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TECHNICAL REPORT RH-76-11

ARMY POINTING AND TRACKING TEST METHODOLOGY (U)

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3 May 1976

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Redstone Arsenal, Alabama 35809

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

(C) In the latter half of calendar year 1975, the mobile test unit pointer/tracker underwent extensive performance testing with a low power helium-neon in lieu of a high power CO_2 laser. The objectives of this test program were to obtain data on overall system pointing and tracking performance, to correlate these data with subsystem performance characteristics, and to evaluate the man/machine interaction. The purpose of this document is to detail the methodology underlying the conduct of this effort.

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(U) CONTENTS

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I. (C) INTRODUCTION

In the latter half of calendar year 1975, the mobile test unit (MTU) pointer/tracker (P/T) underwent extensive performance testing with a low power helium-neon (He-Ne) laser in lieu of a high power CO_2 laser. The objectives of this test program were to obtain data on overall system pointing and tracking performance, to correlate these data with subsystem performance characteristics, and to evaluate the man/machine interaction. The purpose of this document is to detail the methodology underlying the conduct of this effort.

II. (C) MAJOR TECHNICAL OBJECTIVES AND METHODOLOGY SUMMARY

(C) To obtain the type of data that could be utilized most advantageously in support of the MTU Program, four major technical objectives were established as goals for the low power tests. These goals were accomplished by the low power tests and are listed as follows:

1) MTU/advanced system performance - The MTU was exercised on both subsystem and system basis to determine performance limits as they applied to the field environments.

2) Operator/machine interaction - Test plans were formulated to examine the interaction of the operator with the MTU. This interaction was examined from the standpoint of both efficiency and ease of operation. Operator timelines based on active/reactive stimuli were determined. This was done for varying degrees of situational complexity.

3) Standardization of system peculiar tests - A number of tests were defined which provided performance information not only for MTU but also for other similar systems. Hence, a first attempt at formulating tests in which data can be objectively compared for various hardware approaches.

4) Field environment - Routine maintenance, gradual deterioration effects, and system malfunctions were documented. These data will be used to indicate the level of complexity of repairs required to maintain operational status.

(U) Four basic data sources were used during the MTU low power pointing and tracking test (LPP&T) program. Data were recorded in log books, on video tape, magnetic tape, and on film. The following is a listing of the four basic data sources and the types of data in each of their categories.

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1) Data log books -

   a) Meteorological data.
   b) Light intensity data.

2) Video tapes -

   a) Operator's actions.
   b) Operator's comments.
   c) Tracker video.
   d) Laser spot data.

3) Analog magnetic tape -

   a) Azimuth and elevation servo error signals.
   b) Azimuth and elevation tracker error signals.
   c) Accelerometer data.
   d) Roll gyro data.
   e) Optical lock-on signal.
   f) Laser "on-off" signal.

4) Film (contraves camera data).

(U) Once recorded, data were reduced and analyzed according to the flow chart shown in Figure 1. For each category of data, reduction and analysis requirements were written. In each case, the data objective, data source, method of reduction, scale factors, and type of data presentation were defined. Details of these requirements are presented in Section V.

III. (C) LOW POWER TEST CONFIGURATION

(C) A low power (70 to 80 mW) He-Ne laser was installed in the MTU to simulate the high energy laser (HEL) beam. Figure 2 shows schematically how this was accomplished. The coupling optics were designed to properly condition the low power beam prior to entering the beam expander. The beam expander, which will also be used for the HEL application, expanded the incoming beam to a 30-cm diameter and directed it toward the P/T. The P/T employed in these tests featured an elevation over azimuth two gimbal, gyro-stabilized pointer built by Perkin Elmer. The tracker was a modified optical contrast TISEO built by Northrop and integrated to the pointing system by MICOM personnel.

(U) For the LPP&T tests, the beam was allowed to propagate downrange to various types of target vehicles. At the target, the beam impinged on an etched mylar screen containing a grid pattern of 2-in. squares. The etched mylar was diffuse enough to act as a back lighted projection screen.

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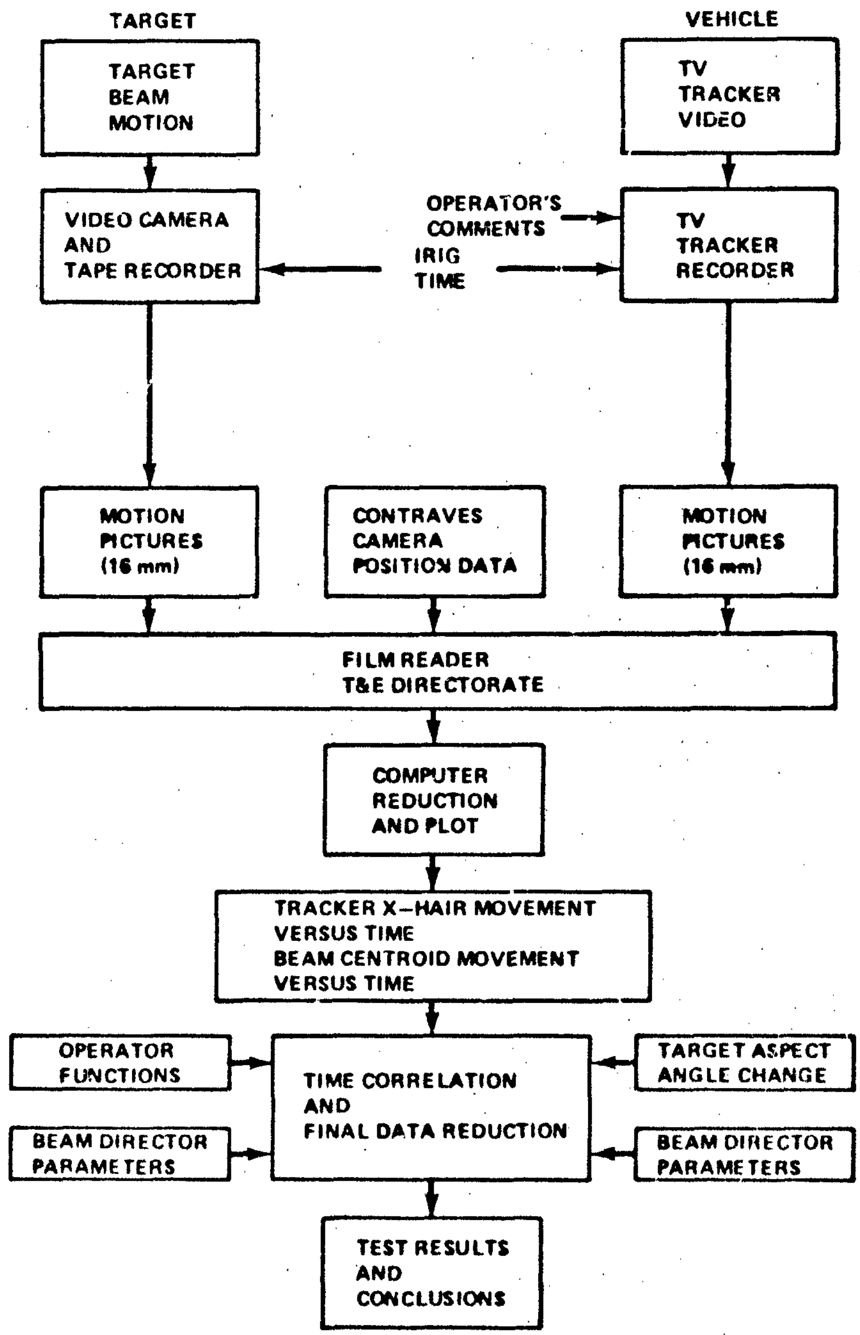


Figure 1. (U) Jitter measurements and data flow chart.

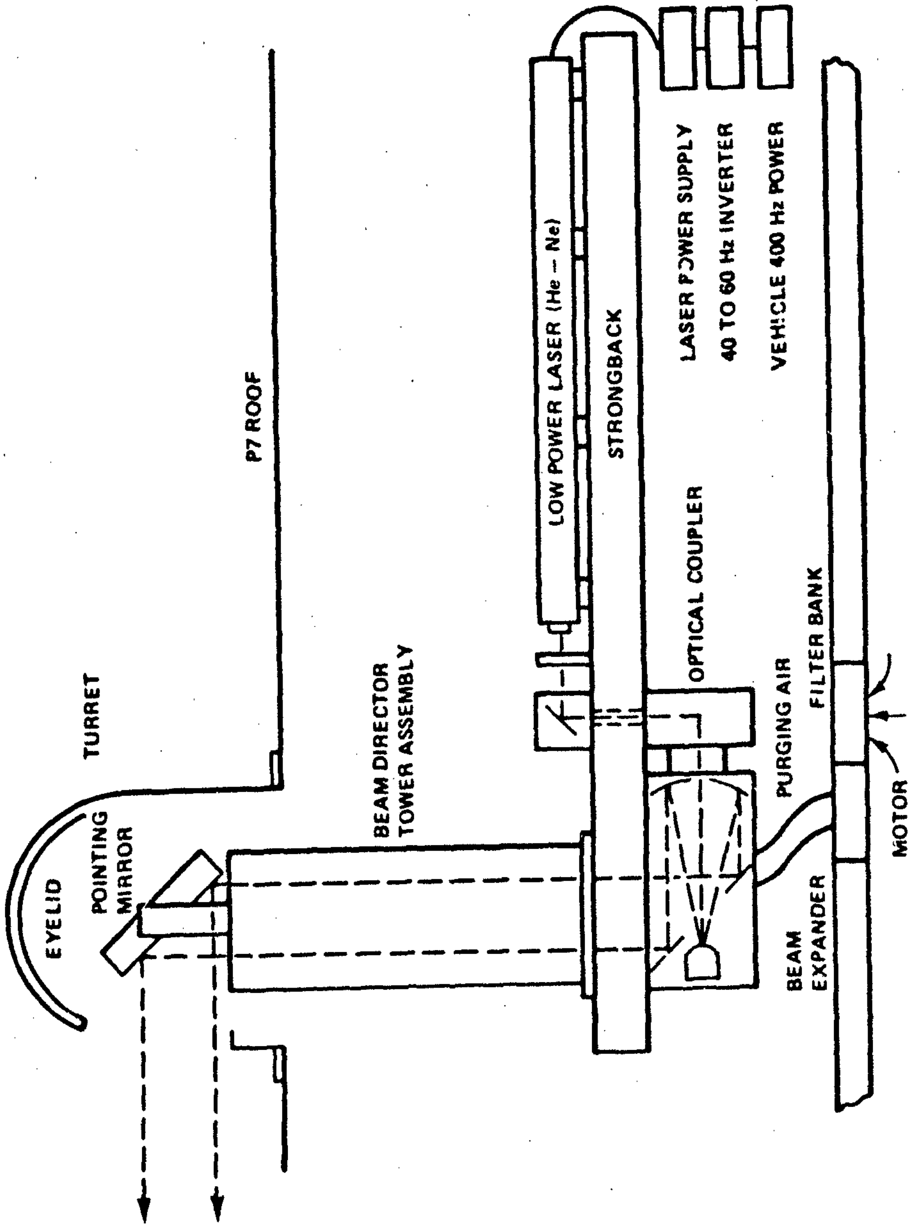


Figure 2. (U) Low power laser vehicle configuration.

(U) A video camera with a silicon vidicon and narrow bandpass red filter was used to monitor the position of the laser spot from onboard the target vehicle. This information, along with tracker video recordings and recordings of several pertinent analog signals, was useful in quantitatively analyzing the MTU system P/T performance characteristics.

IV. (U) DATA COLLECTION SCHEME

A. (U) Data Requirements

To ensure that the performance of the P/T was adequately defined, various kinds of data were obtained and recorded during the field low power test activities. Figure 3 presents the type of data which were obtained and the recording methods used for each data type. The following paragraphs present a description of each block contained in Figure 3.

B. Operator Functions

Video data on operator functions were obtained by a TV camera mounted in the operator's compartment. The camera was equipped with a wide angle lens and mounted so as to look over the operator's shoulder during test activities. These video data were displayed in real time in the blockhouse and were recorded. Provisions were made to record IRIG time on the data.

These data were used to analyze the operator's proficiency in performing those functions that were required during a typical engagement sequence. In addition, recording of the data provided a record of console switch settings for each test, and the real-time display of the data enabled test personnel to monitor all activities in the operator's compartment.

C. Target Aspect

Data on target aspect in relation to the P/T were obtained by using three contraves camera stations. The film obtained from each contraves station was processed and read by the Test and Evaluation (T&E) Data Reduction Facility. The information obtained from the film of each camera was compared to provide target aspect information.

Target aspect data were analyzed to determine its relative contribution to the overall beam spot motion on target.

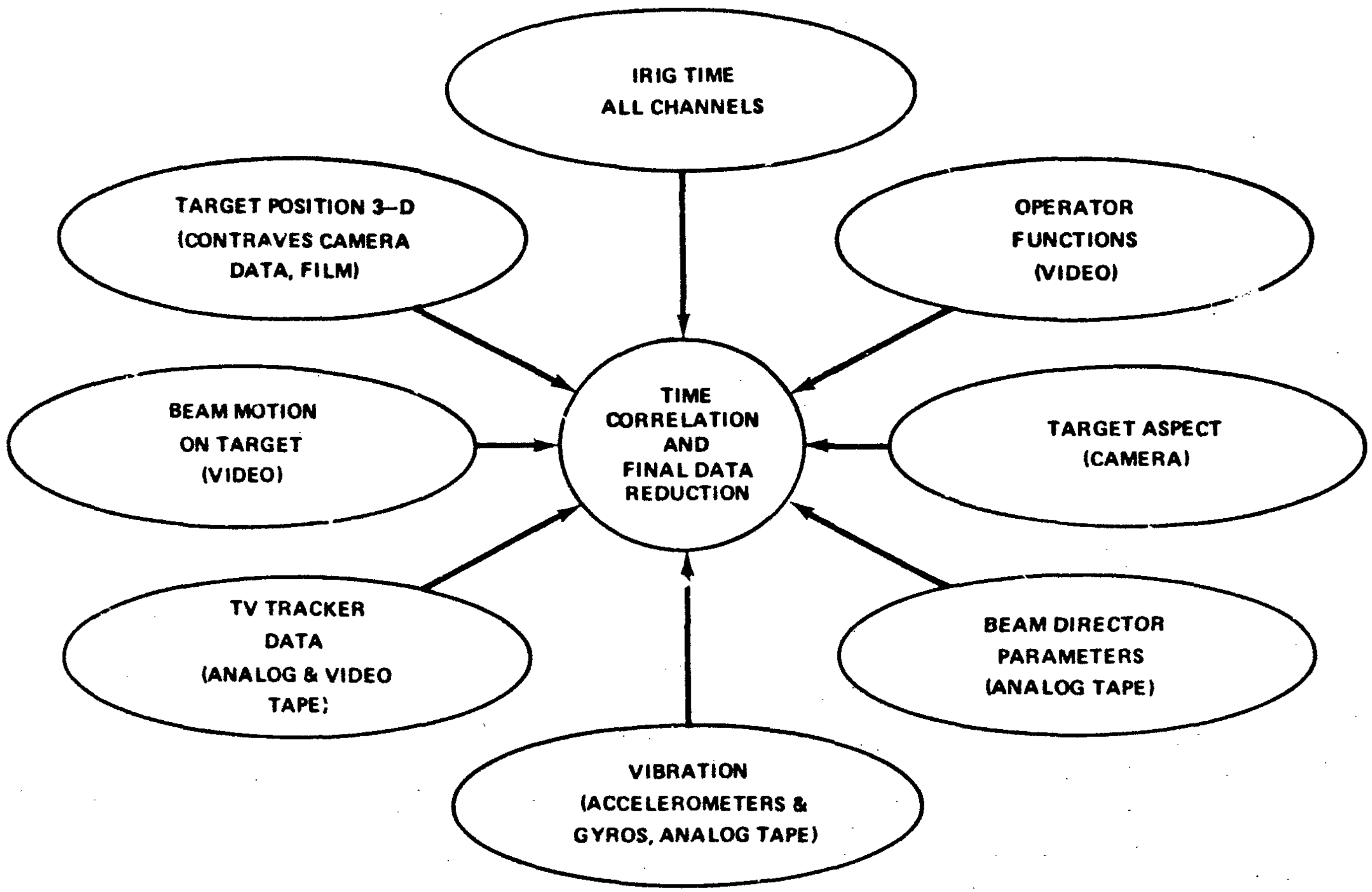


Figure 3. (U) Data collection scheme.

D. Beam Director Parameters

Beam director parameters recorded during field low power test activities are as follows:

1) Analog signals -

a) Servo error azimuth.
b) Servo error elevation.
c) Position azimuth.
d) Position elevation.
e) Tracker jitter azimuth.
f) Tracker jiiter elevation.
g) Roll gyro output.
h) Pitch accelerometer.
i) Roll accelerometer.
j) Inter-Range Instrumentation Group (IRIG) time.

2) Discrete signals -

a) Optical lock-on
b) Laser-on.

These signals were recorded on tape and analyzed to determine beam director performance.

E. Vibration

Vibration data were obtained from the P/T under various operating modes. Accelerometers were mounted at various positions on the P/T, and the P/T gyros were monitored for vibration data. The vibration signals were tape recorded for further evaluation.

F. TV Tracker Data

A video tape recording was made of the TV tracker video. In addition, operator's voice comments were recorded on the video tape.

The tracker video was analyzed to determine tracker jitter.

G. Beam Motion on Target

Data on beam spot motion at the target were obtained by using a TV camera positioned behind the translucent mylar target. The video data were transmitted, in real time, from the target to the blockhouse where it was displayed and recorded. Provision was made to record IRIG time on the video data.

H. Target Position

Data on target positions were obtained by using two contraves camera stations. The film obtained from each contraves station was processed and analyzed to determine target location.

I. IRIG Time

IRIG time in hours, minutes, seconds, and hundredths of seconds was recorded on all video data and on one channel of the tape recorder. In addition, IRIG time was recorded on one channel of an oscillograph recorder which was used in real time.

IRIG time was used as the common time reference for all test activities.

V. (C) DATA REDUCTION AND ANALYSIS

(U) To satisfy the objectives of the test program, the data collection scheme presented previously was developed. This scheme insured that adequate data parameterization of system and subsystem performance would be achieved, and that the major technical objectives would be satisfied.

The following paragraphs describe the data reduction and data analysis methods which are being used to satisfy the test objectives of the MTU (LPP&T) Program.

A. (C) Data Reduction Intervals

(U) An outline of test conditions was formulated from the detailed test plans. This test condition matrix was used to avoid confusion in the sequence of events or for the identification of time coherent data sampling intervals.

(U) The decision was made that for each run only a 10-sec period of raw data should be reduced in depth. The data from each source was reduced for the same 10-sec interval for each run. It was necessary, in some cases, to identify a second or third 10-sec interval during a given run because of changes in test conditions.

(C) It should be noted that 87 tests were performed in all. Thirteen of these tests were performed on 18 September 1975, 15 on 14 October 1975, and the remainder on 15 October 1975. The accelerometer data recorded on 18 September differs from that recorded on 14 and 15 October. The accelerometers were located at the base of the P/T on 18 September and were mounted on top the azimuth turntable for the 14 and 15 October tests.

(U) The method of parameterizing these LPP&T tests is shown graphically in Figure 4. Basically, the parameters called out in the procedure were (1) different operator, (2) turbine and fans on/off, (3) lock point, and (4) contrast setting when locking on to the outline of the helicopter or an arbitrary internal feature of the helicopter outline.

(U) Table 1 shows a sample of the preliminary test condition matrix and the time segments from each run that were to be reduced in depth.

B. (U) Data Reduction

The information on data reduction presented in the following paragraphs are excerpts from a data reduction plan that was prepared to provide data reduction requirements and background information to personnel who performed the data reduction. Included in the report were data reduction requirements, specific time intervals for jitter data reduction, and test procedures which were used during the P/T performance tests.

1. Laser Spot Jitter.

a) Objective: An analysis of the time varying relative motion between the centroid of the laser spot and some reference point in the target screen will yield information to determine beam director stabilization and tracking accuracy in both the time and frequency domain.

b) Data source:

(1) Spot video (30 frames/sec) for each run.

(2) Contraves data will be used for slant range computation.

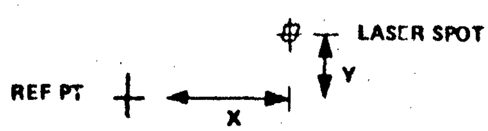
(3) Test condition matrix.

c) Data reduction:

(1) A 16-mm film will be made from the video tape for data reduction.

(2) The same 10-sec time segment determined for reduction for "Tracker Line-of-Sight Jitter" will be reduced for each run (test).

(3) In each frame of data, the distance from the centroid of the laser spot to the selected reference point will be measured and recorded for both X and Y position.



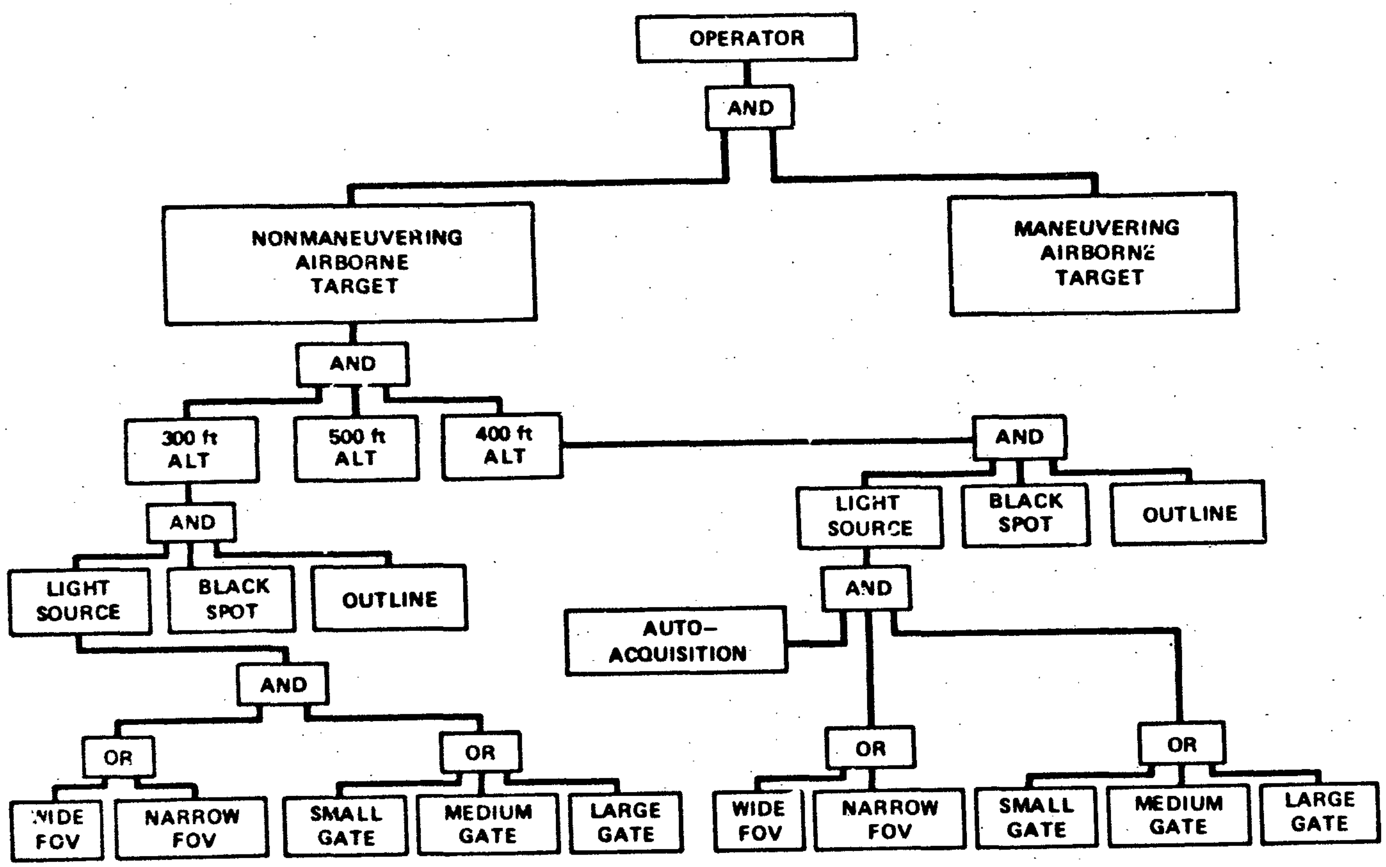


Figure 4. (U) Parameterization of tests.

TABLE 1. (U) TEST CONDITION MATRIX

Date	Start of Run Time	Run No.	Test No.	Target Altitude (ft)	Turbine	Fans	Lock Point	Contrast Setting	Jitter Data Reduction Period (sec)	Remarks
18 Sept	20:12:57	1	1	300	On	On	Light	White	20:13:38 to 20:13:48	Narrow FOV*
18 Sept	20:15:28	2	2	300	On	On	Black Spot	Black	20:15:54 to 20:16:04	Narrow FOV*
18 Sept	20:17:48	3	3	300	On	On	Outline	Auto	20:18:18 to 20:18:28	Narrow FOV*
18 Sept	20:20:19	4	4	400	On	On	Light	White	20:21:07 to 20:21:17	Narrow FOV*
18 Sept	20:26:47	5	5	400	On	On	Black Spot	Auto	20:27:08 to 20:27:18	Narrow FOV*
18 Sept	20:29:24	6A	6A	400	On	On	Outline	Auto	20:29:48 to 20:29:58	Narrow FOV*

*Constant radius flyby - radius is 700 m-70 kn

(4) Record distances X and Y in centimeters and divide these values by the slant range from the MTU to the target. Slant range will be in centimeters. This computation is performed to obtain angular values for laser spot jitter.

(5) Perform a frequency domain analysis of the laser spot jitter data in the frequency range of 0.5 Hz to 6 Hz with 0.1-Hz resolution.

d) Scale factor: Not applicable.

e) Data presentation:

(1) Data shall be presented in both tabular and plot format. Tabular format will include at least the following values: IRIG time (1/100 sec), frame number, X distance (cm), Y distance (cm), X angle (mrad), Y angle (mrad), RSS of X and Y (cm), RSS of X and Y (mrad), and slant range (cm). Slant range should be interpolated to obtain ranges for corresponding IRIG times. At the end of each data segment, a summary of the tabulated data to include the mean and standard deviation of the parameters discussed will be presented.

(2) Data tabulations and plots will be titled "Laser Spot Jitter Data," date, and run number.

(3) A plot of amplitude in milliradians versus frequency in Hz will be provided for each run for the frequency range of 0.5 to 6 Hz with resolution to 0.1 Hz.

2. Tracker Line-of-Sight Jitter.

a) Objective: An analysis of the time varying relative motion between the center of the lock point and the tracker cross hair will yield valuable information for specifying tracker jitter.

b) Data source:

(1) Tracker video (30 frames/sec) for each run.

(2) Contraves data to be used for slant range computation.

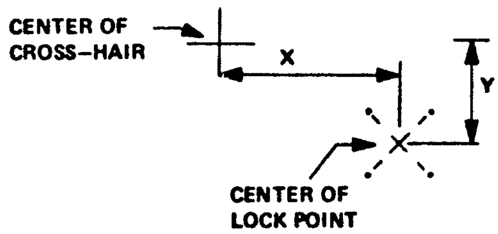
(3) Test condition matrix.

c) Data Reduction:

(1) A 16-mm film (30 frames/sec) will be made from the video tape for data reduction.

(2) A predetermined 10-sec data segment will be reduced for each run (test). In come cases, a second or third 10-sec segment may be specified.

(3) For each frame of data, the distance from the centroid of the tracker gate to the center of cross hair will be measured and recorded for both X and Y position.



The centroid of the tracker gate is determined by connecting diagonals in the manner shown above.

(4) Record distances X and Y in centimeters and divide these values by the slant range from the MTU to the target. Slant range will be centimeters. This computation is performed to obtain angular values for tracker jitter.

(5) Perform a frequency domain analysis of the jitter data. Frequency range will be from 0.5 Hz to 6 Hz with 0.1-Hz resolution.

d) Scale factor: Not applicable.

e) Data presentation: Data shall be presented in both tabular and plot format. Tabular format will include at least the following values: IRIG time (1/100 sec), frame number, X distance, (cm), Y distance, (cm), X angle (mrad), Y angle (mrad), RSS of X and Y (cm), RSS of X and Y (mrad) and slant range (cm). Slant range should be interpolated to obtain ranges for corresponding IRIG times. At the end of each segment there should be a summary of the tabulated data to include mean and standard deviation for the aforementioned parameters. Data tabulations and plots will be titled, "Tracker Line-of-Sight Jitter Data," date, and run number. Frequency domain data will be plotted to show resolution to 0.1 Hz between 0.5 to 6 Hz. Amplitude will be plotted in milliradians.

3. <u>Contraves Data</u>.

a) Objective: The objective is to obtain time coherence helicopter position data referenced to the MTU position.

b) Data source:

(1) Contraves theodolite with film readout.

(2) Test condition matrix.

c) Data reduction:

(1) The contraves camera stations are located at known range positions. The MTU is also located at a surveyed position on the range. Contraves camera stations track the helicopter target board during the flyby. By triangulation, the position X, Y, and Z of the helicopter is obtained relative to the MTU beam director. These data are obtained at a data rate of 10 frames/sec and can be interpolated if required.

(2) A predetermined 10-sec data segment will be reduced for each run (test) which will correspond to the data sampling periods (also 10 sec) for tracker and laser spot jitter data. In some cases, a second or third 10-sec segment may be specified.

(3) Data will b. reduced at a rate of 2 sampes/sec.

(4) Aspect angle changes with respect to time may be required. It is understood that these aspect angle changes can be determined only for pitch and yaw helicopter motion.

d) Scale factors: Not applicable.

e) Data presentation: Data shall be presented in a tabular format. The data shall consist of at least the following: slant range from MTU beam director to helicopter target board (cm), horizontal distance from helicopter target board to MTU beam director (cm), vertical distance from MTU beam director to the helicopter target board (cm), and IRIG time (1/10-sec intervals). The data tabulations will be titled "Contraves Data," date, and run number.

4. Pitch and Roll Accelerometer Signals.

a) Objective: By analyzing pitch and roll motions measured at the bottom of the P/T tower, at the top of the P/T tower, and on top of the P/T turntable, the amount of motion introduced into the optical system by running the MTU turbine and fans can be determined, and the coupling of this motion through the optical system can be quantified. This information is essential for determining an over-all error budget for P/T tracking tests.

b) Data source:

(1) Magnetic tape.

(2) Test condition matrix.

c) Data reduction:

(1) An oscillograph recording of the pitch and roll accelerometer signals will be made for each run and IRIG time will be displayed.

(2) Perform frequency domain analysis of the pitch and roll accelerometer signals in the frequency range of 0.5 Hz to 50 Hz for the same 10 sec interval that will be analyzed for laser spot and tracker line-of-sight jitter data.

d) Scale factor: To be computed.

e) Data presentation:

(1) Data will be presented in plot format. A plot of amplitude in milliradians versus frequency in hertz will be provided for each run for the frequency range of 0.5 Hz to 50 Hz with resolution to 0.1 Hz.

(2) A plot of the pitch and roll accelerometer signals as a function of IRIG time will be prepared for each run.

(3) The plots will be titled by "Pitch or Roll Accelerometer Data" (as applicable), test date, and run number.

5. Roll Gyro Data.

a) Objective: The roll gyro on the Perkin Elmer beam director was initially installed to aid in decoupling vehicle roll motion from the line-of-sight of the laser beam. For the helicopter test however, the roll gyro was configured to measure the roll motion of the azimuth gimbal while the beam director was tracking the helicopter. The roll motion observed during the tests is representative of the motion induced into the turntable by azimuth gimbal bearing wobble. This information was essential in determining the extent of motion induced by the bearing and, therefore, along with pitch and roll accelerometers mounted on top of the azimuth turntable, adequately define one of the basic limitations of the Perkin Elmer system.

b) Data source:

(1) Test condition matrix.

(2) Magnetic tape recordings of Perkin Elmer roll axis gyro output.

c) Data reduction:

(1) For the specified 10-sec interval of roll gyro data, the required reduction will be to plot amplitude versus IRIG time.

(2) A frequency domain analyses should be performed on this analysis data to obtain the frequency content.

d) Data presentation:

(1) Plot of roll gyro amplitue in milliradians versus IRIG time.

(2) Plot of amplitude in mrads versus frequency for frequency range 5 Hz to 50 Hz with 1-Hz resolution.

(3) Plotted data should be titled, "Roll Gyro Data," dated with the date that the test was performed, and numbered with the appropriate run number.

6. Tracker Error Signals.

a) Objective: The objective is to evaluate and time correlate the electronic tracker error signals (X and Y) to the laser spot jitter data and the tracker line-of-sight jitter data.

b) Data source:

(1) Test condition matrix.

(2) Magnetic tape recordings.

c) Data reduction:

(1) An oscillograph recording should be made of the tracker X and Y error signals as a function of IRIG time for the specified 10-sec data sampling period.

d) Scale factor: X - To be computed.
Y - To be computed.

e) Data presentation:

(1) Plot tracker error signals X and Y versus IRIG time.

(2) Title each plot using pertinent information from the test condition matrix (i.e., date of test, run number, etc.).

7. Servo Error Signals.

a) Objective: The objective is to evaluate and time correlate the elevation and azimuth gimbal servo error signals to laser spot jitter, roll gyro data, roll and pitch accelerometer data, tracker line-of-sight jitter, and tracker error signals.

b) Data source:

(1) Test condition matrix.

(2) Magnetic tape recordings.

c) Data reduction:

(1) For a specified 10-sec interval, an oscillograph recording should be made of the elevation and azimuth servo error signals as a function of IRIG time.

(2) Perform a frequency domain analysis for frequency range of 0.5 to 6 Hz with 0.1-Hz resolution.

d) Scale factor:

(1) Elevation - See test notes.

(2) Azimuth - See test notes.

e) Data presentation:

(1) Plot elevation and azimuth servo error signals in milliradians versus IRIG time for each test.

(2) Plot the frequency domain information in mrads versus frequency for azimuth and elevation data.

(3) Title each plot with "Servo Error Signals," data, and run number.

8. Position Azimuth and Elevation Signals.

a) Objective: The objective is to determine the P/T azimuth and elevation position for each run. These data will aid in assessing an operator's ability to manually track a moving target and will also be used in determining the autotracker capabilities.

b) Data Source.

(1) Magnetic tape.

(2) Test condition matrix.

c) Data reduction:

(1) An oscillograph recording of the P/T azimuth and elevation position will be made for each run and IRIG time will be displayed.

(2) For each run, a determination of the P/T azimuth and elevation position will be made for 1-sec intervals.

d) Scale factor:

(1) The azimuth signal is scaled so that 0 V is 0° azimuth, 1 V is 100° azimuth, and -1 V is -100° azimuth.

(2) The elevation signal is sclaed sothat 0 V is 0° elevation and 1.5 V is 30° elevation.

e) Data presentation:

(1) Data shall be presented in both a plot and a tabular format. The tabular format will include IRIG time, and the azimuth and elevation position for each 1-sec interval.

(2) A plot of azimuth position and elevation position in degrees as a function of IRIG time will be prepared for each run.

(3) The average velocity in azimuth should be included on each plot.

(4) Data tabulations and plots will be titled, "Azimuth Position Data" or "Elevation Position Data" (as applicable).

9. Time Line Sequence.

a) Objective: By analyzing the tracker video tapes to obtain the event times for acquisition, wide, and narrow FOV use, and by incorporating the event times for optical lock-on, break-lock, laser-on, and laser-off events determined from reduction of the optical lock-on signals and the laser-on signals, a time line sequence can be constructed. This time line sequence will aid in assessing an operator's proficiency in performing a typical engagement sequence.

b) Data source:

(1) Tracker video tapes.

(2) Data tabulations of optical lock-on and laser-on event times.

(3) Test condition matrix.

c) Scale factor: Not applicable.

d) Data reduction and presentation:

(1) A tabular presentation of acquisition, wide, and narrow FOV use event times will be prepared, and the tabulations prepared from the data reduction of the optical lock-on and laser-on signals will be merged into this table.

(2) From the data in this table, a time line sequence chart will be prepared. The format of this chart is shown in Figure 5.

(3) The tabulations and time line sequence charts will be titled, "Time Line Sequence Data" by date, run number, operator, and other pertinent information obtained from the test condition matrix.

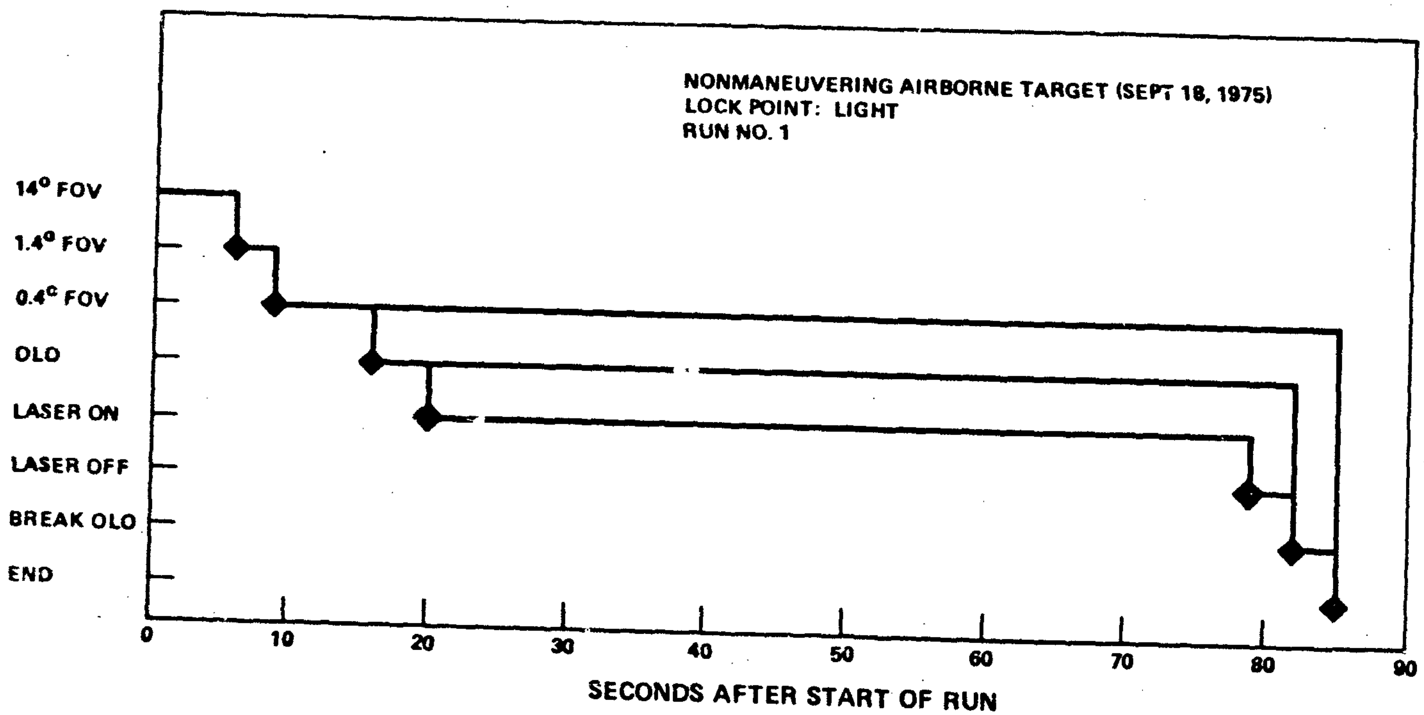


Figure 5. (U) Time line sequence.

10. Optical Lock-on Signal.

a) Objective: The objective is to determine the times at which optical lock-on, break-lock, and relock events occurred during each run. These data will be used in determining operator proficiency in acquiring, locking on, and relocking, if necessary, onto a target.

b) Data source:

(1) Magnetic Tape.

(2) Test condition matrix.

c) Data reduction:

(1) An oscillograph will be made for each run and IRIG time will be displayed.

(2) For each run, a determination of lock-on and break-lock events will be performed as a function of time.

(3) For each run, a determination will be made of lock-on duration for each lock-on event.

d) Scale factor: The optical lock-on signal is bilevel signal. No lock is a 0 and lock-on is a negative excursion.

e) Data presentation:

(1) Data shall be presented in both a plot and a tabular format. The tabular format will include the IRIG time, to an accuracy of 0.1 sec, of each lock and break-lock event and will also include the duration of each lock-on interval.

(2) A plot of the optical lock-on signal as a function of IRIG time will be prepared.

(3) Data tabulations and plots will be titled, "Optical Lock-on Data, date, and run number.

(4) The plot of these data will take the form of those preiously presented.

11. Laser-on Signal.

a) Objective: The objective is to determine the times at which the laser is on during each run. These data will be used in determining operator proficiency in lasing on a target after the target has been placed in optical lock-on.

b) Data source:

(1) Magnetic tape.

(2) Test condition matrix.

c) Data reduction:

(1) An oscillograph will be made for each run and IRIG time will be displayed.

(2) For each run, a determination of laser-on and laser-off events will be performed as a function of time.

(3) For each run, a determination will be made of the lasing duration for each laser-on event.

d) Scale factor: The "laser-on" signal is a bilevel signal. "Laser-off" is a 0 and "laser-on" is a positive excursion.

e) Data presentation:

(1) Data shall be presented in both a plot and a tabular format. The tabular format will include the IRIG time, to an accuracy of 0.1 sec, of each "laser-on" and "laser-off" event, and will also include the duration of each lasing interval. A plot of the laser-on signal as a function of IRIG time will be prepared.

(2) Data tabulations and plots will be titled, "Laser-On/Off Data, date, and run number.

(3) These data will be plotted in the time line sequence plot as shown in the previous example.

12. Meteorological.

a) Objective: Analysis of meteorological data will provide information on parametric changes in various MTU systems resulting from changing weather conditions.

b) Data source:

(1) Test Area 1 weather station.

(2) Test condition matrix.

c) Data reduction: Not applicable

d) Scale factor: Not applicable.

e) Data presentation:

(1) A tabular format will be prepared to present the measured parameters as a function of time.

(2) The data tabulation will be titled, "Meteorological Data" and date.

13. Light Intensity Readings.

a) Objective: Analysis of light intensity measurements will aid in determining the P/T capabilities as a function of ambient light levels (target contrast).

b) Data source:

(1) Data sheets.

(2) Test condition matrix.

c) Data reduction: The light intensity measurements obtained during test activities will be converted from foot candles to lumens per square centimeters.

d) Scale factor: Not applicable

e) Data presentation:

(1) The light intensity measurements, after being converted to lumens per square centimeter, will be tabulated as presented in Paragraph V. C.

(2) The tabulated data will be titled, "Light Intensity Data," date, and run number.

C. Test Procedure Sample

1. Introduction.

In this paragraph, sample requirements for performing P/T performance tests against airborne targets are discussed, and a sample test procedure prepared for tracking a nonmaneuvering airborne target is presented.

This sample test procedure calls for 12 flybys under different test conditions. The flight path of the helicopter is a semicircle about the MTU. Helicopter velocity is 70 kn and altitudes of 300, 400, and 500 ft are specified.

2. Test: Tracking a Nonmaneuvering Airborne Target.

a) Reference: Test Plans, Tests 4.3-1 and 4.3-2

b) Purpose: To demonstrate the MTU's capability to track and lase on an airborne target.

c) System configuration: MTU with low power laser powered by the ground power unit or the turbine module.

d) Test and support equipment:

(1) Helicopter with a mylar target and a light source. In addition, mount a TV camera, video recorder, and RF link to monitor the mylar target located on the side of the helicopter. The mylar target should be located on the left side of a "large window" Huey helicopter.

(2) Blockhouse instrumentation to display and record three sets of video. The displayed video should also have time displayed and audio on tracker video.

(3) Blockhouse instrumentation to record 8 analog and 2 bilevel signals.

(4) Blockhouse instrument to record 3 accelerometer signals.

(5) Weather station to record temperature, relative humidity, and wind velocity.

(6) Light measuring device.

(7) Questar telescope.

(8) Power meter.

(9) Contraves stations 1 and 3.

e) Test procedure:

(1) Connect MTU signals shown in Table 2 to patch panel going to blockhouse.

(2) Mount the 3 sets of accelerometer in the MTU. Connect accelerometer outputs to the patch panel.

(3) Connect MTU tracker video and operator's compartment video to the patch panel. Set up receiving antenna to receive video from the helicopter. This antenna should be positioned to obtain a clear line-of-sight to the helicopter during the time the MTU is tracking the helicopter. IRIG time is to be displayed and recorded on each of the video signals received in the blockhouse. An audio channel containing MTU operator's comments will be recorded on the tracker video.

TABLE 2. (U) SIGNALS TO BE RECORDED

Analog Signals:		
	1)	Servo Error Azimuth
	2)	Servo Error Elevation
	3)	Position Azimuth
	4)	Position Elevation
	5)	Tracker Jitter Azimuth
	6)	Tracker Jitter Elevation
	7)	Roll Gyro Output
	8)	Pitch Accelerometer
	9)	Roll Accelerometer
	10)	IRIG Time
Discrete Signals:		
	1)	Optical Lock-on
	2)	Laser-on

(4) Power up the MTU using the ground power unit (GPU) for 208 VAC power.

(5) Check the output of the He-Ne laser using the power meter. The output should be between 75 and 85 mW.

(6) Place a piece of etched mylar across the beam path at the beam director and look for uniform beam intensity distribution. If the intensity profile is not uniform, then adjust the beam coupling optics on the strongback to achieve proper alignment of the beam to the beam expander. Obtain blockhouse permission to conduct lasing tests against ground targets.

(7) Lock on to one of the black square targets on the 0° azimuth target board. Turn on laser. The laser spot should be located 16 in. to the left of the center and on line with the vertical center of the target. If the laser spot is within specified limits, no adjustment is required. If an adjustment is made, record spot position before and after adjustment (Table 3).

(8) Check the boresight on the other two target boards. Use the Questar telescope to determine laser spot position. If spot is not in the correct position, go back to 0° target and adjust. Continue this procedure until the laser spot is within tolerance at all three target boards. See Figure 6 for target board locations.

(9) Prior to start of airborne test, install elevation stop so MTU cannot lase lower than 5° in elevation. Turn off the GPU and power up MTU with turbine. Turn on fans.

TABLE 3. (U) BORESIGHT VERIFICATION AND ADJUSTMENT

Target Board	Laser Spot		Adjustment Required	Laser Spot	
	Azimuth	Elevation		Azimuth	Elevation

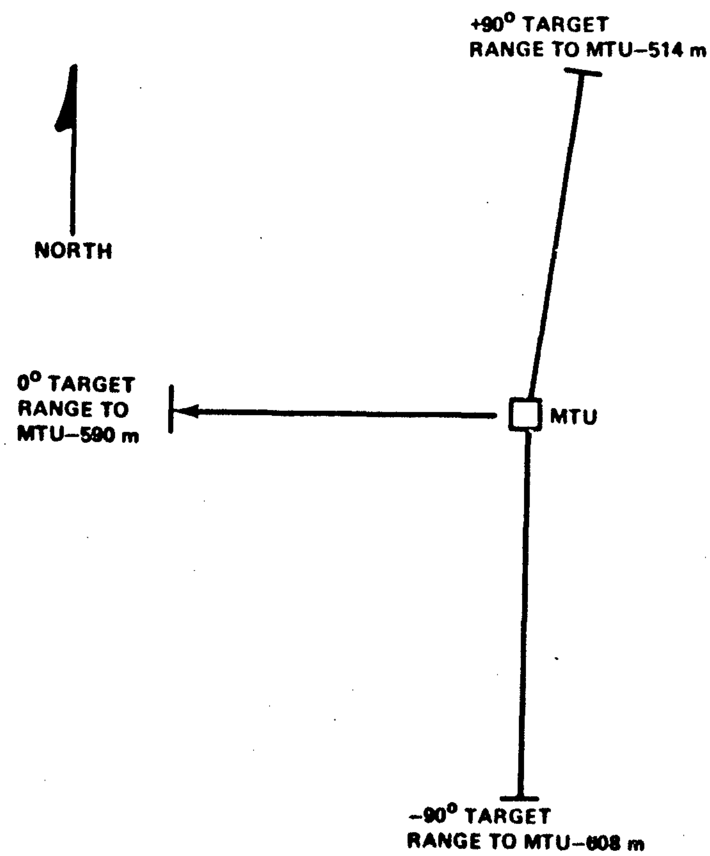


Figure 6. (U) Target board locations.

(10) Obtain permission for helicopter lasing tests.

(11) Have helicopter fly the flight path shown on Figure 7. Helicopter is to fly at an altitude of 300 ft and at a speed of 70 kn.

(12) Have helicopter perform one or more dry runs for familiarization. No lasing on dry runs.

(13) For run 1, have helicopter fly the constant radius flight path. MTU operator will lock-on the light source as soon as possible. Contrast switch setting will be white. No offset bias will be used. The operator will call out all MTU switch setting at start of run plus will note any switch setting changes during the run. During the run, three light intensity measurements will be made. One toward each target board when the helicopter is in the vicinity of the target board. Wind velocity, temperature, and relative humidity will be recorded at the start of the run (Table 4). Any helicopter altitude or airspeed deviations will be recorded for the run. Contraves camera coverage from stations 1 and 3 will be obtained at a rate of 10 frames/sec.

(14) Runs 2 through 12 will be the same as run 1 with the test conditions shown in Table 5.

(15) Upon successful completion of run 12, shut down the MTU.

f) Data reduction: Data reduction will be accomplished as shown in Figure 1.

D. (U) Data Analysis

Analysis of the data will be performed to determine the relative contributors to laser spot jitter. Time domain data on target positions, laser spot and tracker jitter, and tracker performance will be compared so that the cause of any large amplitude or transient variations in laser spot position on target can be determined. The frequency domain data on tracker subsystem performance, and laser spot, and tracker jitter will be compared to determine the relative contributors to "steady state" beam jitter. Finally, the man/machine performance characteristics for each test shall be determined by preparing time line charts from the time domain data on key events.

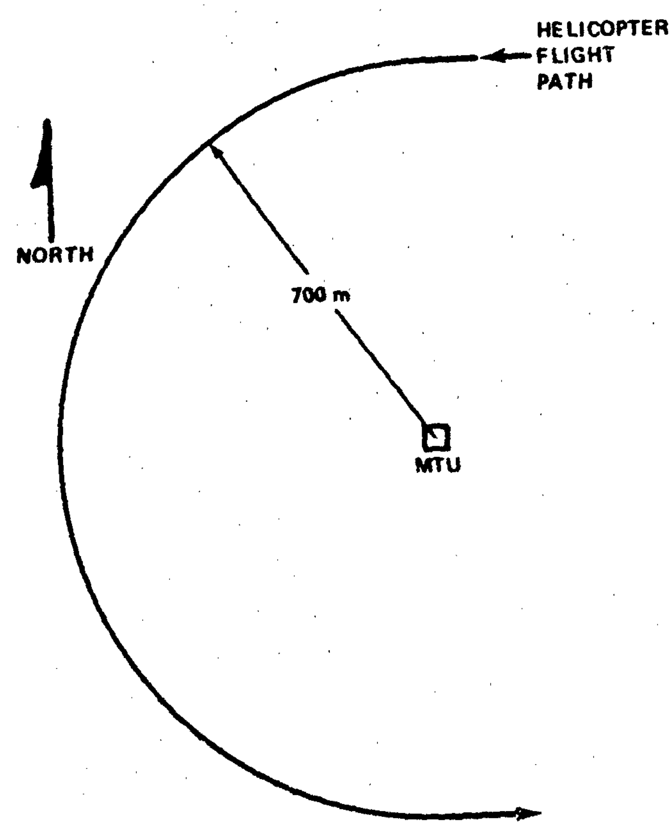


Figure 7. (U) Constant radius flight path.

TABLE 4. (U) METEOROLOGY AND LIGHT INTENSITY DATA

Run Number	Time	Meteorology				Light Intensity		
		Wind Velocity	Wind Direction	Temperature	Relative Humidity	90°	0°	-80°

TABLE 5. (U) TEST CONDITIONS AND OPERATOR'S COMMENTS

Run No.	Target Altitude	Turbine	Fans	Lock Point	Contrast Setting	Type of Tracking	Field of View	Gate Size	Helicopter Flight Path Deviations	Remarks
1	300 ft	On	On	Light Source	White					
2	300 ft	On	On	Black Spot	Black					
3	300 ft	On	On	Heli Outline	Auto					
4	400 ft	On	On	Light Source	White					
5	400 ft	On	On	Black Spot	Black					
6	400 ft	On	On	Heli Outline	Auto					
7	400 ft	On	On	Light Source	White					Auto Acquisition
8	400 ft	On	On	Black Spot	Black					Auto Acquisition
9	400 ft	On	On	Heli Outline	Auto					Auto Acquisition
10	500 ft	On	On	Light Source	White					

TABLE 5. (U) (Concluded)

Run No.	Target Altitude	Turbine	Fans	Lock Point	Contrast Setting	Type of Tracking	Field of View	Gate Size	Helicopter Flight Path Deviations	Remarks
11	500 ft	n	n	Black Spot	Black					
12	500 ft	n	n	Heli Outline	Auto					

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