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Advanced Interface for Tactical Security (AITS) System Evaluation

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ADMINISTRATIVE INFORMATION

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EXECUTIVE SUMMARY

The Advanced Interface for Tactical Security (AITS) project was initiated to improve the task performance of security forces through technology and design improvements to information display systems. The project was implemented in two phases: (1) problem analysis and concept definition, and (2) interface design and validation. This report contains the results of the second phase.

The AITS interface design was subjected to a field exercise to demonstrate the functionality of critical features. All test objectives were met, although environmental conditions and certain internal decisions limited the clarity of the demonstration. The exercise showed that future development of AITS should include improved communications hardware and an improved see-through display.

A user community evaluation program was also conducted with security sensor operators of the U.S. Marine Corps to validate the mission effectiveness of AITS features and concepts. Results were highly consistent between populations of civilians and military sensor operators and confirmed essentially all of the major design features of AITS, including an emphasis on see-through head-mount display concepts.

Taken together, the field exercise and the user evaluation validated the AITS design and provided a foundation for future improvements and for new programs involving portable, mobile interface systems. Several such programs are now underway as a result of the experience gained in the AITS program

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BACKGROUND

The AITS project was conducted in two phases:

Problem analysis and concept definition, which included

- A functional review of the job through field observations and interviews with prospective user communities.
- Definition of user information requirements.
- Comparison of tactical security needs with those of other missions (e.g., military police, site security, surveillance and reconnaissance forces, etc.).
- A survey of relevant interface design principles to guide selection of hardware components and display design concepts.
- A technical review of current and emerging technologies that could support the documented information needs. Candidate technologies were compared with the known working conditions of tactical security forces to prioritize systems according to their mission utility.
- Specification of a baseline interface system.

The results of this analytical process, and the interface products generated from it, were detailed in Murray (1999). A general summary of this effort, however, is presented in the next section.

Interface design and validation, which included

- Developing information display metaphors to provide the essential data elements determined from phase 1. These metaphors were implemented in the prototype system and a demonstration videotape to illustrate their operating characteristics in a sample tactical security scenario.
- Defining and executing a test and evaluation program for the AITS prototype. This effort involved a field exercise and user community survey.

Results of this evaluation process are presented in this report.

BASELINE INTERFACE SYSTEM

Based on the analyses of information requirements and interface design review, and equipped with the results of the technology survey, an initial set of hardware components and features was identified for a prototype interface system. The baseline configuration necessarily reflects tradeoffs between task needs, technology capabilities, acquisition costs, and configuration flexibility. Figure 1 shows the critical components of the AITS interface.

PHYSICAL FOUNDATION

The AITS interface is designed around a Xybernaut® Mobile Assistant IV wearable computer with a 233-MHz CPU, 64-MB RAM, a 2.1-GB hard drive, and sufficient port expansion capability to support all necessary peripherals. The MA IV came equipped with a 1.1-inch (diagonal) see-through, color head-mounted display (HMD) and a 6-inch (diagonal) hand-held, color display, which supported flexible testing of various design metaphors. Voice input was supported through an integrated headset microphone. Figure 1 shows the entire configuration.

The system was expanded by the AITS engineering team with the use of a gesture control glove, powered through a MA IV serial port, and a flux gate compass and tilt table, mounted on the HMD support assembly to measure the position and gaze of the user's head (shown in detail in Figure 2). A Global Positioning System (GPS) location system was mounted on the MA IV vest.

All application software was developed on a Windows NT® platform. Voice control was provided through a commercial Dragon Dictate® software package, while gesture control was provided through a specially configured "data glove" developed by MindTel, LLC. Signals from the data glove were programmed using the public domain *NeatTools* software, also developed by Mindtel, LLC (information available at http://www.pulsar.org/febweb/coretech/neatdwnld.htm).

Figure 1. AITS interface system.

Figure 2. AITS components.

DISPLAY SUBSYSTEMS

A see-through HMD was selected as the primary visual system because it offered a hands-free method for conveying information, i.e., the display is always available where the user can see it without having to look down at a hand-held display, and the display surface can be moved out of the line of sight when not wanted. This HMD provides a field of view of approximately 30 degrees, and does not occlude binocular vision; both eyes had full peripheral vision.

Because the Xybernaut® MA IV came equipped with a hand-held display, all information designs are replicated on both displays to support individual user preferences across the task spectrum. Both displays are capable of 640- x 480-pixel resolution in color and monochrome modes. The effects of color presentation were tested as part of the user evaluation process.

The tilt table mounted on the headgear senses elevation changes to control three system display configurations:

1. A head/eye elevation greater than +30º above horizontal sets the mode for the ***direct sensor display***, providing raw video from appropriate sensors (e.g., Friendly Force Information Requirements [FLIR], Low-Light-Level Television [LLLTV]).
2. A head/eye elevation between –30º to +30º sets the mode for default ***alert response display***, similar in function to a pilot's head-up display (HUD); information is provided in a "world-stabilized" format, with symbols positioned over or near the objects they refer to in the environment. Symbology is kept to a minimum to allow maximum visibility through the HMD.
3. A head/eye elevation less than –30º below horizontal sets the mode for the ***map display***, providing a user-referenced map with target and sensor symbology overlays.

Alternate Displays

The AITS system uses the default MA IV headset and microphone for voice control and communications; although superior systems are commercially available, Xybernaut® performance was considered sufficient for demonstration and test. While directional auditory displays are considered desirable from a human factors perspective (Murray, 1999), cost and equipment complexity deferred this capability in preference to more detailed examination of visual displays. Similar reasoning deferred the use of tactile displays. Initial auditory signal implementations, therefore, are limited to non-directional cueing of intruder alerts.

SYSTEM INTERACTION TOOLS

The Xybernaut® MA IV system came equipped with special mouse and wearable keyboard input devices. These systems were used to the minimum extent possible (e.g., for laboratory configuration and testing), however, as they are not considered desirable for tactical field tasks. The gesture and voice control subsystems are given priority in the AITS baseline design because of their potential to control interface functions without requiring user attention to a physical device (e.g., a keyboard). AITS includes capability for menu item selection using voice and gesture.

Communications

Communications technologies were central to the AITS design effort. A separate project (Tactical Sensor System Internetting and Integration - TSSII) using tactical Internet protocols is employed by AITS in support of voice, video, and data exchange among multiple users and between users and command centers. This capability was evaluated during the AITS validation study, although the technical background of TSSII is reported elsewhere.

INFORMATION CONTENT

The AITS displays emphasizes information presentations to orient the user to the location, type, and threat level of sensor alerts, and to orient the user to the geospatial features in their environment. The user community evaluated several alternative designs for each feature during the validation effort.

Alert Response

A *directional arrow*, or similar graphical icon, appears near the edge of the display when an alert signal is received (Figure 3a). The arrow directs the user's gaze, in azimuth, to the relative bearing of the contact. When the contact location comes within the field of view of the display, the arrow is removed and replaced by a circular *cursor* that—within GPS accuracy—designates the target location in azimuth and elevation (Figure 3b).

Figure 3a. Orienting display.

Figure 3b. Designation display.

Navigation

A compass heading tape is continuously available at the top of the display (*alert response display*, Figure 3) to assist in orienting the user and in directing the user's gaze when a security alert is initiated.

When the user's head is tilted below approximately 30° below the horizontal, a color *map display* (Figure 4) is presented. The map display can be fixed or stabilized in a "north up" orientation for the user and shows the following:

- User's location and direction of gaze, via a bearing line calculated from compass unit and GPS
- Location of all sensors in the vicinity, with highlighting of the sensor issuing the alert
- Other GPS-equipped personnel in the operating area and logged onto the network
- Any desired tactical information (e.g., hazardous zones, patrol boundaries, etc.)

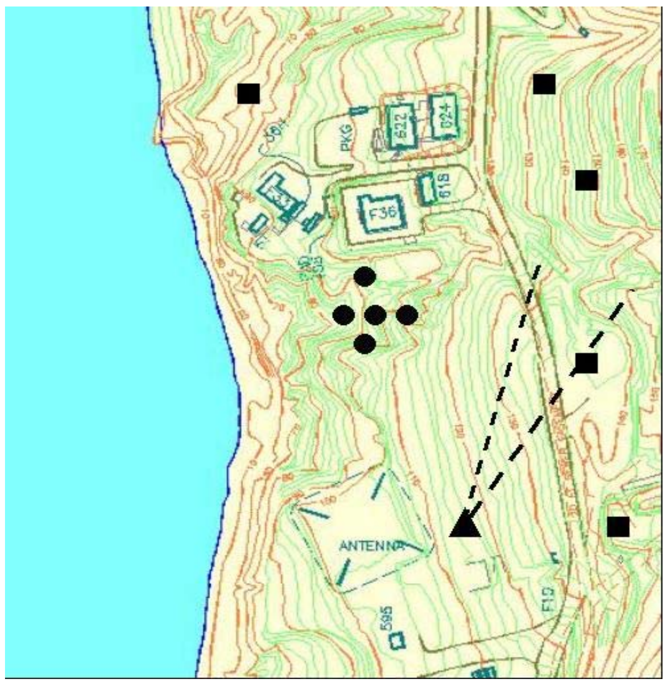

Figure 4. AITS map display.

Detailed Sensor Analysis

The AITS software provides a raw video display from the alerting sensor when the user's head is elevated above approximately 30° from the horizontal. The image is stabilized in the center of the display for the current configuration, but the software can support sensor azimuth panning via a head-coupled signal from the compass unit. Because characteristics of the panning capability require further research, however (e.g., rate versus position control, dynamic stabilization, resolution of competing control inputs from different users, etc.), this feature was not examined during the user evaluation effort.

System Status

Menu items are brought up by voice or gesture control (or using a keyboard, if necessary). System control functions are considered mission specific; that is, no effort was made to generate tactical or operational menus. Only a nominal set of items is included in the AITS design to test the ease of invoking, interacting with, and dismissing menu functions.

AITS DESIGN VALIDATION

The validation effort involved (1) a full-capability field exercise and (2) a structured set of user community evaluations. Most test and evaluation efforts were directed toward establishing the merit of the AITS interface design along a scale anchored by two benchmarks:

1. Does the system satisfy the basic objectives for which it was intended? This benchmark is the minimum performance that should be expected from the design and the first benchmark that should be identified. The functional field test addressed this issue.
2. Does the system represent the optimum design approach? This benchmark is the highest performance attainable, although it is usually not reached because of technology, cost, or schedule limitations. The evaluations of prospective user communities addressed this issue.

FIELD EXERCISE

A "capstone" exercise was conducted in February 2000 to evaluate the performance of the AITS system and the parallel communications effort, Tactical Security Sensor Internetting and Integration (TSSII; Murray et al., 1998). The exercise was designed around a scenario scripted to demonstrate all of the critical functions of the AITS interface and the TSSII Internet protocols.

Objectives

The objectives of the field exercise were to demonstrate the following:

1. Situation awareness: the ability to maintain an accurate sense of all sensor personnel locations while on the move
2. Display effectiveness: the ability to provide synchronized data symbology overviews of the real world (i.e., to implement a soldier's HUD), and to compare head-mounted and hand-held displays so that no one method is a "critical path" for effective information access
3. Alternate interaction methods: the ability to control AITS system functions using hands-free modalities such as voice and gesture commands, as supplements to conventional keyboard devices
4. Information sharing: the ability to access all tactical information from any location by using Internet connectivity (i.e., TSSII)
5. Voice-over IP: the ability to conduct voice communications with Internet protocols

Objective 5 was demonstrated to Defense Threat Reduction Agency (DTRA) sponsors in the laboratory before commencement of the exercise. All other objectives were demonstrated in the field.

Approach

The exercise scenario centered around mobile sensor operators and a tactical command post, typical of the user community methods identified during the analysis phase of the AITS project. One set of observers was placed in the simulated command post (Figure 5) to monitor the overall development of the scenario and another set of observers accompanied one of the mobile AITS operators (Sentry 1), with the opportunity to use and interact with the AITS system as the scenario unfolded. A second AITS user (Sentry 2) was present in the test environment to demonstrate communications and the capability for real-time data sharing.

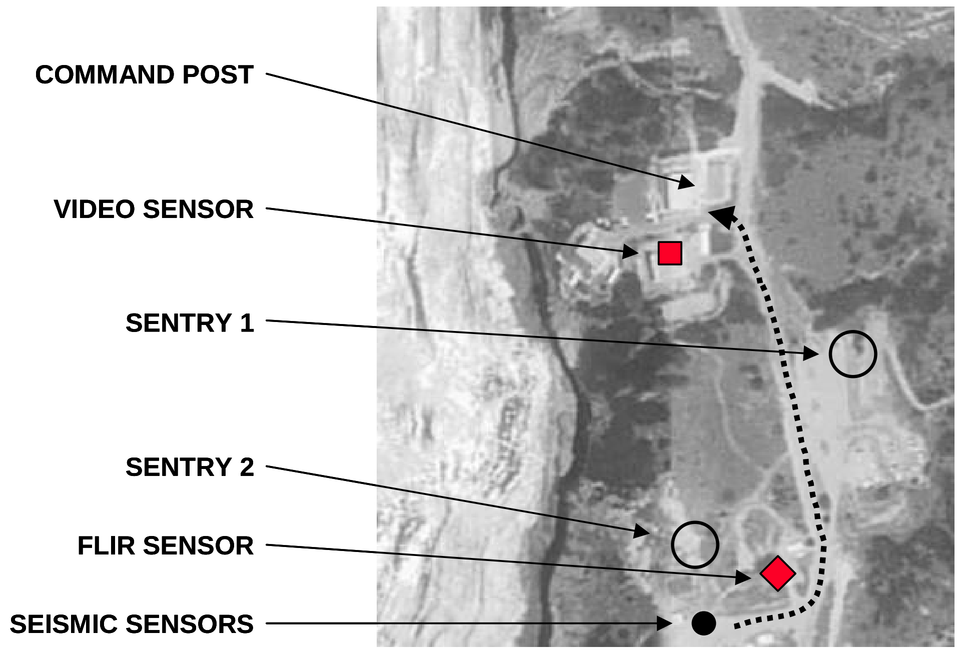

Figure 5. Exercise layout.

A simulated FLIR sensor (a video camera) was positioned at a known location in the test environment to provide an initial intruder alert signal and supporting video imagery back to the command post. A set of imaginary seismic sensors—fixed geographic points, programmed into the controlling computer software—was also established; the software generated seismic "alerts" from these sensors to provide additional signals to all system displays, including the AITS systems.

Procedure

The sequence of events was as follows (see Figure 5 for the initial layout of the exercise; North is at the top of the picture):

1. Sentry (the primary AITS operator, traveling with the field observers) began the exercise by walking south on patrol from command post. Observers could view the positions of all sensors in the test area using either the integrated hand-held display or the HMD in map mode (i.e., by looking down).

2. Sentry 1 continually monitored position information and scenario events, and conducted voice communications between the command post and Sentry 2 to demonstrate the capability of TSSII to support Internet communications.

3. Sentry 2 deliberately occluded the antenna to force a loss of data and voice signals, and to thereby demonstrate the ability of TSSII to maintain other nodes in the network. Sentry 2 re-entered the network after the antenna was uncovered.

4. A FFIR sensor alert signal was initiated. Sentry 1 acquired the position of the alert source on the head-mounted and hand-held displays.

5. Sentry 1 coordinated the threat response using Internet communications with the command post and Sentry 2.

6. Sentry 1 used the head-mounted and hand-held directional information to travel to alert position, then secured from the exercise.

Results

The choice of test environment was dictated by the location of Space and Naval Warfare (SPAWAR) Systems Center, San Diego (SSC San Diego) development facilities and by the availability of open field terrain. This location placed the exercise close to the California coastline, however, where conditions were fairly windy. A major, negative consequence of this situation was that voice communications were extremely difficult using the AITS headphones and microphone, as wind noise overpowered both systems. This situation severely hampered coordination between the command post and the sentries and complicated tracking of scenario events. Ironically, the scenario was sustained by delivery of graphical information from the command post over the AITS visual displays, providing an unexpected demonstration of the value of multi-modal Internet data connectivity.

In addition, the test team decided to control AITS operating modes from the command post—rather than from the AITS interfaces—to enhance the flow of events and to create a smoother exercise. Because all AITS functions had previously been demonstrated before the field events, the test was not invalid. PC Duo™, a terminal emulation software system, was used to accomplish this control. Unfortunately, however, the computing overhead required by this system unexpectedly slowed the interactions between the different terminals, including interactions between the sentries and the command post. These time delays exacerbated the difficulties in voice communications and created considerable confusion among the sentries regarding where they stood in the event timeline. While all the scheduled events were completed, the impression of a tight and coordinated scenario was lost.

These difficulties were frustrating and, in the case of PC Duo™ control, entirely unnecessary. Although all the performance objectives for AITS and TSSII were successfully demonstrated within the exercise scenario, the impact of system performance on the observers was far less than might otherwise have been the case. The AITS system performed as intended, working independently or in coordination with other networked nodes (i.e., the command post and the second sentry). Communications and data connectivity were handled by TSSII as designed, and distributed coordination among sentries was supported by the network concept.

The field performance of the head-mounted display technology, while not a central test item, was examined during the exercise. A see-through device has many advantages (as described in the system analysis report; Murray, 1999) and its mission-related effectiveness was demonstrated during this exercise. No current see-through device, however, has sufficient brightness to be easily read under high sunlight levels and the environment during the exercise confirmed this difficulty for the head-mounted AITS display.

Conclusions

Despite difficulties, the effectiveness of the AITS system and its TSSII infrastructure was successfully demonstrated by a field scenario exercise. Although the AITS headset was unfortunately vulnerable to environmental conditions, the system was not a critical component of the interface—it is likely that any operational version of AITS would employ more appropriate equipment. In addition, an updated technology selection should be considered for the see-through device to ensure its readability under all daylight conditions.

USER COMMUNITY EVALUATION

The field exercise was conducted to assess the technical performance of AITS. The user community evaluation was conducted to assess the mission relevance of AITS and its concept of operation. This effort enabled the development team to ensure that AITS met realistic mission needs and could be used under tactical conditions. Additionally, review by the user community was an opportunity to generate new ideas and suggestions for improvement to the system at an early stage of development—often, this is the most valuable information of an assessment effort.

Objectives

The objectives of the user community evaluation were as follows:

1. Identify the most useful features of AITS, as well as dispensable features.
2. Determine the utility and appropriate domains of use for HMDs and hand-held displays.
3. Evaluate useful display metaphors for head-mounted and hand-held displays, including symbology, data volume, and information layout.
4. Gather new ideas for improvements or redesign of AITS components.
5. Compare expert evaluations (by the target user community with those of a more general population to determine which results might be due to mission –specific needs and which might reflect good, general interface design principles.

Approach

The user community consisted of members of U.S. Marine Corps Sensor Control and Management Platoons (SCAMP), all familiar with Marine Corps security systems such as the Tactical Remote Surveillance System (TRSS). A Navy Science Advisor at Camp Pendleton, CA, arranged to have all participants tested in a single session. The civilian comparison group consisted of engineers and human factors specialists familiar with interface design. Because these individuals were more difficult to schedule, however, they were tested in multiple sessions as they became available.

Procedure

Everyone was first shown a standardized demonstration video of the AITS interface and its employment concepts. Following this demonstration, the AITS hardware was explained and demonstrated. Each participant was then given an opportunity to wear the system and to practice with its features. After a brief discussion, to clear up any questions or concerns, a comprehensive survey (Appendix A) was given to each participant to complete. The survey was designed to elicit information on the following:

1. Control and display configuration, including
   - HMD design
   - Hand-held display design
   - Input controls
   - Sensor alerts
2. Information content, including
   - Information about sensors and the environment, e.g., location and type
   - Information about sensor contacts, e.g., classification of target type and threat level
3. Display methods, including
   - Orienting displays, i.e., methods to get the user's eyes on the target location
   - Classification displays; methods to show friend or foe status
   - Range displays; methods to depict contact range from the user
4. Menu design, display clutter, and system functions.

Sufficient time was allowed for everyone to finish their survey, and all questions were answered as they were posed. Participants were encouraged to offer suggestions for improvement and to record these thoughts on the survey forms.

Results

While 20 Marines participated in this effort, reviews of the data showed that only 12 responses were complete and clear enough to support analysis. Therefore, 12 civilians (i.e., a matched sample size) were selected for comparison.

The complete data summary is presented in Appendix B. Significant results of the analysis are presented here.

Displays

a. By a significant margin, the Marine Corps and civilian participants preferred a see-through HMD for security work, in preference to hand-held displays.

b. There was no clear distinction by either community regarding see-through displays that covered both eyes or only covered one eye.

c. If using a see-through HMD, both communities unanimously preferred to have a design that could be lifted out of the field of vision when not used.

d. If AITS offered a head-mount and a hand-held display option, these communities still preferred a see-through HMD for viewing the following:

   - Geographic locations of sensors
   - Target contacts

- Environmental information (e.g., tactical information about hostile positions, mined areas, etc.)
- Locations of friendly assets
- Target classification data

e. Opinions were mixed about viewing sensor operating status on a head-mount or hand-held display; there was no clear preference here.

f. Opinions were mixed among the civilian participants regarding the best method to display contact range and bearing information. Marines, in contrast, were strongly favored see-through HMDs.

Input Controls

All participants preferred integrated control buttons or a touch panel (i.e., on a hand-held display) for interface control when operating near a command post, that is, gesture and voice control fell low in the rankings when the environment permitted use of more convenient devices.

a. When on moving patrol, Marines again preferred special-purpose controls, followed by gesture control or a wrist panel. Civilians preferred wrist panel and gesture control.

b. This preference continued with regard to support missions or other duties; both communities rated voice and gesture low, preferring wrist panel, buttons, or touch panel.

Sensor Alerts

Civilians preferred sensor alerts presented visually. Marines went along with this preference, but wanted data presented by multiple methods (possibly reflecting a desire for reliability through redundancy).

Information Content

a. Both communities considered the <u>general information</u> that AITS provided and rated the following elements between "important" to "absolutely critical"

   - Geographic location of all sensors in the environment
   - Location of active sensors (i.e., sensors that actually issue an intruder alert)
   - Sensor coverage patterns
   - Sensor operating status (e.g., normal, degraded, off, etc.); Marines thought this feature was slightly more important than civilians
   - Depiction of significant regions in the operating area (e.g., hostile locations, natural hazards, mined areas, etc.)
   - Locations of friendly assets (e.g., command posts, lookout positions, other unit personnel, etc.)

b. Both communities considered the <u>sensor contact information</u> that AITS provided and rated the following elements between "important" to "absolutely critical"–

- Threat classification (e.g., friend, enemy, unknown)
- Contact type classification (e.g., tank, truck, personnel, other)
- Confidence in system classification (i.e., how sure the system is of its classification)
- Contact range from the user

Display Coding

Both communities judged that information to get the user's eyes on the contact was "very important."

a. Both communities preferred directional arrows in the display to accomplish this orienting function (over the other alternative symbols provided).

Both groups preferred to have orienting information presented on a see-through HMD.

b. Both groups thought that information on contact threat status was important; Marines considered it critical.

c. Color-coding of threat status was preferred to flash coding (i.e., a blinking target symbol). Both groups preferred color coding whether it was on a see-through (first choice) or a hand-held (second-choice) display.

d. Shape coding of threat status was rated lower than color or flash coding; text labels were rated lowest.

e. Both groups preferred shape coding for contact type (e.g., vehicle, troops, etc.); this type was distinct from threat classification (i.e., friend, foe, or unknown).

f. Both groups thought it was worthwhile to depict contact range, although this information was considered less important than contact location and classification. Both groups also indicated a preference for depicting this information on the see-through head-mount display.

g. Size coding of contact symbology was preferred as a method to indicate range (e.g., bigger = closer), although this effect was not strong.

Display Clutter

Users were asked to evaluate how much information density they would tolerate on the two major display types (head-mount and hand-held) by viewing pictures with examples of different levels of "clutter." In general, the Marines were less tolerant of display clutter on HMDs than were the civilians, but more tolerant of clutter on hand-held displays. In addition, both groups were more tolerant of clutter on the hand-held than the HMD.

System Functions

a. Marines and civilians considered the ability to capture and transmit an image (e.g., a sighted contact or the surrounding environment) as "important" or "critical." The use of a portable camera and the communications capabilities of AITS were viewed, therefore, as valuable.

b. Both groups thought that the ability to see raw sensor information using the AITS display was "critical" (Marines) or "useful" (civilian).

c. One to two Marines took exception to the mode change design of AITS, i.e., the transition among map, target, and raw sensor displays as a function of head elevation. Specifically, these Marines thought that requiring any kind of head positioning for interface control might be troublesome in a tactical environment. *(These comments were offered verbally during the test session, and recorded by the exercise conductor; they did not appear in any of the survey forms).*

d. Only the Marines offered suggestions for additional functions, as follows:

- Ability to overcome signal jamming
- Simple operation
- Ability for field repair ("swap and pop")

The significant agreement between the civilian and Marine communities on most survey items was a welcome consensus. Where there was disagreement, the Marines tended to show a preference for reliability and utility under anticipated field conditions. These results indicate that general perceptual and cognitive characteristics drive preferences for display design and information content, i.e., that human factors analyses can be relied upon to develop good interface systems (although field validation will always be necessary to ensure readiness for transition and deployment).

Conclusions

Based on these results (presented more completely in Appendix B), several critical observations may be made:

1. This evaluation clearly demonstrated the acceptability of see-through HMDs. User communities appear to have little reservation to their use and, preferred them, in most cases. This preference should justify further development of such displays to ensure that they are usable under operational (e.g., sunlight) conditions. A desire for a display that could be easily moved away from the line of sight was an important observation, as this capability had not been originally designed into AITS.

2. Small control device were more acceptable to users than voice or gesture control (although neither voice nor gesture was explicitly rejected). Participants in this evaluation had very little experience with either mode of control. Nevertheless, further analysis and testing will be required before such novel control methods are used in operating systems.

3. Certain types of information (e.g., contact location, classification, range, etc.) were consistently judged as necessary. This part of the evaluation was useful in that it established critical data needs that should be included in <u>any</u> sensor interface, regardless of its physical design.

4. Certain forms of information presentation (e.g., color coding, shape coding) were consistently preferable to others. This result, too, was useful in that it shows those design paths that appear most promising in support of sensor system operators. The range of design choices, however, should nevertheless be kept as wide as possible, pending more extensive field experience. U.S. Army programs in this area might provide useful additions to the data presented here.

In summary, the user community evaluation confirmed the potential of even the more novel design concepts of AITS. Certainly, this evaluation process yielded a sufficiently consistent database to guide further development and to give confidence to aggressive interface design approaches. With the functional field exercise, this validation effort has confirmed the use of portable, intuitive interfaces for tactical security. Similar interface approaches are now finding their way into other applications requiring mobility (e.g., U.S. Army, 2001), distributed information access (e.g., Billinghurst, Miller, and Weghorst, 2001), and maintenance (e.g., Bath Iron Works, 2001; Mizell, 2001, Murray, 2002). SSC San Diego is already involved in several of these efforts, building on the foundation established through the AITS design process.

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[1] Contact author at SSC San Diego.

APPENDIX A
AITS TEST PROTOCOL

1. What we've done so far
   a. head worn emphasis
   b. head tracking + GPS
   c. display modes
2. What we're trying to find out
   a. what you think of current ideas
   b. what you think of displays
   c. new ideas we haven't thought of
3. Demo
   a. videotape
   b. gesture video
   c. AITS equipment
4. Elements of demo that aren't here
   a. hand held options
   b. voice and gesture
5. Procedure
   a. anonymity
   b. why we need your background
   c. keep it short
   d. we welcome your additional comments
   e. we'll show you final results
6. How to contact me later

Participant Background Survey

ID ____

Service Branch _______________

Pay grade ______________

Time in the military (yrs) ____________

Occupational specialty ___________________________________

Comments / suggestions about this project:

CONTROL AND DISPLAY CONFIGURATION

Security information can be displayed on a flat panel (e.g., a PDA, hand-held computer, etc.), directly in front of the operator's eyes (i.e., a head-mounted display), or on a combination of both displays.

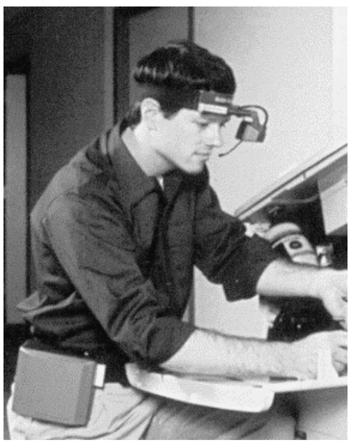
We would like to know what you think, as a security system operator, to the design and use of different display systems for presenting sensor information.

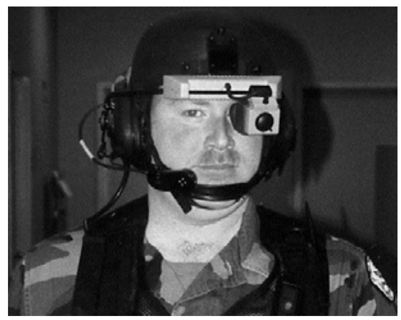
Please rank how essential each piece of information is to your job of determining a response to a security intrusion. Just place a mark along each scale that most closely reflects your opinion.

Head-mounted display design

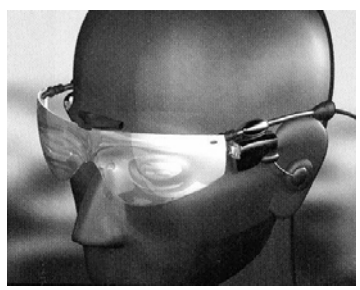
There are two forms of head-mounted displays in use.

a. A conventional display employs a small cathode ray tube (CRT) or liquid crystal display (LCD) and presents information in the same way you view it on a computer monitor.





b. A see-through display presents information on a semi-transparent glass so you can see the outside world at the same time. In many cases, this information is synchronized to objects in the real world, much the same as the symbols on a pilot's HUD.



The person conducting this survey has examples of each type of display, which he/she will be glad to demonstrate.

In addition, either display can be designed to work like a small set of field glasses, i.e., a conventional or a see-through display can be built into a small device that can be held by hand in front of they eye or eyes when needed. For lack of a better term, we refer to these devices as portable for this survey.

1. If I used a head-mounted display for security work, I would prefer

_____ a see-through display

_____ a conventional display

_____ a see-through portable

_____ a conventional portable

_____ other ____

2. If using a see-through display, I'd rather have a display that

_____ covered one eye

_____ covered both eyes (e.g., like a pair of goggles or glasses)

3. [See-through displays only] When I'm just monitoring a sensor suite, and nothing special is happening, I'd rather

_____ leave the head-mounted display in place

_____ flip the head-mounted display up, away from my eyes

3. [Conventional displays only] When I'm just monitoring a sensor suite, and nothing special is happening, I'd rather

_____ leave the head-mounted display in place

_____ flip the head-mounted display up, away from my eyes

Hand-held display design

A hand-held display can be a PDA, portable computer, or other flat panel device. They are different from head-mounted displays because you have to look down at them or hold them up to view their information (i.e., the information is not placed in front of your eyes, like it is with head-mounted systems). Hand-held displays can be strapped to your wrist,

carried in a pocket or pouch, or fastened to your clothing with Velcro until needed.

1. I'd rather view graphical indicators of sensor locations on

   _____ a see-through display

   _____ a conventional display

   _____ a see-through portable

   _____ a conventional portable

   _____ a hand-held display

   _____ other ____

2. I'd rather view graphical indicators of contact (target) locations on

   _____ a see-through display

   _____ a conventional display

   _____ a see-through portable

   _____ a conventional portable

   _____ a hand-held display

   _____ other ____

3. I'd rather view environmental information (e.g., hostile locations, natural hazards, mined areas, etc.) on

   _____ a see-through display

   _____ a conventional display

   _____ a see-through portable

   _____ a conventional portable

   _____ a hand-held display

   _____ other ____

4. I'd rather view graphical indicators of friendly asset locations on

   _____ a see-through display

   _____ a conventional display

   _____ a see-through portable

   _____ a conventional portable

   _____ a hand-held display

   _____ other ____

5. I'd rather view information about sensor operating status on

_____ a see-through display

_____ a conventional display

_____ a see-through portable

_____ a conventional portable

_____ a hand-held display

_____ other ____

6 I'd rather view information about contact classifications (e.g., friend, enemy, tank, truck, personnel, etc.) on

_____ a see-through display

_____ a conventional display

_____ a see-through portable

_____ a conventional portable

_____ a hand-held display

_____ other ____

7. I'd rather view text information about contact range on

_____ a see-through display

_____ a conventional display

_____ a see-through portable

_____ a conventional portable

_____ a hand-held display

_____ other ____

8. I'd rather view text information about contact bearing on

_____ a see-through display

_____ a conventional display

_____ a see-through portable

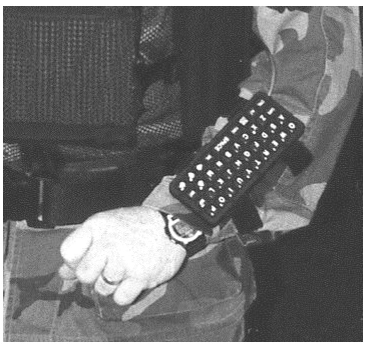
_____ a conventional portable

_____ a hand-held display

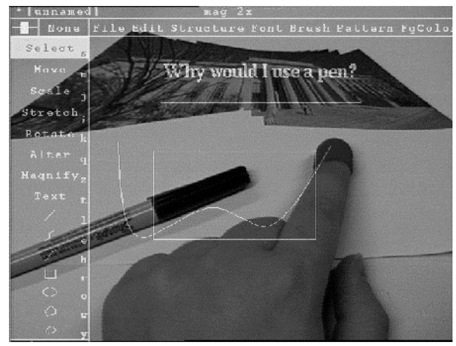
_____ other ____

Input controls

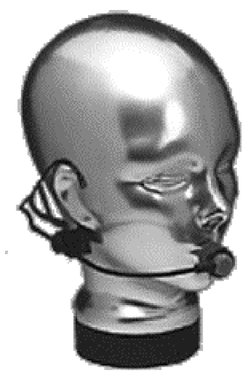
Input controls allow you to configure the operating mode of your sensor systems, call up information on a display and arrange the location of that information, and perform mission-specific functions (e.g., turn on or direct sensors, record alarm information, query databases, etc.). System operators in the field have ruggedized computer terminals to help them now, but other forms of interaction controls are also available. We'd like to get your opinions about some of these devices and methods as they relate to the displays and systems you currently use for your job in the field.



a. Wrist panel



b. Gesture control



c. Voice command

d. Ruggedized keyboard / mouse

e. Integrated surround button or touch-sensitive panel

f. Special purpose hand controls

Please rank order the control devices you'd prefer to use under the following conditions. 1 = most preferred, 6 = least preferred/

Note, too, that if you have ideas on other methods for interacting with your systems you can list them under the "other" category.

1. When operating in or near a field command post

    _____ wrist panel

    _____ gesture control

    _____ voice command

    _____ keyboard / mouse

    _____ buttons or touch panel

    _____ special purpose controls

    _____ other ____

2. When operating on moving patrol

    _____ wrist panel

    _____ gesture control

    _____ voice command

    _____ keyboard / mouse

    _____ buttons or touch panel

    _____ special purpose controls

    _____ other ____

3. Other missions that I perform (specify: __________________________)

    _____ wrist panel

    _____ gesture control

    _____ voice command

    _____ keyboard / mouse

    _____ buttons or touch panel

    _____ special purpose controls

    _____ other ____

Sensor alerts

When a sensor detects an intrusion or other significant contact, you can be alerted to this event so that you can check your sensor displays and other information. This can help by allowing you to do other tasks when nothing is happening, rather than monitoring displays until a significant event sets off a sensor. If sensory system processing were good enough to do this alerting function reliably, please rank order the methods that could be used to set an alarm. 1 = most preferred method, 4 = least preferred method.

_____ visual (e.g., flashing light, change in symbology, etc.)

_____ auditory (e.g., tone, buzzer, or spoken message)

_____ tactile (e.g., buzzer or vibrator, like those used in cell phones)

_____ multiple (i.e., some combination of the above methods)

_____ other ____

INFORMATION CONTENT

If your security system could provide any information you needed about sensors, your operating environment, and sensor contacts, what information would you want? Please rank how essential each piece of information is to your job of determining a response to a security intrusion. Just place a mark along each scale that most closely reflects your opinion.

Information about sensors and the environment

1. Locations of all sensors (relative to you)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

2. Location of any sensors that currently detect an intrusion (e.g., highlighting or pointing out those sensors that are actively sending contact signals)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

3. Depiction of sensor coverage patterns

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

4. Sensor operating status (e.g., normal, degraded, off)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

5. Depiction of significant regions in the operating area (e.g., hostile locations, natural hazards, mined areas, etc.)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

6. Locations of friendly assets (e.g., command posts, lookout positions, other unit personnel, etc.)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

7. Other information I would like to have about the sensor system:

8. Other information I would like to have about the operating environment:

Information about sensor contacts

1. Contact threat classification (e.g., friend, enemy, unknown)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

2. Contact type classification (e.g., tank, truck, personnel, other)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

3. Confidence in system classification (i.e., how sure the system is in its classification)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

4. Contact range (from you)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

   I would like to have range information displayed in

   ____ meters

   ____ kilometers

5. Contact bearing (from you)

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

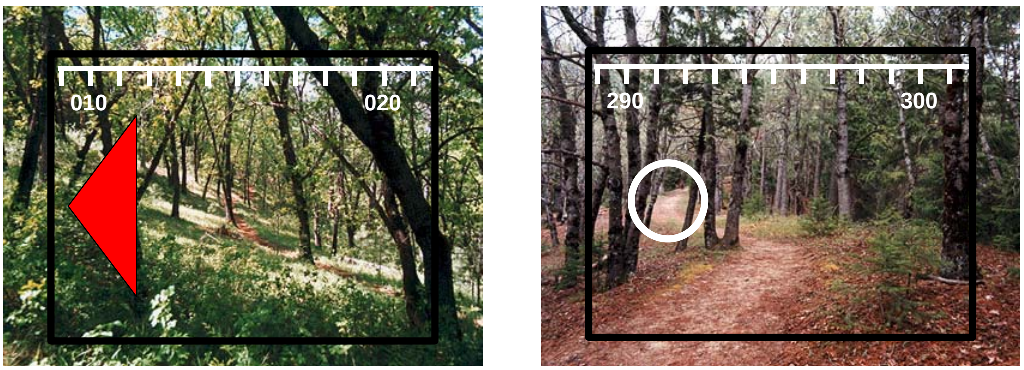
6. Other information I would like to have about contacts:

DISPLAY METHODS

Once a sensor has detected an intrusion, the information needs to be clearly presented to the system operator. We'd like to get your opinions on some display approaches for this task. In particular, we'd like to know how to get an operator's eyes onto an intrusion site quickly, and how to present classification information about contacts.

Orienting displays

I. Figure O-1 shows a system of arrows to indicate whether the contact is to the left or right of the operator's line of vision (i.e., whether the operator should look left or right to find the contact). With this scheme, the user turns his or her head until the bearing of the target comes into the field of view – then, the arrows disappear and a target reticle is displayed.

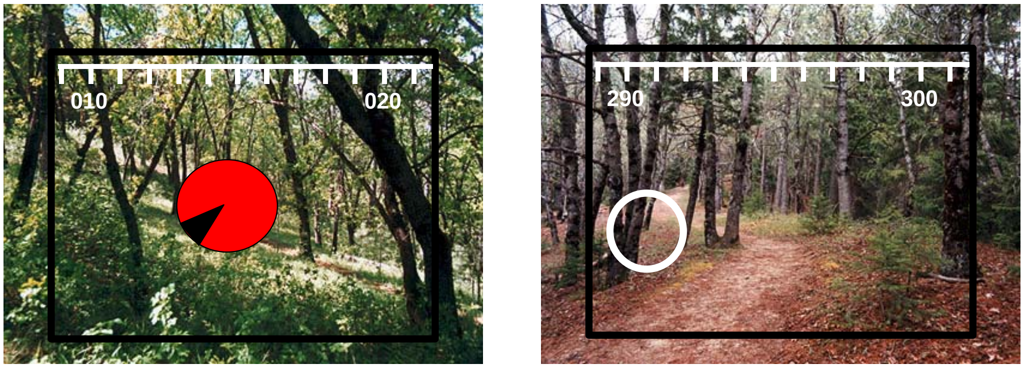


(a) (b)

Figure O-1

(a) looking north, with contact shown to the northwest; operator should turn left to find the target
(b) as operator looks toward the northwest, arrow disappears and is replaced by target reticle

II. Figure O-2 shows the "pacman" approach to directional display. In this display, the open "mouth" shows the direction – horizontally <u>and</u> vertically – that the operator must turn to see the contact, while the size of the opening gives an indication of the distance that he or she must look. When the mouth closes, the contact is within the field of view and the "pacman" is substituted with a target reticle.



(a) (b)

Figure O-2

(a) looking north, pacman symbol indicates a contact to the northwest; operator should turn left and look slightly down to see the target

(b) as operator looks toward northwest, pacman "mouth" gradually closes; when contact is within field of view, pacman disappears and is replaced by target reticle

1. I think that information to orient the operator to a contact is

Absolutely critical	Useful but not essential	I don't see any benefit

1----------2-----------3-----------4------------5

2. When comparing directional arrows with the "pacman" symbol, I prefer (check one):

_____ directional arrows

_____ pacman symbol

_____ other (specify: ____)

3. Please rank order the methods you'd prefer for getting an operator's eyes onto a contact. 1 = <u>most</u> preferred, 4 = <u>least</u> preferred.

Note, too, that if you have ideas on other orienting methods, you can list them under the "other" category.

_____ directional arrows on a **head-worn** display

_____ directional arrows on a **hand-held** display

_____ pacman symbol on a **head-worn** display

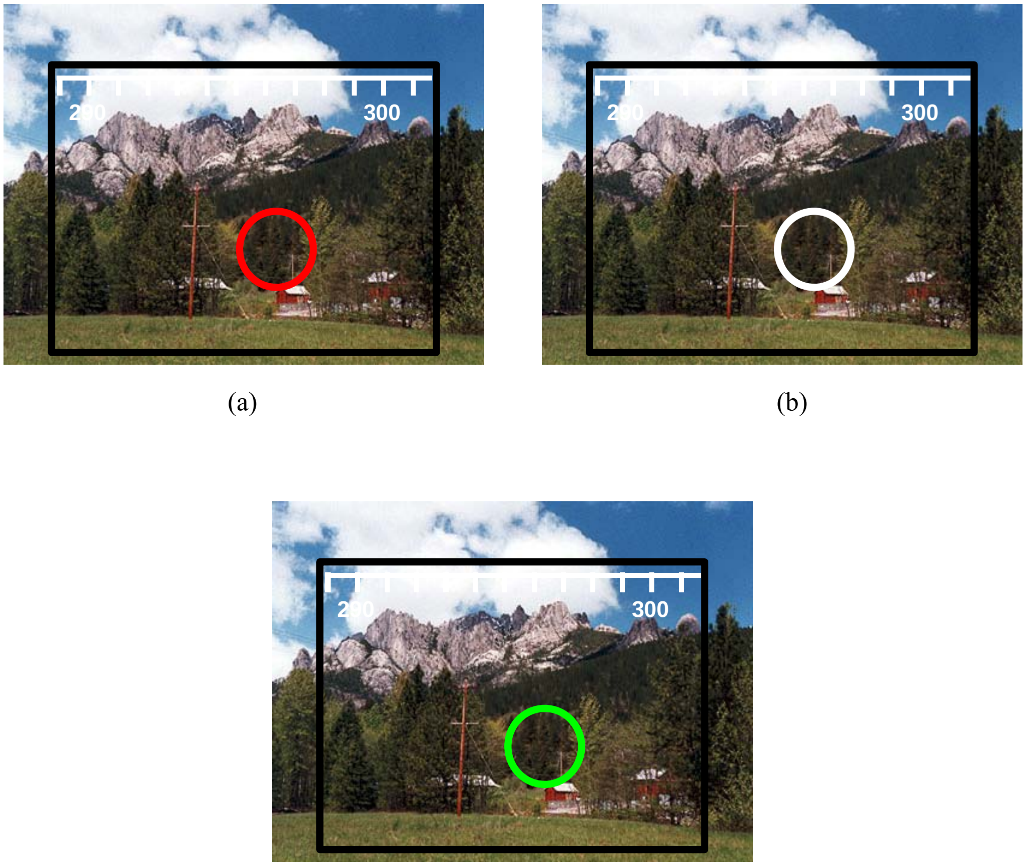
_____ pacman symbol on a **hand-held** display

_____ other (**head-worn** display) __________________________________

_____ other (**hand-held** display)__________________________________

Classification displays

i.	Figure C-1 shows a display of contact threat classification based on color coding.



(a) (b) (c)

Figure C-1

(a)	red reticle indicates contact classified as hostile

(b)	white reticle indicates contact classified as unknown

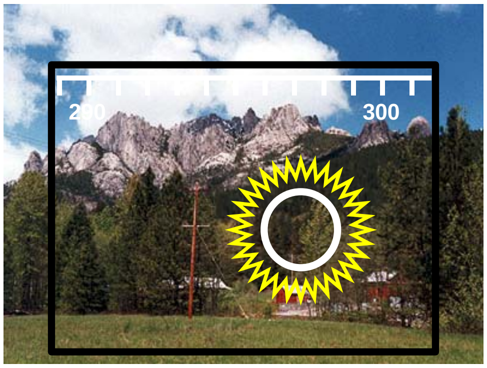
(c)	green reticle indicates contact classified as friendly

4. I think that color-coding of contact threat status is

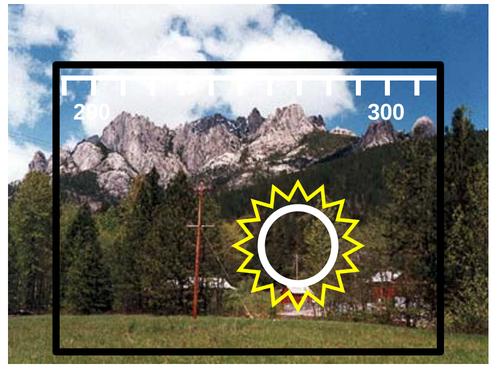
Absolutely critical	Useful but not essential	I don't see any benefit

1----------2-----------3-----------4------------5

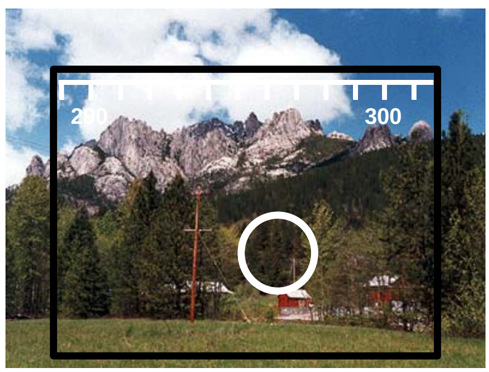
ii. Figure C-2 shows a display of contact threat classification based on flash coding.



(a)



(b)



(c)

Figure C-2

(a) rapid flashing reticle indicates contact classified as hostile

(b) slow flashing reticle indicates contact classified as unknown

(c) continuous (non-flashing) reticle indicates contact classified as friendly

5. I think that flash coding of contact threat status is

Absolutely critical	Useful but not essential	I don't see any benefit

1----------2-----------3-----------4------------5

6. When comparing color coding with flash coding of threat status, I prefer (check one):

   _____ color coding

   _____ flash coding

   _____ a combination of both methods

   _____ other (specify: ____)

7. Please rank order the methods you'd prefer for displaying the threat classification of a contact. 1 = <u>most</u> preferred, 6 = <u>least</u> preferred.

Note, too, that if you have ideas on other classification methods, you can list them under the "other" category.

   _____ color-coded classification (C-1) on a **head-worn** display

   _____ color-coded classification (C-1) on a **hand-held** display

   _____ flash-coded classification (C-2) on a **head-worn** display

   _____ flash-coded classification (C-2) on a **hand-held** display

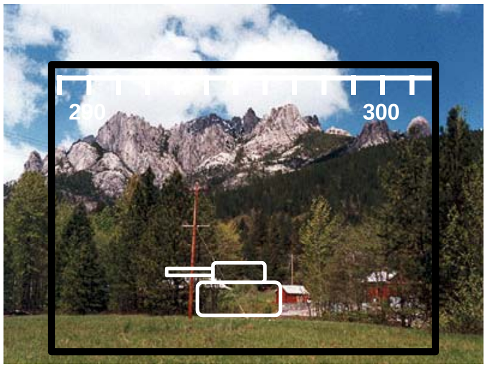
   _____ a text readout on a **head-worn** display

   _____ a text readout on a **hand-held** display

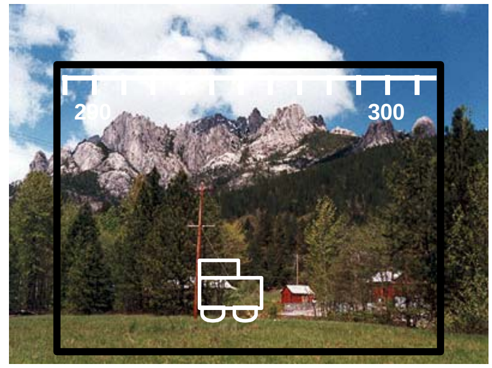
   _____ other (**head-worn** display) __________________________________

   _____ other (**hand-held** display)__________________________________

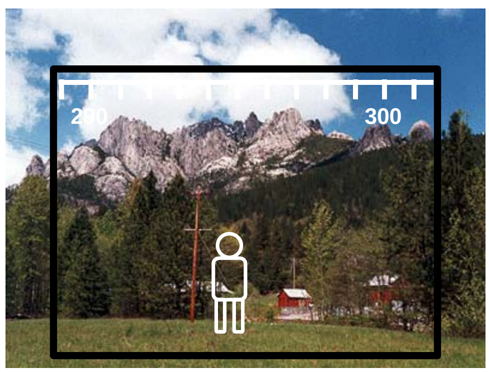
iii. Figure C-3 shows a display of contact <u>type classification</u> based on <u>shape coding</u>. Please note that this is done by changing the shape of the target reticle, and that these are only for illustration; better shapes can probably be found if this method is ever used for operational equipment.



(a)



(b)



(c)

Figure C-3

(a) contact classified as tank or large mechanized vehicle

(b) contact classified as wheeled vehicle

(c) contact classified as dismounted personnel

8. I think that shape coding of contact classification is

Absolutely critical	Useful but not essential	I don't see any benefit

1----------2-----------3-----------4------------5

9. When comparing shape coding with an alternative – e.g., a text label placed in the display – I'd prefer (check one)

_____ shape coding

_____ a text label

_____ a combination of both methods

_____ other (specify: ______________________________________)

10. Please rank order the methods you'd prefer for displaying the type classification of a contact. 1 = most preferred, 4 = least preferred.

Note, too, that if you have ideas on other classification methods, you can list them under the "other" category.

_____ shape-coded classification (C-3) on a **head-worn** display

_____ shape-coded classification (C-3) on a **hand-held** display

_____ a text readout on a **head-worn** display

_____ a text readout on a **hand-held** display

_____ other (**head-worn** display) ___________________________________

_____ other (**hand-held** display)____________________________________

Range displays

Correlation between sensors can provide information about the distance of the contact from the operator. This can be depicted graphically or using text.

i. Figure R-1 shows an estimated range to the contact using size coding.

(a)

(b)

(c)

Figure R-1

(a) contact at (arbitrary) long range
(b) contact at (arbitrary) medium range
(c) contact at (arbitrary) close range

11. I think that size coding to show contact range to the operator to a contact is

Absolutely critical	Useful but not essential	I don't see any benefit

1----------2-----------3-----------4------------5

ii. Figure R-2 shows an estimated range to the contact using <u>flash coding</u>.

(a)

(b)

(c)

Figure R-2

(a) rapid flashing reticle indicates contact at close range

(b) slow flashing reticle indicates contact at medium range

(c) continuous (non-flashing) reticle indicates contact at long range

12. I think that flash coding to show contact range to the operator is

Absolutely critical	Useful but not essential	I don't see any benefit

1----------2-----------3-----------4------------5

13. When comparing size coding with flash coding, I prefer (check one):

_____ size coding

_____ flash coding

_____ a combination of both methods

_____ other (specify: ____)

14. Please rank order the methods you'd prefer for presenting range to a contact. 1 = most preferred, 6 = least preferred.

Note, too, that if you have ideas on other range display methods, you can list them under the "other" category.

_____ size-coded range (R-1) on a **head-worn** display

_____ size-coded range (R-1) on a **hand-held** display

_____ flash-coded range (R-2) on a **head-worn** display

_____ flash-coded range (R-2) on a **hand-held** display

_____ a text readout of range on a **head-worn** display

_____ a text readout of range on a **hand-held** display

_____ other (**head-worn** display) ________________________________

_____ other (**hand-held** display)________________________________

MENUS

Any information system requires a way to set up its displays and to access its functions. Several possible approaches to system interaction are shown here. Note that when you're using menu functions, you're not in a tactical mode; other symbology, such as the target reticle and compass rose, are not shown to make room for readable menu information. Therefore, menu selection is a special mode, similar to adjusting the settings on your desktop display.

I. Figure M-1 shows a system with surround menus. With this approach, you select a function by highlighting one of a single, fixed set of options. When you do this, that menu function is activated. Because of limitations in the amount of display space, however, you can only access a limited number of menu options; what you see is what you get.

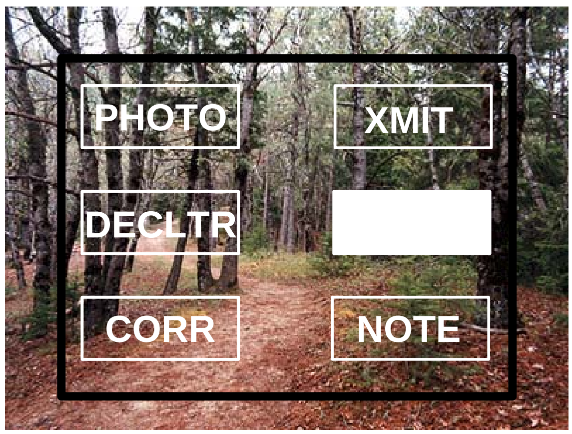


Figure M-1

Surround text buttons

ii. Figure M-2 shows the same set of surround menus, but this approach uses graphical icons instead of labeled boxes. (Please note that the particular icons used here are not necessarily the best choices; they're just examples of this approach to menu selection.)

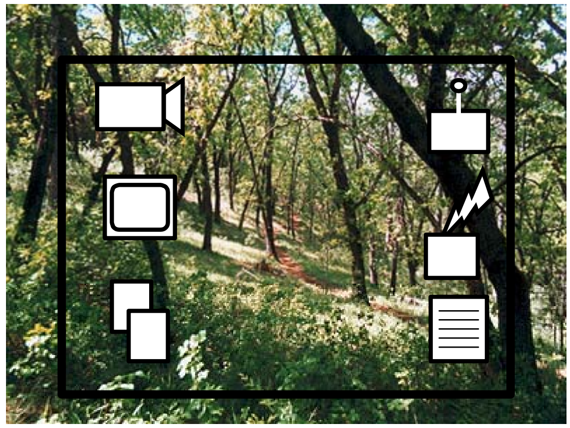


Figure M-2

Surround graphical buttons

iii. Figure M-3 uses a system of pull-down menus like you'd find in any Windows or Macintosh environment. This method allows you to control a larger number of choices, because menus come and go as you select their "parent" label. Navigation through the many options, however, is more complicated than the previous approaches.

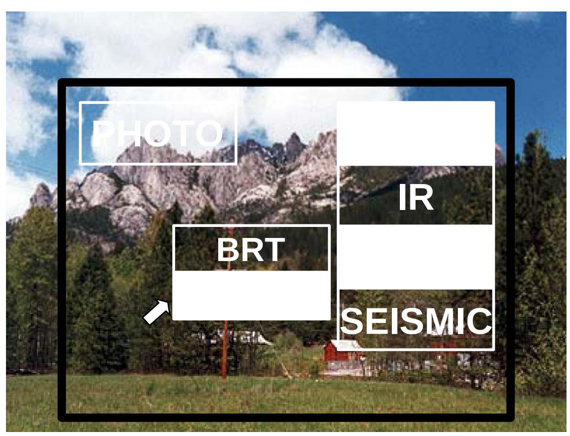


Figure M-3

Pulldown menus

15. Please rank order your preference for these menu options. 1 = most preferred, 7 = least preferred.

Note, too, that if you have ideas on other methods for interacting with your systems you can list them under the "other" category.

_____ surround text menus (M-1) on a **head-worn** display

_____ surround graphic menus (M-2) on a **head-worn** display

_____ pulldown menus (M-3) on a **head-worn** display

_____ surround text menus (M-1) on a **hand-held** display

_____ surround graphic menus (M-2) on a **hand-held** display

_____ pulldown menus (M-3) on a **hand-held** display

_____ system control using voice commands (i.e., speech recognition, with no visual menu displays)

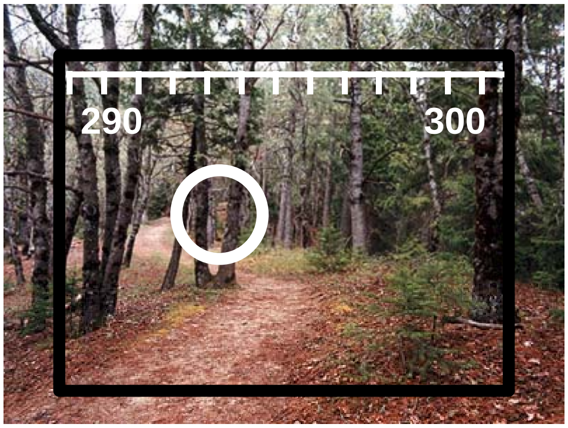
_____ other (**head-worn** display) ___________________________________

_____ other (**hand-held** display) ___________________________________

Display clutter

There is a limit to how much information can be presented on a display before it becomes difficult or time-consuming to read. We would like to know how "cluttered" you think a display can become before the amount of information is objectionable. Please assume that all of the text and symbols (below) are necessary items of information to do your job; we're interested in what you think of the amount of space that these items take up.

16. Please check the **head-worn display** that shows the maximum amount of information that you'd accept while using the system on duty (check one):



(a)____

(b)_____

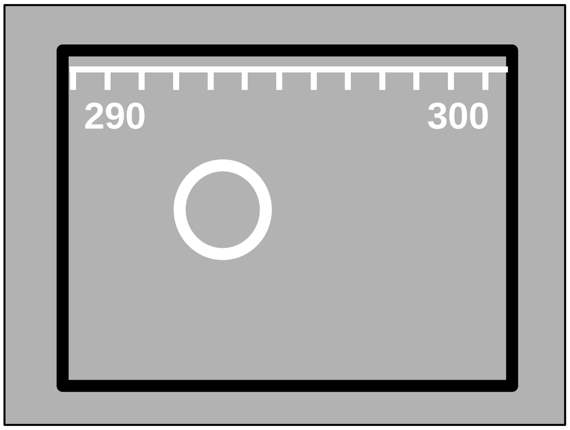
(c)_____

(d)_____

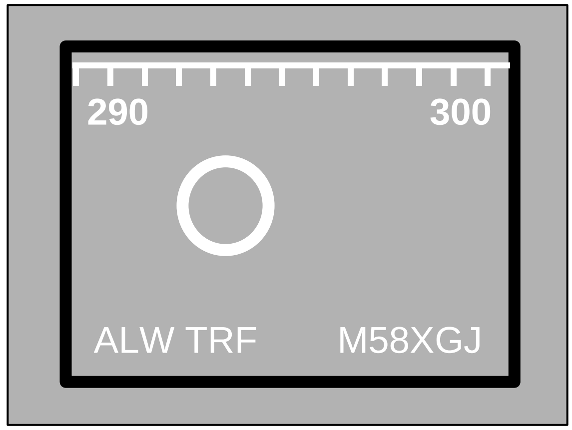
(e) _____

(f) _____

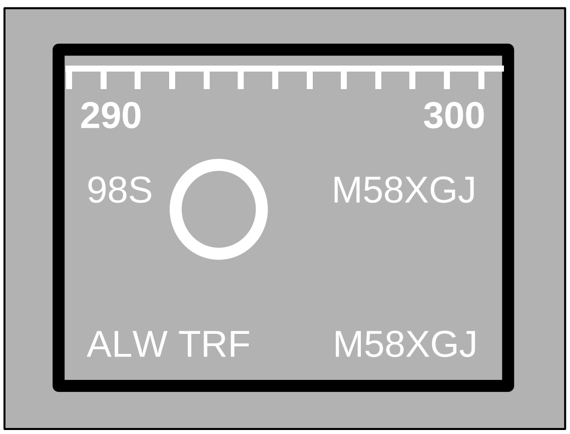
17. Please check the **hand-held display** that shows the maximum amount of information that you'd accept while using the system on duty (check one):



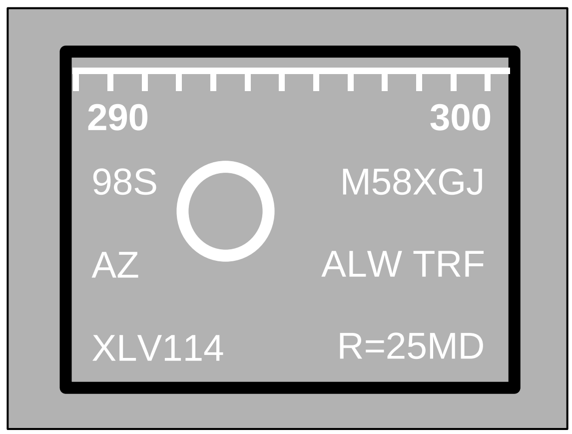
(a) _____



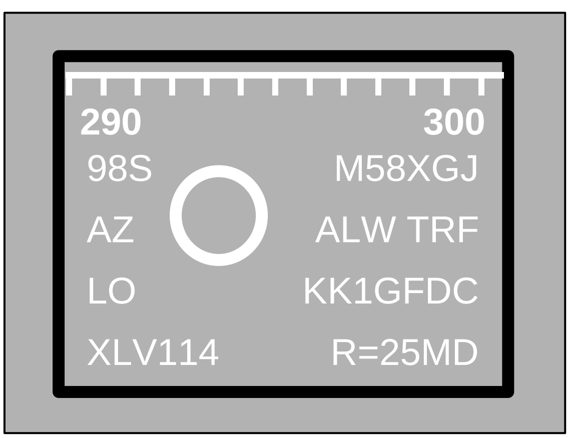
(b) _____



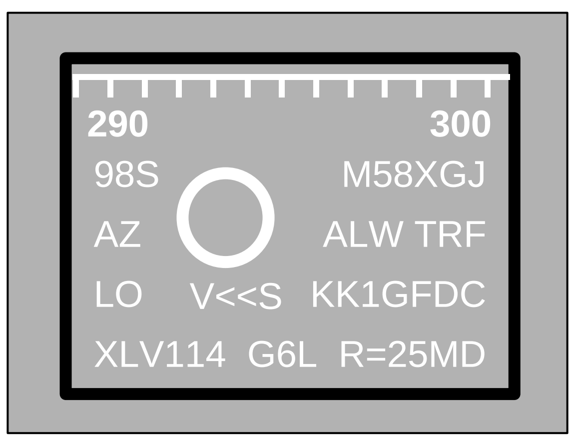
(c) _____



(d) _____



(e) _____



(f) _____

SYSTEM FUNCTIONS

Additional capabilities may be possible with future security systems, even using current technology. Please let us know what you think about how important some of these functions would be to your mission. You can also suggest capabilities that we haven't thought of with the "other" categories below.

1. The ability to capture and transmit an image of the immediate area (e.g., a sighted contact or the surrounding environment).

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

2. The ability to see raw sensor information assuming that all other functions described here work "as advertised."

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

3. Ability to select and control a sensor (e.g., to open a link to an IR sensor and control its coverage in real time).

   Absolutely critical — Useful but not essential — I don't see any benefit

   1----------2-----------3-----------4------------5

4. Other ____

   Absolutely critical — Useful but not essential

   1----------2-----------3

5. Other ____

   Absolutely critical — Useful but not essential

   1----------2-----------3

APPENDIX B
SURVEY RESULTS

NOTES

1. *Four classes of questions were used –*

a. *Select one from a group of options in a list that best reflects the participant's preference*

b. *Rank order a list of options*

c. *Make a judgment along a continuous scale*

d. *Provide open-ended comments or suggestions.*

2. *Numbers shown in table columns normally indicate the number of respondents who selected the particular option(s) from the provided list. Blanks indicate no choices made to that option.*

3. *Where items were to be rank ordered, the resulting orders are shown for each group, together with the mean ranking score for each item in parentheses. When rank ordering, 1 = most preferred or most critical.*

4. *Twelve civilians and twelve members of Marine Corps sensor platoons were surveyed. Every participant did not necessarily record a response to every topic (even though this was requested in the instructions). In such cases, the columns will sum to less than 12.*

5. *Narrative comments, whenever they appeared on the survey forms, are recorded below the items to which they refer.*

6. *Rating scales show the mean group choice for Civilians (C) and Marines (M). Tables are included to indicate the exact breakdowns of these means.*

7. *Some options may not be clear from the material below as they refer to imagery. Complete survey materials (e.g., images, instructions, question statements, etc.) can be found in Appendix A.*

CONTROL AND DISPLAY CONFIGURATION

Head-mounted display design

1. If I used a head-mounted display for security work, I would prefer

	Civilian	Marine Corps
See-through head-mount	8	8
Conventional head-mount		1
See-through portable	3	3
Conventional portable		
Other	1	

Comments

Civilian – Depends on the nature of the foreground and background. Best display could be variable.

2. If using a see-through display, I'd rather have a display that

	Civilian	Marine Corps
Covered one eye	5	6
Covered both eyes	6	4
Other	1	2

Comments

Civilian – One eye only can be distracting

Marine Corps – Cover both eyes OK, but switchable for shooting; or dominant eye

3. **See-through displays only**. When I'm just monitoring a sensor suite, and nothing special is happening, I'd rather

	Civilian	Marine Corps
Leave the head-mounted display in place	1	0
Flip the head-mounted display up, away from my eyes	11	12

Comments

Civilian – Unless it's very lightweight and unobtrusive (e.g., eyeglasses)

4. **Conventional displays only**. When I'm just monitoring a sensor suite, and nothing special is happening, I'd rather

	Civilian	Marine Corps
Leave the head-mounted display in place		1
Flip the head-mounted display up, away from my eyes	11	10

Hand-held display design

1. I'd rather view graphical indicators of sensor locations on

	Civilian	Marine Corps
See-through head-mount	8	6
Conventional head-mount		
See-through portable	1	2
Conventional portable	2	1
Hand-held display	1	3

Comments

Civilian – In conjunction with a head-mounted display. Handheld to survey area; head mount after alert goes off. A planar map might work better on a hand-held.

2. I'd rather view graphical indicators of contact (target) locations on

	Civilian	Marine Corps
See-through head-mount	9	7
Conventional head-mount		
See-through portable	1	3
Conventional portable		1
Hand-held display	1	1

3. I'd rather view environmental information (e.g., hostile locations, natural hazards, mined areas, etc.) on

	Civilian	Marine Corps
See-through head-mount	5	7
Conventional head-mount		
See-through portable	4	3
Conventional portable	1	1
Hand-held display	2	1

Comments

Civilian – Could possibly be mounted on belt; don't clutter up head mounted display too much. In conjunction with a see-through.

4. I'd rather view graphical indicators of friendly asset locations on

	Civilian	Marine Corps
See-through head-mount	7	8
Conventional head-mount		
See-through portable	2	3
Conventional portable		1
Hand-held display	3	

5. I'd rather view information about sensor operating status on

	Civilian	Marine Corps
See-through head-mount	3	5
Conventional head-mount	1	1
See-through portable	1	1
Conventional portable	1	2
Hand-held display	6	3

6. I'd rather view information about <u>contact classifications</u> (e.g., friend, enemy, tank, truck, personnel, etc.) on

	Civilian	Marine Corps
See-through head-mount	8	7
Conventional head-mount		
See-through portable	2	1
Conventional portable		2
Hand-held display	2	2

7. I'd rather view text information about <u>contact range</u> on

	Civilian	Marine Corps
See-through head-mount	5	9
Conventional head-mount		
See-through portable		
Conventional portable		1
Hand-held display	7	2

8. I'd rather view text information about <u>contact bearing</u> on

	Civilian	Marine Corps
See-through head-mount	6	9
Conventional head-mount		
See-through portable	1	
Conventional portable		1
Hand-held display	5	2

Input controls

1. Rank order – When operating in or near a field command post

	Civilian	Marine Corps
Wrist panel	3 (3.08)	5 (4.11)
Gesture control	5 (4.42)	6 (4.33)
Voice command	2 (2.58)	4 (3.67)
Keyboard / mouse	4 (4.00)	3 (3.11)
Buttons or touch panel	1 (2.33)	1 (2.25)
Special purpose controls	6 (4.70)	2 (2.75)
Other		

<u>Comments</u>

Civilian – Voice, <u>if</u> voice instruction was simple and unique. Would use a PDA for this mission. If soldier carries a hand-held, it should be a PDA with touch screen controls. PDA should be silent

Marine Corps – Palm pilot.

Rank order – When operating on moving patrol

	Civilian	Marine Corps
Wrist panel	1 (2.58)	3 (3.13)
Gesture control	2 (3.17)	2 (2.70
Voice command	5 (3.83)	6 (4.67)
Keyboard / mouse	6 (4.58)	5 (4.00)
Buttons or touch panel	3 (3.42)	4 (3.38)
Special purpose controls	4 (3.82)	1 (1.88)
Other		

Comments

Civilian – Mouse with HMD; mouse similar to a rocker bar on a laptop. HMD when on patrol.

Marine Corps – wouldn't use any of this stuff on moving patrol

Gesture control – the rest aren't really tactical

2. Rank order – For other missions that I perform (specify: electronics technician, on patrols, etc.)

	Civilian	Marine Corps
Wrist panel	1 (2.33)	4 (3.33)
Gesture control	4 (3.67)	6 (4.60)
Voice command	5 (4.00)	5 (4.00)
Keyboard / mouse	2 (3.00)	2 (2.40)
Buttons or touch panel	3 (3.33)	1 (2.20)
Special purpose controls	4 (3.67)	3 (3.00)
Other		

Comments

Civilian – Voice command when hands are full

Marine Corps – Palm pilot

Sensor alerts

Rank order the methods that could be used to signal an alarm

	Civilian	Marine Corps
Visual	1 (2.33)	3 (2.50)
Auditory	2 (2.42)	4 (3.09)
Tactile	2 (2.42)	2 (2.27)
Multiple methods	3 (2.60)	1 (2.09)
Other		

Comments

Civilian – (Other) depending on the environment; on patrol, certain tactile stimuli are likely to be missed / ignored

INFORMATION CONTENT

INFORMATION ABOUT SENSORS AND THE ENVIRONMENT

1. Locations of all sensors (relative to you)

	Civilian	Marine Corps
	1.77	1.71

Absolutely critical — Useful but not essential — I don't see any benefit

1------MC--2---------3-----------4------------5

2. Location of any sensors that currently detect an intrusion (e.g., highlighting or pointing out those sensors that are actively sending contact signals)

	Civilian	Marine Corps
	1.10	1.33

Absolutely critical — Useful but not essential — I don't see any benefit

1-C-M------2---------3-----------4-----------5

Depiction of sensor coverage patterns

	Civilian	Marine Corps
	2.27	1.92

Absolutely critical — Useful but not essential — I don't see any benefit

1--------M-2--C------3-----------4------------5

Comments

Civilian – Must show gaps in coverage

Sensor operating status (e.g., normal, degraded, off)

	Civilian	Marine Corps
	2.19	1.79

Absolutely critical — Useful but not essential — I don't see any benefit

1-------M--2-C-------3-----------4-----------5

Comments

Civilian – Only during an alert or periodically - if gaps develop in perimeter, user must be aware of them

Depiction of significant regions in the operating area (e.g., hostile locations, natural hazards, mined areas, etc.)

	Civilian	Marine Corps
	1.51	1.92

Absolutely critical — Useful but not essential — I don't see any benefit

1----C---M-2---------3-----------4------------5

1. Locations of friendly assets (e.g., command posts, lookout positions, other unit personnel, etc.)

	Civilian	Marine Corps
	1.91	2.04

Absolutely critical — Useful but not essential — I don't see any benefit

1-------C--2M--------3---------4------------5

Comments

Civilian – Important to know if these assets change

2. Other information I would like to have about the sensor system:

Civilian –

If sensor patterns overlap, would like to see graphic of where they overlap
When maintenance is required (e.g., battery replace).
Indications of tampering or compromise
Types of coverage, sensor sensitivities
Test status of system - to know all is operational
How to troubleshoot a sensor problem
How system is affected by weather
Vectors showing possible target location

Marine Corps –
System should do paperwork too.
Also, to see picture of what's there.
Battery status.
Battery life; types of sensors that are employed

3. Other information I would like to have about the operating environment:

Civilian –

Terrain and current weather conditions.

Both historical data and trends of enemy movement; actions over stipulated timeframe.

Access to potential intel reports

Marine Corps –

To view 360 degrees of sensor area.

To see check points.

Real world view (photograph) of sensor location

INFORMATION ABOUT SENSOR CONTACTS

1. Contact threat classification (e.g., friend, enemy, unknown)

	Civilian	Marine Corps
	1.30	1.17

Absolutely critical	Useful but not essential	I don't see any benefit

1-MC-----2-----------3----------4-----------5

Comments

Civilian – If classification can be shown to be reliable

2. Contact type classification (e.g., tank, truck, personnel, other)

	Civilian	Marine Corps
	1.84	1.25

Absolutely critical	Useful but not essential	I don't see any benefit

1--M---C--2---------3----------4-----------5

3. Confidence in system classification (i.e., how sure the system is in its classification)

	Civilian	Marine Corps
	1.41	1.46

Absolutely critical	Useful but not essential	I don't see any benefit

1---CM----2---------3----------4-----------5

4. Contact range (from you)

	Civilian	Marine Corps
	1.69	1.63

Absolutely critical — Useful but not essential — I don't see any benefit

1-----MC---2---------3-----------4------------5

Comments

Civilian – Depends on scenario; the change in range is more informative

I would like to have range information displayed in

	Civilian	Marine Corps
meters	5	7
kilometers	4	3

5. Contact bearing (from you)

	Civilian	Marine Corps
	1.62	1.83

Absolutely critical — Useful but not essential — I don't see any benefit

1------MC--2-----------3-----------4------------5

Comments

Civilian – Speed

2. Other information I would like to have about contacts:

Civilian –
How fast is it moving? Quantity

Marine Corps –
How fast are they moving?
What type of equipment do they have?
Real time video or pictures.
Approximate number of contacts/composition.
What it is, how fast is it going, and in what direction. Friend from foe, too. Speed, quantity (numbers?)

DISPLAY METHODS

Orienting displays

1. I think that information to orient the operator to a contact is

	Civilian	Marine Corps
	1.37	1.45

Absolutely critical	Useful but not essential	I don't see any benefit

1--CM------2---------3-----------4------------5

2. When comparing directional arrows with the "pacman" symbol, I prefer (check one):

	Civilian	Marine Corps
Directional arrows	7	7
Pacman symbol	3	2
Other	2	3

Comments

Civilian – Arrows are more intuitive but pacman might be more useful with training
Could use combination of L-R and up-down
Also - size arrow
Smaller arrow and bearing quadrant

Marine Corps – Arrow, with range/bearing shown (drew a sketch)
Pacman, but somewhere beside the middle of the display
Pacman in the corner of display

3. Rank order methods for getting an operator's eyes onto a contact.

	Civilian	Marine Corps
Directional arrows on head-worn display	1 (1.33)	1 (1.50)
Directional arrows on hand-held display	3 (3.44)	3 (2.75)
Pacman symbol on head-worn display	2 (2.11)	2 (2.50)
Pacman symbol on hand-held display	4 (3.44)	4 (3.25)
Other head-worn display		
Other hand-held display		

Comments

Civilian – Smaller arrow

Marine Corps – Special arrow with range/bearing; see sketch. Pacman, but not in middle of display

Classification displays

4. I think that color-coding of contact threat status is

	Civilian	Marine Corps
	2.02	1.50

Absolutely critical — Useful but not essential — I don't see any benefit

1----M----2C---------3-----------4------------5

Comments

Civilian – Concerns: color-blind people, visibility of colors in bright light

Marine Corps – WOW for front line use. For sensor monitor, not used; we give info to intel and they pass to front line.]

5. I think that flash coding of contact threat status is

	Civilian	Marine Corps
	2.97	3.04

Absolutely critical — Useful but not essential — I don't see any benefit

1----------2---------C3M---------4------------5

Comments

Civilian – This would attract user's attention more than color coding.

How much confidence is placed in classification algorithm? I like flashing better.

Overkill and distracting

When comparing color coding with flash coding of threat status, I prefer (check one):

	Civilian	Marine Corps
Color coding	6	8
Flash coding	3	
Combination of methods	3	4

Comments

Civilian – Depends on how cluttered the screen can be and still be useable; if cluttered, flashing might be better – if empty, color might be better or a combination

Marine Corps – Color-coding with text message that says "friendly"

7. Rank order methods you'd prefer for displaying the threat classification of a contact.

	Civilian	Marine Corps
Color-coded on head-worn display	1 (1.27)	1 (1.30)
Color-coded on hand-held display	2 (2.72)	3 (3.20)
Flash-coded on head-worn display	3 (2.92)	2 (2.60)
Flash-coded on hand-held display	5 (4.36)	5 (4.00)
Text readout on head-worn display	4 (4.10)	4 (3.25)
Text readout on hand-held display	6 (4.50)	6 (4.75)
Other head-worn display		
Other hand-held display		

Comments

Marine Corps – "Friendly," "enemy," "unknown" actually written out; combination of color and flash

8. I think that shape coding of contact classification is

	Civilian	Marine Corps
	2.68	2.00

Absolutely critical — Useful but not essential — I don't see any benefit

1---------M-----C----3-----------4------------5

<u>Comments</u>

Civilian – Icon might be better placed elsewhere, instead of over target; make it solid, too

9. When comparing shape coding with an alternative – e.g., a text label placed in the display – I'd prefer (check one)

	Civilian	Marine Corps
Shape coding	7	4
Text label	3	2
Combination	1	5
Other	**	**

<u>Comments</u>

Civilian – Shape coding with details that could be called up on demand;

Icons are usually best, but you may have to experiment

Marine Corps – Shape plus color coding

10. Rank order methods for displaying the type classification of a contact.

	Civilian	Marine Corps
Shape-coded on head-worn display	1 (1.55)	1 (1.54)
Shape-coded on hand-held display	2 (2.55)	3 (3.00)
Text readout on head-worn display	2 (2.55)	2 (2.00)
Text readout on hand-held display	3 (3.45)	4 (3.40

<u>Comments</u>

Civilian – Depends on task and circumstance. Text and shape can both be icons. There is technology available at UCSD to see camouflaged objects

Range displays

11. I think that size coding to show contact range to the operator to a contact is

	Civilian	Marine Corps
	1.75	2.58

Absolutely critical	Useful but not essential	I don't see any benefit

1------C--2-----M----3-----------4------------5

Comments

Civilian – This would require user to maintain a mental model of the different sizes and be able to correlate them with each other and with distances; Suggest using standard size icon with text for range. Large icon doesn't localize the target adequately.

12. I think that flash coding to show contact range to the operator is

	Civilian	Marine Corps
	3.58	2.96

Absolutely critical	Useful but not essential	I don't see any benefit

1----------2---------M3------C----4-----------5

Comments

Civilian – This is better than circle sizes, but might still be difficult to interpret

13. When comparing size coding with flash coding, I prefer (check one):

	Civilian	Marine Corps
Size coding	8	6
Flash coding	1	2
Combination	1	3
Other	2	

Comments

Civilian – Text for range, flash for hostile. Neither - use digits

Marine Corps – Also add color to size coding; Actual distance in numbers

14. Rank order methods for presenting range to a contact.

	Civilian	Marine Corps
Size-coded range on head-worn display	1 (2.08)	1 (1.73)
Size-coded range on hand-held display	2 (3.42)	4 (3.90)
Flash-coded range on head-worn display	4 (4.25)	3 (2.90)
Flash-coded range on hand-held display	6 (4.83)	5 (4.70)
Text readout on head-worn display	3 (3.58)	2 (2.82)
Text readout on hand-held display	5 (4.58)	5 (4.70)
Other head-worn display		

Comments

Civilian – Too distracting (text readout on hand-held display). Other – text for range digits

Marine Corps – All head worn is great for front lines. Hand held best in the rear

Menus

Rank order your preference for these menu options.

	Civilian	Marine Corps
Surround text menus on head-worn display	1 (2.55)	1 (2.70)
Surround graphic menus on head-worn display	1 (2.55)	2 (3.20)
Pull-down menus on head-worn display	2 (4.09)	1 (2.70)
Surround text menus on hand-held display	3 (4.18)	3 (3.64)
Surround graphic menus on hand-held display	2 (4.09)	5 (4.60)
Pull-down menus on hand-held display	5 (5.64)	4 (4.00)
System control using voice commands	4 (4.55)	6 (6.60)

Comments

Civilian – Tied with graphic menus on head worn display. How about a gesture that brings up an appropriate context menu? Couple the procedures for the head mount and the hand-held.

DISPLAY CLUTTER

1. Please check the **head-worn display** that shows the maximum amount of information that you'd accept while using the system on duty :

	Civilian	Marine Corps
(a)	1	2
(b)	3	2
(c)	3	4
(d)	4	3
(e)	1	
(f)		1

Comments

Civilian – Definitely want to minimize clutter, esp. in a hostile environment

2. Please check the **hand-held display** that shows the maximum amount of information that you'd accept while using the system on dut

	Civilian	Marine Corps
(a)		
(b)		
(c)	2	2
(d)	5	4
(e)	3	
(f)	2	6

SYSTEM FUNCTIONS

1. The ability to capture and transmit an image of the immediate area (e.g., a sighted contact or the surrounding environment).

	Civilian	Marine Corps
	2.04	1.71

Absolutely critical	Useful but not essential	I don't see any benefit

1-----M---2C---------3-----------4------------5

2. The ability to see raw sensor information assuming that all other functions described here work "as advertised."

	Civilian	Marine Corps
	2.53	1.54

Absolutely critical | Useful but not essential | I don't see any benefit

1----M----2-----C-----3-----------4-----------5

<u>Comments</u>

Civilian – Only if sensor is video or a still image

3. Ability to select and control a sensor (e.g., to open a link to an IR sensor and control its coverage in real time).

	Civilian	Marine Corps
	2.29	1.71

Absolutely critical | Useful but not essential | I don't see any benefit

1------M---2--C------3-----------4------------5

4. Other

	Civilian	Marine Corps
	1.50	2.00

Absolutely critical | Useful but not essential

1----C-----M----------3-----------4------------5

<u>Comments</u>

Civilian – Very soon sensors will be mobile and we'll have to direct them. System or network status

Marine Corps – Record a 3D image of an area and go back to view it later

NOTE – *To ensure completeness, users were given an opportunity to respond with comments or suggestions to any topic(s) that had not been addressed elsewhere in the survey. Each of the following comments were offered by a member of the Marine Corps and each comment reflects the view of a single (not necessarily the same) individual:*

5. Other _____ ability to overcome signal jamming_____

Absolutely critical — Useful but not essential

X----------2-----------3

6. Other ____ simple operation_____

Absolutely critical — Useful but not essential

X----------2-----------3

7. Other _____get a 3D image of what sensor sees in real time_____

Absolutely critical — Useful but not essential

| |

X----------2-----------3

8. Other _____ability for field repair; easy fix (swap and pop)_____

Absolutely critical — Useful but not essential

X----------2-----------3

9. Other _____factory warranty; easy repair_____

Absolutely critical — Useful but not essential

X----------2-----------3