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CONTRIBUTIONS OF MAN IN THE MOL/DORIAN SYSTEM

October 1967

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This report documents a briefing, "Contributions of Man in the MOL/Dorian System", given to Dr. Land's Panel of the PSAC on 29 August 1967. The briefing was prepared and presented by Mr. Harry Bernstein, Aerospace Corporation, and reflects the work of many people within Aerospace, the MOL SPO, and the MOL Flight Crew.

I. INTRODUCTION

The MOL/Dorian program has as its basic objective the provision of a [redacted] resolution photographic reconnaissance capability. Additionally, this capability is to be provided in both the manned and unmanned configurations. In accordance with these objectives the baseline program includes seven flights, the first two of which are unmanned and associated with launch vehicle and spacecraft performance and integrity checks. These will be followed by three manned flights and two unmanned flights, all of which will incorporate all elements of the complete system.

This document will address the flight-crew's role in the MOL/Dorian system and the results of investigations performed to date on their ability to perform assigned tasks. In a gross sense it is possible to separate the areas of the crew's contributions into three categories; namely, their primary role to aid in the realization at the earliest possible date of a mature system (both the manned and unmanned configurations), and their subsidiary roles of enhancing the value of the primary reconnaissance mission and providing, by virtue of their presence aboard manned flights, system capabilities in addition to those associated with the primary reconnaissance mission. These three categories will be discussed in some detail in Sections II, III and IV, respectively.

II. CREW'S ROLE IN SYSTEM DEVELOPMENT

One of the most significant roles that the crew will play on the early manned flights will be to assist in bringing the total system, particularly those elements of the system associated with the unmanned or automatic configuration, to a mature level at the earliest possible time. Experience on past and current unmanned programs in this mission area has indicated that a considerable number of flights are generally necessary prior to achieving a fully mature operating system. The increased complexity of the Dorian system, as compared to these other programs, suggests that the flight crew can provide valuable services in terms of bringing the system to a mature status, while simultaneously permitting the gathering of a significant amount of high-resolution photographic reconnaissance data.

A. Reliability Projections

The MOL/Dorian system consists of four basic segments: the Gemin-B, the Laboratory, the T-IIIM launch vehicle, and the mission payload. (In the unmanned configuration the Gemini-B is replaced by a support module incorporating the data-recovery vehicles and those elements of the film-transport system associated therewith.) In making some overall assessments of the reliability situation with respect to these segments, the statistical estimates of reliability for the mature configuration are quite high due to the basic design philosophy of incorporating redundancies wherever possible in all of the system components. In particular, probabilities of mission success on the order of .95 for a 30-day mission have been projected for the Laboratory segment, and this figure has been substantiated both by contractor analyses of unmanned orbit-control modules incorporating substantially the same subsystems and designed for the same mission duration, and by analyses of the failure history of the 206-I program.

With respect to the Laboratory segment, a relatively mature system is expected early in the flight program. This assertion is based on the fact that the Laboratory subsystems, for the most part, are derivatives of current technology as developed for Gemini and Apollo. Additionally, the extensive amount of ground testing incorporated within the baseline program instills additional confidence in the Laboratory segment's achieving its estimated high level of reliability from the outset.

Statements similar to the foregoing can also be made with respect to the Gemini-B and TIIIM segments; however, the situation with respect to the mission payload segment is different. The precise resolution requirements for the Dorian system, plus the target acquisition problem associated with the 1° field of view, necessarily result in a very complex mission payload incorporating, in addition to the large optical system, many ancillary devices required to accomplish such functions as image motion compensation, precise pointing, across-the-format image motion compensation, alignment, etc. While the statistical estimates of reliability for a mature mission payload segment are high, this again being due to the extensive redundancies incorporated in the design, many of the subsystems of this segment represent new technologies or extensive engineering adaptations of current technology components. (See Figure 1.) While all possible attempts will be made to achieve specified levels of performance for the mission payload on the initial flights, it would be prudent to expect instances of failure or out-of-spec performance situations on these flights. It is believed, therefore, that with respect to the mission payload, the crew will make its most significant contribution in terms of bringing the system to a mature level.

B. Vehicle Design Philosophy

The baseline system design must necessarily be compatible with the objective of both a manned and unmanned configuration resulting from the program. In addition, however, it must be assured that the design philosophy is compatible with the concept of crew contribution to the realization of early system maturity. Since the MOL/Dorian system must fly in both manned and unmanned configurations, a redundancy philosophy has been adopted in the design for the mission payload and all those Laboratory subsystems associated with the unmanned configuration.

A maintenance concept has been permitted on the life-support subsystem only, which is of course peculiar to the manned configuration. The baseline configuration does, however, provide for a backup manned switching capability in most instances where subsystem or component redundancies exist. In the mission payload segment, the manned configuration incorporates all of the elements of the unmanned mission payload segment, with a single exception being those elements of the film-transport subsystem associated with the multiple data recovery vehicles. That section of the film-transport subsystem is, however, amenable to extensive ground testing.

With respect to the major effort of diagnosis of failure on out-of-spec performance situations, the concept has been one of accomplishing this on the ground, and to this end, extensive instrumentation and telemetry capability has been incorporated in the baseline design. It is reasoned that the primary conduct of these efforts on the ground is desirable, due to the ready availability of extensive engineering personnel support. The crew will, however, contribute significantly, as will be illustrated later in this document, to such diagnostic efforts. Therefore, the manned configuration incorporates several features to facilitate their performance of such functions.

First, there is the malfunction alarm system which monitors approximately 100 Laboratory and 100 mission payload segment parameters giving aural and visual ques to the crew in the event of out-of-tolerance conditions on any of these monitored parameters and, in the event of such an occurrence, will immediately initiate the recording of telemetry data. However, in addition to this subsystem, several hundred instrumentation points for both the Laboratory and mission payload segments are displayed to the crew, and the crew has access to the telemetry data via the keyboard. This, plus the extensive switching capability provided, will allow the crew members to take corrective actions and/or perform diagnostic functions in most instances more readily than these could be performed by the ground. Furthermore, many of the equipments provided for accomplishment of mission or backup functions will be of utility in diagnostic procedures; for example, the acquisition telescope and the main optics visual display. And, finally, a secondary platen has been incorporated in the camera design and an on-board processor provided, which enable the flight crew to process and inspect the photography on the spacecraft.

C. Crew Functions

The crew's role in system development can be broken into three general categories. First, there is their basic ability to keep the manned vehicle operating on orbit for the maximum possible duration, thus permitting the obtaining of more operating data. This is facilitated by their ability to operate the system in a degraded mode, thereby circumventing many types of failure situations, their ability to restore the system to a normal operating configuration more rapidly than can be done from the ground, and their ability to perform certain types of maintenance or parts interchanging. Second, the crew can perform health checks on functioning subsystems, primarily in the mission payload area, but also for the Laboratory segment, to assess whether they are performing up to specification. Third, in situations of either failures or out-of-spec performance, the crew can perform certain types of diagnostic functions to verify the telemetry and provide information to complement that attainable on the ground via telemetry. As will be demonstrated in the following section, these diagnostic actions will in most instances permit identification/isolation of the source of off-nominal performance quite rapidly, as opposed to the extended periods of time required for similar action if it were an unmanned vehicle being flown.

Analyses have been performed on many of the Laboratory and mission payload subsystems to assess where the crew could respond more rapidly than the ground in restoring a normal operating situation after a failure. Basically, this capability arises from the redundancy implementation concept for the automatic operation; namely, in most instances where an out-of-tolerance condition is sensed on the unmanned configuration, the affected subsystem is put in a quiescent state and telemetry recorded until arrival over a ground station. Upon receipt of the telemetry data on the ground, corrective actions are determined and appropriate commands sent to the vehicle. In the manned configuration, while similar deactivations of the subsystem take place, the crew upon observing their instruments can determine and take the necessary corrective actions prior to arrival over the ground station. While many specific examples could be given for these types of situations, this would not be particularly germane to the issue of the crew's role in system development, as these functions are associated with keeping the present flight operating as opposed to trying to determine the reason for the off-nominal situations for purposes of influencing future flight performance.

Similarly, the crew can also correct off-nominal situations by operating the system in degraded modes, in some instances directly inserting themselves into the system operation. This capability becomes of particular importance with respect to some of the mission payload subsystems in that, as discussed previously, they represent technology advancements and hence, higher risk development items. For these mission payload items, manned backup capabilities have been provided in the baseline design, as delineated in Figure 2. For example, if the image velocity sensor is inoperative or not operating properly, the man can perform the tracking function; or, if the star tracker (precise pointing reference) system has malfunctioned, the crew can perform the target centering function. The determination by the crew of when they should perform these backup functions can be based on either a failure indication or as a result of diagnostic procedures in out-of-spec performance situations.

D. Diagnostic Functions

As indicated in the preceding sections, there are many types of functions the crew can perform to restore normal operating conditions and/or circumvent many types of failure or off-nominal performance situations via degraded mode operations which are contributory, though in a secondary manner, to attainment of early system maturity. It is, however, their abilities to perform diagnostic functions to assist in the isolation of sources of off-nominal performance which is of greater significance in this regard. Through such diagnostic operations, considerable data can be made available to the ground to complement that available, and, more significantly, at considerable savings in on-orbit operating time as compared to unmanned approaches. Additionally, since off-nominal situations, especially with respect to payload performance, can be detected early in the mission by the crew, corrective actions or degraded mode operations will still permit the gathering of better quality reconnaissance data during those early flights in which these diagnostic procedures may be utilized, than if the system were flown unmanned.

The MOL/Dorian system is extremely sophisticated as compared to prior optical reconnaissance systems such as Gambit and Advanced Gambit (G^3). In addition to basic problems of optical quality, there are those associated with such things as image velocity sensors, precision tracking mirror drives, across-the-format image motion compensation devices, focus sensors, precision pointing references, and alignment systems, all of which must function properly to achieve the specified performance. Additionally, the inability to effect a simulated zero-g complete systems test prior to launch precludes precise knowledge of the characteristics of the performance capability of a particular optical system and thus, for example, the ability to precisely determine platen position for best focus. There are, therefore, a multitude of possible contributors to off-nominal performance situations which could radically increase, as compared to past programs, the complexities of time requirements for diagnosis and correction, were a purely unmanned development approach attempted. Furthermore, even for a matured system, the limitations on ground testing may require crew peaking-up of the optical system on attaining orbit to achieve best performance.

The preponderance of planning and design effort to date has necessarily been associated with providing crew capability for restoring normal operating conditions and degraded mode operations such that operations could be safely maintained for as long a period as possible on a particular flight. More recently, analyses of crew contributions in the area of diagnostics have been initiated at SAFSL/Aerospace, with the initial objectives of defining a basic approach and establishing specific requirements for more detailed analyses. Thus, the discussion to be presented herein is offered to illustrate the approach and the type of thinking currently underway. Much work remains to be done, and in the near future these initial efforts will culminate in a briefing to be presented to the MOL/Dorian associate contractors to initiate their efforts in support of this work.

By way of illustration of the basic approach, Figures 3 through 7 present some typical diagnostic flow charts for two examples of off-nominal mission payload performance; namely, situations in which poor photographs are being obtained and where targets are not being properly contained within the field of view. In both cases, a preliminary analysis has been made of the possible steps which crew members might take, in conjunction with the ground, in attempting to isolate the source(s) of these performance degradations. While the data of Figures 3 through 7 are presented in flow chart form, this does not imply that these tests need be performed in the order indicated. On the contrary, these tests can in most instances be performed in any order, and in whole or in part, depending on the totality of clues available to the crew and the ground as to the possible sources of the trouble.

1. <u>Poor Resolution</u>

Suppose, for example, that poor pictures are being obtained. As indicated in Figure 3, the crew would be aware of this by virtue of their having processed and inspected photographs from the secondary camera, and in certain limited cases from the primary camera.

(By way of illustrating the time-saving features of this diagnostic approach, the crew would detect this degraded performance essentially on the first day of the mission, whereas if the system were unmanned, the degradation would necessarily go undetected until the first data bucket had been recovered and its film load processed.) Their inspections of these pictures could indicate whether the loss of resolution was due to a smear or to a general degradation of picture quality (blur), as, for example, might be associated with an out-of-focus condition.

If the problem is one of a smear degradation, possible diagnostic steps are illustrated in Figure 4. The asterisks indicate where some telemetry will be available, though in most of these cases the crew can significantly augment the information that will be derived therefrom. For example, is the smear across the entire frame or off-axis only? If off-axis only, the across-the-format image-motion-compensation devices are suspect, and the crew can check the platen and shutter drives. If this is, in fact, the source of the degradation, the crew can perform the target centering function for the remainder of this mission, thus avoiding dependence on this device and retaining performance.

If the smear is across the entire format, it could be attributable to an attitude control jet firing during the photographic operation, in turn due to failure of the inhibit signal to be properly transmitted. The crew would readily detect this, due to the sound of and motions introduced by such jet firings, and if this were the cause, they could report this to the ground and manually inhibit the jets during subsequent passes.

If it is not the attitude jets, the crew might investigate whether all of the frames of a stereo sequence are smeared or just early frames. If it just the early frames, there is a situation of an overly long settling transient attributable either to basic vehicle dynamics or a long time constant in the image velocity sensor control loop. The crew could observe the nature and time duration of the settling transient through the main optics eyepiece, both with and without the image velocity sensor in the loop, and if the settling time is improved without the image velocity sensor, then its time constant is the problem. If not, the problem is attributable to vehicle dynamics, though in either event the crew could determine a new, more desirable settling time for use in the mission planning software.

If all of the frames of a stereo sequence are smeared, then the problem is attributable to the image velocity sensor. The crew could observe, again through the main optics eyepiece, the nature of the discrepancy (e.g., does the scene tend to drift in one direction only, or is the motion of an oscillatory nature?), and for the remainder of this mission can perform the tracking function, thus retaining resolution performance.

If the problem is one of a general degradion (blur), similar diagnostic steps are illustrated in Figures 5 and 6. Has the optical alignment drifted out? The crew can check the optical alignment, realigning if necessary, and if this was the cause, attempt to correlate possible subsequent onset of misalignment with orbital events. The degradation may also be due to focus and to investigate this, a series of secondary camera pictures may be made with the platen biased in incremental steps from the position predicted for best focus. Should a more desirable platen position be determined from an on-board inspection of these photographs, the crew can introduce the appropriate bias into the platen position for subsequent photography.

The degradation could be attributable to an early onset of thermal deformation of the tracking mirror. To investigate this, a series of pictures could be taken with varying door-open times to establish if necessary a new maximum time for use in subsequent target programming.

If none of the foregoing is determined to be the source of the performance degradation, the problem may be one of basic optical quality or perhaps due to an induced high-frequency oscillation. In Figure 6 the latter possibility is addressed with sequential steps to investigate ringing due to attitude control jet firing, bearing stiction or noise, high-frequency oscillations introduced by the image velocity sensor control loop, or mechanical vibrations somewhere in the system.

2. Pointing Error Bias

In another example of possible diagnostic procedures Figure 7 presents a representative flow chart for the case of a pointing error bias. If such a bias existed, targets would either not be contained within the field of view or generally be off to the edge. The crew would detect this readily, depending on the cause, via either acquisition scope observations and/or from the processed secondary camera film. Since this problem could be attributable to erroneous ephemeris inputs from the ground, the flight crew would immediately request the ground to check these inputs, though simultaneously they could initiate steps as indicated in Figure 7 to determine whether the errors were due to vehicle equipments. In Figure 7, the possible sources of error attributable to vehicle equipments are indicated, along with the types of diagnostic and corrective actions which could be taken if the error sources were determined. In any event, if the error could not be corrected, the crew could perform the centering function for the remainder of the mission.

3. Summary

As discussed previously, the foregoing discussion on diagnostic procedures was intended to illustrate the approach, and the data of Figures 3 through 7 should not be misconstrued as a final delineation of such diagnostic procedures for the particular problems addressed. It is apparent, however, that there is considerable potential for crew utilization in this area, and in the forthcoming period this work will be extended, leading to more definitive delineation of such procedures for these and other types of potential operating problems. This work will also include consideration of the technical feasibility (including human performance considerations of each step), the possible utility of special tools such as measurement devices to aid in diagnostic procedures, and techniques for the preparation of the crew to accomplish such tasks.

III. CREW'S ROLE IN RECONNAISSANCE MISSION ENHANCEMENT

Since the manned configuration incorporates all of those devices necessary to permit operation of the mission payload segment in an automatic fashion, this permitted examination of the total reconnaissance operation to identify crew functions which could be used to enhance the intelligence value of the MOL/Dorian photographic take. These considerations led to the development of a concept of operations referred to herein as the active indicator/weather avoidance mode, which will be discussed in some detail in the sections to follow. It will be shown that the manned flights of the baseline program, in addition to facilitating crew utilization in system development, will permit an evaluation of crew effectiveness of this mode.

A. Active Indicator/Weather Avoidance Mode

1. Rationale

In assessing possible crew contributions to mission enhancement it was necessary to first address the question of the types of things of interest to a system capable of achieving [redacted] resolution. Typically, these things tend to be the observation of as fine detail as necessary to assess the performance capability (in its most general sense) of adversary weapon systems, both present and potential. Yet, the occurrence of situations at particular target sites in which such fine detail may be observed is highly transitory in time, for the objects on which these detailed observations are to be made are not always present at the sites or exposed. It was therefore reasoned that from a gross understanding of the operations at these sites, as derived from our present base of intelligence, certain indicators typified by those delineated in Figure 8 could be defined, which if present could increase the probability that a photograph taken of that site at that time would yield valuable technical intelligence information. These technical intelligence indicators, derived primarily from examination of Gambit photography, were defined consistent with expected crew observation capabilities using the acquisition scopes incorporated in the manned baseline configuration.

Figure 8

INDICATORS OF TRANSITORY INTELLIGENCE POTENTIAL

PHOTO TARGET	INDICATORS	ESTIMATED DECISION RESOLUTION
MISSILE SITES (COMPLETED)	MISSILES EXPOSED	10 FEET
	ERECTION/LOADING EQUIPMENT EXPOSED	10
	VEHICULAR ACTIVITY	10
	GSE EXPOSED	5
	SILO DOOR OPEN	5
	SPECIAL VEHICLES	3
	SNOW REMOVAL	10
AIRFIELDS	NEW AIRCRAFT	3-15
	UNUSUALLY CONFIGURED AIRCRAFT	3-10
	AIRCRAFT IN UNUSUAL LOCATIONS	15
	DISASSEMBLED AIRCRAFT	5
	AIRCRAFT/GROUND EQUIPMENT IN WEAPONS LOADING AREA	10
	AIRCRAFT IN MAINTENANCE AREAS	10
	VEHICLE ACTIVITY AROUND AIRCRAFT	5
	AIRCRAFT SUBSYSTEMS IN OPEN	3
GROUND FORCES/ ARMY EQUIPMENT	VEHICLES PRESENT	10
	PARTICULAR VEHICLES PRESENT	3
	VEHICLE ACTIVITY	15

Also of importance in assessing possible areas of crew contributions is the severe limitation imposed by the small (1^{o}) field of view of the Dorian optical system. This is graphically illustrated in Figure 9, wherein comparisons of photographic coverage for a representative target complex attainable by Gambit, advanced Gambit (G^3), and Dorian are made. It is seen that because of the wider field of view and the strip cameras incorporated in the Gambit systems, many target points can be contained within a single frame of photography, whereas the Dorian field of view, represented by the circular areas on the figure, generally permits the containing of but a single target in a frame. Our experience with the Gambit systems has indicated that in many instances little information was derived from the photographs of the pre-selected target about which the Gambit frame was centered, whereas other targets which appeared within the frame by virtue of its extent yielded considerable intelligence information. The limited field of view of the Dorian system denies to us these bonus targets, and this, combined with the aforementioned discussion of the transitory nature of the objects which it is desired that Dorian photograph, makes it particularly critical that the optical system be directed to the right target at the right time.

The possible use of the crew to examine pre-programmed alternate targets in addition to the targets programmed for the main optical system and assessing in real time whether a deviation from the programmed main camera path would be desirable could, if feasible, enhance the probability of imaging the appropriate target at the right time.

2. Concept of Implementation

The use of the crew in accessing targets in addition to those programmed for the main camera system has been examined in detail, leading to a concept of implementation for the active indicator/

weather avoidance mode. This is schematically illustrated in Figure 10. The manned configuration is provided with two acquisition scopes of 10-inch aperture and having magnifications up to 127X. These telescopes are programmed independent of the main camera system against both the main camera and alternate targets. As seen from Figure 10, while the main camera is photographing the previous target the crew uses the acquisition scopes to inspect the next main camera target and its associated alternates and makes decisions on the state of each target so inspected; i.e., is the target cloud covered, clear but in an inactive state, or clear and in an active state. These decisions are indicated by the crew member depressing an appropriate button permitting the on-board computer, based on a pre-programmed decision logic, to select the target to be photographed.

To assist the crew in making proper determinations on target states in as fast a time as possible, a cue projection system is incorporated in the baseline design wherein prior photographs of the programmed target sites can be presented. This cue projector can be used on a pre-pass basis, to study photographs of the targets programmed for the next orbital pass and during the pass itself while the acquisition scope is slewing to the next target. In addition, the acquisition scope contains provisions for cues to be displayed directly through its eyepiece, and forthcoming simulation activities will assess the desirability of this feature and types of cues (alpha-numeric vs. pictorial) to be utilized therewith.

The targets programmed for both the main camera and the acquisition telescope are selected on the ground by the mission planning software, and this information together with value functions for each selected target, in both active and inactive states, are transmitted to the orbital vehicle. In making such target selections, the mission planning software will take into account the kinematics of the system (e.g., orbital speed, mirror slew rates, settle times, etc.)

and will also evaluate the effects of interdiction decisions in favor of any active alternate on subsequent target programming, the latter to ensure appropriate choices of programmed alternate targets. In any event, if the crew members give no indications of activity at any of the programmed alternates, the programmed main camera target will be photographed, it having been selected on the basis of the highest value in an inactive state as compared with other targets in the field.

It is of course desirable, from the point of view of enhancing the number of active target photographs obtained, that the crew members be able to examine as many alternates as possible, particularly in dense target areas. Therefore, in the implementation of this concept of operations, considerable effort has been expended in an attempt to optimize the man/machine interface. Admittedly, this process is not fully complete and future simulation efforts are directed at currently open issues. However, to assess the basic validity of the concept prior to proceeding too far in its implementation, an initial series of simulations has been conducted to verify that the flight crew is in fact capable of performing the necessary target inspections. These simulations and the results therefrom, will be discussed in the following section. Before proceeding to do this it would be well to discuss the characteristics of the particular tool, namely the acquisition telescopes, which will be provided to the flight crew for accomplishment of this task.

As mentioned previously, the acquisition telescopes are of 10-inch aperture and have a high magnification range from 63X to 127X. At 63X, the field of view of the acquisition telescope is 1°, which is equal to that of the main optical system, and necessary if automatic pointing of the acquisition scopes is to be accomplished. The associated apparent field of view is 60° and at 127X the real field of view is $1/2^{\circ}$. The minimum exit pupil at 127X is 2mm. The basis for selection of this particular design was a requirement that it provide 3-ft resolution or better against a high-contrast target from 80 n. mi. altitude. This requirement in turn was developed on the basis of the examination of Gambit photography and the definition of indicators for particular target sites established therefrom. With this level of resolution available to the flight crew, the defined indicators should be readily discernible, though, as will be discussed in relation to the initial simulations performed, the mere visual detection of an apparent indicator is not in itself the total problem.

3. Simulations

a. Description

An initial simulation has been conducted at SAFSL/Aerospace to establish the level of flight crew performance in performing the active target detection function. This simulation also served the basic purpose of educating those involved, thus facilitating better future simulations in the more advanced and sophisticated simulators intended to be a part of the baseline program. In accomplishing this initial round of simulation, seven flight crew members were utilized as subjects, and a base of stimulus material was developed using Gambit product photography. The total sample available for these tests was 240 scenes plus an additional 60 scenes which were used for trial runs.

The simulator, illustrated in Figure 11, was built at the Aerospace Corporation and is a static simulator, in that no apparent motions of the scene due to erroneous tracking rates, for example, are present. The simulator, when used with Gambit material, simulates magnification of 60X and 120X, essentially the same as for the acquisition telescopes, but in discreet steps rather than with a continuous zoom capability. The apparent field of view was slightly less than that associated with the acquisition telescopes, but not significantly. Both monocular and biocular configurations of the simulator were utilized in these tests to establish any difference in performance due to this factor. Additionally, since the positive transparencies being utilized were processed to enhance contrast, the simulator included a mechanism for the introduction of a flooding light into the scene to reduce contrast. The means for calibration of this flooding light and its effect on simulation fidelity will be discussed in the following paragraphs. In conducting these tests the crew members, taken two at a time, were given a two-day training session wherein they were exposed to numerous samples of Gambit materials in an attempt to familiarize them with the types of scenes they would be viewing and the types of indicators associated with particular target classes. Subsequent to this, trial runs were made on the simulator to acquaint the crew members with its method of operation and to familiarize them with the amount of time to be given for each scene examination. It was necessary to establish a set of instructions for the crew members, placing relative priorities on such things as accuracy and response time. In doing this it was judged to be preferable to emphasize accuracy as opposed to speed in this initial series of tests. Therefore, in order of importance, their instructions were first to attempt to identify activity when it existed, second to minimize false alarms (the indication of activity when, in fact, it was not present), and third to respond in less than the maximum time allowed whenever possible. A maximum time of 12 seconds per scene was selected for these tests as being representative of the time between succeeding decision points in a dense target field. The basis for emphasizing accuracy rather than speed in these initial tests stemmed from the belief that with more training, as the crew members will experience as the program progresses, their ability to perform this task rapidly will improve.

This simulator was not intended to be a complete representation of the orbital vehicle equipment. For example, it was not possible in the time available to simulate the cue projection system, and in these tests only verbal cues were given to the crew. This was done on a scene-by-scene basis with the test conductor indicating to the subject the class of target next to be presented in the viewing device.

Due to the limited amount of pre-test training given to the subjects and the inherent inability to familiarize them in this short period of time with all of the types of indicators for various target classes, it was deemed desirable to permit (after a subject's examination of a particular target and a statement of his decision) some discussion between the subject and the test conductor as to the reason for his determination. This procedure was followed primarily in cases where the subject's response did not agree with the pre-scoring of the stimulus material. In such cases, an attempt was made to establish the reason for the subject's response in light of what he had been told in the training session. In certain instances allowances were made in the scoring where the test conductor believed that with better preparation the subjects would have responded more accurately, though the scorings are presented both with and without these allowed answers.

b. Simulator Contrast Setting

Due to the contrast enhancing processing given to the material which constituted the simulation stimulus, it was necessary to degrade the contrast in the simulation. This was done by using a flooding light introduced into the simulator light path. The concept for calibration of the flooding light is depicted in Figure 12. To perform this function, frames of Gambit photography taken of CORN (Coordinated Optical Range Network) targets in the Unites States were utilized. For certain of these frames, reflectance measurement of the black and white edge targets was made on the ground simultaneously with the photography from overhead by the Gambit satellite. The ground instrumentation values of target contrast were utilized with an atmosphere model in the computation of target contrast when viewed from above the atmosphere. To verify the contrast values thus computed, densitometer runs were made on the Gambit original negatives, and computations then made to account for the level of processing given these negatives to estimate the contrast level at the Gambit system entrance pupil necessary to produce the recorded image. Typical results of these computations are shown in Figure 13, which indicates good agreement with the two sets of computed, above-the-atmosphere target contrasts. (The ground camera data is seen to have exhibited considerable scatter, with some contrast values above the 9:1 design value for the edge targets, and was therefore discarded in favor of the ground photometer data.)

The balance of the procedure consisted of setting the positive transparencies of these CORN target photographs in the simulator and then adjusting the flooding light until the target contrast, as measured through the exit pupil, agreed with the calculated above-the-atmosphere values (see Figure 13). This value of flooding light level was then utilized for the actual stimulus sample.

The use of this flooding light technique to offset the effects of film processing to enhance contrast results in a conservative simulation because of two factors. First, within the frame containing the CORN target, an improper rendition of contrast over the entire frame results. This may be shown mathematically, and in particular it may be demonstrated that all points in the frame of lower contrast, as compared with the edge target, will be presented at less than their actual contrast when the edge target is properly displayed. Second, the frames containing the edge targets were generally taken under good weather conditions (little haze), and flooding light values derived therefrom and then used with stimulus material obtained under less favorable conditions results in a very conservative presentation.

The only way to solve this problem is to get stimulus material which has been neutrally processed (no contrast enhancement). Since, however, the original negatives have been processed to enhance contrast, this can only be effected by processing the positive transparencies in a manner to offset this original negative processing. The Special Projects Processing Facility (SPPF) at Westover has been contacted on this problem and is working towards the delineation of appropriate techniques for providing such stimulus. To date, a small sample has been produced and delivered, is currently undergoing examination for quality, and is being compared with materials previously used. There appears to be reason for encouragement that such materials can be made available for subsequent simulations.

c. Aircraft Simulation

Simulations of the active target mode must necessarily be performed in ground-based facilities using photographic stimulus, and to this end such capabilities will be included in the Mission Development Simulator at General Electric and the Mission Simulator at VAFB. This approach is dictated primarily by the necessity to prepare the flight crews for this task using realistic stimulus depicting actual targets. As mentioned previously, the technical intelligence indicators have been defined based upon the best understanding of operations at particular target sites, and are generally unique to these sites. To properly perform the detection task it is necessary that the crew members become thoroughly familiar with the nature of these targets and the meaning, in terms of possible presence of technical intelligence information, of various observed situations. Since it is not possible to find analogous situations at target sites within the United States, the use of photographic simulations is dictated.

In adopting this approach, certain elements of simulation fidelity must necessarily be given up. For example, the stimulus material is in black and white rather than color, it is two-dimensional rather than three-dimensional, and certain of the dynamic aspects, such as motion at the target, variation in haze with line-of-sight angle, etc., cannot be represented. Therefore, the use of an aircraft simulation to complement the ground simulation, primarily for qualitative purposes in familiarizing the flight crew with differences in viewing conditions between the simulator and the orbital case, has been recommended. Such a program, which would involve the utilization of an aircraft incorporating an appropriately scaled acquisition telescope, is currently under definition.

d. Simulation Results

The results of the active target simulations with the flight crew members as subjects are depicted in Figures 14 through 16 inclusive. In Figure 14 overall simulations scores are shown for each crewman and for all the crewmen taken together. For each of the seven crew members the left-hand bar presents the percent correct active target detections, that is, what percent of the time when the target presented was actually active did the crewmem successfully detect the activity. The right-hand bar presents the false alarm rate, that is, the percentage of time when the target was in fact inactive that the crewman indicated the presence of activity. In both cases, scores are presented both with and without the allowances made on the basis of subject debriefings. The data presented in Figure 14 includes the scores of both the biocular and monocular tests made with the crewmen on the simulator. Independent examination of results from these tests indicates no statistical difference in the scorings, thus further substantiating the choice of the monocular configuration for the orbital vehicle acquisition telescope.

The specific nature of the scenes comprising the stimulus base varied considerably. For example, in the case of those scenes which were pre-ranked to be active, there were instances of scenes in which many activity indicators were present making it highly improbable that the presence of these indicators could have been missed. On the other hand, there were scenes in which few indicators or very subtle indicators of activity were present. Similar statements can be made for those scenes pre-ranked to be inactive. Some attempt was therefore made to divide the stimulus sample on the basis of the level of activity or inactivity contained in the particular scenes. In Figure 15, as a function of these activity level categories, the crewmen scores are presented in terms of percent correct active target detections and false alarm rates. The height of each bar again represents the variation in scorings due to the allowance of answers based on the debriefing of the crewmen. Considering the relatively small amount of training the subjects had for this task, and hence their incomplete familiarization with the types of and subtlities of many of the indicator classes, those scenes in the stimulus sample which fell into the marginally active or inactive categories should best have been eliminated from the test. For the more clearly defined active or inactive situations, the crewmen's accuracy on these initial tests was quite good with a correct detect percentage of approximately 80% and false alarm rate somewhat under 10%. It can also be noted from Figure 15 that the greatest variation due to the allowed answers occurred in the marginally inactive category. This is perhaps to be expected on the basis of the instructions given the crew members, that is, emphasis being placed on detection of activity. Since this was stressed more heavily than the minimization of false alarms, their tendencies in these cases were to respond that the target was active.

As mentioned previously, time was not stressed in these initial tests and in most instances the crewmen took the maximum or near-maximum time to respond. As a function of the target activity levels described previously, mean times to respond vary from approximately 7 1/2 seconds for the highly active cases down to about 11 1/2 seconds for the inactive cases. This again was to be expected in that when the target was inactive the crewmen tended to wait out the full time making sure they did not miss any activity. In many instances the crewmen did respond in very short times, and it is of interest to examine accuracy attained for these rapid response cases. Figure 16 presents crewmen's accuracy as a function of target activity level for those cases in which responses were made in 6 seconds or less. The numbers in the left-hand column represent the percentage of those cases in which responses were made in 6 seconds or less for the various activity levels. The numbers in the remainder of the chart indicate the levels of accuracy achieved by the crewmen, and it is encouraging to note that except in the middle categories of activity level the crewmen's responses were quite accurate in those cases when responses were made in 6 seconds or less.

In summary, the active target mode simulations conducted to date, while quite conservative in nature (e.g., contrast, no visual cues, limited training), have produced results which substantiate the belief that the flight crew can, with reasonable accuracy, perform the necessary target inspections. Furthermore, much information has been derived from these tests pertaining to the subjects' reactions to the problems of performing this task, the types of cues and other displays which would be desirable to enhance performance, and the types of future training/simulation necessary.

4. Mission Enhancement Due to Active Indicator Mode

Several statistical calculations have been made to determine, in a quantitative manner, the nature of the mission enhancement attributable to active indicator mode operations. To perform these computations it was necessary to establish numerical values for the percent of targets which were potentially active (i.e., for which indicators could be defined) and for the probability that a potentially active target would in fact be active at any given time. To establish these values, an analysis utilizing information derived from the present base of intelligence data was performed. Statistics pertaining to various target classes were established and weighted averages developed therefrom to yield values of 70% potentially active and 6% probability of activity. These average values were used in all mission enhancement calculations.

The results of these computations are presented in Figures 17, 18 and 19. Figure 17 depicts mission enhancement factor, defined as the ratio of the number of clear active photographs obtained with a manned system to that obtained with an unmanned system, as a function of the crew performance parameters (% correct detections, % false alarms). These calculations are for an overall mission, including, within the computational approach, statistics pertaining to numbers of programmed targets per day (devised from runs uning Gambit software) and to the distribution of alternates with respect to programmed main camera targets (i.e., certain targets have no alternates available, certain targets have only one, etc.). As seen from Figure 17, if the crewmen were perfect (100% correct detections, zero false alarm rate), an overall enhancement factor of 2.75 would result. Superimposed on these parametric curves are the simulation data presented earlier, the lower region representing the area of crew performance based on the pre-ranking of the stimulus sample and the upper area representing crew performance with score adjustments based on the de-briefing sessions. Enhancement factors of 2 to 2.5 are still indicated, and it must be emphasized that this is performance attained with very little crew training for this task.

While this overall mission enhancement factor is by itself significant, the effects of active indicator mode operations against representative target clusters are even more dramatic, and of considerable interest when it is recognized that operations against certain, relatively isolated, target clusters offer the potential of considerable technical intelligence yield. To illustrate this, two sets of computations have been performed, the results of which are presented in Figure 18. In the first, a cluster of approximately 100 n. mi. extent was hypothesized. Within such a cluster, two main camera targets could be programmed with two discrete interdiction decision points. In such a case there is a 50% probability of an interdiction causing the loss of both primaries; namely, if the interdiction occurs at the first decision point. In the second case the cluster was assumed to be 50 n. mi. or less in extent, still with two programmed main camera targets. In this case, because of the timing involved, only one decision point would exist with an interdiction to photograph a single alternate always causing the loss of both primaries. Enhancement ratios are presented in Figure 18, again as functions of the crew performance parameters measured in the simulations, for both of these cases; and it is seen that for operations against such clusters, ratios in the range of 3 to 6 are indicated for crew performance levels as derived from the initial simulation results.

Another method of illustrating the advantages of active-indicator-mode operations is presented in Figure 19. Consider a situation in which there is an isolated cluster containing a large number of possible aiming points, four of which are associated with a particularly critical intelligence problem such that it would be extremely valuable to obtain photographs of these targets in an active state. Depending on the relative importance of photographing these four special targets, as opposed to collecting other intelligence within this cluster, varying targeting strategies can be delineated for unmanned and manned active-indicator-mode operations, in the latter case either of these strategies being compatible with the mission-planning software and on-board decision-logic approaches. Plotted in Figure 19 are the number of clear photos of targets, other than the four special ones obtained, vs. the probability of obtaining at least one clear, active photo of each of the four special targets. The numbers on the curves represent the numbers of flights made.

If the four special targets were of overriding importance, the unmanned vehicle could devote both of its programmed photographs on each pass to two of those four, attempting to gather no other intelligence within the cluster. For this case, the curve lies along the abscissa as seen in Figure 19. A manned strategy optimized for operations against the four special targets would, however, still yield some intelligence elsewhere within the complex, for if the crewmen did not observe activity at these targets but did so at other programmed alternate targets within the complex, they could photograph these. The curve for this manned strategy is the first one above the abscissa, and it may be seen that for equal numbers of flights the manned system has a higher probability of imaging the four special targets. Conversely, for equal probability of imaging the four special targets, it takes fewer manned flights and hence less calendar time.

Similarly, if it was desired that a better balance be maintained between attempts at photographing the four special targets and photographing other targets within the cluster, different strategies could be developed for both the manned and unmanned systems (in the case of the unmanned system only one photo operation per pass would be devoted to the special targets with the other directed at one of the other targets within the cluster). The curves resulting from these calculations (which coincidentally fall on top of one another for the particular set of crew performance parameters assumed: probability of correct detection = 80%, false alarm rate = 10%) again indicate that for equal numbers of flights the manned system has a higher probability of imaging, in an active state, the four special targets, while still gathering more intelligence elsewhere in the complex.

In summary, the manned system operated in the active indicator mode will provide, on a per mission basis, significantly more photographs of targets in which indications of activity are present and from which considerably more intelligence information will be derived. Furthermore, the flexibilities afforded within this mode of operation, by virtue of the mission-planning software and on-board decision logic concepts, will facilitate the gathering of critical intelligence in a much more rapid fashion than an unmanned approach would permit.

5. <u>Assessment Plan</u>

The three manned flights of the baseline MOL program, and their associated operations concept, will permit post-flight evaluation of the effectiveness of the crew in performing the active indicator task. Additionally, it will permit, by examination of the resultant Dorian photographs, verification of the defined indicators (i.e., when the crew detected the presence of defined indicators at particular targets, did the photos in fact yield the types of intelligence data desired? --if not, perhaps a better understanding of the operations at that site should be developed and the indicators re-defined).

The post-flight analyses can be accomplished in that crewmen decisions on the state of all targets observed with the acquisition telescopes (which in almost all instances will include the target pre-programmed for the main camera) will be recorded and transmitted to the ground. Additionally, the crew can record voice comments on reasons for their determinations for similar transmittal. These data can be correlated with the resultant photography to develop statistics on crew performance and indicator validity, these correlations then being compared with statistics on crew performance obtained via preflight simulations.

6. Active Indicator/Weather Avoidance Mode Summary

Operations in the active indicator mode will significantly enhance the intelligence value of MOL/Dorian photography, offsetting operational difficulties due to a limited field of view, and will enable more timely gathering of critical intelligence information. The orbital vehicle equipments and mission-planning software are being designed to optimize the crew's capability for effective operations in this mode. Initial simulation results have indicated that the crew is quite capable of performing the necessary target inspections. Furthermore, an assessment plan consistent with the system configuration and operations concept will permit a post-flight evaluation of the flight-crew's effectiveness in this mode.

B. Other Reconnaissance Mission Enhancement Functions

The crew's presence affords other means of enhancing the effectivity of MOL/Dorian reconnaissance operations. These enhancement functions can be performed on a non-interference basis with active-indicator-mode operations and, in certain cases, are a natural by-product thereof.

1. Verification

More efficient target programming can result in a manned operation due to real-time knowledge that programmed targets had, in fact, been imaged and were not cloud covered. Such information transmitted to the ground can permit countdown of targets for subsequent pass programming. This function is inherently performed when target inspections are made by the crew members in the active indicator mode. In the case of critical targets, observations through the main optics visual display during the photographic sequence could also be made to verify determinations made on the presence or absence of cloud cover while looking forward with the acquisition telescopes. This latter approach would be most useful in cases of broken cloud cover.

2. Visual Reconnaissance

Intelligence data may be derived, even for those programmed targets not photographed by the main camera, by virtue of the crew's inspection of these targets in the active indicator mode. Their determinations on the state of the target, plus any voice commentary on their observations, will be recorded for transmittal to the ground, thus providing an additional base of data from which intelligence information may be extracted.

3. Special Films

The MOL/Dorian baseline system incorporates, in the manned configuration, a secondary platen in the camera back. The crew can insert, on command from the ground, a variety of special films (e.g., color, IR, high-speed black/white) into this secondary platen.

IV. ADDITIONAL SYSTEM CAPABILITIES AFFORDED BY CREW'S PRESENCE

In addition to the flight-crew's ability to enhance the effectivity of the MOL/Dorian reconnaissance mission, additional system capabilities are afforded by their presence aboard manned flights. Specifically, the system, with no hardware modifications, can be used for astronomy work (visible spectrum photography of the planets) [redacted]

A. Astronomy

The utilization of the MOL/Dorian system to accomplish visible spectrum photography of the planets, or other celestial objects of comparable brightness, has been subjected to considerable analysis; and the results of these investigations have indicated that, depending on the particular planet in question, surface resolutions two to eight times better than achievable with ground-based telescopes can be realized, the greater improvements being associated with the closer planets (e.g., Mercury, Venus, Mars). In arriving at these values, tracking data as measured during simulations of this task, with the flight crew members as subjects, were used. The concept of operations requires that the vehicle be rolled to the appropriate altitude for directing the main camera system at the target planet (typically, only roll maneuvers will be required) and that the astronaut then acquire and track the planet using his main optics visual display. The timelines are such that this astronomy work can be performed on a non-interference basis with the primary mission.

Calculations were first made to determine the required range of exposure times for planetary photography(approximately 1/1000 second to 13 seconds for the various planets) and in the simulations of this task, crew tracking capabilities over this entire range were explored.

This was done even though the present camera-back design provides a maximum exposure capability of only 0.08 seconds, for an evaluation of the crew capabilities would be a necessary input to possible future considerations of increasing the exposure latitude of the camera.

The tracking simulations were conducted at SAFSL/ Aerospace using an oscilloscope (cathode ray tube) display plus an eye-piece to simulate the apparent f.o.v. of the main optics visual display. Planet limbs were simulated on the scope face and scaled in diameter to be the same as the planets would appear when viewed at 1000X. Image motions due to such error sources as vehicle rates, vibrations, bearing noise and rate servo biases, were introduced.

Utilizing the image displacement data developed via these simulations, modulation transfer function analyses were performed to establish surface resolutions attainable against the various planets and these were compared with resolutions attainable from the ground. Significant improvements are indicated and, for example, in the case of Mars the 35 n. mi. resolution attainable is essentially equivalent to that achieved by Mariner, though a single Dorian photograph of Mars would include the entire visible side of the planet. Present camera-back exposure limitations limit the range of possible operations to planets out to and including Jupiter; however, even for the more distant planets, the tracking simulations do indicate the possibility of significant resolution improvements should a future decision be made to provide increased exposure latitude.

[redacted]

[redacted]

V. SUMMARY

The presence of the crew on the three manned flights of the baseline MOL/Dorian program will, by virtue of their abilities to perform switching, maintenance, backup, and in particular, diagnostic functions in situations of failures or off-nominal performance, significantly contribute to the early maturity of the Dorian system. This can be accomplished while the system is simultaneously gathering high-resolution reconnaissance data. Admittedly, analyses performed to date on possible diagnostic functions are of a cursory nature, and it is more the approach rather than the final solution which has been discussed. Yet it is apparent that there are many such functions which can be performed. During the forthcoming period, more detailed analysis of diagnostic functions will be made for both the Laboratory and Mission Payload segments to assess feasibility of the tasks, determine special tools which might be required, delineate procedures, and evolve crew preparation techniques.

Simultaneously, other uses for the crew will be developed and explored via simulation and eventually actual flight, for it is believed that the presence of the crew can significantly enhance the effectivity of MOL/Dorian reconnaissance operations. The use of the crew in the active indicator/weather avoidance mode can, in part, circumvent operational difficulties introduced by the transitory nature of intelligence at particular target sites and by the limited 1^{o} field of view of the optical system, which is an unavoidable by-product of optical disigns to achieve [redacted] resolution from 80 n. mi. altitude. By accessing targets other than those programmed for the main camera and making real-time decisions on the relative desirability of photographing the programmed or an alternate target, the crew can significantly improve the intelligence value of the take. Additionally, the crew's performance of such functions as target verification, visual reconnaissance, and the loading of special films into the secondary camera, further enhances the overall effectivity of operations.

Finally, the presence of the crew permits the utilization of the system for astronomy [redacted] their abilities to perform the necessary acquisition and tracking functions.

Initial simulations pertaining to the active target mode and the tracking function necessary for astronomy have provided sound evidence of the crew's capabilities to perform these tasks, and it is believed that with the additional training to be imparted between now and flight time their effectiveness in performing these tasks will show a marked improvement.

Figure 1

MISSION P/L DEVELOPMENT RISK

- ITEMS REQUIRING EXTENSIONS OF CAPABILITIES

    ACROSS FORMAT IMC

    V/H SENSOR

    MIRROR DRIVE SERVOS

    ALIGNMENT MECHANISMS

    MIRRORS

    OPERATING SOFTWARE

- ITEMS REQUIRING ENGINEERING ADAPTATION

    COMPUTER

    STAR TRACKER

    MULTIPLE RE-ENTRY VEHICLE ARRANGEMENT

    THERMAL CONTROL & DOORS

    MM STRUCTURE

    SENSOR STRUCTURE

Figure 2

CREW BACKUP TO PAYLOAD EQUIPMENT MALFUNCTIONS

• MISSION PAYLOAD

PAYLOAD EQUIPMENT REQUIRED FOR AUTOMATIC OPERATION	SUBSTITUTE CREW TASK
STAR TRACKER ASSEMBLY	TARGET CENTERING AND RATE KILLING
IMAGE VELOCITY SENSOR	TARGET RATE KILLING
ALIGNMENT MONITOR	TARGET CENTERING
LOW G ACCELEROMETER	TARGET CENTERING
OPTICS AUTO ALIGNMENT	MANUAL ALIGNMENT
FOCUS SENSOR AND SERVO	MANUAL FOCUS ADJUSTMENT
ACROSS THE FORMAT IMC	TARGET CENTERING

Figure 3

PROBLEM: POOR RESOLUTION

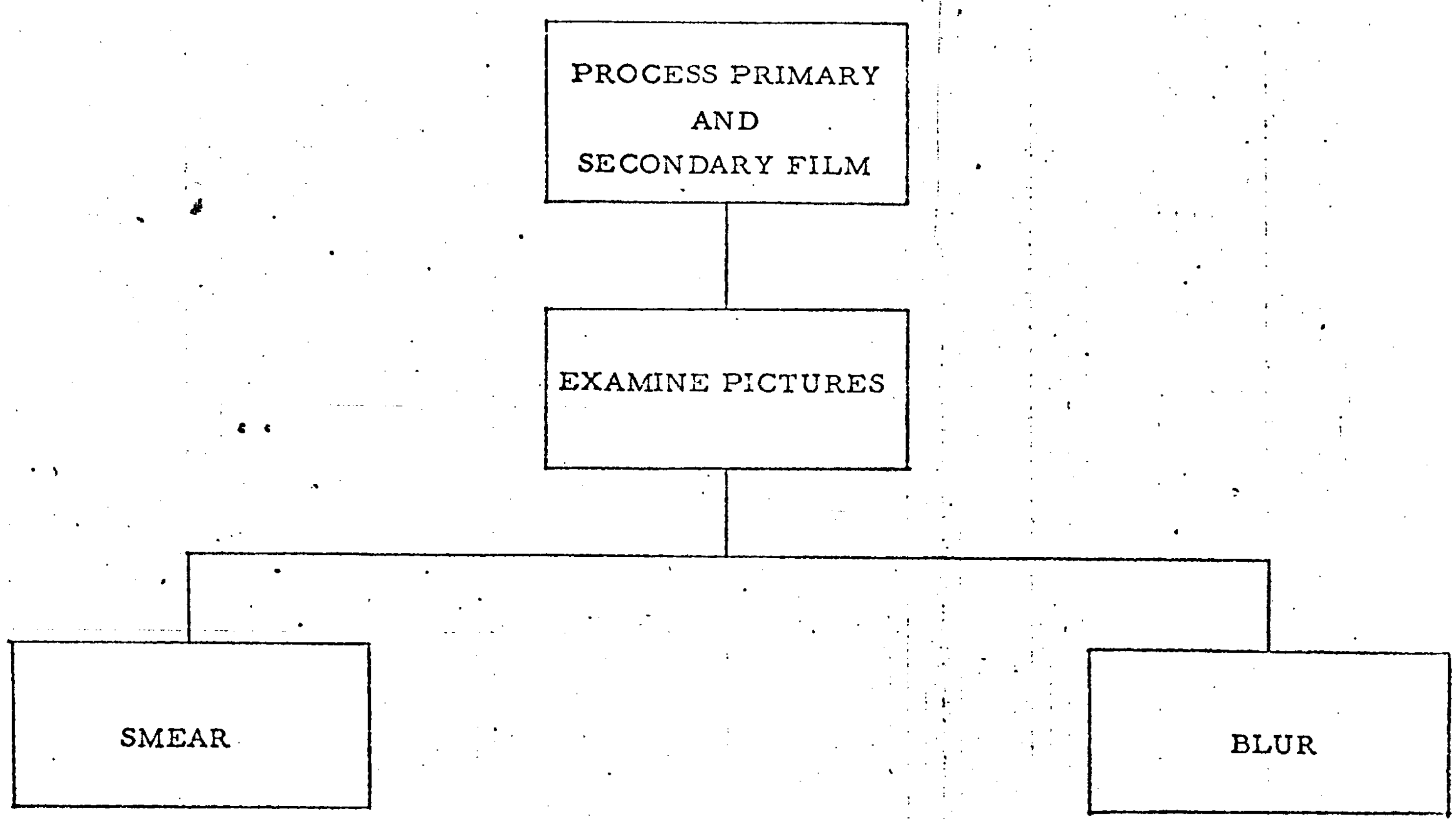

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Figure 4

PROBLEM: POOR RESOLUTION (SMEAR)

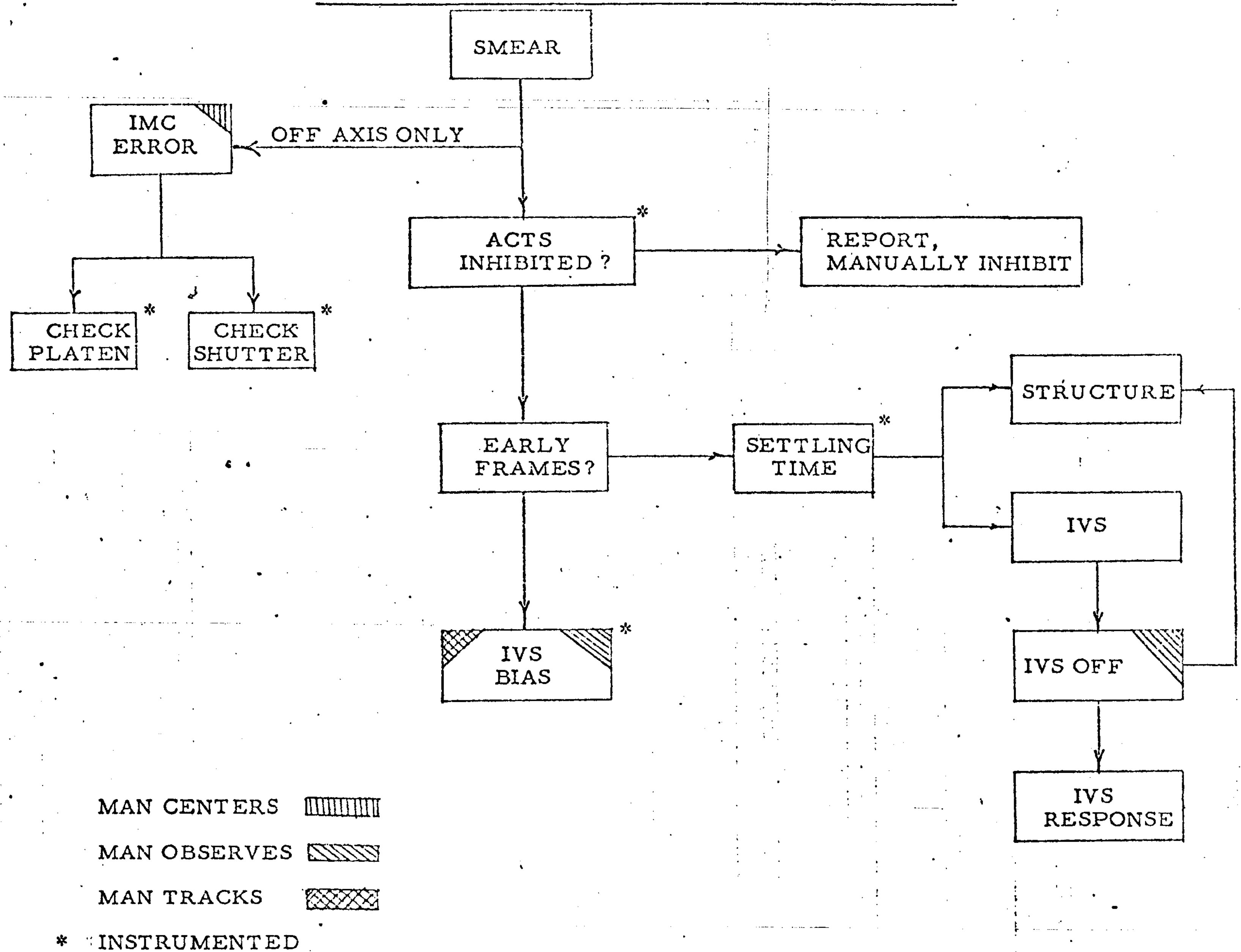

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Figure 5

PROBLEM: RESOLUTION DEGRADATION (BLUR)

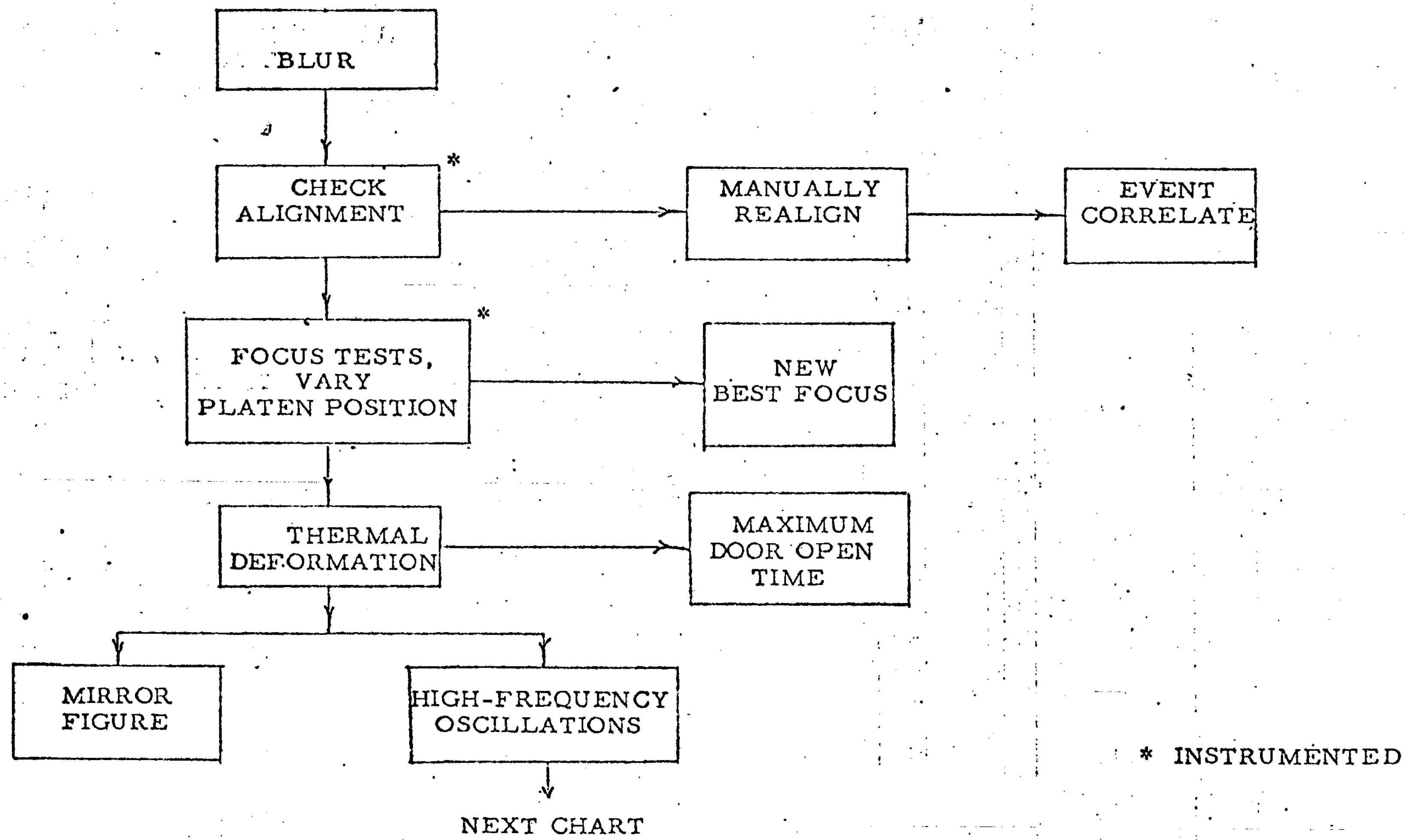

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Figure 6

PROBLEM: RESOLUTION DEGRADATION (BLUR) (CONT'D)

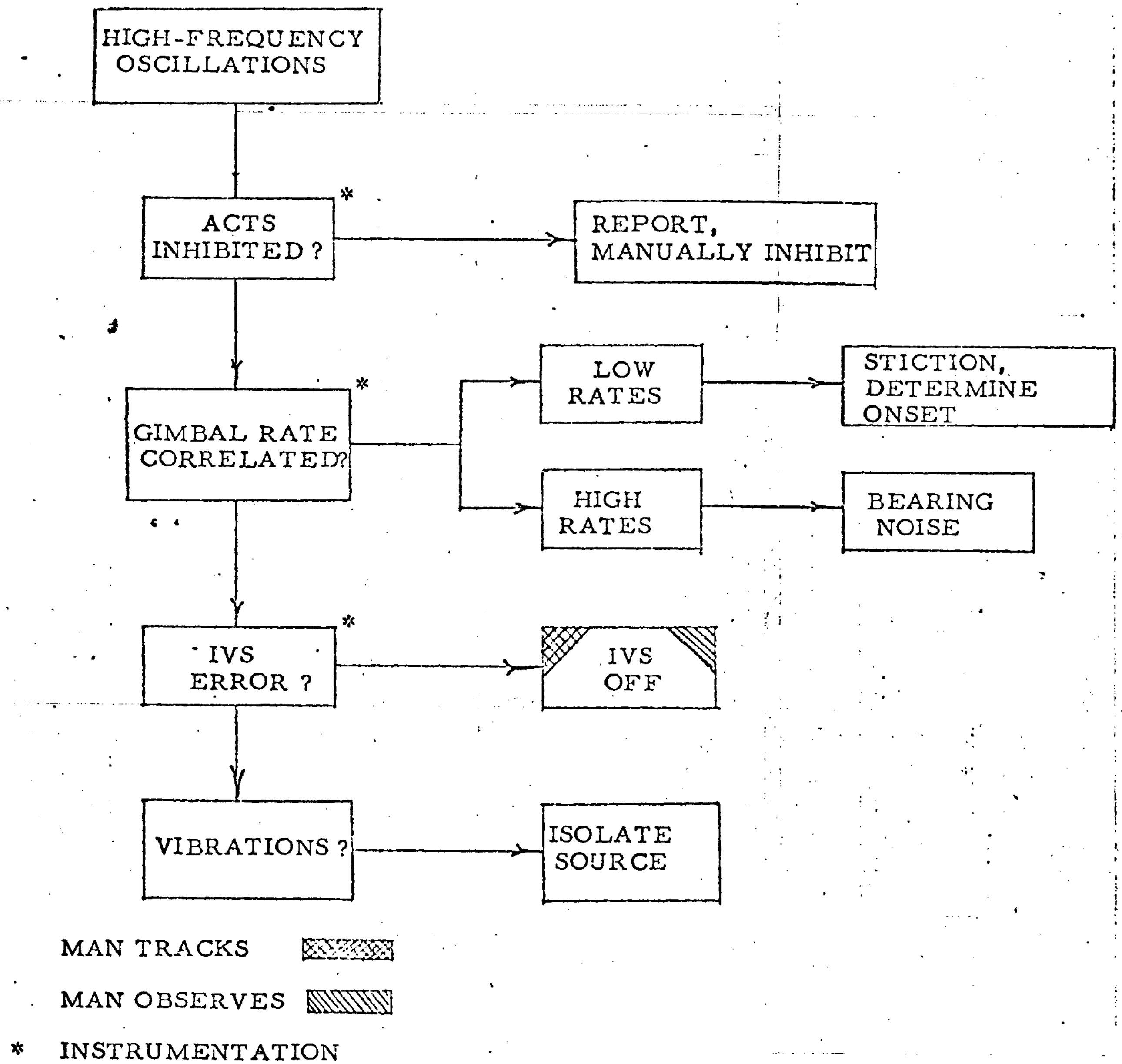
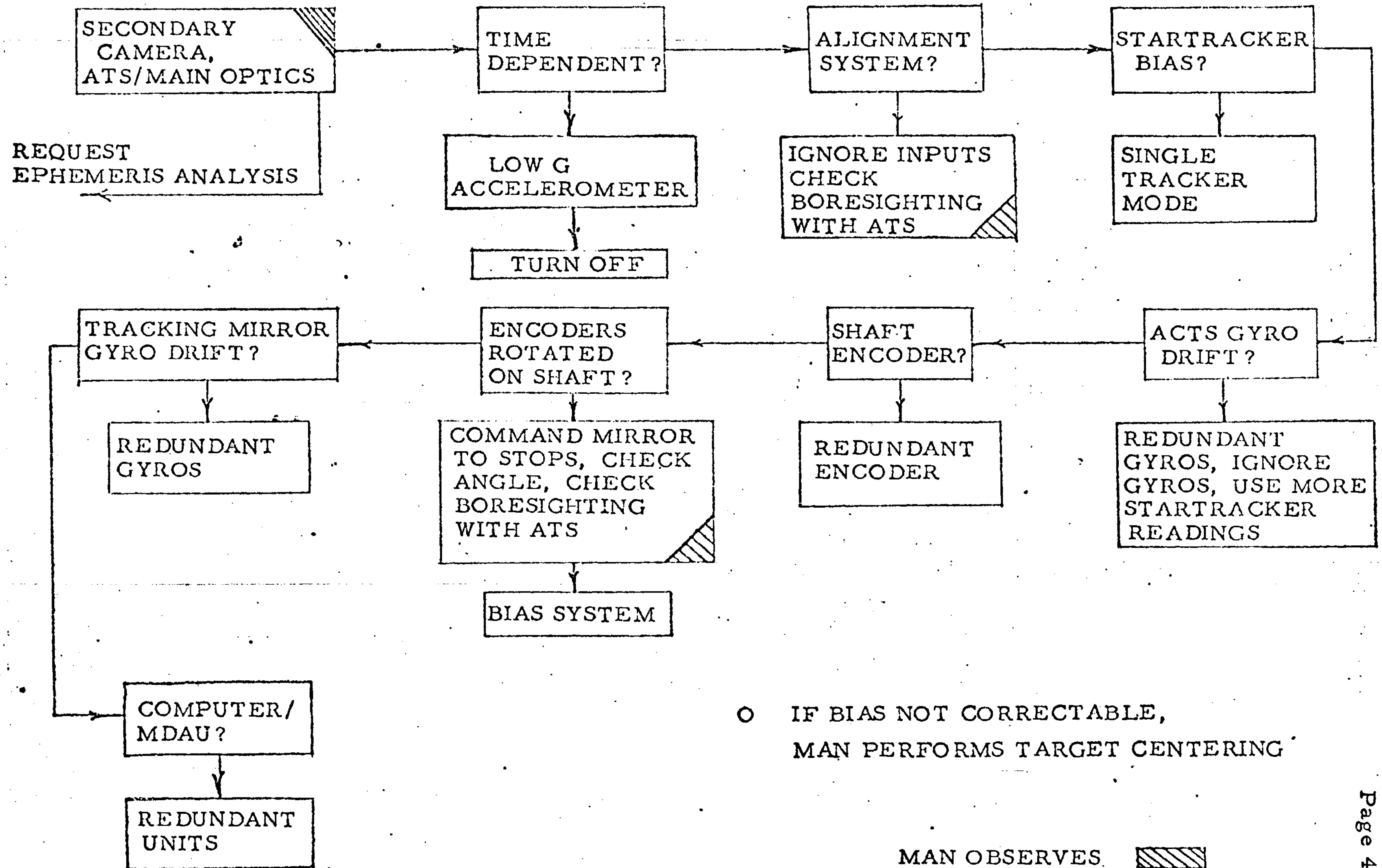


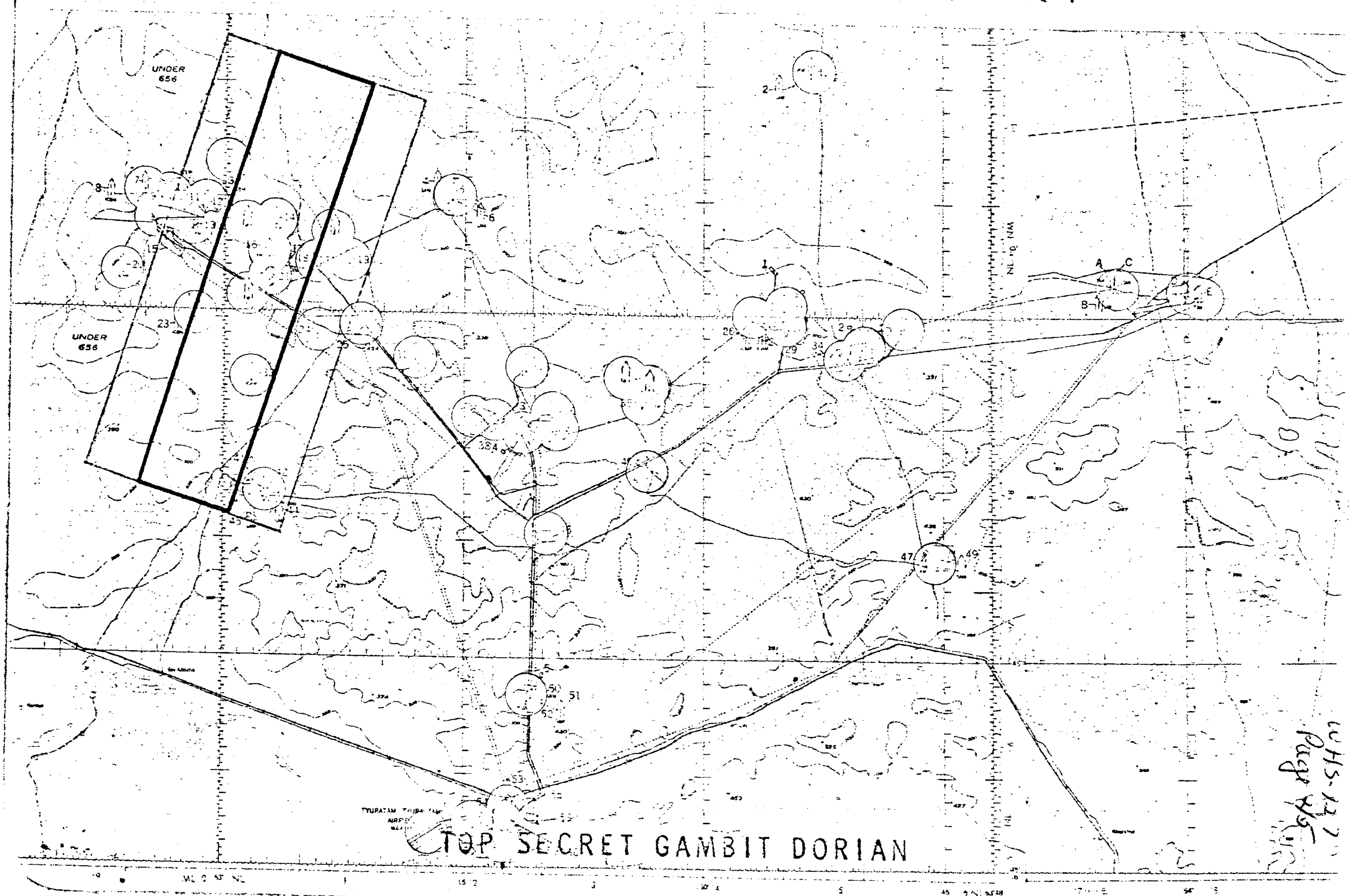
Figure 7

PROBLEM: MAIN OPTICS POINTING ERROR (BIAS)



~~TOP SECRET~~ GAMBIT DORIAN

Figure 9



TOP SECRET GAMBIT DORIAN

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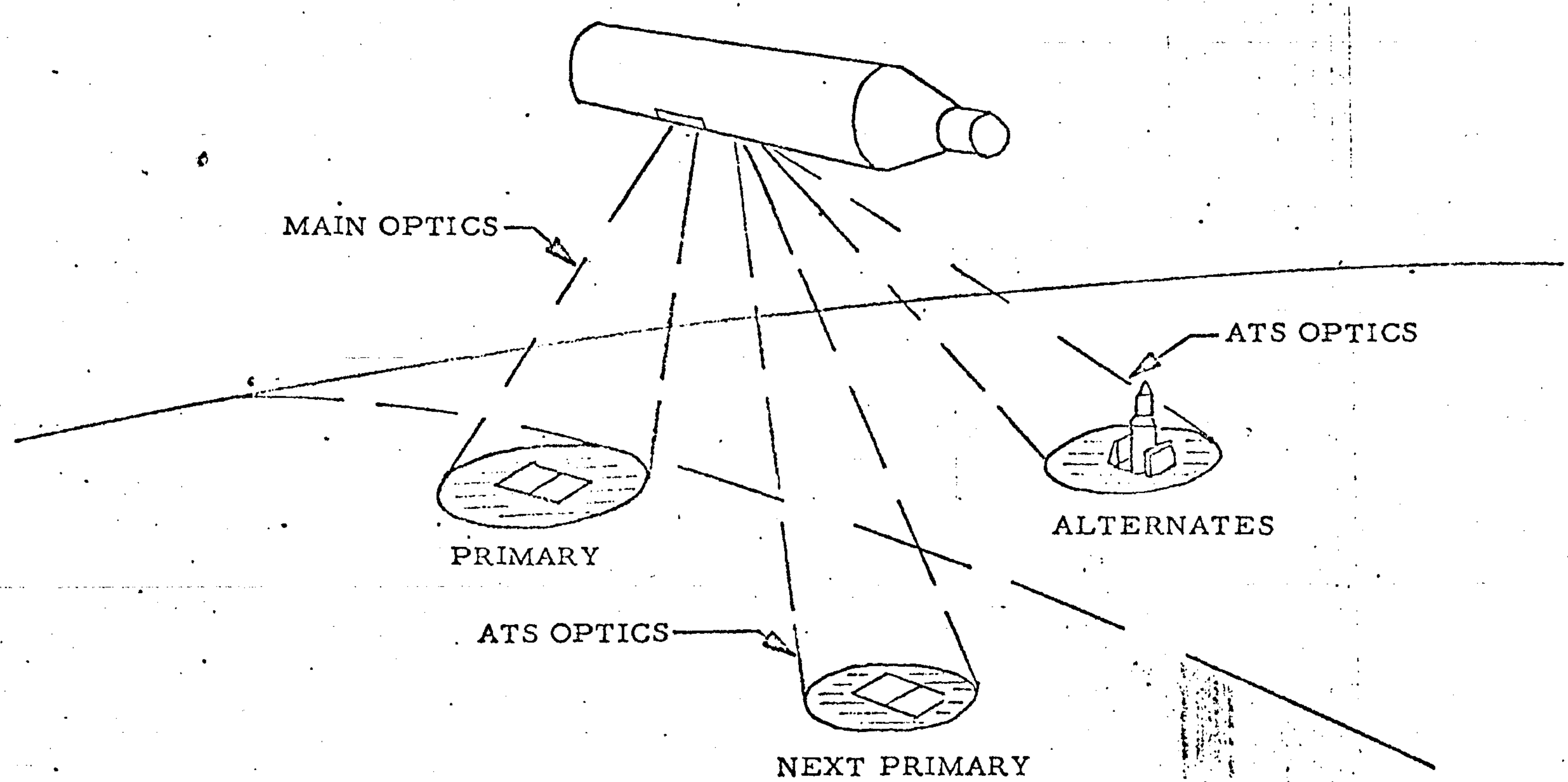
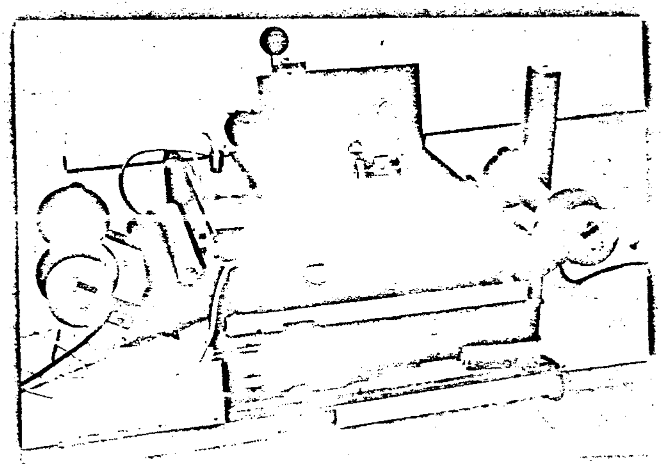
Figure 10

CONCEPT OF MANNED EXAMINATION
FOR
TECHNICAL INTELLIGENCE INDICATORS/WEATHER



- IF EITHER ALTERNATE HAS ACTIVE INDICATORS, TAKE IT
- IF PRIMARY COVERED AND ALTERNATE CLEAR, SWITCH TO ALTERNATE

Figure 11



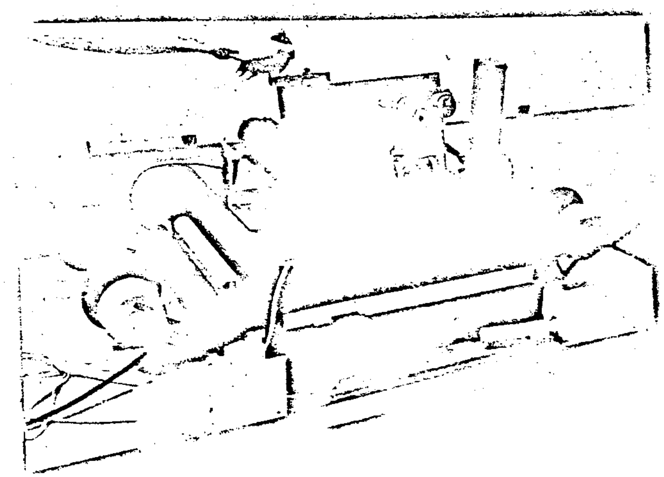


Figure 12

CONCEPT FOR SIMULATOR CONTRAST CALIBRATION

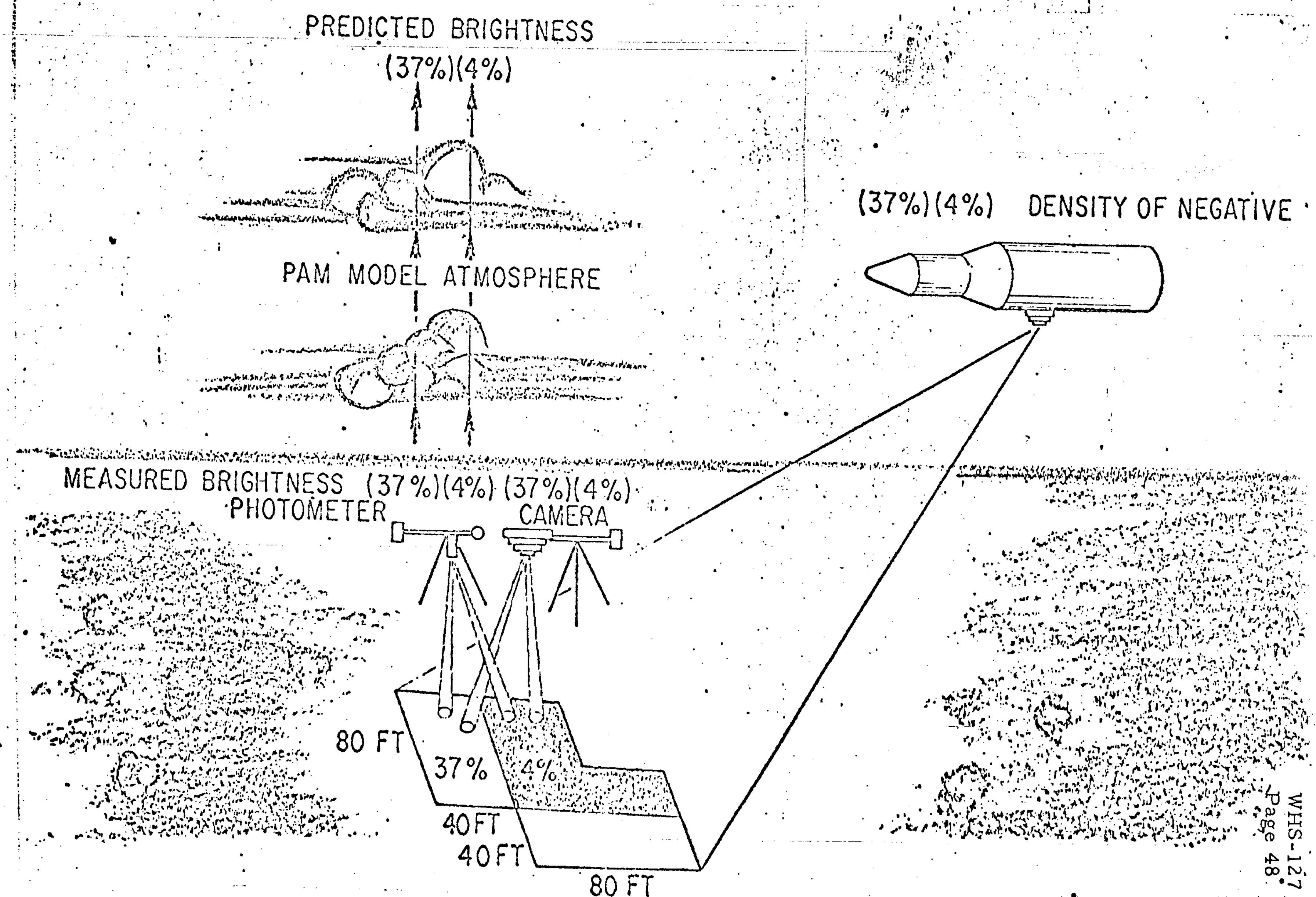


Figure 13

SIMULATOR ILLUMINATION/CONTRAST PARAMETERS

ILLUMINATION LEVEL ~ 3 TO 25 FT LAMBERTS

CONTRAST CALIBRATION (37%/4% TARGETS)

TARGET NO.	BRIGHTNESS RATIO					
	GROUND		ORBITAL			SIMULATOR
	Photometer	Camera	PAM Predicted* (Photometer Input)	"G" Camera Contractor	"G" Camera SPPF	
1	6.2	7.8	3.1	2.4	3.0	2.5
2	6.0	8.2	3.1	2.8	3.1	1.8
3	6.9	10.7	3.4	2.7	2.8	2.9
4	---	16.6	---	2.5	2.7	2.6
AVAILABLE DATA POINTS	11	41	11	45	77	15

* CONSIDERS ONLY VERY LIGHT HAZE

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Figure 14

OVERALL SCORES

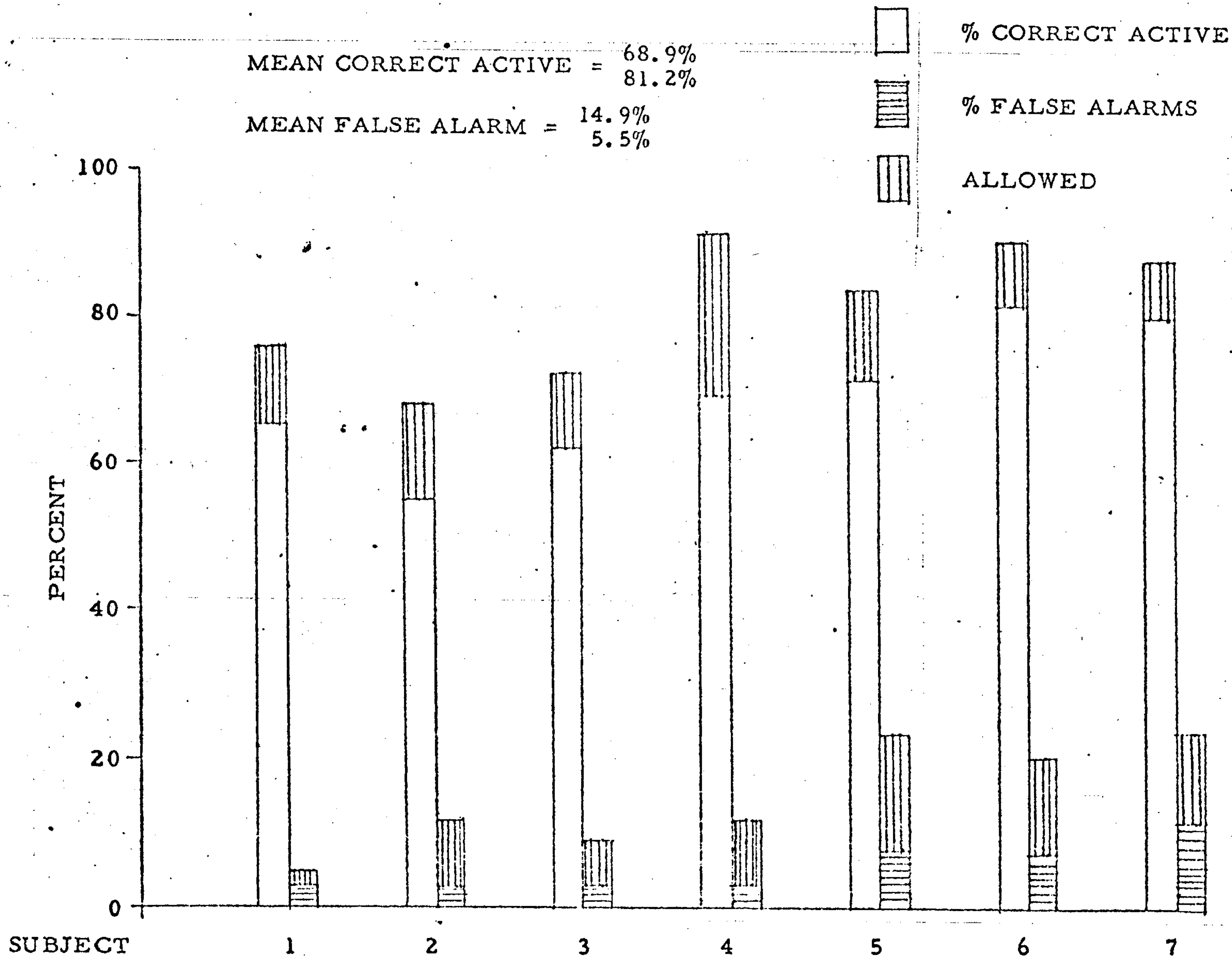

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Figure 15

EFFECT OF ACTIVITY LEVEL

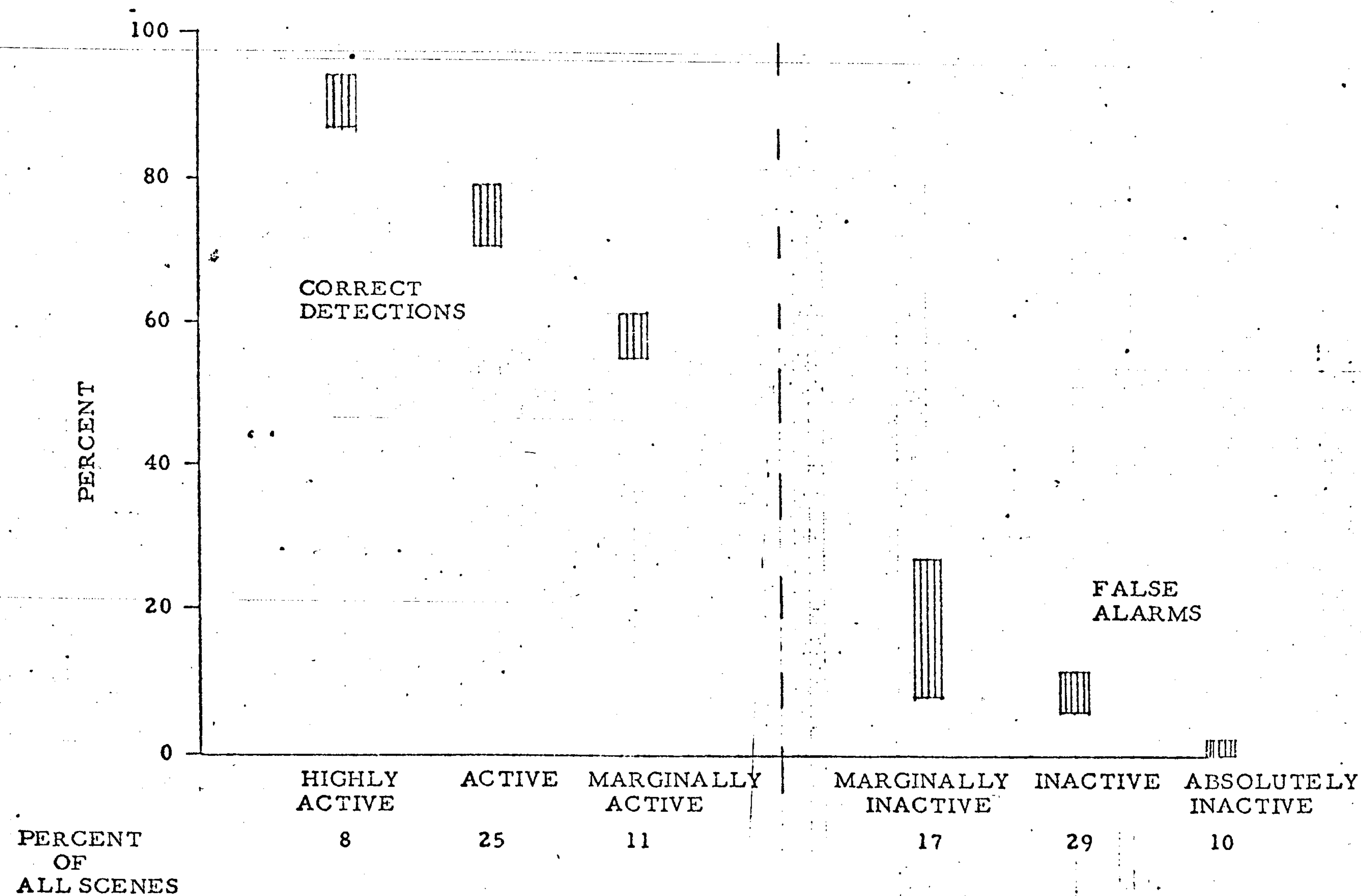

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Figure 16

ACTIVITY LEVEL VS. SCORES

- RESPONSE TIME 6 SECONDS OR LESS

ACTIVITY LEVEL	CORRECT ACTIVE	INCORRECT ACTIVE	ALLOWED INCORRECT ACTIVE	CORRECT INACTIVE	FALSE ALARM	ALLOWED FALSE ALARM
ABSOLUTELY INACTIVE 12%				92%	0	8%
INACTIVE 3%				67%	0	33%
MARGINALLY INACTIVE 5%				20%	20%	60%
MARGINALLY ACTIVE 12%	84%	8%	8%			
ACTIVE 26%	96%	4%	0			
HIGHLY ACTIVE 35%	100%	0	0			

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Figure 17 - ENHANCEMENT FACTOR VS ACCURACY

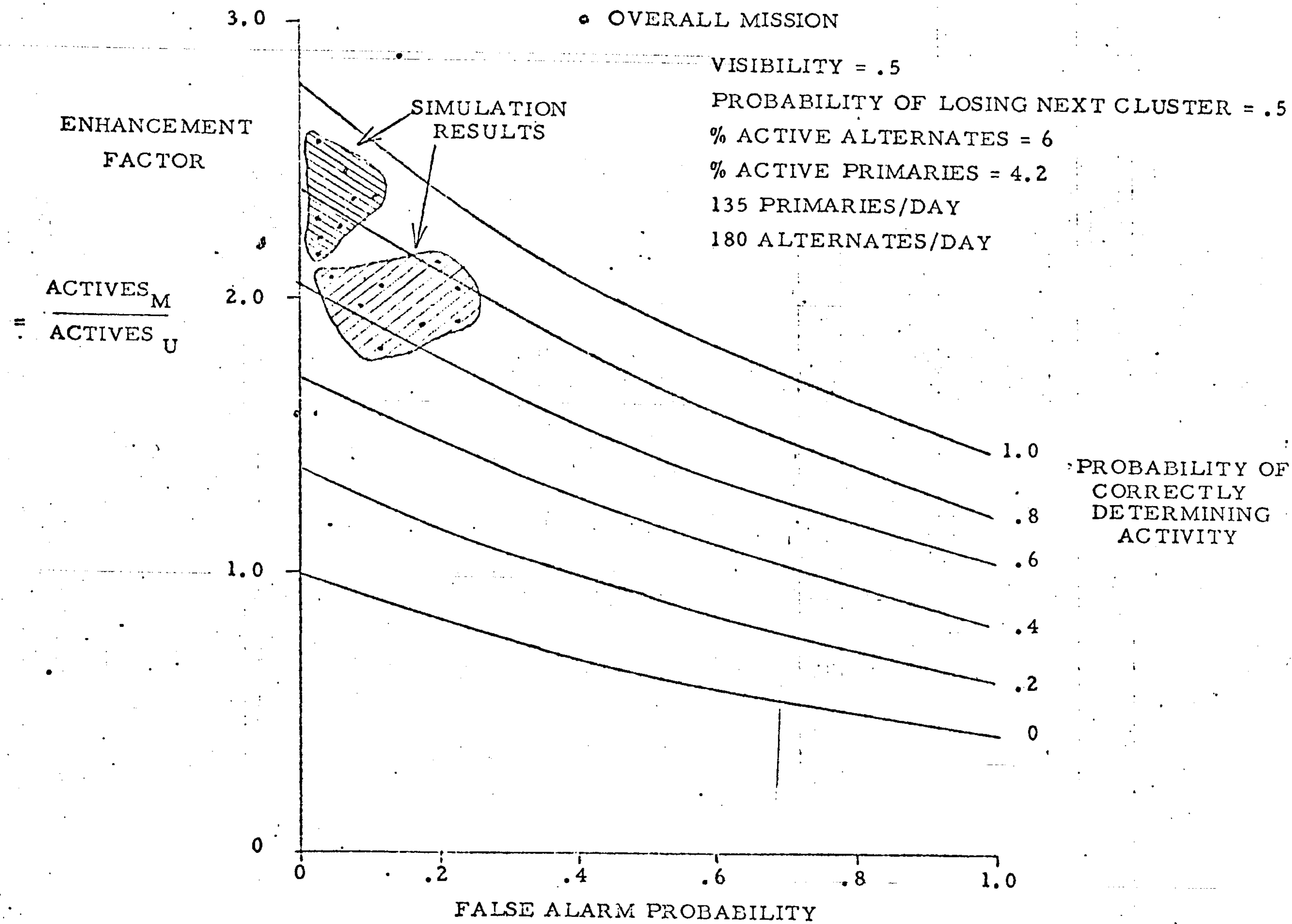

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Figure 18

ACTIVE PHOTO ENHANCEMENT FACTORS FOR CLUSTERED TARGETS

- o 0.5 VISIBILITY
- o 3 ALTERNATES PER CREWMAN

LARGER CLUSTER (~ 100 N. MI.)

- oo 2 PRIMARIES
- oo 2 DECISION POINTS

SMALLER CLUSTER (~ 50 N. MI.)

- oo 2 PRIMARIES
- oo SINGLE DECISION POINT

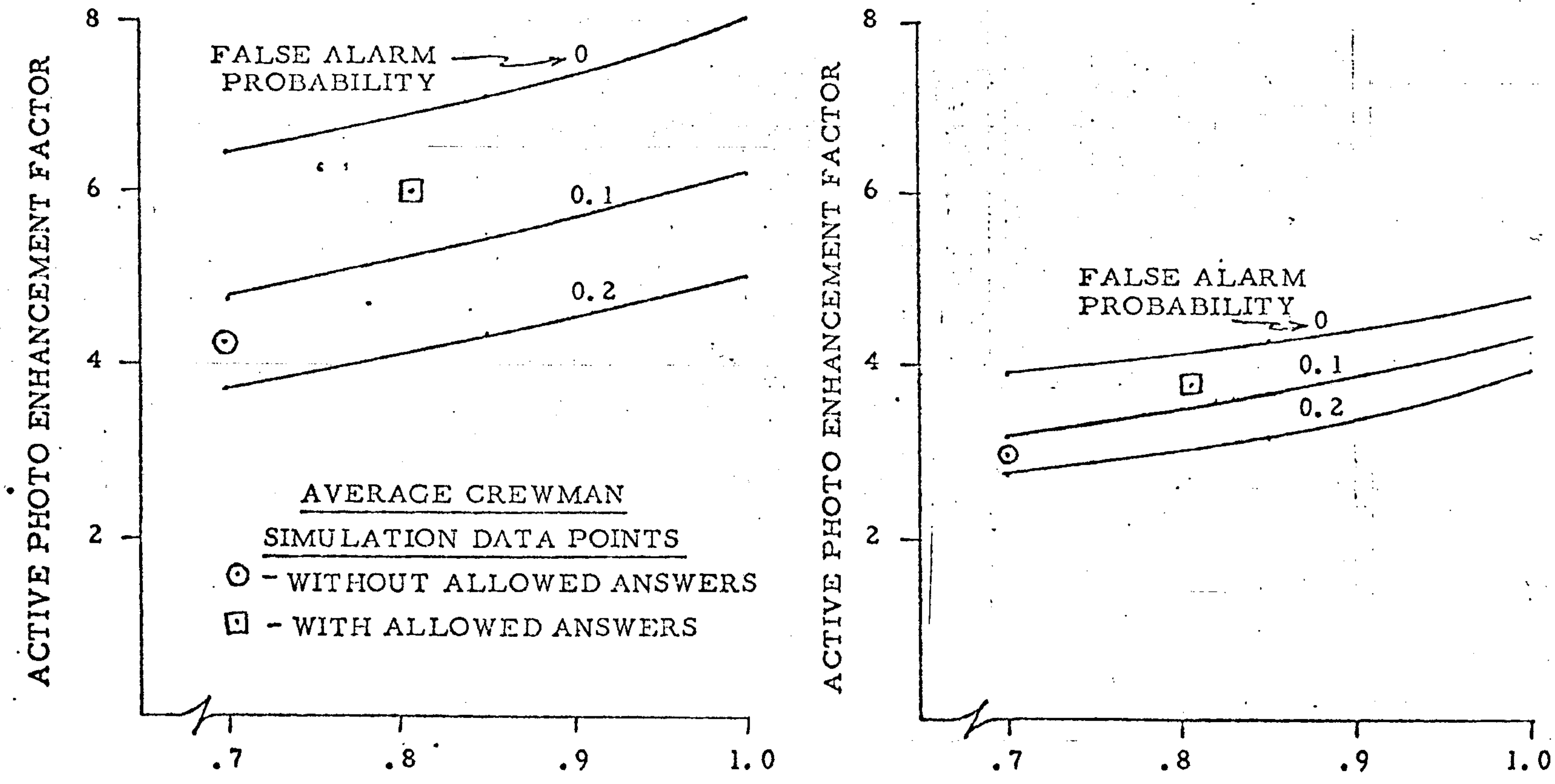

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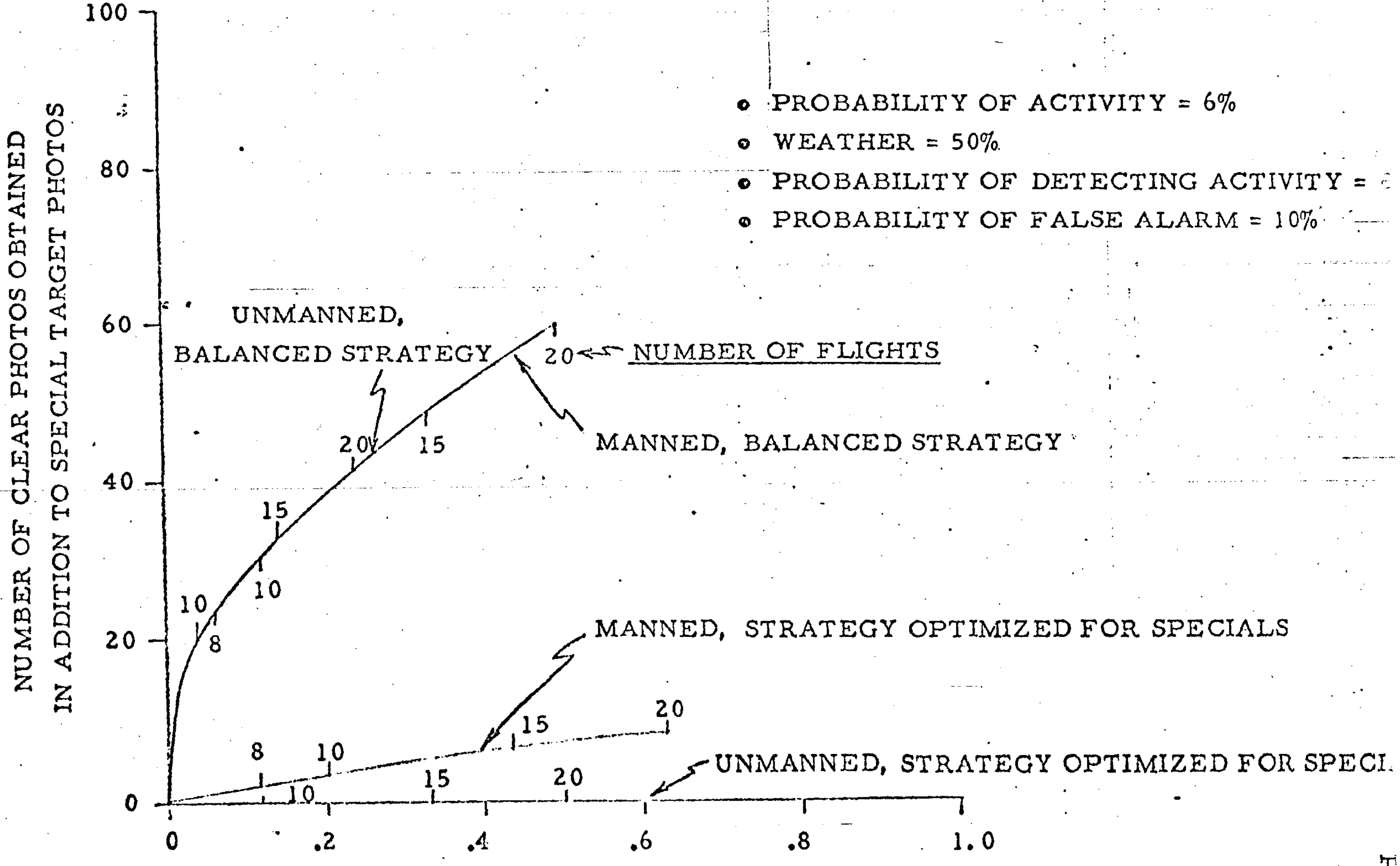
Figure 19

CLUSTER EFFECTIVENESS WITH SPECIAL TARGETS

- CLUSTER WITH MANY AIMING POINTS
- 4 SPECIAL TARGETS WITHIN CLUSTER
- MISSION DURATION= 30 DAYS (4 OVERFLIGHTS)



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