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~~(S)~~ NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

May 4, 1968

DEP. SEC. HAS SEEN

MEMORANDUM FOR MR. NITZE
MR. HELMS
DR. HORNIG

SUBJECT: HEXAGON SI Camera and Reentry Vehicle Subsystems

The development of the HEXAGON system has now progressed to the point where it is essential to bring into the program the SI Camera and Reentry Vehicle subsystem contractors. Initiation of the effort on the SI Camera was until recently held up by the requirements question which has now been resolved by the decision to proceed with an option to include this equipment on the seventh launch. The initiation of work on the Reentry Vehicle was deferred in order to avoid costs associated with carrying this contractor for a longer period than necessary for this development while the sensor subsystem and spacecraft went through their longer initial development and integration cycles.

The attached documents summarize the source selection actions associated with each of these subsystems. In each case the source selection recommendation was primarily on technical grounds. The ITEK 12 inch SI Camera was recommended by the Source Selection Board over the competing Fairchild design because of the considerably greater technical risk associated with the latter. Fairchild's proposed cost, on a cost plus incentive fee basis, was about $5 million lower than ITEK ($14.821 million versus $20.149 million for development plus six flight units). However, the Source Selection Board's evaluation indicated that potential technical problems in the Fairchild design could easily cause this cost advantage to be eliminated in the actual development program. The ITEK design was based on more conservative design practices and the proposed lens system had been built and tested,

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thereby providing much greater confidence. In addition the Source Selection Board determined that the Fairchild estimate of the direct labor required was low; the ITEK direct labor requirement was considered to be more realistic. Since a cost reimbursement contract was proposed, the Source Selection Board's assessments of the relative realism of the proposal costs must be given considerable weight.

The Reentry Vehicle Source Selection Board recommend the McDonnell Aircraft Company design over that of the General Electric Company. This resulted from a second round of competition. In the first round AVCO was eliminated since their proposal was poorest technically and highest in cost. Both the McDonnell and General Electric designs, as proposed in the first round, had major technical deficiencies, but they were considered correctable by the Source Selection Board. In order to have a sounder basis for selection, a second round of competition was held between General Electric and McDonnell in which the specific deficiencies found by the Source Selection Board were identified to each contractor, and appropriate revision of the proposals was requested. The recommendation of McDonnell resulted from the evaluation of these revised proposals. The evaluation assessed the General Electric design as having unacceptable technical risk because of the proposal to use an unsupported "free foam" elastomeric silicone heat shield material. There are neither valid ground nor flight test data to substantiate the adequacy of this heat shield material under the temperature and loading conditions of HEXAGON reentry, and what data (of limited applicability) exist suggest that there may be serious problems with the proposed design. McDonnell's heat shield design was based on use of a honeycomb supported elastomeric material and is supported by their flight experience with the GEMINI heat shield. The General Electric costs were $5 million lower than the McDonnell costs on a cost plus incentive fee basis ($21.167 million versus $26.168 million for development plus six sets of flight vehicles). Much of the General Electric cost advantage is based on their experience with components in the CORONA programs, for which they are the Reentry Vehicle contractor.

However, the only way to establish the validity of the new and untried heat shield material proposed by General Electric would be by a flight test which would cost about $5 million, thereby eliminating their cost advantage.

On the basis of the factors outlined above and in the attachments, I endorse the recommendations of the two Source Selection Boards and request your concurrence in proceeding with the ITEK Corporation as the contractor for the HEXAGON SI Camera subsystem (option for the seventh launch) and with the McDonnell-Douglas Corporation for the HEXAGON Reentry Vehicle subsystem.

Alexander H. Flax

Alexander H. Flax

2 Attachments
1. SI Camera Source Selection Summary
2. Reentry Vehicle Source Selection Summary

Action by the Deputy Secretary of Defense

HEXAGON Contractor Selection

1. ITEK for SI Camera

   A. Approve PHN
   B. Discuss with me _____

2. McDonnell & Douglas for Reentry Vehicle

   A. Approve PHN
   B. Discuss with me _____

HEXAGON STELLAR AND TERRAIN FRAME
CAMERA SOURCE SELECTION SUMMARY

Mapping & Charting Requirements

The HEXAGON system is being designed to meet the mapping and charting requirements approved by USIB on July 14, 1966. The most critical of these requirements are summarized as follows:

		Local Horizontal Accuracy 90% Assurance	Local Vertical Accuracy (Including Datum Degradation) 90% Assurance
1.	Large Scale Topographic Maps at 1:50,000	85 ft over a distance of 25 statute miles	16-33 ft over 10-20 statute miles*
2.	Medium Scale Charts at 1:200,000	333 ft over a distance of 100 miles	50-75 ft over 20-30 miles*
3.	Medium Scale Maps at 1:250,000	415 ft over a distance of 125 miles	82 ft over 20 miles*
	Significant features		20-50 ft over 10 miles

(* These are contour accuracies indicating that 90% of the points on a contour must fall within the accuracies indicated.)

Within an area of 500 by 500 miles, a photogrammetric control network is required to permit mating of map sheets to the accuracy requirements set forth above. The error limits for such a control network are:

(1) The relative error of horizontal control points will not exceed 40 ft over distances up to 20 miles and 400 ft over distances up to 500 miles within the region.

(2) The relative error of vertical control points will not exceed 10-20 ft over distances up to 20 miles nor exceed 80 ft over distances up to 100 miles.

If the HEXAGON system meets the control network accuracy specified above, it will also have met the design goal for mensuration for intelligence purposes.

Source Selection Board Activities

The mapping and charting requirements were incorporated in the Request for Proposal for the stellar and terrain frame camera subsystem which was issued to ITEK, Perkin-Elmer and Fairchild on August 18, 1966. The contractors were allowed 60 days to respond and the ITEK and Fairchild proposals were received on October 17, 1966. Perkin-Elmer, upon notification that they had won the primary sensor subsystem contract award, withdrew from the competition because they felt they could not develop both camera subsystems on schedule with the staff and facilities available to them.

The initial evaluation of the ITEK and Fairchild proposals was completed on October 29, 1966, and was reported to me on November 4, 1966. From this evaluation it was apparent that both contractors had proposed adequate systems but that both proposals had serious shortcomings. Fairchild had proposed a new electronic attitude determination device which involved an unacceptably high risk for an operational program with a relatively tight schedule. Further, this device imposed excessive power requirements and had a major impact on the design of the satellite basic assembly. ITEK proposed a system having no forward motion compensation. This was considered undesirable since the resultant loss of resolution necessitated extensive use of the panoramic photography thus significantly raising the data reduction costs. Neither contractor had proposed a capability for sufficiently accurate attitude determination. Therefore, each contractor was requested to submit additional data to correct their deficiencies and to make any necessary revisions in schedule and cost.

The highlights of the final configuration each contractor proposed are summarized in Tab A.

The Source Selection Board conducted its analysis through two Evaluation Groups; one for scientific, technical and operational matters, and one for management, production and logistics.

Each group was supported by numerous technical advisors. The evaluation required the full time effort of 35 individuals for a period of four weeks. The final report to the DNRO by the Board was received on December 12, 1966.

The findings of the Board can be summarized in the following way. Both proposals met the general requirements stated in the RFP for mapping and charting and both indicated a capability to meet the desired launch date of March 1969; however, there were significant differences in the performance potential and development risk for each design. The ITEK approach was more conservative in that they proposed a lens of medium resolution (53 l/mm) with a relatively long focal length, 12 inches. With such a lens, little or no calibration of the panoramic frame is required. The Fairchild approach was to use lens of shorter focal length (7.5 inches) with a higher resolution of 109 l/mm. The Fairchild design is critical in that the relatively short focal length makes the system highly sensitive to resolution if the stated mapping and charting requirements are to be accomplished without extensive geometric calibration of the panoramic camera. Although the complete ITEK subsystem was 105 pounds heavier than the Fairchild subsystem, the Fairchild design had greater impact on the satellite basic assembly. When the effect on the weight of the satellite basic assembly was considered, the Fairchild subsystem outweighed the ITEK subsystem by 183 pounds.

The Board considered that the Fairchild design posed a significantly larger development risk than did the ITEK design. The ITEK terrain lens has been built and has demonstrated in test that it will meet the proposal specification. The Fairchild terrain lens has not been built nor has its design been finalized. The more critical tolerances associated with the higher resolution required will be more difficult to meet than the corresponding ITEK tolerances. This implies that the Fairchild development program would be characterized by a greater risk of schedule slippage, a greater risk of falling short of the performance objectives, and a greater risk of cost overruns. The tighter tolerances of the Fairchild terrain lens could also give rise to performance and schedule problems in follow-on procurement. In addition, the Fairchild design has less performance margin than does ITEK and therefore, the probability of routinely meeting the performance objectives would be lower for Fairchild than for the ITEK design.

In the area of the management, production and logistics, ITEK presented a strong well thought out proposal covering all aspects in detail. The program manager had complete control of the program and was the primary contact for the SPO. The reporting procedures were designed to keep the SPO and top corporate management informed of all problems as they occur.

The Fairchild proposal was very weak in management, production and logistics. The program manager did not have control of the program although he was designated as the primary contact for the SPO. The Division Vice President had the necessary control but the proposal stated that only five percent of his time would be devoted to the program. The policy Fairchild stated of not reporting problems to the SPO but reporting only solutions, could result in unforeseen schedule slippage and costly overruns.

Fairchild also proposed that the terrain lens development and fabrication be accomplished at their El Segundo, California facility while the program management and all other development and fabrication would be done at their Long Island, New York facility. Finally, the Fairchild management, production and logistics plan was incomplete in a number of areas including configuration control, production control, quality control, facilities, security, and personnel training.

The estimated development and production costs, and estimated costs by fiscal year through FY70, for each proposal, are summarized in Tab B. The development cost for Fairchild is $14.821 million and $20.149 million for ITEK. It should be noted that the development costs include the first six flight units (i.e., six terrain cameras and 12 stellar cameras), the ground qualification unit, all necessary facilities at the contractor's plant, and equipment required at the HEXAGON system integration contractor's plant. The follow-on costs per unit are $600,000 for Fairchild and $960,000 for ITEK, based on a four year program of 24 units. The higher estimate by ITEK of direct labor required, accounts for the major portion of the cost spread between two proposals and was felt to be a much more realistic estimate than the Fairchild estimate.

Based on their review, the Board unanimously recommended the ITEK design and program as clearly superior.

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HEXAGON RE-ENTRY VEHICLE SOURCE SELECTION SUMMARY

SOURCE SELECTION BOARD ACTIVITIES

Four Companies were determined to be well-qualified to undertake this program, and a request for proposal was released to them on 19 July 1966. Proposals were received on 27 September 1966 from AVCO, the General Electric Corporation, and the McDonnell Aircraft Company. The Lockheed Missiles and Space Company declined to propose on the Re-entry Vehicle in order to avoid diluting their effort on the Satellite Basic Assembly Proposal. The Source Selection Board submitted their report in late October 1966.

Detailed analysis and specialized evaluations were performed by three working groups:

(1) Technical, and Operations

(2) Management, Production and Logistics

(3) Costs

Each group consisted of 4 to 7 members supported by a large number of technical advisors. The findings of each technical group were combined into an overall evaluation by the Source Selection Board, using relative weightings which were unknown to the working group members. The actions of the working groups and the SSB were fully documented and represented a careful comprehensive evaluation by highly qualified personnel who worked in strict accordance with the criteria and procedures established for them.

The SS found that the AVCO Proposal was the weakest technically and contained the highest cost. The GE Proposal reflected their considerable experience in this area of technology; however, it contained significant technical deficiencies requiring correction. The McDonnell Proposal was superior in the technical and management areas but was more costly than GE.

The next several paragraphs discuss some highlights of the evaluation:

AVCO

The only outstanding feature of the AVCO Proposal was an excellent electricl harness design. Deficiencies were numerous and included:

(1) Mounting the spin motors in the plane of the C.G. requiring that the heat shield transmit the torque load from the motors to the RV. This raises questions as to the structural integrity of the heat shield.

(2) The proposed parachute is known to be unworkable over the weight range required.

(3) The proposed destruct system is incompatible with the SCF.

(4) A major weakness of the entire Proposal was an inadequate presentation of the analyses, design detail, and backup data.

(5) Program Planning generally lacked adequate detail.

General Electric Corporation

GE presented a thorough structural design and analysis, and thermal analysis. The technical weaknesses included the low shelf life of the phenolic nylon heat shield, a poor concept for the spin despin rocket motor, and an inability to meet the specified dispersion limits on recovery.

McDonnell Aircraft Company

The McDonnell Aircraft Company Proposal was superior in the technical and management areas. They presented a good spin despin system and a thrust termination system which permitted the dispersion limits to be met. They included a complete reliability model, and their program planning was complete and comprehensive. Weaknesses of the McDonnell Proposal included incomplete structural analysis and a higher cost than General Electric.

The SSB considered the technical deficiencies in the General Electric and McDonnell Proposals to be correctable and estimated the revised costs to reflect these corrections, and other cost omissions and excesses contained in the Proposals. Although the revised costs were closer together, the General Electric costs, as estimated by the SSB, were still about six million dollars (about 19%) less. On this basis, they recommended that General Electric be awarded the contract.

Additional Review

After completion of the SSB activities, McDonnell and GE were requested to provide additional technical, cost and schedule data to correct the significant technical and operational deficiencies identified by the SSB, to include costs for items that were omitted, and for changes required to improve system capability. These revisions were analyzed by the HEXAGON System Program Office and submitted to me in December 1966.

The McDonnell response was considered adequate even though additional analysis of the structural design was still considered necessary. On the other hand, the GE response still contained significant technical deficiencies. For example:

a. GE changed their proposal to an unsupported ESM heat shield to replace the shelf life limited phenolic nylon. There is not sufficient test data to warrant the analytical prediction of successful use of the unsupported ESM. The limited test data which is available indicates that the unsupported ESM will erode rather than ablate at heat fluxes of approximately one-half the fluxes expected in the stagnation region.

b. The retro-rocket igniter is designed in such a way that it cannot be installed after the rocket is installed in the re-entry vehicle. It would therefore have to be installed at the factory, and this is unacceptable for safety reasons. A redesign would have a significant impact on the overall re-entry vehicle design and cost.

c. The GE design would result in a total system weight of approximately 300 pounds more than the McDonnell design. The primary reason for the extra weight is that GE has chosen to meet the dispersion requirement by providing a V of 1300 feet per second and controlling the tolerance to one percent. McDonnell, on the other hand, met the dispersion requirement by providing an V of 1000 feet per second and controlling the tolerance of 3/4 of one percent.

A tabular summary of the original proposals and the revised data from GE and McDonnell is presented in Attachment 1.

The costs, as submitted by the contractors in their revised data, are as follows:

	GE	MAC
Total Cost	$22,754,700	$27,179,000
Fee	3,413,200	4,077,000
	$26,167,900	$31,256,000

The cost difference is due in part to the experience GE has had in the DISCOVERER Program with components such as power supplies, programmers, telemetry transmitters, instrumentation and the parachute.

A breakdown of the costs is presented in Attachment 2. The costs in this breakdown are for a four re-entry vehicle configuration.

In view of the serious technical deficiencies which remain in the GE Proposal, the selection of McDonnell Aircraft Company for the design and construction of the HEXAGON Re-entry Vehicles was recommended by the SPO as warranted in spite of the higher cost.

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[illegible] Control System

RV Proposal Summary

	AVCO	GE	GE Supplemental Data	MAC	MAC Supplemental [illegible]
Attitude Control	Solid spin rockets	Solid spin rockets	Cold gas spin subsystem	Nitrogen gas with motion detector	
Dispersion Error Control	1% Retro-rocket tolerance	1% Retro-rocket tolerance	1% tolerance on total impulse (ΔV = 1300 ft/sec) achieved by close manufacturing control.	1% achieved by thrust termination	[illegible] of 1% tolerance on total impulse (ΔV = [illegible] ft/sec) to be achieved by precise manufacturing controls.
Retro-rocket	To be defined. Ignition to be 320 ft from SBA.	Aerojet or thiokol off the shelf rocket.	Igniter - not accessible after installation of rocket in RV.	Composite of proven components	
Heat Shield	Discoverer shape epoxy with phenolic and quartz additives supported by honeycomb matrix.	Phenolic nylon	Unsupported ESM - considered a design risk	Methal silicone elastomeric material supported by phenolic honeycomb matrix.	
Parachute	Tandem pickup	Annular		Conical extension on extended skirt	Annular final stage with mortar ejected drogue parachute
Electrical Subsystem	Automatically activated silver zinc batteries - incomplete circuit details	Automatically activated silver zinc batteries		Manually activated silver zinc batteries	Automatically activated silver zinc batteries

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Attachment [illegible]

COST SUMMARY

		General Electric		[illegible] Aircraft Corp.		[illegible]
		Original	Revised	Original	Revised	[illegible]
TASK I	RV Design, Development, Fabrication, and Evaluation	$14.6858	$16.[illegible]	$[illegible]	$[illegible]	$[illegible]
TASK II	AGE Design, Development, Fabrication, Test, and Evaluation	1.7324	[illegible]	[illegible]	[illegible]	[illegible]
TASK III	System Analysis, Integration, and Evaluation	.6853	1.6689	[illegible]	[illegible]	[illegible]
TASK IV	Planning and Operational Support	.3608	1.2549	2.159	[illegible]	[illegible]
TASK V	Management and Administration	1.8069	1.8[illegible]	2.[illegible]	[illegible]	[illegible]
	Total Cost	19.2712	22.7547	[illegible]	[illegible]	[illegible]
	Fee	2.8907	3.4132	4.217	[illegible]	[illegible]
	Total Proposed	$22.1619	$26.1679	$32.33[illegible]	$[illegible]	$[illegible]

	AVCO	GE	GE Supplemental Data	MAC	MAC Supplemental Data
Aerodynamic Shape	Discoverer with "dished in" base	Family of Shapes analyzed		Discoverer shape with boat tail	
Structural Analysis and Design	Several undesirable discontinuances on the heat shield - spin rockets mounted on the ablation shield are undesirable.	Considered good		Shell bending stresses neglected	Nose cap buckling modes analyzed. Thermal stress caused by gradient through the shell analyzed. Structural analysis still considered weak.
Weight	15% above allotment (615 lbs allotted to each medium size RV)	13% above allotment	12% above allotment	3% above allotment	1% below allotment
AGE	Pad test does not use SBA TT&C subsystem as required by RFP. Design is not compatible with factory to pad procedures.	Shorting plugs require a component be inserted subsequent to final testing.		Excessive electronic checkout equipment proposed.	Reduced quantities of AGE proposed.

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Control System

GE	GE Supplemental Data	MAC	MAC Supplemental Data
Programmer evaluation of Discoverer design		Baroswitch proposed for main chute deployment	
Discussed - no detailed analysis	Design submitted with redundancy TM	Good analysis - Lacked identifying tone	Tone modulation of TM incorporated
Part I-A capability for both water and air - night recovery light shaded below RV	Light still shaded below RV	Omitted modulated RF Homing Beacon. Light shaded below RV satisfactory.	Flashing light added to bottom of canister considered to be satisfactory for night recovery.
Deviations requested not acceptable	Retracted requests for deviations	Satisfactory	
Water soluble plugs		Prima cord detonation	Electro-chemical plugs
Single gas release valve	Data on dual squibs and dual bridge wires submitted	Cold gas jets (canted spin jets). Film chute separation not defined.	Hinged film chute proposed
Some interference between water seal and film chute possible - pressure equalization during re-entry not presented.	Interference question resolved - data on spring loaded relief valves submitted	Nitrogen pressurization provided during re-entry.	Nitrogen system eliminated, simple vent tube incorporated.

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