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VISUAL SEARCH PERFORMANCE IN SIMULATED REMOTELY PILOTED VEHICLE UTILIZATION AS A FUNCTION OF AUXILIARY TASK LOADING ON THE OBSERVER

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HUMAN FACTORS TECHNICAL AREA

U. S. Army
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Baseline data were obtained on how well observers could extract information from a TV monitor while performing auxiliary tasks under task loading conditions that might be encountered in use of a remotely piloted vehicle (RPV) as the sensor platform.

A simulation facility was used. It contained a terrain model, a TV camera transport, hybrid computing equipment, and a television display and control console.

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Six pilots and six nonpilots participated in the three-phase effort. Phase A required participants to detect and recognize tank-sized targets in open and cluttered backgrounds from a simulated altitude of 2,000 feet and a simulated RPV velocity of 100 knots. Phase B required participants to monitor and correct deviations in the RPV course and altitude and to respond to two visual warning indicators. Phase B tasks were presented at two rates: one per 10 seconds and three per 10 seconds. Phase C combined the tasks of Phase A and Phase B with concurrent task demands upon the participants.

Increasing the auxiliary load level decreased the probabilities and ranges of target detection and recognition. Target acquisition task demands similarly increased auxiliary task response times. Cluttered background significantly degraded target acquisition task performance, particularly when the auxiliary task was performed concurrently.

While the results of the research are important to military management, research scientists will be the principal readers of the report.

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Image Interpretation

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FOREWORD

Research in the Human Factors Technical Area involves the demands of the future battlefield, which will require increased man-machine complexity in systems to acquire, transmit, process, disseminate, and utilize information. The research focuses on the interface problems and on interaction within command and control centers and concerns such areas as topographic products and procedures, tactical symbology, information management, user-oriented systems, staff operations and procedures, and sensor systems integration and utilization.

Of special interest in sensor systems are human factors problems in presenting and interpreting surveillance and target-acquisition information. A new source of intelligence information now being explored is the remotely piloted vehicle (RPV). The RPV can be equipped with various sensors whose data are telemetered to a ground control station. The ground control station operator then extracts information from transient data and may also be operating or monitoring the RPV, its flight path, and payload. This report deals with operator performance using one possible RPV sensor--a television camera. Results of the research indicate that assigning the ground station operator to carry out both the auxiliary task and the target detection/recognition task will degrade performance of both tasks under some conditions.

Research in the area of sensor system integration and utilization is conducted by the Army Research Institute as an in-house effort augmented by contracts with organizations selected as having unique capabilities and facilities for research in the area. This project was conducted with personnel from Rockwell International Corporation, Columbus, Ohio, under contract DAHC19-76-C-0011 with the program directed by Robert S. Andrews. The effort was responsive to requirements of Army Project 2Q762717A765 and to special requirements of the Assistant Chief of Staff for Intelligence, the U.S. Army Intelligence Center and School, Fort Huachuca, Ariz., and the U.S. Army Field Artillery School, Fort Sill, Okla. (Special requirements are contained in HRN 75-11.)

JOSEPH ZEIDNER
Technical Director

VISUAL SEARCH PERFORMANCE IN SIMULATED REMOTELY PILOTED VEHICLE UTILIZATION AS A FUNCTION OF AUXILIARY TASK LOADING ON THE OBSERVER

BRIEF

Requirement:

To obtain baseline data concerning observer performance in extracting information from a television monitor while performing auxiliary tasks under task-loading conditions like those that might be encountered in utilizing a remotely piloted vehicle (RPV) as the sensor platform.

Procedure:

Twelve participants took part in a three-phase effort, in a simulation facility. Phase A required the participants to detect and recognize tank-sized targets in open and cluttered backgrounds from a simulated altitude of 2,000 ft and at a simulated RPV velocity of 100 knots. Phase B required the participants to perform simulated flight tasks: to monitor and correct deviations in the RPV course and altitude and to respond to two visual warning indicators. Phase B tasks were presented at two rates: one per 10 seconds and three per 10 seconds. Phase C required the participants to perform the tasks of Phases A and B concurrently.

Findings:

Performance of auxiliary tasks decreased the probabilities and ranges of target detection and recognition. Increasing the load of the auxiliary task heightened this effect.

Target detection/recognition performance was poorer with cluttered than with open background. Auxiliary tasks degraded performance on the target detection/recognition task more with cluttered than with open background.

Response times to the auxiliary task were increased by concurrent performance of target detection/recognition tasks. Response times to auxiliary tasks did not depend on the rate of task presentation.

Utilization of Findings:

These findings provide some basis for establishing doctrine and procedures concerning allocations of auxiliary tasks to an RPV ground station operator. When a mission is likely to involve targets that are difficult to detect, few or no auxiliary tasks should be assigned to the operator. When targets are relatively easy to detect, an operator can perform other tasks with only a small loss of surveillance effectiveness.

These findings are of interest in military surveillance, although this report will be read primarily by other scientists.

VISUAL SEARCH PERFORMANCE IN SIMULATED REMOTELY PILOTED VEHICLE UTILIZATION AS A FUNCTION OF AUXILIARY TASK LOADING ON THE OBSERVER

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VISUAL SEARCH PERFORMANCE IN SIMULATED REMOTELY PILOTED VEHICLE UTILIZATION AS A FUNCTION OF AUXILIARY TASK LOADING ON THE OBSERVER

INTRODUCTION

Remotely piloted vehicles (RPVs) are being considered for use as sensor platforms in real-time TV surveillance, reconnaissance, and target acquisition. Thus, the ground station operator not only would be faced with extracting information from transient TV images, but might also be involved in operating or monitoring the platform systems, the flight path, and the payload (sensor and/or camera). These latter tasks might interfere with the operator's performance of the surveillance/reconnaissance task, because they could use up the operator's reserve capacity--a capacity that exists when only the surveillance/ reconnaissance task needs to be performed.

The available evidence indicates that a secondary task can affect performance of the primary task in a variety of situations. For example, Garvey and Taylor (1959) designed two tracking systems, operable with equal accuracy but requiring different degrees of effort. Secondary tasks of various types impeded performance more on the difficult tracking system. Noble, Trumbo, and Fowler (1967) found that a secondary task requiring attention but no overt response did not interfere with a concurrent tracking task. However, Johnston, Greenberg, Fisher, and Martin (1970), and Trumbo and Milone (1971) found that a secondary task involving the learning of verbal material but requiring no overt responses did interfere with tracking performance. Subsequently, McLeod (1973) showed that tracking performance deteriorated when an additional task was performed concurrently. Equal decreases in performance were observed for overt and covert response conditions.

Thus research has shown that a secondary task adversely affects performance of the primary task, and similar results can also be expected from assigning the RPV operator more than one concurrent task.

The extent of the performance decrement in the surveillance task caused by the concurrent performance of the auxiliary task cannot be predicted from results of previous studies; data were collected with different tasks and experimental conditions and do not permit extrapolation.

OBJECTIVES

The general objective of this research was to obtain baseline data on observer performance in extracting information from a TV monitor while performing auxiliary tasks under task-loading conditions, such as utilization of an RPV as the sensor platform. This required development of a part-task functional simulation of the visual search (main) and flight (auxiliary) task components that could be encountered by an RPV ground station observer. The specific objectives were

1. To determine operator visual search and target acquisition performance as a function of auxiliary task loading.

2. To determine operator ability to respond to various levels of auxiliary task loading.

METHOD

Equipment

The arrangement and relationships among the major components of the simulation configuration are presented graphically in Figure 1 and schematically in Appendix A. Major components include a terrain model and targets, a TV camera and a camera transport system, an RPV operator's display/control console, an experimenter's station, and a computer complex, as described below.

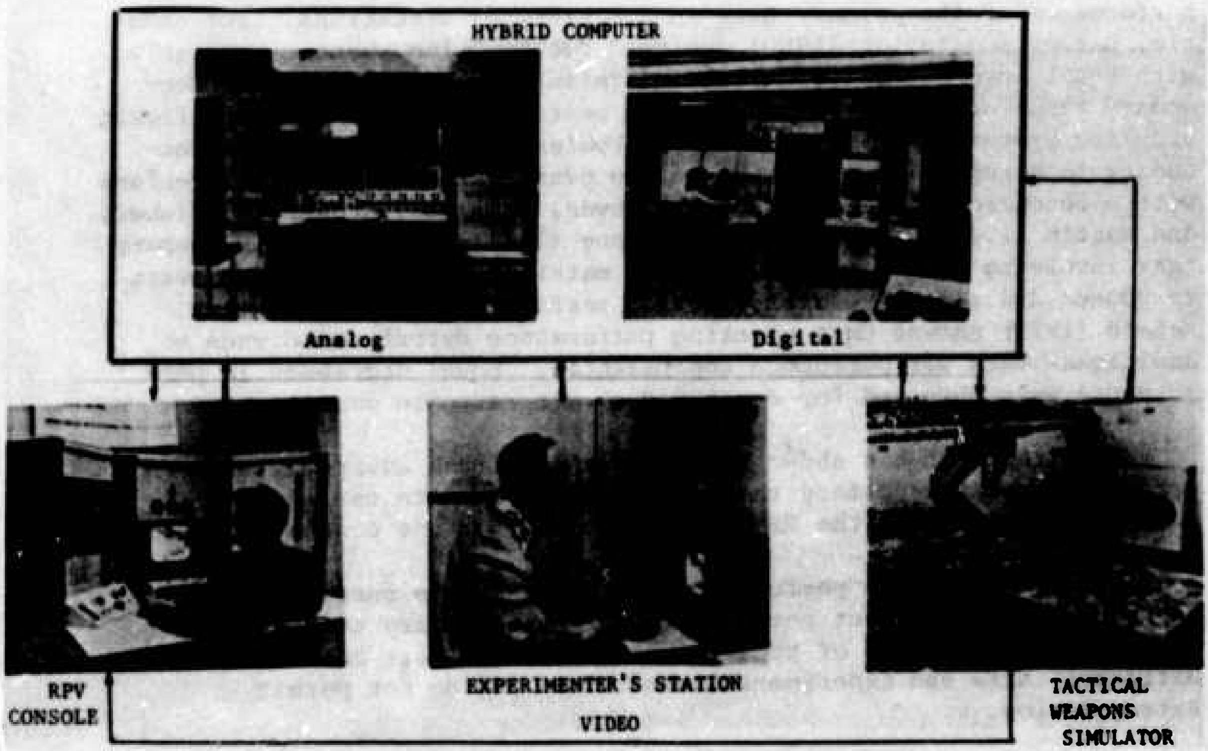

Figure 1. Block diagram--RPV task-loading simulation study, facilities arrangement.

Terrain Model and Camera Transport System. The visual scene for the simulation was generated by a TV camera traversing a scale-model terrain (Figure 2). The scene was presented to the operator via a closed-circuit TV system.

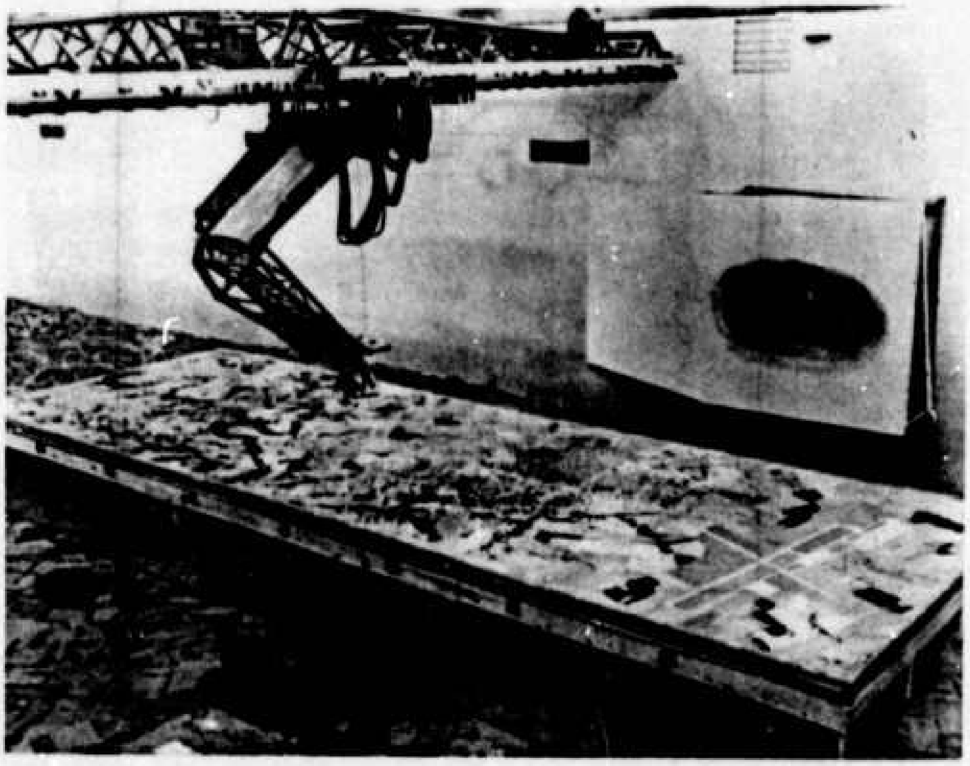

Figure 2. Terrain model and TV camera transport system.

The model represented two specific areas in south-central Ohio. The three-dimensional model measured 36 ft x 12 ft and was scaled at 1,200:1. Trees, shrubbery, buildings, homes, and targets were modeled in three dimensions on the terrain at the 1,200:1 scale. Roads, streams, and fields were painted to provide a realistic appearance when viewed through the TV system.

Three classes of targets were used in the simulated RPV reconnaissance mission: tanks, trucks, and self-propelled anti-aircraft artillery (AAA) (Figure 3).

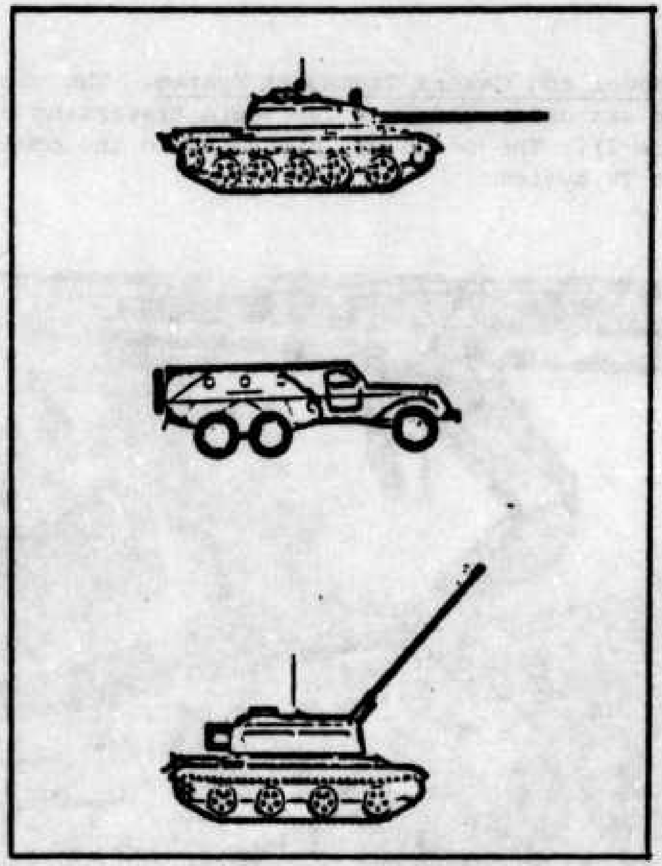

Figure 3. Profiles of vehicle types selected for simulation.

The targets were painted a military olive drab color and were positioned to simulate the open and cluttered conditions specified in the study. Figures 4, 5, and 6 show the three classes of targets as seen on the TV monitor with the camera in the narrow field of view at an altitude of 2,000 ft and a 30° look-down angle.

A closed-circuit TV and 6-degree-of-freedom (DOF) TV camera transport system were used to present the image. The camera, mounted on the transport, was set at a 525-line rate. To provide two fields of view (FOV), namely, 20° diagonal and 5° diagonal, a 1-inch C mount and 4-inch C mount lens were used. The raster was underscanned by 43%, which provided the desired field of view. The lens switching was digitally controlled; the time required to switch from one FOV to the other was less than one-half second. The change was initiated by activation of the trigger switch on the left-hand slew controller at the RPV operator's console.

Figure 4. Tank target as seen on TV monitor.

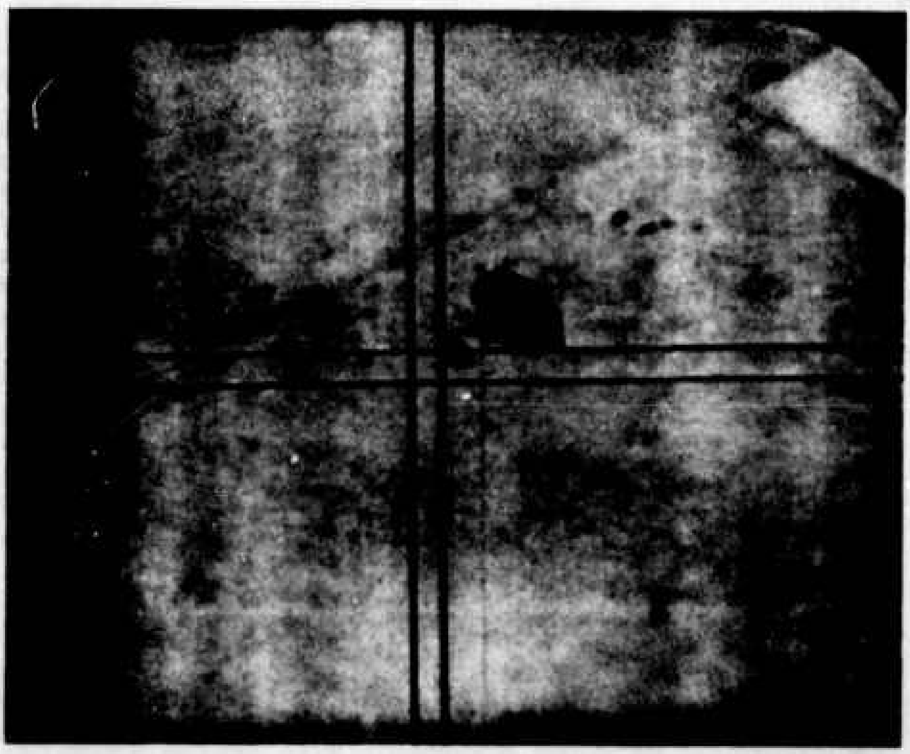

Figure 5. Truck target as seen on TV monitor.

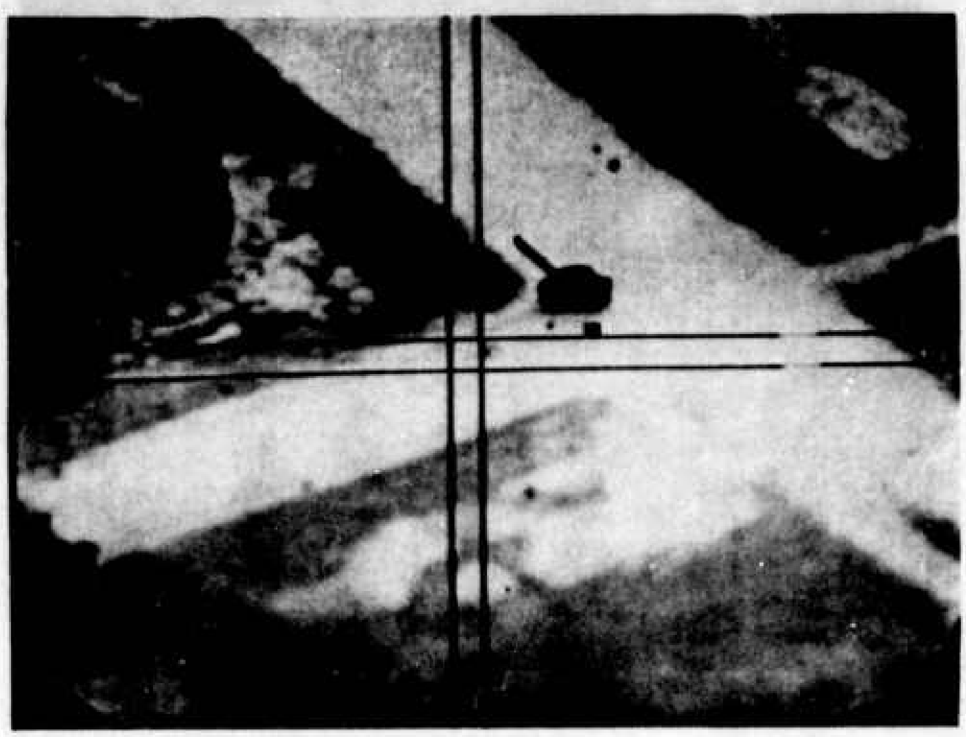

Figure 6. AAA target as seen on TV monitor.

Operator's Console. The RPV operator's console shown in Figure 7 contained all controls and displays necessary for the operator to perform the selected RPV mission tasks. The basic display was a standard 14-inch, 525-line TV monitor with the panel mounted directly in front of the seated operator. In addition to the video display of the terrain model, the TV monitor incorporated a "nose index" indicating the flight-path centerline. The horizontal and vertical crosshairs indicated the center of the camera FOV.

Figure 7. RPV operator's console.

A panel with an airspeed indicator, an altimeter, a course deviation meter, and a radio frequency (RF) warning light was installed directly above the TV monitor.

The left-hand controller slewed the simulated RPV sensor camera in pitch and yaw, and an alternate action trigger-switch on the controller selected either the wide or narrow FOV lens on the simulated RPV sensor.

The right-hand controller, containing two top-mounted switches, was used for pitch and yaw control of the simulated RPV vehicle. To correct a degraded video condition, the operator depressed the right top-mounted switch on the controller. The left top-mounted switch was used to initiate a simulated electronic countermeasures (ECM) function, which turned off a flashing RF warning light on the control panel above the monitor. The trigger-switch on the right-hand controller activated an "altitude-hold" and "flight-path-hold" function after the operator had used the controller to correct deviations from the desired 2,000-ft altitude and the nominal flight path.

Experimenter's Station. The experimenter's station had an 8-inch, 525-line TV monitor slaved to the operator's controls and displaying the same video as the operator's monitor. A headset and microphone permitted verbal communication with the participant, the computer operator, and the rig operator. A control box with switches permitted the experimenter to start a run, put a run in hold or freeze, reset a run, and signal the computer that: (a) a target had been detected by the participant; (b) the target detection was correct or incorrect; (c) the target had been recognized; and (d) the target recognition was correct or incorrect. The detection signal was initiated by the experimenter activating the target-detection (TD) switch. If the detection was correct, the experimenter pushed the target-detection-correct (TDC) switch. An incorrect detection was indicated by no signal from the TDC switch. The target-recognition (TR) switch and the target-recognition-correct (TRC) switch were used in a similar manner for the recognition function.

The control box also contained a control to vary the headset volume and a switch to cut the participant out of the loop so that he or she could not hear conversations between the computer operator, experimenter, and camera transport operator.

Computer Complex. The computing equipment consisted of a digital computer and associated linkage (D/A and A/D converters), an analog console, and two magnetic tape units.

The digital computer provided total program control, vehicle and vehicle control system dynamics, failure and response logic, data storage logic for target detection and recognition, storage of initial conditions for training and data run tracks, randomized participant run matrix logic, data storage on magnetic tape at the end of each run, and the data reduction program. Magnetic tape units were used to store all data from the data flights. The analog console provided the scaling and biasing controls and interface with the random number generator. Appendix B gives the logic for controlling the camera location and attitude through the slew controllers.

Procedures

Operators performed two types of tasks: (a) information extraction tasks ("main tasks") and (b) tasks concerned with the monitoring and control of a simulated RPV ("auxiliary tasks").

The main tasks consisted of target detection and target recognition. Target detection was defined as visual perception of an object to the extent that the operator could determine whether the object was a target or potential target.

Target recognition was defined as visual perception of an object to the extent that the operator could assign the detected object to a class such as trucks, tanks, or AAA vehicles.

Phase A, the first of three phases, examined the operator's ability to utilize a TV presentation to detect and recognize targets (main tasks) via a simulated RPV sensor. In this phase, the operator exercised no control over the simulated preprogramed RPV flight path. He could slew the camera within specified limits and select a wide angle (20° diagonal FOV) or narrow angle (5° diagonal FOV) lens for the target detection and recognition functions. The operator's tasks were to view the television display, detect and recognize tank-size targets, and verbally report the target types to an experimenter.

In Phase B, the operator's ability to monitor and control various functions (auxiliary tasks) associated with the flight of the simulated RPV was examined. The operator's tasks included making corrections in flight-plan heading and altitude, improving the quality of a degraded video presentation, and performing simulated ECM functions. The workload level for the Phase B tasks was determined by the frequency of the task demands.

In Phase C, main tasks and auxiliary tasks were combined to test the effect of the auxiliary tasks on the main tasks. The operator was required to perform the target detection and recognition functions while monitoring RPV performance and correcting any deviations from the flight path.

Participants

Twelve participants were selected from among the engineering and technical personnel at Rockwell International Corporation's Columbus facility (from the Missile Systems Division and the Columbus Aircraft Division, respectively). Six were experienced pilots with current private pilot licenses. The other six had had no previous flight training or experience.

The results of a pilot study conducted prior to the final experimental design formulation indicated no significant difference in the performance of pilots versus nonpilots. This result was confirmed later by the final experimental data.

Experimental Design

The independent variables and the dependent variables were as follows.

Phase A--Independent/Dependent Variables. In Phase A, the objective was to determine the ability of the operator to detect and recognize targets via a TV display. The independent variable for this phase was the type of target/terrain background: open versus cluttered. The dependent variables were (a) number of target detections, (b) number of target recognitions, and (c) slant ranges for the correct detections and recognitions.

Phase B--Independent/Dependent Variables. The objective of Phase B was to quantitatively evaluate the operator's ability to perform RPV reconnaissance "flight" tasks. The tasks simulated were the detection and correction of the following:

1. RF warning indications,

2. Altitude-hold failures (deviation from 2,000 ft),

3. Video, and

4. Flight-path deviations (crosswind drift).

The independent variable was the flight task-load level, i.e., the frequency with which flight tasks needed to be performed. At the moderate load level, frequency was once per 10 seconds of flight; at the heavy load level, it was three times per 10 seconds of flight. The flight tasks were presented in random order.

The Phase B dependent variables were

1. Frequency of nonresponse, e.g., ignoring a low-altitude condition, and

2. Time required to correct error or warning indication.

Characteristics of the flight tasks included monitoring, tracking, evaluating a condition and response, and discrete stimulus-response.

Phase C--Independent/Dependent Variables. For Phase C, the auxiliary (flight) task elements from Phase B were superimposed on the main task elements from Phase A, requiring the participants to perform both sets of tasks. The independent variables were

1. Auxiliary task load (moderate versus heavy) and

2. Type of target/terrain background--open versus cluttered.

The dependent variables were

1. Number of target detections,

2. Number of target recognitions,

3. Slant ranges at the correct detections and recognitions,

4. Correctness of auxiliary task responses, and

5. Time required for auxiliary task responses (latency of response).

For Phase A and Phase C, targets consisted of the three vehicle types described in Figure 3. Target sites and background conditions either cluttered, with shrubs, trees, etc., within 50 ft of target vehicle, or open were selected on the terrain model, and one vehicle was placed at each site. The types of vehicles and background conditions were balanced within and between Phase A and Phase C. Appendix Table C-1 summarizes the target type and background for each site for Phase A, and Table C-2, for Phase C.

All flight paths were straight, of varying length, and contained none, one, or two targets. Each target site was identified by a letter (A, a, B, b), and target sites located on multiple-site data runs were identified by a letter and a subscript (c_1, C_2, g_1, g_2).

No targets were used in Phase B, since the participant was not required to detect and recognize targets. The flight paths varied in length, as in Phase A. Either a moderate or a heavy auxiliary task load was imposed on the operator in each case. Detailed descriptions of all flight paths and any associated targets are contained in Appendix D.

To remove the possibility of any presentation order effects, all six possible presentation sequences of the three phases were used twice in conducting the study. Appendix E shows the phase presentation order for each participant.

Training

Single- and multiple-target flight paths were selected for participant training trials. Each participant was required to complete 10 training runs for each phase prior to the start of data collection. In addition, immediately before starting the data collection runs for any given phase, each participant was required to repeat the training runs for that phase. Problems associated with operation of the RPV console equipment, e.g., control reversal or improper switch response, were not observed after the first three or four training runs.

In Phases A and C, each of the 12 participants flew 10 data collection runs. In Phase B, each of the 12 participants flew five different flight paths under the moderate task load and five under the heavy task load.

Appendix Table F-1 shows the basic 3 x 3 x 2 data matrix for Phases A and C, and Table F-2 shows the basic 3 x 2 x 2 matrix for Phase B and Phase C comparisons of task load levels.

Data Collection

Each participant was read the Initial Orientation and Familiarization briefing contained in Appendix G. Each participant then received the Phase A, Phase B, and Phase C Briefing and Training (Appendix G). Participants were divided into three groups for testing: Group I was tested on Phase C last, Group II on Phase C second, and Group I on Phase C first. At that time, each participant was briefed on the first data collection phase for his group and repeated the training missions for that phase prior to the data collection runs. The same procedure (repeat of training and then data collection) was followed for the other two phases. The Phase A data run presentation sequences for each participant are contained in Table H-1. Each participant flew 10 Phase A data runs.

Since no target acquisition tasks were involved in Phase B, the only variations in the Phase B data runs were the duration and the task-load level, moderate (M) or heavy (H). The Phase B task-load levels for the runs and participants are shown in Table H-2. Each participant flew five Phase B runs at the moderate load level and five runs at the heavy load level.

In Phase C, the data run presentation sequences were the same as in Phase A, except that no participant received the identical sequence in both phases. Participant n in Phase C underwent the sequence given participant n + 1 in Phase A. Also, the task-load levels from Phase B were reversed for Phase C. For example, participants 1-6, who had the heavy task load for the first run in Phase B now had the moderate task load for that run in Phase C. Detailed description of the Phase C data runs are contained in Appendix D.

Phase A Data Collection. Immediately after the Phase A training session, the participant indicated to the experimenter that he was ready to begin data collection.

Initial data run conditions are listed below:

1. Simulated velocity--100 knots;

2. Simulated altitude--2,000 ft aboveground;

3. Initial camera position--30° look-down angle and on flight-path centerlines.

During the mission, the participant was not required to make any corrections in the flight path; the RPV flight was completely programed.

Throughout the simulated mission, the participant was able to control the camera by moving the control stick mounted on the left side of the RPV console shelf (see Figure 7). Moving the controller left or right from the spring-loaded center position would slew the camera look-down angle between approximately 20° and 80°.

The participant's tasks involved (a) searching the terrain displayed on the TV with the 20° FOV lens; (b) detecting the targets along the flight path; and (c) recognizing targets as tanks, trucks, or AAA guns.

As soon as a participant detected a target, the participant said "Target" to the experimenter monitoring the mission progress at the experimenter's station. At that time, on signal from the experimenter's station, the digital computer recorded the time elapsed since mission-start. The experimenter scored the detection as correct by pressing the target-detection-correct (TDC) button on the experimenter's control box, or as incorrect by not activating the TDC button.

The participant then slewed the camera to center the target location in the field of view (indicated by fixed crosshairs on the display) and squeezed the controller trigger. This action switched the TV to the narrow-angle lens (5^{o} diagonal FOV), thus providing an expanded view of the site for target recognition. The participant's verbal report of recognition was recorded by the experimenter, who used the target-recognition and target-recognition-correct buttons, and the computer recorded mission-elapsed-time. The experimenter scored and recorded an incorrect recognition by not activating the TRC button.

Upon completion of target recognition, the participant again squeezed the controller trigger, returning the display to the wide-angle lens mode, slewed the camera back to the flight-path centerline, and continued to monitor the RPV display for additional targets until the data run was terminated.

Appendix I gives an example of the computer data record for two Phase A runs.

Phase B Data Collection. The Phase B auxiliary tasks are listed below:

1. Video degradation--requiring manual corrective action to return to a normal TV image.

2. RF warning--random occurrence of RF warning light, requiring participant to activate simulated ECM.

3. Altitude-hold failure--random failures in altitude hold, requiring the participant to correct deviations from 2,000 ft indicated altitude ($\pm$50 ft) and to reactivate the altitude hold.

4. Course of flight-path-hold failure--random failures in the autopilot causing the course meter to indicate that the RPV was left or right of "0" heading. This failure required the participant to correct the deviations from "0" heading ($\pm$50 ft) and reactivate the course hold.

In a Phase B run, the participant was required to monitor the RPV flight path and altitude and to correct any deviations from normal by using the controller on the right-hand side of the RPV console shelf. Fore or aft motion of the controller increased or decreased the altimeter reading, and left or right controller movement corrected left or right flight-path deviations.

Video degradation, simulated by computer-initiated noise, represented an operational situation requiring manual intervention to improve picture quality. The participant restored image quality by pushing the right top-mounted button on the right-hand controller.

At random time intervals throughout a given mission, an RF warning light mounted on the RPV console panel would flash. This light warned the participant that the vehicle was being tracked by an air defense weapon. To return to normal operation, the participant pushed an electronic countermeasures button which was the left top-mounted button on the right-hand controller. This canceled the warning indication and simulated initiation of a defensive mechanism in an operational RPV.

In summary, the participant's tasks during the Phase B runs were to monitor RPV flight status and to correct errors and emergencies in the flight path and performance of the vehicle. The participant was not involved in any of the main task elements, i.e., searching for and recognizing targets.

Recorded performance data included course-deviation errors (duration of deviation from the flight path); altitude-hold errors (duration of deviation from mission altitude of 2,000 ft); corrective response time to poor video; and corrective response time (RT) to RF warning stimulus. All Phase B data were recorded by the digital computer, including the time of the computer-initiated failure and the time required for the participant to correct the indicated failure. Figure I-2 in Appendix I gives an example of the raw data record for two Phase B data runs.

Phase C Data Collection. Tasks performed by the participants during Phase C data collection were identical to those performed during Phases A and B except that, as previously noted, they were combined to provide performance measures as a function of task-loading levels. That is, main task performance (detection and recognition of targets in open and concealed positions) was scored with respect to range at detection and correctness of response while the participant was exposed to a moderate or heavy load of auxiliary tasks.

Performance data recorded during the Phase C data runs were

1. Main tasks

   a. Target detection time and accuracy

   b. Target recognition time and accuracy

2. Auxiliary tasks

   a. Corrective RT to flight-path deviation

   b. Corrective RT to altitude-hold deviation

c. Corrective RT to poor video stimulus

d. Corrective RT to RF warning stimulus

Appendix Table I-3 presents an example of two Phase C data runs as recorded by the computer.

Data Reduction and Analysis

The number of correct target detections for each participant was converted into probability of target detection by dividing the number of correct detections by 12 (the maximum number of correct detections possible). An analogous procedure was followed to obtain the probability of target recognition (P_{TR}).

To determine a true slant range to target at the time of correct detection and recognition, the time at which the event occurred (recorded by the computer) was subtracted from the time at which the simulated RPV would be directly over the target. This remainder was multiplied by 169.9 feet per second (ft/sec) (100 knots simulated RPV speed) to yield a ground range target. The slant range was easily calculated from the product of this multiplication, since the RPV flew at a constant altitude of 2,000 ft. In those instances where targets were not detected/recognized, an arbitrary figure of 2,000 ft was assigned for the slant range. Ignoring these undetected targets would greatly affect some of the cell means. However, assigning a "zero" would greatly decrease some cell means and exaggerate the effects of some independent variables. The 2,000-ft figure was the highest figure that could have been selected without underestimating the participant's performance (because there was an opportunity to detect the target at that slant range). This figure will yield conservative results in any statistical analyses that are performed, whereas lower figures would tend to exaggerate the statistical significance of some variables.

Flight task response times formed two distinct patterns: The response times to the degraded video and RF warning stimuli were much shorter than the response times for the altitude-hold and course-deviation stimuli. This pattern of response times permitted combining the data for the first two stimulus types (poor video and RF warning) and the third and fourth stimulus types (altitude-hold and course-deviation) to simplify the data analysis. Mean RTs, therefore, were calculated for these combinations. The RTs were further grouped according to moderate or heavy task loads.

With two minor exceptions, all data were analyzed, using analysis of variance (ANOVA) procedures for a three-factor experiment with repeated measures.

RESULTS AND DISCUSSION

Target detection and recognition were impaired by performance of the auxiliary task, particularly with the cluttered background condition: Both the percentage of detection/recognition and the target range at detection/recognition decreased. Similarly, auxiliary task performance deteriorated when the target acquisition task was performed concurrently.

Target Detection

Impacts of the three levels of auxiliary tasks (zero, moderate, heavy) and the two target background conditions (open, cluttered) on the probability of target detection (P_{TD}) are shown in Table 1. The effect of the auxiliary task load level on the P_{TD} was statistically significant at the .01 level of confidence ($F\ (2,\ 18) = 9.24$). (See Appendix J for analysis of variance tables.)

Table 1

Probability of Target Detection (P_{TD}) as a Function of Auxiliary Task Load and Target Background Condition

Background condition	Auxiliary task load Zero	Moderate	Heavy	Overall
Open	.8333	.8958	.7292	.8194
Cluttered	.5555	.3055	.1389	.3333
Overall	.6944	.6006	.4340	.5763

The Tukey (a) Test (Winer, 1962) showed that P_{TD} was significantly (.01 level of confidence) lower at high auxiliary task loads than at either the moderate or no load condition. P_{TD} was not significantly different between the moderate auxiliary task load and the zero-load condition. However, because of the significant interaction between auxiliary task load and target background condition, the overall main effects are not as informative as is an examination of the variable of concern at each level of the other variable. Applying the Tukey (a) Test to the open- and cluttered-background conditions separately shows contrasting results. For the open background, there were no significant differences in P_{TD} for the different auxiliary task-load levels. For the cluttered background, P_{TD} under the zero-load condition was significantly (.01 level of confidence) higher than for either the moderate- or heavy-load condition. There was no significant difference between the latter two for the cluttered-background condition.

P_{TD} was lower with a cluttered background than with an open background at the .01 level of significance ($F(1, 9) = 154.67$). This, of course, was the expected outcome.

The interaction between auxiliary task load and target background condition was significant at the .01 level ($F(2, 18) = 6.03$). The concurrent demands of moderate or heavy auxiliary task-load levels and the more difficult target background condition for the target acquisition task created such a heavy total task load for the subjects that performance broke down.

The key finding was that the auxiliary task had no significant effect on target detection under open background conditions, but that it significantly reduced P_{TD} under cluttered background conditions. Target detection is such a demanding task under cluttered background conditions that a secondary task uses up the operator's reserve capacity.

Target Recognition

The results for probability of target recognition (P_{TR}) generally paralleled those for P_{TD}. Table 2 shows probability of target recognition as a function of the auxiliary tasks and target background conditions.

Table 2

Probability of Target Recognition (P_{TR}) as a Function of Auxiliary Task Load and Target Background Condition

Background condition	Auxiliary task load: Zero	Moderate	Heavy	Overall
Open	.7500	.7500	.6250	.7083
Cluttered	.4583	.1666	.0833	.2361
Overall	.6042	.4583	.3542	.4722

The effect of the auxiliary task load on the P_{TR} was statistically significant at the .01 level ($F(2, 18) = 7.13$).

The difference in P_{TR} between the zero and heavy task-load levels was significant at the .01 level of significance. Between the moderate and zero load levels, the difference in P_{TR} was significant at the .05 significance level. Examining the effect of auxiliary work load with the two different background conditions revealed the same pattern as that found for P_{TD}. There was no significant difference in P_{TR} between the different secondary task-load levels for the open background. However, for the cluttered background, P_{TR} was higher for the zero-load level than for the moderate- or heavy-load level at the .01 level.

Target background also had a significant (.01 confidence level) effect on P_{TR} ($F(1, 9) = 114.68$).

The interaction between task load and target background was significant at the .05 level ($F(2, 18) = 5.41$). The coincidence of the auxiliary task load and the cluttered background condition caused greater performance decrement than the sum of these two conditions.

As was the case for P_{TD}, there was no significant effect on P_{TR} under open-background conditions, but there was a significant reduction in P_{TR} with a cluttered background. Again, the operator's reserve capacity was used up by the secondary task under the more difficult background conditions.

Target Range

Table 3 shows the effect of auxiliary task loads and target background on the slant range at which target detection (R_{TD}) occurred. As task load increased and as the target background condition went from open to cluttered, the R_{TD} decreased. The auxiliary task significantly reduced R_{TD} ($F(2, 18) = 12.00$).

The Tukey (a) Test indicated that the differences in R_{TD} between the heavy-load level and the zero-load level was significant at the .01 level The difference in R_{TD} between the medium-load and the zero-load conditions was significant at the .05 level.

The effect of the auxiliary task on performance was manifest primarily under the cluttered background condition. There, targets were detected at greater distances (.01 level of significance) at zero-load conditions than at either moderate- or heavy-load conditions. No significant differences were found between the moderate- and heavy-load conditions with the cluttered background. Neither were any of the R_{TD} differences between the different auxiliary task-load levels significant for the open-background condition.

Table 3

Slant Range (Ft) at Target Detection (R_{TD}) as a Function of Auxiliary Task Load and Target Background Condition

Background condition	Auxiliary task load			
	Zero	Moderate	Heavy	Overall
Open	3955	3971	3580	3835
Cluttered	3126	2559	2190	2635
Overall	3540	3265	2885	3230

The effect of target background on R_{TD} was significant at the .01 confidence level ($F(1, 9) = 220.43$).

The interaction between task-load level and target background was significant at the .05 level ($F(2, 18) = 3.60$). As was the case for P_{TR} and P_{TD}, the coincidence of moderate or heavy auxiliary task-load levels with the more difficult target background condition created an increased total task load which caused a greater performance decrement than that caused by the sum of these two conditions.

The effects of task loading and target background on the range of target recognition (R_{TR}) are shown in Table 4. Increasing the auxiliary task load reduced the overall R_{TR} from 2,942 ft to 2,505 ft. The overall R_{TR} for open target site was 3,140 ft and for cluttered target sites it was 2,308 ft.

Task loading had a significant effect on R_{TR} ($F(2, 18) = 8.35$). The Tukey (a) Test indicates that the difference in R_{TR} between the zero- and the heavy-level task loads was significant at the .01 level. The other differences were not significant. R_{TR} ANOVA summary (see Table J-4) also shows the change in R_{TR} as a function of target background condition to be significant at the .01 level ($F(1, 9) = 64.91$).

The effect of the auxiliary task on the R_{TD} and R_{TR} was consistent with that on P_{TD} and P_{TR}. There was no significant reduction in either R_{TD} or R_{TR} with an open background, but there was a significant reduction in both, with a cluttered background.

Table 4

Slant Range (Ft) at Target Recognition (R_{TR}) as a Function of Auxiliary Task Load and Target Background Condition

Background condition	Auxiliary task load			
	Zero	Moderate	Heavy	Overall
Open	3284	3202	2934	3140
Cluttered	2599	2250	2074	2308
Overall	2942	2726	2505	2724

Auxiliary Tasks

Another dependent performance measure of interest was the change, if any, in the auxiliary task corrective response times as a function of the frequency of the auxiliary task or stimuli or flight task actions. Moderate frequency would be one task per 10 seconds; heavy frequency, three per 10 seconds. As mentioned earlier, the data for the two stimuli with short RTs--video degradation and RF warning--were combined. This is indicated in Table 5 by the $RT_{1,2}$ symbol. $RT_{3,4}$ identifies the combined data for altitude-hold failure and course- or flight-path-hold failure. The corrective RT for these failures was obviously longer than that for the $RT_{1,2}$ category. $RT_{1,2}$ and $RT_{3,4}$ were not affected in any significant way by increasing the auxiliary task load level. In fact, the $RT_{3,4}$ time was the same for both moderate and heavy levels.

When the auxiliary task RTs were examined as a function of the target acquisition tasks, i.e., Phase B compared with Phase C, both $RT_{1,2}$ and $RT_{3,4}$ were changed significantly. When target acquisition tasks were added to the auxiliary tasks, the $RT_{1,2}$ increased from 1.0 second to 1.5 seconds, an increase by a factor of 1.5. $RT_{3,4}$ was similarly affected as it increased by a factor of 1.7. Data for these results are shown in Table 6.

Table 5

Auxiliary Task Response Time (RT)
as a Function of Task Frequency
(Auxiliary Task Load)

RT	Auxiliary task load	
	Moderate	Heavy
$RT_{1,2}$[a] (Sec)	1.2	1.3
$RT_{3,4}$[b] (Sec)	7.5	7.5

[a] $RT_{1,2}$ = response time to degraded video and RF warning.

[b] $RT_{3,4}$ = response time to altitude-hold and course-hold failures.

Table 6

Auxiliary Task Response Time (RT)
as a Function of Main Task
(Target Acquisition Required)

RT	Target acquisition required	
	No	Yes
$RT_{1,2}$[a] (Sec)	1.0	1.5
$RT_{3,4}$[b] (Sec)	5.6	9.4

[a] $RT_{1,2}$ = response time to degraded video and RF warning.

[b] $RT_{3,4}$ = response time to altitude-hold and course-hold failures.

An additional recorded performance measure was the number of times the participants failed to respond to an auxiliary task stimulus. Table 7 shows the total number of times subjects failed to respond to auxiliary task stimuli as a function of auxiliary task-load level and the presence or absence of target acquisition tasks. Without target acquisition task demands, the increased auxiliary task load did not increase the number of nonresponses. However, with concurrent target acquisition demands, the heavy auxiliary task load nearly doubled the number of nonresponses. Nevertheless, using a chi-square test, this increase was not found to be significant.

Table 7

Summary of Nonresponses to Auxiliary Task Stimuli as a Function of Auxiliary Task Level and Target Acquisition Demands

Target acquisition	Auxiliary task load	
	Moderate	Heavy
Not required	11	8
Required	35	65

Comparing the performance of the six pilots with performance of the six nonpilots on P_{TD}, P_{TR}, $RT_{1,2}$, and $RT_{3,4}$ showed no difference at the .05 level, using the t test (see Table 8).

Much as the secondary task impaired performance of the primary task, the primary task impaired performance of the secondary task. Response times for secondary tasks increased both when they were simple and when they were relatively complex. However, the frequency with which the secondary task needed to be performed had no effect on response time.

Table 8

Comparison of Pilot Versus Nonpilot Performance

Performance measure	Pilots	Nonpilots
P_{TD}	.60	.55
P_{TR}	.60	.55
$RT_{1,2}$	1.3	1.3
$RT_{3,4}$	8.4	6.6

CONCLUSIONS AND RECOMMENDATIONS

The research objective was to obtain baseline data concerning observer performance in extracting information from a TV monitor while performing auxiliary tasks under task-loading conditions like those that might be encountered in utilizing an RPV as the sensor platform.

The participants performed each of three sets of tasks. During Phase A, they were required to detect and recognize tank-size targets in open and cluttered backgrounds. Phase B required the participants to monitor and correct RPV flight parameters and to respond to visual warning indicators. In Phase C, the participants performed the tasks of Phase A and Phase B concurrently.

Operators who received a brief familiarization training could detect and recognize a high percentage of the targets when task demands were at a minimum, i.e., when no auxiliary tasks were to be performed and during open-background conditions. As task demands increased by changing either or both of these conditions, target detection/recognition performance was impaired.

Under open-background conditions, a minor performance decrement occurred when a heavy auxiliary task load was introduced. A moderate auxiliary task load did not impair performance of the target detection/recognition task. A major performance decrement occurred with cluttered background. It became greater when a moderate level of auxiliary task load was added, and even greater when a heavy level of the auxiliary task was imposed.

Within the range investigated--one task per 10 seconds and three tasks per 10 seconds--the frequency of the auxiliary tasks had no effect on the time required to perform the required corrective action. However, when the target detection/recognition task was performed concurrently, the auxiliary task response time was significantly greater. Thus, while either level of the auxiliary task was well within the operator's capabilities when he performed them separately, the combination of the auxiliary task with the target detection/recognition task exceeded the capabilities of the operator.

When the mission involves targets that are difficult to detect or recognize, the RPV ground station operator performing this function should be assigned few, if any, auxiliary tasks.

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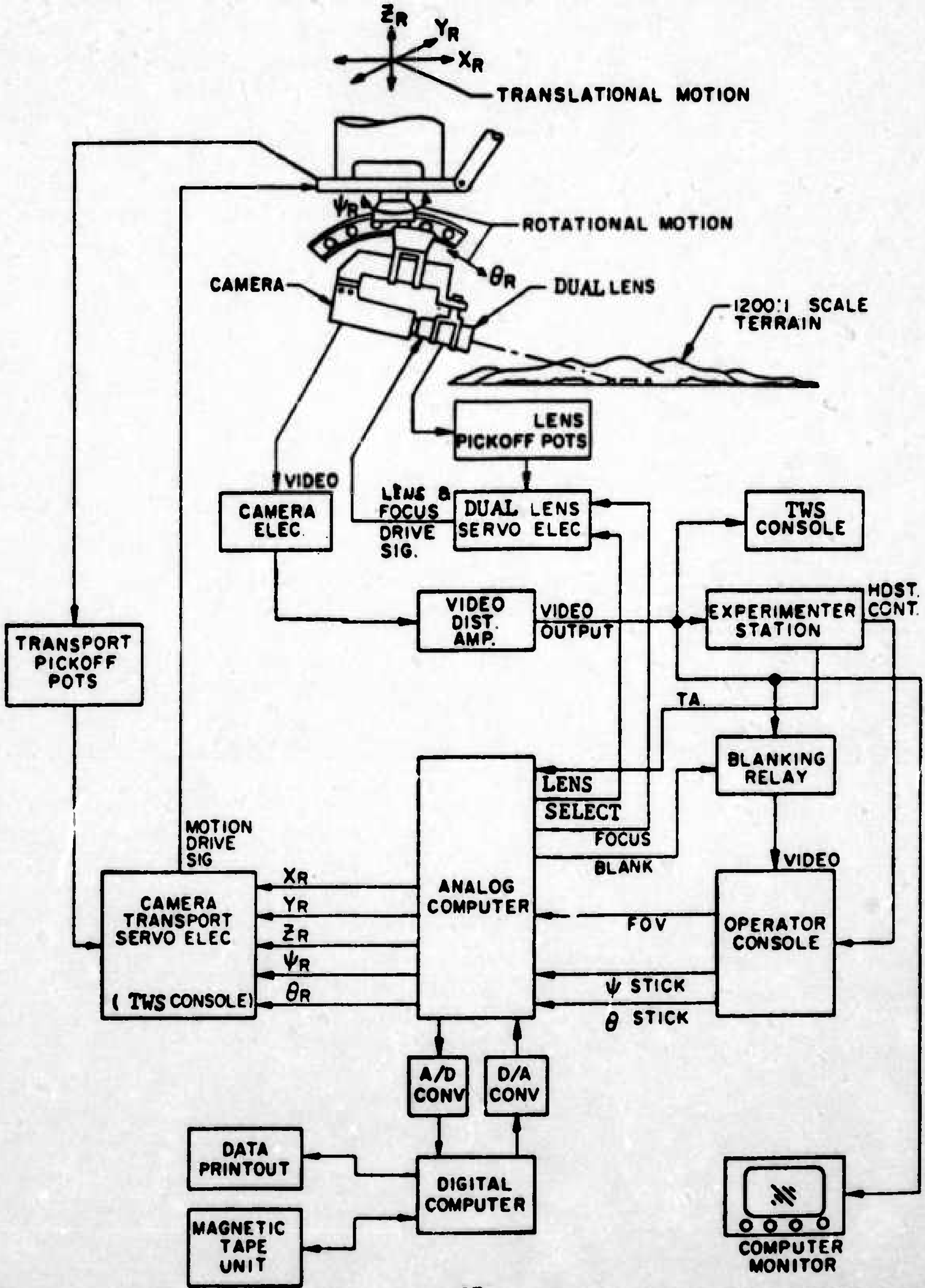
APPENDIX A

RPV TASK-LOADING SIMULATION DIAGRAM



APPENDIX B

CONTROLLER LOGIC

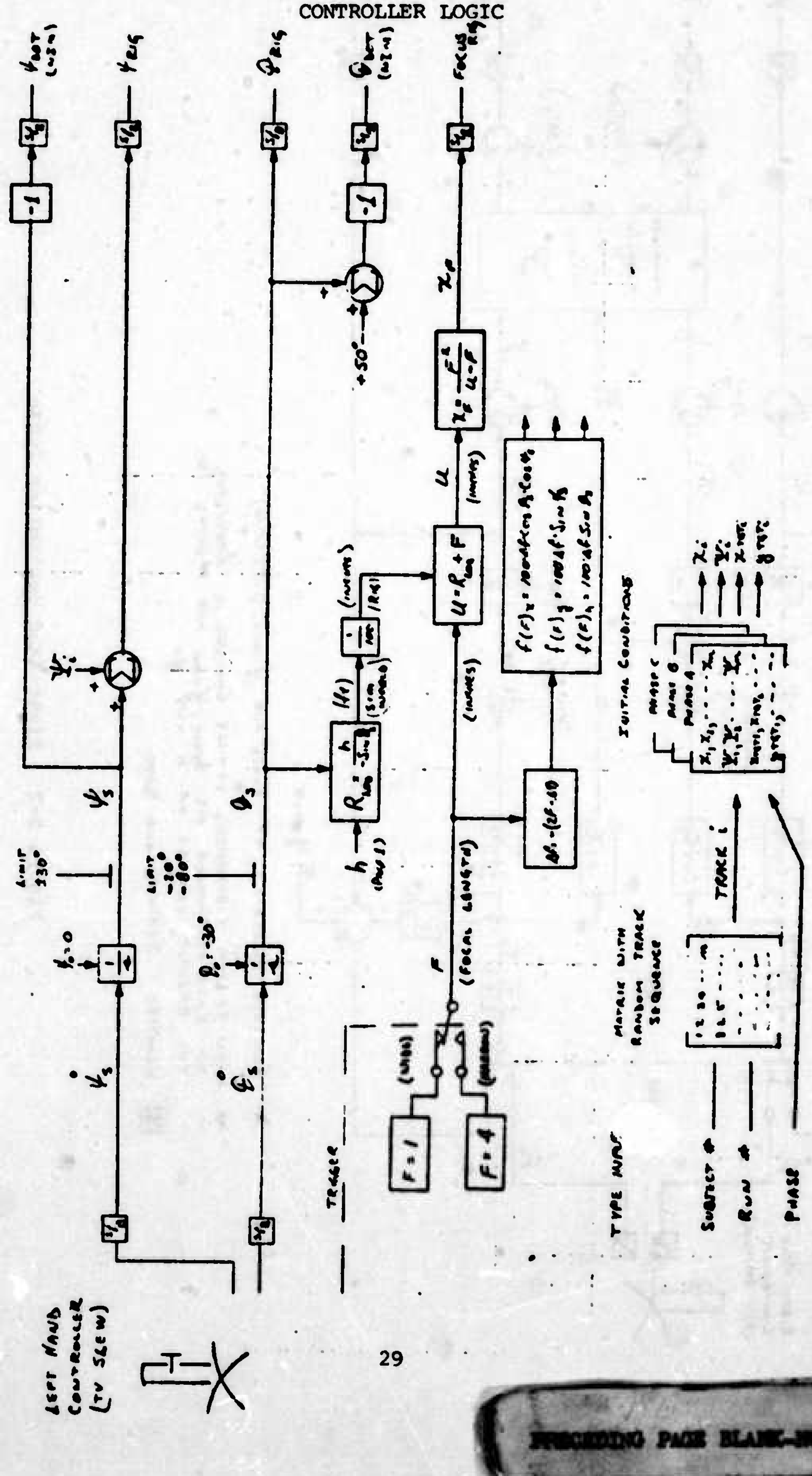
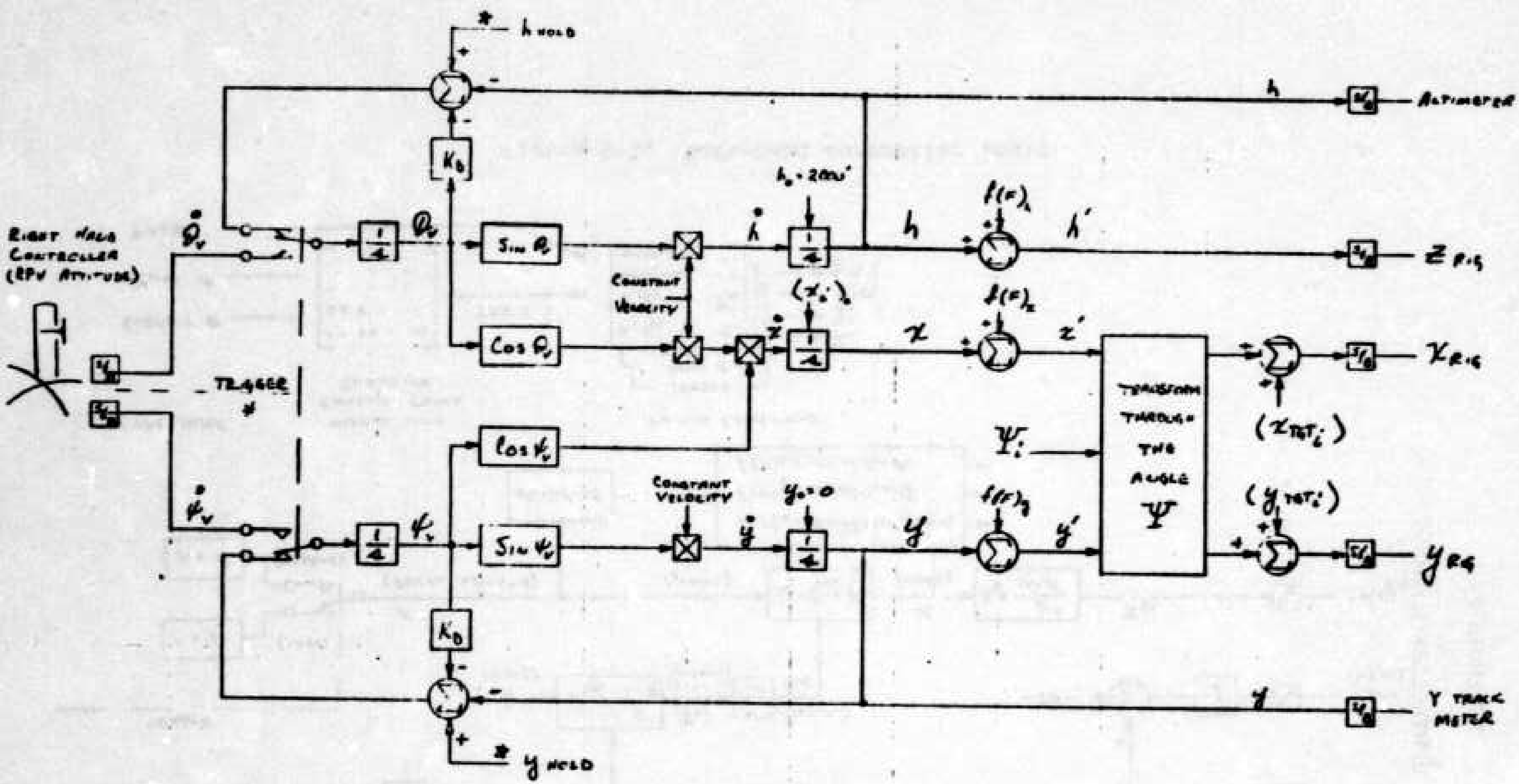


Figure B-1. Left-hand controller logic.



★ FAILURES INSERTED AT h HOLD AND y HOLD. (= ±250 ft)

WHEN TRIGGER IS DEPRESSED VEHICLE CONTROL IS TRANSFERED TO HAND CONTROLLER AND h HOLD, y HOLD ARE UPDATED TO THE PRESENT VALUES OF h AND y.

S/B DENOTES SCALING AND BIAS.

Figure B-2. Right-hand controller logic.

APPENDIX C

SUMMARY OF TARGET/SITE CONDITIONS

Table C-1

Summary of Phase A Target/Site Conditions

Site	Open			Clutter		
	Truck	Tank	AAA	Truck	Tank	AAA
A	1					
B			1			
C_1	1					
C_2		1				
D						1
E				1		
F_1		1				
F_2						1
G_1					1	
G_2			1			
H					1	
I				1		
J			No target			

Table C-2

Summary of Phase C Target/Site Conditions

Site	Open			Clutter		
	Truck	Tank	AAA	Truck	Tank	AAA
a	1					
b			1			
c_1				1		
c_2			1			
d		1				
e						1
f_1	1					
f_2		1				
g_1					1	
g_2						1
h					1	
i				1		
j			No target			

APPENDIX D

SITE AND DATA RUN DESCRIPTIONS

Phase A

Run #1 - site A, open, 1 truck, 250 feet left of flight path, 50 seconds duration

Run #2 - site B, open, 1 AAA, 150 feet right of flight path, 60 seconds duration

Run #3 - site C_1, open 1 truck, on flight path, 62 seconds after run start

- site C_2, open, 1 tank, 50 feet right of flight path, 100 seconds after run start

Run #4 - site D, clutter, 1 AAA, 150 feet right of flight path, 40 seconds duration

Run #5 - site E, clutter, 1 truck, on flight path, 40 seconds duration

Run #6 - site F_1, open, 1 tank, 50 feet right of flight path, 39 seconds after run start

- site F_2, clutter, 1 AAA, 150 feet left of flight path, 70 seconds after run start

Run #7 - site G_1, clutter, 1 tank, 50 feet left of flight path, 57 seconds after run start

- site G_2, open, 1 AAA, 250 feet right of flight path, 80 seconds after run start

Run #8 - site H, clutter, 1 tank, 150 feet left of flight path, 30 seconds duration

Run #9 - site I, clutter, 1 truck, 250 feet left of flight path, 40 seconds duration

Run #10 - no target data run, 60 seconds duration

Phase B

Run #1 - 50 seconds duration

Run #2 - 60 seconds duratior

Run #3 - 80 seconds duration

Run #4 - 70 seconds duration

Run #5 - 30 seconds duration

Run #6 - 40 seconds duration

Run #7 - 40 seconds duration

Run #8 - 40 seconds duration

Run #9 - 100 seconds duration

Run #10 - 60 seconds duration

Phase C

Run #1 - site a, open, 1 truck, 250 feet right of flight path, 30 seconds duration

Run #2 - site b, open, 1 AAA, 150 feet left of flight path, 50 seconds duration

Run #3 - site c_1, clutter, 1 truck, 150 feet right of flight path, 58 seconds after run start

- site c_2, open, 1 AAA, on flight path, 80 seconds after run start

Run #4 - site d, open, 1 tank, 150 feet right of flight path, 40 seconds duration

Run #5 - site e, clutter, 1 AAA, on flight path, 50 seconds duration

Run #6 - site f_1, open, 1 truck, 50 feet left of flight path, 37 seconds after run start

- site f_2, open, 1 tank, 150 feet left of flight path, 100 seconds after run start

Run #7 - site g_1, clutter, 1 tank, 150 feet left of flight path, 26 seconds after run start

- site g_2, clutter, 1 AAA, 250 feet right of flight path, 80 seconds after run start

Run #8 - site h, clutter, 1 tank, 250 feet right of flight path, 40 seconds duration

Run #9 - site i, clutter, 1 truck, 250 feet left of flight path, 40 seconds duration

Run #10 - no target data run, 60 seconds duration

APPENDIX E

PHASE PRESENTATION ORDER

Subject number	Subject's group	Phase presentation order
1	I	A B C
2	II	B C A
3	III	C B A
4	I	B A C
5	III	C A B
6	II	A C B
7	I	A B C
8	II	B C A
9	III	C B A
10	I	B A C
11	III	C A B
12	II	A C B

APPENDIX F

BASIC DATA MATRIX

Table F-1

Basic Data Matrix for Phase A/C Participant Group x Task Load Level x Target Background

		ØA - No Aux. Tasks		ØC - Mod. Aux. Tasks		ØC - Hvy. Aux. Tasks	
	Subj	Open	Clutter	Open	Clutter	Open	Clutter
GROUP I	1						
	4						
	7						
	10						
GROUP II	2						
	6						
	8						
	12						
GROUP III	3						
	5						
	9						
	11						

Table F-2

Basic Data Matrix for Phase B/C Participant Group x Target Acquisition Load x Auxiliary Task Load

		ØB - No Target Acq. Req'd		ØC - Target Acq. Req'd	
	Subj	Mod.Aux.Tasks	Hvy.Aux.Tasks	Mod.Aux.Tasks	Hvy.Aux.Tasks
GROUP I	1				
	4				
	7				
	10				
GROUP II	2				
	6				
	8				
	12				
GROUP III	3				
	5				
	9				
	11				

APPENDIX G

PARTICIPANT BRIEFINGS AND INSTRUCTIONS

Initial Orientation and Familiarization

Remotely piloted vehicles (RPVs) offer a variety of advantages over conventional manned aircraft in the conduct of aerial reconnaissance operations in a hostile environment. The primary advantage, of course, is the removal of the personnel hazards involved in the loss of the aircraft. For the purpose of this study, namely, evaluating the human operator's ability to extract information from a television display under various levels of task loading, the simulated RPV mission is concerned with reconnaissance. In order to provide the data which will allow a quantitative basis for evaluating this ability, you have been asked to participate in the study.

The study is made up of three phases. Each person serving as a subject will be participating in all three phases. In one of the phases, you will be concerned with maintaining certain flight conditions for a simulated remotely piloted vehicle (RPV). In another phase, you will be searching a television display for potential targets while the simulated RPV flies over a terrain model. In the remaining phase, you will be asked to combine the tasks from the other two phases and search for targets while maintaining specific flight conditions.

If you have any questions about the study including the procedures or the equipment you will be using, please feel free to stop me during this orientation and I will answer them.

(Subject is taken to the console. As each display and control is introduced, the experimenter points to the item being described.)

The console represents an RPV display monitor and control station. You will be using the two controllers on the shelf, the television monitor and the simulated flight instruments immediately above the monitor.

The controller on the left is used to slew a simulated television camera being carried by an RPV. Pushing the controller forward causes the camera to point down and pulling the controller back causes the camera to point up. Left and right controller movements cause corresponding movements of the camera.

The trigger switch on the left controller is an alternate action switch which selects either a wide or narrow field-of-view (FOV) lens. (Subject should operate the controller and the trigger switch.) The narrow FOV lens provides a magnification of about 4x the wide FOV lens. Pulling the trigger switch in once and releasing it will change the lens. Pulling the trigger again and releasing it will change the lens back to the original selection.

The right controller corrects the flight of the RPV. Unlike the conventional aircraft control stick which is a pitch/roll device, this is a pitch/yaw device. Pushing the controller forward results in a decrease in RPV altitude and pulling the controller back causes the RPV to climb. Moving the controller to the left causes the RPV to fly to the left and moving the controller to the right will cause the RPV to fly to the right.

There are several switches on the right controller which interact with the display dials above the TV monitor. The airspeed indicator on the left is set to indicate 100 knots always and will not require your attention. The middle dial is a functional altimeter and will change as the right controller is moved in the pitch axis. The dial on the right indicates a deviation left or right from a nominal pre-set course. If the needle moves to the right of 0, this indicates the RPV has drifted to the right of the course. This deviation can be corrected by moving the right controller to the left until the needle is again aligned with 0 on the meter.

Similarly, if the needle moves to the left of 0, the controller should be moved to the right to bring the needle and 0 back into alignment.

Since the altitude and course deviations are meant to represent failures in an autopilot control system, the use of the right controller represents manual override of an automatic function. In order for the controller to be activated the trigger switch must be pulled in and held while altitude and course corrections are being made. When the altimeter and the course meter indicate the assigned readings, the trigger is released, thereby simulating initiation of an altitude and course hold function.

The RF warning light will flash on at various times during a mission; it indicates that the RPV is being tracked by an antiaircraft weapon. The left switch mounted on top of the right controller serves as an ECM initiator and will cancel the RF warning light.

The right switch on top of the right controller represents a fine-tuning adjustment and is used to correct a degraded video presentation on the TV monitor.

The TV monitor will present the scene of the terrain as viewed by the RPV television camera as it flies over the terrain model. The intersection of the double crosshairs in the center of the display indicates the center of the camera FOV. The small dot visible in the lower half of the display indicates the vehicle course. When the dot falls between the pair of vertical crosshairs, the TV camera is centered on the RPV flight path. If the dot is left of the vertical crosshairs, the TV camera is looking to the right of the RPV flight path. Moving the left controller to the left will center the dot within the crosshairs.

After a description of the target vehicles and a description of the study tasks for each of the phases, you will be given a step-by-step operational procedure for all the types of missions. You also will be allowed to practice the tasks on a variety of training missions.

Phase A--Briefing and Training

One part of this study, we will call it phase A, will require you to view the television screen and search for targets as the camera moves over the terrain. The types of targets with which you will be concerned are these: (at this point the experimenter shows the subject photographs of each of the target vehicles; tank, truck, and antiaircraft gun).

The sequence of operation will be as follows:

You will be seated at the RPV console. Upon your signal that you are ready, the experimenter, who will be seated at the table just behind you, will start the run. The start of the run will be indicated by the TV display coming on and you will see the terrain. You will be flying over the terrain at 100 knots and 2,000 feet altitude. The course, altitude, and speed are all automatic and you have no control over them.

When the individual run starts, the initial conditions will include the following:

- Altitude - 2,000 ft above ground
- Velocity - 100 knots
- Camera Look-Down Angle - 30° (indicated by the small dot being under the short horizontal line on the tube face)
- Lens - Wide Angle FOV
- Camera centered on flight path

Immediately after the start of a run you should devote your entire attention to looking for any of the vehicles you have been briefed on. The target locations will contain only one vehicle for each location or site but there may be several sites on any given run. There also may be no sites or targets on a run. The only guarantee I can give you is that if you keep the camera centered on the flight path, as indicated by the crosshairs and the index mark, and use the wide FOV lens, any target sites on the flight path will be shown on the TV display. Therefore, whenever you are searching for targets, you should make sure that the camera is centered on the flight path and in wide field-of-view.

Using the controller on the left side of the console shelf, you can move the camera in pitch between -20^{o} and -80^{o}. Once again, the small dot will indicate the relative camera look-down angle. The higher the dot, the steeper the look-down angle and, of course, the lower the dot, the shallower the look-down angle. The camera can be slewed left or right of the flight + or -30^{o}. This slewing should be done only when you feel you have detected something worth looking at in more detail. A typical sequence would go something like this:

After the mission starts, you detect something that might be a target vehicle off to the right of the flight path. At that time you say, "target." If you still evaluate the object to be a potential target, you use the left controller to slew the camera so that the potential target is centered in the wide FOV (put the center of the crosshairs on the target), squeeze the trigger, and examine the target with the narrow FOV. If it is a target vehicle, classify it as soon as possible by saying, "tank, truck, or AAA" or "no target" and immediately return the camera to the flight path centerline and the wide FOV. It also would be advisable to return to the flight path with the camera depressed at something greater than -30^{o} and then gradually pitch it up to approximately -30^{o}. This will prevent an additional target from going by you without ever being displayed on the TV monitor.

The runs vary in length and in the number of targets on any specific run. You must continue monitoring the TV display for targets until you are notified that the run has ended.

Do you have any questions at this time?

You will now be given the opportunity to practice using the controls and displays while searching for targets. If you have any questions during the training runs, please ask them.

Phase B--Briefing and Training

In this portion of the study, phase B, you will be concerned with maintaining the nominal flight path and operating conditions for the RPV. Your primary information displays will be the altimeter, the course deviation meter, the ECM warning light, and the TV monitor (displaying a degraded video picture). The right controller with its integral switch functions provides all the control capability you will need for this portion of the study.

The RPV will be flying a straight line flight path under the control of a simulated autopilot. As mentioned during the orientation and familiarization discussion, at various times during the mission or data run, failures in the course hold and altitude hold will cause the course deviation meter and the altimeter to change readings. The image on the TV also will change according to the failure with the first cue being the rapid displacement of the small dot in the lower part of the display.

To correct a course or altitude deviation, you will pull in and hold the trigger switch on the right controller. Using the controller you will manually correct the course deviation meter to read 0 $\pm$ 50 ft. or bring the altimeter back to 2,000 $\pm$ 50 feet. When the meters read 0 and 2,000 feet, you will release the trigger, thereby reactivating the simulated course or altitude hold.

Additional signals requiring a response from you will be the flashing RF warning light (cancelled by pressing the left switch on top of the controller) and the degraded video (corrected by pressing the right switch on top of the controller).

In all of these tasks you will be timed from the instant the error signal is presented until you have corrected the error. You should, therefore, be concerned about responding rapidly and accurately (the degraded video correct switch will not cancel the ECM warning).

Remember, you are not searching for targets on the ground. Your entire responsibility is the monitoring and control of the RPV and the TV image quality.

A mission or data run will start when you indicate to me that you are ready. All runs will start at 2,000 feet altitude, 0° course deviation, and the TV display will not be degraded. The runs will be of various durations and will have various levels of task load. Remember to make your corrections as rapidly and accurately as you can.

Are there any questions before we start the training runs?

Phase C--Briefing and Training

This phase of the simulation study program requires you to search for targets on the television display and concurrently monitor and correct errors in the flight path of the RPV. You have been through the phase A and phase B training. As I stated in the initial orientation and familiarization, this portion of the study, phase C, combines the tasks of A and B. You will have no new tasks.

I must caution you that during the data runs for this phase, your performance will be evaluated by the same criteria as it will be during the other two phases. Do not neglect the target acquisition tasks to concentrate on flight vehicle performance. Also, do not do the opposite and perform only target acquisition tasks while ignoring the flight vehicle performance.

At the conclusion of these training runs we will commence our data collection.

Do you have any questions?

APPENDIX H

DATA RUN PRESENTATION ORDER AND TASK-LOAD LEVEL

Table H-1

Phase A Data Run Presentation Sequence

	DATA RUN PRESENTATION ORDER									
PARTICIPANT	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	8	3	5	9	2	1	6	4	10	7
3	2	1	4	5	7	9	8	10	6	3
4	4	8	1	2	6	7	10	3	9	5
5	5	6	2	7	9	10	3	4	1	8
6	9	4	8	1	10	3	2	5	7	6
7	7	9	6	10	8	1	5	2	3	4
8	3	5	10	7	6	4	8	9	2	1
9	6	10	7	9	3	8	4	1	5	2
10	1	7	5	10	6	9	4	2	8	3
11	8	2	9	1	3	10	6	4	5	7
12	6	5	4	8	1	7	3	10	2	9

Table H-2

Phase B Data Run Task-Load Level

	RUN NUMBER									
PARTICIPANT	1	2	3	4	5	6	7	8	9	10
1-6	H	M	M	M	H	M	M	H	H	H
7-12	M	H	H	H	M	H	H	M	M	M

RAW DATA RECORD

```
ANDY        PHASE  A        RUN      5  TRACK     2  TASK    MEDIUM    STUDENT NO.    2
TIME TO TARGET 1      60          TIME TO TARGET 2      60          TIME TO TARGET 3      60
TIME OF TARGET DETECTION
   32
RANGE OF DETECTION
 5332
TIME OF TARGET RECOGNITION
   33
RANGE OF RECOGNITION
 5332

ANDY        PHASE  A        RUN      6  TRACK     1  TASK    MEDIUM    STUDENT NO.    2
TIME TO TARGET 1      50          TIME TO TARGET 2      50          TIME TO TARGET 3      50
TIME OF TARGET DETECTION
   21
RANGE OF DETECTION
 5450
TIME OF TARGET RECOGNITION
   25
RANGE OF RECOGNITION
 4625
```

Figure I-1. Phase A raw data record.

```
REIMLE      PHASE  B      RUN      9   TRACK    9   TASK   HEAVY      STUDENT NO.   1

TIME TO TARGET 1    100            TIME TO TARGET 2    100             TIME TO TARGET 3    100

FAILURE TYPE
  1     3     2     1     2     4     1     3     2     1     2     1     4     2     1
RANDOM TIME FAILURES
 2.4   5.3   6.7  11.4  14.0  17.9  22.2  24.4  29.6  33.2  35.5  37.0  41.3  44.4  48.1
RESPONSE TIME
 9.95  0.0   1.7   1.0  0.20   5.4   1.0   5.0   1.2  0.84  0.91  0.98   6.6   1.0  0.91

FAILURE TYPE
  2     4     2     3     2     1     1     2     3     4     1     4     1     1     4
RANDOM TIME FAILURES
50.3  56.3  59.0  61.6  65.0  66.7  70.0  76.4  77.0  82.1  84.7  89.0  91.3  95.4  97.0
RESPONSE TIME
0.71   5.7   1.0  0.16   1.1   1.0  0.95  0.77  10.3  0.20  0.90   4.6  0.94   1.3  0.00



REIMLE      PHASE  B      RUN     10   TRACK   10   TASK   HEAVY      STUDENT NO.   1

TIME TO TARGET 1    60             TIME TO TARGET 2    60              TIME TO TARGET 3    60

FAILURE TYPE
  4     2     2     3     2     1     2     2     4     2     3     4     1     3     4
RANDOM TIME FAILURES
 2.0   5.2   8.2  12.6  14.3  18.4  22.1  25.1  27.0  30.5  35.5  36.7  43.0  45.6  48.2
RESPONSE TIME
 5.9   1.0   1.0  0.66  0.80  0.92  0.97  0.91   6.5   1.2   4.9  0.30  0.93  0.29  0.19

FAILURE TYPE
  4     3     1     4
RANDOM TIME FAILURES
51.2  54.7  57.9  60.1
RESPONSE TIME
0.28  0.00   1.1  0.98
```

Figure I-2. Phase B raw data record.

```
ANDY        PHASE  C      RUN      3   TRACK     4   TASK   HEAVY      STUDENT NO.   2
TIME TO TARGET 1      40              TIME TO TARGET 2      40              TIME TO TARGET 3      40

FAILURE TYPE
  3      1      4      1      3      4      4      2      2      4      2      3
RANDOM TIME FAILURES
  1.4    5.5    9.0   10.7   14.2   17.6   21.2   24.7   27.4   30.9   34.6   37.7
RESPONSE TIME
 10.2    1.4    5.9    1.7   22.1   0.10    9.1    1.3    1.9   0.00    1.0   0.00

TIME OF TARGET DETECTION
   20
RANGE OF DETECTION
 3605

TIME OF TARGET RECOGNITION
   23
RANGE OF RECOGNITION
 3602

ANDY        PHASE  C      RUN      4   TRACK     5   TASK   HEAVY      STUDENT NO.   2
TIME TO TARGET 1      50              TIME TO TARGET 2      50              TIME TO TARGET 3      50

FAILURE TYPE
  3      4      4      4      1      2      2      2      2      2      2      2      2      2      2
RANDOM TIME FAILURES
 0.41    4.5    8.3   11.3   15.0   19.4   22.4   25.5   27.4   31.0   35.5   38.0   39.9   43.9   48.3
RESPONSE TIME
 49.9   0.40   0.15   30.2    1.2    1.2    1.1    1.1    5.0    4.0    1.0    1.4   0.00    1.6    1.4

TIME OF TARGET DETECTION
   31
RANGE OF DETECTION
 3700

TIME OF TARGET RECOGNITION
   34
RANGE OF RECOGNITION
 3690
```

Figure I-3. Phase C raw data record.

APPENDIX J

ANOVA TABLES

Table J-1

ANOVA Summary for Task Loading and Target Background Effects on P_{TD}

Source of variation	SS	df	MS	F
Between subjects	.7465	11		
A (Groups I, II, III)	.1597	2	.0799	1.23
Subj. W. Groups [Error (a)]	.5868	9	.0652	
Within subjects	7.6393	60		
B (Task Load; O, MOD, HVY)	.8351	2	.4176	9.24**
AB	.1423	4	.0356	0.79
B x Subj. W. Groups [Error (b)]	.8142	18	.0452	
C (Target Background; Open, Clutter)	4.2535	1	4.2535	154.67**
AC	.3045	2	.1522	5.53*
C x Subj. W. Groups [Error (c)]	.2476	9	.0275	
BC	.3907	2	.1954	6.03**
ABC	.0672	4	.0168	0.52
BC x Subj. W. Groups [Error (bc)]	.5842	18	.0324	

*p < .05.
**p < .01

Table J-2

ANOVA Summary for Task Loading and Target Background Effects on P_{TR}

Source of variation	SS	df	MS	F
Between subjects	1.2360	11		
A (Groups I, II, III)	.0040	2	.002	
Subj. W. Groups [Error (a)]	1.2320	9	.1369	
Within Subjects	7.3753	60		
B (Task Load; O, MOD, HVY)	.7569	2	.3784	7.13**
AB	.1904	4	.0476	0.90
B x Subj. W. Groups [Error (b)]	.9554	18	.0531	
C (Target Background; Open, Clutter)	4.0140	1	4.0140	114.68**
AC	.2309	2	.1154	3.30
C x Subj. W. Groups [Error (c)]	.3154	9	.0350	
BC	.2987	2	.1494	5.41*
ABC	.1162	4	.0291	1.05
BC x Subj. W. Groups [Error (bc)]	.4973	18	.0276	

*p < .05.
**p < .01.

Table J-3

ANOVA Summary for Task Loading and Target Background Effects on R_{TD}

Source of variation	SS	df	MS	F
Between subjects	2,539,182	11		
A	821,864	2	410,932.00	2.15
Subj. W. Groups [Error (a)]	1,717,318	9	190,813.11	
Within subjects	43,552,783	60		
B	5,198,668	2	2,599,334.00	12.00**
AB	779,453	4	194,863.75	0.90
B x S's W. Groups [Error (b)]	3,898,183	18	216,565.72	
C	26,345,331	1	26,345,331.00	220.43**
AC	1,293,975	2	646,987.50	5.41*
C x S's W. Groups [[illegible]	1,075,671	9	119,519.00	
BC				
[illegible]				

Table J-4

ANOVA Summary for Task Loading and Target Background Effects on R_{TR}

Source of variation	SS	df	MS	F
Between subjects	4,085,791.11	11		
A	76,815.20	2	38,407.60	0.09
Subj. W. Groups [Error (a)]	4,008,975.91	9	445,441.77	
Within subjects	21,047,494.67	60		
B	2,275,216.78	2	1,137,608.39	8.35**
AB	196,905.55	4	49,226.39	0.36
B x S's W. Group [Error (b)]	2,451,328.34	18	136,184.91	
C	12,450,050.00	1	12,450,050.00	64.91**
AC	402,789.58	2	201,394.79	1.05
C x S's W. Group [Error (c)]	1,726,175.76	9	191,697.31	
BC	222,880.33	2	111,440.17	1.59
ABC	63,885.34	4	15,971.34	0.23
BC x S's W. Group [Error (bc)]	1,258,262.99	18	69,903.50	

*$p < .05$.
**$p < .01$.

Table J-5

ANOVA Summary for Main Task and Frequency of Auxiliary Task Effects on Video Degrade and RF Response Times

Source of variation	SS	df	MS	F
Between subjects	2.03	11		
A (Groups I, II, III)	0.70	2	0.35	2.33
Subj. W. Groups [Error (a)]	1.33	9	0.15	
Within subjects	9.02	36		
B (Target acquisition concurrent)	2.95	1	2.95	19.67**
AB	0.44	2	0.22	1.47
B x Subj. W. Groups [Error (b)]	1.38	9	0.15	
C (Task Load: mod, hvy)	0.17	1	0.17	1.06
AC	0.14	2	0.07	0.44
C x Subj. W. Groups [Error (c)]	1.48	9	0.16	
BC	0.06	1	0.06	0.25
ABC	0.21	2	0.10	0.42
BC x Subj. W. Groups [Error (bc)]	2.19	9	0.24	

**$p < .01$.

Table J-6

ANOVA Summary for Main Task and Frequency of Auxiliary Task Effects on Altitude and Course Deviation Response Times

Source of variation	SS	df	MS	F
Between subjects	163.65	11		
A (Groups I, II, III)	14.72	2	7.36	0.44
Subj. W. Groups [Error (a)]	148.93	9	16.55	
Within subjects	265.31	36		
B (Target acquisition concurrent)	176.33	1	176.33	30.51**
AB	12.18	2	6.09	1.05
B x Subj. W. Groups [Error (b)]	52.04	9	5.78	
C (Task Load: mod, hvy)	-0-	1	-0-	0.00
AC	0.12	2	0.06	0.05
C x Subj. W. Groups [Error (c)]	10.22	9	1.14	
BC	0.45	1	0.45	0.32
ABC	1.12	2	0.56	0.39
BC x Subj. W. Groups [Error (bc)]	12.85	9	1.43	

**$p < .01$.

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4 British Def Staff, British Embassy, Washington
1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
1 Militaerpsykologisk Tjeneste, Copehagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.–Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministeria van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands