Mobile Automatic Tracking System (MATS)

This paper discusses the Mobile Automatic Tracking System (MATS), a man-portable, precision, real-time Tracking system derived from E-O Imaging's extensive video tracking experience. The MATS is a cost-effective tool in providing photo-instrumentation support for weapons system testing and evaluation, and surveillance applications. The system's slave and designate modes also allow the MATS to be used as an adjunct to radars and other E-O instrumentation systems. The MATS is configurable as a standalone Time Space Position Information (TSPI) Site, providing both manual and automatic operation. The MATS provides a new level of flexibility and capability in supporting the increasing demands of the Test and Evaluation community for a cost-effective, reliable solution to E-O instrumentation requirements.

Introduction

The MATS was developed to provide a reliable, easily deployable, cost-effective solution for fielding E-O instrumentation in support of weapon, aircraft and missile testing. The system design allows both Automatic and Manual operations, with both local and remote control capability. The MATS architecture allows E-O Imaging the flexibility to furnish the User a system optimized for his specific needs, from a simple single camera payload to complex payloads and support instrumentation.

The system can be controlled from a Laptop computer or from a remote location over an RS232/422 serial interface or a TCP/IP Ethernet port. The MATS is comprised of four subsystems; the System Controller, Sensor suite, Operator's controls and Positioner. The subsequent paragraphs look at the system architecture, performance characteristics features and available options. Figure 1 shows the MATS system. Figure 2 provides an overview of the MATS system architecture. Highlighted components comprise the basic system; all remaining components shown are available as standard options.

Figure 1. Mobile Automatic Tracking System (MATS)

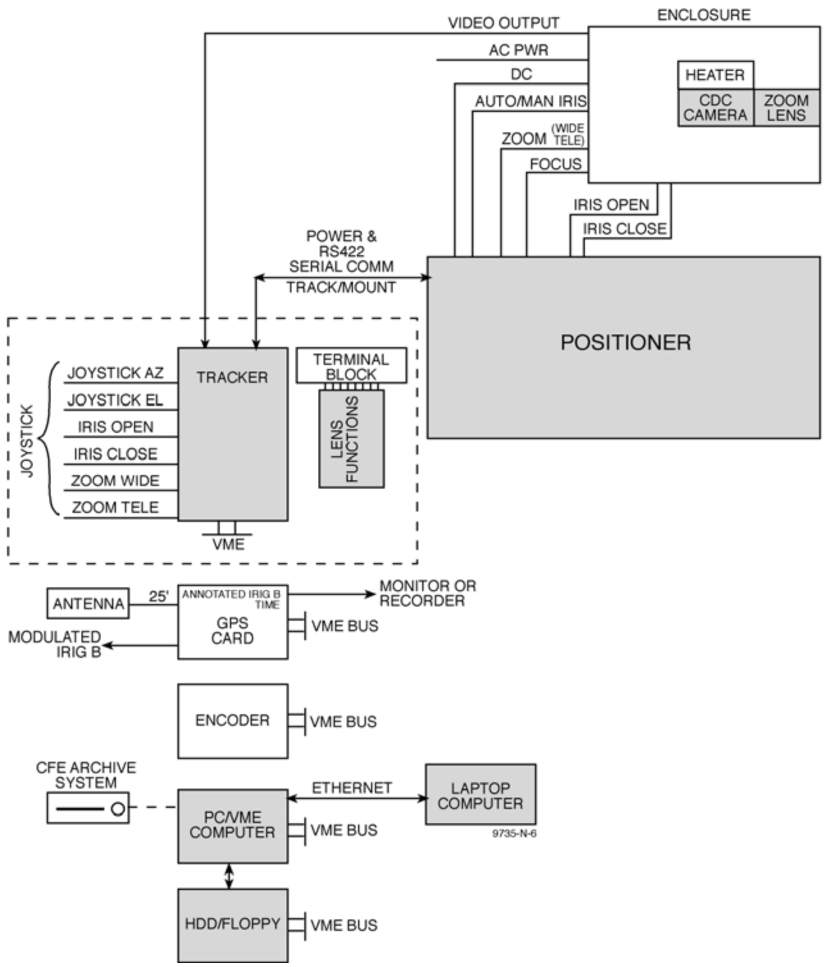

Figure 2. MATS Block diagram

MATS Controller

The MATS Controller is offered in three configurations: VMEbus, PCI, or CompactPCI. Each is housed in a single chassis containing all the necessary interface electronics, power supplies, video tracker, computer and hard/floppy drives. The chassis also provides space for an optional GPS/IRIG board and Encoder/Annotation board, and any custom circuitry required for specialized applications. The chassis front panel contains User controls for the zoom lens, system controls (Master power, System reset, Pedestal and Heater power) and camera functions. Lens control functions are also duplicated on the joystick and/or operator's control station for interfacing during a mission.

The **MATS control and communications interfaces** are structured to provide the User maximum flexibility in configuring and using the MATS to meet varying mission needs. The basic communications protocol is between the Laptop computer and the Control computer through a TCP/IP Ethernet interface providing increased bandwidth over standard RS-232/422 or allowing system control over a LAN for remote operation. The system can also be configured for remote operation over the RS-232/422 serial interfaces.

The **MATS control and data logging** are accomplished from a PC-compatible Pentium computer resident in the chassis. The Pentium computer provides both PC and VMEbus/PCI/cPCI interfacing capability allowing a standard VGA monitor, keyboard and mouse to be used for software development, testing, laboratory operation or normal operation if desired.

The VMEbus/PCI/cPCI interface is used for all control and data transfer between the VMEbus/PCI/cPCI-based system components. Control and data transfers to the Laptop control computer or remote interface are via a TCP/IP Ethernet port or RS-232/422 interface. The MATS currently supports Windows NT 4.0, or Windows 2000 Operating Systems, based on customer requirements. At the completion of a mission the data files are transferred to the laptop computer where they can be displayed or transferred to a removable storage medium. The floppy drive resident with the PC/VME computer can also be used to transfer files from the hard drive.

The **MATS has three primary modes of operation, Auto Track, Scan, and Designate**, ensuring system adaptability/flexibility in meeting the wide diversity of mission requirements found in the Test and Evaluation community.

The **Auto Track mode** allows the system to be used for auto tracking over a wide population of target and background environments. The Tracker's features include:

- Track Modes: Selectable Edge/Centroid (Binary, Gray, Intensity), Correlation
- Analog Video Input: 2 Single-ended, 1 Differential RS170/NTSC/PAL/CCIR, 12-bit resolution
- Digital Video Input: 12-bit differential, 40 MHz pixel clock
- Video Output: 2 Single ended, with tracker symbology
- Auto Target Acquisition
- Coast
- Alphanumeric Generator, Status Information/User-Defined Strings
- 1024 x 1024 Sensor Formats
- Auto/Manual Gate Size and Position
- Auto/Manual Thresholding
- Digital Servo Compensation

Configuring the Tracker is straight forward, and can be accomplished from the system laptop, remote interface or the default settings used. The MATS architecture is compatible with E-O Imaging's complete line of VME tracker products.

The **Scan Mode** provides an additional degree of flexibility in using the MATS. This feature allows the MATS to be programmed to perform horizontal and vertical raster, zigzag scan patterns, or spiral scan patterns for target acquisition and signature analysis applications. Figure 3 shows the Scan Mode Controls.

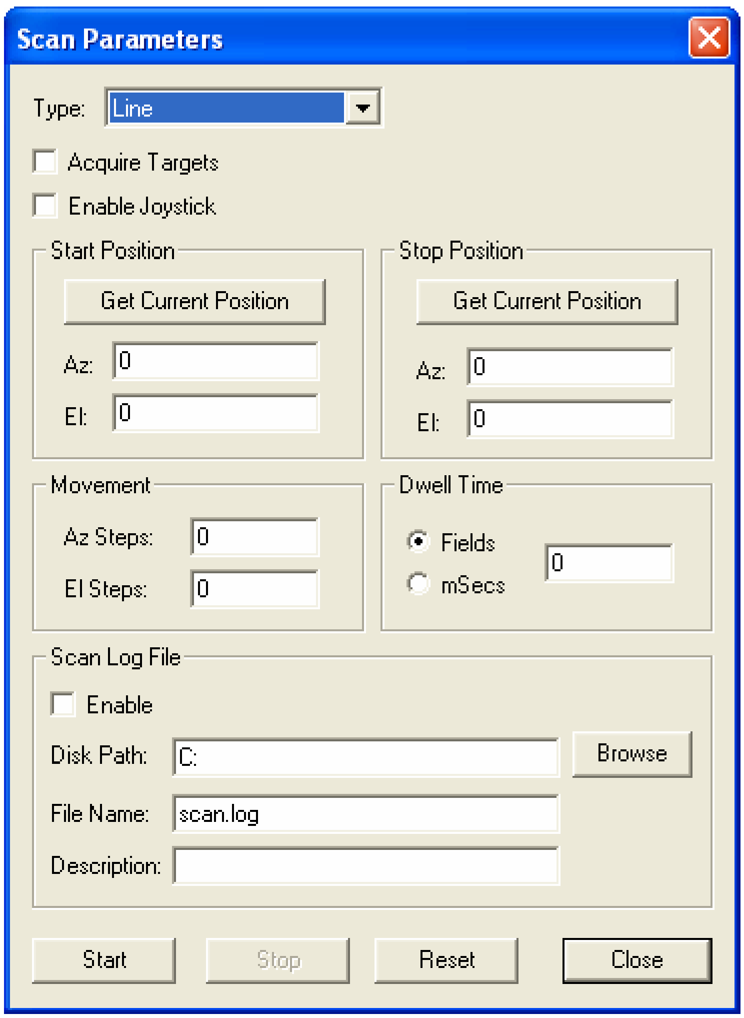

Figure 3. Scan Mode Controls

The Designate Mode/Slave Mode allows the MATS to be slaved to radars or other E-O instrumentation platforms. The system utilizes 17 bit (0.095mr) designate information for positioning the payload. During initial setup, the system's zero set is aligned with the primary instrumentation. Once the calibration is complete, designate data is accepted over the TCP/IP or RS-232/422 serial interfaces.

Data logging is available in Manual and Auto Track modes and the Scan mode of the MATS. During the Auto Track mode a history of the track is stored to hard drive by the chassis' computer. This logged file contains Target position, Encoder position, IRIG-B time, Track mode, Track State and Status. If the Laser Rangefinder option is included, range data is added to the logged data files. All data files are ASCII human-readable characters to facilitate analysis of the logged data. Logged data is available in binary format allowing direct downloading to the data reduction/analysis system.

A GPS/IRIG card is available as an optional feature for the MATS. The card will accept synchronization inputs from range IRIG-A/B, NASA 36, and 1PPS. The GPS card will output IRIG-B time for data logging over the chassis' bus and provides a modulated IRIG-B signal for input to other instrumentation. The GPS processor is capable of providing position data accurate to 1 m SEP[*]. Accuracy of the position data is dependent on the time the system is in contact with the satellites. The board also provides the capability of time tagging external events with an accuracy of 100 nsec.

An IRIG-B time Decoder and Video Character and Graphics Generator board is available as another optional feature for the MATS. The board is used to supplement the Tracker's internal alphanumeric generator and provides an alternative method of adding IRIG-B time or mission data to the video signal. The board also provides the capability of providing 31 bytes of video edge encoded data for use in post mission analysis and data reduction.

The elements comprising the MATS Controller are designed to provide the User flexibility in configuring a system, which will effectively meet mission requirements.

Payload Configuration

The MATS design provides the User a selection of payload configurations. The MATS-L is designed for handling balanced payloads up to 75 lbs. The MATS-H will handle balanced payloads up to 200 lbs. The basic payload mounting structure is an L-bracket casting which mounts to the Positioner. This simple structure can be replaced with more complex payload structures as needed. Figure 4 shows a typical single sensor payload configuration, while Figure 5 shows a complex payload structure capable of holding two instrumentation cameras in addition to a tracking lens/camera package.

[*] Position data accuracy is a function of the installed GPS card. One meter SEP accuracy is based upon Selective Availability being disabled.

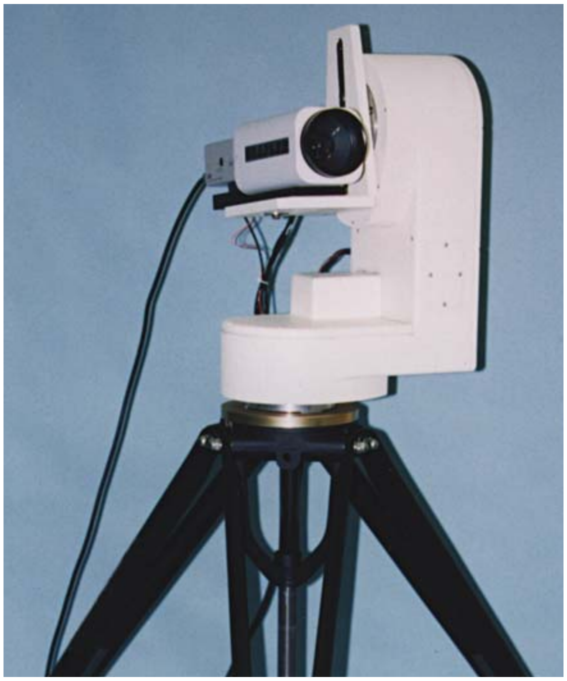

Figure 4. Single Payload Configuration MATS-L

Figure 5. Multi-Payload Configuration MATS-H

The basic MATS configuration comes with a 14-385mm f5.3 zoom optical system, which will satisfy a broad range of tracking applications. Other lens configurations can be provided based on User requirements. The lens provides zoom position feedback required in maintaining the correct gain characteristics for the servo system, with a boresight shift of less than 0.5 mr. The lens also provides both manual and automatic Iris features allowing the operator to optimize the scene contrast.

The standard CCD camera included in the MATS system has a wide dynamic range allowing the system to perform dawn to dusk tracking, with no specialized sensors or large aperture optics systems. The camera provides a usable image with illumination levels as low as 0.0002 lux. The camera incorporates an automatic electronic shutter with a range of 1/60 sec to 1/100,000 sec. The MATS is configurable to handle a variety of sensor systems including Color, sequential, MWIR, LWIR and newer large format CCDs.

The complete MATS is packaged in two ruggedized transportation cases allowing the system to be easily/reliably transported to remote locations. Optionally, the Controller can be housed in a shock-mounted transportation case allowing the system to be easily operated at remote locations from a van or truck. Figure 6 shows one of two transportation cases provided for the MATS.

Figure 6. Transportation Case

A Laser Rangefinder (LRF) option is available allowing the MATS to operate as a standalone **T**ime **S**pace **P**osition **I**nformation (TSPI) site. The laser is eye safe providing ranging information over 20km (Target dependent) with ±2m accuracy. The laser provides pulse rates up to 2pps for short periods and extended operation at pulse rates of 1pps. The LRF's transmit/receive electronics and optics are packaged in an environmentally sealed housing, provided with a dry nitrogen purge. The range information is displayed on the operator's monitor and/or logged to the system hard drive for post mission data reduction.

MATS Positioner

The MATS Positioner was developed using a COTS Pan/Tilt head as a starting point. In order to provide the accuracy and performance for range applications, shortcomings in the original system needed to be overcome. The first was to convert the Pan/Tilt system from a simple position loop to a true closed loop system. The second was to reduce the overall latency in transferring data between the tracker and the positioner. The third was to improve the encoder accuracy. The fourth was to improve the overall reliability of the system. To accomplish these goals, the existing electronics board was replaced with a custom designed board. This approach allowed the redesigned system to achieve all of the stated objectives. The overall system pointing accuracy was improved by minimizing the data latency in the original positioner design and providing a real-time closed-loop tracking system.

The encoder resolution was improved from 13 bits, with the system now providing 16 bits of accuracy. The number of components on the electronics board was reduced by over 50% and the low-end temperature extended to -30 C.

The following are the performance/characteristics for the MATS-L and the MATS-H positioners.

Feature	MATS-L	MATS-H
Payload	75 lbs. (balanced)	200 lbs. (balanced)
Velocity	>60 degrees/sec	
Acceleration	>60 degrees/sec/sec	
Encoder Resolution	17 bits (0.096 milliradians)	
Repeatability	36 arc sec	
Operating Temperature	-30° C to +60° C	
Storage Temperature	-55° C to +100° C	
Azimuth Motion (H/W and S/W Limits)	350 degrees	
Elevation Motion (H/W and S/W Limits)	-10 to +75 degrees	
Encoders	17-bit Incremental	
Gear-train Types	Self lubricating, anti-backlash	

Both configurations of the MATS positioners are provided with a heavy-duty tripod capable of supporting up to four hundred pounds of instrumentation. The tripod is equipped with a bubble level for initial leveling, and a zero set position for alignment to the local coordinate system. Hold-downs for use when working on the system or storage are provided.

Operator's Station

The MATS Operator's Station can be provided in a variety of configurations to satisfy specific User needs. The main interface for the MATS is from the laptop computer's Graphical User Interface (GUI). The GUI allows the User the ability of configuring the tracker through a robust set of Configuration screens. Once the tracker is configured the operator returns to the Run Time screen for operation. Figure 7 shows the Run Time screen, which provides access to the Configuration screens. Supplementing the GUI is a set of system and lens control switches located on the front of the Controller chassis, a joystick and operator's console. The joystick is available in various configurations and types to meet the User's preference and needs.

ELECTRO-OPTICAL IMAGING, INC.

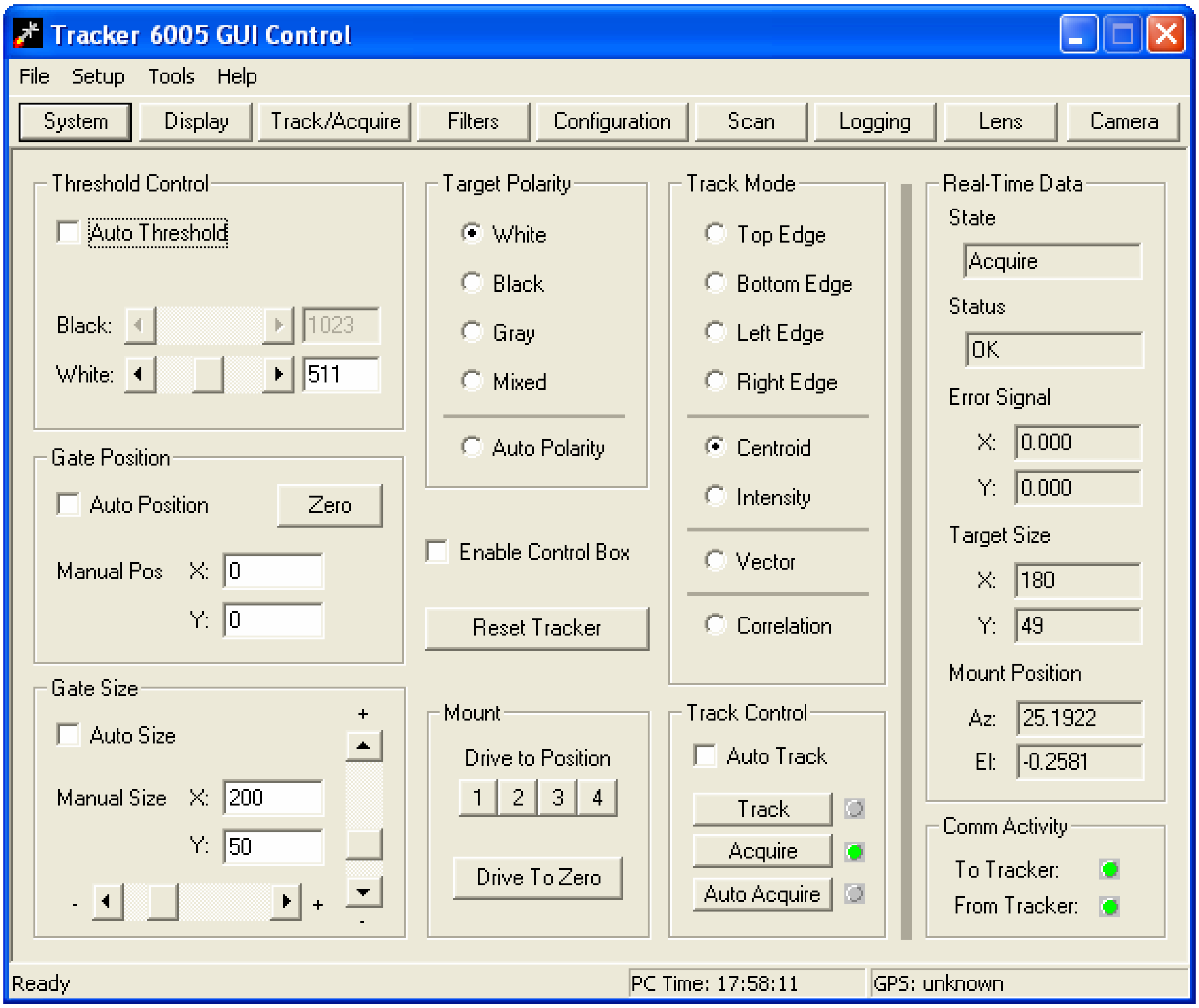

Figure 7. Run Time Screen

The Operator's console, shown in Figure 8, is used to allow rapid access to system functions, which may be changed or adjusted during a mission. Functions provided on the Operator's console include Track Mode select, Track Gate Size, Track Gate Auto/Manual Position, and Target polarity. Other specialized functions can also be incorporated into the console such as LRF Enable, Start/Stop Data Logging, and Enable Scan mode.

Figure 8. Operator's Console

Summary

The MATS is structured to provide a highly adaptable, capable and cost-effective solution for satisfying the diversity of requirements encountered in the Test and Evaluation Communities. The system architecture allows the system to be easily configured for the User’s specific application. The MATS can be provided as a simple manual positioning system or configured with a variety of sensor/lenses combinations, laser rangefinder, GPS and other VME-based instrumentation boards. The diversity of applications supported by the MATS includes:

- Surveillance
- Auto and Manual Tracking
- Test and Evaluation
- Adjunct to Radar Systems
- Signature Analysis
- RF Measurement
- Simulation and Training
- Time Space Position Information
- Countermeasures Evaluation
- Weapons Scoring