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To: FILE

Date: 25 February 1969

Subject: Review Comments of the EK Engineering Analysis Report, dated 27 November 1968

From: G. D. McGhee

The subject Engineering Analysis Report (EAR) has been reviewed by Aerospace. This report was given wide circulation among those involved in MOL support at Aerospace. Comments were solicited from each reviewer. Those comments requiring discussion with the contractor were in turn reviewed with EK personnel in a meeting held at the EK 601 facility on 29 January 1969. Participants in the review with EK were Lloyd Watson, Aerospace and Victor Vinkey and Steve White, EK. Others at EK were consulted as necessary during the meeting.

Attached is a summary of all comments received in-house, organized by the EAR paragraph to which the comment applies. After each comment, a disposition or action status is given. If there are discrepancies between these and your records, or if you desire to add further details or clarification, please contact Lloyd Watson, Extension 86512.

G. D. McGhee

G. D. McGhee

GDM/da

SUMMARY OFEAR COMMENTS REVIEW MEETING

BETWEEN EASTMAN KODAK AND AEROSPACE ON 29 JAN 69

GENERAL COMMENTS

The 27 November 1968 issue of the EAR was informative and helped materially in updating the customer as to the technical achievements and engineering progress which EK has made during the time period covered by this report. In many areas, however, there was not sufficient analytical or technical detail to substantiate data presented. In order to avoid lengthly appendices, the following is recommended by Aerospace:

> In future issues where data are presented resulting from analyses or other justification that is not included, then EK should show by footnote or other reference notation the source of such data. These references will include all such studies, analyses and reports whether deliverable or not and will be made available for review by appropriate Aerospace/SO personnel.

If this is not acceptable by Eastman Kodak, then it is requested that the appendices be expanded to include all pertinent analytical details.

OPEN - After reviewing with EK Program Management, it was stated that as a matter of policy, they did not want to reference any "in-house" reports not generated as deliverable items. However, if specific analyses or reports were completed, these could be reviewed at EK. EK further stated that to include all supporting analyses in the EAR would, in their opinion, make the document too large and cumbersome.

It is EK's current practice to make each EAR issue complete in its own right. This then requires that much of the material presented be redundant, being a duplicate of that presented in the previous issue. The reviewer must then try to sort out the new inputs and ascertain its significance. This appears to be inefficient and wasteful from all standpoints. It is therefore recommended that the report be issued such that pages or sections can be replaced or new sections added whenever significant changes or progress warrant. This would immediately call to attention what is new information and show immediately the significant progress being made.

EK stated that this is contrary to their present concept of the report and prefer to issue it as a complete document each time. They believe that updating by change sheets or sections might prove to be more time consuming than re-issuing the entire document. However, they will investigate a way to highlight new or changed information.

SECTION 1

FLIGHT CONFIGURATION AND MISSION DESCRIPTION

1.1.1 Titan III-M

This paragraph states erroneously that the T-III-M has a liquid fueled transtage. This will be corrected in the next issue.

1.2 Objective and Mission Description

1.2.3 Mission Requirements and Constraints

e. Beta Angle

EK should clarify the impact on their performance or design due to the $\pm$ 60° Beta angle since Beta is normally a design requirement on DAC and GE.

The Beta angle is important to EK since it is one of the factors which determines the temperature profile of the TM, TM bay, and COA. This influences their specifications for thermal coatings, hotdogging, etc.

SECTION 2

FLIGHT CONFIGURATION AND MISSION DESCRIPTION

2.1 Requirements of the Photographic Mission

2.1.2.1 Photo-Optical Quality

The statement that the resolution requirement is [redacted] "geometric mean" should be clarified to indicate geometric mean of what. (Although it is understood by us, it is unclear by itself).

This will be clarified in subsequent issues. It is the geometric mean of the major and minor axis performance.

2.1.2.3 Visual Optics (VO)

This sub-section, page 2-4 is missing from some copies.

The last sentence of the first paragraph is confusing in the definition of "photographic sequence." If the sequence refers to the exposure cycle of a specific frame, magnification changes should be constrained. If the sequence refers to several frames in a group, there is no such constraint stated. We should not endorse such a constraint since it removes flight-crew operational flexibility. EK is requested to elaborate.

The intent is to minimize smear contributors. The "photographic sequence" is meant to be a target photographic sequence. This and EK's recommendations will be clarified in the next EAR.

The angular resolution requirement stated [redacted] is presumably in the apparent field, but it should be stated.

It is the apparent field and this will be so stated in the next issue.

2.2.2 Automatic Mode

The mission module is not literally identical for both types of flights (e.g., EK's door open sensor on AM birds).

EK will investigate the rationale for this and report in next issue.

2.2.3 Operational Capabilities

The EAR briefly discusses the possible combinations of primary and secondary film in a 10 exposure series.

While it is recognized that the looper film load is depleted when 10 frames are exposed at 1 frame/second, no data on total frames possible in sequence versus frame-rate has been submitted. There seems to be considerable uncertainty between individuals at EK about this; therefore, EK is requested to clarify and submit the appropriate data in the next EAR issue.

Frame rate and total number of frames per target is optional. Table 2.3-1 shows some expected "typical exposure sequences" for a MOL/Dorian mission. EK will further clarify in the next EAR.

Reference is made to Para. 2.4.2.3, which is non-existent in the present EAR.

This was in error. The proper reference should be Para. 2.4.7.1.5.

Haze condition changes due to changes in obliquity angle should also be considered in exposure programming.

EK believes these effects are small, can be neglected and would fall well within the ± 1 stop exposure range.

As there are only two frames of secondary film available, exposure considerations are most important. It is suggested that nominal or one stop under exposure be used to minimize the uncompensated smear.

EK will investigate and make appropriate recommendations at a later date.

The citation of 5 sec. intervals between targets represents a design maximum. Is this an EK policy recommendation for universal application? It is not a universal operating necessity.

EK will change in the next issue to show that this is a maximum value. The hardware is not constrained to 5 seconds every case.

The limitation of exposure bracketing to ± 1 conflicts with hardware features incorporated by EK (several exposure steps at half-stop intervals). EK is requested to clarify this impact on operational usage.

EK will recommend that the requirement of para. 2.3.4 of the SOW be changed to ± 1 step rather than ± 1 stop. Supporting data will be submitted.

2.3 Mission Operations (Manned/Automatic Mode)

Figure 2.2-1 angles should be revised in the next issue. They are not consistent with present SP/DR requirements.

Due to cut-off date of this EAR, the changes were not made. These will be corrected in the next EAR issue.

2.3.2.3.1 Focus Sensing and Correction

Some comment or rationale for choosing to use primary mirror movement vs. RFD change could clarify presentation.

Some recognition that the ground path for focus sensing is constrained seems desirable.

This will be clarified in the next issue.

2.3.3.2 Target Sequences, Table 2.3-1

EK's recommendation for a "multiplicative correction factor" has not been accepted by the AF SO. This should be clarified.

EK will show this to be their recommendation.

2.4 Photographic Performance Considerations

2.4.3.1.2 The Modulation Transfer Function (MTF)

To be in keeping with the current accepted practice and terminology, there is a distinction between optical transfer function (OTF) and modulation transfer function (MTF). It is not clear whether EK is using MTF or OTF (although MTF is stated). The performance prediction should be based on the OTF. It is expected that the results will be essentially the same for this particular optical system.

EK is aware of this recent change in terminology and will be consistent with current accepted practices.

2.4.3.1.3 Effect of Aperture Vignetting and Obstruction

Since the total obstruction of the primary mirror is substantially greater than the specified central obstruction (17.2 percent vs. 12.7 percent), EK is requested to show the effect on system performance (OTF) for both cases.

This comparison will be shown in the next issue.

Also, there may be significant vignetting by the Newtonian diagonal as a function of tracking mirror (TM) pitch and roll. EK is also requested to show the projected aperture at the planes of the Newtonian diagonal, Ross diagonal, first Ross-corrector element and the main pellicle.

Table 2.4-1 shows the TM projection at a plane normal to the PM optical axis. Since the pitch axis is not at the front surface of the TM, the line-of-sight center moves at the PM as a function of stereo angle as indicated by the column designated "Offset." Since this occurs, it is expected that the major axis radius (Column 2) will be vignetted by the primary mirror and will only actually be 35.00 inches at the -40° stereo angle. The vignetting undoubtedly will be quite small, but this table shows 2 decimal accuracy, thus EK is requested to show the actual cases.

This will be re-checked and if a correction is in order it will be made for the next issue.

2.4.3.2.1 Residual Aberrations

Table 2.4-2 lists the wavelengths and weighting factors used for the heterochromatic on MTF analyses. Since these are not equally spaced, EK is requested to explain their selection of wavelengths and given details of how the weighting factors were determined.

EK may make some clarification; however, the level of detail may be greater than is planned. Tentatively, reference was to have been made to the EK in-house memorandum. It will be necessary for Aerospace to request this information by TWX, etc., or review at EK.

2.4.3.3 Veiling Glare

In the next EAR, the effect of veiling glare at other than nadir should be treated by EK.

2.4.4.2 Focus Budget

Because of the large number of error contributors in the focus budget, EK is requested to report status (from measured data) on each item on a regular basis in the EAR's.

EK will report in the Performance Analysis Report per 3.1.6 of the SOW.

2.4.5.3 Resolution Loss Related to Equivalent Primary Mirror Tilt

Equivalent primary mirror tilt is a very special kind of description of wavefront error. It is still not clear how the wavefront aberration due to misalignment between the optical axes of the Ross-corrector assembly and the primary mirror can accurately be represented by primary mirror tilt. EK is requested to deal with this in more detail. It may be that an RMS wavefront error tolerance should be given for misalignment and budget this between tilt and decentering.

EK will clarify what is meant and intended by "equivalent". An OQF value may be given.

Figure 2.4-10 which gives resolution as equivalent primary mirror tilt assumes 1/180 second exposure time. 1/165 second is the current estimated exposure time for nominal conditions. The curve should be corrected to reflect the correct exposure time.

EK will change in the next issue.

2.4.7.1.3 Effective Lens Transmittance

The "effective on-axis" lens transmittance given by "T" in this section is a very special transmittance. It is for the nadir case, for a particular solar altitude (30 degrees), for a special spectral scene content and the spectral sensitivity of 3404 film. Thus, T will vary as a function of any of these variables, including pointing angle. Figure 2.4-12 describes T(λ). It is requested that EK supply like curves for W(λ) and S(λ) as well. The details of this analysis should be reviewed with EK so that we have a more complete understanding of the impact that this variable T has on exposure time. Also, in the next issue, they are requested to show how T varies with solar altitude, and with look angle (pitch and roll of the TM) taking into account possible vignetting by the Newtonian diagonal mirror as a function of pitch and roll of the TM.

EK will supply the W(λ) and S(λ) curves in the next EAR. The details of the analysis can be reviewed at EK or be an agenda item on a technical review meeting. The variation of T with solar altitude, etc. will be investigated and reported if possible in the next EAR.

2.4.7.4 Effect of Time Dependent Factors on Performance

We should review with EK their data the substantiates the film threshold modulation curve now being used.

This has been acomplished in a meeting with G. Keene at EK. He will report additional data as it becomes available.

2.6 Data Return

The information in this section consists of descriptive text designed to illustrate the data retrieval scheme for the program. It lacks detailed technical content except for a discussion of film types, footage and weight which is correct. Figure 2.6- is especially useful in becoming familiar with secondary film handling and processing.

If needed, additional ~~detail should be obtained by direct contact~~ with appropriate persons at EK, or as part of a technical review meeting.

No mention is made of the requirement for water-tightness or handle reversal.

This will be corrected in the next EAR issue.

2.6.1.3 Data Return Containers

There is no explanation given as to all the environments the DRC's will experience nor how the contractor expects to cope with those metnioned. The design criteria for the DRC's could have a broad impact on many system parameters (as the number of repressurizations required for the Gemini B) it is necessary that a handling philosophy covering the complete life of the DRC's be developed.

This section will be expanded in the next EAR. In the meantime, specific information should be requested by TWX.

SECTION 4

DESIGN

4.1.1 Optical Performance Parameters

The Optical configuration schematic of Figure 4.1-1 is not of sufficient detail to be useful. EK is requested to update this schematic to show actual dimensions, angles, clear apertures and tolerances.

Schematic diagrams with additional detail similar to F-024496-DH will be scheduled in following issues.

4.1.1.1 On-Axis Aberrations

The data reported for on-axis aberrations is not adequate for a detailed examination of these effects. It is requested that EK supply more complete data from their analyses (on and off axis) which show spot diagrams, secondary spectrum effects, more precise aberration curves and more precise OTF curves (both mono-chromatic and hetero-chromatic) so that these effects can be studied. New systems are being proposed which reportedly have improved aberration characteristics, but the present system is not adequately understood.

EK believes that the present on-axis treatment is adequate for the EAR. They will show off-axis aberration curves in the next issue. More detailed data should be by TWX or through a technical review or working group meeting.

4.1.1.2 Lens Obstruction and Vignetting

Mention is made of the vignetting by the TM, the Newtonian diagnal and mount and the alignment sensor; there may be additional vignetting caused by other components or by TM pointing angle. EK is requested to show in the next EAR issue when and where vignetting occurs, the extent of the vignetting and its effect upon photographic performance (resolution, exposure, field uniformity, etc.).

This will be reported either in the next EAR or MPS Performance Prediction Report.

4.1.2 Primary Optics Design

The method of attaching the optical components to their mounting structures involves the use of potting compounds and specially designed structures. The details of this have not been reported. EK is requested to report on this part of their design in detail and present test data to show that the dimensional tolerances can be maintained throughout the various environments required of the Dorian system, and that there are no residual stresses or strains which will introduce figure distortions.

OPEN - It was not decided how best to resolve this problem. Proably should be a topic on a technical review meeting or a special working group session.

4.1.2.1 Mirrors

The last paragraph of this section states that by reducing the test measurement uncertainty, the total goal OQF of [redacted] will be obtained. Although it is recognized that greater test accuracy may permit better manufacturing, it does not guarantee it. Since the entire area of optical manufacturing and testing is very critical to the Dorian system performance, it is requested that EK review in depth the status of their manufacturing and testing with AF SO and Aerospace and report status of both on a regular (bi-monthly) basis, giving progress summaries in each EAR.

Large glass status is presently being reported by TWX and in monthly progress reports.

Also, it is requested that EK show an error analysis of each critical test method for components and subassemblies, point out problem areas, and show that it is possible to meet the test accuracies required for the [redacted] OQF (including data reduction uncertainties) and how he intends to improve the test accuracy and manufacturing techniques to achieve [redacted] OQF.

This will be tabulated in the next EAR issue.

From the data presented in Table 4.1-2, it is not clear what the basis for the selection of material for the mirror was. The selection of Titanium Silicate (ULE) for the primary, Ross and Newtonian mirrors and its possible selection for the tracking mirror appears to be inconsistent with the optimum rigidity for a given weight concept advocated by the cnntractor. The data presented in Table 4.1-2 indicates that for a given weight Cer-vit would be considerably stiffer than ULE, the data presented in Table 4.1-1 indicating that a Cer-vit mirror would be heavier than ULE may be somewhat misleading in that the Cer-vit mirror is considerably stiffer. EK is requested to clarify his recommendations for his choice of materials.

This will be elaborated on in the next EAR issue.

4.1.2.2.1 Optical Quality Surface Contributions

Since EK states that the tolerances for power, thickness and mounting variations for the Ross elements are sufficiently tight so that the elements contribute no loss in optical quality; it is requested that they show how these accuracies are obtained and maintained and what the associated uncertainties are. In addition, it is requested that Table 4.1-6 be updated to show current status and another table prepared to show status of the various Ross assemblies in meeting required manufacturing tolerances.

OPEN

4.1.3.2 Mirror Launch Locks

This EAR contained the old linkage-type launch lock design as the principal exhibit. The new launch lock which EK has been directed to pursue was presented as the design to use if Cer-vit mirrors are used. Additional information describing the launch locks is needed. The scale of the drawings is too small and there is an insufficient number of them to truly understand the mechanism; the written description of the development tests conducted to evaluate the design omits such important aspects as the severity of the tests, environment in which the tests were conducted and the relationship of the tests to the anticipated failure modes.

EK will furnish additional detail in the next EAR. Design and test data are available for review at EK or may be requested by TWX.

4.1.3.2.3 Mirror Launch-Lock Control

No mention is made of the requirement for single failure protection, EK is requested to clarify the status of this and indicate how this requirement is being met.

EK will investigate.

4.1.4 Lens Alignment Description

To verify alignment claims design details of alignment systems and their performance analyses are needed. EK is requested to provide a more complete description of this system in separate memorandum.

This information should be requested by TWX.

No lamp redundancy is indicated. EK is requested to clarify whether redundancy is planned and if not state expected lifetime of the lamp, showing systems performance impact if light fails.

Lifetime studies of the lamp are in progress, the results will be reported at a later date.

4.1.4.1 One-g Zero-g Alignment Corrections

This section calls out tolerance of 20 arc seconds in conflict with 14 arc seconds (2-sigma) cited in paragraph for which reference is made.

The 20 arc seconds is a SOW requirement. The 14 arc seconds is the design capability.

4.1.4. 2 Alignment Control

Figure 4.1-17 - Several labels are missing (believed to be optical micrometers and sensor). To adequately represent the total system block, more blocks are needed (minimally, add another detector). The encoder is a detector. No indication shown of visual (crew) access to status display or focal plane. Additional information in text or figure as to nature or location of light sources employed would be desirable.

The figure will be completed. The two empty boxes on the left should be entitled, "Tilt Plane", the two in the center "Encoder." Additional information on the light source will be shown in the next EAR.

4.2 Structural Assemblies and Mounts

There is no change from the previous EAR. A good description of the structure and physical assembly of the COA is present, but only a cursory description of load paths through the structure is given. It is requested that EK provide detailed technical data and a technical discussion of the load cycle effort or requirements.

These details will be contained in the 4th load cycle report. A summary will be contained in the next EAR.

4.2.2 Optical Support Structure

It has come to our attention that the mechanical and thermal properties of Invar may vary from batch to batch; it is recommended that all Invar components in any one structure be taken from the same melt and their properties determined by test.

Carpenter Steel Technical Data Sheet of 5/66 indicates a variation in the coefficient of expansion at room temperature of 19% from low to high values; it is our opinion that there would be another variation in different shapes as plate, sheet or tubing.

EK has been investigating these properties. Appropriate consideration will be given.

4.3 Visual Optics

The description of the visual optics system is insufficient detail to permit a design analysis. It is again requested that pertinent detail along with the optical perscription for this system be submitted (separate memorandum and referenced in the EAR) for SO/Aerospace review.

Aerospace will request this information by TWX.

The resolution performance desired is not given in this report. It is requested that EK state their design objectives.

This will be reported in next EAR issue.

4.3.2 Design Considerations

4.3.3 Hardware Description

4.3.3.1.3 Variable Power Relays

The magnification ratios of the relays as stated here may be in error. Without having more detail, it would seem that one relay would have to have magnifications in the ratio of 2 to 1 and the other of 4 to 1 in order to achieve the individual magnifications required.

The report was in error and should have been as stated above. This will be corrected.

4.3.5 Electrical Control

The data and information presented is not sufficient for detailed analysis. It is recommended that EK provide the following information and update as required in future EAR issues:

1. Electrical schematics which will portray the intended system operation in some detail. The block diagrams are not adequate.

2. Motors - including servos - information
   - Number of motors of a partioular type.
   - Location.
   - Why chosen for the function it performs.
   - Other information such as whether it is:
     - Brushless D.C. or brush type.
   - If environmentally sealed and to what extent.
   - If EMI suppressed.
   - Also, qualification status, power rating and any special characteristics.

3. Relays
   - How many of what type and where in the system being described.
   - Qualification status and any special characteritics.

4. Circuit Breakers
   - Distribution and rating of circuit breakers if any.
   - Qualification status.
   - Any other special characteristics such as hermetic seals, trip time, etc.

5. Interfaces for electrical controls and control characteristics should be included for at least all primary interface functions.

EK believes that this is too much detail for the EAR. Aerospace should review this in a special working group, or technical review meeting. Specific information may be requested by TWX.

4.4 Camera Assembly

4.4.4 Shutter

4.4.4.3 Hardware Description

The EAR does not elaborate on curtain acceleration or deceleration in order to provide acceptable tolerances given for slit velocity variations.

EK will expand on this in the next EAR.

4.4.5.3 Interchange of Platens

Platen assembly interchange of not more than two frames of secondary film during any one sequence, can be commanded in series or separated by primary film exposures.

EK is requested to show (not by analog computer) at the earliest possible time that the capability of inserting the secondary platen at the beginning or anywhere during the sequence and again reinserting (i.e., first frame and nadir) without upsetting the stability of the photographic system.

This information will be included in the Performance Prediction Report.

4.4.8 Focus Sensor

4.4.8.2 Principle of Focus Sensor Operation

Figure 4.4-15 indicates that the focus sensor operates open loop; i.e., the photocell and its electronics indicate a certain displacement of the platen is required. The system has no monitoring to determine if this displacement actually occurs. EK is requested to clarify.

The platen position indicator should give sufficient verification. The next EAR will so note.

Also, they should indicate what signal to noise ratio studies of the system have been made and report these results. They are further requested to show why they require three minutes operation time to get a reliable reading. Those who have seen the system operate may understand the problem, but it should be outlined in the report.

EK will summarize what data is available in the next EAR. It is believed that the 3 minutes operating time requirement is erroneous. This will be investigated and clarified.

4.5 Film Handling

4.5.2 Design

4.5.2.1 Configuration

This paragraph states that after loading each DRC, it will be transferred to the Gemini B as soon as possible. At present, there are no plans to repressurize the Gemini this often. EK should clarify this procedure.

EK will investigate and indicate in the next EAR where and how DRC's will be temporarily stored until transferred to Gemini B.

4.6 Environmental Control

4.6.1.1 Requirements (Also applies to para. 4.6.1.2)

There are no specific contamination values specified for either particulates or condensible oils and volatiles. Until these values are specified, it is not possible to realistically specify cleanliness.

This problem is under investigation and the results will be reported soon as available. Appropriate specifications will be recommended and the EAR updated accordingly.

4.1.3.1.1 Primary and Tracking Mirror Mounts

The contractor has established λ/200 as the tolerable limit for mirror distortion due to the flexures although neither the location of this distortion nor its area are specified. We assume that this criteria is valid and has a reasonable margin of safety associated with it. From the data presented in Figures 4.1-7 and 4.1-8, it appears that the size of the flexures has been selected on the basis of their structural capability and not the distortion produced in the mirrors. In addition to removing the strain gage transducers, the contractor might increase the flexure diameter to obtain a stiffer system.

The flexure stiffness values in this section do not reflect the recent direction that the stiffness be increased.

The data presented was on the old flexure design. The next EAR will be updated and data presented for the new design. In the meantime, specific information may be requested by TWX or the design reviewed at EK.

4.6.1.3 Pre-Launch Environmental Control

First sentence of the first paragraph in p. 4-177 contains incorrect requirements (IFS 101.2.6). EK should correct to read:

> "....a procedure for ground conditioning was established which requires that prior to L-10 days, the MES is controlled to 70 $\pm$ 5° F. From L-10 to MES breakup, the MES is controlled to 65 $\pm$ 5° F, and flight heaters are used to trim the system to 70° F."

This correction will be made.

4.6.3.4 Laboratory Module Components

Although a comprehensive and adequate discussion of the environmental control system was presented, there is a complete lack of descriptive data for the EK LM components, (processor/viewer, film handling, etc.) including requirements. EK is requested to supply similar data for these as was supplied for the mirror gradient control, thermal coating specifications, insulation blanket configuration, etc. These should include such physical requirements as humidity, temperature, pressure, etc.

EK will expand this section in the next EAR.

4.7 On-Board Processor

4.7.1 General

EK is requested to clarify the allocation between secondary and primary film footage.

Nowhere is there stated a requirement on the presence or lack of "holidays" in the resulting imagery.

This is part of the overall degradation permitted compared to ground processing, and will be taken into account accordingly.

4.7.2 Requirements

EK is requested to report keeping or "shelf life" data for the imbibed bimat to show that the 30-day mission plus ground time requirement can be met. This will include the effect on processing, including speed, gamma, density and resolution variation as a function of keeping time from appropriate tests.

There is data presently available. This will be summarized in the next EAR.

In addition, EK is requested to report here or in Section 8 any human toxicity or allergy effects of the bimat imbibant fumes or from the drying agent of these chemicals with other components outside of the processor. They are requested to clarify what the expected contamination level to the LM atmosphere is from these sources.

OPEN. Contamination sources are currently being investigated.

4.7.4.4 Film Dryer

A redirection of circulation to dry bimat on drum is indicated. EK is requested to show what prevents excess loss to lab atmosphere due to door opening for retrieval of processed film, and the extent of contamination expected.

Essentially this is a closed system. The expectedloss of bimat chemicals to the lab atmosphere will be investigated as part of EK's contamination studies.

4.9 Electrical Design

The detail of the schematic shown in Figure 4.9-1 is not sufficient for an adequate analysis. EK is requested to update this figure as follows:

1. Show what control signals go to the various units;
2. Clarify the interface called out by indicating between what and whom;

   This will be shown in next EAR.
3. Indicate where and what the electrical system protection is;

   This will be covered in next EAR.
4. Instrumentation type, i.e., press., temp., freq., accel.

   This should be covered in separate working group meeting.

4.9.1 Power

4.9.1.4 Fusing

EK is requested to furnish additional information in the following areas:

1. Fuse sizing criteria for particular loads.
2. Which buses are circuit breaker-controlled and how is non-mission essential unit tied to particular bus and load?
3. Fust versus circuit breaker open-trip characteristics.
4. The VO power bus fusing criteria for wire protection (from the LMPU to VO assembly).
5. Which buses depend on other LM or GE bus protection and how is this tied in with local load protection?

6. Which fuses can be replaced or cannot be replaced?
7. Philosophy behind the use of fuses to protect wiring rather than using circuit breakers for wiring protection and phases for load protection.

EK believes this is too much detail for present intent of the EAR. The additional data desired should be obtained through technical review or working group meetings. Where practical, data can be requested by TWX.

4.9.2 Commands

Additional detail and data is required for both these sections. EK is requested to provide the following:

1. Electrical schematics (as a part of the EAR or separately and referenced in the EAR).
2. Hardware data, development and qualification status,
3. Development testing for particular environmental requirements such as 30-day thermal vacuum life test.
4. Information and planning on electrical power and signal distribution should be included.
   - The planned routing of wiring and cabling to meet the EMC requirements and any other considerations have not been included in this report.
   - The types of wire, connectors, cable ties and harness design and acceptance testing details have not been included.

5. The nature of the incorporated redundancies and the failure modes to include transistor switch for controlled current rise and fall time, the transistor failure mode and consequence, and also describe the variations in the concept of a multiple bus and backup bus.

   EK believes this is too much detail for present intent of the EAR. The additional data desired should be obtained through technical review or working group meetings. Where practical, data can be requested by TWX.

EK is requested to clarify:

1. What the EMI considerations are that limit the voltage and current switching to 5 volts at 5 mg or less. These should be enumerated.
2. How the commands are verified.

EK believes this is too much detail for present intent of the EAR. The additional data desired should be obtained through technical review or working group meetings. Where practical, data can be requested by TWX.

4.9.3 Instrumentation

A schematic of the instrumentation system would greatly clarify this section. The locations, range and response of transducers and interfaces with GE and/or DAC should be included. EK is requested to update this section accordingly.

OPEN. This will be investigated to see if practical to do so.

4.9.4 Electromagnetic Compatibility

This subject should be covered in considerably more detail. It does not give a sufficient system description for EMI control. EK is requested to provide additional detail showing how the rate of current change in switching primary power is limited in particular cases to 30,000 amps/sec or how the interference levels within components will correspond to hardswitched 5 volts, 5 ma., or what is an appropriate EMI filter and where it is used. Bonding requirements are established and the report should include the implementation method.

Controlling interference generated by circuits/parts whose nature of operation requires rates-of-current change higher than that which will meet the required EMI limits by use of appropriate EMI filters will be an impressive accomplishment. The use of an appropriate filter will reduce the rise time to some lower levels of rates of current change to reduce the EMI. If there are circuits whose nature of operation requires higher rates of current change than normally acceptable, then in all probability the EMI result will be higher than normally acceptable unless the associated circuitry is not susceptible to the generated EMI.

Status of EMI design based on breadboard during component design is not acceptable. EMI qualification acceptance must be based on final design test of article in final configuration.

Susceptibility controls should include shielding prac tices, wiring/ cables and component structures (equipment chassis, casings, housings). Decoupling networks should be elaborated on.

Diode suppression and solid state switch (ramp control for rise time) have not been included although they are part of the system. OPEN. This will be reviewed. Additional detail may be possible in next EAR issue. However, much of this probably should be covered in technical review or working group meetings.

VOLUME 2

SECTION 6

6.1 Optical Tests

The area of optical testing, including techniques, instrumentation, data reduction and interpretation is too large to be covered in detail in the EAR. Except for one or two exceptions, specific comments with regard to the content of this section will not be made. Because of the importance of optical testing and the recognized difficulty involved, the following is proposed:

A specific task force be established to review the optical test methods and instrumentation in detail. This review to be conducted during the next six months and a follow-on effort continued for the duration of the program. During the first six-month period, EK would provide complete details (schematics, drawings, optical configurations, instrumentations, data analyses, etc.) of each major test method, and provide a comprehensive error budget analyses for each, taking into account all known sources of error so that the precision and uncertainty of each test can be established.

OPEN

6.1.5.2 Optical Assembly (OA) Tests

Only autocollimation testing is being considered for the OA. This requires "double-pass" interferograms or photographic tests. EK has had trouble trying to relate double-pass to single-pass performance (as actually occurs during normal operation). They are requested to show how this is being analyzed or tested. We would recommend that the conversion factor be determined emperically if possible.

OPEN

6.2.3 Photographic Test Equipment

6.2.3.1 Test Requirements and Approach

This paragraph states that autocollimation can be done in two ways. One method uses the autocollimating mirror normal to the axis (they say parallel, but undoubtedly don't mean it), with the object off-axis. The image is then examined in an off-axis position. It is stated that this method provides double sensitivity to longitudinal focal shift but it is not mentioned that this method leads to complete cancellation of such aberrations as coma, distortion and lateral color. The other method suggested is to rotate the autocollimating mirror, use the object on-axis and examine its image off-axis. EK is requested to clarify the impact on test results of these effects. The possibility of coincident object and image using a beam splitter is not mentioned. For a better understanding of their chosen approach, EK is requested to discuss their consideration of this approach further.

This will be examined and amplified in the next report.

SECTION 7 AND APPENDIX D

RELIABILITY

The comments set forth here will apply to both Section 7 and Appendix D. Appendix D is an official submittal of data presented unofficially several months ago.

It is apparent that the list of essential capabilities have been considerably truncated so as to derive the 92.0 (91.4%) goal.

The total generating time on each component must be cross-checked with those derived for power reporting purposes. EK is requested to point out any discrepancies.

APPENDIX D - RELIABILITY BLOCK DIAGRAMS

There is one significant criticism of this analysis. The visual optics subsystem that is considered to be mission-essential was omitted from the system reliability model. This subsystem was included in the EK unofficial data reviewed some time ago. A mission reliability of 0.97223 was computed for the subsystem. If this number is multiplied by the system reliability estimate shown on Table 7.3-1, "Reliability Estimates for Mission-Essential Operations," there is a significant decrease in system reliability

$$(.920 \times .97223 \approx .895)$$

which is less than specification (.914). It is debatable whether the omission can be fully justified.

EK is therefore requested to either justify this omission or take it into account.

This will be clarified in the next EAR issue.

SECTION 8

SYSTEM SAFETY ENGINEERING

8.1 Introduction

Three techniques are listed which are used to identify hazardous conditions; namely, fault-tree analysis, hazard analysis, and procedural analysis. Procedural analysis is not covered.

The contractor should include in his next EAR:

1) His approach to limitation and control for contamination of LV atmosphere from the use of metallics (mercury, cadmium, etc.) and non-metallics.

2) Testing programs associated with SAFSL 10010, control of available fuels and ignition sources in the pressurized area of the LV.

OPEN

8.2.2 Fault Tree Analysis (Figure 8.2-3)

It is recommended that the contractor present some justification for his selection of 10^{-2} as the probability of a fire occurring in the event of an electrical type of failure, taking into account "off-cycles" of components in the calculation of the probability of failures.

OPEN

4.10-3 Current Mass Properties Values

There is insufficient information presented to perform a meaninful mass properties analysis. If the contractor's mass properties are to be verified then a considerable amount of additional detail is required.

This should be handled through working group meetings.

SECTION 9

NUMERICAL SUMMARY

9.1 General

Some index of stability of values would be helpful, such as changes from last EAR, or changes from SOW values. EK is requested to clearly indicate changes in future EAR issues.

OPEN. EK will consider ways to show changes from EAR to EAR issue.

9.1.6 Weight Summary

This summary indicates a five-pound overweight. The basis of the numbers quoted is not apparent. EK is requested to clarify.

This will be corrected.

9.2 Requirements on Other Subsystems

9.2.1 Electrical Requirements

9.2.1.3 Power and Energy

2. The average frames/day will exceed 450 if 15,000 frames per 30-day mission is realized.

These numbers will be checked.

5. The visual optics magnification change rate given here probably is an upper limit or greater than the maximum which will be realized. The dynamic excitations may limit the setting per target.

This rate was used to establish power requirements for maximum case and not intended to show actual operational conditions.

9.2.1.3 (Cont'd)

8. This seems excessive. Only three minutes per four frames since exercise is required and it is expected that not more than several per day will be needed.

9.2.4 Stereo and Obliquity Ranges (Line-of-Sight)

These values are not correctly quoted. What are listed as TM requirements appear, in fact, to be the net photo range after TM and vehicle motions are both taken into account.

This will be corrected in next EAR.

9.2.5 Laboratory Module (M/A Mode)

Some addedconstraints have been quoted elsewhere on the film system, such as $\Delta T \leq 15^{0}$ between any point in the film system enclosure. EK is requested to clarify this point and also explain what action will be (or can be) taken as a result of the "consultation" cited.

Additional information will be provided.

9.3.4 Camera Parameters - Primary Film Strand

(d) 3. Plus or minus one stop when IPC's commanded at maximum rate (1/sec). Perhaps EK would now prefer $\pm$ 2 steps".

EK will recommend ± 1 "step" rather than ± 1 stop.

(e) 4. 1/160 second does not correspond to any exposure setting offered; EK should clarify and state why the nominal exposure should not be used.

This will be changed to be consistent with nominal exposure.

(f) The maximum frame rate of ten per target is a policy limit, not a design-limited value.

(g) And/or tension, in event vacuum fails.
This will be noted in next EAR.

9.3.5 Camera Parameters - Secondary Film Strand

(c) EK is requested to clarify the basis for the maximum frames per target, i.e., whether it is due to looper capacity or whether it may again be a recommended limit.
EK will clarify in next EAR.

9.3.6 Film

9.3.6.1 Film Requirements

(a) The 12,425 <13,500 (useful photograph frames per mission) in the power budget does not support the average 450 frames/day x 30 days; i.e., 12,425 is less than 15,000 incidentally.
EK will recheck.

9.3.6.2 Property of Films

3. EK is requested to clarify whether the processor will take both TB and UTB.
This will be noted in the Processor Section. Since both primary and secondary film is to be processed on board, the equipment is being designed accordingly.

9.3.7 Focus

The maximum focus change rate includes some settling time after motion is completed. The limit does not apply for rapid slew operations without IPC's. EK is requested to clarify.
This will be noted.

9.3.9 Visual Optics

9.3.9.1 Primary Eyepiece

(d) EK needs to update this to be consistent with current revision of 9.3.1.(e) (page 9). Light input may be 8-10%, ~ 4%, or 0, depending on "second pellicle" option selected.

9.3.11 Optical Alignment

EK should include the statistical descriptors which are omitted (1 σ or 2 σ).

These will be noted in next EAR.

9.3.12 On-Board Processor

(c) See 9.2.1.3.b.3. Not consistent; EK requested to clarify.

(f) This is not consistent with the requirement or intent of the Work Statement. Ground processing has never been considered as "bimat" ground processing. This is not acceptable and EK is requested to change this or delete.

This will be changed to be consistent with SOW.

APPENDIX C

COMMAND AND INSTRUMENTATION LIST

EK is requested to modify Table C.1-1 (page C-2 through C-8) so that entries in the relay configuration column can be easily correlated to the relay configurations shown in Table 4.9-2. To avoid confusion or misunderstanding, one table uses alphabetic designation and the other table uses Roman numeral designation. There is not a one-to-one correlation between the two systems (i.e., A $\pm$ I, B $\pm$ II, etc.)
EK will change in next EAR.

APPENDIX E

ANALYSIS AND DESIGN OF TEST TOWERS

This section only contains the analysis of Chambers I and II. The chambers of greatest concern are III and A, for which no analysis or test results is offered. EK is requested to submit their analysis for Chambers III and A as soon as possible and include this in the next EAR.

ANNEX

3.1 The statement that the IVS detectors favor the infrared is not necessarily true (currently the two contractors are considering S-20 and S-25 responses).