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BYEMAN
~~HEXAGON~~

~~(S)~~ NATIONAL RECONNAISSANCE OFFICE

WASHINGTON, D.C.

September 12, 1966

MEMORANDUM FOR DR. FLAX

SUBJECT: Report of HEXAGON Sensor Source Selection Board

This memorandum responds to your request for:

a. A general evaluation of the SSSB report;

b. Deficiencies in the proposals;

c. Suggested items to be included in the contract awarded to the winner.

Evaluation of SSSB Report:

Based on the presentation given by Mr. Dirks and a review of the SSSB Summary Report, I believe the effort was completely responsive to your instructions. It appears to be an excellent job and obviously is based on rather comprehensive analyses. The major conclusions and source recommendation should stand up under an intensive and critical outside review without significant change.

Itek Proposal Deficiencies:

You will recall that Mr. Dirks listed the important deficiencies identified in both the Itek and Perkin-Elmer proposals. His chart on Itek is attached as Tab 1, with items above the dotted line described as fundamental deficiencies requiring major redesign effort and/or corrective action, and those below the line described as being of much less significance and/or effort involved in correcting them.

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I agree with the deficiencies included in this list; however, I would classify film drum design as a major rather than a minor shortcoming (belt-linked screw-drive mechanism; drum position-keeping by energizing the system, etc).

I assume the first item on the list (Systems Analysis) includes such Itek shortcomings as the peculiar camera mounting structure, the off-center film spool location, inadequate baffling for stray light, the packaging of all electronics in one box, etc.

Additionally, the 14 to 1 thickness ratio of the folding flat must be considered a potential major deficiency until proved otherwise.

Perkin-Elmer Proposal Deficiencies:

Attached as Tab 2 is a copy of the P-E Proposal Deficiencies chart used by Mr. Dirks (with significant items above the dotted line).

I generally agree with Mr. Dirks' list. As he noted, the platen design (mechanism/control) and analysis were the weakest part of P-E's proposal. An alternative approach may be desirable until the primary design is proven satisfactory.

The overall film transport sub-assembly appears to be a major design weakness (four items are noted in the minor deficiencies area).

Not listed by Mr. Dirks, but discussed elsewhere was the material planned for the metering capstan. Probably, Invar should be specified for this component to reduce possible adverse thermal effects.

I am somewhat uneasy about P-E's largely-passive thermal control. Verification of this approach should be made an early milestone in the development program.

As a general observation, the SSSB noted that the amount of thermal and vacuum testing proposed by P-E appeared inadequate, as was the reliability program (or else the words used to describe the latter were inadequate).

Finally, the large stop-start camera interval (on the order of 60-70 seconds) in the P-E design is inefficient from an operational standpoint. This may be an inherent design shortcoming, however, for which there is no good solution (very large masses to accelerate).

Items for Inclusion in Contract:

Since the deficiencies noted by the SSSB already are being worked on by Itek and P-E, I will address other items in this section.

I believe we should insist on an incentive contract (CPIF), with the bulk of the incentive on performance. Although we have not employed this technique in the past for camera contractors, HEXAGON does not represent such an advancement of technology as to make this approach impractical. Further, all other HEXAGON sub-systems will employ incentive contracts.

A vigorous reliability/quality control program should be initiated at the outset, with particular emphasis placed on electro-mechanical devices and so-called "off-the-shelf" components.

If Itek should be awarded the contract, early demonstrations of film drum design, focus sensor, and the acceptability of the 14:1 folding flat should be emphasized.

If P-E should be awarded the contract, early demonstrations of the "continuous polishing" technique, film handling sub-assembly, passive thermal control, and platen mechanism/control should be emphasized.

From an operational standpoint, the following items appear important:

1. Scan Angle: A variable scan angle capability should be a mandatory design requirement. A satisfactory scan

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PERKIN-ELMER PROPOSAL DEFICIENCIES

major

- o SYSTEMS ANALYSIS
- o PLATEN DESIGN AND ANALYSIS
  - BEARING TORQUE
  - E CORE TRANSDUCER
- o THERMAL LAUNCH TRANSIENT

---

minor items

- o FOCUS SENSOR
- o FOCUS ADJUSTMENT PROCEDURES
- o LOOPER POSITIONING MECHANISM
- o DATA BLOCK PRINTING
- o ROLL PITCH MECHANIZATION
- o STEERING DURING FILM REVERSAL
- o [illegible]
- o [illegible]

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CONTROL SYSTEM

I. COLLECTION REQUIREMENTS

An analysis has been completed on the pertinent requirements for which the SOC is responsible. The basis from which the RFP and the subsequent revision was made is USIB-D-41.14/229 dated 19 March 1965. The System Operational Requirement, included as part of the memorandum from DNRO to the EXCOM, incorporated these requirements along with the experience gained by the SOC. The NRO solicited the USIB (COMOR) for a review of the search/surveillance needs so that the latest user requirements could be analyzed for a system of the HEXAGON capability. The USIB forwarded their document D-41.14/294 for guidance. A summation and comparison of the RFP, USIB-D-41.14/229 and USIB-D-41.14/294 documents has provided the frame work under which an identification of the SOC requirements and operating philosophy has been and will be further developed.

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II. SCAN ANGLE

In order to most effectively use the capability of the HEXAGON it is of paramount importance that the system provide a scan angle that maximizes search with a minimum of film expenditure and increments within this scan angle that most efficiently photographs surveillance and MC&G requirements. A number of conditions have been examined and past experience has been analyzed as it affe[illegible] scan angle. A detailed analysis has been made of 132,000 frames of CORONA photographs to determine the effects of weather as a function of miles from Nadir. The loss of useable photography increases as the scan angle increases. The curve indicates an increased loss of clear photography from about 2% at 40° to about 9% at 60°. There will be times when cluster or holiday area access can only be satisfied at maximum scan angle. Using the semi-annual requirement as a basis for determining the frequency of using 120° it was determined that the percentage of time that one would use the full scan angle would be 19%. The remaining 81% of the time the SOC would use something less than the full scan.

The SOC used the reference orbit and one of the proposed designs to determine the amount of total photography required to obtain complete coverage assuming no cloud cover, with a fixed scan angle of 120° and selectable scan angle with 15° increments to determine the unavoidable overlap. The design goal places a premium on minimum weight which results in the minimum film expenditure needed to satisfy requirements. The study shows a 29.5% unavoidable overlap of the total land mass. In accomplishing this coverage there was in addition 8.9% unavoidable water coverage.

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both collectors and users, have concluded that photo usefulness is decreased by 50% as view angle increases from 20° to 60°.

The clustered target complexes identified by the USIB for the HEXAGON system will have to be collected with the maximum resolution and the minimum expenditures of film.

OTHER

The NRO is responsible for exposing and chemically processing the film and providing it to the user. This places the burden for assuring the highest quality chemical processing and reproduction possible on this most important national asset. This is an additional consideration that makes it mandatory that the minimum amount of film for satisfying the requirement should be exposed and chemically processed. The large amounts of film that are cloud covered in order to get a small part of the total frame that could contain a cluster or holiday area is the direct result of the lack of variable scan angles. This is further multiplied by the large production required. Further consideration of the increased film provided by operating with a fixed large scan angle will unnecessarily and at some penalty provide a substantial increased work load on the photo interpreter and the analyst. The very large capacity systems need be very critically reviewed to prevent non-productive large efforts for handling and processing.

CONCLUSION

From the SOC analyses of requirements it is abundantly clear that a variable scan angle capability is a mandatory design requirement. It appears that the 15° scan angle increment would be a satisfactory one.

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EXCLUDED FROM AUTOMATIC REGRADING

III. MULTIPLE RECOVERY

In order to most efficiently program a collection system that has a design life of 30 days and a growth potential to 50 days identifies some areas of concern. If the recovery system provides only two recovery vehicles, some of the data of the first vehicle will be 15 days old at recovery and may be 20 or more days before readout and will have little or no influence on the remaining collection for that mission. The verification of collected information as early as possible will provide for a larger percentage of the requirement being satisfied on a mission-by-mission basis. In a multi-bucket system a cluster satisfactorily photographed in the first access and verified early in the mission releases the remainder of the mission to collect other clusters or holiday areas. The latest USIB requirement establishes that no more than 10 days coverage should be allowed to accumulate prior to recovery. The NPIC views the number of recovery systems as a level of activity to be expended by their organization. The fewer the number of recovery vehicles the older the information and the longer the processing will be per recovery. It is their suggestion that recovery at the end of each access would provide a manageable amount of film and the maximum effect on the remainder of the mission.

CONCLUSION

It is the best judgment of the SOC that the minimum number of vehicles in a 30 day mission should be 4.

IV. OPERATING CYCLES AND COVERAGE

USIB specification of the coverage requirements for the HEXAGON are as indicated previously. In determining the minimum number of on-off cycles, hours of operation, and amount of film necessary to satisfy that requirement it has been assumed that one mission per quarter will be successful.

An analysis of the unavoidable overlap, unavoidable water coverage, weather & other factors has provided the result that approximately 34 days on orbit and 21.4 million square nautical miles of collection capability is necessary and sufficient for each mission based on one mission/quarter.

In addition to the film load an analysis of the number of camera on-off cycles per mission has been determined. During a recent CORONA mission a record was maintained of the number of operations that would have been attempted had a flexible on-orbit programmer been available.

When applied to a 30 day mission it was determined for search (holidays) and highest priority targets (surveillance) for the Sino-Soviet coverage only to be 567 cycles. The new requirement for HEXAGON establishes the necessity for search outside the bloc, mapping and charting external to the bloc, as well as an increased number of surveillance targets.

As analysis of the holiday maps that we use for the CORONA missions clearly indicates that the ability to utilize maximum flexibility of on orbit programming and selectable scan angle is most important. In addition, the available land mass as a function of the time of year necessitates the most flexible system feasible from the standpoint of minimum sun angle. Assuming the capabilities of the proposals are valid, there may be as much as a 10° additional band of latitude available in the winter with the lower F no. system.

CONCLUSION:

The SOC analysis indicates that a 21.4 million square nautical mile capability film load per mission per quarter is required to satisfy the USIB requirements for HEXAGON. The RV's should be designed to provide for growth to 25 million square miles for an anticipated lifetime by SOC of 40 days. The [illegible] design should provide for not less than 1,000 camera on-off cycles per 30 day mission.

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V. SURVEILLANCE

The Hexagon system has a requirement to photograph approximately 100 clusters of up to 120 by 120 nautical miles. Surveillance by its very nature requires the best resolution that the operator can provide. HEXAGON should be designed such that if the search mode (wide scan angle) was underway, at the reference orbit as an example, and a high priority surveillance requirement was coming into view, an orbit adjust to reduce the altitude to 80 miles and then return to the referenced orbit for continuing of search would be highly desirable. In addition, the SOC places a high value on the ability to launch any time during a 24 hour period to get a particular target or special event, i.e., not be restricted to a 1700 to 2300 launch window, and to be able to select orbit parameters as close to launch as possible in order to satisfy as many of the USIB requirements as reasonable. If satisfying these requirements seriously degrades the system, USIB is to be informed.

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NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

OFFICE OF THE DIRECTOR

September 2, 1966

MEMORANDUM FOR THE DIRECTOR OF RECONNAISSANCE, CIA

SUBJECT: HEXAGON Sensor Subsystem

This memorandum confirms Dr. Flax's instructions at the briefing to him by the Chairman of the Sensor Subsystem Source Selection Board on September 1, 1966.

The competing contractors should be requested to provide revised proposal data indicating their plans and approach to correct the significant technical and operational deficiencies in their proposals which have been identified by our review. Revised cost and schedule data necessary for firm contractual negotiations should also be requested.

This revised data should be available at the earliest possible time in order to avoid unnecessary delay in initiating contract negotiations.

James Q. Reber

cc: General Martin, SAFSP

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DRAFT/29 Sep 66

MEMORANDUM FOR EXCOM

SUBJECT: HEXAGON Sensor Subsystem Source Selection

The Source Selection Board which I established to recommend the best design and contractor for the sensor subsystem, has completed its deliberations. The Board unanimously recommended that Perkin-Elmer be selected as the HEXAGON Sensor Subsystem Contractor. I concur in this recommendation.

The Sensor RFP was issued to Itek and Perkin-Elmer on May 23, 1966, essentially in the form considered by the ExCom at the meeting of April 26, 1966. The contractors were allowed 60 days to respond and their proposals were received on July 22, 1966. The extensive effort by each contractor over the past two years was reflected in their ability to respond on such a compressed schedule. Nevertheless, after initial review, it was apparent that additional information in certain areas (more technical details and analyses, cost estimates, etc) was required from each contractor. This information was obtained and included in the evaluation process.

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CONTROL SYSTEM
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A summary of the two proposals was presented to Dr. Land's PSAC Panel for their information on August 13, 1966.

The design proposed by each contractor was essentially identical to that on which he had been working. You will recall that the contractors were given the option of submitting an alternate design if they so desired. Neither contractor took advantage of this option and each submitted a single design.

The highlights of the configuration each contractor proposed are summarized in attachment 1. Attachments two and three show layouts of the Itek and Perkin-Elmer designs. Both contractors' proposals indicated a capability to meet a first launch date of March 1969. The proposed costs of the development program will be discussed later.

The Source Selection Board conducted its analysis through two Evaluation Groups: one for technical and operational matters, and one for management, production, and logistics. Each group was supported by numerous technical advisors. All told, the equivalent of 105 individuals spent four weeks' full-time evaluating these proposals, with an additional two weeks expended by the Evaluation Groups and the Board. The Board reported to me on September 1 and their findings and recommendations have been fully documented.

The findings of the Source Selection Board can be summarized in the following way. Both proposals met the general requirements stated in the RFP for resolution and coverage; however, there were significant differences in performance potential and development risk for each design which clearly point to the Perkin-Elmer design as better suited to the overall search and surveillance mission. The Perkin-Elmer system has a higher performance potential in terms of both resolution and mission duration. The P-E system meets the requirement for 2.7 ft. ground resolution at nadir from a perigee altitude of 92.5 n. miles, while the Itek system must operate from an altitude of 84 n. miles to meet the same requirement. The Perkin-Elmer camera subsystem is about 700 lbs. lighter than the Itek system. When the effect of expendables for a 30-day mission is included, this weight differential increases to at least 1000 lbs.

In addition to the performance margin cited above, the Itek system poses a somewhat larger development risk than does the Perkin-Elmer system. The Itek tolerances throughout the system (associated with their F-2 lens selection) would be more difficult to meet than the corresponding Perkin-Elmer tolerances. This

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implies that the Itek development program would be characterized by a greater risk of schedule slippage and a greater risk of falling short of the performance objectives.

The Itek system contains more and larger optical elements than does the Perkin-Elmer system. As all of these optical elements must be fabricated to very high surface quality specifications, the follow-on production program in the case of the Itek system probably would experience greater difficulty in meeting the schedule and performance objectives than would be the case for the Perkin-Elmer system. The tighter tolerances in the Itek camera mechanism could also contribute to follow-on procurement performance and schedule problems. In addition, the Itek system has significantly less performance margin than does the Perkin-Elmer system, and therefore, the probability of routinely meeting performance objectives will be lower for the Itek system than the Perkin-Elmer system.

The level of design detail presented in the Perkin-Elmer proposal as compared to that presented in the Itek proposal indicates that the Perkin-Elmer design is more mature (from an engineering analysis standpoint) than that of Itek. The Source Selection Board concluded that the schedules proposed by both companies were rather tight; however, from a technical risk viewpoint, Perkin-Elmer has a better chance of meeting its schedule than does Itek.

Although both contractor proposals were deficient in the presentation of technical detail and analysis, and both made numerous errors in design and analysis as well as in computing the performance parameters specified in the RFP, the Source Selection Board concluded that either company has adequate technical resources to successfully pursue the development program if it allocated the necessary resources to the program.

From the viewpoint of management, production, and logistics, the two proposals were evaluated as essentially equal, with Itek displaying a slight advantage. This small differential in favor of Itek is attributable for the most part to Itek's experience on the CORONA and LANYARD programs. While the differential is rea it is not large enough to cause a re-evaluation of the selection of Perkin-Elmer as the recommended contractor. From a management, production, and logistics point of view, there is no serious doubt about the capability of Perkin-Elmer to carry out the proposed program. However, this program will tax the corporate resources to the extent that prior to the award of any substantial new government business, a contractor facility capability survey should be conducted.

Ad indicated earlier in this memorandum, the Board evaluation identified a number of technical and cost deficiencies in both proposals. I therefore funded both contractors through September at their previous levels of effort in order to obtain additional technical information and cost data. This information was presented to me on September 29 and indicates that both contractors can correct all deficiencies and/or shortcomings not fundamental to the camera concept selected.

Summaries of the estimated development and production costs for the Perkin-Elmer and Itek proposals are included as attachments 4 and 5. The development costs for Perkin-Elmer range from $89.6 to $90.5 million and Itek from $97.2 to $92.4, depending on the flow of hardware from factory to pad (this decision must await the selection of the spacecraft contractor). It should be noted that the development costs include the first six flight articles (i.e., six pairs of cameras) plus the ground-qualification sensor subsystem (which possibly might be refurbished and flown later in the program), plus all necessary facilities at the sensor contractor. The higher production costs for Itek reflect the more rigid design tolerances of this system.

Attachment 6 sets forth the estimated costs by Fiscal Year through FY 74 for Perkin-Elmer against the indicated launch schedule. This attachment also projects a possible upper dollar limit for the additional TRW costs in support of the Sensor Subsystem Project Office; however, the totals are uncertain since the magnitude and scope of the total TRW effort in the HEXAGON Project has not yet been fully defined.

The sensor development and production costs generally agree with our earlier budget estimates. The variations in cost estimates at this point in time were not a significant factor in the selection of Perkin-Elmer as the preferred choice. The Selection Board felt--and I agree--that over a long term program, these costs would tend to equate.

I have reviewed the report of the Source Selection Board in detail, and have been briefed at length by its Chairman. There is no question that the Board has been completely responsive to the guidance and instructions I gave it and has accomplished a comprehensive analysis of all of the significant elements of each proposal. The conclusions reached, and the recommendations as to the better design, will stand an intensive and critical independent review without significant change. Although both designs are feasible, the P-E design is clearly the superior approach.

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Although a number of program decisions are still pending (assembly and check-out hardware flow, number of RV's, camera operating modes, film load, etc) which affect the sensor, none of them would alter the selection. Therefore, with your approval, I plan to direct CIA to negotiate a contract with Perkin-Elmer for the development of the HEXAGON sensor and to terminate the effort at Itek.

Alexander H. Flax

Attachments

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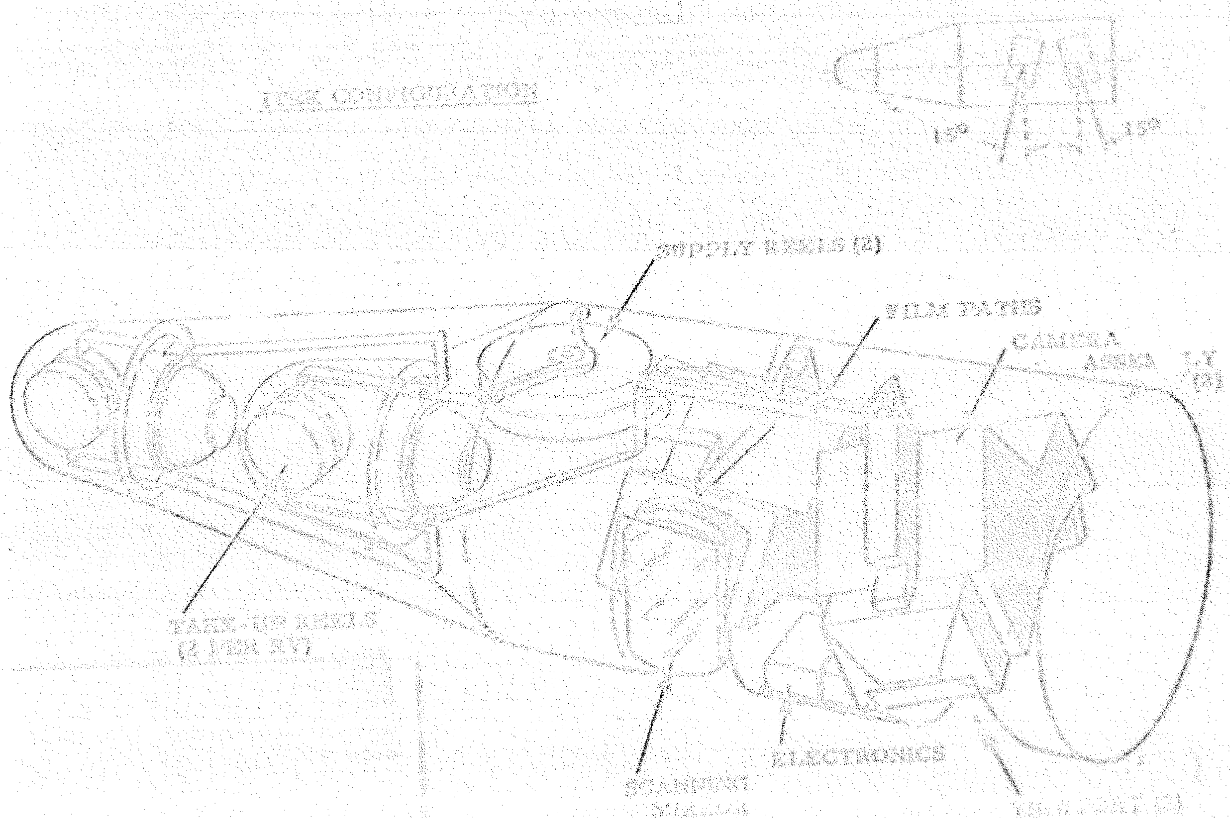
SENSOR CONFIGURATION COMPARISON

	ITEK	P-E
OPTICAL PARAMETERS		
FOCAL LENGTH	[illegible]	[illegible]
APERTURE	24 INCHES	20 INCHES
f/NUMBER	2	3
T-NUMBER	2.48	3.77
FILTER	[illegible]	WR-12
CENTRAL OBSTRUCTION (PER CENT OF APERTURE)	[illegible]	13.3%
FILM		
FORMAT WIDTH	5.5 INCHES	6.0 INCHES
FILM WIDTH	6.6 INCHES	6.6 INCHES
FILM TYPE	SO-380	SO-380
FILM QUANTITY (TOTAL - 2 CAMERAS FOR A 30-DAY MISSION)	1439 LBS	1682 LBS
FORMAT LENGTH (120-DEGREE SCAN)	100.5 INCHES	126 INCHES
CONFIGURATION AND WEIGHT		
SCAN ANGLE	120 DEGS	120 DEGS
STEREO CONVERGENCE ANGLE	30 DEGS	20 DEGS
WEIGHT, SENSOR SUBSYSTEM	3569 LBS	2829 LBS
[illegible] SUBSYSTEM MAXIMUM DIAMETER	116 INCHES	[illegible] INCHES
[illegible] SUBSYSTEM MAXIMUM LENGTH	[illegible] INCHES	[illegible] INCHES
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]


SUPPLY REELS (2)
FILM PATHS
CAMERA
ELECTRONICS

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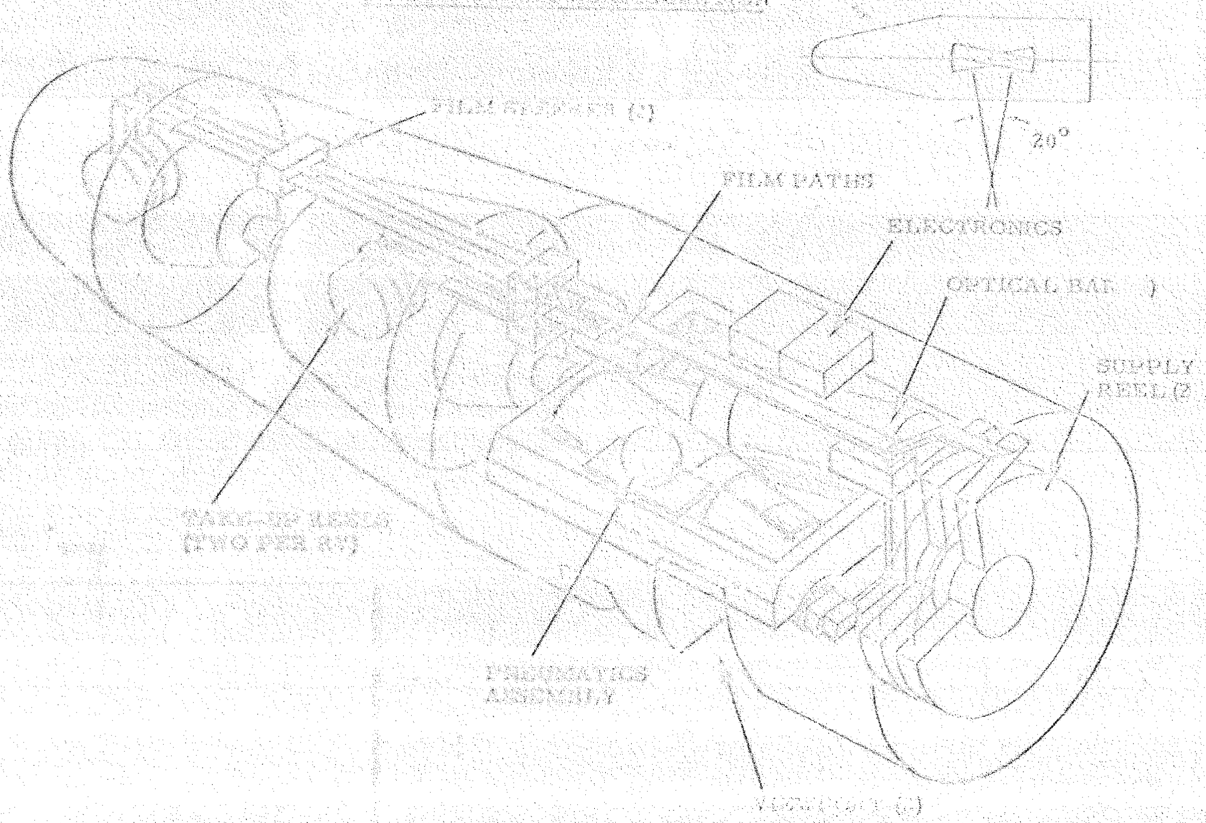

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ITEK COST ESTIMATES

Development	Plan A (1)	Plan B (2)
Development Cost	72.6	70.4
Target Incentive Fee	6.1	5.9
Facilities	18.5	16.1
	$97.2	$92.4

Production		
6 units	17.8	17.6
12 units	33.3	33.2
18 units	49.0	48.9

(1) Envisages assembly and test of Sensor, Sensor Shell, RV, SI camera, etc, at sensor contractor's facility.

(2) Envisages integration of sensor into sensor shell at sensor contractor's facility and remainder of assembly and test at spacecraft contractor's facility.

Attachment 6

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PERKIN-ELMER COST ESTIMATES

Development	Plan A[1]	Plan B[2]
Development	$67.2	$68.2
Fixed Fee	8.0	8.2
Facilities	14.4	14.1
	$89.6	$90.5
Production		
6 units	$14.8	$16.8
12 units	27.5	27.5
18 units	40.3	40.3

(1) Envisages assembly and testof Sensor, Sensor Shell, RV, SI camera, etc, at sensor contractor's facility.

(2) Envisages integration of sensor into sensor shell at sensor contractor's facility and remainder of assembly and test at spacecraft contractor's facility.

Attachment 5

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SENSOR SUBSYSTEM LAUNCH SCHEDULE AND COSTS
(by Fiscal Year)

	FY 67	FY 68	FY 69	FY 70	FY 71	FY 72	FY 73	FY 74	Total
Launch Schedule			2	5	5	5	5	2	24
Reserve Systems			0	1(1)	2	2	2	2	--
Perkin-Elmer Costs (millions)	$33	$37-38(2)	$23	$17	$11	$8	$2	$1	$132-133
TRW Costs (3) (millions)	$3.6	$4.9	$4.6	$3.2	$1.8	$1.3	$1.1	$.5	--

(1) Present programming contemplates overalp of 6 CORONA's in FY 70.

(2) Depends on assembly and check-out hardware flow factory-to-pad.

(3) Upper limit--complete scope of TRW effort not yet defined.

Attachment 6