~~TOP SECRET~~
SPECIAL HANDLING

Attachment 2
BYE-69318-66
cy 1

ITEK EVALUATION SUMMARY

Evaluation Group Numerical Ratings
(rated on the basis of 0 to 9)

	Rating Category	Rating
I.	Performance Evaluation	4.0
II.	Development Risk	5.4
III.	Design Margin	4.2
IV.	Value Function	6.8
V.	Reliability	3.8
VI.	Operational Considerations	6.0
VII.	Effect on Space Vehicle	4.0
VIII.	Interface Definition	3.2
IX.	Master Program Plan, Design Development Plan, Qualification Plan, Integration Assembly and Checkout Plan	5.0
X.	Fabrication and Delivery Plan, AGE Design Development and Delivery Plan, Mass Properties Control Plan, Reliability Program Plan	5.0

[redacted]

[redacted]

[redacted]

Albert W. Johnson
Maj. Albert W. Johnson

Leslie C. Dirks
Leslie C. Dirks

~~TOP SECRET~~

HANDLE VIA BYEMAN CONTROL

Attachment 2
BYE-69318-66

ITEK EVALUATION SUMMARY

Rating Category I: PERFORMANCE EVALUATION Rating: 4.0

Under the Performance Evaluation rating category the contractor's proposal is evaluated from the point of view of the adequacy of his proposal design as measured against the design requirements and the completeness of the analysis and data presented by the contractor in support of his proposal.

The numerical rating of 4.0 assigned to the contractor in the area of performance evaluation was largely influenced by the general incompleteness of the proposed design and the supporting analysis. Although in most of the subsystem areas the basic design concepts proposed appear to be sound, in many instances the detailed designs discussed are inadequate to meet performance requirements of the system or are so incomplete as to make it difficult to assess their adequacy. In several key areas the contractor has failed to identify what are clearly critical performance requirements and to establish the feasibility of meeting these requirements. In addition, numerous errors of various sorts were detected during the course of the evaluation. The following is a critique of the contractor's performance in the systems analysis area and in each of the five major subsystem areas. This critique discusses briefly all of the major factors which influenced the Technical and Operations Evaluation Group in forming its judgment in the area of Performance Evaluation.

SYSTEMS ANALYSIS

Design Concept - The basic system choice of 48" focal length F/2 optical system with a rotating mirror capable of scanning the optical axis through $\pm 60^\circ$ cross track angle was apparently based on an analysis of Value Function. According to the analysis presented by the contractor, the chosen configuration represents a near maximization of this function. While the Value Function was included in the RFP for the specific purpose of guiding the contractor in his choice of camera configurations, the contractor did not conduct a detailed analysis of the design and performance consequences of the configuration chosen in this manner. Performance at high scan angle is strongly degraded by both the exposure and diffraction effects of aperture vignetting. Although the vignetting is discussed by the contractor, the exposure variation is given only passing mention and no attempt is made to analyze its impact on image quality.

There are two added effects operating in the proposed system which have a significant impact on the system performance. The first of these is defocus due to drum curvature. While the contractor did recognize this problem, he did not examine its impact across the entire operating envelope. In particular, the low sun angle-high V/h resolution data presented by the contractor apparently does not include any allowance for this image degrading source (see Figures I and II).

HANDLE VIA BYEMAN

The second image degrading mechanism is associated with operating the scanning mirror over a range of incidence angles. As the incidence angle changes the effect of surface irregularities on image quality changes. While the contractor accounted for surface errors at zero degree scan angle (45° incidence angle), he did not include (or even recognize) increased degradation as the incidence angle increases. This effect is a non-linear function of incidence angle and, depending upon the character of the surface error, can have a substantial impact on optical system resolution.

The general error budget approach adopted by the contractor reflects a design decision to implement a system which is as near as possible film resolution limited system. While this approach has the merit of achieving a maximum information packing density on the film and, therefore, offers the potential of minimizing film weight, the camera system weight is unfavorably impacted in that such a system requires a large physical aperture with extremely tight tolerances on all of the system error budgets. Although the contractor conducted parametric analyses to support his design selection from the stand point of minimizing camera weight plus film weight, he apparently did not review the results of this study on the basis of a more detailed systems analysis and, therefore, has arrived at non-optimum balance for the mission defined in the RFP. This inbalance is further aggravated by the relatively high film wastage associated with the proposed design (see Table I).

In summary, although the parametric analysis results do indicate a maximization of the Value Function, a more detailed examination of the particular configuration proposed would have revealed a number of factors not adequately accounted for in the parametric analysis which should have modified the contractor's configuration decision.

<u>Smear Error Budget</u> - The smear budget developed by the contractor was reasonably complete. Also, the statistical methodology for combining the various sources of error was correct. However, there were a number of errors in the analysis of some of the contributing sources as well as a number of omissions. In particular, the following items were either omitted or not accounted for accurately:

a. Lens distortion
b. Earth curvature
c. Command approximation
d. Scan angle error
e. Folding flat alignment
f. Alignment of optical axis to axis of rotation of scanning mirror

Table II is a detailed list of the smear error budgeting. The numbers in parentheses indicate revisions of contractor's estimates.

[redacted]

Defocus Error Budget - There are several important errors in the defocus budget as presented by the contractor. One of the major contributors to defocus is thermal effects on the penta prisms incorporated into the automatic focus sensor. There are two such prisms in each system and the contractor assumed that thermal effects caused statistically independent deviation errors in the two prisms. These errors should be handled as correlated. In addition, the contractor assumed without supporting analysis that his proposed drum diameter sensor would eliminate all defocus due to film thickness variations. The Evaluation Group has conducted an examination of the available information on this subject and concluded that the contractor's unsupported assertion is probably incorrect. Table III is a summary of the defocus budget. The numbers in parentheses indicate modifications to the contractor's error budget.

Value Function Computation - The contractor made several significant errors in the evaluation of the value function. The value per day computed by the contractor for his design was low by a significant percentage, apparently due to an inaccurate computation of the linear nautical miles of ground track over the Sino Soviet Bloc. Although the contractor was instructed in the RFP to present the data on which he based his computations he did not do so and, therefore, a conclusive assessment of the source of errors cannot be made. In addition, the contractor computed the mission duration incorrectly. His major error was in film weight where he did not account for the film wastage inherent in his design.

Exposure Selection - The contractor has proposed seven discrete exposure slit settings. Analysis of these settings indicates that they were made on the basis of providing the capability of accommodating scene brightness from 200-750 foot-lamberts over the defined range of V/h with a maximum exposure error of approximately 16%. While this in itself appears to be an adequate design choice, the problem of operational exposure selection with the particular configuration proposed by the contractor is a significantly more complex problem than such an analysis would indicate. First there is a factor of two variation in system transmittance due to vignetting as the scanning mirror scans from zero to 60° scan angle. The impact of this effect on resolution can be seen in Figure III. While the contractor mentions this effect he does not analyze the significance of this variation on performance nor does he discuss an optimum criteria for exposure setting given this transmittance variation. Secondly, at low light levels and high V/h the exposure slit must be set at large values resulting in performance degradation due to drum curvature (see Figure 1). While the contractor discusses proper methodology for treating the effects of drum curvature on systems performance, he does not develop an optimum criteria for exposure setting taking this effect into account.

Performance Over the Design Envelope - The RFP calls out a nadir resolution of 2.7' for the design orbit. A set of criteria are defined for the selection of the design orbit. In addition, the camera system must be designed to operate over a broad range of orbits. The specified range in altitude is from 80 nm to 240 nm with a corresponding V/h range from .054 radians per second to .018 radians per second. Although the contractor does not present a detailed analysis of camera performance over this range, it appears that camera performance is well behaved. However, it should be noted that in order to meet the design resolution specification at 2.7' the system must be operated in an orbit with a perigee altitude of 84 nm. This means that little increased resolution performance can be gained within the bounds of the orbital envelope prescribed.

In addition, as noted above the low sun angle/high V/h performance of the system is seriously degraded by the curved drum effect. In view of this behavior the operational utility of the camera system will be seriously impaired for some operating conditions.

Figures II, III and IV together summarize the resolution performance of the contractor's system and compare the contractor's claimed performance with the Evaluation Group's assessment. The Evaluation Group's estimation of performance does not take into account any potential image quality degradation due to high scanning mirror incidence angle or veiling glare and assumes that a number of performance deficiencies in the design as proposed can be rectified. These are discussed in more detail below.

OPTICAL SUBSYSTEM

Basic Optical Design - The contractor's proposed optical design is an F/2 flat field Schmidt. The design has been thoroughly analyzed and probably represents about the best that can be done across the 6 1/2° useful field. There is no residual spherical aberration and the color correction across the field is as good as can be expected. The off-axis performance represents what appears to be an intelligent balance across the energy spectrum of interest.

Optical Subsystem Packaging - The choice of a 48" focal length along with the Schmidt design (which requires an aspheric corrector plate placed two focal lengths away from the image plane) result in a packaging problem. This is compounded by a choice of a scanning mirror to generate a panoramic action across the ±60° scan sector. In order to stay within the 120" diameter vehicle constraints, the contractor has been forced to include an additional flat, folding mirror which is perforated to give access to the image plane. In addition, the 120" vehicle diameter constraint plus the 24" optical aperture diameter have resulted in a placement and sizing of the scanning flat which gives rise to significant (50%) vignetting at the ends of the scan.

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A Schmidt design by its very nature poses a difficult problem from the point of view of baffling the system to reduce veiling glare due to stray light entering the system. While the contractor has a limited amount of baffling to prevent non-image forming light from impinging directly on the field corrector group, he did not address the problem of non-image forming light reaching the corrector group by internal scattering. It appears that this may be a fundamental problem to which there is no completely adequate solution. In any case, the contractor has not made any effort to estimate the possible reduction of image quality due to this difficulty.

Tolerancing - The contractor presents a detailed statement of optical element tilt and decenter tolerances along with surface fabrication tolerances (see Table IV). The tilt and decenter tolerances specified by the contractor are consistent with his performance predictions. As mentioned above, the resolution performance prediction at high scan is not consistent with the 1/40 wavelength figure tolerance on this mirror.

Element Materials and Configuration - The contractor has selected fused silica eggcrate structures for the 42" scanning mirror and the spherical primary mirror. There has been considerable experience with these materials and there is little doubt about their basic suitability. Furthermore, although there is a high rejection rate due to fabrication faults, the required production lead times have analyzed satisfactorily.

The internal folding flat will be made from solid fused silica. The mechanical packaging problem has led the contractor to set the thickness of this flat at 2". This results in a 14:1 diameter to thickness ratio which is considerably higher than what is normally regarded as good practice for large precision mirrors. As the folding mirror thickness can be increased at a resolution performance penalty, the contractor should have justified the risk associated with the selection of an unusually thin mirror on the basis of appreciable performance gains. No such analysis was presented.

Element Mounting - All of the large optical elements as proposed by the contractor will be potted into a mounting bezel. This scheme is particularly satisfactory for eggcrate structures and has been used in the past successfully.

Optical Subsystem Test and Assembly - The contractor is clearly aware of the problems associated with the test and assembly of high performance optical systems. His test procedures and assembly techniques as presented in the proposal are well thought through and adequate for the purpose.

Rating Category I: PERFORMANCE EVALUATION

FOCUS CONTROL

Design Approach - As noted above, the contractor has chosen to meet the required resolution performance by proposing a camera system which operates as close to film limited as possible. This means tightening the tolerances on both defocus and smear to an absolute minimum. One of the penalties of this design choice is a serious focus problem. As the contractor has clearly identified, staying within his overall defocus budget (see Table III) of ± 4 microns requires not only extraordinarily tight mechanical tolerances but also requires some means of locating and controlling both the image plane and the film position with respect to the image plane. The design approach selected is to use an autocollimating type of focus sensor to locate the image plane and a second device to precisely determine the diameter of the 12" film drum. These two measurements are then combined to develop an error signal which positions the drum coincident with the image. These two devices are critical to the successful performance of the proposed camera system. However, the contractor did not present in his proposal any detailed treatment of the overall problem nor did he justify as optimum his particular design selections. The most serious deficiency in this area is a lack of analysis or experimental data demonstrating that the aperture sampling type of autocollimating device proposed does in fact determine the location of the plane of best image quality. In view of the criticality of this design problem area, this omission is a serious shortcoming of the proposal.

Image Plane Sensor - The basic autocollimating scheme proposed is probably workable as described by the contractor, however, the mechanization of the general concept in the particular system proposed suffers from several shortcomings. One problem area which probably has no adequate solution given the choice of an autocollimating scheme is that the image plane sensor cannot detect any focus errors arising from deformations of the scanning mirror. The small penta prisms which autocollimate the system are located just outside the aspheric corrector plate and behind the scanning mirror. Although the contractor has concluded that the scanning mirror will not introduce significant defocus, his analysis of this problem is questionable (see Thermal Analysis below). At best, the analytical predictions of the thermal behavior of this element cannot be made with high confidence to the tolerances required in the contractor's focus budget.

As mentioned above, the error analysis of the penta prisms suffers from a flaw in methodology. The contractor proposes to use quartz for these devices and in view of the 1/10 arc sec angular accuracy required, temperature affects are of critical significance. The contractor's budget calls for these penta prisms to stay within 2.8°F of the optical system temperature. He presents no analysis to justify this number and the location

In addition to measuring drum diameter, the contractor is relying on this same sensor to eliminate any defocus effects due to film thickness variation. If the film thickness varies slowly enough along the length of the film, this will indeed be the case; however, data received as a result of a measurements program at Eastman-Kodak casts serious doubt on this assumption. According to the E-K data, variations as great as ± 4 microns may on occasion be found even across the 6" width of the film. These of course will not be seen at all by the drum diameter sensor as it measures the drum radius at only one field position. At the highest V/h film is passed over the drum at the rate of approximately 140" per second. As the time constant of the whole focus adjust servo loop given the massive character of the drum probably cannot be reasonably reduced below one second, film thickness changes along a length as great as 12' will not be compensated. It has been judged that at a minimum ± 2 microns must be added to the contractors defocus budget to account for this problem. Again the contractor presented no analysis or data.

Drum Design and Fabrication - As is evident from the defocus budget contained in Table III the entire drum assembly is characterized by extraordinarily tight mechanical tolerances. While the contractor presents a relatively detailed design of this critical assembly, there are a number of notable deficiencies with his design which in all likelihood will necessitate a complete reworking of the assembly. In order to provide forward motion compensation the drum is translated parallel to its axis during photography. The bearing design to permit this motion is of the ball-on-cylinder contact type which will probably be inadequate to withstand dynamic launch loads without Brinnelling. A ball spline arrangement will solve this problem and seems to be adequate from all points of view. The motor arrangement on the drum shaft is such that there is no convenient means for assembling the unit. In addition, the motor is cantilevered outside the drum bearings which may also prove to be a marginal design for dynamic launch loads. A similar problem exists with the FMC drive torquer. The drum assembly must also be translated for focus adjustment. This motion is mechanized using two ball screw drives which in the proposed designs are belted together. Such an arrangement does not provide positive synchronization between the two shaft drives. In addition, there are a number of other detailed design problems of this character. While none of the design problems identified are fundamental ones, the overall mechanical tolerances can only be met by application of the best possible design practices and fabrication techniques. The fact that the contractor did present a detailed design of this assembly would indicate some awareness of this problem, however, the marginal character of his design as presented tends to indicate a lack of appreciation of the full magnitude of the problem.

FILM TRANSPORT

Design Approach - Although the inherently high photographic speed of the system tends to reduce the impact of smear contributing error sources in an absolute sense, the smear budget must be kept to a minimum in order to realize the correspondingly high linear resolution of the optical system. The result is a camera system with critical mechanical tolerancing on many of the smear contributing error sources. The basic design approach for the film transport control system mechanization represents an excellent selection. In most areas it is characterized by simplicity of design and use of conventional components. However, the overall analysis of the design is grossly deficient in several key areas. In many cases little has been done beyond identifying the design concept. Although most of the critical components have been identified, in several instances the components selected by the contractor are inadequate for their function. The proposal is characterized by an extraordinary lack of concern in the area of film path control both from the point of view of steering and from the point of view of film tension disturbances. Although no fundamental problem has been identified from a design point of view the film transport system is immature and it appears likely the contractor has only begun to identify the various design and component problem areas.

Film Drum Control System - The critical control system from the point of view of high inherent accuracy required is the film drum angular position control system. This control system must synchronize the angular position of the drum to the angular position of the scanning mirror to an accuracy of better than .03%. The contractor has selected as his design concept a digital control system which appears well suited for the task. Unfortunately, the analysis of the performance of this servo is incomplete. In particular, the disturbance torque rejection characteristic of the control system as computed by the contractor appears to be 10db better than can be expected. At low V/h tension variations in the film as small as 0.2 ounce out of an overall tension of approximately 2 1/2 lb. can cause significant drum disturbances. Since the contractor has given little attention to the control of tension variations in the film path, this is cause for some concern.

The contractor proposes to hold the drum in position during stand-by operation (non-photographic operation) by maintaining the control system in an energized state. While this is certainly a workable arrangement, it has the disadvantage of keeping some relatively high failure rate components in operation for the entire mission duration. The contractor presents no trade-off analysis of various approaches to the drum positioning design problem.

Scan Mirror Control System - The mirror control system as designed cannot meet the accuracy requirement of 0.12% as specified in the contractor's budget. However, this is a non-critical tolerance and by relaxing the budget by a factor of two and employing improved design practices in the control system itself, the performance can be made adequate. The cross track IMC drum velocity modulation signal is derived from a non-linear potentiometer driven on the mirror shaft. The four arc sec accuracy tolerance on the potentiometer as specified by the contractor is much tighter than can be realized in practice although it appears that this tolerance can be relaxed without a performance penalty.

Forward Motion Compensation Control System - Forward motion compensation is mechanized by translating the film drum parallel to its axis of rotation. As mentioned above, the mechanical design of this assembly is inadequate in several respects. A more basic problem with the device as proposed has to do with torque disturbances introduced into the FMC servo system due to high friction loads between the cam follower and the cam itself. Great care must be taken to minimize these friction loads and it appears likely that a redesign of the control system to increase its torque rejection characteristics will be necessary. In the proposed design of the FMC servo, good design practice has been violated by differentiating the output of a dc tachometer in the feed-back loop. The FMC cam is toleranced by the contractor to a profile accuracy of 64 microinches.

Take-up and Supply Spool Control Systems - The basic servo design in this area is excellent, however, the particular take-up spool hub sizing selected results in an extreme torque motor speed range as the spool goes from empty to full. At no penalty the hub size can be increased to reduce this range to a more acceptable value.

Shutter Mechanization and Control - The mechanical time constant of the shutter (approximately 3 milliseconds) coupled with the shutter open and close pulse uncertainty generated by the optical commutator mounted on the scanning mirror shaft, gives rise to uncertainties which are not consistent with the one quarter inch spacing specified by the contractor between the end of the frame and the interframe data block. While this uncertainty can be lived with by allowing approximately one more inch of interframe film wastage, it should be possible to design a more efficient shutter mechanism. It appears that the contractor did not do a careful analysis of the errors associated with this proposed design.

Torque Motor Sizing - Of the six major torque motors contained in the proposed camera design, four have been undersized in terms of their torque/speed requirement. While in all cases adequate torquers are available, the errors in sizing indicate lack of attention to the most rudimentary design analysis. In addition, the contractor apparently has not recognized a major problem area in that all six torquers proposed are dc machines utilizing brushes for commutation. Even after proper resizing of the torque motors, several have torque/speed requirements outside the good commutation envelope. This will result in excessive brush wear even in an atmospheric pressure environment. This problem is further complicated by the vacuum operation requirement, and there is reason to be concerned about the adequacy of the basic motor selection. At best, the key torquers will have to be designed specifically for this application with careful selection of brush materials. A complete qualification program will be required. No mention of this development problem was made by the contractor.

Torque Disturbances - During camera operation there are a number of cyclical torque disturbances generated in the camera machinery. Unless the reaction torques coupled to the space vehicle are kept within acceptable bounds, excessive smear rates may occur. Although the contractor appears to have been aware of this problem in that he provided a dynamic balance wheel to counteract the drum acceleration torques during interframe cycling, he did not conduct a thorough analysis of the dynamic behavior of the camera system. In particular, the looper shuttle action can result in vehicle rates of up to $.013^{\circ}$ per second. As the vehicle attitude rate error budget calls for two sigma error of $.015^{\circ}$ per second, it is clear that the looper action must be balanced. In the full scan operating mode this balancing can be accomplished by proper synchronization of the two cameras. However, in the short scan mode this synchronization is no longer adequate and it may be necessary to balance each shuttle separately. A potentially more serious problem is associated with the asynchronous start characteristics resulting from the particular mechanization proposed. In general, at the start of the camera operation the two supply spools will begin acceleration at different times. The result will be high torque disturbances to the vehicle during the first frame of photography. Although an attitude control system mechanization might be found to adequately handle these high disturbances, a much more satisfactory solution is to provide a mechanism for synchronizing start-up. Again the contractor did not address these problem areas.

THERMAL DESIGN

The basic concept for thermal control of the camera proposed by the contractor is a combination of passive and active techniques. Passive coatings on the exterior of the space vehicle maintain the average internal vehicle temperature below 70°F. The cameras themselves are insulated and are provided with heaters which are intended to maintain the camera structure at $70^{\circ}\text{F} \pm 0.5^{\circ}$. While there is nothing inherent in this basic approach to the problem which appears to be unworkable, the contractor has not developed a thermal design nor has he conducted a thorough analysis of the problem areas. Such basic information as the location and types of heaters and temperature sensors to be used is not provided. An analysis has led to the conclusion that the contractor has probably underestimated the power requirements for maintaining the cameras at 70° by a factor between 1.5 and 2. The only detailed analysis performed was an analysis of the thermal gradients to be expected through the various optical elements

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during camera operation. While this analysis appeared relatively complete, the contractor provided no data as to his assumptions and, therefore, it was not possible to verify his computations. A major problem overlooked by the contractor has to do with thermal gradients through the scanning mirror which develop while the mirror is in the stowed position with the thermal door closed. An analysis has indicated that these gradients may get as large as 1.8°. This will result in a massive degradation in optical system performance. While this problem can be substantially alleviated by placing additional heaters on the inside of the operating doors, the contractor apparently had not identified even the possibility of a problem in this area. There are a number of other areas such as the film chutes, film drum compartment, and the scanning mirror compartment which were not treated in the proposal.

STRUCTURAL DESIGN

The overall structural design of the camera proposed appears to be sound and was analyzed by the contractor in considerable detail. The location of the film supply spools forward of the camera and well above the center line of the vehicle will result in substantial space vehicle center of gravity shifts as film is transferred into the R/V's. This problem, however, can be solved by simple relocation of the supply spools.

Attachment 2
BYE-69318-66
Category I
Table I

TABLE I: ITEK SENSOR SUBSYSTEM WEIGHTS & POWER

(30 day mission)

Weight

Cameras (2)	2510 lbs.
Intercamera Structure	155
Supply and Take-up Spools	536
Film Handling Hardware	75
Thermal Provisions	168
Electronics, Cables, etc.	125
Empty Weight	3569 lbs.
Film (30 days) (includes 34.7% wastage)	1439 lbs.

Electrical Energy

Camera Run	3848 w-hrs.
Start-Stop (500 times)	806
Standby	16554
Thermal Heaters	61200
	82,400 w-hrs.

Note: Power and Weight Budgets do not include space vehicle penalties due to the thermal door requirement. Depending upon the overall insulation efficiency, the thermal heater energy may be as low as 44,000 w-hrs.

Attachment 2
BYE-69318-66
Category I
Table II

TABLE II: ITEK SMEAR BUDGET

(Numbers in parenthesis are revisions identified during the course of the Evaluation)

I. Systematic Linear Smear (Worst Location)

Source	Smear Rate (M Rad/Sec) Along Track	Across Track
Edge Effects		
Forward Motion	.20 (.22)	.124
Earth Rate	.059	.032
Distortion	.002 (.0009)	.043 ($7x10^{-6}$)
Slit Width Effects		
Forward Motion	.008 (.015)	.004
Scan Rate	.046	.004 (.016)
Offset Slit	0 (.059)	0 (.02)
Earth Curvature	.096 (.835)	.084 (.224)
C_L Command Approximation	(.03)	(.129)

II. Random Smear Error Budget (Worst Location)

Source	Tolerance - 2 σ Itek (S E)	Along Track	Smear Rate (M rad/sec) (across track)
Scan Angle Error	4 arc sec (.5°)	.0008 (.29)	.0002 (.09)
Focal Length (Sync Determination)	.0048 in	.0 (.001)	.21
Drum Alignment	45 arc sec	.47	0
Vibration			
Folding Mirror			
pitch	(.0002 rad/sec)	(.2)	(0)
crab	(.000121 rad/sec)	(0)	(.1)
Camera			
pitch	.0003 rad/sec	(.3)	(.01)
Roll	.0003 rad/sec	.3 (.068)	.3 (.24)
yaw	.0003 rad/sec	(.24)	(.068)

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Attachment 2
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Table II, cont.

Film Velocity Sync	.038%	.011	.82
Film Velocity Modulation	.4% (1.34%)	.0	.002 (.07)
Drum Modulation	.4% (2.5%)	.038 (.24)	.0
$\Delta (V_x/h)$	.00027 rad/sec	.252	.034
$\Delta (V_y/h)$	(.00003 rad/sec)	(0)	(.03)
Scan Mirror Rate	.1% (.8%)	.039 (.312)	.005 (.04)
Drum Dimensions	10^{o}F ($4x10^{-4}$in)	0	.12 (.14)

III. Random Smear Error Budget (Worst Location)

Source	Tolerance-2σ Itek (S E)	Smear Rate (M rad/sec) Along Track	Across Track
Camera Alignment			
Pitch	6 arc min	.035	.031
Roll	6 arc min	.057	.065 (.018)
Yaw	6 arc min	.0	.017 (.067)
Diagonal Mirror Alignment			
Pitch	(5 arc min)	(.05)	(.5)
Crab	(12 arc sec)	(.2)	(.003)
Optical Axis Alignment to Rotating Mirror			
Pitch	(1.4 arc min)	(.015)	(.1)
Yaw	(4.1 arc sec)	(.043)	(0)
Vehicle Attitude			
Pitch	.5 deg	.18	.15
Roll	.5 deg	.289	.089 (.07)
Yaw	.6 deg	.0 (.03)	.40
Vehicle Rates			
Pitch	.015 deg/sec	.262	.013
Roll	.015 deg/sec	.059	.262 (.25)
Yaw	.015 deg/sec	.219	.068

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Category I
Table III

ITEK DEFOCUS BUDGET

o	FOCUS SENSOR	
	Gain Change	.75 microns
	Unbalance (Detector 4%)	.50
	Servo Loop Threshold	.75
	Penta Deviation	2.2(5.2) microns
o	FILM POSITION SENSOR	.62 microns
o	FILM DRUM CONTACT	1.0 microns
o	DRUM/BEARING ECCENTRICITY	0.38 microns
*	(FILM THICKNESS VARIATION)	(2.0) microns
o	VIBRATION	1.1
o	INITIAL FOCUS SETTING	
	Collimator Error	1.0
	Determination of Best Focus	2.25
o	SCANNING MIRROR DISTORTION	1.1
	RSS	5.9 microns
o	OBJECT DISTANCE VARIATION	2.24 microns

* This term accounts for film thickness variations which occur at frequencies beyond the the band pass of the focus adjust mechanism.

Attachment 2
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Category I
Table IV

ITEK OPTICAL MANUFACTURING TOLERANCES

SURFACE TOLERANCE (RMS)

Scanning Mirror	1/40 wavelengths
Corrector Plate	1/14
Folding Mirror	1/34
Primary Mirror	1/50
Field Lens Group	1/50

DECENTER

Primary Mirror	.001 in.
Corrector Plate	.001 in.
Field Lens Group	.008 in. (total)

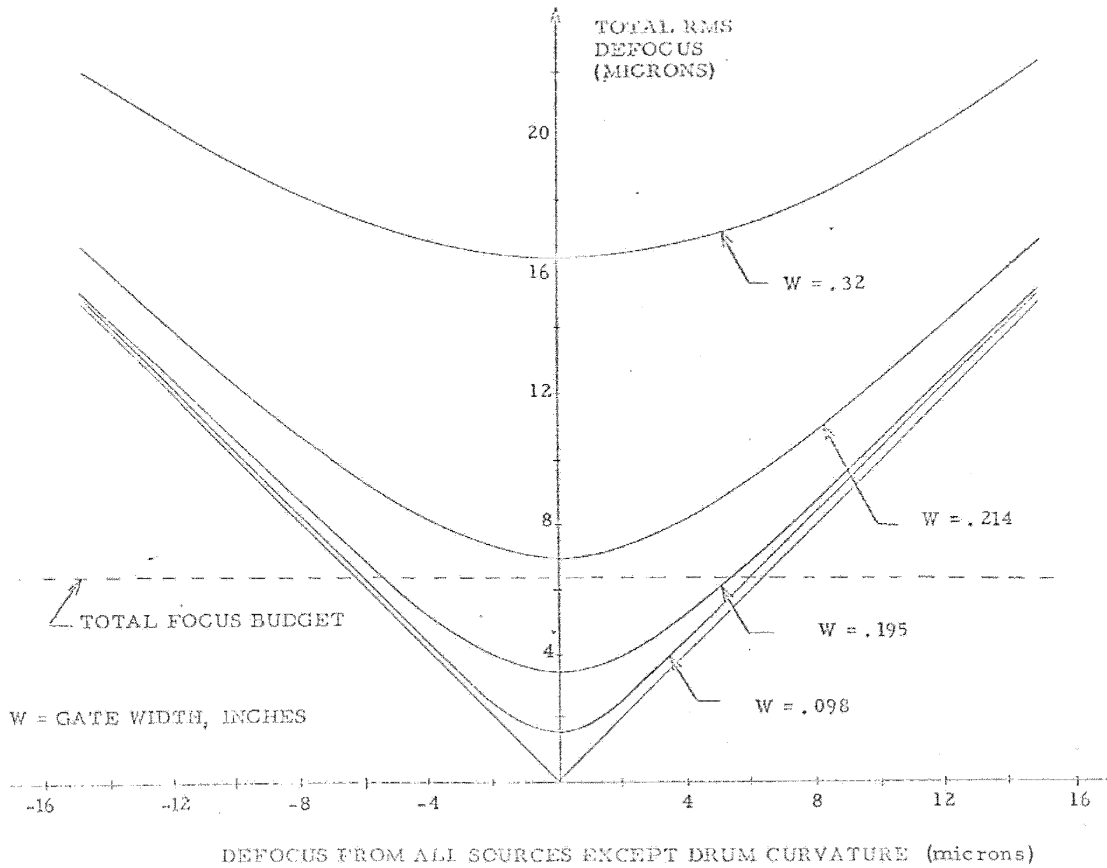
TILT

Primary Mirror	3.3 arc sec
Corrector Plate	19 arc min
Field Lens Group	44.5 arc sec (total)

Attachment
Category I
Figure I

ITEK

CURVED PLATEN DEFOCUS EFFECT



Attachment
BYE-69[illegible]
Category I
Figure II

ITEK
NADIR RESOLUTION VS. SUN ANGLE

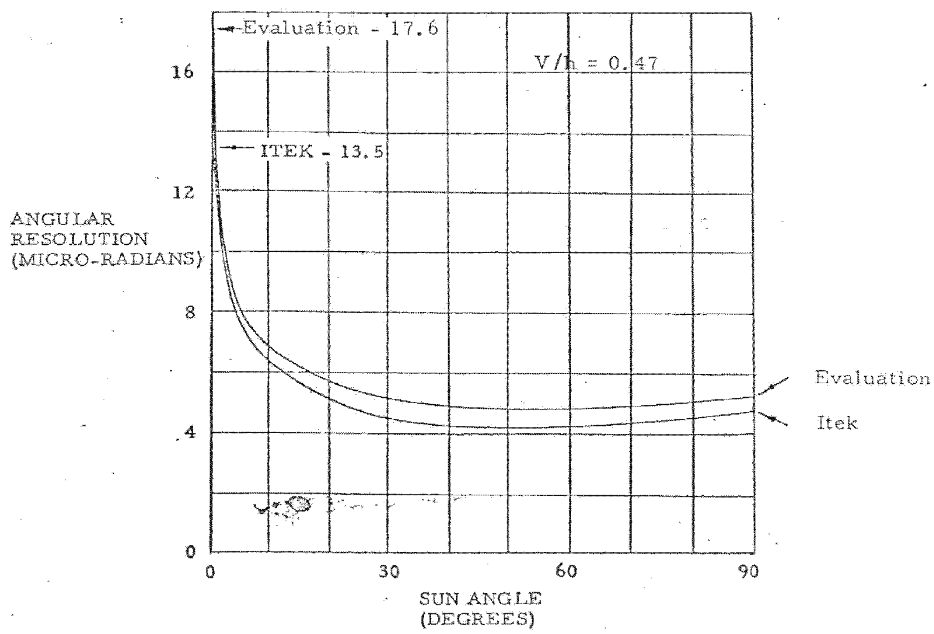


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Figure III

V[illegible]
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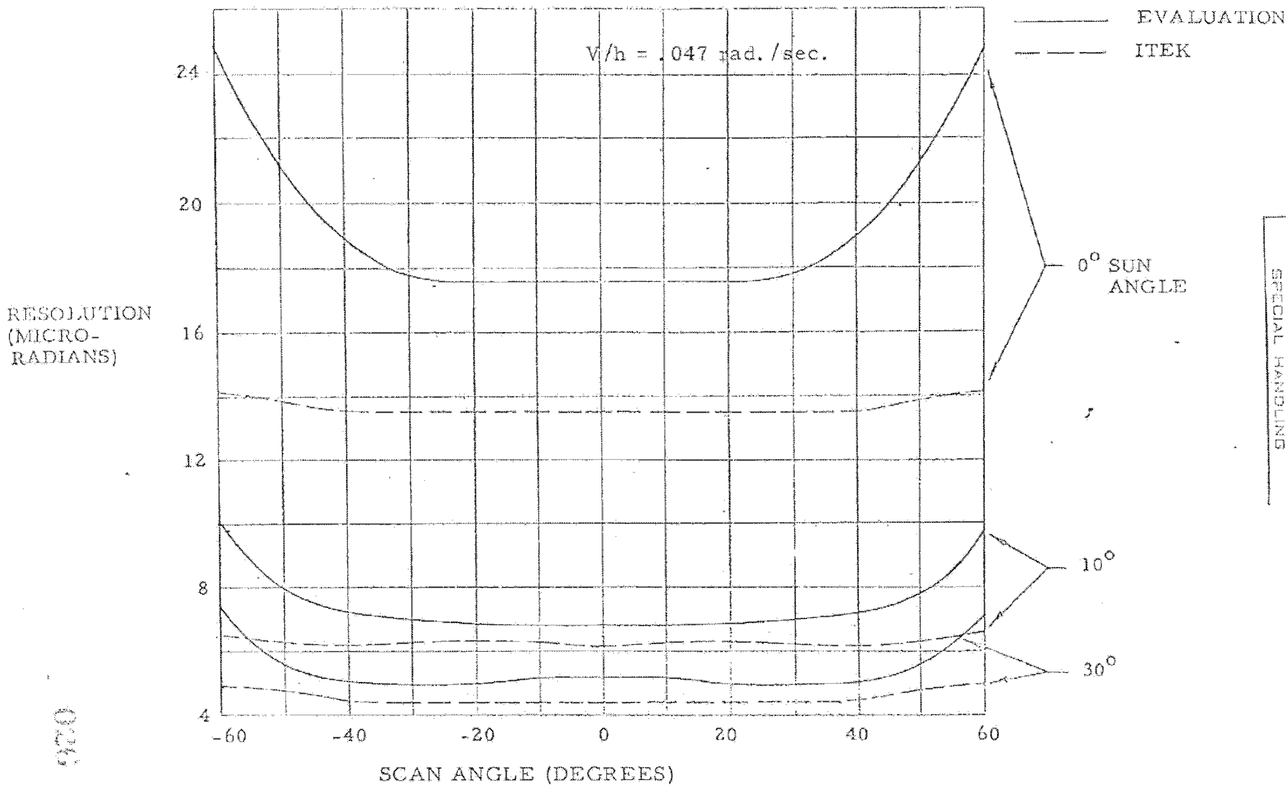
CENTER LINE RESOLUTION VS. SCAN ANGLE

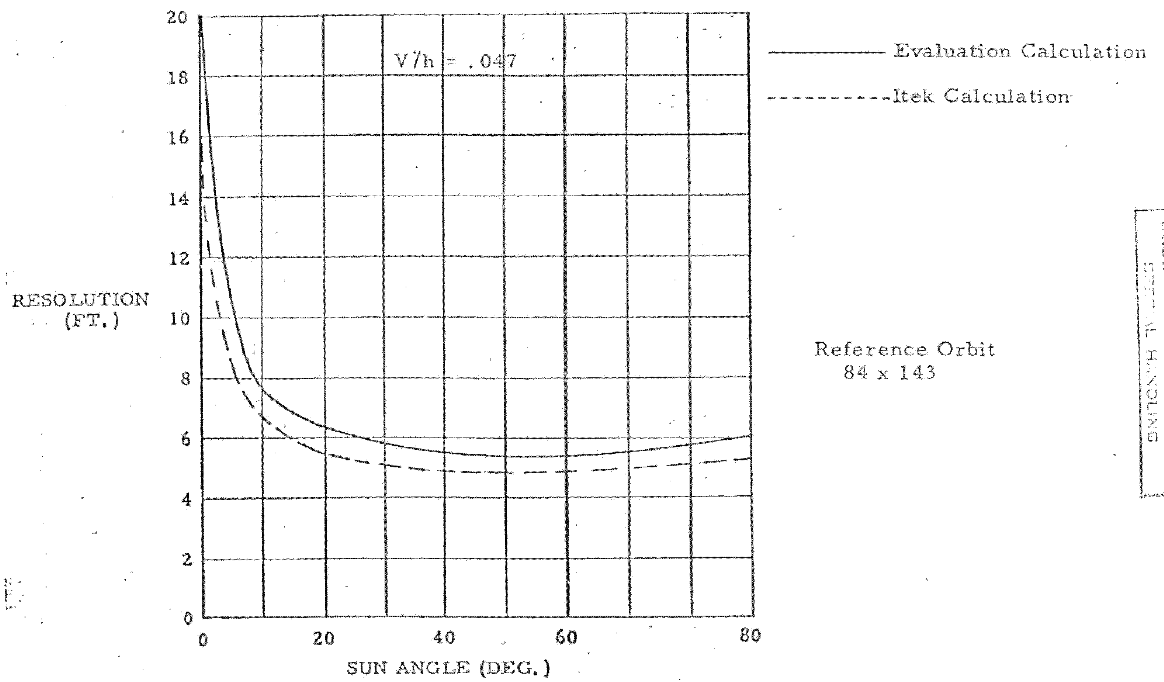


SPECIAL HANDLING

Attachment 2
[redacted]
Category I
Figure IV

ITEK

AREA WEIGHTED AVERAGE GROUND RESOLUTION



Reference Orbit
84 x 143

Attachment 2
BYE-69318-66

ITEK EVALUATION SUMMARY

Rating Category II: DEVELOPMENT RISK — Rating: 5.4

In this category, items and assemblies were identified and evaluated from the viewpoint of the risk involved in meeting the performance objectives within the schedule and cost constraints. In many areas, performance risk can be reduced at the cost of schedule slippage. In arriving at a numerical rating, the evaluators exercised their judgment not only in establishing the magnitude of the risk areas but also in weighting these risks in accordance with their judgments of the real significance of associated performance or schedule penalties.

Optics - The major development risk in the optical system is associated with meeting the surface figure tolerances within the requirements of the development schedule. One of the most critical optical elements from this point of view is the folding flat. This element as proposed has an unusually high diameter to thickness ratio (14:1) with the additional complication of a center race track perforation. Both the fabrication of this element to the 1/34 wavelength RMS surface quality and the mounting of this relatively flexible element involve potential risks. It may be necessary to increase the thickness of this piece in order to ease the fabrication and mounting problems, but the price will be a performance penalty caused by the increase in central obscuration.

Another critical optical element in the development risk sense is the 42" x 27" double-sided scanning mirror. The diameter to thickness ratio on this element in the worst direction is almost 6:1; and, therefore, it is not anticipated that any major mechanical handling or mounting problems will be encountered. The fabrication risks are associated with the requirement for a 1/40 wavelength RMS surface quality on both sides of this very large element. Experience has shown that flat mirrors are at best difficult to fabricate to these surface qualities and there has been no experience with double-sided mirrors in this performance class. From a performance risk viewpoint, the problem of the scanning mirror is further complicated by the effect on image quality of this mirror at high incidence angles. As was mentioned in the Performance Evaluation summary, the contractor's 1/40 wavelength surface quality tolerance was

HANDLE VIA BYEMAN

computed at an incidence angle of 45°. It is likely that either high scan angle performance must be sacrificed or a substantially better surface tolerance achieved on this element.

The aspheric Schmidt corrector plate proposal does not constitute the same degree of risk as the folding flat or the scanning flat. However, there is a strong (100 wave) aspheric component on this surface and experience has shown that while such elements can be made they require a significant optical shop effort coupled with good measurement techniques.

As discussed in the Performance Evaluation summary, the contractor has not adequately treated the problem of baffling the optical system to stray light. There is a very real possibility that a completely adequate solution to this problem cannot be found and, therefore, a performance degradation may have to be accepted.

The contractor proposes to use a Ritchey test for measuring the surface figure on the optical elements. This type of test requires the fabrication of large spherical test mirrors with a surface quality as good or better than the elements to be tested. As these test spheres are required in the process of fabricating the initial sets of optics, any delays in the procurement of these spheres could impact the development schedule.

While any one of these optical elements may not pose insurmountable fabrication problems given the contractor's capability in this area, there is significant concern that the necessity for attacking all of them simultaneously in the context of a very tight development schedule can result in serious difficulties. The contractor defends his capability by noting that he has fabricated the elements for a 20" aperture F/2 system and has tested this system to required resolution level. However, in the proposed design all the elements are larger, particularly the scanning mirror, and according to the contractor, will have to be fabricated with better surface figures than was achieved in the 20" system. In the optics area, it will be possible to exchange performance and schedule risk by accepting substandard optical elements to meet the schedule objectives, or, alternatively, slip the schedule to provide sufficient time to meet the optical element tolerance requirements.

I think the risk is overstated

Rating Category II: DEVELOPMENT RISK

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Page 3

Focus Control - As noted in the Performance Evaluation summary, the entire drum assembly will probably have to be redesigned. To meet the performance requirements of the smear budget and the focus budget this drum assembly must stay within a very stringent mechanical tolerance budget. There is a schedule risk in that this redesign must be accomplished early in the program in order to meet the Critical Design Review milestone and a further performance and schedule risk in that the fabrication of this assembly within the tolerances required will be a difficult task.

The focus sensor, too, must meet critical performance standards. As discussed in the Performance Evaluation summary, there appear to be some basic problems with the design as proposed. While the autocollimating concept is workable, a significant redesign and repackaging of the focus sensor may well be required. This item also could impact the Critical Design Review milestone.

The drum diameter monitor was in the conceptual stage at the time the contractor submitted his proposal. As mentioned in the Performance Evaluation summary, he had not yet conducted a detailed design analysis and had not identified several critical problems with the proposed concept. In the Performance Evaluation, the contractor was penalized an additional two microns of defocus for film thickness variations. With this added penalty, a drum diameter monitor of some type can probably be designed with a performance adequate to the intended function. However, there is a significant schedule risk associated with this item particularly as the contractor has just begun to study the problem.

A major flaw in the contractor's design as proposed was discovered during the course of the evaluation. The contractor had failed to recognize the possibility of a thermal gradient developing through the scanning mirror during standby operation. This gradient could get as large as 1.8^{o}. A gradient of this magnitude results in a focus error of over twice the contractor's total defocus budget. In the Performance Evaluation, it was assumed that a means could be found for controlling this gradient to less than 0.2^{o}F and, therefore, no performance penalty was assigned to this deficiency. Possible solutions are the installation of additional heaters in the scanning mirror compartment or in the use of Cer-Vit instead of eggcrate fused silica in the fabrication of this mirror. In any case, there is a high probability of a schedule slippage associated with the solution of this problem.

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Film Transport - As discussed in the Performance Evaluation summary, the film transport concept chosen by the contractor is adequate to meet the performance objectives. However, major detailed design inadequacies were discovered during the course of the evaluation. In general, the design of the film transport subsystem has not progressed beyond the block diagram stage. In addition, four of the six torque motors in the film transport system are undersized. The contractor is proposing to use brush type dc torquers which must be specially developed for his application and qualified for extended operation in a vacuum environment. Particularly since the contractor did not appear to appreciate the problems associated with such a development, there is the possibility of a schedule slippage.

The contractor proposed to package all of his electronics in one box. This is an unacceptable approach to the electronic packaging problem, and will have to be modified to a packaging arrangement to permit a more reasonable design, fabrication, test, and replacement.

Thermal Design - As discussed in the Performance Evaluation summary, the contractor presented no detailed thermal analysis or design in his proposal. While a few of the critical thermal problems had been addressed, a number had been overlooked by the contractor and others, while mentioned, were not treated in detail. As discussed under Focus Control above, the most critical such problem is the scanning mirror gradient problem. In general, the design of an active thermal control system which maintains the entire structure at $70^{o}F \pm 0.5^{o}F$ is an extensive undertaking. While experience has shown that this requirement can probably be met, it will be a major effort with possible schedule consequences.

Contractor Engineering Capability - The lack of detailed design information in the proposal together with the many errors in what was presented lead to a concern that the engineering capability the contractor has applied to this program to date suffers from a serious inadequacy. While the thermal, mechanical, and optical tolerances that must be met can probably be achieved, this can only be done if the contractor brings to bear an expert engineering design team. The degree to which he does not do so will have serious consequences not only on schedule but ultimately on performance as well.

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ITEK EVALUATION SUMMARY

Rating Category III: DESIGN MARGIN Rating: 4.2

Design Margin category covers the evaluation of the proposed system's operational dependability and producability after the initial flight has been accomplished. The sensitivity of the system performance to variations in tolerances were weighted by the evaluators judgment of the likelihood of these variations actually occurring together with an assessment of the performance consequences of these variations.

SYSTEM PERFORMANCE

The rating of the Design Margin of this system was strongly influenced by the criticality of all the mechanical, electrical, and thermal tolerances associated with the design. As discussed in the Performarce Evaluation summary this critical tolerancing situation has arisen out of the contractor's attempt to design a camera system which is as near as possible film resolution limited. As a result the contractor has proposed a low relative aperture system with all the attendant critical optical, mechanical, and focus tolerance problems. All of these tolerances are so tight that a performance degradation in any category is unlikely to be compensated by better than predicted performance in another category.

In an attempt to measure quantitatively the sensitivity of system resolution performance to tolerance variations, the evaluation group has examined several numerical measures. The two most meaningful were the rate of change of angular resolution with smear and the rate of change of angular resolution with defocus:

$$\frac{dR}{dS} = 0.14 \text{ micro-rad/micron}$$

$$\frac{dR}{dD} = 0.30 \text{ micro-rad/micron}$$

The sensitivity of the system to defocus is particularly critical in that the 0.3 micro-radians per micron rate of change of performance amounts to a 6% overall resolution degradation per micron of additional defocus.

HANDLE VIA

Rating Category III: DESIGN MARGIN

Attachment 2
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CRITICAL SUBSYSTEMS

Optics - As has been discussed above, there are major fabrication problems with three of the optical elements in the proposed system: the folding flat, the scanning flat, and the aspheric corrector plate. These elements are all large and must be fabricated to unusually tight surface figure tolerances. There is serious question about the contractor's capability to deliver these optics to the performance requirements at the rate of one set per month required to support the acquisition phase of this program. This is of particular concern in that the contractor is proposing to fabricate the flat mirrors with conventional polishing techniques. This risk is mitigated to some extent by the contractor's successful development of an excellent scheme for measuring surface figure and reducing the data to terms meaningful to optical shop personnel. However, at best the process of hand figuring to achieve the ultimate surface figure objectives is unpredictable and will require the application of large numbers of skilled personnel.

Film Drum Assembly - In order to meet the requirements both for focal control and for film velocity control, the film drum assembly must be fabricated throughout to tolerances which are close to the state of the art. Any variation from these tolerances is likely to result in appreciable performance degradation. These assemblies are required at the rate of one a month in the acquisition phase of the program. While this is not as serious a problem as the optical fabrication problem, it is likely there will be a continuing schedule and performance risk associated with this assembly.

Focus Control and Film Velocity Control - The assemblage of electronics and sensors associated with the focus sensor, the drum diameter sensor, and the film transport system can be designed and fabricated to meet the performance objectives required. However, the integrated system is complex and the resolution sensitivity to any performance variation in these systems means that a rigorous fabrication control and careful acceptance testing will be necessary to maintain performance standards. The potential of schedule problems in the acquisition program cannot be overlooked.

The proper functioning of the thermal control system is critical to the maintenance of overall systems focus and optical performance. Camera structural gradients greater than the 0.5°F tolerance will result

Rating Category III: DESIGN MARGIN

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in optical element tilting and decentering which will have a strong influence on optical system resolution. In addition, since the focus sensor does not "see" the scanning mirror, the thermal control of gradients through this element is critical. The contractor did not provide an analysis of the behavior of the overall system in a degraded thermal environment nor has it been possible during the course of the evaluation to conduct such an analysis. However, past experience together with an assessment of performance sensitivity to various types of mechanical deformations and misalignments has identified this as accritical problem area.

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ITEK EVALUATION SUMMARY

Rating Category IV: VALUE FUNCTION   Rating: 6.8

Points in this category were assigned to the contractor strictly on the basis of the numerical size of the Value Function computed according to the instructions in Attachment II of the RFP. The proposing contractor with the highest Value Function was automatically assigned a maximum rating of 9.0. The other contractor was then assigned a rating in this category using the following formula:

$$R = 9.0 \frac{(V_m)}{(V_m)\ max.}$$

Instructions in the RFP called for computing the Value Function for both winter and summer conditions and for STB and UTB film. For the purposes of assigning a rating to the contractor in this category, only the UTB Value Functions were utilized. An analysis was conducted to determine the proper weighting of the summer Value Function and the winter Value Function. This analysis examined the distribution of sun angles to be expected during the course of a year. Approximately 60% of the target acquisitions occur at sun angles greater than 30° and approximately 40% at sun angles less than 30°. As the contributions to the summer Value Function are almost all at sun angles above 30° and those for the winter Value Function below 30°, it seemed reasonable to weight the summer Value Function 0.6 and the winter Value Function 0.4. Accordingly, the following formula was used in computing a single Value Function for rating purposes:

$$V_m = 0.6\ (V_m)s + 0.4\ (V_m)w$$

where $(V_m)s$ is the summer mission value and $(V_m)w$ is the winter mission value.

As has been pointed out in the Performance Evaluation discussion, this contractor evaluated the Value Function incorrectly. During the course of the evaluation the Value Function had been recomputed using the error budget presented in the Performance Evaluation discussion above and correcting the other errors made by the contractor. Table V presents these recomputed Value Functions for all four cases. In addition, Table V includes the value per day numbers and the nominal mission duration numbers as defined in Attachment II of the RFP.

SPECIAL HANDLING

Attachment 2
BYE-69318-66
Category IV
Table V

TABLE V

ITEK VALUE FUNCTION SUMMARY

Nominal Mission Duration:	27.7 days	
Value/day (summer):	2.91×10^6 nm^2	
Value/day (winter):	1.88×10^6 nm^2	
	UTB	STB
Value/Mission (summer):	8.06×10^7	7.28×10^7 nm^2
Value/Mission (winter):	5.21×10^7	4.70×10^7 nm^2

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CONTROL SYSTEM ONLY

Attachment 2
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ITEK EVALUATION SUMMARY

Rating Category V: RELIABILITY   Rating: 3.8

GENERAL

In this category, the contractor was graded on his understanding of the over-all reliability problem as well as on the numerical failure rate predicted for his proposed system. In this area, the contractor clearly did not indicate an understanding in depth of the trade-off between subsystem and component redundancy and reliability. The contractor's method of computing failure rate was in error, which, when coupled with his incorrect parts count list, necessitated the use of hi-rel parts (which he had not considered) in order for him to achieve the reliability goal.

DATA PRESENTED BY THE CONTRACTOR

With a given reliability goal of .003 failures per day for the Sensor Subsystem, the contractor elected to consider that all failures would occur only during a normal 10 minutes of operating time per day. The various cameras subassemblies were allocated predicted failure rates, which, when totaled, resulted in a failure rate for the Sensor Subsystem, exclusive of the eight heaters per camera, of .000438 failures per day. Additional data was requested of the contractor relating to a breakdown as to part type (resistors, diodes, et cetera) within each listed subassembly, and this data was submitted, along with comments as to when the part was operating in the "standby," "ready," or "operate" mode. The contractor elected at this time also to mechanically cage the rotating mirror, rather than leave power on for electronic positioning during the non-operating periods.

TECHNICAL ANALYSIS

Using the contractor's method of computation, but considering failure during the non-operating periods, an unacceptably high failure rate of .038 failures per day resulted. Another calculation based on contractor parts count and mil-standard components resulted in a .0047 failure rate per day. Only when hi-rel components were substituted did the failure rate meet the reliability goal.

EVALUATION GROUP KEY COMMENTS

The predicted Sensor Subsystem failure rate was achieved only by allowing the use of hi-rel parts, which, incidentally, would impact the proposal in other areas, such as cost. 037

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CONTROL SYSTEM ONLY

Rating Category V: RELIABILITY

Attachment 2
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The contractor's approach to failure rate analysis was deficient in the following areas:

1. Methodology - in error.

2. Parts count - incorrect.

3. Identification of requirement for hi-rel parts - lacking.

4. No failure mode analysis with respect to redundancy and simplification considerations.

In the area of reliability testing, the contractor made only general statements with regard to the requirement for a demonstration of the failure rate with a 75% confidence. In the life test area, the contractor's statistical design was wrong in that it allowed for the replacement of critical parts during the test. Furthermore, it did not provide for the required number of start-stop operations.

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ITEK EVALUATION SUMMARY

Rating Category VI: OPERATIONAL CONSIDERATIONS — Rating: 6.0

1. Operational considerations include the factors associated with the ease of checkout and launch, the ease of control by the Satellite Control Facility, the mission planning, and the targeting implications, the film processing requirements, and the photographic interpretation and mensuration.

2. The operational flexibility of this system is considered to be excellent. The provisions for variable scan and patch surveillance modes can be incorporated with few complications and little risk to the basic system.

3. The start-up time of approximately two seconds is as short as can be reasonably expected in a system of this type; however, there will be four frames of monoscopic coverage with every stop and start because the cameras will be operated together to balance the momentums.

4. There may be a detectable degradation in resolution during the patch mode when surveillance photographs are being taken off to one side. This is due to the film shuttle momentums adding together and causing a vehicle roll rate of .013 degrees per second.

5. The attitude control system gas will be expended at a slightly faster rate if only monoscopic photography is taken.

6. The checkout at the launch pad is a potential problem because of the requirement to either open the camera door or bypass the scanning mirror. Opening the camera door involves environmental, security, and structural problems. Bypassing the scanning mirror, which is the master clock of the system, involves additional electrical connectors and simulating the scanning mirror servo.

7. The variation of the exposure across the scan due to vignetting will increase the number of film processing control changes.

8. The high resolution of this system makes quality control of the film processing and reproduction important.

9. The types of supplemental information for mapping and mensurations proposed are considered to be desirable; however, the accuracy of the control geometry was not specified.

SPECIAL HANDLING

Attachment 2
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ITEK EVALUATION SUMMARY

Rating Category VII: EFFECT ON SPACE VEHICLE — Rating: 4.0

GENERAL

In this category, the contractor was evaluated on the impact of his proposed Sensor Subsystem upon the over-all design of the Space Vehicle and in each of the critical SBA subsystem areas. The contractor's thermal design philosophy consists of a combination of active and passive thermal controls. Active electrical heaters are utilized to maintain the structural and optical component temperatures at 70°F, while passive thermal control methods (a mosaic of black paint, white paint, and aluminum foil tape) are employed to maintain the shell mean temperature at approximately 50°F for all orbits. Thermal doors must be incorporated into the SBA to protect the cameras from the "cold" earth during the non-photographic periods (closed position) and to act as thermal shields, with fold-out side curtains, during the photographic periods as protection against direct sunlight (open position).

The contractor also proposed that the two cameras be individually mounted to the SBA and that the supply spools be oriented along the vehicle yaw axis and near the top of the Space Vehicle for easy access. (See Figure V-A)

CAMERA IMPACT ON SATELLITE BASIC ASSEMBLY SUBSYSTEMS

Structures - The major structural problem associated with the contractor's proposed camera system is the requirement for large viewports which must beclosed during camera standby operation for thermal protection. As proposed, the contractor's camera arrangement requires two viewports, one for each camera. Each viewport cuts approximately 160° of space vehicle circumference. The two viewports are offset in angle with respect to each other and are skewed along the space vehicle rather than forming right cylindrical sections. The structural problems associated with this arrangement are so severe that it is doubtful whether a reasonable design

Rating Category VII: EFFECT ON SPACE VEHICLE

could be implemented. The external doors must be load-carrying during launch. Since the two doors together cut through almost 240° of space vehicle circumference, a substantial weighting penalty must be paid to provide a vehicle sufficiently rigid for ground handling with the structural doors removed.

During the course of the evaluation, an alternative camera arrangement was examined which alleviated some of the space vehicle structural difficulties (see Figure V-C). This rearrangement eliminates the requirement for skewing the viewport cutout along the space vehicle and reduces the total area of the external doors. In addition, it is possible if necessary to frame these doors so that they need not be load-carrying during launch; but, even with this configuration, the structural problems implied by the camera viewport requirements are substantial and have adverse effects on the space vehicle.

The operating doors for thermal protection as proposed by the contractor are large clam shell sections (see Figure VI). During door open times, the optical system must be thermally protected by side curtains which fold out as the doors open. When the doors are open, the frontal area of the space vehicle is approximately doubled. This arrangement (particularly in view of the folding curtains) will be difficult if not impossible to implement. An alternative mechanization of these doors may be possible although none was identified during the course of the evaluation. The reliability impact of the requirement for operating doors was not included in the camera reliability computation. Good design should minimize door reliability problems, but they have historically been a source of difficulty.

The supply spool location as proposed by the contractor (see Figure V-A) results in appreciable space vehicle center of gravity shift as the film moves from the supply to the take-up spools. There appears to be no camera associated reason why the spools cannot be relocated as shown in Figure V-B. The evaluation was conducted with the assumption that the supply spools would be relocated.

The method proposed by the contractor for mounting the cameras separately into the space vehicle results in poor control of inter-camera alignment. Consequently, it was judged necessary to add an inter-camera structure as depicted in Figure V-B. In any case, this is probably more economical from a structural weight point-of-view than the configuration proposed by the contractor.

The outside diameter of the camera package is 110" requiring a space vehicle outside diameter of 120". This poses no special structural problem in that the launch vehicle interface diameter is 120".

Attitude Control System - Due to the fact that the contractor's proposed mechanization of the cameras start-up sequence can result in a synchronous supply and take-up spool start-up, severe disturbance loads will be imposed on the attitude control system. The straightforward solution to this problem is to synchronize camera start-up. With this modification to the contractor's design, there are no unusual requirements on the attitude control system. Rate roofs will probably be required particularly for monoscopic operation.

Power - Although the power requirements for the camera system are large because of the active thermal control required, no special power supply requirements are imposed on the space vehicle. The contractor did not provide a detailed statement of the transient power requirements during camera operation. However, a power analysis has led to the conclusion that, while start-up currents will be high, the number of batteries required to support the over-all space vehicle is sufficiently large so that this surge can be absorbed without catastrophic voltage drops.

Orbit Adjust System - With the supply spools relocated to reduce the center of gravity shift through the mission, no special requirements are imposed on the orbit adjust system.

The doubling of the space vehicle cross section area with the doors open does not increase the propellant requirements substantially, since the total door open time is short compared to the mission duration.

Telemetry and Command - The telemetry requirements are not specified by the contractor. However, no problem is anticipated in supporting any reasonable requirements in this area.

A detailed analysis of the command system required to support camera operation was not made, but there appears to be nothing in the basic camera design which would impact the command system feasibility.

Rating Category VII: EFFECT ON SPACE VEHICLE

Integration with SBA - The integration sequence discussed by the contractor requires an inordinate number of re-entry vehicle assemblies and disassemblies. A reprogramming of the assembly flow should eliminate this shortcoming.

Since the viewport doors must be open in order to operate the camera, the space vehicle must be designed with sufficient rigidity so that it can be handled without doors in the ground environment.

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SPECIAL HANDLING

Attachment 2
BYE-69318-66
Category VII
Table VI

TABLE VI

ITEK SPACE VEHICLE WEIGHT BREAKDOWN

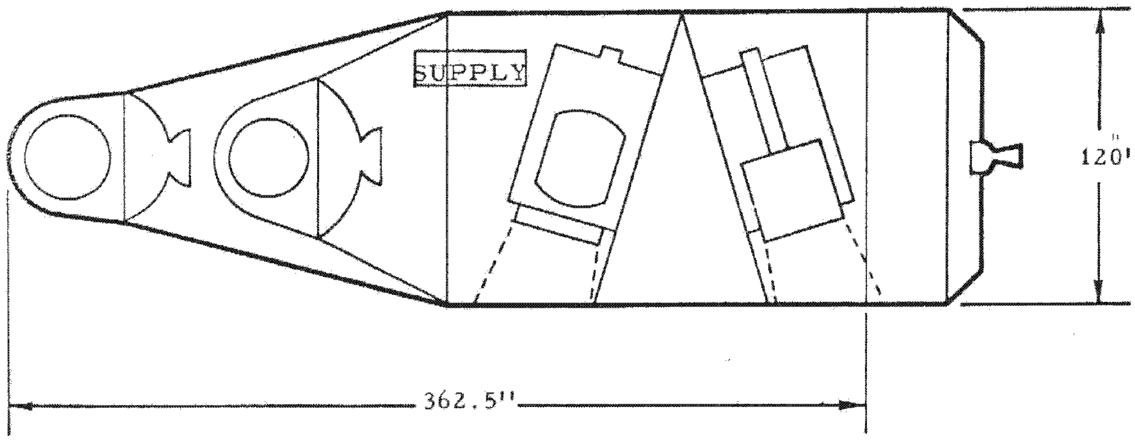
(Expendables Sized for 30 Day Mission)

		Evaluation Group Estimate
Sensor Subsystem		3,569 lbs
2 Reentry Vehicle		1,480 lbs.
SI Camera		150
Film		1,439
Satellite Basic Assembly		6,672
Forward Section		
RV#1 Cone	350 lbs.	
RV#2 Cone	110	
Sensor Section		
Primary Structure	825	
Support Structure	110	
Viewport Structural Door	225	
Viewport Thermal Door	175	
Thermal (coatings only)	40	
Aft Section		
Primary Structure	435	
Support Structure	90	
O A Hardware	186	
ACS Hardware (propul.)	255	
ACS Hardware (elect.)	50	
TT&C Hardware	175	
Thermal Material	80	
Power & Signal Dist.	100	
Back-up Recovery	35	
Separation	55	
Expendables		
Batteries	1,940	
OA Gas	1,106	
ACS Cold Gas	330	
System Lift-off Weight		13,310
10% Contingency		1,331
Expected Total Space Vehicle Weight (30 day mission)		14,641 lbs.

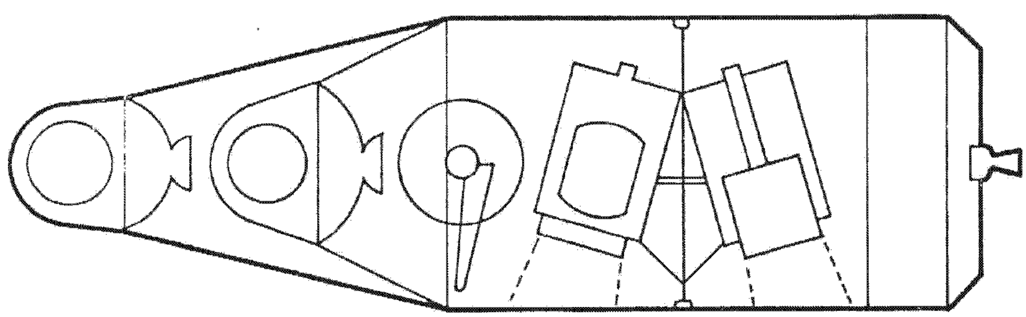
041

HANDLE VIA BYEMAN

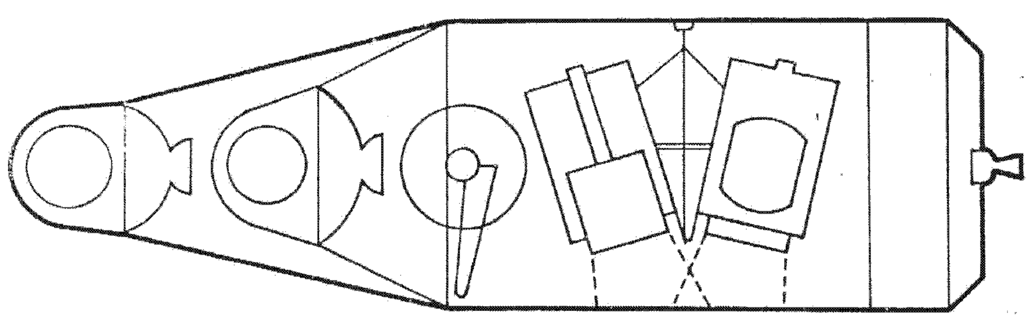
A. CONTRACTOR-PROPOSED CONFIGURATION



B. WITH SUPPLY SPOOL MOVED AND WITH INTER-CAMERA STRUCTURE



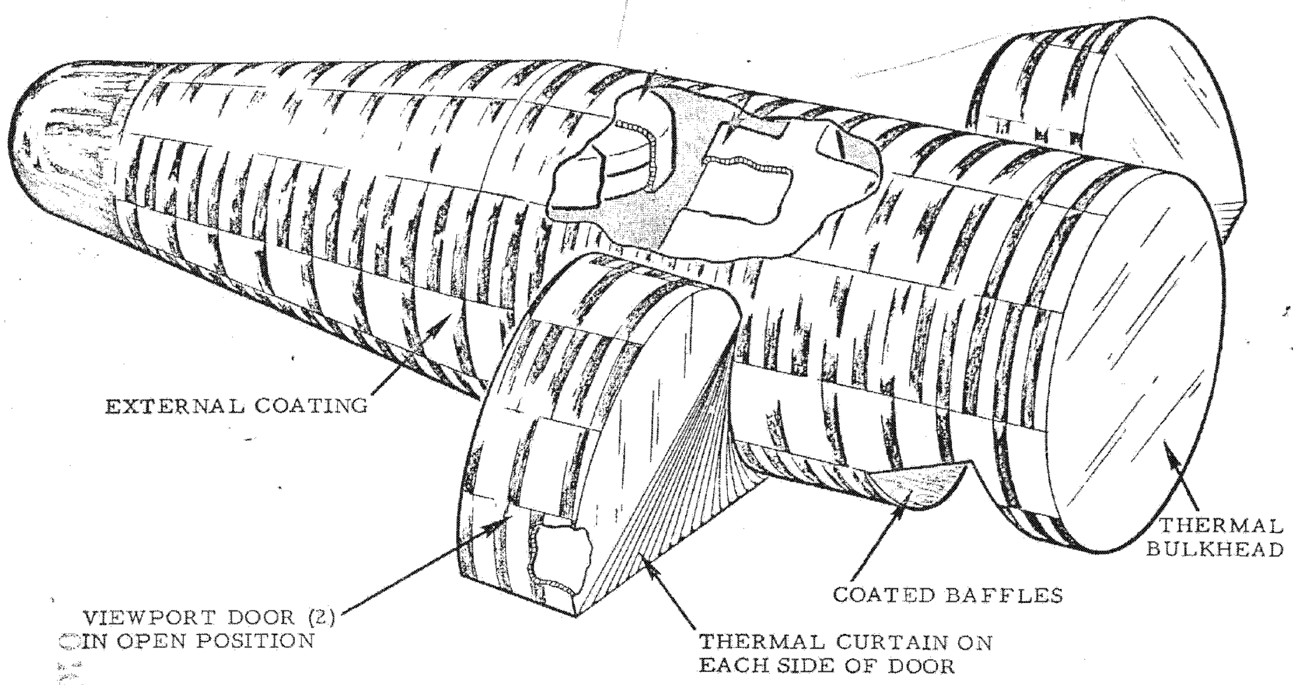
C. WITH REVERSED CAMERA ORIENTATION



AMERA SUPPORT STRUCTURE AND SUPPLY SPOOL ARRANGEMENT

ITEK

VIEWPORT DOOR AND THERMAL CONFIGURATION



Attachment 2
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ITEK EVALUATION SUMMARY

Rating Category VIII: INTERFACE Rating: 3.2

1. In this category, attention was focused on the contractor's definition of the interface requirements. The contractor's understanding of these interfaces as well as the adequacy of the interface requirements from the viewpoint of the sensor were examined.

2. With regard to the thermal interface, the contractor's estimates of the required heater power was low by a factor of two. The paint pattern specified results in a larger variation in average temperature with beta angle than that specified by the contractor. The contractor neglected heaters on doors and film chutes. He seems to have a good general understanding but lacked sufficient detailed analysis and made significant errors in the analyses presented. No thermal requirements were mentioned for the take-up in the R/V. Ground conditioning requirements on the launch pad were not defined.

3. The requirement that the SBA contractor furnish mounting points for the film chutes was defined but alignment tolerances in general were undefined.

4. The environmental doors as proposed are critical to thermal control of the SS but were poorly defined. The contractor should have called this out as a critical area for their performance and asked for tight control of this interface.

5. There was little mention of telemetry interface and no definition of how many and what instrumentation points. It is merely stated that TM functions will be designated at a later date.

6. There was no definition of any AGE for integrated testing, checkout, and launch readiness verification.

7. Although a good description of the take-up and separation operations for the R/V's was given, no interface requirements with the R/V were given. No requirement was made for film path alignment into the R/V or provision for removal of test film.

Rating Category VIII: INTERFACE

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8. In summary, the contractor devoted an entire section of 67 pages to interface requirements, but, despite this large volume of narrative, he failed to clearly define his interface requirements.

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ITEK EVALUATION SUMMARY

Rating Category IX: MASTER PROGRAM PLAN, DESIGN DEVELOPMENT PLAN, QUALIFICATION PLAN, INTEGRATION ASSEMBLY AND CHECKOUT PLAN — Rating: 5.0

GENERAL

The plans discussed herein have been evaluated on the basis of technical content only. The criteria applied were:

1. completeness of the information supplied.
2. understanding of systems implications.
3. compatibility of plans with requirements.

MASTER PROGRAM PLAN

This plan is reasonably detailed and generally good; however, there is little discussion of the Sensor Subsystem design's impact on the total system, nor of interface considerations. Scheduling is sketchy in some areas (such as test and AGE equipment) and not adequately justified in others; for example, final interface definition is set at three months, the thermal model is set at four months, and SS CDR at eight months. It is by no means clear that these goals are realistic. Similarly, (prototype) optical system alignment and static test is scheduled at ten months. Along with fabrication and mounting of the elements themselves, this requires production of initial test optics--all in a period during which the optical shop will be relocated! Finally, it is not clear that a sufficient sense of urgency exists with respect to the film drum assembly, which is nearly a pacing item.

DESIGN AND DEVELOPMENT PLAN

This plan is also reasonably detailed. However, considerable reliance is placed upon tests to be run on (and/or experience already gained from) the 40" engineering model. For example, the contractor expects to be able to eliminate the breadboard stage for many assemblies in the film drive servo system (p. 2-52). On the basis of the information supplied, this reliance on the engineering model is viewed as risky.

The plan identifies certain optical areas of concern, but slights other major areas such as electronics and focus sensor. The optical discussion itself glossed over problems associated with production of the scanning and folding flats.

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SPECIAL HANDLING

Rating Category IX: MASTER PROGRAM PLAN, DESIGN DEVELOPMENT PLAN, QUALIFICATION PLAN, INTEGRATION ASSEMBLY AND CHECKOUT PLAN

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The corrector plate fabrication problem is expected to be solved by direct aspheric grinding, followed by "Meinel" polishing. Aspheric grinding has had a long - and checkered - history, and the detailed application of the polishing method is viewed as risky by its originator.

Optical coating technology is another identified area of concern. The contractor proposes to do this in-house for Q-C reasons. In view of the tight tolerances and the contractor's relative lack of experience in applying multi-layer coatings to large optics on a production basis, this concern (particularly as it impacts schedule) is justified.

The third contractor-identified area of optical concern is potting techniques for element mounting. The contractor has pioneered in this field; hence, it may be significant that he has raised the issue. There is reason for confidence that the problem can be solved, though not necessarily within the proposed schedule.

QUALIFICATION PROGRAM PLAN

This plan, in general, is good. However, all assemblies are to be completely qualified prior to installation in the SBA; this multi-level testing requires 5 vacuum chambers. Also, the method of albedo simulation in the thermal/vacuum photo test (p. 2-78) is unclear.

ASSEMBLY AND CHECKOUT PLAN

This plan is quite general and contains very little information on pad or launch aspects. Excessive assembly/disassembly operations are required, particularly of the R/V's (following the film path alignment and following vibration and light tightness tests). (Note: It is estimated that unload-reload of expended spools in the SS will require 36 hours [p. 2-204].) A baseline functional test required at completion of A&C sequence prior to transport to pad is not specified. Ordnance hazards during A&C are not cited.

HANDLE VIA BYEMAN

Attachment 2
BYE-69318-66

ITEK EVALUATION SUMMARY

Rating Category X: FABRICATION AND DELIVERY PLAN, AGE DESIGN DEVELOPMENT AND DELIVERY PLAN, MASS PROPERTIES CONTROL PLAN, RELIABILITY PROGRAM PLAN

Rating: 5.0

GENERAL

The plans discussed herein have been evaluated on the basis of technical content only. The criteria applied were:

1. completeness of the information supplied.
2. understanding of systems implications.
3. compatibility of plans with requirements.

FABRICATION AND DELIVERY PLAN

This plan calls out as critical aspects the production of large, precise optics and scheduling/availability problems with respect to the extensive thermal-vacuum facilities required. Again, problems associated with production of the scarcely less demanding drum assemblies are largely glossed over.

RELIABILITY PROGRAM

The general format of the reliability program conforms to standard practice. However, proposal that critical parts will be replaced and system cleaned during the reliability test suggests a curious interpretation of the intent of this test. It appears the contractor has not identified the necessity of a full high-reliability program and hence has not explored its consequences with respect to schedule, manpower, cost, et cetera.

MASS PROPERTIES CONTROL PLAN

In general, this plan ignores necessity of data interchange between associate contractors and compatibility of SS properties with over-all system control plan. Essentially the plan presented is a reiteration of the requirements in the RFP. It is unclear how the weight engineering group will insure that mass properties specifications are met for actual flight articles.

051

Rating Category X: FABRICATION AND DELIVERY PLAN, AGE DESIGN DEVELOPMENT AND DELIVERY PLAN, MASS PROPERTIES CONTROL PLAN, RELIABILITY PROGRAM PLAN

Attachment 2
BYE-69318-66

AGE DESIGN, DEVELOPMENT AND DELIVERY PLAN

This plan is fairly comprehensive as it applies to in-plant and optical test equipment. Otherwise it is sketchy, with little consideration of on-pad and launch AGE or combined SV-AGE. Tests for AGE are largely omitted (except for environmental tests on the shipping containers). Installation and checkout tests for ACF equipment are not delineated.