TITLE: An Automated System for Observer Probability of Detection Experiments

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ABSTRACT

The Army is looking at signature management as a way of increasing the survivability of combat vehicles for upcoming programs such as the Future Combat System. As part of the Army's work in this area, the TACOM Survivability Technology Area has the mission of integrating and maturing advanced survivability technologies for combat vehicle systems. In order to determine the real world effectiveness of new camouflage technologies, it is sometimes necessary to do Observer Probability of Detection (Pd) experiments on military targets. In these experiments multiple military observers are asked to search for a military target positioned within a field of regard on a test range. When a target is detected the time of the detection is logged, and then it is verified whether the target is an actual target of interest or a false detection. Early Pd tests used paper log sheets, range maps, stopwatches, and a variety of other manual devices to complete the experiment. This kind of data collection was very manpower intensive and had many opportunities for errors during the data collection and analysis. In order to reduce the manpower requirements and improve the reliability of the data from Pd experiments, TACOM as developed an automated system for Pd data collection. This new system has a master control system, an instrumented station for each observer, and adds the ability review results immediately after completing a Pd run. This paper presents an overview of this new Pd data collection system and discuses plans for the continued development of the system.

SYSTEM DESCRIPTION

The TACOM developed observer data collection system consists of two trailers with a total of 24 observer stations and instrumentation to automate the data collection. A picture of the observer trailers is shown in figure 1. The point of a field of and observer regard experiment is to determine the Probability of detection (Pd) of a target at different ranges. A Pd test is executed by having military observers search for a target at an unknown location within a defined field of regard. The TACOM developed system has 24 stations with a set of input switches, a digital display and a pan/tilt head instrumented with optical absolute encoders with a sight mounted at each station. There is also a manual controlled electric window shade that is part of the system to block the view of the observers of the range between runs while the target is being positioned. Figure 2 shows an example of a typical Pd test layout:

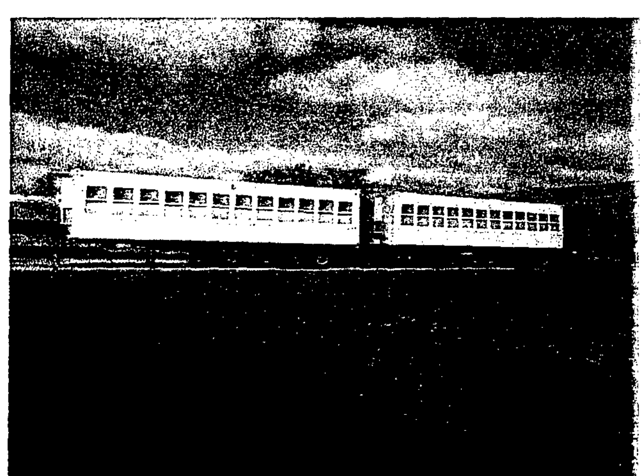

Figure 1 Picture of the Observer Trailers

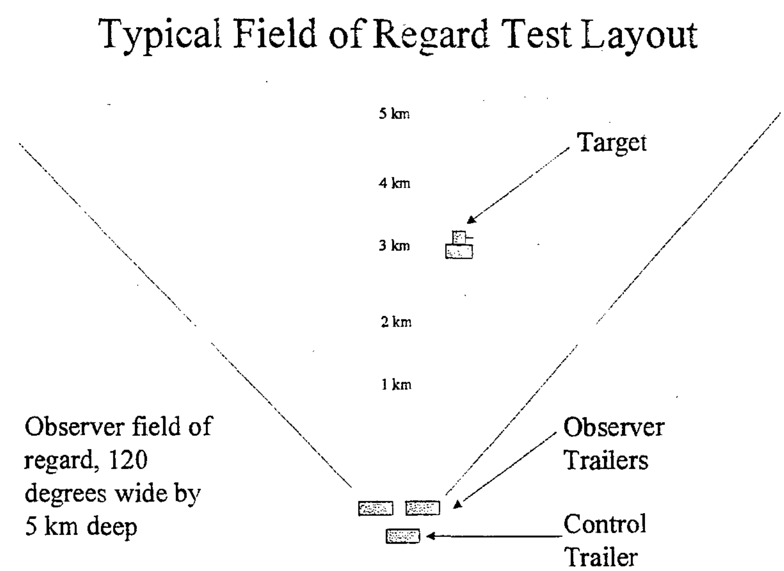

Figure 2 Typical field of regard test layout

A Pd test run is completed as follows: With the window shade down to block the view of the observers, the target is positioned within the field of regard. Then the shade is raised and the observers are given a fixed search time to locate the target, usually two minutes for visual tests. If an observer locates a target, he or she hits the red detect switch, aims the sight on the pan/tilt head on the target, and hits the green verify switch. When the search time has run out, the observers who found a target late in the run are given a few moments to finish verifying the target location and the window shade is lowered again.

Only two sensors have been used on the system to date, they are binoculars and the unaided eye. The standard binocular station has a set of military 7×50 binoculars that the observer holds up to his or her eyes by hand while searching. If the observer finds a target, there is a variable zoom rifle sight that is fixed at 7× magnification with a piece of tape mounted to the pan/tilt head for verification. Unfortunately the rifle sight is designed for about four inches of eye relief which makes it a little tricky to use. A picture of the binocular observer station is shown in figure 3.

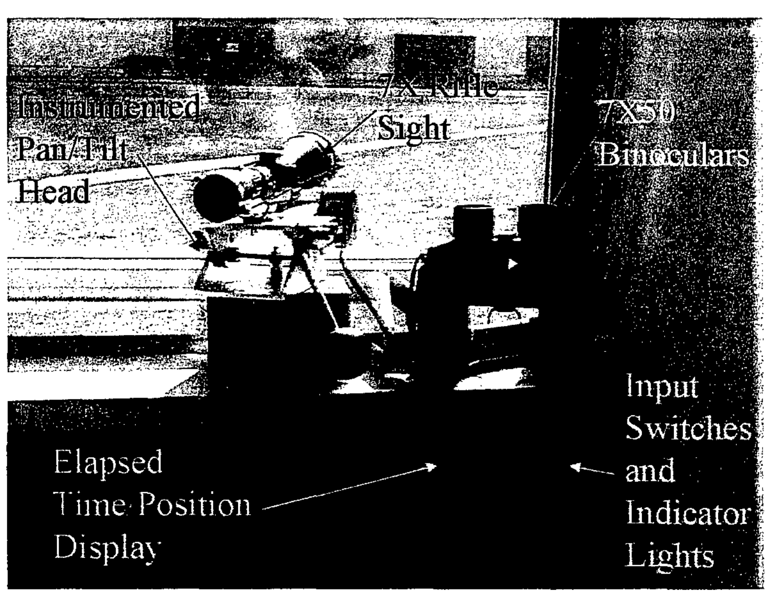

Figure 3 Binocular observer station layout

For the unaided eye station the observer obviously uses his or her naked eye for the search. The unaided eye station has a red dot pistol sight mounted to the pan/tilt head. This sight is nice because it has no eye relief problems and it also corrects for the angle at which the observer looks trough it. If the sight is aimed at a target, any head movement changing the angle of viewing through the sight will cause the red dot projected from an LED to move staying on the target. Figure 4 shows the layout for an unaided eye observer station.

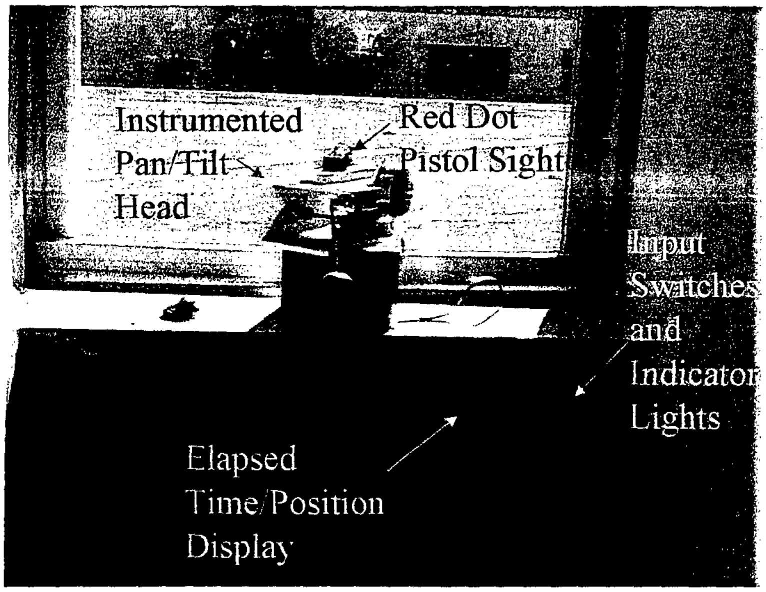

Figure 4 Unaided eye observer station layout

The entire data collection system is computer controlled using National Instruments LabVIEW developed software. LabVIEW is a visual programming language designed for instrument control making it easy to create virtual switches, indicators, displays, controls and communicate with external instruments. A LabVIEW program is referred to as a Virtual Instrument (VI). There is a screen grab of the front panel of the Observer Control System VI in figure 5. The top section of the panel has virtual buttons that control the operation of the system. The middle section lists the detailed information about the run including the range, position, orientation, and timing information. Finally the bottom section of the panel shows the state of all of the observer stations and the Pd for each type of sensor computed in real time during the run. At the end of each run all of the data displayed on the LabVIEW front panel is saved to a tab delimited file that can be easily exported into Microsoft Excel for further analysis.

There is a Master Targeting Station that determines the position of the target within the field of regard. The Master Targeting Station uses a video camera for visual tests and is mounted to a QuickSet precision pan/tilt head on a tripod positioned between the observer trailers. The QuickSet pan/tilt head is remotely controlled and is connected the control PC via a RS-232 port. Its position is continuously monitored while the system is running. When an observer detects a target, the position of the Master Station is compared with the observer target position when the target is verified to determine if the observer has found a real target. Also documentation video of the target during the run can be collected using the Master Station.

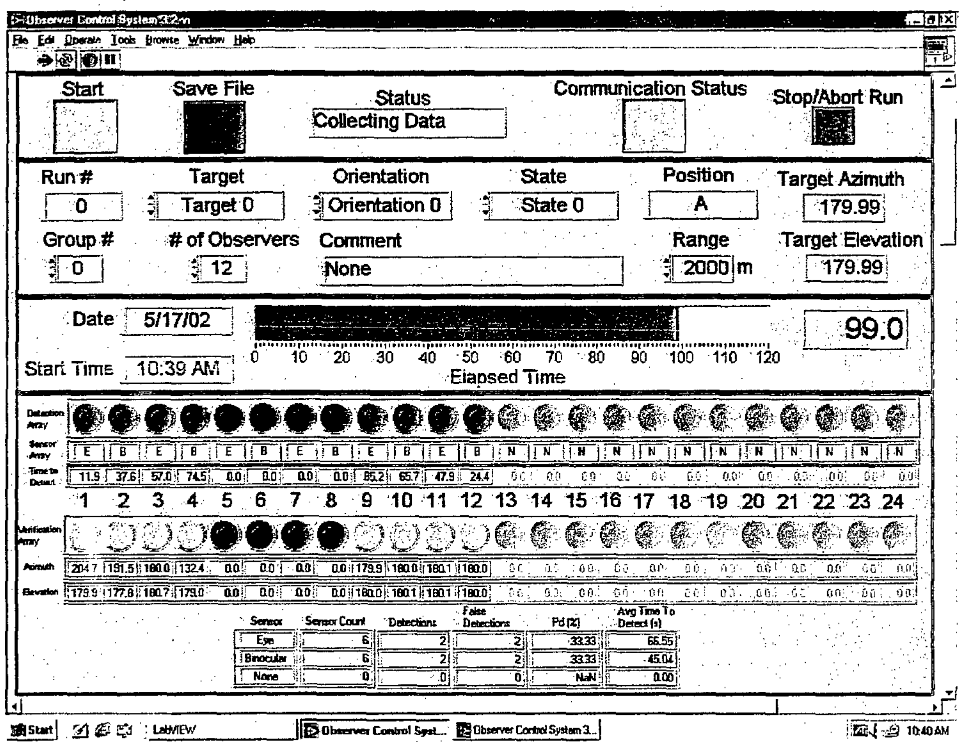

Figure 5 Screen grab of Observer Control System LabVIEW front panel

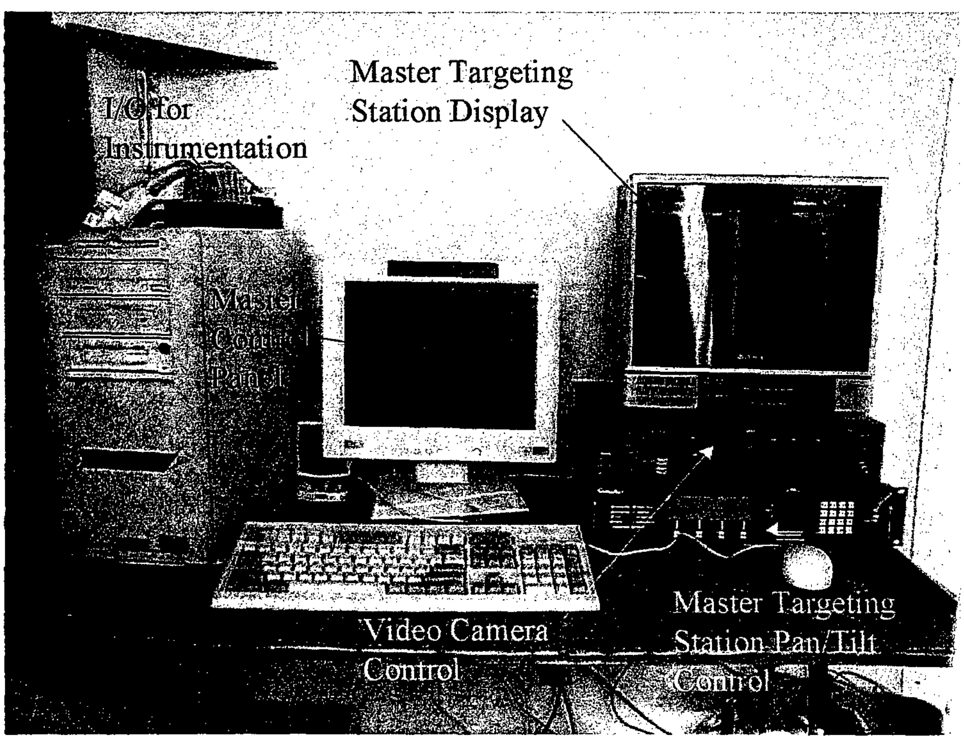

Figure 6 Control Station Layout

SYSTEM ARCHITECTURE

The instrumentation for the observer stations in the trailers communicates using an U.S. Digital SEI bus. Up to 16 SEI devices can be hooked up to a single SEI bus, each observer station has an A2 absolute encoder, an A2 absolute inclinometer, and a digital display. Using inclinometers for the elevation has advantages over using standard encoders because small differences in the azimuth planes between the observer stations does not effect the elevation measurement using inclinometers which work off of gravity. There also are SEI-M1 digital I/O modules that read the input switches in the observer stations. A diagram of a single SEI bus is shown in figure 7. Each of the observer trailers has three separate SEI busses all containing fifteen devices. The SEI busses are color-coded and all busses run from end to end of the trailers. A single power supply is needed to power each SEI bus.

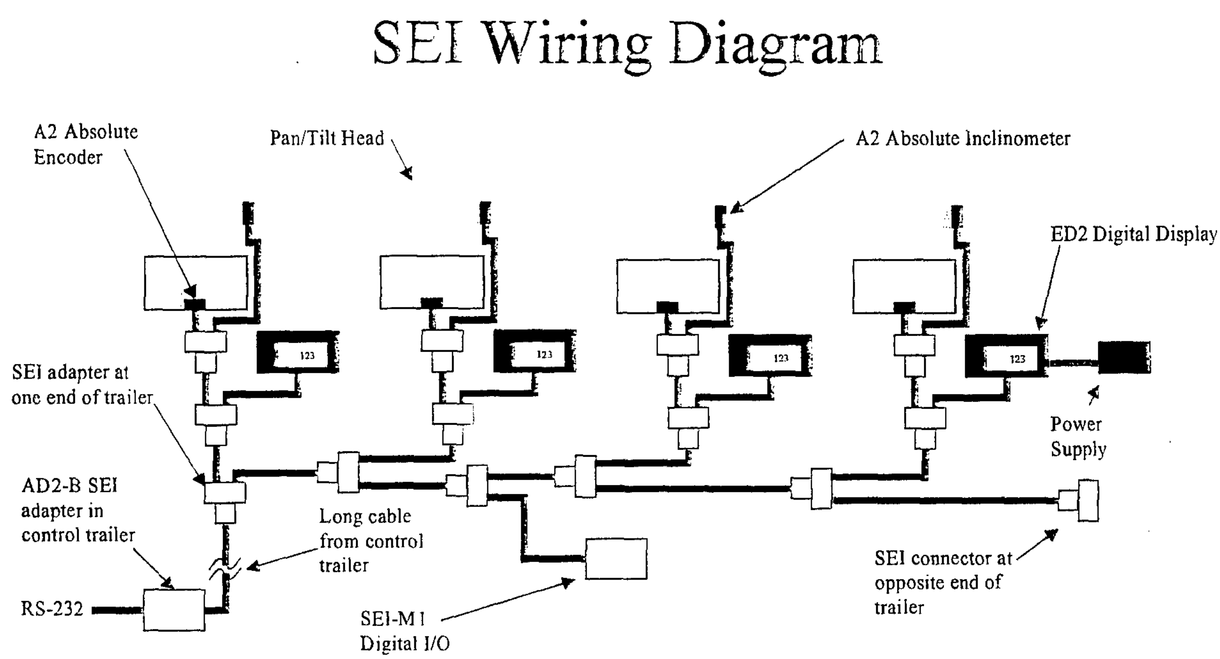

Figure 7 SEI bus diagram

Each SEI bus is connected to the control computer via an U.S. Digital AD1-B SEI adapter connected to an RS-232 serial port. A National Instrument 16-port serial breakout box is used to provide the rather large number of ports needed by the system. The input switches and indicators are wired to the SEI-M1 I/O modules and draw their power from the SEI bus through the digital display.

SOFTWARE DESCIPTION

The Observer control VI has four main sections. Initialization, Pretest Setup, Data Collection, and Verification. The Initialization section of the VI resets the value of all the variables used by the program during a run, and initializes all of the RS-232 ports used by the system. Then the program enters the Pretest set up mode which reads the current values of all of the observer instrumentation to verify that everything is functioning properly, and gives the data collector a chance to enter information about the upcoming run in the second panel of the main screen. The Target, Orientation, State, and Group # fields on the front panel come up with a selection list when clicked on with the left mouse button. This panel was set up this way so these fields would be filled out consistently to make the data easy to sort for later analysis. A screen grab with the Target selection list open is shown in figure 8. The Pretest Setup mode is also the section of the program is also were the system is calibrated. To calibrate the system, a reference target within the field of regard is selected and the master targeting station and all of the observer sights are aimed at the reference target. In the calibration panel located below the main panel of the observer control VI, there are fields to enter the distance between the trailers, reference target range. There are also buttons on the panel to calibrate the master targeting station along with all of the observer stations. The calibration aligns all of the encoders are such that the azimuth and elevation readings are the same when all of the pan/tilt heads are aimed parallel to one another. Then the system corrects the azimuth parallax difference for each station based on the station distance from the master targeting station and the range of the current target. A screen grab of the calibration panel is shown in figure 9.

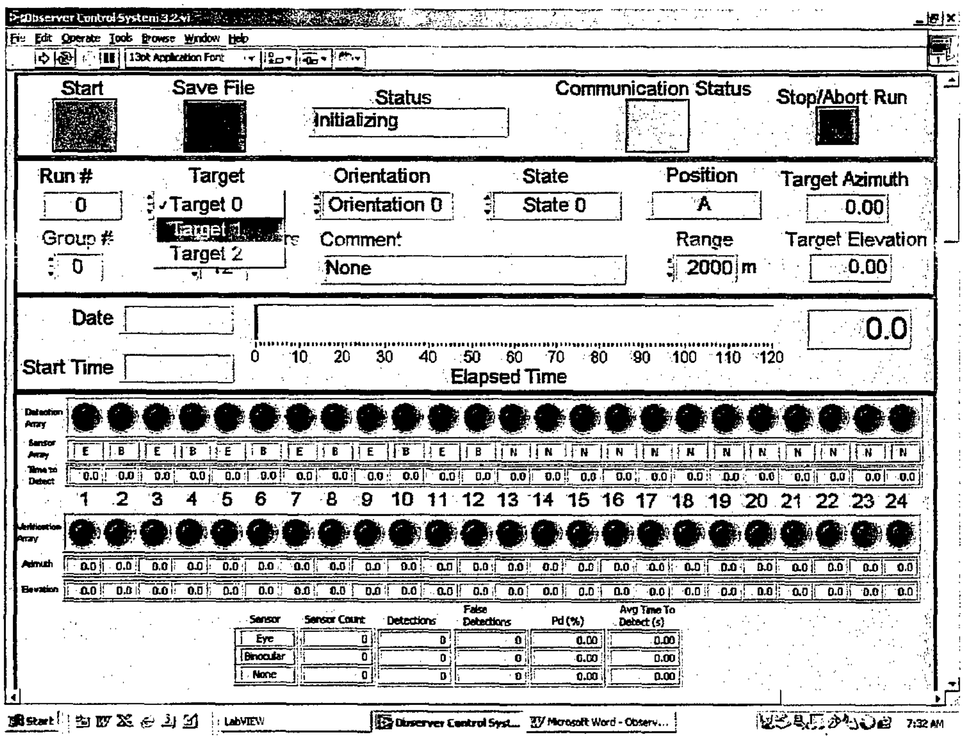

Figure 8 Screen grab of front panel with Target selection list open

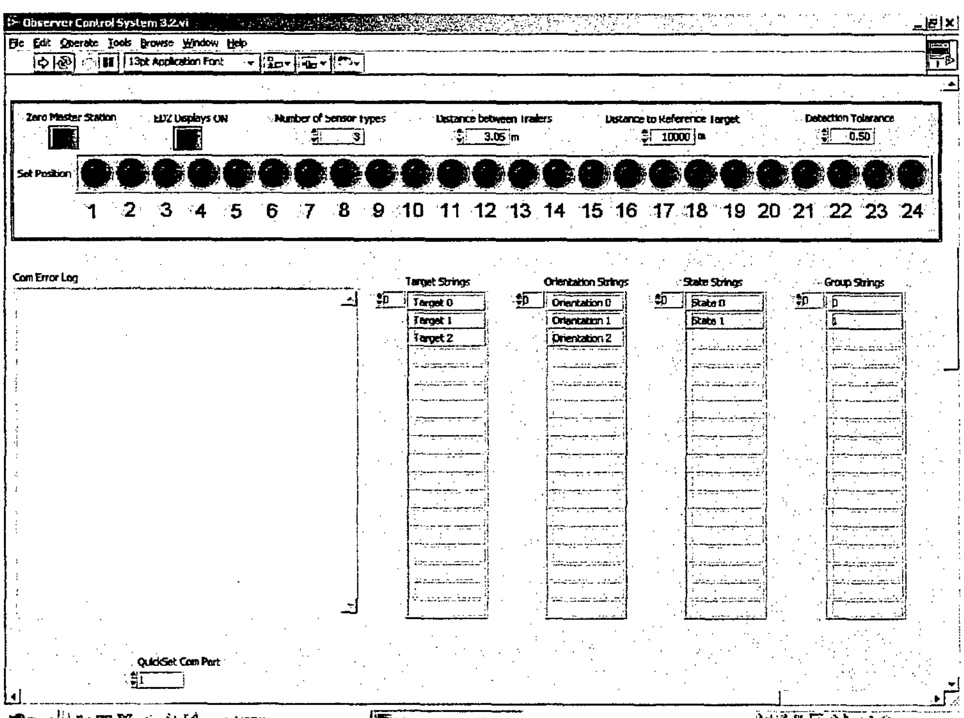

Figure 9 Screen grab of calibration panel located below main panel

Hitting the Start button in the upper panel puts the Observer Control VI into the Collecting Data mode. This will start the run timer, and log the start time and date of the run. As the test proceeds any target found and verified by the observers that is within the detection tolerance set on the lower panel will be counted as a correct detection. All of the observer actions are displayed on the main screen as the run proceeds. When the run clock has expired the program enters the verification mode, which give the observers who found a target late in the run a chance to verify their target. When all of the observers are done with their task the data from the run is saved by hitting the Save File button. Every piece of information collected on a run is saved into the data file created by the system. The data file is a tab delimited text file that can easily be imported into Microsoft Excel. There is an Excel Template with all of the columns of the data file labeled provided with the system. Every field shown on the main panel is saved in the file plus some extra information not directly shown on the screen. Most of the fields saved in the file are self-explanatory. The only new field not shown on the screen is the Detect field that shows the detection state for each of the observers. Table 1 explains what the values in the Detect field mean:

Value	Explanation
0	no detection
1	correct detection
-1	false detection
invalild	observer station empty

Table 1 Detect field explanation

The number of fields saved in the file does not change with the number of sensor types, or the number of observers. Data is saved for three types of sensors and all 24 observers no matter what the test configuration is. This eliminates the possibility of the columns of data not lining up in the file because the number of observers changed, or one type of sensor was not working for one particular run. The overall detection data from the bottom table on the main screen will be filled with zeros for any unused sensor, and the data for any unused observer stations will be filled with invalid values to make sure the data does not get included in any future analysis. Once the file is saved the VI jumps back and reinitializes and the process begins again.

THE FUTURE

Focusing on its mission of integrating Survivability Technologies, the TACOM Survivability Technology Area has given the Observer Data Collection System on long-term loan to the Chicken Little Joint Project Office. This loan makes the system available to the entire Survivability Community, although TACOM gets priority if there are any scheduling conflicts. In exchange Chicken Little is making improvements to the system. These improvements include refurbishing the trailers, which were in need of some repair, adding the capability to run tests using multiple targets in a single run, and adding GPS tracking of targets. Chicken Little is also modifying observer pan/tilts heads to accept both military FLIR and Image Intensifier sights and reconfiguring the observer stations fixing eye relief problem with rifle sight. This system is available to anyone in the DoD community that has a need for this sort of testing, and with the planned improvements the system should improve the quality and reduce the cost of doing Observer Testing in the future.