit-type star-tracker attitude reference cameras (SSA basic design) could meet the pointing accuracy requirements only with extensive integration effort with the vehicle [redacted] This was considered unacceptable. (b)(1) (b)(3)

b. Film stellar cameras which would either image stars on Hexagon intra-op film or on a separate film web were considered but were determined to have an unacceptable impact on the host vehicle.

c. The Solid State Stellar (S^3) Camera concept had the potential to meet the accuracy requirements and was the only candidate which met the criteria for minimal impact on the current Hexagon vehicle.

2. After evaluating the S^3 concept further, SAFSP concluded that the S^3 cubed camera was a high risk development program due to its use of Charge Coupled Devices (CCD's) as the focal plane. In addition, the whole concept that the panoramic camera line of sight was stable to a 5 arc-second accuracy appeared to be a high risk assumption. For these and other concerns, the recommendation was made that S^3 not be implemented. This recommendation was made by SAFSP to SAFSS during the fall of 1974.

3. Based on these concerns for the S^3/Panoramic Metric Pan concept, SAFSS requested a study be performed to evaluate the risks involved. This study was initiated in November 1974 and was intended for completion by July 1975, so a decision for SV-17 and SV-18 mapping requirements could be made. Shortly after the study was begun, direction was received stating that S-Cubed implementation would be no earlier than Block IV so the study completion date was changed to 1 January 1976 and made more comprehensive.

4. In February 1975, the Star Sensor Assembly (SSA) to be used by another program was reviewed by SAFSP with LMSC and customer personnel. This device was determined to be similar to the hardware reviewed in 1974 and would have the same problems meeting accuracy requirements without extensive integration with [redacted] on the Hexagon vehicle. In addition, the problems being experienced by the SSA at that time concerning cost, schedule, and performance did not make it appear as an attractive alternative. (b)(1) (b)(3)

5. Prior to completing the S^3 risk evaluation but after extensive effort had been completed (November 1975), the Staff requested a risk evaluation on the S-Cubed concept. A revised risk assessment (i.e., S^3 was now considered a low risk project) combined with other factors resulted in the following direction to SAFSP.

a. Cancel Itek mapping cameras for SV-17 and SV-18, and

b. Continue MPS work to assure SV-17 implementation with the proviso that not more than $1 million be expended until SAFSS reviewed the mapping requirement and alternatives further with DMA. The final decision has been delayed from February 1976 until 1 April 1976.

B. SELECTED SOURCE CONSIDERATIONS FOR S^3

1. After the decision to cancel SV-17 and -18 mapping cameras, SAFSP looked at the justification for continuing what had evolved as a selected source procurement. Sufficient justification was considered to be available for the following reasons:

a. Only S^3 appeared as a workable concept that had been verified by detailed study and still met the criteria of minimal impact on the host vehicle.

b. Perkin-Elmer had the best chance of meeting system performance objectives because:

(1) They had two years to study and understand the problem from a system standpoint.

(2) They would have overall performance responsibility for meeting the 5 arc-second system pointing accuracy.

(3) They have a 900-man task force capable of working any unforeseen problems in either the stellar camera or the panoramic camera.

c. Only Perkin-Elmer had the capability to continue to work the Metric Pan problem from November 1975 until SAFSS decides on a course of action with the limited dollars available. Perkin-Elmer is continuing with the sustaining engineering labor force available.

d. The sustaining engineering available at Perkin-Elmer made any alternative to S-Cubed questionable from a cost standpoint, especially if Block IV systems are considered without the non-recurring development costs.

e. Schedule requirements to meet a SV-17 effectivity were very tight, and open competition procurement schedule was considered to be prohibitive from a total program schedule standpoint.

PART IV

The following management concerns are presented to provide a summary of the problems this group feels are involved in achieving a metric panoramic capability.

A. SSA CONCEPT MATURITY

Use of the SSA as an attitude sensor for the Hexagon Program uses a totally different attitude determination concept than does S^3, and the SSA has significantly different impacts on the Hexagon Program. This group recommends a detailed study be performed on the SSA concept. The following is a list of areas of concern which have not been addressed adequately by the SSA Technical Evaluation Group and should be studied in more depth:

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(b)(3)

(b)(1)
(b)(3)

d. A total look at an integrated MPS using the SSA has not been performed to verify that the overall concept is sound. This study should also be performed.

3. Verification of 6.5 Star Magnitude Sensitivity. The ability to modify the SSA to detect 6.5 magnitude or greater is so important to this concept that this group feels this capability must be demonstrated or thoroughly evaluated through study.

4. Error Budget. Some of the pointing MPS error budget are interdependent on the star sensor and the panoramic camera. One example is the error in determining the interlock angle between the star sensor line of sight and the panoramic line of sight. This error is significant and needs further study for the SSA concept.

B. SCHEDULE

Meeting the SV-17 schedule is a concern since commitment to a metric pan program regardless of its form has seen so much delay. The current S^3 schedule is tight and further delay will jeopardize SV-17 effectivity. Changing to the SSA concept is an even more difficult schedule problem because of (1) concept study required, (2) procurement process delays involved, and (3) manufacturing lead time for the SSA (23 months from go-ahead). The schedule shown in Figure I-A is that currently being pursued for the S^3 sensor. Additionally, the SSA delivery schedule of 23 months is superimposed as is the 27 month Hexagon Program MOD II procurement time. (b)(1) (b)(3)

C. MPS INTEGRATION

Regardless which star sensor is used, an effective MPS integrating contractor is required. At this point, only Perkin-Elmer is considered to have the total understanding of the MPS concept and has the overall resources to assure success. This group feels that Perkin-Elmer is the only integrator which the government would be able to incentivize based directly on meeting DMA overall mapping requirements. Perkin-Elmer also would best be able to respond to new problems or requirements as the integrator.

PART V

A. CONTRACT APPROACHES

1. Taking into consideration the management concerns and the overall program schedule as set forth in the preceding parts, this group evaluated

various contract approaches that could be taken to effect a competition for the procurement of a star sensor sub-system. The basic ground rules and assumptions used were:

a. Decision defining approach required by 1 April 1976.

b. Star Sensor Sub-System hardware required by 1 July 1978 to avoid jeopardizing overall Hexagon Program schedule.

c. Launch date for SV-17 - Fall 1980.

2. Each approach was evaluated in detail and a list of pros and cons prepared for each. The approaches were:

a. Issue an RFP to all qualified sources, approximately 12, to provide a sub-system that would meet DMA's performance requirement. This approach was evaluated at some length but proved to be unfeasible based on the lengthy procurement cycle and production schedule (see Figures I-B and I-H).

b. Procure SSA from Bendix-Itek as a directed sub to P-E and have P-E integrate sub-systems hardware. Even though the approach is not a competitive procurement, it was evaluated and again proved to be unfeasible not only from a technical and schedule standpoint, but it would be impossible to justify exclusion of the S^3 sub-system from consideration (see Figures I-C and I-H).

c. Procure SSA direct from Bendix-Itek and provide to P-E as Government Furnished Equipment (GFE) for integration. Again, even though this approach is not a competitive procurement, it was evaluated and again proved to be unfeasible not only for the same reasons as stated in para b., above, but the government would be accepting full responsibility that the total system worked (see Figures I-D and I-H).

d. Issue an RFP to LMSC, as integrator, to provide a sub-system that would meet DMA's performance requirements. This approach showed merit over the first three approaches; however, from an overall management standpoint it was also considered to be unfeasible as it would be impossible to incentivize the accuracy of the sub-system by itself (see Figure I-E). In addition, the procurement cycle required to effect this approach still presents an overall schedule problem (see Figure I-H) and is not the most preferred approach.

e. Issue an RFP to P-E, as integrator, to provide a sub-system on a make or buy decision that would meet DMA's performance requirements. This approach, in addition to effecting a competition, was considered to be the most feasible of all, not only for the management concerns but provides a better understanding of overall systems requirements (see Figure I-E). However, even with this approach the total procurement cycle presents a slight problem (see Figure I-H).

The group also prepared a pro and con chart and procurement timeline for procuring the S^3 sub-system from P-E as a selected source to compare total time required to deliver a sub-system on or before 1 Jul 78 (see Figures I-G and I-H). Of all approaches evaluated, this is the most feasible based not only on the overall schedule considerations but it also increases the confidence in satisfying the DMA requirements.

B. CONCLUSIONS/RECOMMENDATIONS

Based upon the above, the group concluded that P-E is the only contractor that can integrate the sub-system/pan camera combination into the Hexagon metric pan camera system and that the S^3 and SSA systems cannot be competed effectively until the additional concept study ~~in~~ of the SSA is completed. Therefore, the conclusions and recommendations are to procure the S^3 sub-system from P-E as a selected source or recognize an overall program schedule impact if competition of a sub-system is effected.

FINAL REPORT

OF

STAR SENSOR ASSEMBLY

EVALUATION GROUP

15 MARCH 1976

FOREWORD

This report covers the facts, recommendations and data collected by the Star Sensor Evaluation Group established by Major Ceneral John E. Kulpa, Jr.

[redacted] Chairman

(b)(3)

Final Report

of

Star Sensor Assembly Evaluation Group

INTRODUCTION

This report consists of three parts. The first part is a brief summary of facts gathered and the conclusions drawn by the Group. The second part is a copy of the briefing charts used by the Group to brief General Kulpa on the results of the evaluation. To facilitate understanding of these charts, editorial comment for each has been added to the back of the previous chart. The third portion of the report is a copy of data provided by ITEK/ Bendix during and subsequent to the briefing presented on 5 March 1976.

PART I

The Star Sensor Assembly Evaluation Group was formed at the request of General Kulpa to evaluate the capability of the [redacted] (b)(1) (b)(3) [redacted] to fulfill the Hexagon program's mapping requirements for vehicle 17 and up. The ability of the Star Sensor Assembly, built by Bendix with ITEK as subcontractor for the telescope, to fulfill the Hexagon requirements was questioned because the [redacted] (b)(1) (b)(3) [redacted] the Hexagon vehicle is relatively

stable and slow moving, operating at a constant geocentric pitch rate.

Of course this worry fosters a host of subconcerns associated with the impact of design changes necessary to make the sensor work in a new application. These include such items as mounting requirements, mechanical and electrical modifications, and the error budget distribution throughout the overall system.

After a brief introduction by Lockheed Missile Space Company to the design and application of the Star Sensor Assembly, the Group approached the problem of understanding the basic requirements established by the Defense Mapping Agency (DMA) for the Hexagon system. These requirements reflect DMA's responsibility to provide precise geodetic positions of predetermined Department of Defense targets. In anticipation of advanced ICBM system (MX) requirements, DMA has been tasked to achieve, as a technical objective, point target positioning accuracies to within 23 meters horizontal circular error, 90 percent reliable, and 17 meters vertical linear error, 90 percent reliable.

To satisfy these requirements with the Hexagon pan cameras, it is necessary that the system provide:

(a) Attitude rate of 1.5 arc sec/sec continuous, (b) Satellite Vehicle (SV) orbital position to 30 feet in-track, cross-track and radially, (c) 10 micrometers limitation on film

distortions, (d) a one-tenth millisecond film exposure-time resolution granularity, and (e) an absolute attitude error of each camera line-of-sight less than 5 arc seconds. These are all one sigma numbers and represent a formidable challenge to any system.

As the Group investigated the impact of these requirements to the Star Sensor Assembly application, still another criterion not previously addressed was defined. This requirement, established by DMA, was for the relative attitude of each camera line-of-sight to be determined to less than 3 arc seconds for any given set of stereo exposures.

The 5 arc seconds absolute attitude and the 3 arc seconds relative attitude error requirements are the driving functions for a star sensing device/panoramic camera system design.

After evaluating the necessity of the Star Sensor Assembly to provide the close coupling required between itself and the TCA the group concluded that the SSA would have to be mounted to the TCA. It was concluded that attempts to mount on the vehicle longerons, would be complicated by undefinable motions between the SSA and the TCA, e. g. thermal hot-dogging.

The ability to closely couple the Star Sensor Assembly to the vehicle attitude using the existing [redacted] as suggested in the baseline approach of ITEK/Bendix, was evaluated. (b)(1) (b)(3)

The degree of interdependence between the star sensing device and the vehicle attitude is directly related to the rate at which the sensor acquires stars. The electronic modifications proposed by ITEK/Bendix to the Star Sensor Assembly increases its star acquisition rate by nearly an order of magnitude. This is accomplished by allowing the SSA to sense stars of about 6.5 magnitude visual (MV) versus [redacted] (b)(1) (b)(3) [redacted] After evaluating the impact of the proposed change to the electrical design and concluding that it appeared feasible, the Group had the task of adjudicating the capabilities of the modified design. An analyses was run using the re-designed reticle pattern proposed by ITEK/Bendix which substantiated the fact that star crossing would typically occur at somewhat less than 10 second intervals.

A first order evaluation of the suitability of the existing [redacted] (b)(1) (b)(3) determination to keep track of the TCA attitude between these infrequent star sightings was conducted. It was concluded that the existing [redacted] specifications would not guarantee sufficient precision. (b)(1) (b)(3)

Limited data do exist that indicate the existing [redacted] (b)(1) (b)(3) perform considerably better than specification. If the specifications were tightened and made appropriate for this purpose, which appears feasible, the question of alignment/ stability between the [redacted] and the SSA mounted on the (b)(1) (b)(3)

TCA would remain unanswered. Tests, studys and/or modeling might resolve this dilemma but time limitations dictated that the Group leave it as an open question. The Group elected to evaluate an alternative approach which was recognized by ITEK/Bendix as a fall-back position. This approach includes mounting a dedicated [ ] reference assembly in close proximity to the SSA. The addition of a [ ], which could be procured by Bendix or the integrating contractor, was considered a viable option to satisfy the system requirements and obviate the dependence on the [ ]. To thoroughly evaluate possible impacts (weight, space, and power) of a [ ] package on the vehicle requires a vendor survey and an evaluation by the integrating contractor. However, a cursorary review by the Group indicated the possibility that an acceptable [ ] might be found.

(b)(1)
(b)(3)
(b)(1)
(b)(3)
(b)(1)
(b)(3)

Based upon these steps the Group concluded that the SSA could not be eliminated as a possible contender to fulfill the DMA requirements for the Hexagon metric pan camera system. The Group recognizes that time and lack of data left many significant areas only superficially reviewed. Should a decision be made to pursue a more definitive proposal for the SSA use, it is suggested that the following areas be given additional attention:

(a) Adequacy of [ ]

(b) Impact of [ ] on vehicle power budget.

(b)(1)
(b)(3)

(c) The method, accuracy and mission impact of calibration of the overall system

(d) Signal/noise analysis of SSA operating at 6.5 MV

(e) Possibility of reducing SSA detection capability below the 6.5 MV thereby increasing star acquisition rate and lowering dependence on [redacted] (b)(1) (b)(3)

(f) capability of any proposed system to fulfill the overall system requirements with special emphasis on the 3 arc sec relative accuracy.

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REPORT

OF

STAR SENSOR ASSEMBLY EVALUATION

11 MARCH 1976

~~SECRET/H~~ [redacted]

(b)(1)
(b)(3)

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(b)(3)

COMMENTS

[redacted] WAS REQUESTED BY GENERAL KULPA TO FORM THE STAR SENSOR ASSEMBLY (SSA) EVALUATION GROUP. THE PURPOSE OF THE GROUP WAS TO PROVIDE AN UNBIASED TECHNICAL EVALUATION OF THE CAPABILITY OF THE BENDIX/ITEK STAR SENSOR ASSEMBLY, [redacted], TO FULFILL THE HEXAGON PROGRAM'S MAPPING REQUIREMENTS FOR VEHICLE 17 AND UP.

THE MOST SIGNIFICANT DATA THE GROUP RECEIVED WAS THE LOCKHEED MISSILE AND SPACE COMPANY [redacted] BRIEFING ON 27 FEBRUARY 1976 COVERING [redacted] AND THE COMBINED BENDIX/ITEK BRIEFING ON 5 MARCH 1976.

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SUMMARY OF EVENTS

DATE	EVENT
24 FEB	INITIAL MEETING WITH COL ANDERSON
26 FEB	APPROVAL OF SELECTED BOARD MEMBERS
27 FEB	STAR SENSOR ASSEMBLY BRIEFING BY LMSC
1 MAR	TEAM ASSIGNMENTS AND BRIEFINGS
	* SECURITY - [redacted] SP-3 (b)(3)
	* S^3 SYSTEM [redacted] SP-7
2 MAR	DMA REQUIREMENTS - [redacted]
	TWX SENT TO ITEK DELINEATING TECHNICAL QUESTIONS OF GROUP
	DISCUSSION WITH LOCAL ITEK REP - [redacted]
4 MAR	ADDITIONAL DISCUSSIONS ON REQUIREMENTS - [redacted] (DMA)
5 MAR	ITEK PRESENTATION AND TECHNICAL WORKING SESSION
8 MAR	FORMULATION OF COMMITTEE CONCERNS AND ASSIGNMENTS FOR INVESTIGATION

~~SECRET/H~~[redacted] HANDLE VIA BYEMAN

[redacted] (b)(1) (b)(3)

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COMMENTS

PERSONNEL FROM ALL MAJOR DISCIPLINES REQUIRED FOR EVALUATION OF THE SSA WERE SELECTED FROM AIR FORCE/AEROSPACE/DEFENSE MAPPING AGENCY. WITH THE EXCEPTION OF [redacted] AND DR. LARKIN, WHO WERE CONSIDERED NECESSARY TO PROVIDE CONTINUITY, EMPHASIS WAS PLACED ON SELECTING PERSONNEL WHO HAD NOT BEEN DIRECTLY ASSOCIATED WITH THE PERKIN-ELMER SOLID STATE STELLAR STUDY EFFORT.

(b)(3)

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TEAM COMPOSITION

NAME	OFFICE	DISCIPLINE
[redacted]	[redacted]	CHAIRMAN
COL J.R. BLANKENSHIP	SS	ASST CHAIRMAN
[redacted]	[redacted]	REQUIREMENTS
	DMA	REQUIREMENTS
	[redacted]	PROCUREMENT
		TT&C/SYS ENGINEERING
	SP-7	OPTICS/SYS ENGINEERING
	AEROSPACE SUBDIVISION	TECHNICAL CHAIRMAN
	" "	CONTROL THEORY
	" "	OPTICS
	" " (A-17)	SYSTEM ENGINEERING
	" SUBDIVISION	CONTROL SYSTEMS
	" LABS	ELECTRONICS
	" "	SSA EXPERIENCE
DR B.K. LARKIN		
[redacted]	[redacted]	

(b)(1)
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(b)(3)

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COMMENTS

AS THE EVALUATION PROCEEDED, IT BECAME EVIDENT THAT THE PROBLEM HAD THREE MAJOR FACETS. FIRST, WAS THE REQUIREMENTS, WHICH UNTIL THE EVALUATION GROUP BEGAN TO FOCUS ATTENTION ON THEM, WERE NOT TOTALLY DELINEATED. SECOND WAS THE TECHNICAL EVALUATIONS WHICH DEALT MAINLY WITH THE ABILITY OF THE STAR SENSOR ASSEMBLY IN CONJUNCTION WITH THE HEXAGON PANORAMIC CAMERA TO PROVIDE SUFFICIENT ACCURACY TO FULFILL THE DEFENSE MAPPING AGENCY'S REQUIREMENTS. AND FINALLY, A CURSORY ANALYSIS OF THE POSSIBLE CONTRACTUAL IMPLICATION OF USING THE BENDIX/ITEK, STAR SENSOR ASSEMBLY ON THE HEXAGON VEHICLE.

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OVERVIEW

REQUIREMENT

TECHNICAL BRIEFING

CONTRACTUAL ASPECTS

LT/COL LEHMANN

[redacted] (b)(3)

~~SECRET/H~~ [redacted] (b)(1) (b)(3)

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COMMENTS

THE ATTITUDE RATE OF THE SYSTEM MUST BE KNOWN ON A CONTINUOUS BASIS TO 1.5 ARC SECONDS/SECOND AT ONE SIGMA. THIS CAPABILITY EXISTS NOW.

THE POSITION OF THE VEHICLE MUST BE KNOWN FOR EACH PHOTOGRAPHIC EXPOSURE TO WITHIN 30 FEET, ONE SIGMA, IN-TRACK, CROSS-TRACK, AND RADIALLY. THIS WILL BE POSSIBLE WITH NAVPAC EFFECTIVE WITH SV-13.

THE PAN SENSOR MUST BE CALIBRATED SO THAT PHOTOGRAPHIC DISTORTIONS CAN BE REMOVED TO PERMIT THE LOCATION OF A POINT ON THE FILM FORMAT TO AN ACCURACY OF 10 MICROMETERS, ONE SIGMA, IN BOTH THE IN-TRACK AND CROSS-TRACK DIRECTIONS. THIS IMPROVED CALIBRATION WILL BE AVAILABLE WITH SV-14.

THE EXPOSURE TIME OF ANY PORTION OF THE PAN PHOTOGRAPH MUST BE DETERMINED TO WITHIN 0.1 MILLISECONDS, ONE SIGMA. A TIE-IN BETWEEN THE NAVPAC CLOCK AND THE PAN CAMERA SYSTEM ON SV-14 WILL PROVIDE THE CAPABILITY.

THE ABSOLUTE ATTITUDE OF EACH PAN SENSOR LINE-OF-SIGHT MUST BE KNOWN TO WITHIN 5 ARC SECONDS, ONE SIGMA, WITH RESPECT TO THE THREE AXES OF THE LOCAL VERTICAL THROUGHOUT THE LIMITS OF THE SCAN. THE ONLY KNOWN WAY TO ACCOMPLISH THIS TYPE OF ACCURACY IS WITH A STAR SENSING DEVICE.

THE RELATIVE ATTITUDE OF ONE PAN SENSOR LINE-OF-SIGHT TO THE OTHER PAN SENSOR LINE-OF-SIGHT FOR ANY GIVEN SET OF STEREO EXPOSURES MUST BE KNOWN TO WITHIN 3 ARC SECONDS, ONE SIGMA, FOR EACH AXIS. THIS AGAIN IS A REQUIREMENT THAT FORCES CONSIDERATION OF A STAR SENSING DEVICE.

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METRIC PAN CAMERA SYSTEM REQUIREMENTS

PARAMETER	ACCURACY @ ONE SIGMA	AVAILABILITY
ATTITUDE RATE	1.5 ARC SEC/SEC CONTINUOUS	CURRENT CAPABILITY
SV ORBITAL POSITION	30 FEET	NAVPAC - SV 13
CAMERA CALIBRATION	10 MICROMETERS (FILM DISTORTIONS)	SV 14
FRAME EXPOSURE TIME	0.1 MILLISECOND	NAVPAC - SV 14
ABSOLUTE ATTITUDE OF EACH CAMERA LINE-OF-SIGHT	5 ARC SECONDS	STAR SENSOR - SV 17
RELATIVE ATTITUDE OF EACH CAMERA LINE-OF-SIGHT BETWEEN STEREO EXPOSURES	3 ARC SECONDS	STAR SENSOR - SV 17

~~SECRET/H~~ [redacted]

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COMMENTS

THE METRIC PAN SYSTEM (MPS) NEED NOT ACHIEVE EXACTLY A 23-METER HORIZONTAL AND 17-METER VERTICAL ACCURACY TO SUPPORT THE ICBM (MX) SYSTEM. THE DASHED LINE SHOWS THE 23/17 METER REQUIREMENT. THE HEAVY CURVED LINE FORMS AN ENVELOPE WITHIN WHICH THE REQUIREMENT MAY ALSO BE SATISFIED: E.G., IMPROVED ACCURACY IN THE HORIZONTAL DIRECTION WILL ALLOW COMPROMISING IN THE VERTICAL DIRECTION.

AN ABSOLUTE ATTITUDE ACCURACY OF 5 ARC SECONDS WITH A RELATIVE ATTITUDE ACCURACY OF 3 ARC SECONDS WILL SATISFY THE REQUIREMENT OUT TO 30 DEGREES OF SCAN IN EACH DIRECTION FROM NADIR. DMA HAS INDICATED THIS IS AN ACCEPTABLE LIMIT.

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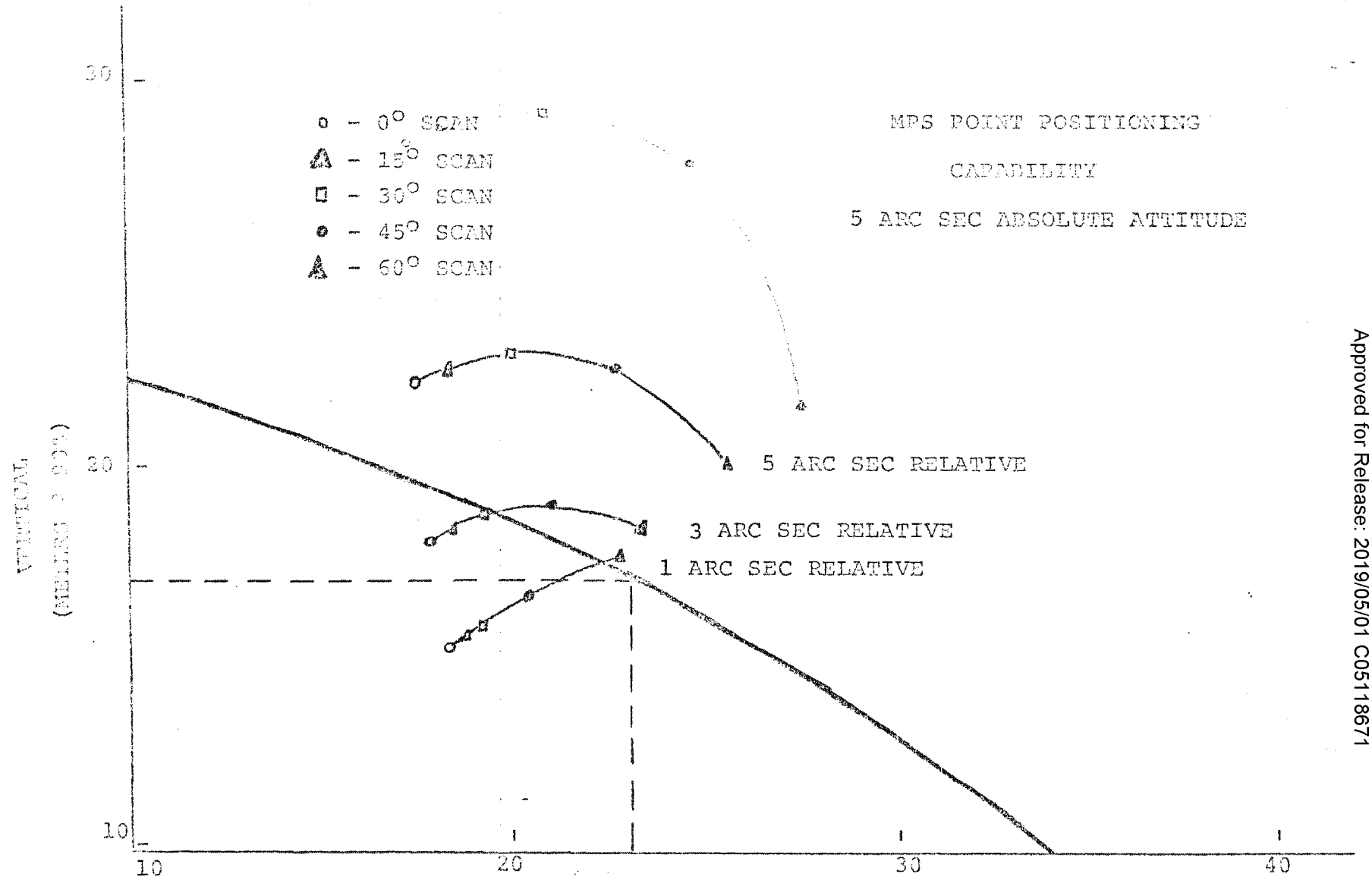

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COMMENTS

THE TEAM, DURING THE INVESTIGATION, SOUGHT TO UNCOVER POINTS OF INCOMPATIBILITY BETWEEN THE SSA AND THE H SYSTEM METRIC PAN APPLICATION. THESE ARE THE MAJOR AREAS PROBED. SINCE SOME OF THESE ARE NOT CLEARLY SEPARABLE, THE DISCUSSION IS NOT ORGANIZED SEQUENTIALLY BASED UPON THEM.

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TECHNICAL DISCUSSION

* OVERVIEW
* DESCRIPTION OF SSA
* PRINCIPAL TECHNICAL ISSUES AND CONCERNS
* FINDINGS

~~SECRET/H~~ [redacted]

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COMMENTS

THE INFORMATION AVAILABLE FOR REVIEW WAS LIMITED IN THAT THE CONTRACTORS, BENDIX AND ITEK, WERE NOT WORKING TO A CLEARLY DEFINED SET OF REQUIREMENTS FOR THE SYSTEM OR ITS ASSOCIATED INTERFACES. HOWEVER, BASED ON THE AVAILABLE INFORMATION, THE TEAM FOUND NO REASON FOR ELIMINATING THE SSA (MODIFIED) FROM CONSIDERATION. TO DEFINE THE EXTENT THE SSA WILL HAVE TO BE MODIFIED WILL REQUIRE (A) ADDITIONAL DATA ON VEHICLE [redacted] PERFORMANCE, (B) THE DIMENSIONAL STABILITY OF CERTAIN VEHICLE ASSEMBLIES, AND (C) A COMPLETE AND ACCURATE POINTING ERROR ANALYSIS. THE RESIDUAL CONCERNS REFERRED TO LIE LARGELY IN THESE AREAS. THESE DATA MAY ELIMINATE APPLICATION OF THE SSA IN ITS SIMPLEST FORM: HOWEVER THE TEAM BELIEVES THAT THE MOST MODIFIED CONFIGURATION, EMPLOYING ADDITIONAL DEDICATED [redacted] IS FEASIBLE.

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(b)(1)
(b)(3)

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TECHNICAL OVERVIEW

* BENDIX/ITEK REQUESTED CONSIDERATION OF USING [redacted] STAR SENSOR ASSEMBLY (SSA) IN THE H SYSTEM
* INDEPENDENT TEAM FORMED TO ASSESS TECHNICAL FEASIBILITY
* TEAM REVIEWED DMA REQUIREMENTS, THE SSA AND THE APPLICATION
* THE TEAM FINDS NO TECHNICAL GROUNDS FOR ELIMINATING THE SSA (MODIFIED) AS A VIABLE OPTION TO SATISFY THE METRIC PAN REQUIREMENTS
* MORE DETAILED STUDY IS REQUIRED TO RESOLVE RESIDUAL CONCERNS

~~SECRET H~~ [redacted]

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COMMENTS

THIS CHART PRESENTS THE AGENDA FOR THE TECHNICAL DISCUSSION.

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PRINCIPAL TECHNICAL ISSUES

* CONCEPT COMPATIBILITY - SSA DESIGNED FOR ANOTHER APPLICATION
* HARDWARE COMPATIBILITY - FORM, FIT AND FUNCTION; REQUIRED MODS; INTEGRATION
* PERFORMANCE COMPATIBILITY - MAPPING REQUIREMENTS SATISFACTION; ERROR ANALYSIS
* PRODUCT ACCEPTABILITY TO USER - SOFTWARE, DATA RATE, FORMAT
* RELIABILITY
* DEVELOPMENT STATUS/RISKS

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Approved for Release: 2019/05/01 C05118671

COMMENTS

THE SSA [redacted] IN THE HEXAGON APPLICATION, THE VEHICLE PITCH RATE IS CONSTANT AT 0.068 DEGREES PER SECOND AND THE ROLL AND YAW RATES ARE HELD ESSENTIALLY CONSTANT. THESE RATE DIFFERENCES GIVE RISE TO ALL OF THE REQUIRED DESIGN CHANGES IN THE SSA SENSOR.

IN BRIEF, THE DIFFERENCE BETWEEN THE SSA AND S^3 SYSTEMS IS DUE BASICALLY TO HOW STARS ARE SENSED. THE FIELD-OF-VIEW, VIEWING GEOMETRY, AND MOUNTING LOCATIONS OF THE TWO SYSTEMS ARE ESSENTIALLY THE SAME. THE MAIN PERFORMANCE DIFFERENCE BETWEEN THE TWO SYSTEMS IS THAT AN SSA DETECTS A STAR ON THE AVERAGE ABOUT EVERY 7 TO 8 SECONDS WHEREAS THE S^3 DETECTS A STAR EVERY SECOND. THE LOWER STAR SIGHTING RATE OF THE SSA SENSOR GIVES RISE TO THE REQUIREMENT THAT THE VEHICLE RATE BE DETERMINED ACCURATELY SO THAT THE ANGULAR DISPLACEMENT BETWEEN STAR SIGHTINGS CAN BE MEASURED. THE CURRENT SYSTEM SPECIFICATION, INCLUDING [redacted] IS ENTIRELY ADEQUATE FOR THE S^3 APPROACH.

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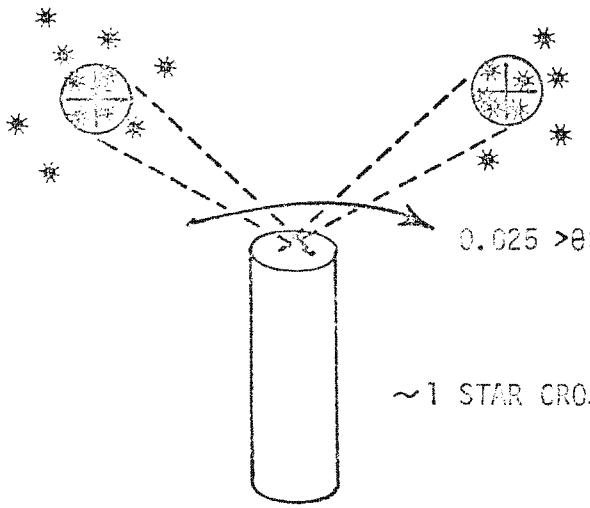
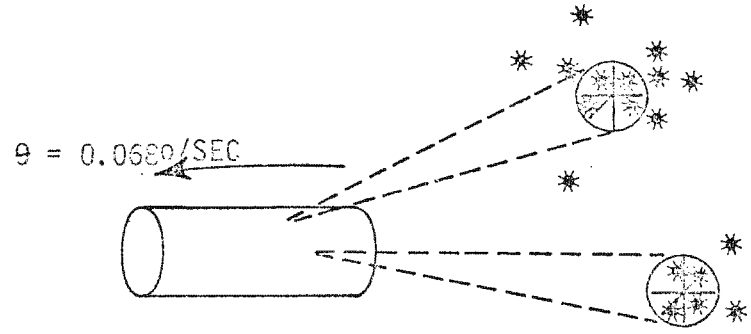
STAR SENSING CONCEPTS



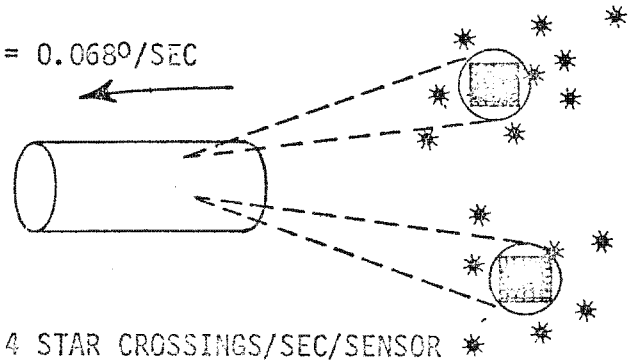
~1 STAR CROSSING/SEC/SENSOR

SSA = SLEWING VEHICLE



~.14 STAR CROSSINGS/SEC/SENSOR

SSA - STABILIZED VEHICLE



~1.4 STAR CROSSINGS/SEC/SENSOR

S^3 - STABILIZED VEHICLE

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COMMENTS

THE S^3 FOCAL PLANE CONSISTS OF SIX CCD ARRAYS CAPABLE OF PROVIDING TWO AXIS POSITIONAL INFORMATION. STAR SCAN IS AT 45 DEGREES TO THE ARRAYS. STAR CENTROID DETERMINATION IS PROVIDED VIA GROUND DATA PROCESSING OF TELEMETERED DATA.

THE SSA FOR THIS APPLICATION HAS A THREE SLIT CONFIGURED RETICLE IN THE FOCAL PLANE. STAR SCAN IS NORMAL TO THE SLIT WHICH BISECTS THE 90 DEGREE ANGLE FORMED BY THE REMAINING TWO SLITS. A STAR PULSE IS GENERATED WHEN A STAR ENTERS ANY SLIT ANYWHERE ALONG THE LENGTH OF THE SLIT. THE STAR ENERGY IS CONCENTRATED ONTO A PHOTOMULTIPLIER TUBE BY A LENS SYSTEM PLACED BEHIND THE SLITS. TRAILING EDGE TRANSIT TIME AND STAR MAGNITUDE DETERMINATION IS THEN TRANSMITTED TO THE GROUND STATION.

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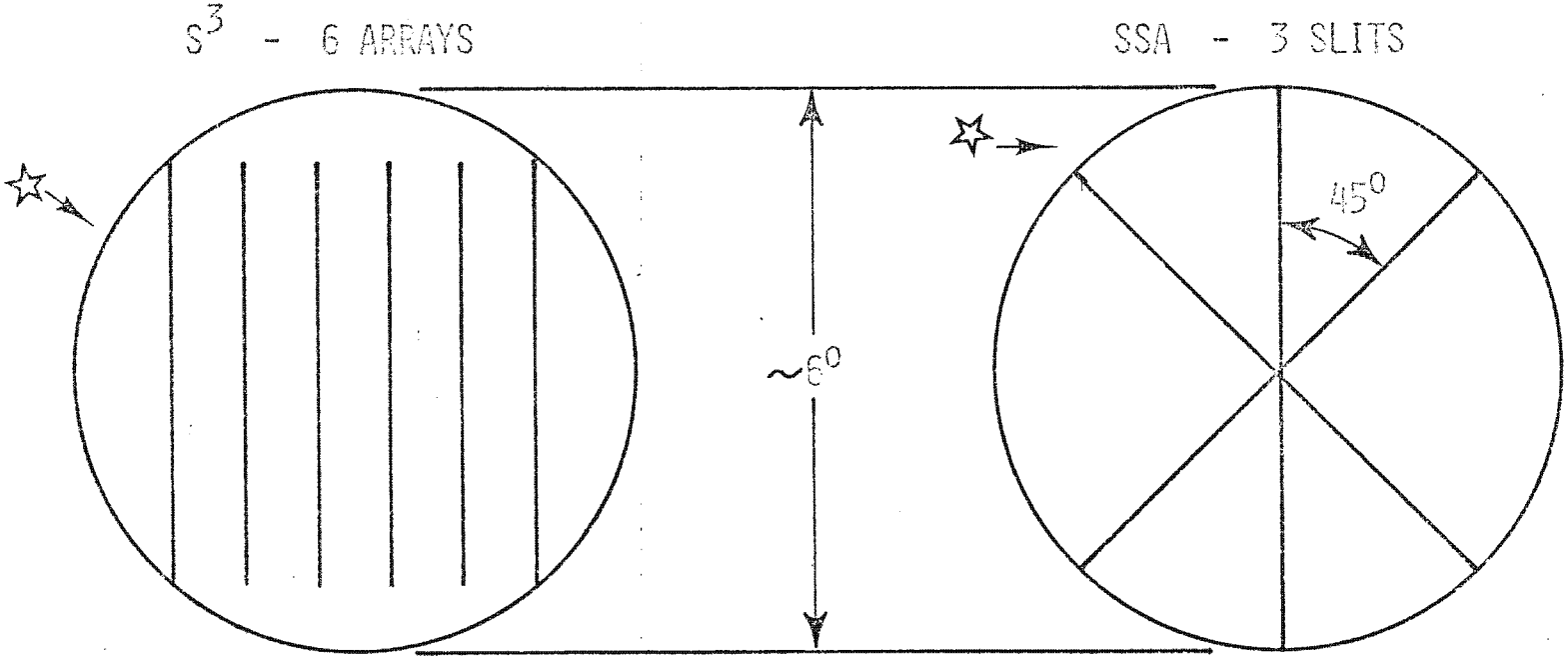

- CHARGE COUPLED DEVICE ARRAYS
- TWO AXIS INFORMATION
- CENTROID DETERMINATION BASED ON SIGNALS RECEIVED ON GROUND FROM SEVERAL DETECTOR ELEMENTS

- SINGLE PHOTOMULTIPLIER TUBE
- SINGLE AXIS INFORMATION ONLY
- TRANSIT TIME AND MAGNITUDE

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COMMENTS

THIS CHART DEPICTS THE AVERAGE CUMULATIVE NUMBER OF STARS WITHIN THE FIELD OF VIEW VS VISUAL STAR MAGNITUDE.

THE AVAILABILITY OF STARS FOR DETECTION AS A FUNCTION OF VISUAL STAR MAGNITUDE WAS CALCULATED VIA COMPUTER SIMULATION FOR TWO REPRESENTATIVE HEXAGON VEHICLE ORBITS. THE CALCULATED VIA COMPUTER SIMULATION FOR TWO REPRESENTATIVE HEXAGON VEHICLE ORBITS. THE 190 DEGREE AND 100 DEGREE RIGHT ASCENSION ORBITS ARE REPRESENTATIVE OF MAXIMUM AND MINIMUM STAR POPULATION CASES RESPECTIVELY. THE AVERAGE NUMBER OF STARS WILL INCREASE EXPONENTIALLY AS STAR MAGNITUDE INCREASES TO INCLUDE FAINTER STARS FOR STAR CROSSING APPLICATION.

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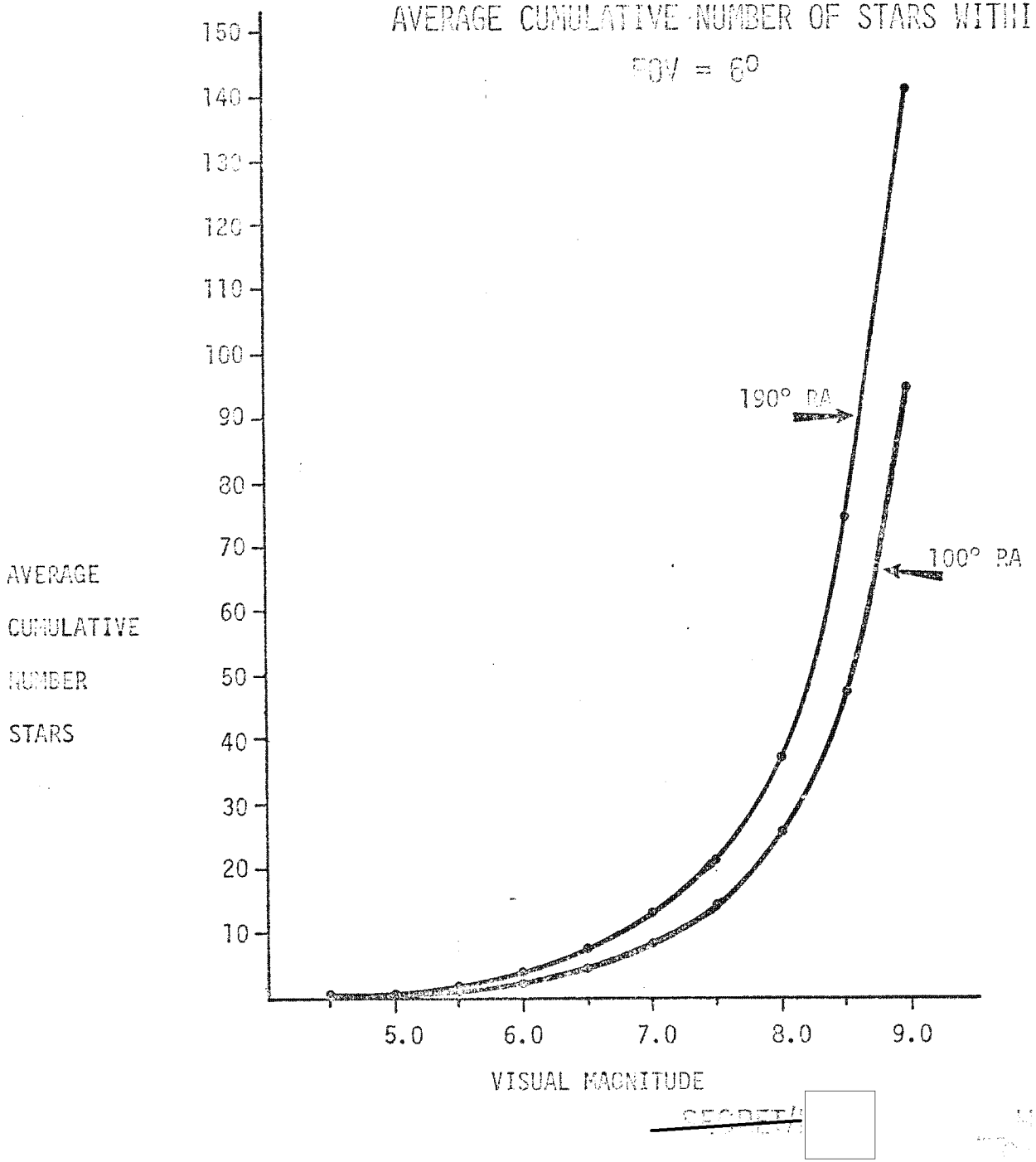

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COMMENTS

THE AVERAGE TIME BETWEEN STAR SIGHTINGS VS MAGNITUDE IS PROVIDED FOR THE 190 DEGREE RIGHT ASCENSION ORBIT FOR THE SSA AND S^3 SYSTEMS. FOR THE SSA OPERATING AT THE CONTRACTOR SUGGESTED 6.5 MAGNITUDE, STAR CROSSINGS WILL AVERAGE APPROXIMATELY ONE EVERY SEVEN SECONDS. WITH THE S^3 SYSTEM WHICH OPERATES AT 7.6 MAGNITUDE, STAR SIGHTINGS WILL OCCUR APPROXIMATELY EVERY ONE SECOND. CLEARLY, IF THE SSA WERE TO OPERATE AT THE 7.5 MAGNITUDE, THE TIME BETWEEN SIGHTINGS WOULD BE SIGNIFICANTLY REDUCED.

FOR REFERENCE, AN ADDITIONAL CURVE IS PROVIDED FOR THE S^3 SYSTEM WITH STAR SCAN NORMAL TO THE CCD ARRAY PATTERN.

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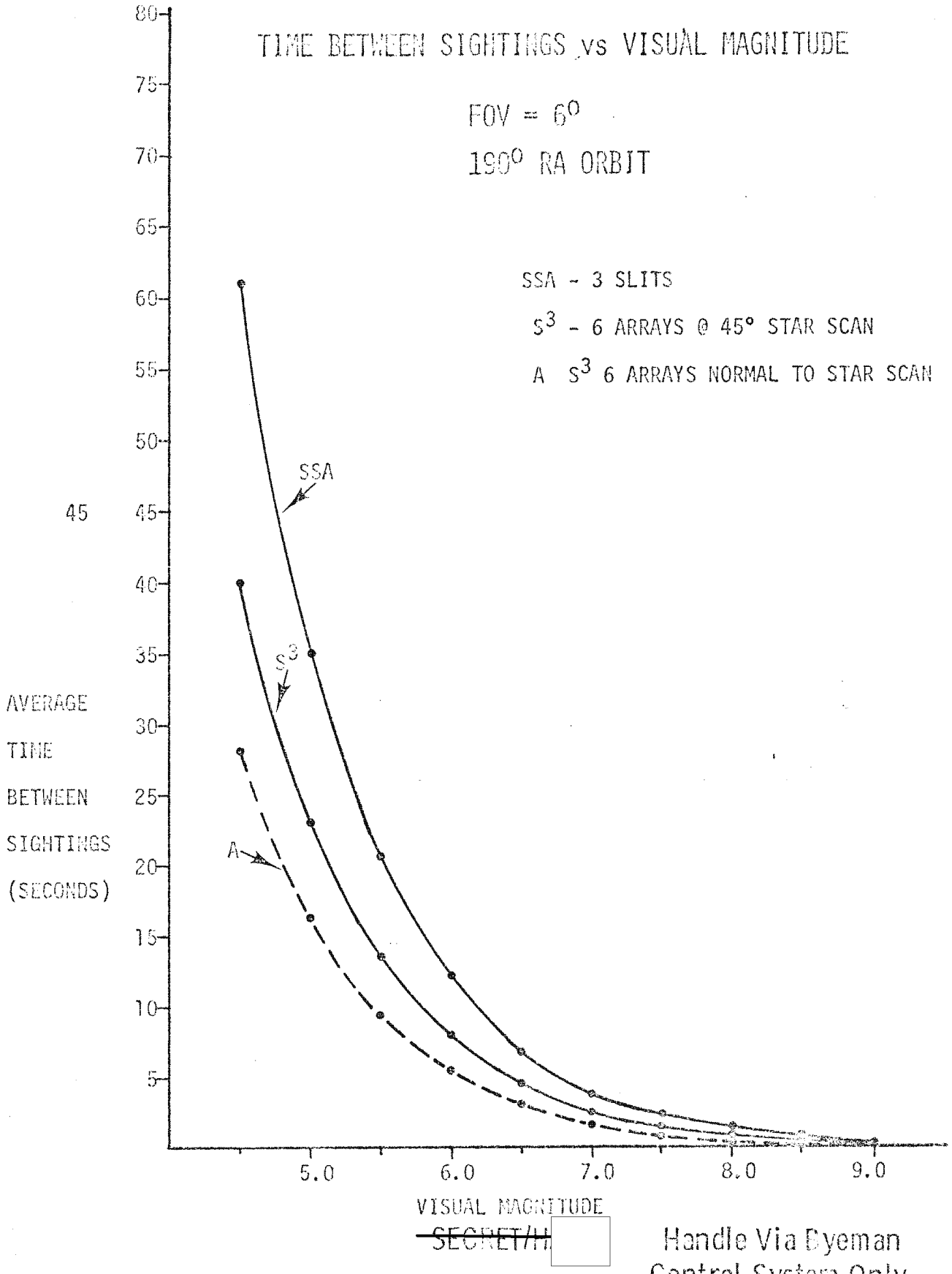

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COMMENTS

BOTH THE STAR SIGNAL AND BACKGROUND INTENSITY ARE FOCUSSED IN THE PETICLE PLANE OF THE SSA TELESCOPE. AN AUXILIARY LENS SYSTEM COLLECTS ALL ENERGY PASSING THROUGH THE SLITS AND CONCENTRATES THE PHOTONS ONTO THE PHOTOMULTIPLIER TUBE. DARK NOISE IS SUBTRACTED AND THE SYSTEM ELECTRONIC PROCESSORS ANALYZE THE STAR CROSSING PULSE VIA PHOTON COUNTING TO PRODUCE A STAR TIME OF TRANSIT AND MAGNITUDE DETERMINATION. THIS DATA IS IN TURN TELEMETERED TO THE GROUND RECEIVING STATION.

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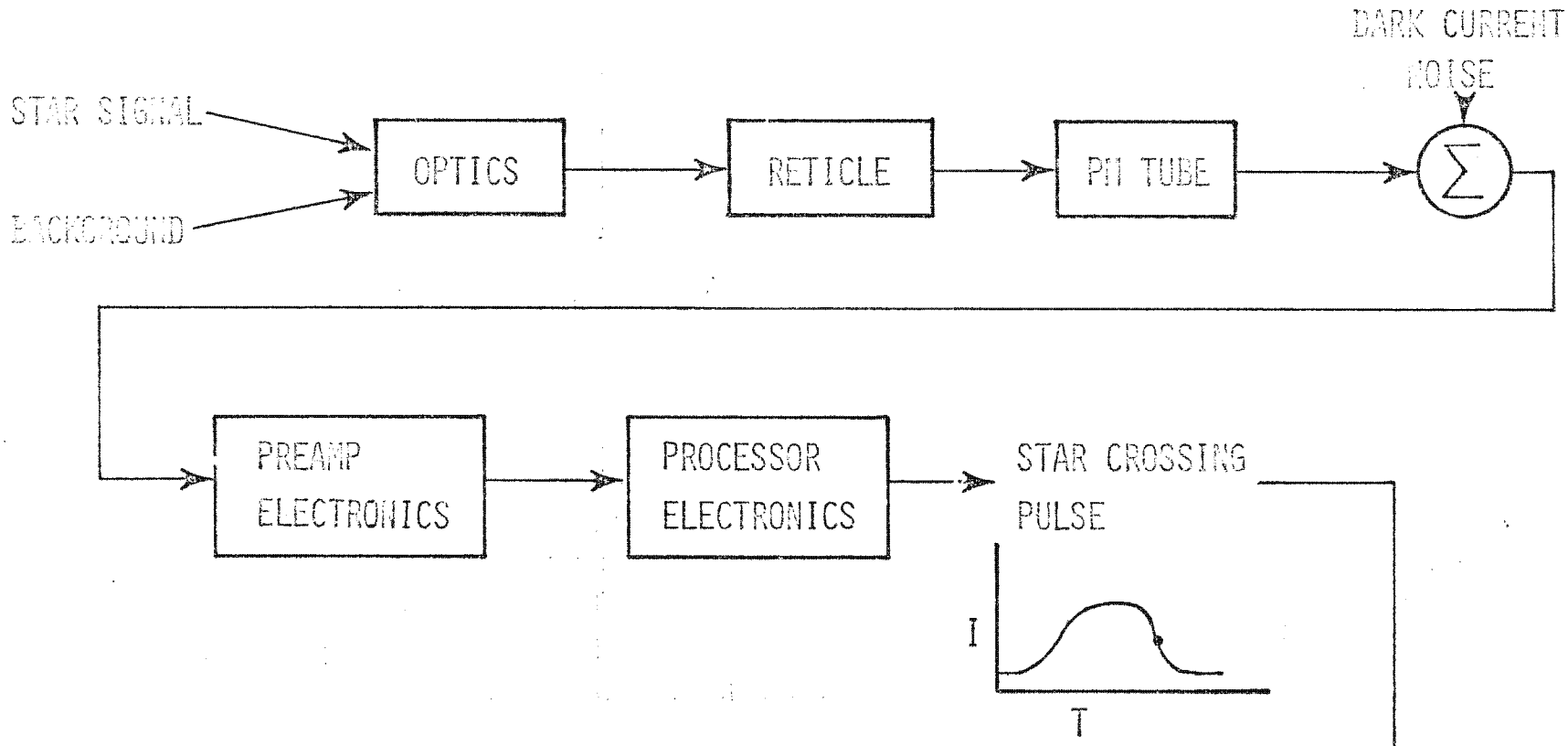
STAR SENSOR ASSEMBLY FUNCTIONAL BLOCK DIAGRAM



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COMMENTS

CONSIDERABLE CARE HAS BEEN EXERCISED IN THE OPTICAL ASSEMBLY TO ASSURE A HIGH LEVEL AND STABILITY OF PERFORMANCE. NO CHANGE TO THE SSA OPTICS WOULD BE NECESSARY TO MEET THE REQUIREMENTS OF THE CONTRACTOR PROPOSED APPROACH.

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STAR SENSOR ASSEMBLY (SSA) OPTICS

* PRECISION FIELD CORRECTED CASSEGRAIN TELESCOPE
  * MECHANICAL STABILITY ACHIEVED VIA SUPER LAPPED MATTING SURFACES
  * THERMAL STABILITY ACHIEVED VIA USE OF LR 35 INVAR

* OPTICAL SYSTEM MEETS ALL REQUIREMENTS FOR PROPOSED APPLICATION WITH NO MODIFICATIONS

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COMMENTS

IN SOME RESPECTS THE SSA APPLICATION IN H WOULD BE EASIER [redacted] - THESE ARE SHOWN AS SUGGESTED BY THE CONTRACTORS. THE LAST POINT ON THE LEFT, LESS SUN AND BACKGROUND PROBLEM BEARS FURTHER STUDY. IN OTHER RESPECTS, THE JOB IS HARDER; RELIANCE ON [redacted] INFORMATION IS THE PRINCIPLE SOURCE OF DIFFICULTY. NOT SHOWN HERE, BUT YET OF SOME CONCERN, IS THE FACT THAT THE CONTRACTORS PROPOSE USING THE SSA FOR DETECTING FAR DIMMER STARS (6.5MV) THAN THAT FOR WHICH IT WAS ORIGINALLY DESIGNED (4MV).

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(b)(3)

USING SSA IN H [redacted]

SIMPLER APPLICATION BECAUSE

* ONE DIRECTION STAR CROSSING
* ONE CROSSING RATE
* NO ONBOARD PROCESSING
* MORE BENIGH ENVIRONMENT/LIFE
* LESS SUN AND BACKGROUND PROBLEM

HARDER BECAUSE

* PLATFORM PROVIDES MUCH LOWER STAR CROSSING FREQUENCY
* [redacted]
* QUESTIONABLE ALIGNMENT STABILITY BETWEEN SSA [redacted]

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COMMENTS

THE CENTROIDING ACCURACY FOR THE TWO SENSORS ARE APPROXIMATELY THE SAME. THE S^3 DEVICE PROVIDES AN INSTANTANEOUS TWO-AXIS STAR POSITION MEASUREMENT WHEREAS THE SSA PROVIDES A SIGNLE-AXIS INSTANTANEOUS MEASUREMENT. AS STARS TRAVERSE TWO ORTHOGONAL SLITS ON THE SSA, TWO AXIS ATTITUDE INFORMATION IS OBTAINED.

THE HIGHER STAR SIGHTING RATE OF THE S^3 DEVICE IS DUE TO THE FACT THAT IT HAS MORE DETECTION AREA COVERING THE FOCAL PLANE AND DETECTS HIGHER MAGNITUDE STARS. THE LONGER AVERAGE STAR SIGHTING INTERVAL OF THE SSA DEVICE GENERATES THE REQUIREMENT THAT VEHICLE RATE BE MEASURED WITH AN ACCURACY OF 0.3 ARC SEC/SEC IN ORDER TO MEASURE THE VEHICLE ANGULAR DISPLACEMENT BETWEEN STAR SIGHTINGS.

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MEASUREMENT CHARACTERISTICS AND PERFORMANCE

PARAMETER	S^3	SSA
ACCURACY FOR SINGLE STAR SIGHTING	2 - 3 $\overset{\frown}{\text{SEC}}$ (2 σ)	2 - 3 $\overset{\frown}{\text{SEC}}$ (2 σ)
INTERVAL BETWEEN STAR SIGHTINGS	~ 1 SEC (7.6 Mv)	~ 8 SEC (6.5 Mv)
COORDINATE INFORMATION	2 AXIS MEASUREMENT	1 AXIS MEASUREMENT
INTEGRATION INTERVAL (TIME RESOLUTION)	50 - 100 MSEC	8 MSEC
[redacted]		

[redacted] (b)(1) (b)(3)

[redacted] (b)(1) (b)(3)

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COMMENTS

THE BASIC APPROACH PROPOSED FOR THE SSA IS COMPATABLE WITH THE WEIGHT, POWER, AND VOLUME ALLOCATIONS CURRENTLY DEDICATED TO THE S^3 APPROACH.

THE SSA WITH DEDICATED [redacted] MAY DEMAND A CONTINUOUS POWER ALLOCATION WHICH COULD IMPACT THE CURRENT VEHICLE POWER ALLOCATIONS. SINCE S^3 SHOULD NOT REQUIRE DEDICATED [redacted], IT WOULD NOT REQUIRE CONTINUOUS POWER USE.

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ESTIMATED SYSTEM CHARACTERISTICS

	S^3	SSA	SSA [redacted]
WEIGHT	300 Lbs	≈250 (Based on 63 Lbs Current)	≈300
POWER	300 Watts	≈25 Watts (Based on 7 Watts)	75 Watts Operating *50 Watts Continuou
SIZE	COMPATIBLE	LESS THAN S^3	COMPATIBLE

* IMPACTS CURRENT VEHICLE CAPACITY

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COMMENTS

ALTHOUGH THE CONTRACTORS EXPRESSED A PREFERENCE FOR MOUNTING THE SSA ON A VEHICLE STRUCTURAL LONGERON FOR THE REASONS INDICATED, THE TEAM BELIEVES THAT THE ALIGNMENT INSTABILITY BETWEEN THE LONGERON AND THE TWIN CAMERA ASSEMBLY (TCA) WOULD PROHIBIT THIS APPROACH. SINCE THE S^3 IS PLANNED FOR MOUNTING ON THE TCA AND THE SSA IS NO LARGER NOR HEAVIER THAN THE S^3, THE TEAM CONSIDERS IT TECHNICALLY FEASIBLE AND PREFERABLE TO CONSIDER THE SSA MOUNTED ON THE TCA.

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LOCATION OF SSA IN VEHICLE

* CONTRACTOR PROPOSES MOUNTING SSA ON EITHER

STRUCTURAL LONGERON	OR	TCA
∘ NO PE HARDWARE INTERFACE		∘ INTERFACE WITH PE
∘ SHORT SUN-SHADE NECESSITATED		∘ TIGHTER COUPLING WITH PAN LOS
∘ UNMEASURED LONGERON/TCA DYNAMICAL MOTION (≈20 SEC)		∘ S^3 TO BE MOUNTED ON TCA

* TEAM CONSIDERED SSA TO BE MOUNTED TO TCA

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COMMENTS

TIME AND LACK OF DETAILED SCHEMATICS LIMITED THE ABILITY OF THE GROUP TO MAKE A DETAILED EXAMINATION OF THE ELECTRONICS OR DETERMINE THE EXACT IMPACT ON THE DESIGN CAUSED BY "NECESSARY" OR "PERFORMANCE ENHANCEMENT" CHANGES. RECOGNIZING THESE LIMITATIONS, THE REVIEW DOES INDICATE THE ENGINEERING DESIGN, PACKAGING, AND PARTS SELECTION ARE SATISFACTORY. THE ELECTRONICS ARE NOT DENSELY PACKAGED AND THE CONTRACTOR ASSERTS THAT ADEQUATE SPACE IS AVAILABLE TO ACCOMMODATE REQUIRED ELECTRONIC CHANGES TO INCREASE THE SENSITIVITY OF THE STAR SENSOR WITHOUT MAJOR BOARD REDESIGN. OTHER ELECTRONIC CHANGES FOR INPUT/OUTPUT TELEMETRY INTERFACES OR PERFORMANCE ENHANCEMENT COULD PROBABLY BE ADDED BY THE ADDITION OF CARDS WITHOUT INCREASING THE PACKAGE ENVELOPE. BASICALLY, THE SSA ELECTRONICS ARE NOT CONSIDERED BY THE TEAM AS SIGNIFICANT DEVELOPMENT RISK AREAS.

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CONTRACTOR PROPOSED MODIFICATION

REQUIRED MODIFICATIONS

* ENGINEERING DESIGN MODIFICATIONS CONSIDERED MINOR

* PRESENT PACKAGING DENSITY WILL ACCOMMODATE MODIFICATIONS

* IMPACT ON SSA RELIABILITY -- NEGLIGIBLE

ADDITIONAL SUGGESTED MODIFICATIONS

* CHANGES SHOULD ENHANCE CONFIDENCE IN SATISFACTORY SSA PERFORMANCE

* FURTHER STUDIES DESIRED TO DEFINITIZE SPECIFIC SELECTIONS AND TRADE-OFFS

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COMMENTS

THIS CHART ATTEMPTS TO COMPARE EXPECTED PERFORMANCE AT A SYSTEM LEVEL WITHOUT PERFORMING A DETAILED ERROR ANALYSIS. A COMPARISON OF THE THREE MAJOR ERROR SOURCE CATEGORIES IS INDICATIVE OF THE EXPECTED SYSTEM ABSOLUTE POINTING PERFORMANCE.

THE THERMAL STABILITY OF AN INFLIGHT INTERLOCK CALIBRATION IS ESSENTIALLY INDEPENDENT OF WHICH ATTITUDE SENSOR IS UTILIZED.

THE S^3 AND THERMAL STABILITY ERROR ESTIMATES WERE EXTRACTED FROM AN EXISTING P.E. ERROR ANALYSIS.

THE RELATIVE POINTING REQUIREMENT WAS NOT ADDRESSED.

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ABSOLUTE L. O. S. POINTING ERROR ESTIMATES
(ARC SECONDS @ ONE SIGMA)

	S^3 BASELINE	SSA BASELINE *	SSA - MODIFIED **
ATTITUDE DETERMINATION	1.8	2.3 - 6.8	1.1 - 1.6
INTERLOCK	2.2	2.6 - 6.9	1.6 - 2.0
THERMAL STABILITY	3.4	3.4	3.4
	4.4	4.9 - 10.3	3.9 - 4.3

BASELINE

* SSA BASELINE ASSUMES LEAST MODIFICATIONS, SSA MOUNTED ON TCA NO SSA [redacted] ALIGNMENT ERRORS (RANGE OF VALUES ENCOMPASSES VEHICLE [redacted] PERFORMANCE Vs SPEC)

** SSA MODIFIED ASSUMES [redacted] ON TCA (RANGE OF VALUES REFLECTS UNCERTAINTY IN CALIBRATION TECHNIQUES)

~~SECRET~~ [redacted]

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COMMENTS

THE COMPONENT OF THE LOS ATTITUDE ERROR DUE TO STAR SIGHTING AND [redacted] INACCURACIES IS DISCUSSED IN THIS CHART. THE BUDGETED AMOUNT OF THIS ERROR COMPONENT IS ABOUT 2.5 ARC SEC. THE STAR SENSOR LOS ATTITUDE DETERMINATION ERROR VARIES WITH TIME DUE TO THE VARIATIONS IN THE STAR SIGHTING ENTERVAL AND THRUSTER FIRING TIMES. THE WORST CASE ERROR BOUND FOR THE SSA OCCURS DURING AN EXTREMELY LONG INTERVAL BETWEEN STAR SIGHTINGS (SAY 20 SECONDS) IN WHICH ONE OR MORE ATTITUDE CONTROL THRUSTER FIRINGS OCCUR. THE LOWER ATTITUDE ERROR BOUND OCCURS WHEN SEVERAL STAR SIGHTINGS ARE MADE IN RAPID SUCCESSION.

A SINGLE AXIS MONTE CARLO SIMULATION WAS DEVELOPED TO DETERMINE THE DISTRIBUTION OF THE STAR SENSOR ATTITUDE DETERMINATION ERRORS BY ALLOWING THE STAR SIGHTINGS AND THRUSTER FIRINGS TO OCCUR AT RANDOM INTERVALS WITH SPECIFIED AVERAGES. THE RESULTS SHOW THAT THE ATTITUDE DETERMINATION ACCURACY USING THE SSA SENSOR DEGRADES WITH LESS ACCURATE RATE INFORMATION, I.E. A LARGER PERCENTAGE OF THE ERROR BOUNDS EXCEEDS THE BUDGET LIMIT. THE S^3 SENSOR HAS A VERY HIGH PERFORMANCE MARGIN COMPARED WITH THE SSA. THE SSA IS BELOW THE BUDGET LIMIT 98% OF THE TIME WITH RATE INFORMATION ACCURATE TO 0.3 ARC SEC/SEC.

THE RESULTS OF THIS SIMPLE SINGLE AXIS SIMULATION ARE VALID FOR RELATIVE COMPARISONS BETWEEN THE TWO SENSORS, BUT THE ACTUAL ABSOLUTE ERROR MUST BE DETERMINED BY A VEHICLE SIMULATION WITH BOTH THE STAR DISTRIBUTION AND THRUSTER FIRINGS MODELED IN A REALISTIC MANNER.

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COMPARISON OF AVERAGE ATTITUDE ERROR BOUNDS

SYSTEM	PERCENTAGE OF RECORD WITH ATTITUDE BETTER THAN 1.25 SEC	PERCENTAGE OF RECORD WITH ATTITUDE BETTER THAN 2.5 SEC	PERCENTAGE OF RECORD WITH ATTITUDE BETTER THAN 5.0 SEC
	85%	98%	100%
	75%	93%	97%
	98%	100%	100%

NOTE: SINGLE AXIS MONTE CARLO ANALYSIS ASSUMING:

RIGID COUPLING BETWEEN TCA AND

OPTICAL DATA PROCESSING

(b)(1)
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COMMENTS

ADDITIONAL TESTS AND/OR ANALYSES COULD BE UNDERTAKEN IN ORDER TO REDUCE THIS RISK. HOWEVER, THIS EFFORT MAY NEVER REDUCE THE RISK TO AN ACCEPTABLE LEVEL.

[redacted] WOULD ELIMINATE THIS CONCERN.

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SUITABILITY OF [redacted] DETERMINATION

FUNDAMENTAL PROBLEM

* SPEC PARAMETERS NOT CONSISTENT WITH PROPOSED APPLICATION
  (SPEC DRIFT STABILITY: 0.1°/HR/100 SEC RMS)
* PROPOSED CONCEPT REQUIRES ATTITUDE ERROR DURING 1 TO 100 SECOND RANGE
* EXPECTED ATTITUDE ERROR MUST BE INFERRED FROM SPECIFICATION
* INFERRED (FROM SPEC) PERFORMANCE NOT ACCEPTABLE
* FLIGHT EXPERIMENT (SINGLE TEST) INDICATES ACTUAL PERFORMANCE MAY BE ACCEPTABLE

[redacted]

~~SECRET~~/H [redacted]

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COMMENTS

STRAP-DOWN INERTIAL REFERENCE UNITS ARE AVAILABLE "OFF THE SHELF". THESE UNITS ARE QUALIFIED OR ARE IN THE QUALIFICATION PHASE. THE QUALIFICATION TESTS ARE APPLICABLE TO AN H ENVIRONMENT AND LIFE REQUIREMENT.

THE EXAMPLES CITED ARE INDICATIVE OF THE WEIGHT, POWER, AND VOLUME REQUIREMENTS NEEDED TO SUPPORT A TYPICAL UNIT DEDICATED TO THE SSA MODIFIED APPROACH.

THE PERFORMANCE OF THESE UNITS WOULD HAVE TO BE INVESTIGATED, AS DISCUSSED IN THE PREVIOUS CHART, IN ORDER TO INSURE ADEQUATE PERFORMANCE COMPATIBILITY. IN SOME CASES [redacted] SPECIFICATION CHANGES WOULD BE NEEDED.

ADDITIONAL ELECTRONICS WOULD BE REQUIRED TO INTERFACE WITH THE PRESENT VEHICLE TELEMETRY SYSTEM.

[redacted]

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TYPICAL CANDIDATE INERTIAL REFERENCE UNITS QUALIFIED/*NEAR QUALIFICATION

	INERTIAL UNIT	WEIGHT 2-UNITS LB	POWER 1-UNIT WATTS	VOLUME 1-UNIT INCHES	PERFORMANCE
	H	36	55	9 x 9 x 6.5	SPEC CHANGE TO INSURE PERFORMANCE
*	H MOD II	56	70	9 x 11 x 6.4	ADEQUATE
*	[redacted] ARA				
	DMSP (Honeywell)	45	37	11 x 10 x 7	0.065°/Hr 3 Sigma

SYSTEM IMPACT:

- FREQUENT TURN-ON INCURS RISK (HARD START)
- [redacted] T/M ELECTRONICS REQUIRED - NOT QUALIFIED
- H, H MOD II [redacted] INERTIAL REFERENCE UNITS ARE APPLICABLE TO ENVIRONMENT AND LIFE REQUIREMENTS

~~SECRET~~ [redacted]

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(b)(3)

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COMMENTS

REGARDING DATA REDUCTION, THE SSA APPROACH APPEARS MORE COMPLEX THAN THE S^3 APPROACH.

THE SSA DATA REDUCTION IS TIED TO [redacted] MEASUREMENTS AND MAY INCLUDE THRUSTER FIRING CONSIDERATIONS AND A VEHICLE DYNAMIC MODEL. THE GROUND PROCESSING SOFTWARE FOR THE SSA IS CONSIDERED TO HAVE A SOMEWHAT HIGHER DEVELOPMENTAL RISK. ONCE THE SOFTWARE IS DEVELOPED, HOWEVER, THE TOTAL DATA PROCESSING LOAD APPEARS TO BE APPROXIMATELY EQUAL FOR BOTH APPROACHES.

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GROUND DATA PROCESSING

* NOT DEFINED OR UNDERWAY FOR EITHER APPROACH

* ESTIMATE OF RELATIVE MERITS:

ISSUE	ASSESSMENT
TASK/ALGORITHM COMPLEXITY	SSA MORE COMPLEX THAN S^3
DEVELOPMENT RISK (S/W DESIGN & IMPLEMENTATION)	HIGHER RISK THAN S^3 BASED UPON COMPLEXITY, BUT ACHIEVEABLE
DATA PROCESSING LOAD	SAME AS S^3

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COMMENTS

[redacted]

THE H REQUIREMENTS. THE VARIOUS MODIFICATIONS CONSIDERED WOULD PROBABLY REQUIRE ADDITIONAL QUALIFICATION TESTING, BUT WOULD NOT LIKELY HAVE A SIGNIFICANT IMPACT ON RELIABILITY.

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SSA RELIABILITY

* DESIGNED AND QUALIFIED FOR MORE STRINGENT APPLICATION
  - ENVIRONMENTAL SPECS SATISFIED
  - QUALIFICATION PROGRAM COMPLETE
* NO SINGLE POINT FAILURE MODES IN SENSING OR ELECTRONICS
* LIFETIME MORE THAN AMPLE
* PROBABLE MODIFICATIONS NOT LIKELY TO JEOPARDIZE QUALIFICATION STATUS

~~SECRET/H~~ [redacted]

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COMMENTS

THE SUM OF THESE INDIVIDUAL FINDINGS SUPPORT THE EARLIER STATEMENT THAT THE TEAM FOUND NO BASIS FOR EXCLUDING THE SSA (MODIFIED) FROM CONSIDERATION. HOWEVER, NOT ALL TECHNICAL CONCERNS HAVE BEEN ADEQUATELY ADDRESSED DURING THIS BRIEF EVALUATION. PRESUMABLY THEY WOULD BE IN A PROPOSAL/SOURCE SELECTION ACTIVITY.

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TECHNICAL FINDINGS

* SSA [redacted]
* USE OF SSA IN THE HEXAGON SYSTEM APPLICATION SEEMS FEASIBLE BUT DEPENDS ON:
  * ACCURACY OF VEHICLE RATE INFORMATION - [redacted] MAY BE REQUIRED
  * ABILITY OF SSA TO DETECT 6.5 MAGNITUDE STARS
* MOUNTING SSA ON TCA APPEARS NECESSARY
* REQUIRED MODIFICATIONS (EXCLUDING [redacted] PROBABLY NOT EXTENSIVE
* NO MAJOR HARDWARE/DEVELOPMENT RISKS APPARENT
* A BENDIX/ITEK PROPOSAL WOULD PROBABLY BE TECHNICALLY COMPETITIVE
* IN THE EVENT OF SOURCE SELECTION, ADDITIONAL REVIEW OF KEY CONCERNS IS WARRANTED

~~SECRET/H~~ [redacted]

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(b)(1)
(b)(3)

(b)(1)
(b)(3)

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COMMENTS

THESE ARE THE AREAS SUGGESTED BY THE TEAM FOR FURTHER INVESTIGATION OR ATTENTION IF THE SSA APPROACH IS PURSUED.

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(b)(1)
(b)(3)

RESIDUAL CONCERNS

IN THE EVENT OF SOURCE SELECTION, ATTENTION IS REQUIRED ON:

* CALIBRATION DURING OPERATION - METHOD, ACCURACY, MISSION IMPACT
* S/N ANALYSIS OF SSA OPERATING AT 6.5 MAGNITUDE
* LOWER MAGNITUDE STAR DETECTION (FAINTER THAN 6.5 M_V
* SATISFACTION OF RELATIVE ACCURACY (3 SEC) REQUIREMENT

~~SECRET/H~~

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(b)(3)

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OPTICAL TECHNOLOGY DIVISION
SYSTEMS TECHNOLOGIES DEPARTMENT
SYSTEMS ANALYSIS SECTION

Memorandum #1512

25 January 1977

TO: R. Kohler

FROM: [redacted] (b)(3)

SUBJECT: Requirement for On-Orbit Snubbing

It is the Systems Technologies Department recommendation that on-orbit snubbing of the port pitch link be provided for SX-17 and 18. Preliminary requirements for the snubber design have been outlined in Systems Technologies Memo #1506, dated 14 January 1977.

The above recommendation is based on evaluation of SBAC analysis of S^3 and C vibration during orbital operation. Table 1 summarizes the SBAC analysis of S^3 and O vibration with the T supported on a single pitch link. In this mode, the vibration rate of the O will be .043°/sec peak (.030°/sec RMS) during mono-operation. This value exceeds the previous ICD rate of .010°/sec (95% high). During s operation the calculated angular vibration just meets current error budget requirements. However, this analysis may not have been based upon the worst case of thruster disturbances as a very limited number of cases were run. To improve confidence in the T vibration stability for S^3 and meet ICD budgets for the O s a snubbing device, which is actuated during [redacted] operation, is indicated. In addition to the above considerations, this modification will allow some potential for improvement in error budget values.

(b)(3)

Prepared by: [redacted]

[redacted]

cc: [redacted]

Prepared by:

Approved by:

U

TABLE I

S[13] DISTURBANCE ANALYSIS

ITEM	S^3, sec RMS			, °/sec,		
	θ_x	θ_y	θ_z	$\dot{\theta}_x$	$\dot{\theta}_y$	$\dot{\theta}_z$
ERROR BUDGET	1.0	1.0	1.0	.010 MONO = 8 SEC SETTLING	.010	.010
S OPERATION CASE A THRUSTERS 6 CASE B PL TORQUE CASE G22 SU SERVO CASE J1 01 START ALL RCS, RMS = .1707 RCS $\dot{\theta} = \theta\omega_f$ (ω = 27m8 Hz)	.9	.4	.1	.018 PK .013 RMS	.008 PK .006 RMS	.0014 PK .001 RMS
MONO CASE H15 THRUSTERS 5 11 +SU	N/A	N/A	N/A	.043 PK .030 RMS	.027 PK .019 RMS	.017 PK .012 RMS

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MEMO FOR FILE 1100, 28 January 1976

A meeting was held in Col Campbell's office with [redacted] (b)(3)
[redacted] Lt Col Powell, [redacted] and Ron Toman. The purpose was to discuss the method of contracting for S-Cubed which would provide the greatest cost visibility.

[redacted] pointed out that so far 500K has been authorized in the budgets for S-Cubed, however if one was to take a hard look at the on-going effort and count "HERP" hours utilized - we would estimate that over 2 million dollars has been spent on S-Cubed to date. (This corresponds to Charge 8992, 19 Nov 74 from Anderson-Hofmann, Subject: Study Plan for S-Cubed Camera). We had told Whig that the estimate cost for the Study was 500K... "for materials and subcontracts. The labor required is within existing sustaining engineering." (b)(3) (b)(1)

After the hiatus in procurement of the mapping camera follow-on and the fact that we are again about to embark on a high technology, convenience procurement for DMA (at virtually a fixed price between Government agencies), we in [redacted] want a clear picture of costs and a contractual instrument that can be identified as exclusively DMA effort. (b)(3) (b)(1)

At this morning's meeting all generally concurred that a milestone should be defined in the S-Cubed development effort at which point we convert the effort to a separate contract. An appropriate point may be - at completion of breadboard testing.

Meanwhile we have a 20 January (WHIG 0098) message to answer asking for refined costs by fiscal year. The history goes something like this.

1. Sep 74: We estimated 24.15M.

2. 14 Jan 75: Bradburn told Plummer the high number could be 41.4.

3. Interim: Contractor gave us budget estimates of 10.5M unescalated.

4. Oct 75: Anderson briefed 25.4 million to Mr Plummer.

5. Jan 76: Proposals are in preparation. We hear numbers of 30M.

~~Scott/14~~ Working Paper Handle via Byeman

Our strategy for the 15 Feb message is to give a clear picture of dollars required during the development - with the caveat that HERP hours are being consumed - then tell, very candidly, what inputs we have (30 million or whatever) and say that the final contract may work out to be about X amount per year, we guess.

Also we probably will go so far as to say that HERP won't be necessarily available on the production contract - and whatever the production contract costs - DMA is liable for.

Ronald G. Toman

RONALD G. TOMAN, Major, USAF

S^3/L^2 CHRONOLOGICAL SUMMARY

SBAC CONTRACTUAL CHANGES

DATE	EVENT
9 Oct 75	SPO requested S^3 ROM
15 Oct 75	SBAC presented S^3/Large SU Planning and study cost Estimate
18 Nov 75	SPO requested a second ROM for S^3/SMFT in 2 configurations
9 Jan 76	SBAC presented Planning ROM for requested configuration
17 Feb 76	CSE presented Configuration Baseline for study effort
22 Jun 76	Long-Lead ECPs 24 and 82 initiated
22 Jul 76	ECP-24 definitive long-lead proposal submitted. Approved 8 August (P00040) Phase I
2 Aug 76	ECP-82 Definitive Long-Lead Proposal submitted. Approved 5 August (P00121). Phase I
3 Sep 76	Customer requests revision to ECPs 24 and 82 to task quote effort
7 Oct 76	Phase 1 (revisions) to ECPs 24 and 82 submitted
27 Sep 76	Customer-directed request for TPC Box Addition Proposals
19 Oct 76	ECP-90 (-0038) definitive proposal submitted for TPC additions. Approved by P00141
22 Oct 76	ECP-29 (-0050) definitive proposal submitted for TPC additions. Approved by P00048
15 Dec 76	P00136/ECP-82 (-0038) negotiated
11 Jan 77	ECP-33 (-0050) Phase 2 definitive proposal submitted. Approved by P00052
12 Jan 77	P00141/ECP-90 (-0038) negotiated
2 Feb 77	ECP-94 (-0038) Phase 2 definitive proposal submitted. Approved by P00149
10 Mar 77	Complete revision of Phase 2 ECPs due to C and TPC box growth initiated
14 Mar 77	Negotiations began on P00046/ECP-24 (-0050) with a significant increase in cost.

~~SECRET~~/H WORKING MATERIAL

S^3/L^2

HISTORY OF ASSOCIATE CHANGES

13 Jul 76	TPC BOX FIRST PROPOSED
18 Aug 76	TPC BOX ADDITION FIRMED UP
30 Sep 76	N_2 PURGE LINE REQUIREMENT DEFINED
22 Oct 76	CABLE PENETRATION ENLARGEMENT REQUIREMENT IDENTIFIED
5 Nov 76	M2/M3 I/F ATTACH NDW SIZE CHANGE PROPOSED
12 Nov 76	TPC BOX WT AND POWER INCREASED 30%
19 Nov 76	ASYNCHRONOUS L^2 OPERATION PROPOSED L^2C BOX TO BE ENLARGED
6 Dec 76	REVISED M2/M3 I/F HDW SIZE CHG AGREED TO
17 Dec 76	FOUR INTERFACE CONNECTOR BRACKETS ADDED DURING MOCKUP
15 Jan 77	IMC DISABLE REQUIREMENTS IDENTIFIED EXTRA I/F CONN ADDED
27 Jan 77	ASYNCHRONOUS L^2 OPERATION PROPOSAL CANCELLED BUT L^2C BOX ENLARGED
2 Feb 77	TPC BOX AGAIN ENLARGED NOW 2 TO 3 TIMES ORIGINAL WT
23 Feb 77	PITCH LINK SNUBBER CONCEPT PROPOSED

~~SECRET~~ H WORKING MATERIAL

SEQUENCE OF EVENTS

9 Oct 75 — SPO requested a ROM estimate for inclusion of S^3 on SV-17 and 18. ROM required by 13 Oct 75.

15 Oct 75 — SBAC provided SPO a ROM for S^3 and a large SU at a value of $4,275,000 including $435,000 to study the impact of the change. The following summarizes the study recommendations:

Ascent Loads - Analyze Stage 1 shutdown with the baseline configuration to determine what electrical changes are required. Verify by examining remaining load conditions and vary configurations as required.

Orbital Dynamics - Study basic configuration and variants to determine critical parameters. Examine 3-4 critical cases to define feasibility. Examine to extent required all cases to verify concept.

Thermal Control - Isolate TCA from new equipment to minimize thermal distortion. Thermal shielding of corrector photo when in non-operating position. Disconnect one of two forward attachment links on orbit.

These activities were scheduled for completion 17 Dec 1976.

18 Nov 75 — Customer requested a second ROM for S^3/SMFT with 2 configurations and added costs for NAVPAC, DBS, etc. Due date for this ROM was 7 January 1976.

9 Jan 76 — SBAC transmitted a planning ROM for the two S^3/SMFT configurations, as follows:

Modify existing design:	$3,800,000 CPIF
Design new mid section:	$6,675,000 CPIF

17 Feb 76 — CSE [redacted] developed a presentation outlining S^3/SMFT near-term requirements. The projected effort, funded by studies, is highlighted below: (b)(3)

- Requested contractual go-ahead in July 1976
- Analyses required to: determine changes to hardware and SBAC activities; predict basic mission on-orbit performance resulting from changes; and provide information for associate design.

- o Customer directed "piece-wise" study funding to provide; ceiling ROM in July 76 for hardware changes necessary to get through test and into orbit and hardware design information only for associate CDR's.

- o Major accomplishments to date include: data and output for Stage 1 shutdown transients loads, on-orbit response to tuned REM pulse (Seg. 1), and maximum cut out for doors without beef-up; analyses for streamlined response to loads (one versus five hours), buffet model and thermal distortion model initiated, and model for control simulation being documented;design for working layouts of change areas complete, redesign study of sway brace installation for external removal versus extra MS doors and relocated shroud door, and developed concepts for shield/shutter interface; and the integrated hardware schedule developed.

- o Engineering had initiated a five months in-depth analysis/ preliminary design to incorporate the S^3/SMFT to be concluded 30 June with generation of a "pink" EJA to define hardware/electrical changes.

22 Jun 76 — Program Letter published to initiate long-lead ECPs 24 and 82 to cover labor/material requirements for the period 1 August through 17 December 1976.

27 Jul 76 — The definitive long-lead proposal for ECP-24 (-0050) was submitted at a value of $455,873 CPIF to cover tasks to be performed prior to 17 December 1976 and included the following effort:

- o Initiate the mid-section electrical mock-up

- o Continue (begun in the study phase) the following space sciences analyses:

  - Ascent loads, dynamics, and structures and Stage II ignition.

  - Limited orbital dynamics and mass properties

  - Thermal distortion for S^3

  - Transporter load effects and sway brace changes

- o Initiate a flexible body analysis of the SV and control system and support the associate in the application of the SV performance data to the S^3 performance.

- o A rigid body control system performance analysis with SMFT disturbances was completed with study funds, the ECP will fund the documentation of results.

- o Determine special acoustic and thermal vacuum test instrumentation criteria for SV-15 testing to support environmental effects analyses.

ECP-24 was approved on 8 August 1976 by P00040.

2 Aug 76 — The definitive long-lead proposal for ECP-82 (-0038) was submitted at a value of $362,857 CPIF to cover tasks to be performed prior to 17 December 1976 and included the following effort:

- o Initiate the mid-section detail structural design engineering, fabrication, and support tooling engineering.

- o Review alignment change criteria.

- o Provide for redesign effort at SCI on the mid-section remote unit.

- o Initiate wire harness design.

- o Review mid-section modal vibration and Static Load Test criteria.

ECP-82 was approved on 5 August 1976 by P000121.

3 Sep 76 — At customer request the revision 1 - phase 1 ECPs were initiated to supersede and replace the long-lead ECPs and task quote all effort scheduled to begin prior to year-end and quote them to completion.

7 Oct 76 — The Phase 1, revision to ECPs 24 (-0050) and 82 (-0038) were submitted to supersede and replace the long-lead ECPs. The differences resulting from the change in quoting groundrules are summarized below.

- o ECP-82 (-0038) - All items listed in the long-lead ECP remained in effect and the following additions resulted in a revised proposal value of $440,939 CPIF.

  - TT&C support for the ADS was to have been a Phase 2 item but the schedule dictated it must be stated in Phase 1.

  - Subcontract increase for transmitter long-lead.

  - Delete ICD drawings.

Approved by P00136 replacing P00121 effective 10-29-76.

- o ECP-24 (-0050) - All items remained in effect and the following additions resulted in a revised proposal value of $499,484 CPIF.
  - Added ICD drawings from ECP-82
  - Added Acoustic Test instrumentation for 9027 to help environmental effect analyses.
  - Extended the flexible body analyses to completion. Contained 4 analyses and no long-term support.
  - Increased number of development M2/M3 doors to two from one.
  - Reduced the space sciences effort approximately 1000 hours in the structural dynamics analysis of loads and responses of a heavy payload in place of APSA.

Approved by P00046 replacing P00040 effective 10-22-76

27 Sep 76 — In response to a customer-directed request ECP-90 (-0038) and ECP-29 (-0050) were initiated to price the structural design and electrical mockup effort required to support the addition of an Associate "TPC" Box to the S^3/L^2 mods.

19 Oct 76 — ECP-90 (-0038) was submitted at a value of $24,205 CPIF to accomplish the following:

- o Mounting provisions and master tooling design, fabrication, and installation.
- o Engineering support for electrical harness mock-up.

Approved (verbally) on 9 November by P00141.

22 Oct 76 — ECP-29 (-0050) was submitted at a value of $18,826 CPIF to accomplish the following:

- o Perform environmental effects analyses of the structural changes necessitated by the added TPC Box.
- o Provide the structural/electrical mock-up manufacturing fabrication and installation.

15 Dec 76 — P00136 Phase 1 (-0038) was settled and the deletion of the transmitter requirement in the ADS was recognized and an adjustment for cost was accomplished.

11 Jan 77 — ECP-33 (-0050) for Phase 2 was submitted proposing completion of the S^3/L^2 modifications and presented the following proposed tasks at a value of $527,900 CPIF.

- o Provide modified thermal blanket and shield design, fabrication, and installation.
- o Forward section structural/electrical mock-up design, fabrication, and installation including ADS accelerometers.
- o Modification of three SSC AGE Remote Units.
- o Data reduction and evaluation of ADS Telemetry Flight data.
- o Added test instrumentation for Acoustic and Thermal Vacuuming Testing and increase of 4 days to the A-1 chamber test of SV-15 to support environmental effects analyses.
- o Provide space sciences support to: evaluate thermal blanket and shield modifications; evaluate results of SV-15 acoustic and thermal vacuuming added instrumentation and testing; monitor the static structural test and evaluate results; evaluate TCA modal test results; and evaluate liftoff and orbital flight performance of SV-17.

ECP-33 was approved by P00052 effective 25 January 1977.

12 Jan 77 — P00141, added TPC Box provision, was settled.

2 Feb 77 — ECP-94 (-0038) for Phase 2 was submitted proposing completion of the S^3/L^2 modifications and presented the following proposed tasks at a value of $649,256 CPIF.

- o Engineering installation design and manufacturing installation of mid section structural modifications.
- o Engineering design fabrication and installation of forward and aft section structure modifications including mock-up.
- o Engineering design fabrication and installation of new/modified wire harnesses and the deletion of non-functional APSA wire harnesses, including mock-up.

- o Perform the static test of the SV-18 mid section to validate modifications.

- o Design fabricate/procure the ADS consisting of 1 RF switch, 1 PCM encoder, 1 S-band antenna, and 15 accelerometers.

- o Provide AGE modifications to the Module Test Lab in support of Aft section changes.

- o Provide fabrication of one additional development M2/M3 door.

ECP-94 was approved by P00149 effective 14 February 1977. It should be noted that this approval related to a revision 1 ECP TWX which proposed a PCM Encoder in lieu of an expensive PCM Telemeter Unit. The definitive proposal submitted 16 February did not reflect Revision 1 since this was the first submittal but should be compared to the Revision 1 TWX.

10 Mar 77 A complete revision of both Phase 2 ECPs was initiated at customer request to recognize the growth in the Associate's TPC and C boxes. This effort is currently in process and the proposal revisions are scheduled for submittal 8 April. The key elements in the increased effort are summarized below and have been ROM estimated at a $36,000 CPIF increase for the "C" box growth and $180,000 CPIF for the "TPC" box growth.

- o ECP-94 growth elements

  - Addition of a mid-section structural test to validate growth modifications.

  - Modification of released engineering and creation of new engineering to support the growth of the boxes.

  - Fabrication of redesigned and new parts and installation of new details required by the growth.

- o ECP-33 Growth elements

  - Space sciences support to develop requirements and monitor and evaluate added test of the 1909 bulk head due to the growth in the "TPC" box.

- Added structural/electrical mock-up and shield redesign.

Stop work orders issued in February to minimize redesign and wasted fabrication when the box growth was defined are in the process of being lifted in lieu of new released engineering. However, this box growth has resulted in a slip to the planned ship date of the SV-17 mid-section to 14 October 1977 and SV-18 on 14 October 1978.

14 Mar 77 — Negotiations began on P00046/ECP-24 with a presentation of an increase in cost to recognize unforseen growth as well as support to customer directed additional effort resulting from a series of problems. This increase is valued at $157,742 CPIF and relates principally with increased effort in the orbital dynamic, control system analyses, and the structural dynamic model reevaluation.

Year-end 1977 — Phase 3 ECPs against the -0038 and -0050 contracts, are scheduled to price the added systems test effort and increased VAFB support due to the S^3/L^2 changes.

Also, the performance incentive changes resulting from the control system analysis will be defined.

SUMMARY

The totally fluid environment, with constantly changing configuration requirements, has contributed to an understandable inability to sort "directed" changes from "evolution" changes, with little correlation between cause and effect. The message here is that each of the affected customer/SBAC offices must maintain a constant interface to identify changes as they occur so that appropriate action can take place. In defense of the evolutionary (growth) changes SBAC feels the effort to be expended is necessary and mutually beneficial. Here again, however, constant cooperation can help alleviate the magnitude of this evolutionary growth.

PRELIMINARY

REPORT

OF

STAR SENSOR ASSEMBLY EVALUATION

11 MARCH 1976

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SUMMARY OF EVENTS

DATE	EVENT
24 FEB	INITIAL MEETING WITH COL ANDERSON
26 FEB	APPROVAL OF SELECTED BOARD MEMBERS
27 FEB	STAR SENSOR ASSEMBLY BRIEFING BY LMSC
1 MAR	TEAM ASSIGNMENTS AND BRIEFINGS
	* SECURITY - [redacted] - SP-3 (b)(3)
	* S^3 SYSTEM - [redacted] - SP-7 (b)(3)
2 MAR	DMA REQUIREMENTS - LT COL LEHMANN
	TWX SENT TO ITEK DELINEATING TECHNICAL QUESTIONS OF GROUP
	DISCUSSION WITH LOCAL ITEK REP - ART KJONTVEDT
4 MAR	ADDITIONAL DISCUSSIONS ON REQUIREMENTS - MR DENNIS MOELLMAN (DMA)
5 MAR	ITEK PRESENTATION AND TECHNICAL WORKING SESSION
8 MAR	FORMULATION OF COMMITTEE CONCERNS AND ASSIGNMENTS FOR INVESTIGATION

(b)(1) (b)(3)

TEAM COMPOSITION

NAME	OFFICE	DISCIPLINE
[redacted]	[redacted]	CHAIRMAN
COL J.R. BLANKENSHIP	SS	ASST CHAIRMAN
LT/COL C.T. LEHMANN	[redacted] (b)(1) (b)(3)	REQUIREMENTS
[redacted]	DMA	REQUIREMENTS
	[redacted]	PROCUREMENT
		TT&C/SYS ENGINEERING
	SP-7	OPTICS/SYS ENGINEERING
	AEROSPACE SUBDIVISION	TECHNICAL CHAIRMAN
	" "	CONTROL THEORY
	" "	OPTICS
	" " (A-17)	SYSTEM ENGINEERING
	" SUBDIVISION	CONTROL SYSTEMS
	" LABS	ELECTRONICS
	" "	SSA EXPERIENCE
MR B.K. LARKIN		
[redacted] (b)(3)		

~~SECRET/I~~ [redacted] (b)(1) (b)(3)

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OVERVIEW

LT/COL LEHMANN

[redacted]

REQUIREMENT

TECHNICAL BRIEFING

CONTRACTUAL ASPECTS

~~SECRET/H~~[redacted]

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METRIC PAN CAMERA SYSTEM REQUIREMENTS

PARAMETER	ACCURACY @ ONE SIGMA	AVAILABILITY
ATTITUDE RATE	1.5 ARC SEC/SEC CONTINUOUS	CURRENT CAPABILITY
SV ORBITAL POSITION	30 FEET	NAVPAC - SV 13
CAMERA CALIBRATION	10 MICROMETERS (FILM DISTORTIONS)	SV 14
FRAME EXPOSURE TIME	0.1 MILLISECOND	NAVPAC - SV 14
ABSOLUTE ATTITUDE OF EACH CAMERA LINE-OF-SIGHT	5 ARC SECONDS	STAR SENSOR - SV 17
RELATIVE ATTITUDE OF EACH CAMERA LINE-OF-SIGHT BETWEEN STEREO EXPOSURES	3 ARC SECONDS	STAR SENSOR - SV 17

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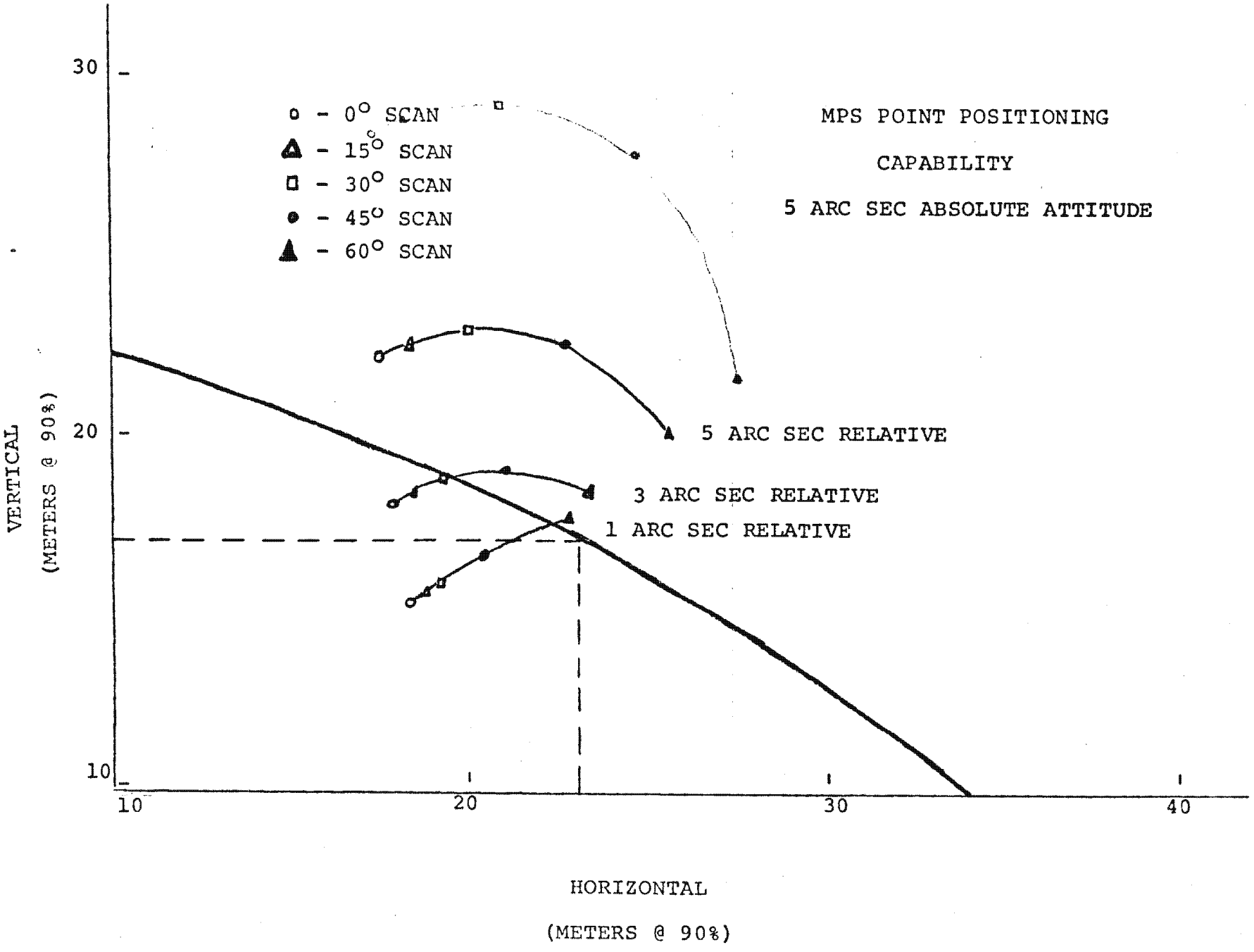

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TECHNICAL DISCUSSION

* OVERVIEW
* DESCRIPTION OF SSA
* PRINCIPLE TECHNICAL ISSUES AND CONCERNS
* FINDINGS

~~SECRET/H~~ [redacted]

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(b)(1)
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TECHNICAL OVERVIEW

* BENDIX/ITEK REQUESTED CONSIDERATION OF USING [redacted] STAR SENSOR ASSEMBLY (SSA) IN THE H SYSTEM

(b)(1)
(b)(3)

* INDEPENDENT TEAM FORMED TO ASSESS TECHNICAL FEASIBILITY

* TEAM REVIEWED DMA REQUIREMENTS, THE SSA AND THE APPLICATION

* THE TEAM FINDS NO TECHNICAL GROUNDS FOR ELIMINATING THE SSA (MODIFIED) AS A VIABLE OPTION TO SATISFY THE METRIC PAN REQUIREMENTS

* MORE DETAILED STUDY IS REQUIRED TO RESOLVE RESIDUAL CONCERNS

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PRINCIPLE TECHNICAL ISSUES

(b)(1)
(b)(3)

* CONCEPT COMPATIBILITY - SSA [redacted]
* HARDWARE COMPATIBILITY - FORM, FIT AND FUNCTION; REQUIRED MODS; INTEGRATION
* PERFORMANCE COMPATIBILITY - MAPPING REQUIREMENTS SATISFACTION; ERROR ANALYSIS
* PRODUCT ACCEPTABILITY TO USER - SOFTWARE, DATA RATE, FORMAT
* RELIABILITY
* DEVELOPMENT STATUS/RISKS

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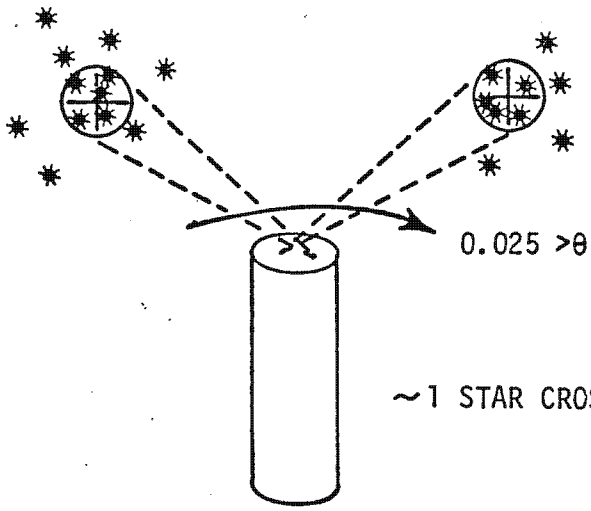
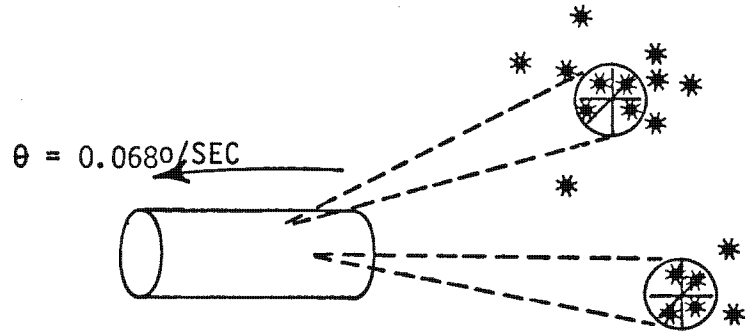
STAR SENSING CONCEPTS



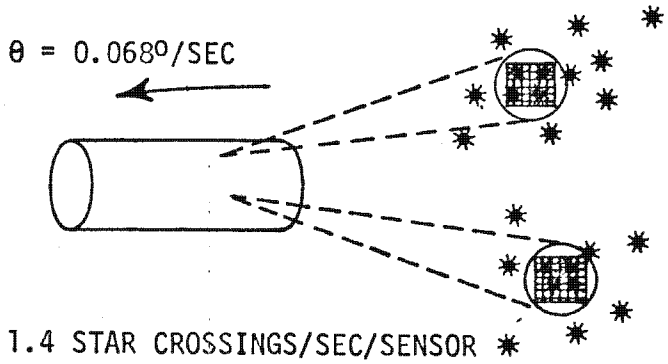
~1 STAR CROSSING/SEC/SENSOR

SSA = SLEWING VEHICLE



~.14 STAR CROSSINGS/SEC/SENSOR

SSA - STABILIZED VEHICLE



~1.4 STAR CROSSINGS/SEC/SENSOR

S^3 - STABILIZED VEHICLE

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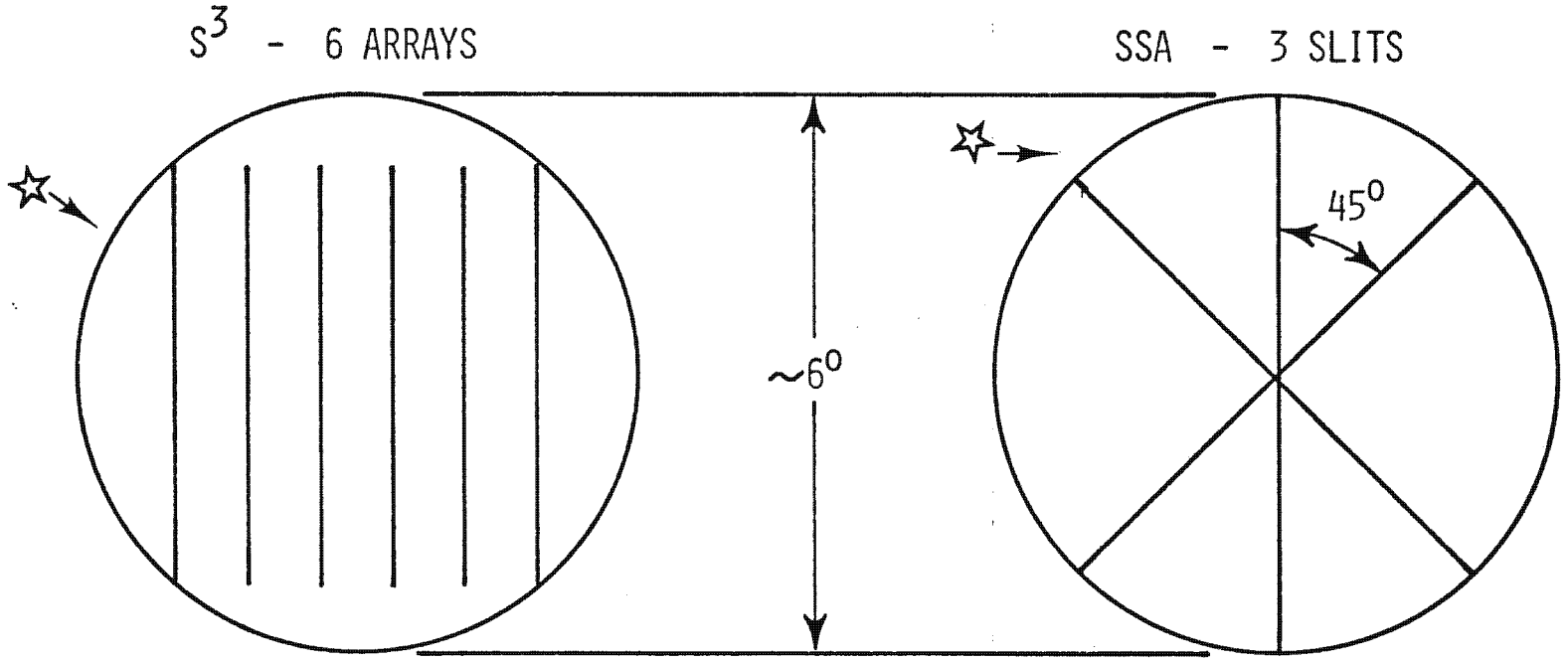

- CHARGE COUPLED DEVICE ARRAYS
- TWO AXIS INFORMATION
- CENTROID DETERMINATION BASED ON SIGNALS RECEIVED ON GROUND FROM SEVERAL DETECTOR ELEMENTS

- SINGLE PHOTOMULTIPLIER TUBE
- SINGLE AXIS INFORMATION ONLY
- TRANSIT TIME AND MAGNITUDE

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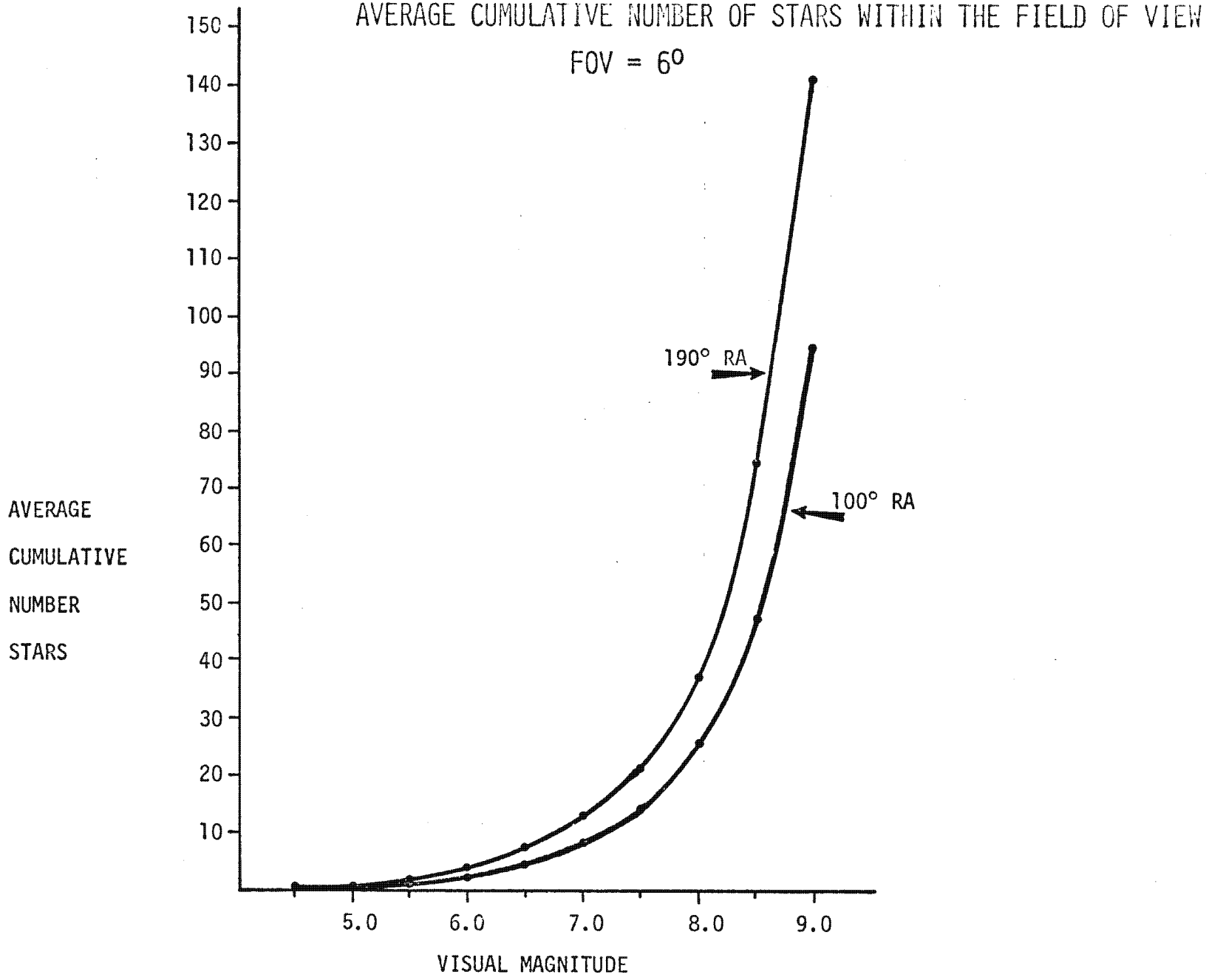

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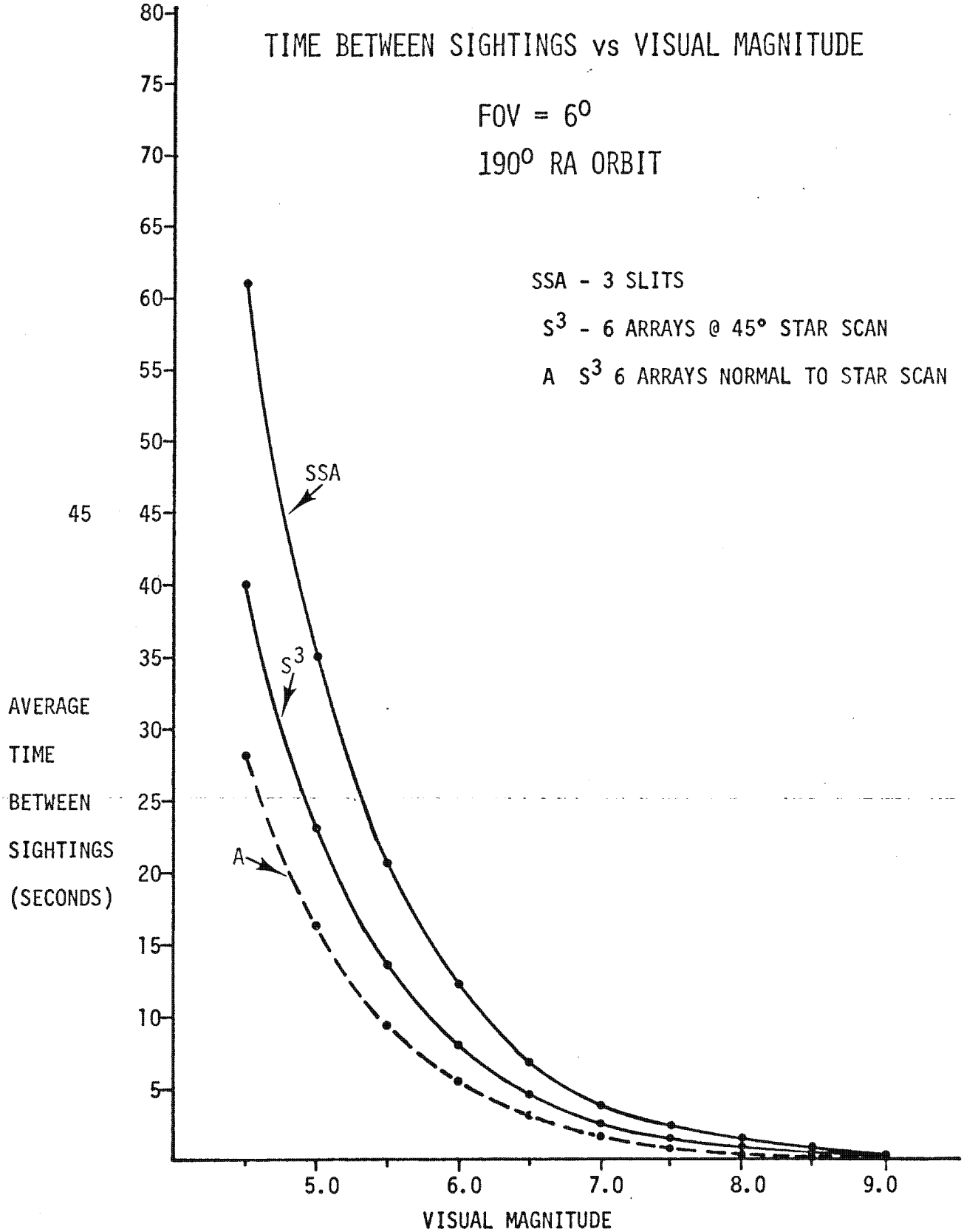

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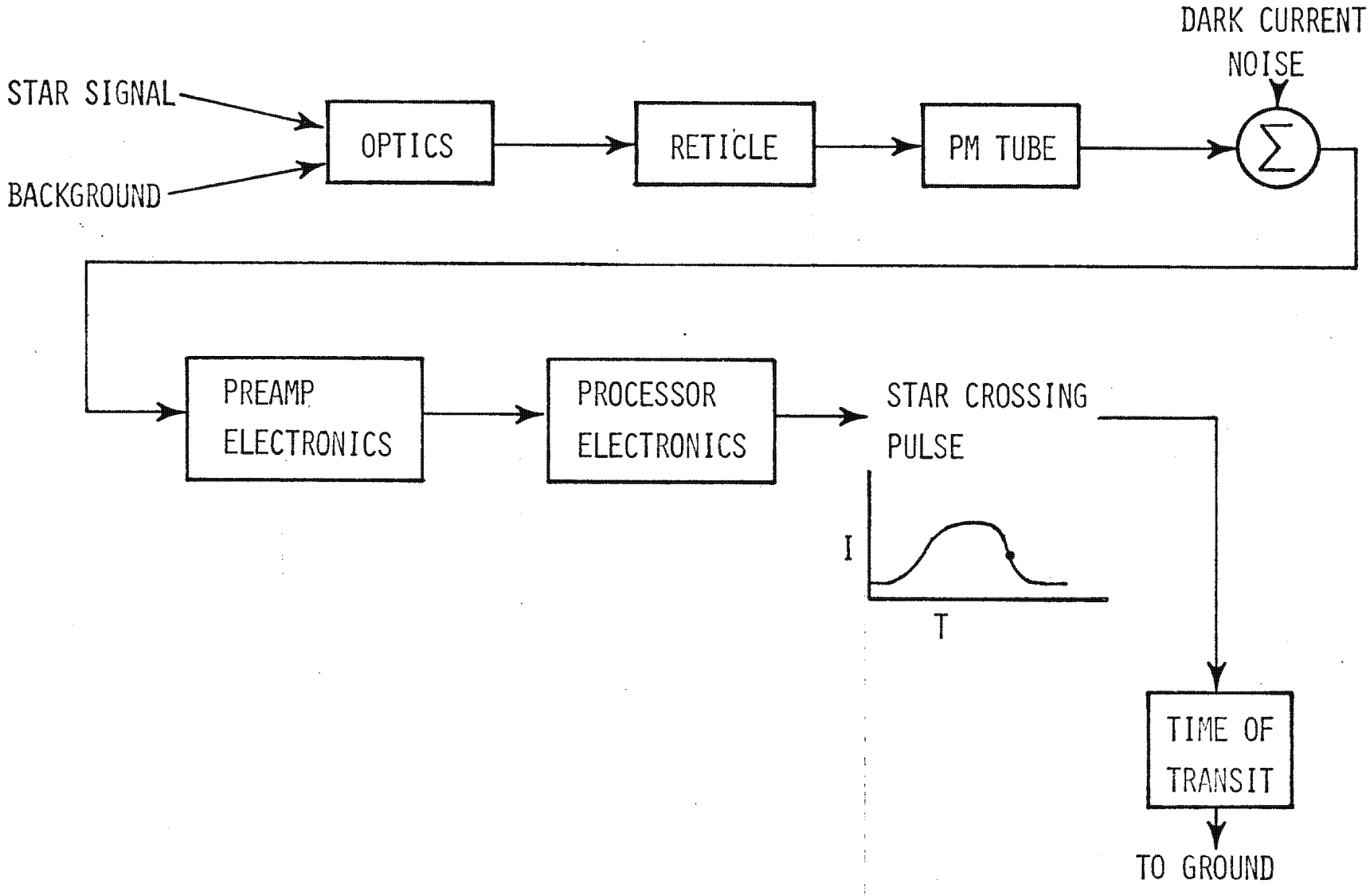
STAR SENSOR ASSEMBLY FUNCTIONAL BLOCK DIAGRAM



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STAR SENSOR ASSEMBLY (SSA) OPTICS

* PRECISION FIELD CORRECTED CASSEGRAIN TELESCOPE (EFL = 10 IN. DIA = 4 IN.)
* AUXILIARY LENS SYSTEM COLLECTS AND CONCENTRATES STAR ENERGY ON PHOTOMULTIPLIER TUBE AFTER PASSAGE THROUGH FOCAL PLANE SLIT
* TELESCOPE MECHANICAL STABILITY ACHIEVED BY SUPER LAPPED SUBASSEMBLY MATING SURFACES
* THERMAL STABILITY ACHIEVED BY USE OF LR 35 INVAR WITH THERMAL EXPANSION COEFFICIENT MATCHING THAT OF OPTICAL ELEMENTS
* OPTICAL SYSTEM MEETS ALL REQUIREMENTS FOR THIS APPLICATION WITH NO MODIFICATIONS

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USING SSA IN H [redacted]

SIMPLER APPLICATION BECAUSE

* ONE DIRECTION STAR CROSSING
* ONE CROSSING RATE
* NO ONBOARD PROCESSING
* MORE BENIGN ENVIRONMENT/LIFE
* LESS SUN AND BACKGROUND PROBLEM

HARDER BECAUSE

* PLATFORM PROVIDES MUCH LOWER STAR CROSSING FREQUENCY
* [redacted]
* QUESTIONABLE ALIGNMENT STABILITY BETWEEN SSA [redacted]

~~SECRET H~~ [redacted] (b)(1) (b)(3)

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MEASUREMENT CHARACTERISTICS AND PERFORMANCE

PARAMETER	S^3	SSA
ACCURACY FOR SINGLE STAR SIGHTING	2 - 3 $\overset{\frown}{\text{SEC}}$ (2 σ)	2 - 3 $\overset{\frown}{\text{SEC}}$ (2 σ)
INTERVAL BETWEEN STAR SIGHTINGS	~ 1 SEC (7.6 Mv)	~ 8 SEC (6.5 Mv)
COORDINATE INFORMATION	2 AXIS MEASUREMENT	1 AXIS MEASUREMENT
INTEGRATION INTERVAL (TIME RESOLUTION)	50 - 100 MSEC	8 MSEC
[redacted]		

(b)(1)
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ESTIMATED SYSTEM CHARACTERISTICS

	S^3	SSA	SSA [redacted]
WEIGHT	300 Lbs	≈250 (Based on 63 Lbs Current)	≈300
POWER	300 Watts	≈25 Watts (Based on 7 Watts)	75 Watts Operating *50 Watts Continuou
SIZE	COMPATIBLE	LESS THAN S^3	COMPATIBLE

* IMPACTS CURRENT VEHICLE CAPACITY

~~SECRET/H~~ [redacted] (b)(1) (b)(3)

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LOCATION OF SSA IN VEHICLE

* CONTRACTOR PROPOSES MOUNTING SSA ON EITHER

STRUCTURAL LONGERON	OR	TCA
○ NO PE HARDWARE INTERFACE		○ INTERFACE WITH PE
○ SHORT SUN-SHADE NECESSITATED		○ TIGHTER COUPLING WITH PAN LOS
○ UNMEASURED LONGERON/TCA DYNAMICAL MOTION ($\approx$20 $\overset{\frown}{\text{SEC}}$)		○ S^3 TO BE MOUNTED ON TCA

* TEAM CONSIDERED SSA TO BE MOUNTED TO TCA

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CONTRACTOR PROPOSED MODIFICATION

REQUIRED MODIFICATIONS

* ENGINEERING DESIGN MODIFICATIONS CONSIDERED MINOR
* PRESENT PACKAGING DENSITY WILL ACCOMMODATE MODIFICATIONS
* IMPACT ON SSA RELIABILITY -- NEGLIGIBLE

ADDITIONAL SUGGESTED MODIFICATIONS

* CHANGES SHOULD ENHANCE CONFIDENCE IN SATISFACTORY SSA PERFORMANCE
* FURTHER STUDIES DESIRED TO DEFINITIZE SPECIFIC SELECTIONS AND TRADE-OFFS

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ABSOLUTE L. O. S. POINTING ERROR ESTIMATES
(ARC SECONDS @ ONE SIGMA)

	S^3 BASELINE	SSA BASELINE *	SSA - MODIFIED **
ATTITUDE DETERMINATION	1.8	2.3 - 6.8	1.1 - 1.6
INTERLOCK	2.2	2.6 - 6.9	1.6 - 2.0
THERMAL STABILITY	3.4	3.4	3.4
	4.4	4.9 - 10.3	3.9 - 4.3

BASELINE

* SSA BASELINE ASSUMES LEAST MODIFICATIONS, SSA MOUNTED ON TCA NO SSA [redacted] (RANGE OF VALUES ENCOMPASSES [redacted] PERFORMANCE Vs SPEC)

** SSA MODIFIED ASSUMES [redacted] ON TCA (RANGE OF VALUES REFLECTS UNCERTAINTY IN CALIBRATION TECHNIQUES)

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COMPARISON OF AVERAGE ATTITUDE ERROR BOUNDS

SYSTEM	PERCENTAGE OF RECORD WITH ATTITUDE BETTER THAN 1.25 SEC	PERCENTAGE OF RECORD WITH ATTITUDE BETTER THAN 2.5 SEC	PERCENTAGE OF RECORD WITH ATTITUDE BETTER THAN 5.0 SEC
SSA WITH IMPROVED [redacted] ACCURACY OF 0.3 SEC/SEC	85%	98%	100%
SSA WITH NOMINAL [redacted] ACCURACY OF 1.5 SEC/SEC	75%	93%	97%
S^3 WITH NOMINAL [redacted] ACCURACY OF 1.5 SEC/SEC	98%	100%	100%

NOTE: SINGLE AXIS MONTE CARLO ANALYSIS ASSUMING:

RIGID COUPLING BETWEEN TCA AND [redacted]
OPTIMAL DATA PROCESSING

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(b)(3)

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SUITABILITY OF [redacted] DETERMINATION

(b)(1)
(b)(3)

FUNDAMENTAL PROBLEM

* SPEC PARAMETERS NOT CONSISTENT WITH PROPOSED APPLICATION
  (SPEC DRIFT STABILITY: 0.1°/HR/100 SEC RMS)
* PROPOSED CONCEPT REQUIRES ATTITUDE ERROR DURING 1 TO 100 SECOND RANGE
* EXPECTED ATTITUDE ERROR MUST BE INFERRED FROM SPECIFICATION
* INFERRED (FROM SPEC) PERFORMANCE NOT ACCEPTABLE
* FLIGHT EXPERIMENT (SINGLE TEST) INDICATES ACTUAL PERFORMANCE MAY BE ACCEPTABLE

[redacted]

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TYPICAL CANDIDATE INERTIAL REFERENCE UNITS QUALIFIED/*NEAR QUALIFICATION

	INERTIAL UNIT	WEIGHT 2-UNITS LB	POWER 1-UNIT WATTS	VOLUME 1-UNIT INCHES	PERFORMANCE
	H	36	55	9 x 9 x 6.5	SPEC CHANGE TO INSURE PERFORMANCE
*	H MOD II	56	70	9 x 11 x 6.4	ADEQUATE
*	[redacted] (b)(1) (b)(3)				
	ARA DMSP (Honeywell)	45	37	11 x 10 x 7	0.065°/Hr 3 Sigma

SYSTEM IMPACT:

- FREQUENT TURN-ON INCURS RISK (HARD START)
- [redacted] T/M ELECTRONICS REQUIRED - NOT QUALIFIED
- H, H MOD II [redacted] INERTIAL REFERENCE UNITS ARE APPLICABLE TO ENVIRONMENT AND LIFE REQUIREMENTS

(b)(1) (b)(3) (b)(1) (b)(3) ~~SECRET/H~~ (b)(1) (b)(3)

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GROUND DATA PROCESSING

* NOT DEFINED OR UNDERWAY FOR EITHER APPROACH

* ESTIMATE OF RELATIVE MERITS:

ISSUE	ASSESSMENT
TASK/ALGORITHM COMPLEXITY	SSA MORE COMPLEX THAN S^3
DEVELOPMENT RISK (S/W DESIGN & IMPLEMENTATION)	HIGHER RISK THAN S^3 BASED UPON COMPLEXITY, BUT ACHIEVEABLE
DATA PROCESSING LOAD	SAME AS S^3

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SSA RELIABILITY

* DESIGNED AND QUALIFIED FOR MORE STRINGENT APPLICATION
  - ENVIRONMENTAL SPECS SATISFIED
  - QUALIFICATION PROGRAM COMPLETE
* NO SINGLE POINT FAILURE MODES IN SENSING OR ELECTRONICS
* LIFETIME MORE THAN AMPLE
* PROBABLE MODIFICATIONS NOT LIKELY TO JEOPARDIZE QUALIFICATION STATUS

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TECHNICAL FINDINGS

* SSA IN CURRENT APPLICATION IS A QUALITY DEVICE

*

  * SSA APPEARS COMPATIBLE WITH VEHICLE

  * NO MAJOR HARDWARE DEVELOPMENT RISKS

* AS A SENSOR, SSA PERFORMANCE SATISFACTORY, BUT --

  * MORE DETAILED SYSTEM STUDY REQUIRED TO SPECIFY IF MINIMUM MOD VERSION WILL DO OR IF INCREASED SENSITIVITY [redacted] REQUIRED

TECHNICAL FINDINGS (Con't)

* A BENDIX/ITEK PROPOSAL WOULD PROBABLY BE TECHNICALLY COMPETITIVE

* ANY PROPOSAL SHOULD REFLECT INTERFACE CONSIDERATIONS INCLUDING FUTURE SYSTEM MODS

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RESIDUAL CONCERNS

IN THE EVENT OF SOURCE SELECTION, ATTENTION IS REQUIRED ON:

* [redacted]
* [redacted]

(b)(1)
(b)(3)

* CALIBRATION DURING OPERATION -METHOD, ACCURACY, MISSION IMPACT
* S/N ANALYSIS OF SSA OPERATING AT 6.5 MAGNITUDE
* LOWER MAGNITUDE STAR DETECTION (FAINTER THAN 6.5 M_V) [redacted]

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* SATISFACTION OF RELATIVE ACCURACY (3 SEC) REQUIREMENT

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TECHNICAL FINDINGS

(b)(1)
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* SSA [redacted]
* USE OF SSA IN THE HEXAGON SYSTEM APPLICATION SEEMS FEASIBLE BUT DEPENDS ON:
  * ACCURACY OF VEHICLE RATE INFORMATION - [redacted] MAY BE REQUIRED
  * ABILITY OF SSA TO DETECT 6.5 MAGNITUDE STARS
* MOUNTING SSA ON TCA APPEARS NECESSARY

(b)(1)
(b)(3)

* REQUIRED MODIFICATIONS [redacted] PROBABLY NOT EXTENSIVE
* NO MAJOR HARDWARE/DEVELOPMENT RISKS APPARENT
* A BENDIX/ITEK PROPOSAL WOULD PROBABLY BE TECHNICALLY COMPETITIVE
* IN THE EVENT OF SOURCE SELECTION, ADDITIONAL REVIEW OF KEY CONCERNS IS WARRANTED

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S^3 COST COMPARISON

(000's omitted)

	OCT '74	Oct '75	15 JAN '76 ROM	ECP 128-71
LABOR				
HRP MM		1,154	1,548	1,744
HRP $		6,277	10,061	11,293
New MM	1,256	438	535	543
New $	6,668	2,383	3,479	3,197
MATERIAL	2,861	2,576	3,002	2,401
SUBCONTRACTS				
DATA PROC. ELECTR.	(	2,643 (ASD)	4,960	4,182
FOCAL PLANE ARRAY	(3,844 (	1,083	909	1,081
LN_2	0	0	382	276
TOTAL S/C	3,844	3,776	6,251	5,539
COMPUTER	0	561	638	658
TRAVEL	0	301	444	510
INTERDIVISIONAL				
EO	2,135	480	2,026	2,026
ASD BOX MODS	0	0	950	1,405
ASD FP ELECTR	0	1,088	888	1,591
TOTAL INDIV	2,135	1,568	3,864	5,022
SPARES	0	0	0	1,006
COMMON PARTS	0	0	0	338
PROGRAM COST WITH HRP	?	11,121	17,678	18,771
PROGRAM COST WITHOUT HRP	$15,508	17,398	27,739	30,064

OCTOBER 74 QUOTE (PREVIOUSLY SUBMITTED AUG 28, 74)

PRIOR TO STUDY

BASED ON PRELIMINARY CONCEPTS

OCTOBER 75 QUOTE [redacted] INPUT) (b)(3)

IDENTIFIED 2.4M NEW LABOR

COMPUTER AND TRAVEL ADDED (860K)

15 JAN 76 ROM

NEW LABOR UP $ 1.1M

ADDED HRP $ 3.8M

RATES 1.7M (USED 6.5K/MM VS 5.44K/MM)

S^3/SMFT INTEGRATION 0.750M

ADDED 2.34M IN NEWLY DEFINED MANUFACTURING AND TEST REQ'TS (ALL HRP)

ADDED 2.3M FOR DATA PROCESSING (PROBABLE $ 1M PAD)

LIQ N_2 382 (ADDED TESTS)

EO WORK EXPANDED BY $1.5M (0.5M HAS GONE AWAY IN QUOTE)

ASD BOX MODS /PDS; DLF (TIMING)/ 0.950M

ECP 128 - 71

ASD BOX MODS AND FP ELECTRONICS ROM

ASSUMED STRETCH INITIALLY TAKING THAT OUT THE PRICE

WENT UP BY $ 1.1M

SPARES $1.006M (COULD BE DELETED AND USE DUAL)

COMMON PARTS 0.338M

PADDED HRP BY ≃ 200 MM

COST REDUCTION POTENTIAL

SCHEDULE

$ 1.0 M * LABOR IN 76/77
0.6 M FP ELECTRONICS
$ 1.6 M (REAL DOLLARS)

$ 1.0 M HRP LABOR

SCOPE

$ 1.0 * SPARES (USE QUAL MODEL)
0.34 * RELIABILITY
0.50 * EO COST REDUCTION (ALREADY QUOTED
0.75 INTEGRATION COSTS (TRANSFER)
0.50 BOX MODS (MODS REDUCED OR HRP'ED)
.50 * DELETE AREA ARRAY OPTION
$ 3.59 M

MISC

$ 1.0 * DATA PROC ELECT PAD
$ 1.0 * NEGOTIATION PAD (WAG)
$ 2.0

$ 1 - 2 M HRP HRS PAD

TOTAL OF REAL DOLLARS = $7.19 M

TOTAL OF REAL $ PLUS HRP = $9.2 - $10.2

ECP TARGET COST = 18.78 - 5.34 (*) = $13.44 M

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EVALUATION OF

THE MANAGEMENT CONCERNS AND CONTRACTING CONSIDERATIONS

FOR PROCURING A

STAR SENSOR SUB-SYSTEM

25 MARCH 1976

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SUMMARY OF EVENTS

DATE	EVENT
11 MAR 76	PRELIMINARY REPORT OF STAR SENSOR ASSEMBLY EVALUATION GROUP TO MAJ GEN KULPA
12 MAR 76	INITIAL MEETING WITH COL ANDERSON AND COL CAMPBELL REGARDING ESTABLISHMENT OF MANAGEMENT/CONTRACTING EVALUATION GROUP
15 MAR 76	APPROVAL OF SELECTED COMMITTEE MEMBERS/CHARTER BY MAJ GEN KULPA AND FORMULATION OF COMMITTEE CONCERNS AND ASSIGNMENTS FOR EVALUATION
15 MAR 76	FINAL REPORT OF STAR SENSOR ASSEMBLY EVALUATION GROUP
25 MAR 76	MANAGEMENT/CONTRACTING EVALUATION GROUP REPORT TO MAJ GEN KULPA

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TEAM COMPOSITION

NAME	OFFICE	DISCIPLINE
[redacted]	[redacted]	PROCUREMENT
		PROCUREMENT
	SP-7	ENGINEERING
MAJ D. RASPET	SP-7	ENGINEERING

OVERVIEW

- BACKGROUND
- INITIAL SELECTED SOURCE CONSIDERATIONS FOR S^3
- MANAGEMENT CONCERNS
- CONTRACTING CONSIDERATIONS
- COMMENTS ON SSA EVALUATION GROUP REPORT
- CONCLUSIONS/RECOMMENDATIONS

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BACKGROUND

APPROX TIME	ACTIVITY	RESULTS/CONCLUSIONS
SUMMER 1974	SAFSP, SAFSS, DMA, AEROSPACE, LMSC, PE REVIEW OF CONFIGURATION TRADES	(1) [redacted] (2) FILM TYPE STELLARS WOULD REQUIRE EXTENSIVE FILM PATH MODES (3) S-CUBED CONCEPT MET ACCURACY AND MINIMUM IMPACT CRITERIA
FALL 1974	SAFSP COMPLETED REVIEW OF S-CUBED CONCEPT	RECOMMENDED NOT TO PROCEED WITH S-CUBED DUE TO HIGH RISKS
FALL 1974	SAFSS REQUESTED STUDY OF HIGH RISK CONCERNS	STUDY INITIATED IN NOVEMBER 1974
FEB 1975	SAFSS STATED S^3 SHOULD BE A BLOCK IV CONSIDERATION	STUDY COMPLETION REVISED FROM 1 JULY 75 TO 1 JAN 76

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[redacted]

BACKGROUND (Cont'd)

APPROX TIME	ACTIVITY	RESULTS/CONCLUSIONS
FEB 1975	SAFSP REVIEWED SSA WITH LMSC/ CUSTOMER	(1) CONCEPT DETERMINED TO BE SAME AS PROPOSED EARLIER
		(2) [redacted]
		(3) COST, SCHEDULE, AND PERFORMANCE RECORD VERY POOR
NOV 1975	NRO/DMA RE-EVALUATED SV-17 & 18 MAPPING REQUIREMENTS AND SAFSP REVIEWED S^3 RISKS	(1) SAFSP NOW CONSIDERED DEVELOPMENT RISK LOW
		(2) SV-17 & 18 MAPPING CAMERAS CANCELLED
		(3) METRIC PAN CAPABILITY TO BE PURSUED TO INSURE SV-17 EFFECTIVITY
		(4) FUNDING LIMITED TO $\prec$ $1M UNTIL MAPPING REQUIREMENTS/ ALTERNATIVES REVIEWED
FEB 1976	MAPPING DECISION DELAYED UNTIL APRIL 1976	LIMITED FUNDING COMMITTED TO PRESERVE SV-17 EFFECTIVITY

[redacted] SECRET

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INITIAL SELECTED SOURCE CONSIDERATIONS

- S^3 WAS THE ONLY CONCEPT VERIFIED BY DETAILED STUDY
- PERKIN-ELMER HAD BEST CHANCE TO MEET SYSTEM PERFORMANCE REQUIREMENTS
  - STUDIED OVERALL PROBLEM FOR TWO YEARS
  - COULD BE INCENTIVIZED FOR OVERALL PERFORMANCE
  - HAD 900 MAN FORCE AVAILABLE FOR UNFORESEEN PROBLEMS
- DURING DELAY IN MAKING MAPPING DECISION ONLY PE HAD CAPABILITY TO CONTINUE MPS STUDY WITHIN FUNDING LIMITS
- SCHEDULE REQUIREMENTS MADE OPEN COMPETITION SEEM UNWISE

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MANAGEMENT CONCERNS

- SSA CONCEPT REQUIRES FURTHER STUDY
- SCHEDULES
- INTEGRATION

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PRUDENT SSA DEVELOPMENT REQUIRES FURTHER STUDY

- [redacted] INTEGRATION
  - NEED
  - POWER
  - HEAT DISSIPATION
  - DATA RATES
- 6.5 MAGNITUDE CAPABILITY NEEDS DEMONSTRATION
- CALIBRATION TECHNIQUE
- TOTAL INTEGRATED SYSTEM

SCHEDULE IS A PROBLEM

SSA CONCEPT ANALYSIS REQUIRES TIME AND MONEY

PROCUREMENT PROCESS

MANUFACTURE

TOTAL SYSTEM TESTING

DYNAMICS OF HEXAGON PROGRAM/MAPPING REQUIREMENTS

SCHEDULE COMPARISON

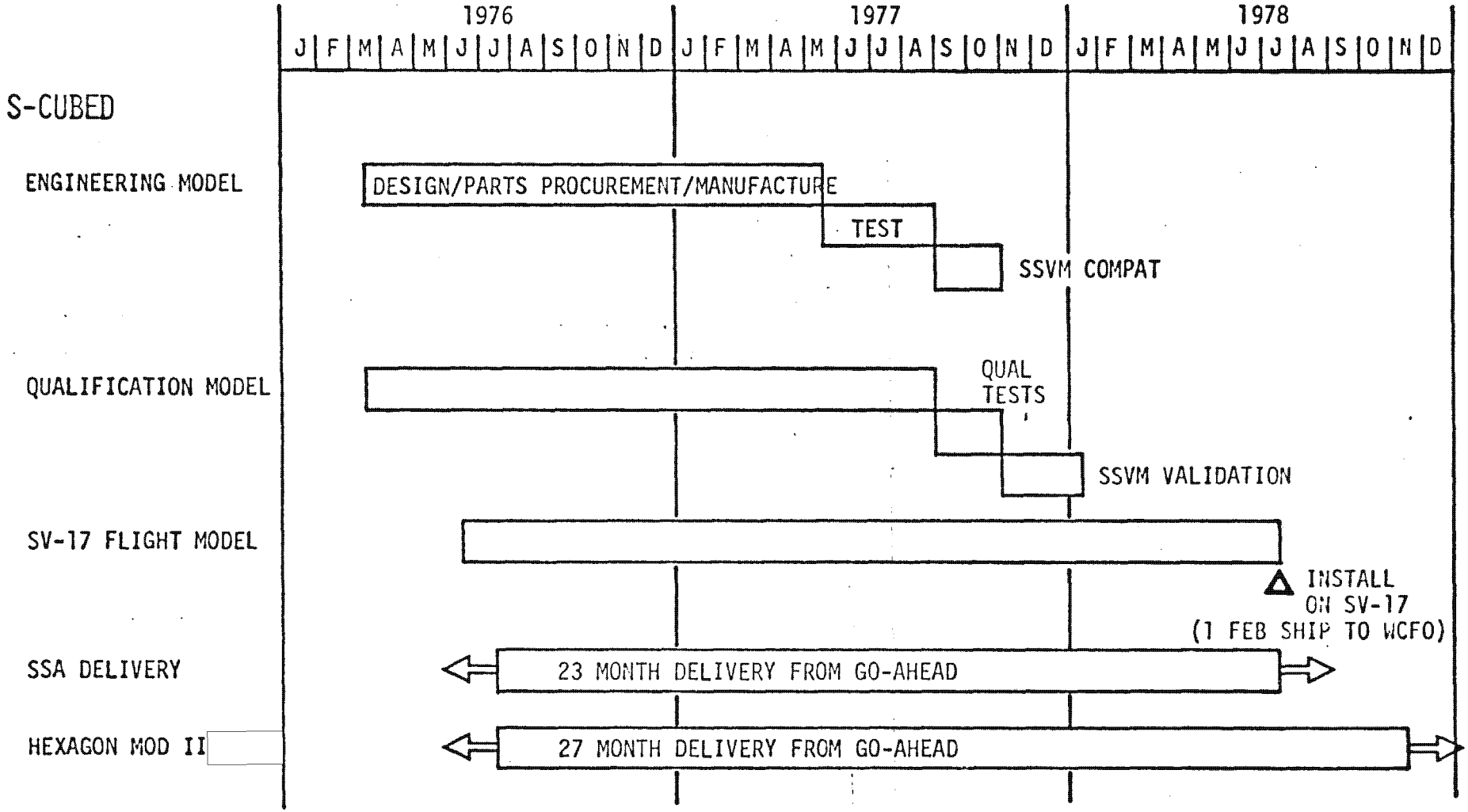

Figure I-A

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INTEGRATION

MPS REQUIRES AN EFFECTIVE INTEGRATOR

- MUST UNDERSTAND TOTAL PROBLEM
- MUST BE ABLE TO WORK UNEXPECTED PROBLEMS
- MEETING 5 $\overset{\frown}{\text{SEC}}$ POINTING REQUIREMENTS SHOULD BE INCENTIVIZED

CONTRACTING CONSIDERATIONS

- GROUND RULES AND ASSUMPTIONS
- CONTRACT APPROACHES TO BE TAKEN TO EFFECT A COMPETITION OF A STAR SENSOR SUB-SYSTEM:
  - OPEN COMPETITION TO ALL QUALIFIED SOURCES
  - SSA AS DIRECTED SUB TO PERKIN-ELMER
  - SSA PROVIDED AS GFE TO PERKIN-ELMER
  - LMSC AS INTEGRATOR AND PROVIDE A SUB-SYSTEM
  - PERKIN-ELMER AS INTEGRATOR AND PROVIDE A SUB-SYSTEM ON A MAKE-OR-BUY DECISION
- CONTRACT APPROACH WITHOUT COMPETITION - PERKIN-ELMER PROVIDE S^3 SYSTEM AS SELECTED SOURCE
- PROCUREMENT LEADTIMES

GROUNDRULES AND ASSUMPTIONS

- DECISION DEFINING APPROACH REQUIRED 1 APR 76
- STAR SENSOR SUB-SYSTEM HARDWARE REQUIRED 1 JUL 78
- LAUNCH DATE FOR SV-17 - FALL 80

ISSUE AN RFP TO ALL QUALIFIED SOURCES TO PROVIDE A SUB-SYSTEM THAT WOULD MEET DMA'S PERFORMANCE REQUIREMENTS

PRO'S	CON'S
• POTENTIAL FOR LOWER COST OF SUB-SYSTEM	• MAY SURFACE ADDITIONAL TECHNICAL PROBLEMS
• OPEN COMPETITION	• POSSIBLE SECURITY PROBLEMS
• BROADEN TECHNICAL BASE	• REQUIRES MORE PROCUREMENT LEAD TIME
• MINIMIZES POTENTIAL DISPUTE FROM EITHER P-E OR BENDIX/ITEK OR OTHER CONTRACTORS	• BECOMES GFE TO P-E WITH ALL ATTENDANT PROBLEMS THERETO
• RETAIN TECHNICAL CONTROL OF SOURCE SELECTION	• ADDITIONAL INTEGRATION COSTS FOR BOTH ASSOCIATE CONTRACTORS
	• INCREASES COMPLEXITY OF TECHNICAL INTERFACES AND SOURCE SELECTION PROCESS

Figure I-B

~~TOP SECRET~~

PROCURE STAR SENSOR ASSEMBLY (BENDIX-ITEK) AS DIRECTED SUB TO P-E

AND P-E INTEGRATE SUB-SYSTEM HARDWARE

PRO'S	CON'S
• POSSIBILITY OF USING HRP FOR INTEGRATION EFFORT-AVOIDS ADDITIONAL COSTS	• VERY RISKY FROM A TECHNICAL, SCHEDULE AND COST POINT OF VIEW DUE TO LACK OF FULL SUPPORT BY P-E • DIFFICULT IF NOT IMPOSSIBLE TO INCENTIVIZE PERFORMANCE • VERY TOUCHY INTERFACE PROBLEM WITH SUB • MORE COSTLY • POSSIBLE SCHEDULE PROBLEM • IMPOSSIBLE TO JUSTIFY EXCLUSION OF S^3

Figure I-C

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PROCURE STAR SENSOR ASSEMBLY (BENDIX-ITEK) DIRECT AND PROVIDE TO P-E AS GFE FOR INTEGRATION

PRO'S

- GOVERNMENT RETAINS TECHNICAL CONTROL OF SOURCE SELECTION
- GOVERNMENT MAINTAINS MANAGEMENT CONTROL OVER ASSOCIATE CONTRACTOR
- POSSIBILITY OF USING HRP FOR INTEGRATION EFFORT - AVOIDS ADDITIONAL COSTS

CON'S

- GOVERNMENT ACCEPTS FULL RESPONSIBILITY THAT TOTAL SYSTEM WORKS
- DIFFICULT IF NOT IMPOSSIBLE TO INCENTIVIZE PERFORMANCE
- LESS THAN FULL SUPPORT BY P-E
- VERY TOUCHY INTERFACE PROBLEM BETWEEN P-E/BENDIX-ITEK
- TWO PROCUREMENT ACTIONS REQUIRED
- POSSIBLY MORE COSTLY
- POSSIBLE INCREASE FOR CLAIMS BASED UPON LATE OR DEFICIENT GFE
- IMPOSSIBLE TO JUSTIFY EXCLUSION OF S^3

Figure I-D

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[redacted]

ISSUE AN RFP TO LMSC (AS INTEGRATOR) TO PROVIDE A SUB-SYSTEM THAT WOULD MEET DMA'S PERFORMANCE REQUIREMENTS

PRO'S

- GOVERNMENT IS OUT OF SOURCE SELECTION CYCLE ADMINISTRATIVE EFFORT
- GOVERNMENT IS NOT PROVIDING THE SYSTEM AS GFE
- ELIMINATES POSSIBLE INTERFACE CONFLICTS BETWEEN PE/BENDIX-ITEK
- LMSC EXPERIENCED AS INTEGRATOR

CON'S

- GOVERNMENT LOSES TECHNICAL CONTROL OF SUB-SYSTEM SOURCE SELECTION
- ADDITIONAL COST FOR INTEGRATION OF SUB-SYSTEM
- ADD MORE COMPLEXITY TO LMSC/PE INTERFACE
- IMPOSSIBLE TO INCENTIVIZE THE ACCURACY OF SUB-SYSTEM BY ITSELF
- WOULD HAVE TO INCENTIVIZE BOTH THE SUB-SYSTEM AND PAN CAMERA INDIVIDUALLY
- FAIR AND OBJECTIVE COMPETITION OF SELECTING A SUBCONTRACTOR WOULD BE DIFFICULT

Figure I-E

[redacted]

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ISSUE AN RFP TO P-E (AS INTEGRATOR) TO PROVIDE A SUB-SYSTEM, ON A MAKE-OR-BUY DECISION, THAT WOULD MEET DMA'S PERFORMANCE REQUIREMENTS

PRO'S

- GOVERNMENT IS OUT OF SOURCE SELECTION CYCLE ADMINISTRATIVE EFFORT
- GOVERNMENT IS NOT PROVIDING THE SYSTEM AS GFE
- ELIMINATE SOME OF THE PERFORMANCE INCENTIVE PROBLEM
- APPROVAL OF MAKE-OR-BUY, GOVERNMENT WOULD NOT LOSE TECHNICAL CONTROL OF SUB-SYSTEM SOURCE SELECTION
- MORE CLEARLY DEFINED SYSTEM PERFORMANCE RESPONSIBILITY TO ATTAIN REQUIREMENT
- POSSIBILITY OF USING HRP FOR INTEGRATION EFFORT
- BETTER UNDERSTANDING OF OVERALL SYSTEM REQUIREMENTS
- POTENTIAL FOR LOWER COST

CON'S

- POSSIBLE INTERFACE PROBLEM WITH BENDIX-ITEK
- NOT AS EXPERIENCED AS LMSC IN THE INTEGRATOR ROLE
- FAIR AND OBJECTIVE COMPETITION OF SELECTING A SUBCONTRACTOR WOULD BE DIFFICULT

Figure I-F

PROCURE S^3 SUB-SYSTEM FROM P-E AS SELECTED SOURCE

PRO'S

- GOVERNMENT RECEIVES BENEFIT OF EFFORT ACCOMPLISHED TO DATE ON S^3
- ELIMINATES THE PERFORMANCE INCENTIVE PROBLEM
- MORE CLEARLY DEFINES SYSTEM PERFORMANCE RESPONSIBILITY TO ATTAIN REQUIREMENT
- AVOIDS ADDITIONAL COSTS FOR INTEGRATION EFFORT BY USE OF HRP
- ACHIEVES BETTER UNDERSTANDING OF OVERALL SYSTEM REQUIREMENTS
- REDUCES PROCUREMENT LEADTIME BY APPROXIMATELY 4 MONTHS
- PROTECTS TOTAL PROGRAM SCHEDULE
- GREATLY SIMPLIFIES INTERFACE PROBLEMS
- INCREASES CONFIDENCE IN SATISFYING THE DMA REQUIREMENT
- EFFECTIVELY USES AVAILABLE SUSTAINING LABOR

CON'S

- POSSIBLE PROTEST BY BENDIX-ITEK OR OTHER CONTRACTORS

Figure I-G

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PROCUREMENT LEADTIMES
(IN MONTHS)

	OPEN COMPETITION	SSA AS DIRECTED SUB TO P-E	SSA AS GFE TO P-E	LMSC OR P-E AS SELECTED SOURCE INTEGRATOR	S^3 AS SELECTED SOURCE
PREPARE PROC ACTION REQUEST	1	1	1	1	0/½
ISSUE RFP	1	½	1	½	0/0
RECEIVE CONTRACTOR PROPOSAL	3*	3	2	2	0/0
TECHNICAL EVALUATION	4	2	2	2	1½/0
NEGOTIATION CYCLE	1	1	1	1	1/0
CONTRACT PROCESSING UP TO CONTRACTOR SIGNATURE	1	1	1	1	1/0
SIGNATURE/DISTRIBUTION CYCLE AWARD	1	1	1	1	½/½
TOTAL PROCUREMENT CYCLE	12	9½***	9	8½***	4/1**
FROM CONTRACT AWARD TO FIRST DELIVERY:					
- SSA/SSA MODIFIED	23/27	23/27	23/27	23/27	-
- S^3	27/?	-	-	27	27

*LIMITED COMPETITION = 2 MOS
**4 MOS = DEFINITIVE DOCUMENT
1 MO = CHANGE ORDER
***WITH CHANGE ORDER COULD SHORTEN CYCLE SOMEWHAT

Figure I-H

CONCLUSIONS/RECOMMENDATIONS

- P-E SHOULD INTEGRATE THE SS/PAN CAMERA COMBINATION INTO THE METRIC PAN SYSTEM (MPS)
- OPEN OR LIMITED COMPETITION OF SUB-SYSTEM WOULD JEOPARDIZE OVERALL PROGRAM SCHEDULE
- SSA CONCEPT REQUIRES ADDITIONAL STUDY WHICH WOULD JEOPARDIZE OVERALL PROGRAM SCHEDULE
- OVERALL PROGRAM/PROCUREMENT SCHEDULE DICTATES SELECTION OF S^3 SUB-SYSTEM AS A SELECTED SOURCE
- IF COMPETITION OF SUB-SYSTEM IS REQUIRED:
  - P-E SHOULD PROVIDE BASED ON A MAKE-OR-BUY DECISION
  - RECOGNIZE AN OVERALL PROGRAM SCHEDULE IMPACT

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BACKGROUND

APPROX TIME	ACTIVITY	RESULTS/CONCLUSIONS
SUMMER 1974	SAFSP, SAFSS, DMA, AEROSPACE, LMSC, PE REVIEW OF CONFIGURATION TRADES	(1) [redacted] (2) FILM TYPE STELLARS WOULD REQUIRE EXTENSIVE FILM PATH MODES (3) S-CUBED CONCEPT MET ACCURACY AND MINIMUM IMPACT CRITERIA
FALL 1974	SAFSP COMPLETED REVIEW OF S-CUBED CONCEPT	RECOMMENDED NOT TO PROCEED WITH S-CUBED DUE TO HIGH RISKS
FALL 1974	SAFSS REQUESTED STUDY OF HIGH RISK CONCERNS	STUDY INITIATED IN NOVEMBER 1974
FEB 1975	SAFSS STATED S^3 SHOULD BE A BLOCK IV CONSIDERATION	STUDY COMPLETION REVISED FROM 1 JULY 75 TO 1 JAN 76

(b)(1)
(b)(3)

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BACKGROUND (CON'T)

APPROX TIME	ACTIVITY	RESULTS/CONCLUSIONS
FEB 1975	SAFSP REVIEWED SSA WITH LMSC/CUSTOMER	(1) CONCEPT DETERMINED TO BE SAME AS PROPOSED EARLIER (2) [redacted] (b)(1) (b)(3) (3) COST, SCHEDULE, AND PERFORMANCE RECORD VERY POOR
NOV 1975	NRO/DMA RE-EVALUATED SV-17 & 18 MAPPING REQUIREMENTS AND SAFSP REVIEWED S^3 RISKS	(1) SAFSP NOW CONSIDERED DEVELOPMENT RISK LOW (2) SV-17 & 18 MAPPING CAMERAS CANCELLED (3) METRIC PAN CAPABILITY TO BE PURSUED TO INSURE SV-17 EFFECTIVITY (4) FUNDING LIMITED TO ≤ $1M UNTIL MAPPING REQUIREMENTS/ ALTERNATIVES REVIEWED
FEB 1976	MAPPING DECISION DELAYED UNTIL APRIL 1976.	LIMITED FUNDING COMMITTED TO PRESERVE SV-17 EFFECTIVITY

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INITIAL SELECTED SOURCE CONSIDERATIONS

- S^3 WAS THE ONLY CONCEPT VERIFIED BY DETAILED STUDY
- PERKIN-ELMER HAD BEST CHANCE TO MEET SYSTEM PERFORMANCE REQUIREMENTS
  - STUDIED OVERALL PROBLEM FOR TWO YEARS
  - COULD BE INCENTIVIZED FOR OVERALL PERFORMANCE
  - HAD 900 MAN FORCE AVAILABLE FOR UNFORESEEN PROBLEMS
- DURING DELAY IN MAKING MAPPING DECISION ONLY PE HAD CAPABILITY TO CONTINUE MPS STUDY WITHIN FUNDING LIMITS
- SCHEDULE REQUIREMENTS MADE OPEN COMPETITION SEEM UNWISE

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MANAGEMENT CONCERNS

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MANAGEMENT CONCERNS

1. SSA CONCEPT REQUIRES FURTHER STUDY

2. SCHEDULES

3. S^3 - H MUTUAL BENEFIT

4. INTEGRATION

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PRUDENT SSA DEVELOPMENT REQUIRES FURTHER STUDY

1. [redacted] INTEGRATION
   - A. NEED
   - B. POWER
   - C. HEAT DISSIPATION
   - D. DATA RATES

2. 6.5 MAGNITUDE CAPABILITY NEEDS DEMONSTRATION

3. CALIBRATION TECHNIQUE

4. TOTAL INTEGRATED SYSTEM

[redacted]

(b)(1)
(b)(3)

[redacted]

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SCHEDULE IS A PROBLEM

SSA CONCEPT ANALYSIS REQUIRES TIME AND MONEY

PROCUREMENT PROCESS

MANUFACTURE

TOTAL SYSTEM TESTING

DYNAMICS OF HEXAGON PROGRAM/MAPPING REQUIREMENTS

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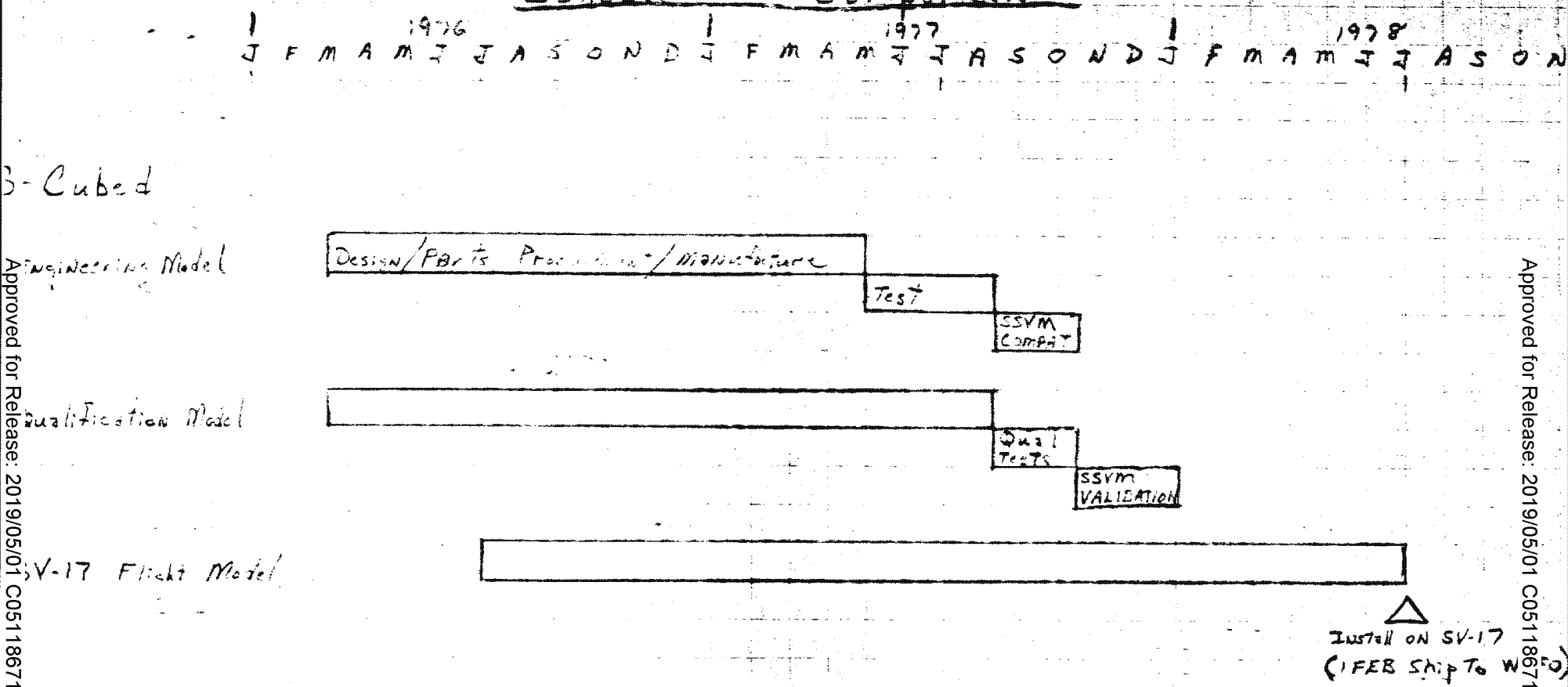
Schedule Comparison



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(b)(1)
(b)(3)

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S^3 - H MUTUAL BENEFIT

- S^3 PROVIDES INCENTIVE/CHALLENGE TO P-E SUSTAINING FORCE UNTIL BLOCK 4 DETERMINATION

TOO STRONG

- CURRENT H SUBCONTRACTORS E-O, ASD, RADIATION/GE WOULD ALSO BENEFIT
- S^3 AT PE WOULD LIMIT NUMBER OF CONTRACTORS TO BE SUSTAINED UNTIL BLOCK 4 DECISION
- H SUSTAINING FORCE AT P-E PROVIDES MOST OF P-E LABOR
- P-E SUSTAINING FORCE IS A GOOD GUARANTEE FOR S^3 SUCCESS

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INTEGRATION

MPS REQUIRES AN EFFECTIVE INTEGRATOR

- MUST UNDERSTAND TOTAL PROBLEM
- MUST BE ABLE TO WORK UNEXPECTED PROBLEMS
- MEETING 5 SEC POINTING REQUIREMENTS SHOULD BE INCENTIVIZED

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Brett

I. BACKGROUND

1. In the Summer of 1974, SAFSP, DMA, Aerospace and SFASS personnel reviewed a number of proposed methods of determining Hexagon vehicle attitude to meet DMA mapping requirements. Basic conclusions made from this review were:

a. Slit-type star-tracker attitude reference cameras (SSA basic design) could meet the pointing accuracy requirements only with extensive integration effort with the vehicle gyros. This was considered unacceptable.

b. Film stellar cameras which would either image stars on Hexagon intra-op film or on a separate film web were considered but were determined to have an unacceptable impact on the host vehicle.

c. The Solid State Stellar (S^3) Camera concept had the potential to meet the accuracy requirements and was the only candidate which met the criteria for minimal impact on the current Hexagon vehicle.

2. After evaluating the S^3 concept further, SAFSP concluded that the S^3 cubed camera was a high risk development program due to its use of Charge Coupled Devices (CCD's) as the focal plane. In addition, the whole concept that the panoramic camera line of sight was stable to a 5 arc-second accuracy appeared to be a high risk assumption. For these and other concerns, the recommendation was made that S^3 not be implemented. This recommendation was made by SAFSP to SAFSS during the Fall of 1974.

3. Based on these concerns for the S^3/Panoramic Metric Pan concept, SAFSS requested a study be performed to evaluate the risks involved. This study was initiated in November 1974 and was intended for completion by July 1975, so a decision for SV-17 and SV-18 mapping requirements could be made. Shortly after the study was begun, direction was received stating that S-Cubed implementation would be no earlier than Block IV so the study completion date was changed to 1 January 1976 and made more comprehensive.

4. In February 1975, the Star Sensor Assembly (SSA) to be used by another program was reviewed by SAFSP with LMSC and customer personnel. This device was determined to be similar to the hardware reviewed in 1974 and would have the same problems meeting accuracy requirements without extensive integration with [redacted] on the Hexagon vehicle. In addition, the problems being experienced by the SSA at that time concerning cost, schedule, and performance did not make it appear as an attractive alternative. (b)(1) (b)(3)

5. Prior to completing the S^3 risk evaluation but after extensive effort had been completed (November 1975) the Staff requested a risk evaluation on the S-Cubed concept. A revised risk assessment (i.e., S^3 was now considered a low risk project) combined with other factors resulted in the following direction to SAFSP.

a. Cancel ITEK mapping cameras for SV-17 and SV-18 and,

b. Continue MPS work to assure SV-17 implementation with the proviso that not more than $1 million be expended until SAFSS reviewed the mapping requirement and alternatives further with DMA. The final decision has been delayed from February until 1 April.

II. SELECTED SOURCE CONSIDERATIONS

1. After the decision to cancel SV-17 and -18 mapping cameras, SAFSP looked at the justification for continuing what had evolved as a sole source procurement. Sufficient justification was considered to be available for the following reasons:

a. Only S^3 appeared as a workable concept that had been verified by detailed study and still met the criteria of minimal impact on the host vehicle.

b. Perkin-Elmer had the best chance of meeting system performance objectives because -

(1) They had 2 years to study and understand the problem from a system standpoint.

(2) They would have overall performance responsibility for meeting the 5 arc-second system pointing accuracy.

(3) They have a 900-man task force capable of working any unforeseen problems in either the stellar camera or the panoramic camera.

c. Only Perkin-Elmer had the capability to continue to work the Metric Pan problem from November 1975 until SAFSS decides on a course of action with the limited dollars available. Perkin-Elmer is continuing with the sustaining engineering labor force available.

d. The sustaining engineering available at Perkin-Elmer made any alternative to S-Cubed questionable from a cost standpoint, especially if Block IV systems are considered without the non-recurring development costs.

e. Schedule requirements to meet a SV-17 effectivity, were very tight and open competition procurement schedule was considered to be prohibitive from a total program schedule standpoint.

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FINAL REPORT

OF

MANAGEMENT AND CONTRACTING EVALUATION GROUP
FOR PROCURING A STAR SENSOR SUB-SYSTEM

INTRODUCTION

This report is a supplement to "Final Report of Star Sensor Assembly Evaluation Group" dated 15 March 1976. This report consists of six parts. The first part is a brief summary of facts gathered and conclusions drawn by the SSA Evaluation Group. Parts II through V contain background, management concerns, various contract approaches and conclusions drawn by the Management and Contracting Evaluation Group. The sixth part is a copy of the briefing charts used by this group to brief Major General Kulpa on the results of the evaluation.

PART I

The Star Sensor Assembly Evaluation Group was formed at the request of Major General Kulpa to evaluate the capability of "off-the-shelf" Star Sensor Assembly (SSA) to fulfill the Hexagon Program's mapping requirements for Vehicle 17 and up. Based upon the group's evaluation, it was concluded that the SSA could not be eliminated as a possible contender to fulfill the DMA requirements for the Hexagon metric pan camera system. However, it was also recognized that time and lack of data left many significant areas only superficially reviewed and should a decision be made to pursue a more definitive proposal for the SSA use, the following areas required additional attention:

1. [redacted] (b)(1) (b)(3)

2. Impact of [redacted] on vehicle power budget.

3. The method, accuracy and mission impact of calibration of the overall system.

4. Signal/noise analysis of SSA operating at 6.5 MV.

5. Possibility of reducing SSA detection capability below the 6.5 MV thereby increasing star acquisition rate and lowering dependence on [redacted] (b)(1) (b)(3)

6. Capability of any proposed system to fulfill the overall system requirements with special emphasis on the 3 arc sec relative accuracy.

In the process of performing the technical evaluation of the SSA, it became apparent that certain management and contractual factors also required attention. Some of the concerns were verbally addressed

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during the preliminary briefing on 11 March 1976. As a result of this briefing, General Kulpa requested another group be formed to evaluate the management and contracting factors associated with contracting for a star sensor sub-system on a competitive basis, i.e., Solid State Stellar (S^3) and SSA systems.

PART II

The Management and Contracting Evaluation Group was formed to evaluate:

1. Reasons S^3 was originally considered to be a selected source.

2. Various contract approaches that could be taken to effect a competition for the procurement of the systems from PE or Bendix-Itek.

3. Opening the competition for the procurement of a system to all qualified sources.

4. In conjunction with the above, procurement lead times and development/production schedules of the total Hexagon system.

PART III

A. BACKGROUND

1. In the summer of 1974, SAFSP, DMA, Aerospace and SAFSS personnel reviewed a number of proposed methods of determining Hexagon vehicle attitude to meet DMA mapping requirements. Basic conclusions made from this review were:

a. Slit-type star-tracker attitude reference cameras (SSA basic design) could meet the pointing [redacted] (b)(1) (b)(3) This was considered unacceptable.

b. Film stellar cameras which would either image stars on Hexagon intra-op film or on a separate film web were considered but were determined to have an unacceptable impact on the host vehicle.

c. The Solid State Stellar (S^3) Camera concept had the potential to meet the accuracy requirements and was the only candidate which met the criteria for minimal impact on the current Hexagon vehicle.

2. After evaluating the S^3 concept further, SAFSP concluded that the S^3 cubed camera was a high risk development program due to its use of Charge Coupled Devices (CCD's) as the focal plane. In addition, the whole concept that the panoramic camera line of sight was stable to a 5 arc-second accuracy appeared to be a high risk assumption. For these and other concerns, the recommendation was made that S^3 not be implemented. This recommendation was made by SAFSP to SAFSS during the fall of 1974.

3. Based on these concerns for the S^3/Panoramic Metric Pan concept, SAFSS requested a study be performed to evaluate the risks involved. This study was initiated in November 1974 and was intended for completion by July 1975, so a decision for SV-17 and SV-18 mapping requirements could be made. Shortly after the study was begun, direction was received stating that S-Cubed implementation would be no earlier than Block IV so the study completion date was changed to 1 January 1976 and made more comprehensive.

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5. Prior to completing the S^3 risk evaluation but after extensive effort had been completed (November 1975), the Staff requested a risk evaluation on the S-Cubed concept. A revised risk assessment (i.e., S^3 was now considered a low risk project) combined with other factors resulted in the following direction to SAFSP.

a. Cancel Itek mapping cameras for SV-17 and SV-18, and

b. Continue MPS work to assure SV-17 implementation with the proviso that not more than $1 million be expended until SAFSS reviewed the mapping requirement and alternatives further with DMA. The final decision has been delayed from February 1976 until 1 April 1976.

B. SELECTED SOURCE CONSIDERATIONS FOR S^3

1. After the decision to cancel SV-17 and -18 mapping cameras, SAFSP looked at the justification for continuing what had evolved as a selected source procurement. Sufficient justification was considered to be available for the following reasons:

a. Only S^3 appeared as a workable concept that had been verified by detailed study and still met the criteria of minimal impact on the host vehicle.

b. Perkin-Elmer had the best chance of meeting system performance objectives because:

(1) They had two years to study and understand the problem from a system standpoint.

(2) They would have overall performance responsibility for meeting the 5 arc-second system pointing accuracy.

(3) They have a 900-man task force capable of working any unforeseen problems in either the stellar camera or the panoramic camera.

c. Only Perkin-Elmer had the capability to continue to work the Metric Pan problem from November 1975 until SAFSS decides on a course of action with the limited dollars available. Perkin-Elmer is continuing with the sustaining engineering labor force available.

d. The sustaining engineering available at Perkin-Elmer made any alternative to S-Cubed questionable from a cost standpoint, especially if Block IV systems are considered without the non-recurring development costs.

e. Schedule requirements to meet a SV-17 effectivity were very tight, and open competition procurement schedule was considered to be prohibitive from a total program schedule standpoint.

PART IV

The following management concerns are presented to provide a summary of the problems this group feels are involved in achieving a metric panoramic capability.

A. SSA CONCEPT MATURITY

Use of the SSA as an attitude sensor for the Hexagon Program uses a totally different attitude determination concept than does S^3, and the SSA has significantly different impacts on the Hexagon Program. This group recommends a detailed study be performed on the SSA concept. The following is a list of areas of concern which have not been addressed adequately by the SSA Technical Evaluation Group and should be studied in more depth:

1. SSA Dependence on [redacted] Can current Hexagon Program [redacted] be used with the SSA concept? This was a key concern of the Technical Evaluation Group. Relying on the current [redacted] for attitude reference between SSA star detections has not been proven feasible.

2. Impact on Hexagon Program. If new [redacted] are required, are reasonable solutions available to Hexagon Program impacts regarding power usage, heat dissipation, and telemetry data requirements? (b)(1) (b)(3)

a. [redacted] will probably require continuous power and this will affect an already power limited power subsystem. This impact should be studied to determine not only the impact to the primary Hexagon mission but to other tertiary payloads planned to ride on the Hexagon vehicle.

b. [redacted] will require relatively high sampling data rates. This area of concern needs to be studied further.

c. [redacted] located in the mid-section mounted on the Two Camera Assembly (TCA) will impact the thermal characteristics of Hexagon camera system. This impact requires study to verify that H-Camera performance is not affected. (b)(1) (b)(3)

d. A total look at an integrated MPS using the SSA has not been performed to verify that the overall concept is sound. This study should also be performed.

3. Verification of 6.5 Star Magnitude Sensitivity. The ability to modify the SSA to detect 6.5 magnitude or greater is so important to this concept that this group feels this capability must be demonstrated or thoroughly evaluated through study.

4. Error Budget. Some of the pointing MPS error budget are interdependent on the star sensor and the panoramic camera. One example is the error in determining the interlock angle between the star sensor line of sight and the panoramic line of sight. This error is significant and needs further study for the SSA concept.

B. SCHEDULE

Meeting the SV-17 schedule is a concern since commitment to a metric pan program regardless of its form has seen so much delay. The current S^3 schedule is tight and further delay will jeopardize SV-17 effectivity. Changing to the SSA concept is an even more difficult schedule problem because of (1) concept study required, (2) procurement process delays involved, and (3) manufacturing lead time for the SSA (23 months from go-ahead). The schedule shown in Figure I-A is that currently being pursued for the S^3 sensor. Additionally, the SSA delivery schedule of 23 months is superimposed as is the 27 month Hexagon Program MOD II [redacted] procurement time. (b)(1) (b)(3)

C. MPS INTEGRATION

Regardless which star sensor is used, an effective MPS integrating contractor is required. At this point, only Perkin-Elmer is considered to have the total understanding of the MPS concept and has the overall resources to assure success. This group feels that Perkin-Elmer is the only integrator which the government would be able to incentivize based directly on meeting DMA overall mapping requirements. Perkin-Elmer also would best be able to respond to new problems or requirements as the integrator.

PART V

A. CONTRACT APPROACHES

1. Taking into consideration the management concerns and the overall program schedule as set forth in the preceding parts, this group evaluated

various contract approaches that could be taken to effect a competition for the procurement of a star sensor sub-system. The basic ground rules and assumptions used were:

a. Decision defining approach required by 1 April 1976.

b. Star Sensor Sub-System hardware required by 1 July 1978 to avoid jeopardizing overall Hexagon Program schedule.

c. Launch date for SV-17 - Fall 1980.

2. Each approach was evaluated in detail and a list of pros and cons prepared for each. The approaches were:

a. Issue an RFP to all qualified sources, approximately 12, to provide a sub-system that would meet DMA's performance requirement. This approach was evaluated at some length but proved to be unfeasible based on the lengthy procurement cycle and production schedule (see Figures I-B and I-H).

b. Procure SSA from Bendix-Itek as a directed sub to P-E and have P-E integrate sub-systems hardware. Even though the approach is not a competitive procurement, it was evaluated and again proved to be unfeasible not only from a technical and schedule standpoint, but it would be impossible to justify exclusion of the S^3 sub-system from consideration (see Figures I-C and I-H).

c. Procure SSA direct from Bendix-Itek and provide to P-E as Government Furnished Equipment (GFE) for integration. Again, even though this approach is not a competitive procurement, it was evaluated and again proved to be unfeasible not only for the same reasons as stated in para b., above, but the government would be accepting full responsibility that the total system worked (see Figures I-D and I-H).

d. Issue an RFP to LMSC, as integrator, to provide a sub-system that would meet DMA's performance requirements. This approach showed merit over the first three approaches; however, from an overall management standpoint it was also considered to be unfeasible as it would be impossible to incentivize the accuracy of the sub-system by itself (see Figure I-E). In addition, the procurement cycle required to effect this approach still presents an overall schedule problem (see Figure I-H) and is not the most preferred approach.

e. Issue an RFP to P-E, as integrator, to provide a sub-system on a make or buy decision that would meet DMA's performance requirements. This approach, in addition to effecting a competition, was considered to be the most feasible of all, not only for the management concerns but provides a better understanding of overall systems requirements (see Figure I-E). However, even with this approach the total procurement cycle presents a slight problem (see Figure I-H).

The group also prepared a pro and con chart and procurement timeline for procuring the S^3 sub-system from P-E as a selected source to compare total time required to deliver a sub-system on or before 1 Jul 78 (see Figures I-G and I-H). Of all approaches evaluated, this is the most feasible based not only on the overall schedule considerations but it also increases the confidence in satisfying the DMA requirements.

B. CONCLUSIONS/RECOMMENDATIONS

Based upon the above, the group concluded that P-E is the only contractor that can integrate the sub-system/pan camera combination into the Hexagon metric pan camera system and that the S^3 and SSA systems cannot be competed effectively until the additional concept study ~~in~~ of the SSA is completed. Therefore, the conclusions and recommendations are to procure the S^3 sub-system from P-E as a selected source or recognize an overall program schedule impact if competition of a sub-system is effected.