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AN OPERATIONS CONCEPT FOR THE MOL/DORIAN MANNED/AUTOMATIC CONFIGURATION

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I. INTRODUCTION

This document presents some of the current Test Operations Directorate/Aerospace concepts of the operating modes of the MOL/DORIAN manned/automatic configuration. It defines some flight crew procedures and on-board computer logic necessary to implement the flexibilities and capabilities desired and/or required of the manned/automatic vehicle configuration.

Analitical and simulation studies are continually being performed on these concepts and they are subject to modification and verification to ensure positive control, reliability, and the ability to satisfy user requirements.

II. GROUND RULES AND DEFINITIONS

The following ground rules and definitions are generally agreed upon and form the basis for this concept:

A. The primary target path is generated by the ground-based mission planning software. This path is generated by a strategy which considers the following:

1. User requirements expressed as priorities and weighting factors.
2. Orbiting Vehicle (OV) operational status and capabilities.
3. Specific intelligence requirements, including desired stereo or mono modes, exposures, category allocations, and other user inputs.
4. Weather in the area of interest.

B. <u>Primary Targets</u>. Primary targets are those targets which lie on the programmed path for the primary optics. There are two distinct subclasses of primary targets, namely mandatory primary targets and interdictable primary targets.

1. Mandatory Primary Targets. Mandatory primary targets are those targets of unusually high technical intelligence value which, upon user request, will be photographed under any circumstances. Normally photography of mandatory targets should not be inhibited by the Airborne Digital Computer (ADC)/Flight crew.

2. Interdictable Primary Targets. Interdictable primary targets are those targets which lie on the primary optics path and can be interdicted by the ADC based upon flight crew inputs. Targets may be programmed for the path of the primary optics for which photography may be desired only if "activity indicators" are present.

C. Alternate Targets. Alternate targets are defined as any preselected non-primary target which can be observed through an ATS and photographed by the primary optics. Alternate targets are selected by the ground based mission planning software as a function of their geometrical relation to the primary optics path, expected value of mission enhancement, and specific user requirements. There are two basic classes of alternate targets; active alternates and weather alternates.

1. Active Alternates. Active alternates are those alternates that have predefined activity indicators which if found to be present through crew inspection make that target of relatively high intelligence value.

2. Weather Alternates. Weather alternates are those targets which are observed by the flight crew and selected for photography only when weather conditions dictate a change of the primary optics path to secure a visible target for photography.

The main differentiation between the two types lies with the amount of scheduled dwell time allocated for viewing each target. In principal, alternates which are being viewed for weather only require a smaller recommended viewing time than alternates being viewed for activity. Nothing in these definitions precludes the use of an activity alternate for a weather alternate should the situation so dictate.

D. Visual Intelligence Targets. Visual Intelligence Targets are those targets preselected for flight crew inspection and oral comments, but not for photography. Generally these types of targets would be selected for one of the following three reasons:

1. When associated with a mandatory primary.

2. When the confirmation of the presence or the absence of something in the target area, or a verbal description of the target area satisfies intelligence requirements.

3. When vehicle constraints prevent actual photography of the target, or the penalty associated with photography is unacceptable.

E. Flight Crew Inputs to the Computer are:

1. REJECT - used to denote clouds/weather, or other undesirable conditions, which would prohibit satisfactory photography of a target.

2. INACTIVE - denotes that the target is visible but that no "activity indicators" are present.

3. ACTIVE - used to denote that the target is clear and that the pre-defined activity indicators are present.

4. OVERRIDE - used to denote the presence of unusually high intelligence value in a target which should be photographed. This input will cause the computer to commit the primary optics to that target at the decision time without considering other crew inputs for that decision time.

F. The ATS's will be scheduled a path of targets to be viewed. One ATS path will contain all the primary targets and some selected alternate and visual intelligence targets. The other ATS path will contain only alternate and visual intelligence targets. (See Section IV, Figure 3).

It is an operational requirement that the primary targets be scheduled on the same ATS path throughout an active pass over the areas of interest.

G. The ATS will slew to the next target scheduled for viewing within a target group only after one of the four possible flight crew inputs is made to the computer. When the target group decision time is reached, the ATS's will step automatically to the next target group unless the flight crew intervenes. (See Section IV, c.)

H. Decision Times. Decision times are generated by the ground based computer mission planning software. At a given decision time, the inputs from the flight crew are polled and, based upon on-board decision logic, a decision is made whether to interdict the primary optics path in favor of an alternate target.

I. Target Groups. In general, each decision time has associated with it a group of targets which are scheduled to be viewed before that decision time. There are two types of target groups; a basic target group and a special target group.

1. Basic Target Group. A basic target group consists of a group of targets which includes the primary target.

2. Special Target Group. A special target group consists of a group of alternate targets between basic target groups and does not contain a primary target. (Within this group interdiction of the primary path occurs only for an active alternate).

J. Decision Logic for Basic Target Groups. Primary and alternate targets are assigned a preference within the target group for both active and inactive states. For any group, the primary target will always have the highest inactive state preference. These preferences are established through user inputs. A logical table may be constructed which gives the decision rules for interdiction of the primary path. Table 1 below gives the decision logic and assumes that the primary target was viewed.

	Crew Observation at Primary		
Alternate Targets Status	Obscured	Inactive	Active
All Obscured	Take None	Take Primary	Take Primary
No Active But at Least One Clear	Vote Among Alternates	Take Primary	Take Primary
At Least One Active	Vote Among Alternates	Vote Among Alternates & Primary	Vote Among Alternates & Primary

TABLE 1

For further explanation of the above table the following comments are made:

1. When a vote is made among clear inactive alternates and the primary is obscured, it is possible that no clear alternate will be of sufficient value to interdict the primary path.

2. When activity is discovered in an alternate, it will still be necessary to weight this value against the existing value (active or inactive) of the primary.

3. In the absence of flight crew inputs, the main optics will track and photograph the primary targets.

K. If the crew does not observe and input to the ADC on the primary target, the ADC will consider the primary to be inactive and clear.

L. <u>Decision Logic for Special Target Groups</u>. The two basic logic rules which are followed for special target group interdiction are:

1. If the observed alternates are obscured by weather, then no interdiction occurs.

2. If at least one of the observed alternates is active, then a vote is taken among the alternates.

M. Validation of vehicle performance for unmanned flights shall be accomplished on the manned flights.

N. The capability to slave the primary optics to either ATS is an operational requirement arising from system diagnosis/contingency needs.

O. Flight crew displays and controls shall be implemented to give the necessary information and control capability to implement this concept. (See Displays and Controls, Section IV).

III. ORBITING VEHICLE OPERATING MODES AND FEATURES

There are two basic modes of operation for the manned/automatic vehicle configuration. Mode A is the automatic mode in which the mission payload and its subsystems are operating properly, and all target centering, image motion compensation (IMC), and photography are accomplished without crew assistance. The flight crew's functions in this mode range from enhancing the technical intelligence of the photography through the target selection process, to completely checking out the operation of the automatic systems. Mode B is the backup mode in which the crew is required to assist in centering, IMC, or other functions which the crew can perform, but which normally would be satisfactorily accomplished on computer command in Mode A. Mode B stresses continued use of all available automatic features that are operational.

Both of these operating modes provide a wide range of flexibility so that the system can be responsive to user and/or contingency requirements. This flexibility is attained, wherever possible, without requiring changes in the ADC logic.

The ground-based mission planning software will be required to handle these modes and sub-modes to obtain the optimum strategy for the ATS, main optics, and the flight crew.

A. Mode A (Manned/Automatic)

Mode A consists of two basic operational sub-modes which may be employed depending on the degree of confidence in the operation of the complete system in the manned/automatic configuration or on the degree of diagnosis or verification desired of payload performance.

1. Operational Sub-Mode I. This sub-mode assumes that all automatic functions are being performed satisfactorily. Either or both ATS's (depending on one or two-man operation) are assigned targets for crew inspection. Crew inputs are gathered by the computer and the computer selects the target in each target group for photography. Provisions are currently available for seven alternates per primary, making the maximum size of any target group eight targets. (Studies and trade-offs have been, and will continue to be, made in an attempt to obtain an optimum number of targets in a target group. These studies and trade-offs include computer core storage available, up-link data time requirements, flight crew capabilities, target distribution and density, and total time available for viewing any one target group.) The Flight crew would view as many targets per target group as possible, indicating their observations to the computer. Targets would be viewed (including the primary) in a ground selected order. This order may be selected chronologically; i.e., when the best viewing angles, etc., are proper, or may be selected in order of preference within the group. Any alternate target in a target group not viewed by the decision time would be rejected by the computer from consideration for photography within that group.

If the primary has not been viewed, due to time limitations, the primary will be considered inactive (and clear) in the decision process. Any target of the group may be checked only for weather conditions or for the presence of "activity indicators" depending on the instructions given to the flight crew by the Mission Director. Generally, weather decisions would be accomplished much more rapidly than activity decisions.

This sub-mode provides the greatest number of targets to be viewed, thus increasing the chances of enhancing the technical intelligence content of the mission results. It also provides weather verification in the target area.

2. Operational Sub-Mode II. In this sub-mode one crewman observes the selected target through the main optics while it is being tracked and photographed. This provides the highest degree of verification of weather and/or evaluation of the systems manned/automatic performance. It is also possible to view the selected target through the ATS while it is being tracked and photographed. This capability requires different operating procedures for the flight crew (see Section IV, c). Fewer targets will be viewed by the flight crew prior to the decision in this mode because one crewman is busy viewing through the main optics when he could be viewing and making inputs on targets in the next group. This mode will be very useful in verifying, diagnosing, and evaluating automatic systems performance.

This sub-mode may be further modified to require that one crewman continually observe through the main optics during slewing and settling, as well as during tracking and photography.

No mode changes within the airborne digital computer (ADC) are necessary to implement all the provisions of this sub-mode; however, the mission planning software should take them into account to maximize the efficiency of the ATS schedules.

B. Mode B (Back-Up). This mode assumes that flight crew intervention, in some way, is necessary to allow successful photography. No attempt is made here to identify every possible flight crew action or operating mode that may be dictated by circumstances. Several operational sub-modes are identified which illustrate how some of the main system failures are handled by the flight crew. Continuous study is underway to insure that the maximum capability of the mission payload is maintained as much as humanly possible for every malfunction. Contingency analysis and crew procedures will be developed through simulation throughout program development. Displays and controls will be modified as necessary to insure satisfactory accomplishment of the mission objectives.

1. Operational Sub-Mode I. This sub-mode is utilized whenever the Image Velocity Sensor (IVS) is not operating satisfactorily (automatic fine rate-killing not available). This sub-mode requires that one crew member view the target selected for photography through the main optics and manually, through a controller, do the fine rate-killing task. This will reduce the number of targets viewed prior to a decision time because one crewman will be tracking the selected target when he could have been checking targets in the next group. This mode may be operated by both crewmen with either a "leapfrog" or "specialist" technique. In either event, either of the two ATS paths may be followed by the crewman making inputs for the target selection process. This sub-mode requires no changes within the on-board computer. The signal from the IVS will be

inhibited by the crew, and manual controller tracking information will be supplied by the flight crew.

2. Operational Sub-Mode II. This sub-mode is utilized whenever the automatic target centering/gross rate-killing is degraded but the IVS is working properly. This mode requires that both crewmen center and provide gross rate-killing on targets inspected in the group to update pointing angles and tracking information for the computer. At decision time, the computer would select a target, apply the corrections, and slew and settle the main optics on that target. The IVS should then fine rate-kill to provide satisfactory photography of that target. This mode will reduce the number of targets viewed prior to decision time due to the increased requirements on the crew to center and track targets in their ATS's.

This sub-mode requires no changes in on-board computer operation, just the capability for the on-board computer to accept updated target position and tracking information. This capability is an operational requirement.

3. Operational Sub-Mode III. This sub-mode assumes that target centering/gross rate-killing and the IVS are all operating in a degraded or unsatisfactory manner. This sub-mode is similar to I and II and combines the features and handicaps of both. In this mode, it is preferable to view the primary target first through the ATS and concentrate on assuring good photography of it throughout the time normally spent evaluating the whole target group. Provisions are provided to make this possible with no change in the on-board computer logic. (See Displays and Controls, Section IV.) This sub-mode may be operated with either a "leapfrog" or "specialist" technique.

4. Operational Sub-Mode IV. This sub-mode assumes that the pellicle in the main optics is degraded to the extent that neither the IVS or primary optics viewing are available for fine rate-killing, such as caused by a damaged pellicle. In this mode the main optics would be slaved to the ATS, after a target is selected for photography. The ATS would be held on the primary target from initial acquisition until the completion of photography, and fine rate-killing to the main optics would be supplied by the flight crew through controller inputs determined by viewing the target through the ATS. Moderate resolution could be obtained when operating in this sub-mode. This submode can only be operated through a "leapfrog" technique by the crew and a very limited number of alternate targets could be utilized.

IV. DISPLAYS AND CONTROLS

This section discusses the displays and controls which are currently baselined for the mission bays (#2 & #8) of the OV. Extensive simulation and contingency analysis will be accomplished throughout program development to insure adequate flight crew back-up capability while maintaining overall system reliability and response to user requirements. Figure 1 shows a schematic of a typical mission console.

Only the displays and controls necessary to implement the operations concept will be discussed here. Other displays and controls provided for crew information or to enhance photographic quality will not be covered.

A. ATS Path Controller Switch. This switch is a three position switch located on each mission console which selects the path followed by the ATS on that console. From either console, either of the two ATS paths may be selected. Both ATS's may follow the same path which facilitates a leapfrog operation in Mode B. The third position of this switch is labeled "PRIMARY". When the ATS controller switch is placed in this position, three things happen:

1. The ATS path which contains the primary targets is selected for viewing.

2. All alternate targets on that path which were scheduled to be viewed prior to the primary target of each group are deleted.

3. The automatic stepping function of the ATS is inhibited for active, inactive, or override inputs to the computer.

Alternate targets scheduled for viewing after the primary of each group are still available for viewing and photography if the primary is covered. Activating the REJECT button will cause the ATS to slew to any remaining alternate of the group on the path containing the primary targets.

The PRIMARY position of this switch allows implementation of Mode B, Operational Sub-Modes III and IV. These sub-modes will require a crew member to operate on a primary target from initial acquisition in the ATS through tracking and photography of the target.

The ATS path 1 and 2 positions allow selectivity in the path to be monitored during one-man operation (if two paths are supplied by the ground-based mission planning software) and are useful in implementing various forms of leapfrog, specialist, or hybrid operations when operating in Mode B.

B. Acquisition Scope Eyepiece Display System. This display system is composed of a time display and an information display. These displays are common to both ATS eyepieces. (See Figure 2.)

1. Time Display. This display consists of an outer ring of twenty-five small white lights and an inner ring of twenty-five small green lights. The appropriate number of white lights are lit at the start of viewing of a particular target group to indicate the total seconds remaining until the computer will make a photographic decision on that target group. These lights will wipe out at one second intervals until decision time is reached at which time the display will be re-initialized by the computer for the next target group.

The small green lights will be selectively lit by the computer to denote ground computed recommended maximum viewing times for a particular target of a group. In the example given in Figure 2, if twenty white lights were lit, there would be twenty seconds to group decision time. As the white lights wipe out at one second intervals, they will pass the first illuminated green light (approximately six seconds later). A decision should be input to the computer on the first target viewed by that time. The same information is supplied for the second and third target represented by green lights that are lit. This display provides the additional information of how many targets are scheduled to be viewed on that ATS path in each target group.

2. Discrete Target Status Lights. Ten small lights are provided in each eyepiece to provide the flight crew the following information:

(a) Primary target being viewed.

(b) Active Indicator target being viewed.

(c) Weather alternate being viewed.

(d) Visual intelligence target being viewed.

(e) Mandatory primary being viewed.

(f) Benchmark target being viewed.

In principal, much more information could be displayed to the crew including cueing information, i.e., the class of target being viewed, etc., through the use of a simple code. Simulations will be accomplished to determine just how much information can be given to the flight crew on this display without detracting from their primary task of target viewing. An additional ten small discrete lights are provided at present for possible cueing information.

C. Acquisition Hold Button. Depressing this button allows the flight crew to continue tracking a target with their ATS after the group decision time has been reached. This button, in conjunction with the PRIMARY position of the ATS controller switch, allows the primary target to be tracked from initial acquisition through the completion of the photographic sequence on the ATS if desired. To release the ATS to the next target group, the REJECT button must be depressed. This will not be interpreted by the computer as a target input.

D. Main Optics Eyepiece Display System. Displays in the main optics eyepiece are being studied, which will give the crew some or all of the following information:

1. A timer wipeout of the scheduled photographic sequence for the selected target.

2. Event indicators to supply the scheduled number of exposures and relative exposure times (allows improved centering between frames if sufficient time available).

3. Secondary camera scheduled exposure.

The amount of information incorporated in the main optics eyepiece display will be determined on the basis of operational need, complexity, and system cost. Simulations will be used to verify the requirements

E. Primary Optics/ATS Magnification/Zoom Controller. This controller is a throttle type controller which controls the magnification of the ATS in the lower range and the primary optics in the upper range. Moving the controller from the highest magnification on the ATS to the primary optics range (left) releases the ATS to step ahead to the next target group if it has not already done so. The controller has three of the flight crew target input buttons located on it (ACTIVE, INACTIVE, and REJECT).

F. Override Button. Each mission console has an OVERRIDE button located on it. It is purposely remote from the other target input buttons. This button will operate on a first-come-first-served basis when used on any target in a group and will then be inactivated until the next target group. This button is used to commit the main optics to a particular target in a group without considering the computer target selection logic. It is envisioned that this button will only be used on the extremely rare occasions that a particular target is so highly "active" (much more so than that activity indicated by the pre-defined activity indicators) that it is of extremely high technical intelligence value.

G. Primary Optics Control Switch. This switch is located on panel 1 C and allows the primary optics to be switched from console to console as directed by the computer (automatic position) or to be manually locked to one console or the other. It will be useful for one-man operations or for implementing "specialist" operations in Mode B. In the "automatic position", the computer will assign the primary optics to that console which made the target input that was dominant in the target selection logic.

H. Rate Null Switch. The IVS may be turned "on" or "off" with this switch. If the IVS is malfunctioning, as indicated by the IVS SATURATE light or as determined through primary optics viewing, it may be turned off by the flight crew and IMC can then be done through the control stick.

I. Control Stick. A single control stick is present on each mission console which controls both the ATS and main optics. ATS control is available any time the ATS is "on" and the magnification controller (See E.) is in the ATS range. In order to accomplish manual IMC, the primary optics must be assigned to that mission bay (automatically or manually), the magnification controller must be in the primary optics range, and the IVS switch must be "off".

J. Computer Update Button. When the computer update button is activated, the computer updates the position and tracking rate of the target being viewed. This allows centering and gross rate-killing corrections made in the ATS to be passed on to the primary optics by the computer. If the target being viewed is flagged by the mission planning software as one whose geographic position is very accurately known, (i.e., benchmark target) then the position update will be applied to update the ephemeris (landmark navigation).

V. SUMMARY

This concept, in its present form, stresses:

A. A simple flight crew/computer interface in the target selection process.

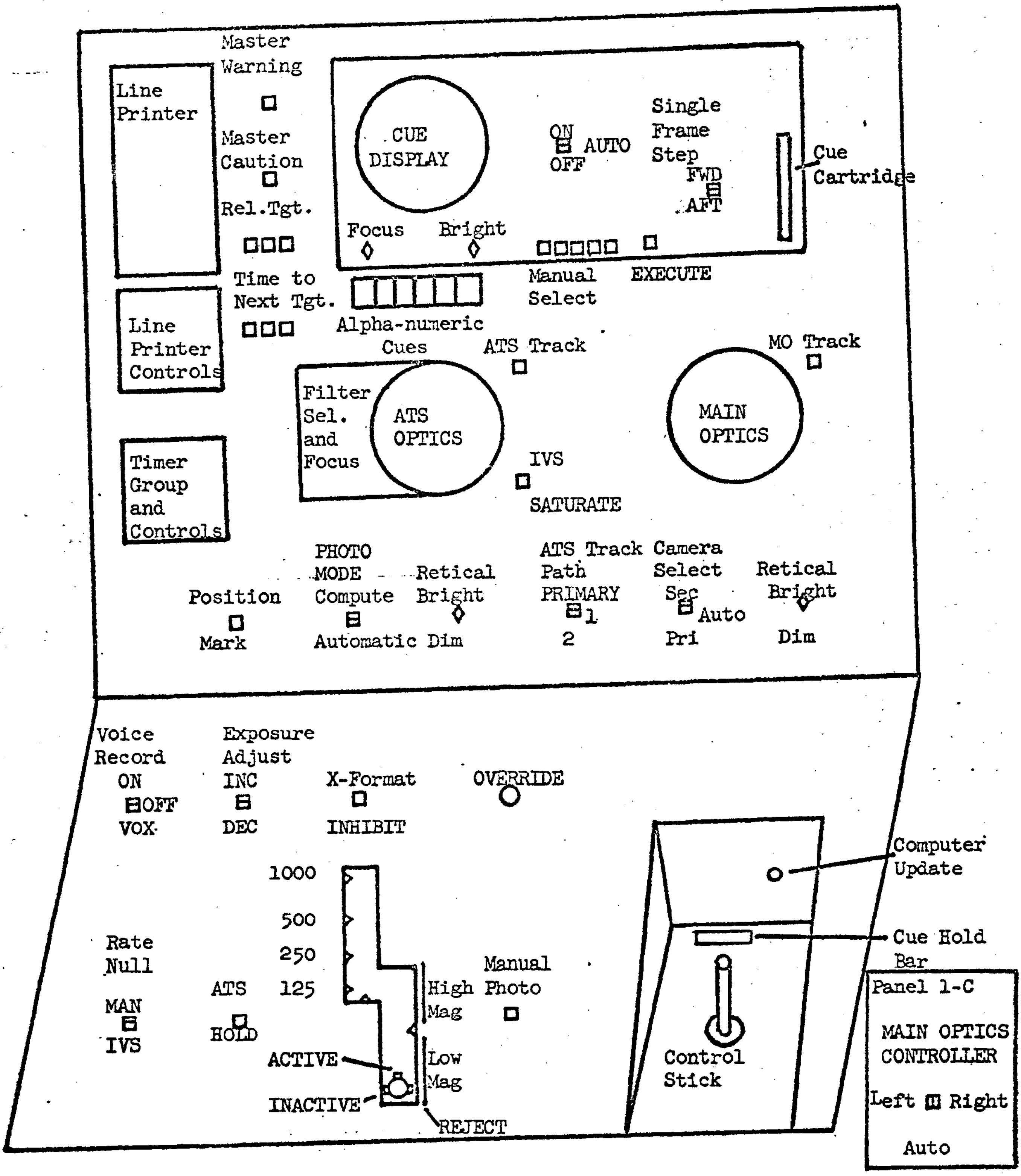
B. Flight crew capability for immediate reaction to mission contingencies with minimum mission degradation.

C. Validation for unmanned flights.

D. No on-board computer logic changes to handle contingency situations.

E. The requirement for the mission planning software to efficiently handle various operating situations.

Operations concepts for the MOL/DORIAN system will be continuously studied as the program develops. Effort will be applied to insure reliability, flexibility, response to user requirements, and the accomplishment of all mission objectives.



TYPICAL MISSION BAY DISPLAYS AND CONTROLS SCHEMATIC

Figure 1

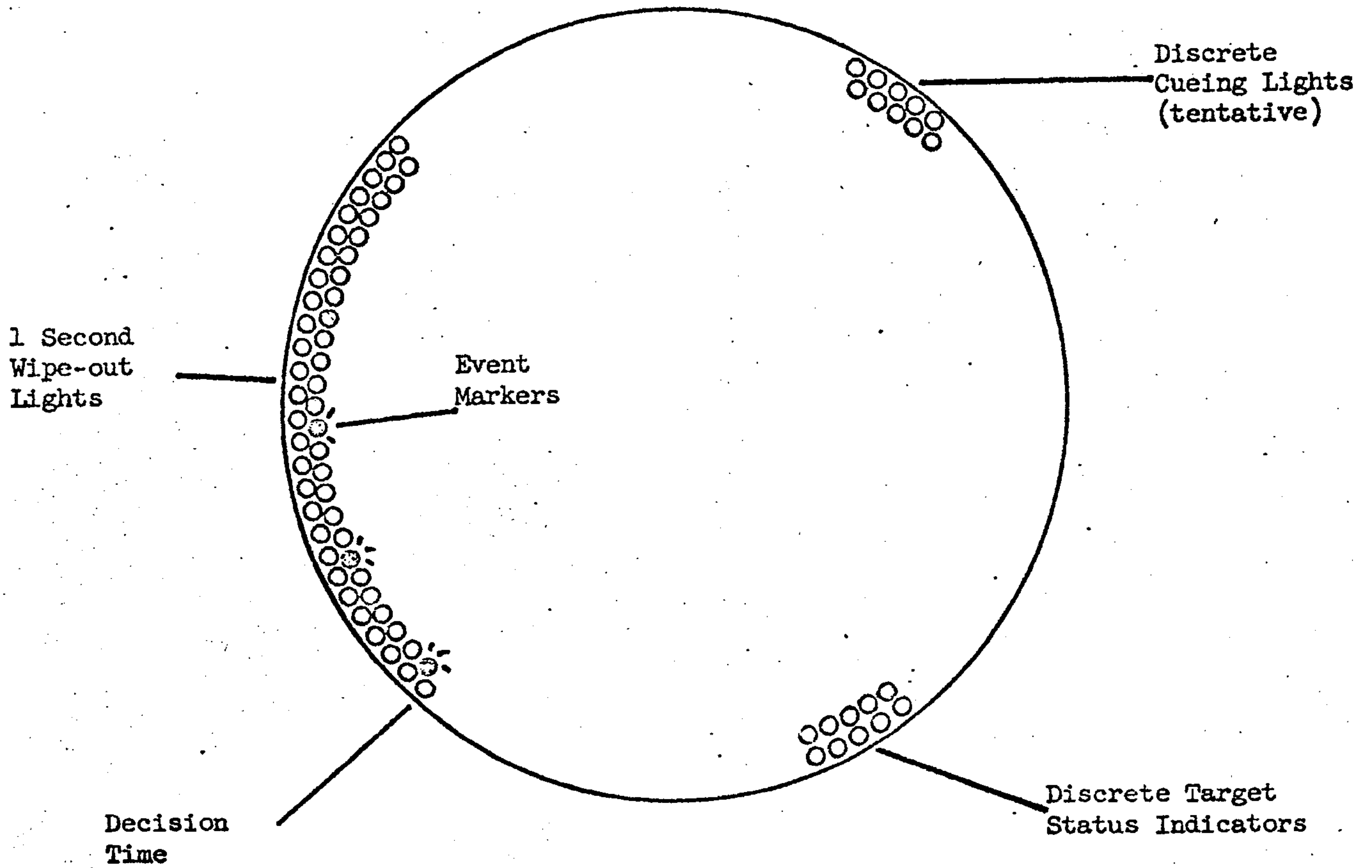


FIGURE 2 - ATS EYEPIECE DISPLAY

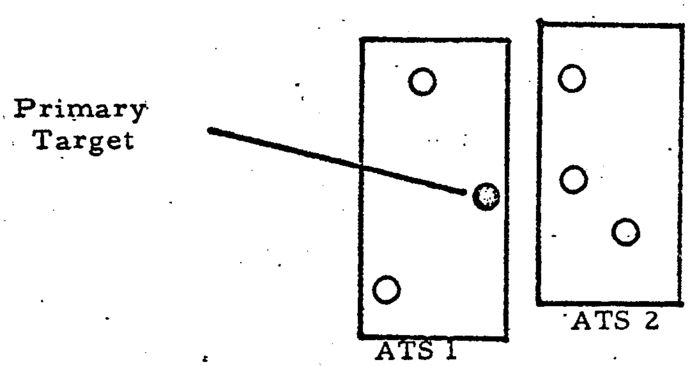


FIGURE 3 - ILLUSTRATION OF ATS PATH TARGET ALLOCATION