[illegible]

SUBSYSTEM AND [illegible] PERFORMANCE

INTRODUCTION

The [illegible]ally optimistic technical attitudes expressed in [illegible] engineering analysis report are felt to be without [illegible] substantiation. The extreme sensitivity of the photographic system, in addition to the overall system complexity raises the question as to whether there is a real basis for such optimism. This portion of the discussion will be limited to those parameters involved in the image forming to image scanning processes, but will not concern itself with the telemetry link which is covered separately herein.

SYSTEM RESOLUTION

The [illegible] system's performance is quoted consistently at 200 lines per MM high contrast of 100 lines per MM. A direct conversion to measurement in object space immediately reveals descrepancies related to the anticipated 20-feet ground resolution. A high contrast target (100:1) at 200 lines per MM yields a detectable dimension of approximately 9 feet on the ground at a scale of 528,000:1 (300 statute miles). It is generally accepted that to recognize an object, it must have from 3-5 times the [illegible]. Therefore, this 9-foot dimension (detection) will be approximately 30-50 feet in size before recognition level is attained. In view of the fact that operationally we are dealing with low contrast targets (and accepting the [illegible] figure of 100 lines per MM), the expected ground object recognition threshold is [illegible] to such objects whose [illegible] is not less than [illegible]. At this point, it should also emphasizes that the above conditions are based upon a static relationship of camera to ground. The effects of system dynamics during the time of exposure are discussed in the further body of this report, in addition to the effect of weather upon system output.

Further, the above discussion is related to nadir position only, and obviously implies that conditions become worse for increased obliquity.

CAMERA ORIENTATION PROBLEMS

The E-2 camera is basically a strip camera. The slit is, of necessity, oriented such that it is perpendicular to the flight path. The 70 MM film is then fed in a path parallel to the flight line, and at a velocity equivalent to the relative ground velocity. Object and image planes are thereby synchronized, and exposed by means of a slit in the focal plane. The slit width and film velocity establishes the exposure time, with the forward motion of the vehicle providing the "scan" motion. The camera is supported in a 3-axis gimbal system so that the optical axis may be directed to ± 150 miles of the vehicle nadir for preselected target areas.

The preselection function is seriously questioned by virtue of the implicit aiming problem. The transverse dimension of the film represents for this focal length a total angular field of 3.2 degrees. Assuming a safety factor of 50%, a target must, therefore, be angularly determined within a strip of 1.6 degrees from a vertical height of 300 miles! This represents an accuracy of approximately one part in 50 as related to the accura[illegible] of three camera gimbals, compatable vehicle stabilization control, and accuracy of vehicle location in orbit. As may be seen in Table D-2, page D-6, the maximum tolerances for roll is inconsistent with the desired accuracy, and the suggested tolerance just adequate rather than a safe value. There is obviously a very low probability that the preselected 17x17 mile target area can be photographed.

In effect what has occured in this design, is that the image motion compensation problem has been simplified and the aiming problem made substantially more difficult. For comparison, the "C" program equipment is more suited for the problem. The "C" camera is properly oriented such that a panoramic sweep occurs <u>across</u> the flight line. The long dimension of the "C" film (wide angle) is then suited to easily satisfy the E-2 aiming problem. With "C" camera, [illegible] and overlapping photographs would then virtually insure target area coverage. The "C" configuration is decidedly an improvement over that of the E-2 configuration.

<u>STABILIZATION PROBLEMS</u>

As a further result of the tight control required, the vehicle stabilization demands motion control consistent with the anticipated performance. As may be seen in Table D-2, page D-6 (appendix), the tolerances for roll, pitch, and yaw rates are stated as maximums of $\leq 2.1^\circ$/min, $\leq 2.4^\circ$/min and $\leq 4.1^\circ$/min respectively.

[illegible] consistent with the fact that from orbit attitude ([illegible]) a roll rate [illegible] 1°/minute corresponds to a motion of 126 arc seconds/second, or 1.26 arc seconds in an exposure of 0.01 second. The 1.26 arc seconds represents a ground motion of approximately 9.6 feet which at nominal value already borders on deterioration of resolution, for this represents the blur component along the photographic slit axis. By the same token, the roll axis component contributes to a lack of IMC, which in turn contributes image flur in the film feed direction.

A twenty-(20) foot object on the nadir at an attitude of 300 miles represents an image on the film of 0.0004 inches, or 10 microns. Accepting for the moment the criterion of 60% image motion compensation the <u>residual</u> acceptable blur is but <u>[illegible]</u>! Small motion indeed for exposures of 0.01 seconds time. This means that in 0.01 seconds the stabilization equipment must be capable of maintaining this degree of control. If stabilization control is not closely affected, or, if exposure time increases (longer), resolution of the systems is adversely affected.

It is doubtful that this degree of accuracy is presently inherent in the E-2 system, or that this is even presently possible within the current state of the art of photographic equipment and satellite vehicles of these generic types. Vehicular stabilization to the degree required (0.5°/min.) is believed to be most optimistic and incautious.

<u>WEATHER PROBLEMS</u>

[illegible] the fact that much data exists regarding cloud cover, no true operational level of performance is stated for the [illegible]

Operational photographic performance does not mention the effect of haze (industrial or natural) which would most certainly effect such performance. The latter is of less significance, as compared to the cloud cover problem.

From available weather data, it has been determined that approximately 50% of the area of the USSR is cloud covered most of the time. At least 40% of the remaining areas are determined to be partially cloud covered. Only 20% of the entire area is considered open and clear, and this on a rather sporadic basis as related to moving cloud pattern.

The E-2 system operates on a basis of preselected target areas. There are no sensors aboard which provide remote ground indication for the presence of cloud cover. This is a problem of significance as related to the E-2 photographic system, for the angular field of its film record is but 3.2 degrees square! It is, therefore, not at all inconceivable that cloud cover can completely obscure the full field angle of 3.2 degrees. Moreover, this may occur even when a normally usable condition of 0.2 to 0.3 cloud cover exists. Here again the problems of narrow angle lenses obliquely related to cloud cover is evident. Solar position is important too for the sun at the incorrect angle to the cloud openings will provide undesirable shadow on the ground scene below the opening. Such a situation is at best most difficult, and reduces to approximately zero the probability of overlapping exposures. The low probability of accurately locating a single exposure through the cloud openings is most evident.

The effect of clouds on exposure, compatable with a high acuity system, is also discussed in this report.

[illegible] CRITE[illegible]

Photographic systems of high resolution [illegible] particularly subject to deteriorating performance as a result of motion. The greater the resolution, the more [illegible] in the environment of motion. As the [illegible] (smaller image size) the reduced contrast function also [illegible] to a lowered performance. The atmosphere plays its usual role and as usual represents yet another large undesirable contributi[illegible] among many others. The slit camera does have one unique characteristic which sets it apart from all other cameras - a dynamic shutter capable of very short exposures. There is no [illegible] cheaper or more reliable means for minimizing the effects of motion than shutter speed. It is obvious that this markedly useful characteristic of the slit shutter has been forsaken under the attraction of "high resolution", overlooking the complexity of the exacting compensations necessary to make a strip camera useful at exposures of 0.01 second. This represents the penalty purchase of high resolution at the cost of very slow emulsion speed.

This leads next to the problem of camera exposure control. The camera is provided with a glass plate in the focal plane upon which metalized slits are plated. This method was previously employed as an expedient to the problem of slits which are difficult to maintain in parallism at narrow separation. The slit plate is capable of indexing a variety of slit widths to provide exposure [illegible]), [illegible] is subject [illegible] command [illegible] by course and ground [illegible] system cannot, however, provide the necessary control [illegible] presence of cloud cover. Here it is necessary to [illegible] overexpose in order to render the [illegible] usable. The present system does not [illegible] nor does it supply the necessary sensory devices to [illegible] possible. It is even questionable as to whether the ground control system is capable of providing advance data for optimum exposure which accomodates the normal change of ground reflectivity encountered on each orbit.

Addi[illegible], [illegible] [illegible] base slit plate assembly also introduces the undesirable light loss by insertion into the optical path. While the thickness of the plate is not indicated, some light [illegible] energy is lost due to surface reflection, and absorption [illegible] thickness. While the narrow angular field is helpful in [illegible] circumstance, it is still not preferable where nominal exposures are already stipulated at 0.01 seconds.

FILM

The film, SO 24[illegible]3, is but another modified version of a very popular and long standing favorite - Microfile, an emulsion long known for its inherently high resolution and low speed. It is indeed surprising that the E-2 system, which represents a decided sophistication in the state of the art, has been tailored [illegible] emulsion. There is no question but that an [illegible] suitable resolution capability coupled with high emulsion sensitivity would have substantially lessened the design and control burden until such time as the state of the art in [illegible] came to be adequate to the task of supporting very high resolution systems. What this means at present, is that the 242 (200 lines per mm) resolution suffers markedly in the [illegible] of [illegible]. This image degradation is not linear in function, [illegible] that with the added complexity and burden of the [illegible] and control, the stabilization requirements [illegible] with the resolution requirement. [illegible], lower resolution film (e.g., 80 lines per mm) could provide the associated high emulsion sensitivity (as much as 5-10 times faster than SO 243) resulting in a desirably short exposure with its attendant image freezing ability. This degree of relief would also remove the present E-2 burden of exacting control of its stabilization system ensuring its compatibility with the present state of the art.

There is no question but that the emulsion problem is one which should receive pertinent attention and inclusion in present technical development planning, on an accelerated basis.

OPTICAL SYSTEM WINDOW

No sufficiently detailed optical description is [illegible] that one may determine if the lens system window has been considered as a part of the basic optics. The matters of [illegible] the fact that in operation the optical [illegible] and heated to maintain [illegible] with [illegible]
[illegible]

effect of window quality, heating and pressure loading.

The pressurization level is stated at one atmosphere of nitrogen. Assuming a 10-inch diameter window, the total load upon the window is 1100 pounds approximately. Unless the window thickness is sufficiently thick to withstand this load, the window will become bowed and its zero lens power characteristic changed. If lens power is so introduced, it may be of such magnitude as to shift the focal plane position. This is critical in view of the extremely narrow range of critical focus.

The lens system window is critical, under load, for internal stresses (from temperature gradients and/or pressure) can approach such magnitudes where its resultant quality sets the <u>resolution limit</u> of the entire optical system. It is essential that the window be kept in a stable condition, for the existence of thermal gradients will vary the quality until such time as the window resumes thermal stability.

The present IMSD procedure for ground collimator test of the E-2 camera does not provide that the camera be pressurized to match the expected airborne situation. This should be remedied such that the ground and air conditions be as identical as possible. Data derived from adjacent program areas have also indicated that one atmosphere of pressurization is not required. This, too, should be reviewed.

<u>GROUND CONTROL OF RESOLUTION</u>

The E-2 photographic system provides for command control of resolution. This is not practical for there are too many parameters which [illegible]

[illegible] image motion [illegible] raises the question [illegible]

on the ground is able to determine which of [illegible]. How is the operator to know if the [illegible] is thermal stability, window effects, misalignment due to launch forces? [illegible] of resolution targets somewhere on the ground it is virtually impossible to make an adjustment in resolution remotely. This operational mode absolutely requires redefinition and evaluation.

STEREO PHOTOGRAPHY

Brief comments are also included in the [illegible] report regarding the availability of stereo photographic coverage at angles up to $\pm$ 17 degrees. It is not at all clear just how camera orientation is programmed for this purpose. Intuitively, the value of such stereo is questionable in view of the involved geometry. It is considered doubtful that such height data could be of value unless points of known elevation are located in the overlap area. On this basis relative measurements might be of some value, but at best, questionable. A convergence angle of 34 degrees at a scale of 528,000:1 (nadir only) cannot begin to provide elevation detail much less than 500 feet. This is not considered worthwhile in the light of the equipment complexity required to provide this motion, nor in the light of the complex [illegible] previously discussed above.

PROCESSING LIMITATIONS

The chemical processing in flight involves the use of monobath solutions. There is no doubt that if a data link is to be used that this be the process used. The monobath process does effect the latent image resolution, for unlike conventional processing it cannot provide the compensation for continuous gamma and density control. On a film recovery basis there is no doubt but that conventional processing with the close control available will yield desirably high results than a monobath process. The ground process would even compensate for the unexpected variations of airborne exposure.

FILM SCAN METHOD

Subsequent to monobath processing and drying the film is then presented in a gate to be scanned by a flying spot scanner and related optics. Here image resection occurs. The 2x2-inch frame is then scanned in 0.1-inch x 2-inch strips for the data link transmission. This means that in a 2-inch frame length, the system deliberately introduces 19 breaks in image continuity. Assuming a 1% linearity (sweep) the abritted areas can vary by ∠ .001 inch, or ∠ 44 feet at each scan section interface. This appears most undesirable.

SUMMARY

As a result of the above considerations, the following summary is offered in the hope of more properly reorienting the program direction. It is recommended that we proceed to:

1. Reevaluate for the E-2 system the "C" program equipment in view of the benefits to be derived for the [illegible]

[illegible] table [illegible] for [illegible]

[illegible]ographic missions.

[illegible] geodetic control.