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Instrumentation Requirements for Collecting Soldier Performance Data

Tary D. Wilkinson and Michael M. Copenhaver
Allen Corporation of America

Lloyd M. Crumley
U.S. Army Research Institute

for

Contracting Officer's Representative
Arthur Marcus

Field Unit at Fort Sill, Oklahoma
Edwin R. Smootz, Acting Chief

MANPRINT Division
Robin L. Keesee, Director

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EDGAR M. JOHNSON
Technical Director

MICHAEL D. SHALER
COL, AR
Commanding

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Wilkinson, Tary D.; Copenhaver, Michael M. (Allen Corp.); Crumley, Lloyd M. (ARI)

Allen Corporation of America
209 Madison Street
Alexandria, VA 22314

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U.S. Army Research Institute for the Behavioral and Social Sciences
ATTN: PERI-S
5001 Eisenhower Avenue
Alexandria, VA 22312-5600

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Contracting Officer's Representative, Arthur Marcus.
LTC A. W. Schopper prepared the Statement of Work for this report.

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This report describes the four steps used to determine the best equipment to use for collecting soldier performance data. Special attention was paid to field data collection, where operational requirements often restrict the data collection capability. The four steps involved (a) conducting structured interviews with experienced research persons, (b) analyzing questionnaires mailed to researchers, (c) preparing a list of the data collection instrumentation identified, and (d) locating sources for the equipment items and doing trade-off analyses to identify the most cost-effective supplier. The equipment needed fell into six classes: (a) audio, (b) video, (c) support and selected supplementary, (d) environment and weather, (e) work space, and (f) psychological and physiological. This report does not include the equipment specification, source, and cost data because such data will become obsolete as models and prices change.

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INSTRUMENTATION REQUIREMENTS FOR COLLECTING
SOLDIER PERFORMANCE DATA

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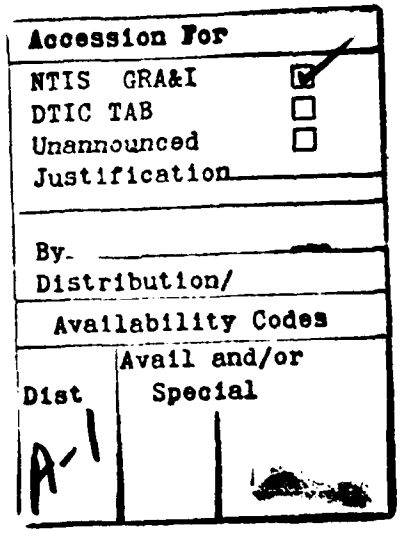

INSTRUMENTATION REQUIREMENTS FOR COLLECTING SOLDIER PERFORMANCE DATA

The Army Research Institute (ARI) Fort Sill Field Unit (FSFU) is involved in a project to collect data on soldier errors in automated systems. The data are being collected as part of a larger ARI research effort that includes the creation and validation of analytic models for use in the development of weapon systems. This larger effort, generally referred to under the rubric "MANPRINT", requires that analytic techniques that will enable materiel developers to assess the impact of the soldiers in the system be supported by a data base that reliably depicts the potential performance of soldiers using automated systems.

Information--data--concerning soldier error, and analytic techniques to manipulate these data, are needed by system designers for a variety of reasons. System designers require this information in order to design systems that reduce the potential for error rather than increase it; they need soldier performance data in order to improve the maintainability of weapon systems and the effectiveness of maintenance procedures; they need to know what errors soldiers may make in order to develop training equipment and training programs; and they need to know how soldier errors are likely to impact weapon system performance in combat situations so that they can reduce the potential of soldier error affecting the reliability of the weapon system.

The process of collecting soldier error data for automated systems permits, even requires, the data to be collected in a variety of situations. Some data can be acquired in a laboratory setting; some requires a research presence in the classroom; in some cases it will be necessary to instrument weapon systems in the field under conditions that simulate--or are at least representative--of actual battle conditions. The purpose of the study reported in this document was to determine what data collection equipment should be available in order for the FSFU to be able to respond effectively to opportunities to collect soldier performance data.

Because the collection of data in the field is difficult, and the field is likely to be the place where constraints are most severe, this study had as its primary emphasis the collection of data in situations where the weapon systems were in use, or being tested, in operational conditions. The goal of the study reported here was (a) to identify those items of equipment that behavioral scientists would need to collect data in the field; (b) to put the items into a reasonable order of priority; (c) to identify sources and price information for the equipment deemed necessary, or at least desirable.

A previous study by Duchein and Scott (1987) addressed some of these same issues. In their report the authors noted that soldier performance is now recognized as a vital component of weapon system effectiveness, and that Army Regulation 602-2 requires measurement of soldier performance of critical operations and maintenance tasks. They also noted that the instrumentation traditionally used to record such performance tends to be obvious and may in fact intrude on the simulated tactical play of most operational tests. Their report presented the results of a survey which identified electronic instrumentation which is suitable for detecting and measuring soldier performance. The instrumentation must also be sufficiently unobtrusive as to not distract soldiers from freely attending to the tactical situation of the test. The four appendixes to the Duchein and Scott report contain instrumentation listings with summary technical specifications, American vendor sources, and authors' comments.

The study reported here went beyond the Duchein and Scott (1989) work (which focused on miniaturized video cameras, video and audio recorders, pan and tilt control units, and database recorders) and addressed a variety of electronic and other types of instruments. The researchers went to Army test organizations to draw upon their experience in order to obtain data to identify and prioritize data collection equipment; to identify sources; to make judgements--based on cost and utility--of what was the best item; and provide current cost data. This report does not include the source-cost type data because such data is subject to somewhat rapid change, and is likely to be quite obsolete in a relatively short time. This information has been furnished separately by the researchers, however, and questions concerning specific items will be answered, and appropriate material furnished, by the ARI FSFU upon request during the period it is considered still current.

Approach

This study involved four phases. In the first phase structured interviews were conducted at selected organizations who had extensive experience at data collection in the field. In the second phase the structuring questionnaire was converted to a mailable questionnaire and sent to additional organizations to obtain a broader set of responses. In the third phase a list of equipment, and data collection requirements, was prepared which identified the data collection--and support--equipment which researchers felt was needed. During the fourth phase sources were found for the various equipment items; analyses were performed to arrange equipment items according to priority; and cost effectiveness analyses were done to develop recommendations for specific items.

This report describes how the study was conducted and discusses the equipment requirements. The source and cost data, which was provided to ARI, is not included here because such information is rather ephemeral, and is subject to rapid obsolescence as models and prices change.

Structured Interviews

The Instrumentation Questionnaire developed for the structured interview phase of this project consisted of five sections. The first section asked what equipment was currently used to collect data on human performance. Later sections asked for physiological instrumentation; environment data; atmospheric condition data; and anthropometric and workspace data collection equipment. A 26 page form, a sample page of which is shown in Figure 1, was used to guide, and record data from, the interview. At each location the interviewer asked the subject matter expert (SME), or experts, about the specific items of equipment which were already entered in the form, and then the interviewer encouraged the SMEs to add other equipment types and models which they had used. After each section the SMEs were also asked about equipment that could be useful in field data collection. The questionnaire was used in the conduct of personal interviews with personnel at five ARI field units (Ft. Sill, Ft. Knox, Ft. Rucker, Ft. Bliss, and Ft. Hood) and five TEXCOM representatives (Aviation Test Board, Armor and Engineering Board, Air Defense Board, Field Artillery Board, and the Instrumentation Directorate of TEXCOM).

Mail Survey

Following the completion of the personal interviews, a second survey instrument was developed for use in a mail solicitation. A sample of the revised form is shown in Figure 2. It included specific equipment items and space to add items, as with the first form. The respondents were asked to indicate if they had in fact used specific items of equipment, and also to list items they thought would likely be needed. The mail survey was sent to eleven ARI field units (Ft. Knox; Ft. Rucker; Ft. Hood; Ft. Leavenworth; Ft. Benning; Boise, Idaho; St. Louis, Missouri; Orlando, Florida; Ft. Huachuca; Monterey, California; and Ft. Bliss) to determine their instrumentation needs. Of the eleven mail surveys sent out, eight were completed and returned (Ft. Knox; Ft. Rucker; Ft. Hood; Ft. Leavenworth; Ft. Benning; Boise, Idaho; St. Louis, Missouri; and Orlando, Florida).

Equipment Requirements

The results of the interviews and the surveys were then used to develop a list of the basic instrumentation and ancillary equipment identified by the SMEs. As the data were being collated it became apparent that the five categories (human

QUESTIONNAIRE

1. What equipment are you currently using to collect human performance data? (Please place a check mark next to the answer(s) that is/are applicable).

None_____ (if you checked None go to next question)

Human Observer(s) ____

Equipment Type	In Use Yes	No	Description (Make & Capability	Quant
Videotape-Recording System				
Audio Tape Recorder				
Multiple Event Counter				

Figure 1. Specimen page from structured interview questionnaire.

QUESTIONNAIRE

VIDEO DATA COLLECTION

1. Of the video equipment listed below, which have you used to collect human performance data, and which equipment would you use if it were available to you?

Please place a check mark where applicable.

Equipment Type	Have Used YES	Have Used NO	Would Use YES	Would Use NO	COMMENTS (INCL. TYPE OF DATA COLLECTED)
Micro-video-camera sys. -monochrome -low light level cap					
Mini-video-camera sys. -color -high resol.					
Video Cam-corder -w/audio cap.					
Time code generator -for video cameras					

LIST BELOW ANY VIDEO EQUIPMENT THAT YOU HAVE USED THAT IS NOT LISTED ABOVE:

Figure 2. Specimen page from revised questionnaire used for mail survey.

performance; physiological; environmental; atmospheric; and anthropometric and workspace) used in the interview and mail data collection process were not suitable for presenting the actual equipment listings. Therefore, a new set of categories were developed. The new classification system reflects the fact that SMEs see a need to collect both audio and video data in order to determine soldier performance; that in order to meaningfully analyze these data, information concerning the conditions under which the soldiers performed is needed; and that some equipment is needed to support the data collection process, and the data collection team itself. It appeared that six kinds of equipment were required: (a) audio equipment; (b) video equipment; (c) support equipment; and three kinds of supplementary equipment (d) psychological and physiological; (e) environment and weather; (f) workspace and anthropometric.

Since part of the project involved the prioritizing of the equipment items nominated by the various SMEs, some of the item sets were further divided intc primary and secondary lists which reflect the need-to-have versus nice-to-have division, which permeates the opinions of SMEs who have always had to deal with both the constraints of the field environment and the needs of research.

Audio Equipment.

The audio equipment identified by the SMEs included: directional microphones, voice activated microphones, head sets, and tape recording systems for use with these systems. Implicit in the SME identifications was the realization that the audio collection process would often require individually mounted radio transmitters which would make it possible to instrument soldiers in work locations where space was at a premium but do the recording elsewhere.

Video Equipment.

SMEs felt that both micro and mini video cameras would be needed, and that video camcorders should also be available for use when space conditions permitted. Recording systems for the video cameras were also specified, along with time-code generators and suitable editing systems. Camera mounting fixtures and tripods were considered nice-to-have items. SMEs apparently believed that the camera mounting requirement was often so unique that unless custom built fixtures were created, duct tape or velcro would need to be used.

Support Equipment.

The field research experienced SMEs who were interviewed, or who responded to the mail survey, were quick to point out that an important consideration in field data collection is the need to

provide support for the data collection process itself. One, often overlooked, requirement that is of overwhelming importance to the success of a field data collection effort is the requirement to move data collection equipment to and from the field site. Many SMEs noted that suitable shipping containers are an important support requirement. They felt that all equipment which may be taken to the field should have suitable, rugged containers. The containers need to be types which can be shipped by commercial or military air or standard surface shipping methods. To the extent possible equipment should be shipped in containers small enough to meet the size requirement of United Parcel Service (UPS), the United States Post Office or even to carry on commercial aircraft. When items are in cases that are large or heavy the cases should have handles and wheels to make transporting them easy for individuals.

The need for computer support for research teams in field locations was also noted. Often field researchers must work out of motels, or from relatively unfurnished office space at or near the field research location. Potential computer requirements for the test site and the research base include laptop computers for field site use; a transportable ruggedized PC for base operations; a modem for communicating "back home"; and appropriate software. Software that has proven useful includes word processing, spreadsheet, statistical and communication programs. Some researchers felt that the relatively new electronic clipboard technology held promise, and recommended such systems, with the appropriate download capability,as a good extension of the data collection process.

Communications among researchers was often seen as a requirement and most SMEs felt that handheld CB radios, and a CB base station should be available for use in the field if needed. It was also suggested that since cellular phone service is becoming so common a good equipment suite should include the phone sets and service subscriptions needed to operate in the field if the service is available. Although it is not an equipment item it is worth noting that a research group that takes radio operated data collection equipment, CB radios, or cellular phones to an operational unit will need to make the necessary checks, and get the necessary approvals, to assure that the frequencies they use do not interfere with unit operations--or the local TV station--and that no [illegible] occur.

Of course with so much battery operated equipment, and the potential for having to supply the research teams 110 volt ac requirement the need sometimes arises to provide the research teams with power support. Thus, a small generator; rechargeable batteries, in all sizes; and battery rechargers are required. Other nice-to-have items include 35mm cameras and Polaroid cameras to obtain site views and sometimes data; and night vision goggles for those occasions when the researchers need to operate

during blackout conditions. And, of course, there is a final essential support requirement: there must be a tool kit to help with wiring and make minor repairs.

Supplementary Equipment (Environmental and Weather Related). SMEs indicated that the sound level and illumination level were important data items in many tests; and that a gas analyzer could often be used to obtain important information about the soldiers immediate work areas. It was also clear that for testing in the field a portable set of weather measuring devices (temperature, humidity, and wind) would often be needed to measure both the actual work area conditions and the general conditions at the field site. Vibration level measuring equipment, an accelerometer, and an air-flow meter were identified as of secondary importance but occasionally required.

Supplementary Equipment (Psychological and Physiological).

A digital thermometer for body temperature; a general purpose vision test device to obtain acuity, color-vision, and stereoscopic measures; and a stop watch to obtain pulse rate and time other events, were considered essential. A reaction time measuring device and a blood pressure monitor were considered of secondary importance.

Supplementary Equipment (Workspace related).

The only piece of equipment that was considered of primary importance was a good tape measure (25' perhaps) which would be used to measure distances, room and area sizes, and space access restrictions. A scale, a set of anthropometric measuring tools, a torque meter, and a force gauge were considered nice to have for occasional use.

Trade off Analyses, Cost and Sources.

As a part of this study the equipment items identified were subjected to further analyses to provide data of value to persons actually needing to order equipment for field data collection. There were three steps to this process: (a) creating specific statements--functions and specifications--for the needed items (b) conducting a market survey to identify sources; and (c) doing a trade-off analysis in order to recommend what appeared to be the most cost effective source.

For each specific type of instrumentation or ancillary equipment requirement identified, functional and technical descriptions, and specifications were prepared. The descriptions were prepared to a level consistent with the level of detail required to initiate a government procurement action. The functions and specifications were obtained from persons who had ordered such

equipment, by personal contact with suppliers, and from catalogues.

After obtaining a suitable, specific item description the researchers identified three sources for equipment items that met the specification. When three sources were not available it was so noted and the reason recorded. Cost data was then obtained. The cost data included: item cost; duration of initial warranty; cost of maintenance contract, if available, on items exceeding $1000; and shipping or set up costs if required.

These cost data; the SME "need" and "could use" data; the specification; and the source and cost data were then used to perform a trade-off analysis by which the most cost effective equipment items were identified. The results of the trade-off analyses were then collated and provided, under separate cover, for possible use in ordering equipment. Because the specific cost, source, and model information is only applicable in the period when the analyses were run they are not included in this report. However, it is worth noting that to obtain a basic field data collection capability, a laboratory would have to expend about $75,000 to $125,000 depending on how many data collection points it was necessary to instrument. To obtain the additional items that are only occasionally of value an additional $25,000 to $50,000 would need to be spent.

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