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14. ABSTRACT
The material in this Test Operations Procedure (TOP) is intended to provide guidance for the planning and conduct of a human factors engineering (HFE) analysis of the Soldier-computer interface (SCI), during development testing (DT) by the Army Test and Evaluation Command (ATEC). The procedures and criteria contained herein will analyze the adequacy of those aspects of the software, hardware, and workspace design for the test function of operability that influence operator performance in a computer-based system.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 01-1-059A — 27 January 2015
DTIC AD No.

SOLDIER-COMPUTER INTERFACE

*This TOP supersedes TOP 01-1-059, Soldier-Computer Interface, dated 30 November 1985.

Approved for public release; distribution is unlimited.

1. SCOPE.

The material in this Test Operations Procedure (TOP) is intended to provide guidance for the planning and conduct of a human factors engineering (HFE) analysis of the Soldier-computer interface (SCI), during developmental testing (DT) by the U.S. Army Test and Evaluation Command (ATEC). The procedures and criteria contained herein will address the adequacy of those aspects of the software, hardware, and workspace design for the test function of operability that influence operator performance in a computer-based system. Other test functions are not applicable. This TOP should be used in conjunction with TOP 01-2-610, Human Factors Engineering, Part I[**1] and Part II[2].

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

The facilities for the testing of a computerized system will vary depending on the stage of development of the test item. During the early stages of development, the system software is rarely available. Therefore, full-scale testing is not possible. During later stages of development, when full-scale testing is possible, the facilities may include equipment or systems that interface with the test item, simulators, and field analysis. During a human factors analysis it is important to include the human user since effectiveness of the final products includes the typical user input, both intentional and unintentional. In this regard, Soldier, Operator, Maintainer, Test and Evaluation (SOMTE) personnel who represent a range of user experience from novice to expert should be used if and when available. Simulation of typical missions should be in "real time" and should include typical environmental, dynamic, and personnel elements, depending upon the stage of design during which the simulation is being performed. Analysis methods should include quantitative and qualitative measures of system or Soldier-computer interface performance. Given the stage of development of the test item, the human factors engineer should determine what facilities are necessary to fully exercise the computer system.

2.2 Instrumentation.

At a minimum, the following items from the HFE Instrumentation package will be used for this test (see Table 1 for instrumentation specification):

a. Light meter.

b. Photometer.

c. Sound level meter/analyzer.

d. Anthropometry kit.

e. Timer.

** Superscript numbers correspond to Appendix G, References.

f. Event counter.

g. Torque/force meter.

h. Ruler.

i. Camera.

j. Video recording equipment.

TABLE 1. ATEC INSTRUMENTATION PACKAGE[a]

MEASUREMENT	INSTRUMENT	RANGE AND/OR ACCURACY
Noise	Sound level meter/analyzer	10 to 13 decibel (dB) ± 1 dB
Illumination and brightness	Photometer	.002 to 300 foot (ft)-lambert ± 4% R (.007 to 1027 candela per square meter (cd/m²) ± 4% R) (X100 attenuator to 30,000 ft-lambert ± 5% R)
	Spot brightness	10^1 to 10^8 ft-lambert ± 5% R (0.3 to 3.43 x 10^8 cd/m² ± 5% R)
Force and dimension	Torque meters	0 to 5 inch-pounds (in-lbs) ± 4% R (above 20% FS) (0 to 0.6 Newton meter (N·m) ± 4% R) 0 to 160 foot pounds (ft-lbs) ± 4% R (above 20% FS) (0 to 217 N·m ± 4% R)
	Force meter	0 to 250 lbs ± 1.75 lbs (0 to 1112 N ± 7.8 N)
Anthropometry	Anthropometry kit	± 0.1 centimeter (cm)
Performance	Digital timer	± .001% R
	Multiple event counter	Not applicable (NA)
	Camera	NA
	Camcorder	NA
Recording and analysis	Scientific calculator	NA

[a] See Table 2-1 of TOP 01-2-610 (Part I) for other types of instrumentation.

3. PREPARATION FOR TEST.

3.1 General Guidelines.

The primary emphasis for performing an HFE test of a computer-based system is the analysis of how well the SCI supports the operator in the performance of those tasks necessary for successful completion of the system mission. The major requirements in the preparation of an HFE test plan for the Soldier-computer interface are to identify what is to be tested, how the test is to be conducted, and what criteria are to be used. The determination of what is to be tested and analyzed in an HFE test of the SCI requires the identification of objectives and critical issues for testing, and the selection of test measures. In the process of determining critical issues, previous test records on the item should be studied to ascertain any human factors problems that may have been identified in earlier development testing. HFE test objectives, as well as related critical issues, may be designated in the System Evaluation Plan (SEP), Detailed Test Plan (DTP) or other pertinent information concerning the test item. Such background information shall be used to tailor the HFE subtest of the SCI, as well as the data-collection techniques, to the particular item being tested. For some tests of the SCI, the human factors engineer should coordinate with other test elements to ensure the availability of facilities and instrumentation or data appropriate for the SCI subtest. The specific steps to be followed in preparing an HFE test plan for the SCI are described below.

3.2 Step 1 – Review Documentation.

a. For an analysis of the SCI to be effective, the human factors engineer must be as knowledgeable as possible about the test item. All available system documentation should be read to determine the nature of the system's mission and how the operator interacts with the system. The following are typical types of documentation that should be reviewed:

(1) System specifications.

(2) System description.

(3) Operator manuals.

(4) Appropriate task analysis data, if available.

(5) Any previous HFE analysis of the test item.

(6) International Test Operations Procedure (ITOP) 01-1-056[3] (Software Performance Testing and Analysis).

(7) Requirement documents.

(8) Operational and organizational concept.

(9) Parts I and II of TOP 01-2-610.

(10) Any other relevant documentation available.

b. The human factors engineer should then use this information to aid in the classification of the SCI and the selection of design checklists and criteria appropriate for inclusion in the test. This documentation is also useful in selecting:

(1) Appropriate scenarios for system performance testing.

(2) Appropriate topic areas for inclusion in questionnaires and interviews.

c. If military personnel are required, ensure a Test Schedule and Review Committee (TSARC) request is submitted within one year from the start of testing or as early as possible. A Safety Release (SR) must be obtained from the U.S. Army Evaluation Center (AEC) and a Human Resource Protection Plan (HRPP) must be obtained from the ATEC Safety Manager prior to using military personnel as test participants.

3.3 Step 2 – Classification.

The objective of this step is to aid the human factors engineer in the selection of appropriate checklist criteria by providing guidance for classifying the computer-based subsystem of the test item. The classification is based on two factors that influence the design of the Soldier-computer interface; the expected deployment of the system, and the expected tasks that the operator performs when interacting with the SCI. By defining these two elements, typical types of checklist criteria can be defined. Paragraphs 3.3.1, 3.3.2, and 3.3.3 discuss this. While this classification process will aid the user in selecting typical checklist criteria, it is based primarily on general classes of systems. It is important to be aware that some test items may not lend themselves to classification due to special design considerations or emerging technology. Therefore, the test item should be carefully examined to ensure that all the applicable criteria are being used during the test.

3.3.1 Define System Deployment.

Deployment is defined as the physical manner in which the system will be used in the field. While most systems will be deployed in only one manner, some may have several different modes of deployment. The human factors engineer should review the system documentation and determine the expected system deployment based on the following list:

a. Aircraft: Any computerized system that has the Soldier-computer interface located in an aircraft.

b. Ground vehicle: Any computerized system that has the Soldier computer interface located in a ground vehicle, excluding shelters.

c. Portable: Any computerized system that is physically transported by one or more Soldiers. This includes systems such as radios, weapons, and other systems that are not physically part of a larger system. This type of system is typically used outside or in a tent where the environment is not very controlled, not in a shelter, building, or vehicle.

d. Shelter: Any computerized system that is placed in a transportable or mobile shelter.

e. Building: Any computerized system that is deployed in a non-mobile structure.

3.3.2 Define Operator Tasks.

The tasks that the operator performs when interacting with the SCI act to define how it is designed. The operator tasks will define Soldier interaction with the system; e.g., entering information or commands. The computer's processing steps to handle the inputted information or commands may not directly correlate with the Soldier's task as written but should produce the outcome required to meet the task step of standard. The computer-based system may require that the operator perform more than one task, especially for complex systems. The human factors engineer should review the system documentation and select the appropriate tasks from the list below. This list is representative of typical operator tasks, but may not be inclusive of all possible tasks.

a. Recordkeeping/File Maintenance: This task consists of simple data entry into already existing files, editing of files, monitoring of the data in the files, and some limited self-test capability. The data tends to be numerical in nature and static as opposed to dynamic. Examples of this type of task include keying in of frequencies for communications, parameter files for Electronic Warfare Intelligence (EWI) devices, or fire control parameters.

b. Text Editing: This task is analogous to word processing. There is extensive entry of alphanumeric data with extensive manipulation by editing commands. Information can be communicated between distributed networks of terminals.

c. Data Communication: This task consists of the formatting, sending, and reception of data in the form of messages, either alphanumeric or just numeric. The format may be fixed or variable.

d. Target Tracking: This task consists of the detection, recognition, identification, and tracking of targets. Examples of this type of task include tactical data display, air defense, and fire control. The data are dynamic in nature.

e. Target Tracking: This task consists of the detection, recognition, identification, and tracking of targets. Examples of this type of task include tactical data display, air defense, and fire control. The data are dynamic in nature.

f. Simulation: This task consists of the extrapolation from existing data to predict possible outcomes based on specific scenarios.

g. Status Monitoring: This task consists of monitoring of dynamic information regarding system status. The computer integrates various data sources into a display for operator decision making, and system or process control.

3.3.3 Determine Classification.

Once the deployment and tasks have been determined, the classification of the system should be determined. Some systems may have more than one classification. The classifications should be ascertained from Table 2. The terminology used to designate a specific classification is arbitrary and does not denote any other meaning.

TABLE 2. CLASSIFICATION OF THE SOLDIER-COMPUTER INTERFACE BY DEPLOYMENT AND TASK

DEPLOYMENT	TASK	CLASSIFICATION
Aircraft	Recordkeeping/File Maintenance	1
	Data Communication	2
	Target Tracking	3
	Data Management	4
	Status Monitoring	5
Ground Vehicle	Recordkeeping/File Maintenance	1
	Data Communication	2
	Target Tracking	6
	Data Management	4
	Status Monitoring	7
Portable	Recordkeeping/File Maintenance	8
	Text Editing	19
	Data Communication	9
	Target Tracking	10
	Data Management	11
	Status Monitoring	2
Shelter	Recordkeeping/File Maintenance	12
	Text Editing	13
	Data Communication	14
	Target Tracking	15
	Data Management	16
	Simulation	17
	Status Monitoring	18
Building	Recordkeeping/File Maintenance	12
	Text Editing	13
	Data Communication	14
	Target Tracking	15
	Data Management	16
	Simulation	17
	Status Monitoring	18

3.4 Step 3 – Identify Criteria.

3.4.1 General Guidelines.

a. The SCI can be analyzed in terms of various hardware, software, and workspace user considerations. These considerations conform to general human factors characteristics found to be basic to good system design in other applications. These considerations include:

(1) Compatibility: Workspace, input and output devices and software should be compatible with user needs. Input required of the user should be compatible with the output of the computer and vice versa. Information presented to the operator should be appropriate for the task.

(2) Flexibility: A system should be flexible to the degree that individual differences in skill are encompassed to ensure optimal performance of all users under all anticipated conditions.

(3) Workload Reasonability: The tasks required of the operator should be within the operator's capability and should require the operator to perform a useful, meaningful role. Optimum design takes advantage of the best capabilities of both operator and machine and does not induce information or work overload.

(4) Brevity: Human memory can accept a limited amount of information. This implies that information presented to the operator or entered by the operator should be grouped into short, readily understandable units.

(5) Immediate Feedback: Operators should always be presented with readily understandable information so that they know where they are, what they have done, and whether the operation was successful. They should be given every opportunity to correct errors.

b. A complete analysis of any Soldier-computer interface requires that the human factors engineer or a human factors specialist working under the direct supervision of the human factors engineer observe the operators perform a simulated mission. This provides both quantitative and qualitative data that are derived from actual system operation. The interaction of all the system components (human, hardware, and software) should be analyzed in a typical use environment. The specific criteria for system performance are usually defined by the requirement documents. General criteria include the following:

(1) Time: Response time is constrained by system requirements. Within these requirements, the computer system shall respond in a timely manner. The operator shall receive an indication of command acceptance within an acceptable time. The output of required information shall be within an acceptable time. The completion of the system mission shall be within acceptable limits.

(2) Errors: Number and effect of errors committed by the user due to the system hardware and software design shall not jeopardize mission success.

(3) Acceptability: The system shall be designed to meet user expectations to ensure acceptance.

3.4.1.1 Workspace.

The nature of the tasks performed by a user when interacting with an automated data processing system levies special requirements on the design of the workspace. The user spends a large proportion of time monitoring system performance or interacting with the system software. The design of the work station should support the user's ability to interact with the system. To this end, the workspace shall be designed to ensure compatibility with the physical demands placed on the user by the required tasks. Design areas that are of concern include seating, input and output device location and design, ambient illumination, document storage, and work surface availability. Detailed criteria are contained in Appendix A and should be selected in accordance with Paragraph 3.4.2.

3.4.1.2 Input and Output Devices.

The design of the input and output devices is also influenced by the nature of the user tasks. The following general criteria are applicable to the input and output device design. Detailed criteria are contained in Appendix A and should be selected in accordance with Paragraph 3.4.2.

a. Input Devices: Input devices shall be designed to facilitate the manipulation and control of the computer system function and data. Areas of design that are of concern include appropriateness of the input device, accessibility, dimensions, and compatibility with operator needs.

b. Output Devices: System output devices shall be designed to ensure that the information being displayed is detectable, discriminable, recognizable, and readable. Areas of design that are of concern include viewing angle and distance, visual angle of characters, character form, luminance contrast and display lighting, and auditory signal volume and frequency.

3.4.1.3 Software.

User considerations involving software should include the following, at a minimum. Detailed criteria are contained in Appendix A and should be selected in accordance with Paragraph 3.4.2:

a. Data Display: Information displayed should be organized in a way which facilitates operator performance. This includes presentation and structuring of information on the computer display. The major areas of concern should include information coding, information density, labeling, and format.

b. Data Entry Procedures: Procedures for data input should be efficient and reliable.

c. Interactive Control:

(1) The extent to which a user feels in control of the interactive process depends significantly on which information is presented. Dialogues should be designed to be compatible with operator needs and to accommodate individual differences for optimal system performance.

Considerations should include choice of dialogue mode, form-filling, computer prompting, menu selection, and command languages. Command language should reflect the user's point of view and training, allowing the user to request help at any time.

(2) Concerns should include organization of commands, command nomenclature, use of default values, user control of multiple commands, macros and priority commands, command operation, system response time, and special commands.

d. Feedback: Operators should always be presented with readily understandable information on the status of system functioning. Considerations deal primarily with information presented to the operator on the display. The major areas of concern should include system status and error messages.

e. Error Management/Data Protection: Operator error is intrinsic to every Soldier-computer interface. Software should be designed so that catastrophic situations such as inadvertent deletion of data are avoided and error recovery is accomplished easily and quickly. Areas of concern should include error recovery control, help and documentation, computer aids, hard copy output; command cancellation, verification of ambiguous or destructive actions, sequence control, and system failures.

3.4.2 Design Checklist Criteria Selection.

Using Table 3, identify those design checklists that are appropriate for the classification of the SCI test item identified in Paragraph 3.3. Table 3 provides a matrix that lists each classification and the design considerations applicable to the Soldier-computer interface. Each cell of the matrix indicates the number and subsection of the appropriate checklist for that class of SCI, by the design consideration. As stated in Paragraph 3.1, the design checklists identified using this table is appropriate for general classes of the SCI. Some systems may not lend themselves to this table. In addition, the design checklists include some criteria that are not drawn from MIL-STDs or other requirements documents. They are included to provide suggested improvements for preferred design of the SCI. The Checklist Identification Aid guide (see Appendix F) may be used to facilitate checklist selection for systems with multiple classifications.

3.5 Step 4 – Identify Use Conditions.

The human factors engineer will ensure that the test of the SCI is performed under conditions representative of item use to the extent that such conditions are expected to have an effect on performance in operating the system. Applicable use conditions should be selected from the list below. Additional information can be found in Paragraph 3.3 of TOP 01-2-610 (Part I).

3.5.1 User (Test Participant) Conditions.

a. Gender (male, female).

b. Body size (height, weight, etc.).

c. Limb size (dimensions, reach distance, etc.).

d. Clothing (size, type).

e. Encumbrances (combat pack, weapon, radio, etc.).

f. Skills and knowledge (military occupational specialty (MOS), experience, training).

g. Special considerations (handedness, physical strength, wearing of eyeglasses, and facility of spoken English).

TABLE 3. SOLDIER-COMPUTER INTERFACE CRITERIA SELECTION BY DESIGN CHECKLIST NUMBER

	DESIGN CONSIDERATION							
CLASSIFICATION	WORK SPACE	INPUT DEVICE	OUTPUT DEVICE	INTERACTIVE CONTROL	DATA DISPLAY	DATA PROTECTION ERROR MANAGEMENT	DATA ENTRY	FEEDBACK
1	NA	3, 4, 11, 12	13, 14, 15, 18	19	20	21	22	23
2	NA	3, 4, 11, 12	13, 14, 15, 18	19	20	21	22	23
3	NA	3, 4, 6, 11, 12	13, 14, 16, 17, 18	19	20	21	22	23
4	NA	3, 4, 11, 12	13, 14, 15, 18	19	20	21	22	23
5	NA	3, 4, 6, 11, 12	13, 14, 15, 18	19	20	21	22	23
6	NA	3, 4, 6, 10, 11, 12	13, 14, 18	19	20	21	22	23
7	NA	3, 4, 6, 10, 11, 12	13, 14, 15, 18	19	20	21	22	23
8	NA	3, 4, 11, 12	15, 18	19	20	21	22	23
9	NA	2, 3, 4, 11, 12	15, 16, 18	19	20	21	22	23
10	NA	3, 4, 5, 11, 12	15, 18	19	20	21	22	23
11	NA	2, 3, 4, 11, 12	15, 18	19	20	21	22	23
12	1	2, 3, 4, 6, 8, 11, 12	15, 16, 17, 18	19	20	21	22	23
13	1	2, 3, 4, 11, 12	13, 15, 16, 17, 18	19	20	21	22	23
14	1	2, 3, 4, 5, 7, 8, 9, 11, 12	13, 14, 15, 16, 17, 18	19	20	21	22	23
15	1	2, 3, 4, 5, 6, 8, 10, 11, 12	13, 14, 15, 17, 18	19	20	21	22	23
16	1	2, 3, 4, 6, 10, 11, 12	13, 14, 15, 16, 17, 18	19	20	21	22	23
17	1	2, 3, 4, 5, 6, 8, 10, 11, 12	13, 14, 15, 16, 17, 18	19	20	21	22	23
18	1	2, 3, 4, 5, 6, 8, 10, 11, 12	13, 14, 15, 16, 17, 18	19	20	21	22	23
19	NA	2, 3, 4, 11, 12	13, 15, 18	19	20	21	22	23

3.5.2 Environmental Conditions.

a. Temperature (extremes of heat and cold).

b. Climate (temperate, tropic, desert and cold regions).

c. Ventilation (effects on comfort, safety and performance).

d. Lighting (type, location, levels --effects on visibility).

e. Noise (spectrum, loudness --effects on comfort, safety, reception of communication, and performance.

f. Vibration (spectrum and intensity --effects on comfort, safety and performance).

3.5.3 Operational Conditions.

a. Threat characteristics (type, number, distance, deployment).

b. Force characteristics (mission profile, operational mode summary, crew composition).

c. Conditions of readiness.

d. Blackout conditions.

e. Logistical constraints.

f. Emergency conditions (e.g., wearing nuclear, biological, chemical (NBC) equipment, Extreme Cold Weather Clothing System (ECWCS), etc.).

g. Personnel attrition (need for cross-training, ease of training).

h. Duty cycle durations.

3.6 Step 5 – Develop Test Plan.

The HFE SCI subtest plan shall be written in accordance with the following format:

a. Objective: This shall be a concise statement of the objective or issue to be addressed in the subtest, including the subtest's relationship with the overall test objectives.

b. Criteria: This shall be a statement of the criteria contained in or referred to in the requirements document(s) or ATEC directive. The sources of all criteria should be clearly identified down to the paragraph number.

c. Data Required: This shall be a statement that details the specific data to be obtained during the test. This shall specify the accuracy requirements of the data and the numbers of samples or observations.

d. Data Acquisition Procedure: This shall detail the procedures to be used in collecting the data. The TOP procedure should be referenced along with a brief description of the procedure. If the procedure deviates from a TOP or in the absence of a TOP, the procedure shall be described in detail.

e. Analytical Procedures. This shall describe how the data listed in the data required section will be reduced and analyzed, and how comparison against the criterion statements will be made.

4. TEST CONTROLS.

The test controls appropriate to the test item must be followed. In addition, the test controls from TOP 01-2-610 (Parts I and II) should be followed. Test controls specific to the Soldier-computer interface are given in the following paragraphs.

4.1 Control of Test Participants.

The personnel selected for operators of the test item should be representative of the expected user population once the test item is fielded. Test project personnel, therefore, shall review the item documentation to determine, at a minimum, the following characteristics of the intended user population. In addition, any specific training programs necessary to operate the item must be identified. The information listed below represents sample criteria for subject selection. The distribution of each characteristic in the test participant sample shall be similar to that of the population distribution within selection constraints. The characteristics to be determined and recorded for all participants shall include consideration of the following:

a. Physical Dimensions: Ranges of heights and weights shall be specified, giving due consideration to the range of these dimensions expected of typical user personnel when the system is fielded. Specifically, the range should encompass the 5th through 95th percentile as described in Figure 25.8.7 of TOP 01-2-610, Part II. Determination must be made of specific body dimensions of importance for item use (reach, seated height, kneeling, etc.) and the 5th through 95th percentile values of these dimensions should be used (Figure 10.D.1 of TOP 01-2-610, Part II). No person with a special-duty or limited duty profile can be permitted to participate unless a task analysis reveals that the restriction on activities has no impact on the tasks required in the test.

b. Sensory Acuity: All test participants should have had a recent (within the last 12 months) test of vision and audition. If vision or audition are critical to the test functions, the appropriate test shall be given both immediately before and after test operations. Minimum standards should be stated for each of these sensory modalities depending upon an analysis of the requirements of the tasks to be performed. The inclusion of participants who wear glasses should be considered if appropriate to the particular test.

c. Military Occupational Specialty (MOS): The required MOS will normally be specified in the test directive or TOP. If it is not, a determination must be made of the MOS and whether the specified MOS must be test participant's primary MOS or whether a Soldier with this specialty in a MOS is acceptable. If alternate specialties include the required training and are acceptable substitutes, these are to be listed in the test plan. In addition, the training-requirements specification will state whether the MOS must be a school-trained qualification or whether an On the Job Training-qualified Soldier meets the requirements.

d. Time in MOS: Each participant should have been assigned to the specified MOS for a sufficient time to be fully qualified.

e. Rank: Test participants should represent the rank and skill levels specified for test item users or as specified in the Requirements Document.

f. Item Specific Training: If training is required for use of the test item, this training shall be provided to test participants prior to data collection. The human factors engineer should ensure that all test participants received standardized training. Exceptions to training should be noted in the test report.

4.2 Control of Procedures.

Operators should perform tasks with the test item in accordance with standard Army procedures and those procedures identified in the technical manuals and operating instructions. Additionally, if data are collected by simulation of missions, the scenarios used should be carefully scripted. Tests should be designed and implemented to exercise the Soldier-computer interface through all phases of the operating scenario --both normal and emergency conditions. The scenario should be complete in analyzing all aspects of the Soldier-computer interface: visual, auditory, controls, communications, etc.

5. TEST PROCEDURES.

5.1 Method.

a. An HFE test of the SCI is performed using three basic methods:

(1) Human factors analysis and walk-through.

(2) Mission simulation.

(3) Questionnaire and interview.

b. These methods are interdependent in that the results from one method may dictate changes in the other methods. The appropriateness of the specific methods will depend on the stage of development of the test item and the type of data being collected. During early stages the software is rarely complete; therefore, mission simulation is very difficult if not impossible. The human factors analysis and walk-through can be performed at all stages of development. The questionnaire and interview method require the use of a trained operator. Each method is discussed below.

5.1.1 Human Factors Analysis and Walk-Through.

In these methods, the human factors engineer examines the test item using appropriate design checklists selected from Table 3 and any other human factors engineering criteria identified during the document review (Paragraph 3.2). This analysis should be aided by a trained operator. This analysis tends to be iterative in nature, typically performed over days or weeks. In addition to immediate data collection, the HFE analysis and walk-through can serve to identify areas for further analysis, identify data requirements for the mission simulation, and further familiarize the human factors engineer with the operation of the system. The operator directs the human factors engineer through the operation of the test item, explaining each procedural step, how the system is responding, and how the operator must interact with the equipment. The human factors engineer analyzes each step of the operation and element of the system for conformance to the criteria contained in the design checklists. Physical measurements are taken as necessary. Times for system response to command input, update rates, and other system response times that can be measured without a full mission simulation will be recorded. The operator will be asked to initiate various system tasks while the human factors engineer observes and records time (see Table 4 for typical response times). The design checklists should be used to ensure that all relevant criteria have been addressed. Detailed information on the use of design checklists is contained in Section 5.10, Test Procedure -HFE Design Checklists of TOP 01-2-610 (Part I). Details of these methods as they relate to hardware, software, and system performances are described below.

TABLE 4. SYSTEM RESPONSE TIMES

SYSTEM INTERPRETATION	RESPONSE TIME DEFINITION	MAXIMUM ACCEPTABLE RESPONSE TIME (seconds)
Key Response	Key depression until positive response; for example, “click”	0.1
Key Print	Key depression until appearance of character	0.2
Page Turn	End of request until first few lines are visible	1.0
Page Scan	End of request until text begins to scroll	0.5
XY Entry	From selection of field until visual verification	0.2
Function Selection	From selection of command until response	2.0
Pointing	From input of point to display point	0.2
Sketching	From input of point to display of line	0.2
Local Update	Change to image using local data base; for example, new menu list from display buffer	0.5
Host Update	Change where data are at host in readily accessible form; for example, a scale change of existing image	2.0
File Update	Image update requires an access to a host file	10.0
Inquiry (Simple)	From command until display of a commonly used message	2.0
Inquiry (Complex)	Response message requires seldom used calculations in graphic form	10.0
Error Feedback	From entry of input until error message appears	2.0

5.1.1.1 Workspace.

The human factors engineer will analyze all aspects of the workspace design that are relevant to the Soldier-computer interface. This will include, but not necessarily be limited to, the following:

a. Workstation Configuration: The physical dimensions of the workstation will be measured using the appropriate instrumentation from the HFE Instrumentation Kit. These measurements will include, but not be limited to, the following: viewing angle; viewing distance; keyboard height from floor; keyboard slope; reach distance to the back of the keyboard and other controls; height, width, and depth of writing and work surfaces; height, width, and depth of the operators' leg space and kick space. Refer to Figure 1 for an illustration of typical measurements.

b. Seating: The seating available to the operator will be analyzed for the following, at a minimum:

(1) Adjustability to accommodate the 5th percentile female and the 95th percentile male population.

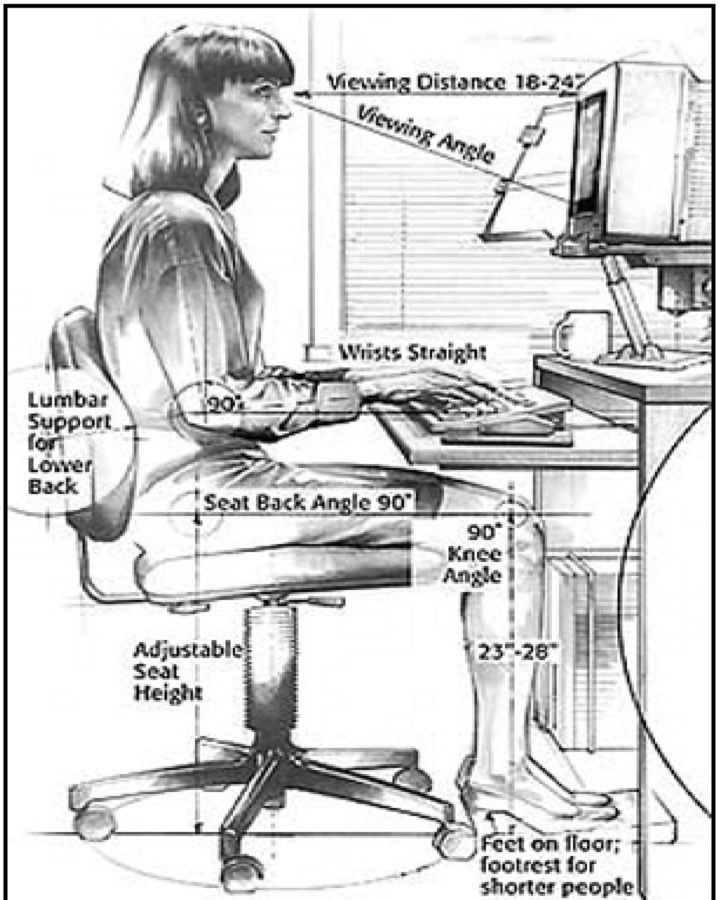
(2) Support for maintaining proper body posture.

(3) Availability and design of armrest.

(4) Support provided by backrests.

(5) Availability of footrests

c. Ambient Illumination: Ambient illumination will be measured in accordance with the procedures contained in TOP 01-2-610 (Part I), Paragraph 5.1, Test Procedure Lighting. Measurement should be made at hard copy devices, displays, controls, and writing surfaces, if present.



CONFIGURATION	MEASUREMENT
Keyboard	Slope, 15 degrees Height, home row, 29 to 30 inches Front desk to back row of keys, 16 inches maximum
Desk	Top height, 29 to 30 inches Leg room, 25 inches Kick space, 4x4 inches
Writing Surface	Height 29 to 30 inches (to floor)
Seating	Backrest recline, 10 to 15 degrees
Body Position	Arm and leg angle, (posture) 90 degrees Head tilt, 20 degrees
View	Preferred viewing distance, 18 to 24 inches Viewing angles, 90 degrees maximum, 45 degrees preferred

Figure 1. Typical workspace measurements for the Soldier-computer interface.

5.1.1.2 Input and Output Devices.

Using design checklists, the human factors engineer will analyze all aspects of the design of the input and output devices that are relevant to the soldier-computer interface. The following, at a minimum, will be measured:

a. Control dimensions, resistance, and displacement.

b. Display size, viewing distance, and viewing angle.

c. Display character size and visual angle.

d. Control labeling dimensions.

e. Luminance contrast of display characters in accordance with Paragraph 5.1, Test Procedure -Lighting from TOP 01-2-610 (Part I).

f. Frequency range and signal-to-noise ratio of auditory signals in accordance with Paragraph 5.2, Test Procedure -Noise Measurement from TOP 1-2-610 (Part I).

5.1.1.3 Software.

The human factors engineer will observe the operator interact with the software. The operator will call up all available software formats or a representative sample if many formats are identical, and demonstrate the techniques used to manipulate the system. The human factors engineer will, at a minimum, use design checklists to analyze the aspects of the software interface presented below. The human factors engineer should identify and discuss with the operator potential HFE problems in system performance or design characteristics of the hardware.

a. Data Display: How data are displayed on a screen is critical to effective communication between a computer system and its users. A display format should be easily read, interpreted, and able to be used by people of varying skill. The human factors engineer should pay particular attention to information format, labeling, coding, density, and screen layout. Software formats should be standardized within the system.

b. Data Entry Procedures: One of the most critical aspects of the SCI is the technique used for requesting input from the user. Poorly designed data entry procedures can make a system inaccessible to all but highly trained and experienced users. Errors by terminal users are inevitable; however, careful design of input procedures can reduce the frequency and consequences of errors and simplify the correction of errors. A well-designed system permits users to perform their job with a minimum of time and effort spent on data entry. In analyzing this aspect of the software interface, the human factors engineer will review data entry procedures using design checklists and observe the operator interact with the computer system. Times for system response to command input will be measured and recorded.

c. Interactive Control: One of the determinants of user satisfaction and acceptance of a system is the extent to which the user feels in control of the interaction. If users are unable to control the pace and direction of the interaction they will feel frustrated or threatened by the system. The extent to which a user feels in control of the interactive process depends significantly on which information is presented. The appropriate information presented at the correct time can make an otherwise difficult and time consuming task easy and fast. Language and coding should be legible, brief, clear, concise, and consistent within the system. When ambiguity and confusion are minimized, performance is faster and more accurate. Displayed messages should be reviewed keeping the above principles in mind. During this aspect of the software analysis, the human factors engineer will focus on command methods, organizations and languages; system response times; dialogue modes; prompting; and menus. System response times will be measured and recorded.

d. Feedback: Users need to know that the system is functioning and that their commands are received and being processed by the system. Major areas of concern include status and error messages; help and documentation; and hard copy output. The human factors engineer should have the operator interact with the system such that the various forms of feedback provided by the system are demonstrated. During this aspect of the software analysis the human factors engineer will focus on command methods, organizations and languages; systems response times; dialogue modes; prompting; and menus. System response times will be measured and recorded.

e. Data Protection/Error Management: Errors made by system users are inevitable. However, careful design of procedures for correcting errors, cancelling commands, and protecting data from destructive actions can reduce the frequency and consequences of errors and simplify correction of errors. The human factors engineer should review the sequence of events in command cancellation, verification of destructive actions, and system failures. HFE problem areas should be identified for further analysis during mission simulations and/or operator interviews.

5.1.2 Mission Simulation.

The objective of a mission simulation is to analyze the operational characteristics of the Soldier-computer interface under realistic use conditions. The human factors engineer observes simulated missions that are based on scenarios that exercise to the fullest extent possible the capabilities of the system under test. The scenario should be representative of the range of mission profiles and tasks, especially the worst case. Given that a mission simulation can be expensive in terms of man-hours and other resources, it is imperative that the detailed planning be performed well in advance. Part of this planning should include the determination of the feasibility of performing a mission simulation given the expected data return. The following steps should be performed in the planning of a mission simulation.

5.1.2.1 Define Data Requirements.

Based on the documentation review and a thorough understanding of all system mission profiles, the types of data to be collected during the mission simulation should be defined. These data should consist of performance measures such as time for task performance, error rates, analysis of workload, analysis of crew interaction, and any other measures that may indicate the efficiency of the Soldier-computer interaction. These data requirements should include estimations of the number of trials required for reliability and validity, and estimations of methods for collecting the data. In defining data requirements, it will be necessary to specify what constitutes an error, and whether errors can be prioritized in terms of system consequence.

5.1.2.2 Define Data Collection Methods.

Based on the data requirements developed in Paragraph 5.1.2.1, methods for collecting the data should be defined. These methods should include the instrumentation, facilities, dependent and independent measures, and subject demography (i.e., number, skill level, etc.) required. Since each system is significantly different, there is not a well-defined group of methods that are appropriate for all types of systems. The methods will be dependent on the type of range facilities, support facilities, number of test items, and stage of development of the system software. The human factors engineer should determine the best method for collecting the required data, determine the type of support available at the test facility, and modify the data collection methods, as appropriate. The methods should be as non-obtrusive as possible. Potential types of data collection techniques include the following:

a. Performance Times: Performance times can be measured in several ways. These include direct observation by the human factors engineer, the use of videotaping or movies, hardwired event timers, and the use of a computerized data collection tool. The computerized data collection tool is preferable but not always feasible.

b. Error Rates: Error rates can be collected through the same types of methods as performance times. Like performance times, the most accurate method is computerized data collection, but this is not always feasible.

c. Workload: Workload is a very difficult concept to operationally define for purposes of measuring in a quantifiable manner. There are two basic, interactive types of workload, physical and mental. The basic issues in which the human factors engineer should be interested include allocation of tasks between the user and the computer, and the allocation of tasks between the crew members. Some approaches that can be used to measure workload include: time-line analyses; the use of secondary tasks to load the user's information processing capacity; physiological response measures such as heart rate; and subjective ratings of workload by users. Prior to embarking on an attempt to measure workload, the human factors engineer should review the literature on workload analysis.

d. Crew Interaction: Crew interaction, while a facet of workload, can be measured independently. The critical issues include communications between the crew members and potential physical interference between operators during task performance. Methods for measuring crew interaction include direct observation, videotaping or filming, voice recording and subjective analysis by the operators.

5.1.2.3 Define Degree of Simulation.

The degree to which the mission of the system under test should be simulated is dependent on several factors. These factors include the following:

a. Stage of System Development: During different stages of development, the completeness of system software and, in some cases, the hardware will vary. The human factors engineer must determine to what degree the system is complete and how the data requirements are affected. The mission simulation plan should be adjusted accordingly. In some cases, the requirement for a mission simulation may be waived due to the lack of sufficient system software or reliability for accurate and valid measurement.

b. Availability of Necessary Support: The availability of the necessary facilities, instrumentation, personnel, and other support requirements identified in Paragraph 5.1.2.2 will help determine the degree of simulation that can be performed to respond to the data requirements identified in Paragraph 5.1.2.1. The human factors engineer should analyze the availability of the necessary support and modify the data collection methodology accordingly.

c. Estimated Cost: Costs of mission simulations vary depending on the level of support necessary for performance. Range facilities, complex instrumentation, large amounts of ancillary equipment and large numbers of people are a significant contributor to the cost of the conduct of a mission simulation. The more complex the simulation means the greater the support and higher cost. The human factors engineer should estimate the cost of the mission simulation based on the data collection techniques identified in Paragraph 5.1.2.2. The above three factors should be reviewed in regard to the item under test and any necessary trade-offs made to maximize the quality of the data. In some cases, the use of a mission simulation may not be appropriate or may be prohibitively expensive, and therefore waived. In other cases, the degree of simulation may vary from extremely simple to very complex.

5.1.2.4 Develop Mission Scenarios.

The human factors engineer, working in concert with others, should develop mission scenarios. The scenarios should be developed from a review of the various information sources cited in Paragraph 3.2 and discussions with subject matter experts (SMEs). A task analysis should be used to identify critical missions and task sequences, points of peak operator workload, and expected performance times. The scenarios should contain missions and task sequences that represent worst case operational conditions that are as realistic as possible. A detailed script should be developed and verified as correct well before the initiation of the mission simulation. The human factors engineer should become thoroughly familiar with each script to ensure that there is no loss of data during the observation of the mission simulation. The complexity of the scenario will depend on how complete the test item's software is and the availability of support personnel and equipment.

5.1.2.5 Develop Detailed Data Collection Plan.

A detailed plan for how the mission simulation data are to be collected should be developed. This plan should define all support requirements, including equipment, instrumentation, facilities, personnel, and methodology. The methodology should contain the detailed scenarios. The human factors engineer should schedule briefings for all personnel involved to discuss the simulation and ensure that everyone knows their roles and responsibilities, and the schedule. These coordination meetings should be held as frequently as necessary to ensure that the simulation provides the necessary data.

5.1.3 Questionnaire/Interview Guide.

In these methods, operator's subjective analysis concerning the SCI will be elicited. The questionnaire or interview guide should be developed using information contained in the design checklists (Appendix A). A sample questionnaire/interview guide is provided in Appendix C. The use of questionnaires and interviews to elicit data on system performance should be geared toward user acceptance of the system. Items of discussion should revolve around whether the test item meets the user's expectations and needs. More detailed information is contained in Test Procedure 5.18 -Questionnaires and Interviews from TOP 01-2-610 (Part I).

a. Workspace: This is usually thoroughly analyzed using quantitative measurement methods. Questionnaires and interviews can also be used to elicit data that are not readily apparent by direct observation. These methods can also be used to gain subjective analysis of discrepancies from criteria.

b. Input and Output Devices: The analysis of controls and displays is primarily accomplished by quantitative measurement methods. Workspace, questionnaires, and interviews can also be used to elicit data and gain subjective analysis of discrepancies from criteria.

c. Software: Questionnaires or interviews used for software should focus on those criteria which are difficult to analyze quantitatively and which involve more subjective analysis of the system item by the user. For example, the questionnaire/interview should elicit information from the operator such as the ease or difficulty of operating the system. Routine problems the operator encounters involving inputting or accessing data, display organization, difficulty in remembering commands, difficult sequences of operation, and identifying and correcting errors should also be addressed.

d. Interaction Workload: The physical demands experienced by soldiers using SCI systems may greatly influence cognition/perception, the interaction workload experienced, and mission success. Considering the importance of the “mind-body connection”, it is important to judge any HSI/SCI system to include the critical issues of the physical body’s limitations and abilities under changing environments. The National Aeronautics and Space Administration (NASA) Task Load Index (TLX) subjective workload analysis tool is often used for this purpose. More information can be found at the following sites:

http://humansystems.arc.nasa.gov/groups/tlx/index.html, and

http://humansystems.arc.nasa.gov/groups/tlx/downloads/TLXScale.pdf

5.1.4 Test Conduct.

Conducting a test requires careful planning by the human factors engineer in terms of (1) the arrangements to be made prior to conducting the test; (2) any practice conducting the test prior to the main test; and (3) the procedures to be used during the test. Once the test has begun, every effort should be made to continue it to completion without interruptions.

a. Arrangements to be made prior to conducting the test: The human factors engineer will first determine who (i.e., the human factors engineers or other test agency personnel) will conduct different parts of the analysis. The test engineer will select relevant checklists to be used during analysis, acquire the instrumentation needed to conduct the test, and schedule the time of operator(s) and work station(s) of interest. If a particular analysis involves special considerations, such as clothing, the human factors engineering will make these arrangements.

b. Practice prior to the test: Every effort should be made to ensure smooth conduct of the tests described above. The human factors engineer will ensure that personnel conducting test, using checklist or administering questionnaires or interview are thoroughly familiar with procedures to be followed and equipment used during analysis. Practice prior to the test may expedite conduct of the test and enhance the quality of results.

c. Procedures used during the test: Tests will be performed as described in Section 5.1.

5.2 Data Required.

The data required should include the following:

a. A comprehensive list of all physical measurements taken. This should include equipment used to take measurements, their serial numbers, and calibration dates.

b. The results of checklist administration. This should also include copies of the checklist used. Photos of all discrepancies should be obtained for use in data analysis and test reporting.

c. The results of questionnaires and interviews. This should include copies of responses to questionnaire, and interview forms.

d. The results of mission simulation (if appropriate). This should include videotape of the simulation, results from any checklists or recording forms used, and any system times or error rates recorded during simulation.

6. DATA REDUCTION AND PRESENTATION.

a. The degree to which the test item conforms or does not conform to HFE specifications, standards, and requirements should be presented in narrative form. Instances of nonconformance should be supported by relevant measurements and photographic illustrations. The causes and consequences of nonconformance shall be analyzed with regard to effect on systems and mission performance. All quantitative measurement data (e.g., anthropometric, illumination, etc.) shall be presented in tabular or graphic form for direct comparison with the specified criteria and to show the degree of compliance or noncompliance. The results' of checklists and questionnaires/interviews shall be summarized and presented in tabular form. When adequate samples are available, the results should be submitted to statistical analyses. Any degradation of the effectiveness of the man-item relationship with regard to operation of the system shall be analyzed and a corrective action recommended.

b. Each discrepancy from the criteria should be analyzed for its impact on mission performance. This analysis will include, at a minimum, the following:

(1) Potential Type of Error: The type of error that the discrepancy could induce should be determined. In some tests the mission simulation will provide this information. Types of general errors are defined in Paragraph 5.12.4 of TOP 01-2-610 (Part I).

(2) Probability of Error: Estimations should be made of the probability of errors occurring. These estimations should be based on the frequency and difficulty of tasks involving the discrepancy, and the potential for a stressful environment during task performance involving the discrepancy. Reference should be made to Paragraph 5.12 Test Procedure-Error Likelihood Analysis in TOP 01-2-610 (Part I).

(3) Recover from Error: Estimations should be made of the probability of the operator (s) recognizing that an error has occurred and correcting it. The effect of the error correction on mission performance should also be determined.

(4) Error Propagation: Estimation should be made of the potential one error leading to one or more other errors.

(5) Synergistic Effects: The human factors engineer should consider the cumulative effects of discrepancies. While individual design problems may not seem important, groups of discrepancies can interact to create a composite potential for error.

(6) Consequences of Error: The consequences on mission performance of the error(s) induced by the discrepancy should be determined from mission simulation data, documentation, and/or SMEs.

c. The human factors engineer should integrate the results of the above analyses and develop a list of well-defined design problem areas.

d. Judgments will be made as to whether these problems represent deficiencies or shortcomings. In determining whether a problem is a deficiency or shortcoming, the following checklist should be used:

(1) Does the incident (performance or component):

(a) Create a hazard-to personnel or equipment?

(b) Seriously impair operational capability?

(c) Cause serious damage if operations were to continue?

(2) If the answer is "yes" to one or more of the above, is the incident:

(a) Something not anticipated in equipment of this type?

(b) A characteristic of design that requires change?

(c) Expected to occur again at similar frequency (i.e., not random)?

(3) If the answer is "yes" to all three, the problem is a true deficiency. If the answer to anyone of the three is "no," it is a shortcoming.

e. Test Incident Reports (TIRs) should be completed for all discrepancies and forwarded to the responsible agency.

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APPENDIX A. SAMPLE DESIGN CHECKLISTS.

This appendix contains a series of sample design checklists for analyzing the Soldier-computer interface. These checklists could be used as guidance in developing checklists tailored to the test time. Paragraph numbers in parentheses at the end of a checklist item refer to the Military Standard (MIL-STD)-1472G[4] paragraph number. Other checklist items are not requirements, but principles of good human factors design.

TABLE A-1. DESIGN CHECKLIST AND MIL-STD-1472G CROSS-REFERENCE

NUMBER	TITLE	MIL-STD-1472G PAGE
1	Workspace	237
2	Keyboards-Alphanumeric	32
3	Keyboard-Function Keys	32
4	Keypads-Alphanumeric	32
5	Light Pens	40
6	Joysticks	34
7	Printed Circuit Switches	64
8	Mouse	34
9	Grid and Stylus	40
10	Trackballs	34
11	Toggle Switches	61
12	Cursor	28
13	Computer Visual Display Unit	82
14	Cathode ray tube (CRT)	108
15	Dot Matrix/Segmented/Light emitting diode (LED) Displays	114
16	Printers	107
17	Plotters and Recorders	297
18	Auditory Signals	118
19	Interactive Control	43
	General	43
	User Control	43
	Multiple Users	43
	Command Organization	47
	Command Language	47
	Command Operation	47
	System Response Time	43
	Form-Filling	46
	Menu Selection	45

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-1. CONTINUED

NUMBER	TITLE	MIL-STD-1472G PAGE
20	Data Display	86
	Dynamic Displays	105
	Information Coding	101
	Format	86
	Text/Program Editing	96
	Display Content	87
	Tabular Data	96
	Textual Data Displays	96
	Graphic Displays	87
21	Data Protection/Error Management	24/297
	Verification of Ambiguous or Destructive Actions	47
	System Failure	125
	Error Recovery	25
22	Data Entry Procedures	41

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-2. WORKSPACE DESIGN CHECKLIST

Test Title____
Test Project No.________________________ Date of Test_______________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Illuminance of working areas for printers and other hard-copy devices is between 540 and 1075 Lux (50 to 100 ft-c). (5.5.3)[a]				
2. The height of the home key row of keyboards is between 720 and 750 mm (29 to 30 in.) from the floor.				
3. Desk top height is 720 mm (29 in.).				
4. There is leg room under desks that meets or exceeds the following (5.7.3.5). Height 640 mm (25 in.) Width 510 mm (20 in.) Depth 460 mm (18 in.)				
5. If a fixed footrest or foot control is used, the knee room height is increased accordingly. (5.10.3.2.14)				
6. A kick space of at least 100 mm (4 in.) in depth and 100 mm (4 in.) in height is provided under the desk. (5.10.2.3)				
7. The keyboard is in easy arm's reach with the back row of keys no more than 400 mm (16 in.) from the front of the desk/work surface.				
8. Work seating provides adequate support for the body relative to the task. (5.10.3.2.4)				
9. Work seating is operationally compatible with the console configuration. (5.10.3.2.4)				
10. Seating is vertically adjustable from 380 to 535 mm (15 to 21 in.) in increments of no more than 25 mm (1 in.) each. (5.10.3.2.7)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-2. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
11. Backrests and seats are cushioned with at least 25 mm (1 in.) of compressible material. The surface is smooth. (5.10.3.2.9)				
12. Backrests recline between 1745 and 2005 Mrad (100 and 115 degrees). (5.10.3.2.8)				
13. Backrests engage the lumbar and thoracic regions of the back. (5.10.3.2.8)				
14. The backrest supports the torso so that the operator's eyes can be brought to the "eye line" with no more than 75 mm (3 in.) of forward body movement. (5.10.3.2.8)				
15. Armrests are provided. (5.10.3.2.10)				
16. Armrests that are integral to the chair are at least 50 mm (2 in.) wide and 200 mm (8 in.) long. (5.10.3.2.10)				
17. Modified or retractable armrests are adjustable from 190 to 280 mm (7.5 to 11 in.) above the compressed sitting surface. (5.10.3.2.10)				
18. If possible, the work station is designed so that the operator's sitting posture allows a 90° angle between the forearm and upper arm and a 90° angle between the shin and the thigh.				
19. The work station is designed so that the user's head is tilted forward 20° from the vertical plane.				
20. There is a minimum of sideways and downward twisting of the head.				
21. The user's footrest flat on the floor.				
22. Footrests are adjustable from 0 to 50 mm (2 in.) in height and between 10° and 15° in inclination.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-2. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
23. Adequate and suitable storage space is provided on consoles and immediate workspaces for manuals, worksheets, and other material required by operator. (5.10.2.8)				
24. Writing surfaces, if used, are between 740 and 890 mm (29 and 31 in.) above the floor. (5.10.3.2.3)				
25. Writing surfaces are at least 610 mm (24 in.) wide and 400 mm (16 in.) deep. (5.10.3.2.3)				
26. Work surfaces, if used, are at least 760 mm (30 in.) wide and 400 mm (16 in.) deep. (5.10.3.1.2)				
27. Document holders, if used, are located between 450 and 500 mm (18-20 in.) from the user's eyes at a 20° angle from the vertical plane.				
28. Document holders are located as close to the display screen and keyboard as possible.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-3. KEYBOARDS (ALPHANUMERIC) DESIGN CHECKLIST

Test Title____
Test Project No.______________________________ Date of Test____________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Numeric keyboards, used only for numeric information entry, are arranged in a 3 x 3 x 1 matrix with the zero digit centered on the bottom row. (5.1.3.2.2)[a]				
2. Alphanumeric keyboards are of QWERTY design and conform to MIL-HDBK-1280[5].				
3. Alphanumeric keyboards, where there is equal entry of alpha and numeric characters, have a visual separation of the numeric keys. (5.1.3.2.2)				
4. Keys conform to the following dimensions (5.1.3.2.3): Diameter Min. 10 mm (0.385 in.) Max. 19 mm (0.75 in.) Preferred 13 mm (0.5 in.) Resistance Numeric Min. 1 N (3.5 oz.) Max. 4 N (14.0 oz.) Alphanumeric & Dual Function Min. 250 MN (0.9 oz.) Max. 1.5 N (5. 3 oz.) Displacement Numeric Min. 0.8 mm (0.13 in.) Max. 4.8 mm (0.19 in.) Alphanumeric Min. 1.3 mm (0.05 in.) Max. 6.3 mm (0.25 in.) Dual Function Min. 0.8 mm (0.03 in.) Max. 4. 8 mm (0.19 in.) Separation Between Adjacent Key Tops Min. 6.4 mm (0.25 in.)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-3. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
5. The slope of non portable keyboards is between 260435 Mrad (15-25º) from the horizontal. (5.1.3.2.4)				
6. Multiple keyboards have the same configuration throughout the system. (5.1.3.2.5)				
7. Feedback is provided to inform the user that the intended key was pressed. (5.1.3.2.6)				
8. Feedback is provided to inform the user that the next operation may be initiated. (5.1.3.2.6)				
9. Keyed data, except security items, are echoed on the display within 0.1 sec.				
10. The key used to enter is explicitly labeled "ENTER.”				
11. Mechanical overlays covering the keyboard are not used. (5.1.3.4.3.d)				
12. Systems requiring substantial numeric input have a numeric keypad. (5.1.3.4.2.e)				
13. Function keys on alphanumeric keyboards conform to the salient criteria on checklist 3 - Function Keys.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-4. KEYBOARD (FUNCTION KEYS) DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Function keys are used for time-critical, error-critical, or frequently used control inputs. (5.1.3.4.3.a)[a]				
2. Function keys, if legend pushbuttons, conform to the following dimensions (5.1.3.2.3): Size Min. 19mm (0.75 in.) Max. 38mm (1.5 in.) Displacement Min. 3mm (0.125 in.) Max. 6mm (0.25 in.) Barrier width (separation) Min. 3mm (0.125 in.) Max. 6mm (0.25 in.) Barrier height Min. 5mm (0.188 in.) Max. 6mm (0.25 in.) Resistance Min. 2.8N (10 oz.) Max. 16.7N (60 oz.)				
3. Keys are logically grouped in distinctive locations on the control panel. (5.1.3.4.3.f)				
4. The most important and frequently used keys are located in the most convenient and visible part of the panel.				
5. Critical keys or keys subject to inadvertent activation are guarded.				
6. Barriers are used for critical switches that are likely to be inadvertently activated. (5.1.4.2.1.d(4)(b))				
7. Barriers, if used, do not obscure visual access to controls, labels or displays. (5.1.4.2.1.d(4)(c))				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-4. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
8. There is a positive indication of key activation in the form of a detent or click. (5.1.4.2.1.c(4))				
9. Backlit keys have lamp test capability, dual lamp/filament reliability, or a mean time between failures (MTBF) of 100,000 hours. (5.1.4.2.1.d(2)(e))				
10. Backlit key lamps are replaceable by hand from the front of the panel or keyboard. (5.1.4.2.1.d(2)(c))				
11. Key covers are keyed to prevent the chance of interchange.				
12. Keys require only single activation to accomplish their function. (5.1.3.4.3.g)				
13. Fixed function keyboards are used when the command set is small and the users are naive.				
14. Lockout of fixed function keys is minimized. (5.1.3.4.3.d)				
15. Non-active fixed function keys are replaced by a blank key on the keyboard. (5.1.3.4.3.e)				
16. Fixed function keys are standardized throughout the system. (5.1.3.4.3.b)				
17. System provides acknowledgement of user input if fixed function key activation results in no immediate response. (5.1.3.4.3.h)				
18. Touch-sensitive keys are provided with feedback such as an integral light. (5.1.4.2.1.d(5))				
19. Keys with a continuously available function have a single label on the key.				
20. The label on the key is visible at all times. (5.1.4.2.1.d(2)(d))				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-4. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
21. Labels have a maximum of three lines. (5.1.4.2.1.d(5))				
22. Multifunction keys are used when design considerations make it necessary.				
23. Multifunction key labels are located on the control or adjacent to the control.				
24. The key-label relationship is unambiguous.				
25. The labels are self-illuminated to indicate what function is operational.				
26. Different functions in different operational modes for a function key are as consistent as possible.				
27. Functions occurring in different modes are assigned the same key in each mode, unless sequential or functional grouping dictates otherwise.				
28. Once assigned a function, a function key is not reassigned a different function for a given user. (5.1.3.4.3.c)				
29. Function key assignments are displayed at all times. (5.1.3.4.3.i)				
30. Provisions are made for easily relabeling variable function keys. (5.1.3.4.4.d)				
31. If direct marking of keys is not possible, the assigned key functions are displayed on the visual display unit (VDU) screen. (5.1.3.4.4.b)				
32. Key caps are used if the uses of the keys vary across users.				
33. Function keys not currently needed are temporarily disabled by the computer.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-4. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
34. Functions of keys that are specific to a particular step in a sequence are displayed on the user's display.				
35. The mode-select key is a dedicated control.				
36. The mode selected is prominently displayed adjacent to the mode-select key.				
37. A list of available modes of operation is provided.				
38. The list of available modes is located and organized so that the operator can readily determine what action is required to obtain a mode.				
39. Keys that are not always active are backlit when enabled.				
40. Variable function keys are not shifted characters. (5.1.3.4.4.e)				
41. If the effect of a function key varies, its status is displayed. (5.1.3.4.4.b)				
42. If a variable function key with a labeled default value is deactivated or reprogrammed, a visual warning is provided. (5.1.3.4.4.c)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-5. KEYPADS (ALPHANUMERIC) DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Keys conform to the following dimensions (5.1.3.2.3)[a]:				
2. Diameter Min. 10 mm (0.385 in.) Max. 19 mm (0.75 in.) Preferred 13 mm (0.5 in.)				
3. Resistance Min. 250 MN (0.9 oz.) Max. 1.5 N (5.3 oz.)				
4. Displacement Min. 1.3 mm (0.05 in.) Max. 6.3 mm (0.25 in.)				
5. Separation Between Adjacent Key Tops Min. 6.4 mm (0.25 in.)				
6. Multiple keyboards have the same configuration throughout the system. (5.1.3.2.5)				
7. Feedback is provided to inform the user that the intended key was pressed. (5.1.3.2.6)				
8. Feedback is provided to inform the user that the next operation may be initiated. (5.1.3.2.6)				
9. Keyed data, except security items, are echoed on the display within 0.1 sec.				
10. The key used to enter is explicitly labeled "ENTER."				
11. Mechanical overlays covering the keyboard are not used. (5.1.3.4.3.d)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-5. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
12. Systems requiring substantial numeric input have a numeric keypad. (5.1.3.4.2.e)				
13. Keys are logically grouped in distinctive locations on the control panel. (5.1.3.4.3.f)				
14. The most important and frequently used keys are located in the most convenient and visible part of the panel.				
15. Barriers are used for critical switches that are likely to be inadvertently activated. (5.1.4.2.1.d(4)(b))				
16. Barriers, if used, do not obscure visual access to controls, labels or displays. (5.1.4.2.1.d(4)(c))				
17. There is a positive indication of key activation in the form of a detent or click. (5.1.4.2.1.d(5))				
18. Backlit keys have lamp test capability, dual lamp/filament reliability, or a mean time between failures (MTBF) of 100,000 hours. (5.1.4.2.1.d(2)(f))				
19. Backlit key lamps are replaceable by hand from the front of the panel or keyboard. (5.1.4.2.1.d(2)(c))				
20. Key covers are keyed to prevent the chance of interchange.				
21. Keys require only single activation to accomplish their function. (5.1.3.4.3.g)				
22. Multifunction key labels are located on the control or adjacent to the control.				
23. The key-label relationship is unambiguous.				
24. The mode-select key is a dedicated control.				
25. The mode selected is prominently displayed adjacent to the mode-select key.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-5. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
26. If direct marking of keys is not possible, the assigned key functions are displayed on the VDU screen.				
27. Variable function keys are not shifted characters. (5.1.3.4.4.e)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-6. LIGHT PENS DESIGN CHECKLIST

Test Title____
Test Project No.___________________________ Date of Test_________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Light Pens are used for noncritical, relatively imprecise input functions. (5.1.3.4.6)[a]				
2. The selectable area for an item is as large as possible, at least the size of the displayed label plus one-half a character's distance around the labels.				
3. Light Pens have a discrete activating mechanism such as a push-tip switch that requires 0.5 N - 1.4 N (2-5 oz.) of force to activate. (5.1.3.4.5.c)				
4. Light Pens are between 120 - 180mm (4.7 - 7.1 in.) long and have a diameter between 7 - 20mm (0.3 -0.8 in.). (5.1.3.3.6.c)				
5. A convenient clip is provided at the lower right side of the CRT to hold the light pen when not in use. (5.1.3.3.6.c)				
6. Feedback is provided for light pen placement (e.g., an illuminated circle on the display screen), pen actuation, and system reception of the input. (5.1.3.3.6.a)				
7. Light Pen placement causes a follower to appear at a corresponding point on the display. (5.1.3.3.6.a)				
8. Light Pen movement results in a smooth, equal movement of the follower. (5.4.3.2.5.2)				
9. Refresh rate for the follower is sufficiently high to enhance the appearance of a continuous track for free drawn graphics. (5.1.3.3.5.a)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-7. JOYSTICKS DESIGN CHECKLIST

Test Title____
Test Project No.______________________________ Date of Test___________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Joysticks are used for tasks that require precise or continuous control in two or more related dimensions. (5.1.3.3.3.a(1))[a]				
2. Joystick dimensions conform to the following (5.1.3.3.3.c(3)): Length Min. 75 mm (3 in.) Max. 150 mm (6 in.) Diameter Min. 6.5 mm (0.25 in.) Max. 16 mm (0.625 in.) Resistance Min. 3. 3 N (12 oz.) Max. 8.9 N (32 oz.) Displacement Max. 45° Clearance Display Clearance to Stick Clearance Min. 0 Max. 400 mm (15. 75 in.) Around Stick Max. - Max. stick excursion plus 100 mm (4 in.) Stick to Shelf Front Min. 120 mm (4.75 in.) Max. 250 mm (9.875 in.)				
3. A discrete mechanism is provided for actuation/ deactuation of the joystick. (5.1.3.3.3.b(3))				
4. Isotonic joysticks (displacement joysticks) are used for data pickoff from a CRT, generation of free drawn graphics, and other tasks where accuracy is more critical than positioning speed. (5.1.3.3.3.a(2))				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-7. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
5. If the follower can transit beyond the display edge, indicators aid the operator in bringing the follower back onto the display. (5.1.3.3.3.a(4))				
6. Isotonic joysticks used for rate control are spring-loaded for return to center. (5.1.3.3.3.a(5))				
7. Isotonic joysticks are not used in connection with automatic sequencing of a CRT follower. (5.1.3.3.3.a(6))				
8. If used in above application, isotonic joysticks are instrumented for null return or are zero-set to the instantaneous position of the stick at the time of sequencing. (5.1.3.3.3.a(6))				
9. Isotonic joystick movement is smooth in all directions. (5.1.3.3.3.b(2)(b))				
10. There is no noticeable backlash, cross-coupling or need for multiple corrective movements in rapid positioning of a follower on a display. (5.1.3.3.3.b(2)(c))				
11. Control ratios, friction and inertia meet the dual requirements of rapid gross positioning and precise fine positioning. (5.1.3.3.3.b(2)(d))				
12. Delay between control movement and display response is not greater than 0.1 second. (5.1.3.3.3.b(2)(f))				
13. Isometric joysticks (output is a function of applied force, not movement) are not used if the operator must maintain a constant force on the stick. (5.1.3.3.4.a(2))				
14. The isometric joystick deflects minimally in response to applied force but perceptibly against a stop at full applied force.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-7. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
15. The X and Y output is proportional to the magnitude of the applied force as perceived by the operator.				
16. Isometric joysticks without integral switching are finger-grasped. (5.1.3.3.4.b(1))				
17. Isometric joysticks with integral switching are hand-grasped. The dimensions should conform to the following (5.1.3.3.3.b(6)): Length 110 – 180 mm (4.3-7.1 in.) Grip diameter Max. 50 mm (2 in.) Side clearance 100 mm (4 in.) Rear clearance 50 mm (2 in.) Force required for full output Max. 118 N (26.7 lbs.)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-8. PRINTED CIRCUIT SWITCHES DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Printed circuit (PC) switches are used for manual programming of PC boards.				
2. Switches are sufficiently tall to permit error-free operation when using a commonly available stylus (e.g., pencil or pen). (5.1.4.2.1.h(2)(a))[a]				
3. Special tools are not required for operation. (5.1.4.2.1.h(2)(b))				
4. Resistance is sufficiently high so that the switch will not be inadvertently activated under the expected use conditions. (5.1.4.2.1.h(2)(c))				
5. Resistance gradually increases, then drops when the switch snaps into position. (5.1.4.2.1.h(2)(d))				
6. The switch cannot be placed between positions. (5.1.4.2.1.h(2)(e))				
7. Slide-type switches have sufficient travel to allow for easy recognition of switch position. (5.1.4.2.1.h(2)(f))				
8. Slide-type switch travel is at least twice the length (height) of the switch. (5.1.4.2.1.h(2)(g))				
9. Rocker-type switch wings, when activated, are flush with the module surface. (5.1.4.2.1.h(2)(h))				
10. Switches are sufficiently separated to preclude inadvertent activation. (5.1.4.2.1.h(2)(i))				
11. The switch surface is sufficiently indented to accept the point of the stylus without slippage. (5.1.4.2.1.h(3))				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-9. MOUSE (FREE-MOVING XY CONTROLLER) DESIGN CHECKLIST

Test Title____

Test Project No._____________________________ Date of Test___________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. A mouse is used for data pickoff or entry of coordinate values. (5.1.3.3.1.a)[a]				
2. A mouse is not used for the generation of free drawn graphics. (5.1.3.3.1.a)				
3. The generation of X and Y outputs by the mouse controller results in proportional displacement of a follower. (5.1.3.3.1.a)				
4. The user can orient the controller to within ±175 Mrad (10°) of the correct orientation without visual reference to the controller. (5.1.3.3.1.b(1))				
5. The controller is easily movable in any direction without a change of hand grasp. (5.1.3.3.1.b(2))				
6. Movement of the controller results in smooth movement of the follower in the same direction ±175 Mrad (10°). (5.1.3.3.1.b(1))				
7. The controller operable with either the right or left hand. (5.1.3.3.1.b(3))				
8. Complete movement of the controller from one side of the maneuvering area results in equal movement of the follower, regardless of scale setting or offset. (5.1.3.3.1.b(4))				
9. If the controller is capable of driving the follower off the display edge, indicators are provided to assist in bringing the follower back onto the display. (5.1.3.3.1.b(5))				
10. The controller has no sharp edges and is roughly shaped as a rectangular solid. (5.1.3.3.1.e)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-9. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
11. The dimensions of the mouse controller are as follows (5.1.3.3.1.e): Width Min. 40 mm (1.6 in.) Max. 70 mm (2.8 in.) Length Min. 70 mm (2.8 in.) Max. 120 mm (4.7 in.) Thickness Min. 25 mm (1.0 in.) Max. 40 mm (1.6 in.)				
12. A discrete mechanism is provided for actuation/deactuation. (5.1.3.3.1.d)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-10. GRID AND STYLUS (SENSOR TABLES) DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Grid and stylus devices are used for graphic entry, not for hand-printed characters.				
2. Grids used as display overlays are the same size as the display. (5.1.3.3.5.c)[a]				
3. The size of a displaced grid approximates the size of the display and is located below the display. (5.1.3.3.5.c)				
4. The orientation of the grid is the same as that of the display. (5.1.3.3.5.c)				
5. A follower is presented on the display that corresponds to the stylus. (5.1.3.3.5.a)				
6. Movement of the stylus causes a smooth, equal movement of the follower. (5.1.3.3.5.b)				
7. Refresh rate for the follower is sufficiently high to ensure the appearance of a continuous track for free drawn graphics. (5.1.3.3.5.b)				
8. A discrete mechanism is provided for actuation/deactuation.				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-11. TRACKBALLS DESIGN CHECKLIST

Test Title____

Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Trackballs are used only as position controls. (5.1.3.3.2.a)[a]				
2. Trackballs are not used when an automatic return to center is needed.				
3. Trackballs used for precise or continuous adjustments have wrist and/or arm support. This support is as follows: a. Large hand movements: elbow b. Small hand movements: forearm c. Finger movements: wrist				
4. Trackball dimensions conform to the following (5.1.3.3.2.e): Diameter Min. 50 mm (2 in.) Max. 150 mm (6 in.) Preferred 100mm (4 in.) Surface Exposure Min. 1545 Mrad (100°) Max. 2445 Mrad (140°) Preferred 2095 Mrad (120°) Resistance Precision Required Max. 1. 0 N (3. 6 oz.) Preferred 0.3 N (1.1 oz.) Vibration or Acceleration Conditions Max. 1. 7 N (6 oz.) Clearance Display Clearance to Ball				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-11. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
4. Trackball dimensions conform to the following (5.1.3.3.2.e): Clearance Min. 0 Max. 320 mm (12.625 in.) Around Ball Min. 50 mm (2 in.) Fall to Shelf Front Min. 120 mm (4.75 in.) Max. 250 mm (9.75 in.)				
5. Smaller diameter trackballs are used only where space is limited and precision is not required. (5.1.3.3.2.e)				
6. Trackballs are mounted on a shelf or desk top. (5.1.3.3.2.e)				
7. Trackballs are used to draw straight lines or circles.				
8. A discrete mechanism is provided for actuation/deactuation.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-12. TOGGLE SWITCHES DESIGN CHECKLIST

Test Title____

Test Project No.______________________________ Date of Test____________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Toggle switches are used where two discrete control positions are required. (5.1.4.2.1.c(1))[a]				
2. Toggle switches with three positions are used only where the use of other switches is not feasible or when it is a spring return to center-off type. (5.1.4.2.1.c(1))				
3. Resistance gradually increases then it drops off when the control snaps into position. (5.1.4.2.1.c(3))				
4. The dimensions conform to those given below (5.1.4.2.1.c(3)): Length Use by Bare Finger Min. 13 mm (0.5 in.) Max. 50 mm (2 in.) Use with Heavy Hand wear Min. 38 mm (1.5 in.) Max. 50 mm (2 in.) Control Tip Diameter Min. 3 mm (0.125 in.) Max. 25 mm (1 in.) Resistance Min. 2.8 N (10 oz.) Max. 11 N (40 oz.) Displacement 2 Position Min. 525 Mrad (30°) Max. 1400 Mrad (80°) 3 Position Min. 295 Mrad (17°) Max. 525 Mrad (30°) Preferred 435 Mrad (25°)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-12. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
4. The dimensions conform to those given below (5.1.4.2.1.c(3)): Separation Single Finger Min. 19mm (0.75 in.) Optimum 50mm (2 in.) Single Finger w/Lever Lock Min. 25mm (1 in.) Optimum 50mm (2 in.) Single Finger Sequential Operation Min. 13mm (0.5 in.) Optimum 25mm (1.0 in.) Simultaneous Operation by Different Fingers Min. 16mm (0.625 in.) Optimum 19mm (0.75 in.)				
5. A positive indication of control activation is provided. (5.1.4.2.1.c(4))				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-13. CURSOR DESIGN CHECKLIST

Test Title____
Test Project No.______________________________ Date of Test___________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Cursor control dialogues are used for systems that use interactive graphics but also use menu selection.				
2. Cursor blink rate is 3 Hz.				
3. The cursor has a distinctive visual shape. (5.1.3.4.1.h(2))[a]				
4. Cursors include a point designation feature when fine accuracy of positioning is required. (5.1.3.4.1.h(2))				
5. The cursor does not obscure any other character displayed in the designated position. (5.1.3.4.1.h(2))				
6. The cursor is stable and does not drift.				
7. The target for the cursor is at least 10 times the size of the positioning accuracy required for interactive graphics or 6mm (0.25 in.) square, whichever is smaller (e.g., the precision required does not hinder human performance).				
8. Cursor placement does not cause actual data entry.				
9. Multiple cursors are distinct from each other.				
10. Multiple cursors controlled by the same device provide a clear indication of which cursor is currently under control.				
11. Multiple cursors controlled by different devices have compatible controls.				
12. Cursor control is consistent with the speed and accuracy requirements of the operator. (5.1.3.4.1.h(7))				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-13. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
13. If position designation is combined with keyed data input, cursor movement is controlled at the keyboard by function keys, joystick, etc.				
14. If position designation is the prime means of data entry, cursor placement is controlled by a direct pointing device such as a light pen.				
15. Continuous position designation is done by continuously operable controls.				
16. Cursors that are positioned incrementally by discrete steps have a step size for cursor movement that is consistent in both right and left directions and both up and down directions.				
17. For arbitrary position designation, the cursor control permits both fast movement and accurate placement.				
18. Rough cursor positioning takes no more than 0.5 seconds for a displacement of 200-300 mm (8-12 in.).				
19. If displayed character size is variable, incremental cursor positioning has a step size that corresponds to the currently selected character size.				
20. Sequential cursor positioning in predefined areas is accomplished by programmable tab keys.				
22. User action, confirming entry of multiple data, results in input of all data, regardless of cursor location.				
23. Areas of the display that are not needed for data entry are inaccessible to the user by cursor placement.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-13. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
24. Cursor-predefined home position is consistently located for all displays and different windows of a partitioned display.				
25. Cursor home position is consistent across similar types of displays. (5.1.3.4.1.h(3))				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-14. COMPUTER VISUAL DISPLAY UNIT (VDU) DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Preferred distance for visual display unit (VDU) is 635 mm (25 in.). (5.10.3.6.4.c(3))[a]				
2. For short periods of VDU observation, or if dim signals must be detected, the viewing distance is not less than 250 mm (10 in.). (5.10.3.6.4.c(4))				
3. The operator is able to view the screen from as close as desired. (5.10.3.6.4.c(1))				
4. If the viewing distance is 700 mm (28 in.) and viewed by a single seat operator, the screen is 300 mm (12 in.) in diagonal.				
5. For screens that must be viewed from greater than 400 mm (16 in.), the screen size, symbol size, brightness range, line-pair spacing and resolution have been appropriately modified.				
6. VDU viewing angle: Optimum 90° Minimum for seated viewer 45° Absolute minimum 30°				
7. Ambient luminance in the VDU area is compatible with other necessary visual functions, but does not interfere with the visibility of signals on the screen. (5.2.1.3.6)				
8. Ambient luminance doesn't contribute to more than 25% of screen brightness through diffuse reflection and phosphor excitation.				
9. If the detection of faint signals is required and if the ambient luminance is above 2.7 Lux (0.25 ft-c), the screen is hooded, shielded or recessed. (5.2.1.3.3)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-14. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
10. Reflected glare is minimal and does not interfere with readability. (5.2.1.3.9)				
11. Luminance range of surfaces immediately adjacent to the VDU is between 10% and 100% of the screen background luminance. (5.2.1.3.14)				
12. With the exception of emergency indicators, no light source in the immediate surrounding area of the VDU has a greater luminance than the signals on the screen. (5.2.1.3.15)				
13. The adjacent surfaces to the VDU screen have a dull matte finish with a low reflectance. (5.2.1.3.13)				
14. The screen background luminance is between 78.8 cd/m² (23 ft-L) and 157.6 cd/m² (46 ft-L).				
15. If the VDU is used in both bright and dark environments, the alphanumeric character/screen brightness is variable between 0.2 cd/m² (0.058 ft-L) and 200 cd/m² (58.13 ft-L).				
16. The contrast of characters to background on the VDU screen is between 88% and 94%.				
17. Geometric and pictorial symbols subtend a minimum of 48 Mrad (16 minutes) of visual angle.				
18. Critical targets, or targets of complex shape that must be distinguished from non-targets of complex shape, subtend a visual angle of not less than 2.9 Mrad (10 minutes) and subtend not less than 10 scan lines per symbol height. (5.2.2.4.1.g)				
19. Alphanumeric characters subtend not less than 3.6 - 4.5 Mrad (12-15 minutes) of visual angle.				
20. Alphanumeric characters are uppercase letters.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-14. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
21. Flight display alphanumerics subtend not less than 7.2 Mrad (24 minutes) of visual angle.				
22. Alphanumeric characters have a height to width ratio of between 7:5 and 3:2.				
23. Alphanumeric characters for airborne displays have a height to width ratio of between 2:1 and 1:1.				
24. Alphanumeric characters have a stroke width to height ratio of 1:6 to 1:10. Light characters on a dark background have the thinner width.				
25. Red symbols on a green background are not used.				
26. Discernible flicker is avoided.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-15. CRT DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Viewing distance is 400 mm (16 in.).				
2. For short periods of observation or when dim signals must be detected, viewing distance is 250 mm (10 in.). (5.2.3.1.d)[a]				
3. Pip subtends a visual angle of no less than 6 Mrad (20 minutes).				
4. Ambient illumination is not greater than 0.1 ft-c. If the operator must perform other tasks, the ambient illumination is not brighter than 100 times the average brightness of the scope.				
5. The screen luminance is between 10 and 100 ft-L.				
6. The scanning rate for a 178 mm (7 in.) screen is not less than 12 RPM.				
7. The pip persists for a minimum of 0.1 second.				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-16. DOT MATRIX/SEGMENTED/LED DISPLAY DESIGN CHECKLIST

Test Title____

Test Project No.______________________________ Date of Test____________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Dot matrix characters are a minimum of 5 by 7 dots; 7 by 9 is preferred. (5.2.3.12.3)[a]				
2. If there is symbol rotation, the characters have a minimum of 8 by 11 dots, with 15 by 21 being preferred. (5.2.3.12.4)				
3. Seven segment displays are only used for numeric characters. (5.2.3.12.2)				
4. Characters subtend a minimum of 4.7 Mrad (16 minutes) of visual angle. (5.2.3.12.5)				
5. Flight display characters subtend a minimum of 7 Mrad (24 minutes) of visual angle.				
6. All alphanumeric characters are uppercase. (5.2.3.12.6)				
7. Viewing angle of dot-matrix or segmented displays shall be not more than 35 degrees off axis. (5.2.3.12.7)				
8. Monochromatic displays use the following colors, in order of preference: Green (555 nm), yellow (575 nm), orange (585 nm), and red (660 nm). Blue is not used. (5.2.3.12.8)				
9. A control for dimming is available. (5.2.2.12.10)				
10. Lamp testing capability is available unless the lights have a minimum of 100,000 hours MTBF. (5.2.3.9.4)				
11. The regeneration rate is high enough to preclude perceptible flicker.				
12. The screen luminance is a minimum of 21 ML (19.52 Ft-L) with a character to background contrast ratio of at least 8.5:1.				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-16. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
13. A 0.75mm (0.03 in.) dot is used for reading tasks and a 1.5mm (0.06 in.) dot is used for search tasks.				
14. If both tasks are performed, the dot is between 1.0 and 1.2mm (0.04 and 0.048 in.).				
15. LEDs have dimming controls. (5.2.3.10.3)				
16. Red LEDs are not located in the proximity of red warning lights. (5.2.3.10.4)				
17. LEDs have lamp testing capability unless their MTBF is 100,000 hours or more. (5.2.3.10.5)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-17. PRINTERS DESIGN CHECKLIST

Test Title____
Test Project No.______________________________ Date of Test____________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. The operator can obtain a paper copy of the exact contents of the alphanumeric or digital graphic display. (5.2.2.8.1)[a]				
2. Printed information is directly usable, with minimal requirements for decoding, transposing, and interpolating. (5.2.2.8.2)				
3. The printed material can be easily read (i.e., not obscured). (5.2.2.8.6.b)				
4. The luminance contrast not less than 3:1 shall be provided between the printed material and the background on which it is printed. (5.2.2.8.6.c)				
5. If the printed material is not legible in the expected operational ambient illumination, the printer has internal illumination. (5.2.2.8.6.d)				
6. A take-up device for printed material is provided. (5.2.2.8.6.e)				
7. The printer is mounted so that the printed matter can be easily annotated while still in the printer.				
8. There is a positive indication of the remaining supply of paper, ink, or ribbon.				
9. The insertion, adjustment and removal of paper, the replenishment of the ink supply, the replacement of the pen, and other items determined to be operator tasks do not require disassembly, special equipment, or tools.				
10. The printed output is legible. (5.2.2.8.6.f)				
11. Printed tapes do not require any cutting and pasting to be read but are readable as they are received. (5.2.2.8.6.g)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-18. PLOTTERS AND RECORDERS DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Plotters and recorders are used when a visual record of continuous graphic data is necessary. (5.14.2.1)[a]				
2. Critical graphics are not obscured by any hardware. (5.14.2.2)				
3. A luminance contrast not less than 1:1 shall be provided between the plotted function and the background. (5.14.2.3)				
4. A take-up device for the extruded plotting material is provided. (5.14.2.4)				
5. Graphic overlays are provided if they are critical to proper interpretation of the graphic data. (5.14.2.5)				
6. These overlays do not obscure or distort the data. (5.14.2.5)				
7. The plot doesn't smudge or smear. (5.2.6.4.6)				
8. The plotter or recorder paper can be written or marked on while in the equipment. (5.14.2.7)				
9. There is a positive indication of the remaining supply of plotting materials.				
10. The insertion, adjustment and removal of paper, replenishment of ink, replacement of pen or other items determined to be operator tasks can be performed without disassembly, special equipment, or tools.				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-19. AUDITORY SIGNALS DESIGN CHECKLIST

Test Title____
Test Project No.______________________________ Date of Test____________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Auditory signals are used to warn, alert, or cue the operator that an additional response is required. (5.3.1.1)[a]				
2. Auditory signals are used to alert the user that an attempt has been made to enter data into a blank area rather than an entry field.				
3. Auditory signals are used to alert the operator to a critical change in system or equipment status. (5.3.1.2.1)				
4. False signals are avoided.				
5. Failure of the computer system does not cause a failure of the auditory signal.				
6. Auditory signals are testable.				
7. Auditory signals used for warnings consist of two elements: an alerting signal and an identifying or action signal. (5.3.2.2)				
8. Two element signals where reaction time is critical have an alerting signal of 0.5 second duration. (5.3.1.2.1.d(2))				
9. All essential information is conveyed in the first 2.0 seconds of a two element signal. (5.3.1.2.1.d(1))				
10. Single-element signals where reaction time is critical convey all essential information in the first 0.5 seconds. (5.3.1.2.1.d(2))				
11. Caution signals are used to indicate conditions requiring awareness, but not necessarily immediate action. (5.3.1.2.2.b)				
12. Caution signals are easily distinguishable from warning signals. (5.3.1.2.2.a)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-19. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
13. The frequency range of auditory signals is between 250 and 5,000 Hz. (5.3.1.4.1)				
14. Auditory signals do not cause discomfort. (5.3.1.3.4.e)				
15. Signal-to-noise ratio of at least 20dB is provided in at least one octave band between 200 and 5,000 Hz. (5.3.4.1)				
16. Signals of a high alerting capacity are used. (5.3.1.4.2.a)				
17. If different auditory signals are used, they are discriminably different. (5.3.1.4.3.a)				
18. For signals that require fast reaction time, the first 0.5 second is discriminable from the first 0.5 second of any other signal. (5.3.1.4.3.d)				
19. The action segment of an audible warning signal specifies the precise condition requiring action. (5.3.1.4.3.e)				
20. Auditory signals are consistent with established signals for that function. (5.3.1.4.4.a)				
21. Auditory signals do not interfere with other critical functions or auditory signals. (5.3.1.4.5)				
22. Audio signals used in conjunction with visual displays are: (5.3.1.7.a) a. Supplementary to the visual signals. b. Used to alert and direct the user's attention to the appropriate visual display.				
23. The intensity, duration, and source location of the signal is compatible with the acoustical environment of the intended receiver as well as the requirements of other personnel in the signal area. (5.3.1.3.4.a)				
24. Signals are intermittent, allowing the user sufficient time to respond.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-19. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
25. Signals are automatically terminated by operator response action or by manual control. (5.3.1.7.b)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. INTERACTIVE CONTROL DESIGN CHECKLIST

Test Title____

Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Control actions selected from a discrete set of alternatives have those alternatives displayed prior to the time of selection. (5.1.3.5.1.i(1))[a]				
2. The current value of any parameter with which the operator is interacting is displayed. (5.1.3.5.1.i(2))				
3. When an operator steps through multiple display levels (5.1.3.5.1.j): a. The number of required levels is minimized. b. The current position within the sequence of levels is provided. c. Display and input formats at each level are similar.				
4. Users are not required to learn mnemonics, codes, special or long sequences, and special instructions are minimized. (5.1.3.5.1.k)				
5. All operator control inputs result in a positive response displayed to indicate performance of requested actions. (5.1.3.5.1.1(3))				
6. When numeric data is displayed or required for control input, such data is in the decimal, rather than binary, octal, hexadecimal, or other number system. (5.1.3.5.1.m)				
7. The user is able to manipulate data without concern for internal storage and retrieval mechanisms of the system. (5.1.3.5.1.n)				
8. The sequence of transaction selections is generally dictated by the user's choices and not by internal computer-processing constraints. (5.1.3.5.1.o)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
9. An acknowledgement message to correct input is used only in those cases where the more conventional mechanism is not appropriate or where feedback response time must exceed 1 second. (5.1.3.5.1.p)				
10. When control input errors are detected, error messages are available and error recovery procedures are provided. (5.1.3.5.1.q)				
11. Correct user input causes logical and expected changes in state or value of the displayed data being controlled. (5.1.3.5.1.p)				
12. The presence and location of control input data entered by the user are clearly and appropriately indicated. (5.1.3.5.1.r)				
13. In tasks where transaction sequences vary, the user is able to request a displayed list of previous entries to determine present status.				
14. Control inputs are simplified to the extent possible. Permit logical task sequences with a minimum number of control manipulations to achieve task completion.				
15. If two or more users have simultaneous access to the system there is no interference between operations unless mission survival requires preemption. (5.1.2.1.7)				
16. Preempted operators can resume operations at a point of interference without information loss. (5.1.2.1.7)				
17. Commands are entered and displayed in a standard location on the display. (5.1.2.2.e)				
18. The information displayed to the user is limited to that which is necessary to perform specific actions or to make decisions. (5.2.2.2.1.a)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
19. In on-line communication among users, the input from each speaker is buffered to prevent any interference.				
20. Except for broadcast communication systems, the transmitter of each message in inter-user communications is identified automatically, if possible. (5.1.3.5.1.s)				
21. Separate areas of the display screen are provided for each communicator in inter-user communication.				
22. Quantifiers and logical operators (e.g., and, or, not. implies. equivalence) in a command language are avoided.				
23. Global commands are provided only for data that are normally retrieved together (e.g., name, age, sex).				
24. The words chosen for a command language reflect the user's point of view and not the programmer's. (5.1.3.5.5.b)				
25. Abbreviations are distinctive to avoid confusion. (5.1.3.5.5.e)				
26. Command entries contain a minimum of punctuation or other special characters. (5.1.3.5.5.d)				
27. Commands shall be entered and displayed in a standard location on the display (5.1.3.5.5.g)				
28. The command language allows the user to request prompts, as necessary, to determine required parameters in a command entry. (5.1.3.5.5.h)				
29. Distinct command names are used.				
30. Command language words are standardized in meaning and consistently used from one transaction to another and from one task to another.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
31. Each word has only one acceptable abbreviation.				
32. A standard delimiter (a special character used to denote boundary between adjacent syntactic components of a program), preferably slash (/), is used.				
33. Blanks in command entries are verified and corrected by the computer, the user does not have to distinguish between one and multiple blanks.				
34. Command operation is consistent throughout the system.				
35. Ease of command operation is compatible with the desired ends: frequent procedures are easy; destructive actions are difficult.				
36. Command sequencing is flexible and controlled by the user.				
37. Emergencies are automatically signaled to the user.				
38. The user is required to take a specific action to leave a command loop (e.g., text editing).				
39. Command entry requires the same actions as data entry or selection of menu options.				
40. If specific control options are not displayed in a defined transaction sequence, then a standard command is provided so that the user can continue to the next step.				
41. The user is able to return easily to previous steps in a transaction sequence.				
42. The user is able to change any data that are currently displayed, unless data security considerations are involved.				
43. Command sequencing never results in a dead-end for the user.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
44. If control input is accomplished by command entry, then the user has some consistent means to request prompting for options or control parameter values not already shown on the display.				
45. Users can control inputs directly at any step in a transaction sequence without having to return to a general options display.				
46. Stacking of input or multiple entries is allowed.				
47. In command stacking, the user's inputs are in the same order as they would normally be made in a succession of separate command entry actions.				
48. Users are allowed to use user-defined macros (labeled command sequences) for frequently used command sequences.				
49. The user can stop ongoing processing and regain immediate control at any time.				
50. A CANCEL option is provided, which has the consistent effect of regenerating the current display without processing any interim changes made by the user.				
51. A RESTART option is provided, which has the consistent effect of returning to the first display in a defined transaction sequence, permitting the user to review a sequence of entries and make necessary changes.				
52. An END option is provided, which has the consistent effect of concluding a repetitive transaction sequence and returning control to a general options menu.				
53. System response time shall not be greater than 100 milliseconds. (5.1.6.5)				
54. A form-filling dialogue is used when the user is entering commands which have been written or typed previously on a hardcopy form.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
55. For delayed entry, the user is required to enter a special symbol in the field to indicate that the missing item is delayed, not overlooked. (5.1.3.5.3.k)				
56. The program allows for orderly shutdown and establishment of a check-point to ensure restoration without loss of data.				
57. Related items are grouped together. (5.1.3.5.3.b)				
58. A standard input form is used.				
59. Fields or groups of fields are separated by lines, or other delineation cues. (5.1.3.5.3.d)				
60. Field labels are easily distinguishable from data entry. (5.1.3.5.3.e)				
61. Labels for data entry fields incorporate additional cueing of data format where the entry is made up of multiple inputs, e.g., DATE (M/D/Y):___/___/___. (5.1.3.5.3.e)				
62. The cursor is advanced by a tab key to the next data entry field when the user has completed entry of the current field. (5.1.3.5.3.f)				
63. Data entry by overwriting a set of characters in a field (such as a default) is not used. (5.1.3.5.3.h)				
64. When the dimensional unit varies for a given field, it is provided, or selected, by the users. (5.1.3.5.3.j)				
65. The image of the form on the display screen looks like the hardcopy input form.				
66. Optional fields are distinguished from required fields. (5.1.3.5.3.d)				
67. When an item length is variable, the user does not have to remove any unused underscores. (5.1.3.5.3.i)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
68. When required data entries have not been entered by the user but can be deferred, their omission is indicated, and either immediate or delayed input of the missing items is allowed. (5.1.3.5.3.k)				
69. Non-entry areas are designated. (5.1.3.5.3.l)				
70. Non-entry areas of the display are made inaccessible to the user via the cursor. (5.1.3.5.3.l)				
71. The system presents only menu selections for actions which are currently available. (5.1.3.5.2.c)				
72. Menus are presented in a consistent format throughout the system. (5.1.3.5.2.d)				
73. Menus are readily available at all times. (5.1.3.5.2.d)				
74. Menu selections are listed in a logical order, or, if no logical order exists, in the order of frequency of use. (5.1.3.5.2.e)				
75. Selection codes and associated descriptors are presented on single lines. (5.1.3.5.2.g)				
76. When menu selection is employed to train in the use of a command language, the wording and order is consistent with the command language.				
77. Dependent or mutually exclusive options are grouped together.				
78. When options can be selected by coded entry, the code associated with each option is included on the display in some consistent, identifiable manner. (5.1.3.5.2.i)				
79. If menu selections must be made by keyed codes, options are coded by the initial letter or first several letters of their displayed labels. (5.1.3.5.2.j)				
80. Menu items are numbered beginning with one, not zero.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-20. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
81. At least one blank is used between the selection number and the text descriptor.				
82. Each menu frame presents a set of selectable items and a space for entering the item selected.				
83. The field for entering the selection code is separated from the menu items by at least one blank line.				
84. When the number of selections can fit on one page in no more than two columns, a simple menu is used. (5.1.3.5.2.f)				
85. When the user must step through a sequence of menus to make a selection, the hierarchic structure is designed, within the constraints of display space, to minimize the number of steps required.				
86. The current position in a hierarchical menu is indicated on the display.				
87. If selecting from a discrete set of options, these control input options are displayed at the time of selection.				
88. A standard location for the user to enter the code for the selected item is provided.				
89. An initial menu of control options is available for user selection.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. DATA DISPLAY DESIGN CHECKLIST

Test Title____
Test Project No.______________________________ Date of Test____________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Changing alphanumeric values which the operator must reliably read are not updated faster than 1 per second. (5.2.2.6.1.a)[a]				
2. Changing values which the operator uses to identify rate of change or to read gross values are not updated faster than 5 per second, nor slower than 2 per second when the display is to be considered as real time. (5.2.2.6.1.b)				
3. The rate of update is controllable by the user. (5.2.2.6.4)				
4. A display freeze mode is provided. (5.2.2.6.7)				
5. A display freeze option is provided to allow resumption at either point of stoppage or at the current, real-time point. (5.2.2.6.6)				
6. Feedback is provided to remind the operator when the display is in the freeze mode. (5.2.2.6.8)				
7. Information coding (color, shape, blinking) is used to discriminate among different classes of items presented simultaneously on the display screen and to call attention to changes in the state of the system.				
8. Coding is used for critical information, unusual values, changed items, items to be changed, high priority messages, special areas of the display, errors in entry, criticality of command entry, and targets. (5.2.2.3.1.a)				
9. Coding does not reduce legibility or increase transmission time. (5.2.2.3.1.c)				
10. Consistent, meaningful codes are used. (5.2.2.3.1.b)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
11. Brightness intensity coding is employed only to differentiate between an item of information and adjacent information. (5.2.2.3.3.a) a. No more than three levels of brightness are used. b. Each level is separated from the nearest by at least a 2:1 ratio.				
12. Pattern coding is employed to reduce operator information search time. (5.2.2.3.6)				
13. Color coding is employed where appropriate, to differentiate between classes of information in complex, dense, and critical displays. (5.2.2.3.2.a)				
14. The color selected agrees in principle with those specified for other visual tasks.				
15. Information is not coded solely by color if the data must be accessed from monochromatic as well as color terminals or printed in hardcopy versions.				
16. The colors shall be associated with the common color meanings presented in Table XV. (5.2.2.3.2.j)				
17. Color coding is generally limited to three hues; the maximum is 10.				
18. Blink coding is used for alarms.				
19. Blink coding is not used with long persistence phosphor displays.				
20. The user is able to turn off the blinking.				
21. Flash coding is employed to call the operator's attention to mission critical events only. (5.2.2.3.4.a)				
22. No more than 2 flash rates are used. (5.2.2.3.4.c)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
23. Where one rate is used, the rate is between 3 and 5 flashes per second.				
24. Where two rates are used, the second rate is less than 2 per second.				
25. No more than 10% of the display is highlighted at one time.				
26. Alphanumeric coding is used when absolute identification is essential.				
27. Emergencies or adverse conditions do not degrade the interpretation of single or combination codes.				
28. Modifiers (additional geometric forms or lines) add status (e.g., engaged, heading, etc.) to the basic symbol.				
29. Modifiers do not cross, distort, obscure, or interfere with the basic symbol.				
30. No more than two basic symbols are combined to form a new or different symbol.				
31. Symbols are analogs of the event or system element they represent or are in general use and well known to the operators. (5.2.2.3.8.b)				
32. Where size difference between symbols is employed, the major dimensions of the larger are at least 150 percent of the major dimension of the smaller with a maximum of three size levels permitted. (5.2.2.3.5)				
33. Only data essential to the user's needs is displayed.				
34. Data are presented to the operator in a readily usable and readable format. Requirements for transposing, computing, interpolating, or mentally translating into other units or numerical bases are avoided.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
35. Recurring data fields within a system have consistent names and consistent relative position within displays. (5.2.2.2.4.f)				
36. Display formats are consistent within a system. (5.2.2.2.4.d)				
37. When appropriate for users, the same format is used for input and output. (5.2.2.2.4.e)				
38. Formats for data entry match the source document formats. (5.2.2.2.4.i)				
39. Essential data, text, and formats are always under computer, not user, control. (5.2.2.2.4.j)				
40. Frame identification conforms to the following (5.2.2.2.4.o): a. Every display frame has a unique identification. b. The frame identification is an alphanumeric code or an abbreviation which is dominantly displayed in a consistent location. c. The frame identification is short enough (3-7 characters) and/or meaningful enough to be learned and remembered easily.				
41. When five or more digits and/or alphanumeric are displayed, and no natural (i.e., population stereotyped) organization exists, characters are grouped in blocks of 3-5 characters within each group. (5.2.2.4.2.c)				
42. Groups of information are separated by a minimum of one blank space or other separating character such as a hyphen or slash. (5.2.2.4.2.d)				
43. Each display is labeled with a title or label that is unique within the system. (5.2.2.4.2.n)				
44. Every field or column heading in a display is labeled. (5.2.2.4.4)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
45. Labels are displayed in upper-case only. (5.2.2.4.4)				
46. Each individual data group or message contains a descriptive title, phrase, word or similar device to designate the content of the group or message. Labeling conforms to the following (5.2.2.9.1.d(4)): a. Labels are unambiguously applied to data groups or messages. b. Labels are highlighted or otherwise accentuated. c. Accentuated labels are easily distinguishable from those used to highlight or code emergency or critical messages. d. Labels are unique to preclude operator confusion. e. When presenting a list of operator options, the labels reflect the question being posed to the operator. f. Labels are located in a consistent fashion adjacent to the data group or message they describe.				
47. The units for every variable or column heading that is displayed are marked.				
48. Data fields are arranged in a naturally occurring order (e.g., sequentially, functionally, by importance, or by frequency). (5.2.2.2.6.a(1))				
49. Separation of groups of information is accomplished by blanks, spacing, lines, color coding, or other means consistent with the application. (5.2.2.2.6.b)				
50. Data fields to be compared on a character-by-character basis are positioned one above the other.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
51. At a minimum, the last four lines on each display page are reserved for messages, to indicate errors, communication links, or system status.				
52. Displays are designed so that information relevant to sequence control is distinctive in position and/or format.				
53. The home position for the cursor is consistent across displays.				
54. Frequently appearing commands appear in the same area of the display at all times.				
55. Important or infrequent messages and alarms are enhanced by being placed in the central field of vision relative to the display window.				
56. When inserting characters, words or phrases (e.g., editing), items to be inserted are collected in a buffer area and displayed in the prescribed insert area of screen for subsequent insertion by user command. (5.2.2.4.3.a)				
57. Display mode rather than line mode is used for text editing. (5.2.2.4.3.b)				
58. Tab controls or other provisions for establishing and moving from field to field are provided for editing programs and tabular data. (5.2.2.4.3.d(5))				
59. In text editing, the special commands (e.g., move, copy) are based on sentences, paragraphs, or higher-order segments. (5.2.2.4.3.d(1))				
60. In program editing, the special commands are based on lines or subprograms. (5.2.2.4.3.d(2))				
61. Program lines reflect a numbering scheme for ease in editing and error correction. (5.2.2.4.3.d(3))				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
62. Easy to use, special editing commands, such as MOVE, COPY, and DELETE, for adding, inserting, or deleting text/program segments are provided. (5.2.2.4.3.d)				
63. Users are provided a means to search for groups of related files and to store the sorted collection into a new file for processing.				
64. In text editing, the user is able to search for synonyms and/or logical relations.				
65. If scrolling is incorporated for displaying portions of a large data base, standard commands for UP, DOWN, LEFT, and RIGHT are provided.				
66. ROLL and SCROLL commands refer to the display window, not the text/data; that is, the display window appears to the user to be an aperture moving over stationary text. (5.2.2.4.3.c)				
67. Scrolling is avoided when the user must discern a pattern (e.g., trend).				
68. When available, line by line syntax checking is under user control. (5.2.2.4.3.d(4))				
69. The content of displays within a system is presented in a consistent, standardized manner.				
70. Information density is held to a minimum in displays used for critical task sequences.				
71. Information is displayed in plain concise text wherever possible.				
72. Entry codes without any contextual meaning to the operator, when used, are no longer than four alphabetic characters or five digits.				
73. Data entries longer than seven characters are partitioned into smaller symbol groups.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
74. Abbreviations and acronyms conform to the following (5.2.2.2.3.b): a. Abbreviations and acronyms conform to MIL-STD-2525D[6] and MIL-STD-1787C[7]. b. Words have only one consistent abbreviation. c. No punctuation is used in abbreviations. d. Definitions of all abbreviations, mnemonics, and codes are provided at the user's request.				
75. A minimum of one character space is left blank vertically above and below critical information with a minimum of two character spaces left blank horizontally before and after.				
76. Irrelevant items can be eliminated from the display and recalled.				
77. When presented in tabular form, alphanumeric data are left-justified.				
78. Lists of numbers without decimals are right justified.				
79. Lists containing decimals use decimal alignment.				
80. When tabular data are divided into classifications, the classification titles are displayed and sub-classifications are identified. (5.2.2.4.6.d)				
81. When tabular data extend over more than one page vertically, the columns are titled identically on each page. (5.2.2.4.6.e)				
82. Tabular displays do not extend over more than one page horizontally. (5.2.2.4.6.f)				
83. Locations of recurring data are similar among all tabular data displayed and common throughout the system. (5.2.2.4.6.b)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
84. Tabular data are displayed in a left-to-right, top-to-bottom array. (5.2.2.4.6.c)				
85. Each item in a list starts on a new line. (5.2.2.4.7.b)				
86. Where lists extend over more than one display page, the last line of one page is the first line on the succeeding page. (5.2.2.4.7.c)				
87. Items in a list are arranged in some recognizable and useful order such as chronological, alphabetical, sequential, functional, frequency of use, or importance. (5.2.2.4.7.a)				
88. Tabular displays are broken into blocks whenever possible.				
89. Left or right justification of data entries and the justification of numeric lists on the decimal point are automatic.				
90. If a list extends beyond the amount that can be shown on one display page, a short message or symbol is provided to indicate that the list is not complete.				
91. In alphanumeric grouping, when a code consists of both letters and digits, common character types are grouped by common character type for ease of location. (5.2.2.4.2.b)				
92. Numeric punctuation conforms to the following: a. Long numeric fields are punctuated with spaces, commas, or slashes. b. Conventional punctuation schemes are used if in common usage. Where none exist a space is used after every third or fourth digit. c. Leading zeros are not used in numerical data except where needed for clarity.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-21. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
93. Textual data formats conform to the practices established for the particular type of textual data displayed; e.g., the format for display of specifications should conform to MIL-STD-961E[8].				
94. Paragraphs are numbered.				
95. Short simple sentences are used.				
96. Paragraphs are separated by at least one blank line.				
97. Text is displayed in a mixture of uppercase and lowercase letters, rather than in all uppercase.				
98. Text is left-justified.				
99. Graphic displays requiring operator visual integration of rapidly changing patterns are updated at the maximum refresh rate of the display device consistent with the operator's information handling rates.				
100. The axes of graphs are always labeled. (5.2.2.5.2.b(1))				
101. When trend lines are to be compared, multiple lines are on a single graph. (5.2.2.5.2.b(2))				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-22. DATA PROTECTION/ERROR MANAGEMENT DESIGN CHECKLIST

Test Title____

Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Sign-on processes require minimum input from the user consistent with requirements prohibiting illegal entry. (5.2.2.7.8.c)[a]				
2. User confirms aborts. (5.2.2.7.8.d)[a]				
3. When a user signals for log-off, the system checks pending transactions to determine if data loss seems probable. If so, the computer prompt for confirmation before the logoff command is executed. (5.2.2.7.8.c)				
4. If data loss seems probable due to log-off, user must confirm before command is initiated. (5.2.2.7.8.c)				
5. Erasing a file, permanently modifying data, or changing system operation requires user verification. (5.2.2.7.8.c)				
6. When command entries are subject to misinterpretation (as in the case of voice input), the user reviews and confirms the computer's interpretation of the command.				
7. Critical actions require more than one keystroke for verification.				
8. Automatic backups exist to restore files in case of a system crash.				
9. System failures do not cause errors to be entered into user data files.				
10. In the event of system failure, tasks can be performed using other methods or modes.				
11. The operator is able to stop his or her control process at any point in a sequence as a result of indicated error or as an option. (5.1.2.1.5.f)				
12. The operator is able to return easily to previous levels in multistep processes in order to correct an error or to make a desired change. (5.1.2.1.5.f)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-22. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
13. The system permits correction of individual errors without requiring re-entry of correctly entered commands of data elements. (5.1.2.1.5.a)				
14. A capability is provided to facilitate detection and correction of errors before they are entered into the system. (5.1.2.1.5.b)				
15. Error checking occurs at logical data entry breaks, e.g., at the end of data fields rather than character-by-character. (5.1.2.1.5.b)				
16. Sessions are not terminated by user error.				
17. Escape from a partially completed procedure does not lead to incorrect or accidental modification of stored data or the initiation or modification of other system functions.				
18. User errors are minimized by use of internal software checks of user entries for (5.1.2.1.5.c): a. Validity of item b. Sequence of entry c. Completeness of entry d. Range of value				
19. The system requires the user to acknowledge critical entries prior to their being implemented by the system. (5.1.2.1.5.d)				
20. All error corrections by the user are acknowledged by the systems either by indicating a correct entry has been made or by another error message. (5.1.2.1.5.e)				
21. Error messages are constructive and neutral in tone, avoiding phrases that suggest a judgment of the user's behavior. (5.1.2.1.5.e)				
22. The error messages reflect the user's view. (5.1.2.1.5.e)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-22. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
23. Error messages are appropriate to the user's level of training and are as specific as possible to the user's particular application. (5.1.2.1.5.e)				
24. Computer-corrected commands, values, and spellings are displayed and highlighted for user confirmation. (5.1.2.1.5.i)				
25. To prompt for corrections of an error in stacked commands, the system displays the stacked sequence with the error highlighted. (5.1.2.1.5.j)				
26. A procedure is provided to correct the error and salvage the stack. (5.1.2.1.5.j)				
27. When missing data are detected, the system prompts the user for these data. (5.2.2.7.8.e)				
28. When the missing data involve a relatively small set of alternatives, an argument list is provided for the user to select missing information.				
29. When the system detects an error, the cursor is automatically positioned at the field which contains the first error.				
30. Correction of an error requires an explicit action before the computer accepts the corrected inputs. (5.1.2.1.5.h)				
31. Error messages provide as much diagnostic information and remedial direction as can be inferred reliably from the error condition. (5.1.2.1.5.g)				
32. When errors occur in stacked commands, the command sequence is processed up to the error and then the user receives an indication of the problem and guidance to permit completion of the control input.				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-23. DATA ENTRY PROCEDURES DESIGN CHECKLIST

Test Title____
Test Project No.__________________________ Date of Test________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. The display/data entry system indicates to the operator (5.1.3.4.1.c)[a]: a. Acceptance of an input. b. Inadmissibility of an input. c. Existence of delay due to computer overload.				
2. Data entry is user-paced. (5.1.3.4.1.a)				
3. Data entries are validated by the system for correct format, legal value, or range of values. Where repetitive entry of data sets is required, data validation for each set is completed before another transaction can begin. (5.1.3.4.1.e)				
4. Special characters used in data entry (, * = /) are available without shifting from one case to another on the keyboard.				
5. Procedures for entering data are standardized.				
6. Data entry requires an explicit completion action, such as the depression of an ENTRY key. (5.1.3.4.1.d)				
7. The user is not required to enter data already available to the software. (5.1.3.4.1.f)				
8. Data are entered in units familiar to the user. (5.1.3.4.1.g)				
9. Right or left justification of tabular data entries is not required by the user. (5.1.3.4.2.d)				
10. A single entry device is used to eliminate time spent switching among devices.				
11. When data entry is a significant task function, it is accomplished via the user's primary display.				
12. An easy means for correcting erroneous operator entries is provided. (5.1.3.5.1.q)				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-23. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
13. In data entry, all required fields are placed before all optional fields.				
14. If several levels of hierarchical menus are provided, a direct function call capability is provided such that the experienced user does not have to step through multiple menu levels. (5.1.3.5.2.h)				
15. Users are able to enter a series of menu selections (command stack) to speed the dialogue by avoiding the need to display each menu.				
16. Prompts are (5.2.2.7.8.k): a. Clear and understandable. b. Do not require reference to coding schemes or conventions which may be unfamiliar to occasional users.				
17. Input prompts are placed in a consistent screen location if possible.				
18. A special character is used to denote an input prompt. If possible, the character is reserved to use only as an input prompt.				
19. Currently defined default values are displayed automatically in their appropriate data fields with the initiation of a data entry transaction. (5.2.2.4.5.b)				
20. A displayed cursor is positioned by the system at the first data entry field when the form is displayed. (5.1.3.5.3.f)				
21. Easy cursor movement is employed for movement from field to field as well as from line to line and character position to character position.				
22. Information necessary for the operator to select or enter a specific control action is available to the operator when selection of that control action is available. (5.1.3.5.1.h)				
23. The maximum acceptable length for variable length fields is indicated. (5.1.3.5.3.g)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-23. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
24. Dimensions (e.g., size, speed, etc.) consistently associated with a data field are a fixed label and do not have to be entered by the user.				
25. Spelling and other common errors do not produce valid system commands or initiate transactions different from those intended. (5.1.2.1.5.i)				
26. The user is permitted to enter the full command name or an abbreviation for any command of more than 5 characters. (5.1.3.5.5.e)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-24. FEEDBACK DESIGN CHECKLIST

Test Title____
Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Feedback is provided to the operator to indicate the status of system functioning. (5.1.2.1.4.a)[a] Feedback conforms to the following: a. During a delay the operator receives periodic feedback. (5.1.2.1.4.b) b. Positive indication is presented to the operator about the outcome of the process and the requirements for subsequent operator actions. (5.1.2.1.4.c) c. Selected items from a display are highlighted to indicate acknowledgement by the system. (5.1.2.1.4.l) d. Feedback is provided to indicate the reason for input rejection and the required corrective action. (5.1.2.1.4.k) e. Feedback is self explanatory. (5.1.2.1.4.n)				
2. Confirmation of user input occurs without removing the data display. (5.1.2.1.4.j)				
3. When multiple modes of operation are possible, some method is provided to remind the user of the current operating mode. (5.2.2.1.1.)				
4. The log-on frame is presented immediately after connection regardless of user input.				
5. If the baud rate is less than 250 wpm (reading rate), more compact (i.e., shorter, more succinct) messages are used.				
6. Output abbreviations are avoided.				
7. Abbreviations used are consistent.				
8. Terminology inconsistent with user expectations is avoided.				

[a] Numbers in parenthesis refer to paragraphs in MIL-STD-1472G.

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-24. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
9. Alarm signals and messages are distinctive and consistent for each class of events.				
10. Both the old and new values are displayed simultaneously before stored data entry items are changed.				
11. A status message indicates the current functions of multiple-purpose special function keys.				
12. Control values currently operative are displayed for user reference.				
13. Information concerning control options specifically appropriate at any step in a transaction sequence is provided for the user.				
14. Error messages appear as close physically as possible to the user entry that caused the error.				
15. Prompting messages are displayed in a standardized area of the displays. (5.2.2.7.8.i)				
16. Prompts and help instructions for system controlled dialogue are explicit. (5.2.2.7.8.j)				
17. On-line documentation, offline documentation, and help sequences use consistent terminology. (5.2.2.7.7)				
18. All error messages are listed and explained in the off-line system documentation.				
19. A dictionary of abbreviations and codes is available on-line. (5.2.2.7.5)				
20. After accessing help, the user is provided with an easy way to return to the main dialogue.				
21. Default values are used to reduce user workload. (5.2.2.4.5.a)				
22. The user indicates acceptance of the default. (5.2.2.4.5.c)				

APPENDIX A. SAMPLE DESIGN CHECKLISTS.

TABLE A-24. CONTINUED

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
23. The user has the option of generating default values based on operational experience. (5.2.2.4.5.e)				
24. The user can replace any default value during a transaction without changing the current default definition. (5.2.2.4.5.d)				
25. Users can accept stored data or default values by a simple means such as a single, confirming keystroke. (5.2.2.4.5.c)				
26. Prompting and structuring features conform to the following (5.2.2.7.8): a. When operating in special modes, the system displays the mode designation and file(s) being processed. b. Requests which would result in extensive, final and permanent changes to existing data require acknowledgement. c. System prompts for missing data.				

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APPENDIX B. SAMPLE TASK CHECKLISTS.

TABLE B-1. FEEDBACK TASK CHECKLIST

Test Title____

Test Project No.____________________________ Date of Test__________________________

DETAILED DESIGN CONSIDERATIONS	YES	NO	N/A	COMMENTS
1. Load discs, tapes or other storage media				
2. Initialize system				
3. Boot program				
4. Display master menu				
5. Display subordinate menu				
6. Identify/select function from existing menu				
7. Call-up/display file				
8. Print file				
9. Create new file				
10. Edit file				
11. Delete/purge file				
12. Format data prior to input				
13. Input data				
14. Store/retrieve data				
15. Transmit/receive message via keyboard/screen				
16. Transmit/receive message via teletype/printer				
17. Transmit/receive message via communications system				
18. Scroll screen forward/backward to preview/review content				
19. Transfer screen content to peripheral device (e.g., printer)				
20. Transfer screen content to other screen (i.e., intra-station or inter-station transfer)				
21. Transfer data from one screen area to another				
22. Display log of recent activities				
23. Analyze/plot data				
24. Detect errors				
25. Determine cause of errors				
26. Correct errors				
27. Exit program				
28. Terminate session				

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APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

SCI USER INTERVIEW GUIDE

NAME____ RANK_____________ DATE_______________
(First) (M.I.) (Last)

MOS ____________________________________ TIME IN MOS__________________________

WORKSPACE

1. Do you ever find that your work area is not arranged to aid you in performing your assigned tasks?

   Yes _________

   No _________

   If yes, please explain: ____
   ____
   ____
   ____

2. Do you ever have difficulty reading displays, labeling, or documents because of poor lighting or glare?

   Yes _________

   No _________

   If yes, please explain: ____
   ____
   ____
   ____

3. Do you experience any arm, neck, or back fatigue while performing your assigned tasks?

   Yes _________

   No _________

   If yes, please explain: ____
   ____
   ____
   ____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

INPUT AND OUTPUT DEVICES

1. Do the controls provide you with the speed and accuracy to input data and perform other assigned task?

   Yes ________

   No ________

   If yes, please explain: ____
   ____
   ____
   ____

2. Do you feel that another type of control would be better?

   Yes ________

   No ________

   If yes, what type and why? ____
   ____
   ____
   ____

3. Can the information on the displays be easily read and interpreted?

   Yes ________

   No ________

   If no, what causes the difficulty? ____
   ____
   ____
   ____

   What would make it easier? ____
   ____
   ____
   ____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

DATA DISPLAY

1. Do you always have enough information to do your job?

   Yes ________

   No ________

   Please explain: ____
   ____
   ____
   ____

2. Are there ever times when the information presented is more than you used?

   Yes ________

   No ________

   If yes, when: ____
   Does this interfere with performing your job? Please explain: ________________________
   ____
   ____
   ____

3. Is the organization of information displayed helpful for doing your job?

   Yes ________

   No ________

   If not, what would you change and why? ____
   ____
   ____
   ____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

4. Have you ever found information coding to be a problem?

Yes ________

No ________

If yes, when? ____
____
____
____

5. Do the symbols used in this system ever confuse you?

Yes ________

No ________

If yes, which ones and why? ____
____
____
____

6. Is there anything that you can think of that you don't like about the software?

Yes ________

No ________

Please explain: ____
____
____
____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

USER INPUT

1. Have you ever had any problems entering data?

   Yes ________

   No ________

   If yes, what was the problem and when did it occur? Please explain: ________________
   ____
   ____
   ____
   ____
   ____

2. Would you change anything about the way you enter data?

   Yes ________

   No ________

   If so, what would you change? Please explain: ________________________________
   ____
   ____
   ____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

FEEDBACK AND ERROR HANDLING

1. Are the displayed messages ever confusing or difficult to remember?

   Yes ________

   No ________

   Please explain: ____
   ____
   ____
   ____

2. Do error messages give you enough information to correct your errors?

   Yes ________

   No ________

   Please explain: ____
   ____
   ____
   ____

3. Is there anything about the way the system handles errors or provides feedback that you would change?

   Please explain: ____
   ____
   ____
   ____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

4. Can you always correct errors you have made while entering information into the computer?

Yes ________

No ________

Please explain: ____
____
____
____

5. Can you always return to your place in the program after seeking help?

Yes ________

No ________

Please explain: ____
____
____
____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

INTERACTIVE CONTROL

1. Are the menus formatted so that you can quickly and easily select options?

   Yes ________

   No ________

   Please explain: ____
   ____
   ____
   ____

2. Can you always retrieve the information you need from the computer database?

   Yes ________

   No ________

   If no, please explain: ____
   ____
   ____
   ____

3. Have you ever had any problems moving or positioning the cursor?

   Yes ________

   No ________

   If yes, when? ____
   ____
   ____
   ____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

COMMAND METHODS

1. Is the command language confusing or difficult to use?

   Yes ________

   No ________

   If yes, when? ____
   ____
   ____
   ____

2. Are there enough computer commands which specify various functions to accomplish your job?

   Yes ________

   No ________

   If no, please explain: ____
   ____
   ____
   ____

3. Are there computer commands available that are not needed to accomplish your job?

   Yes ________

   No ________

   If yes, what are they? ____
   ____
   ____
   ____

APPENDIX C. SAMPLE SCI USER INTERVIEW GUIDE.

GENERAL

1. Are there any other comments regarding the usability of the soldier-computer interface which you would like to make?

   Yes ________

   No ________

   If yes, what are they? ____
   ____
   ____
   ____

APPENDIX D. GLOSSARY.

Term	Definition
Abort	A capability that cancels all user entries in a defined transaction sequence.
Address	Specific location where instructions or data are stored.
Alphanumeric	Pertaining to a character set that contains both letters and numerals.
Analog	Is similar or comparable.
Application	The system or problem to which a computer is applied. Reference is often made to an application as being either of the computational type, wherein arithmetic computations predominate, or of the data processing type, wherein data handling operations predominate.
Arithmetic and Logic Unit (ALU)	The part of the CPU logic chip that actually executes the operations requested by an input command 1 is called the arithmetic and logic unit (ALU) since, in every case, some combination of arithmetic and/or logical operations is required. Another part of the CPU chip logic, the control unit, decodes the instruction (stored in the instruction register) in order to enable the required ALU logic and, thus, implement the arithmetic and/or logical operations required by the instruction.
ASCII (American Standard Code for Information Interchange)	A standard 8-bit information code used with most computers and data terminals. It may be used in the parallel mode (all bits present simultaneously on separate lines) or the serial mode (one bit at a time on a single line).
Backup	A capability that returns the user to the first display in a defined transaction sequence.
Baud	A measure of the transmission speed capability of a communications line or system, in a sequence of binary signals, 1 Baud = 1 Bit/sec.
Binary	A numbering system based on 2 which uses only the digits 0 and 1 when written, also it is a characteristic, property, or condition in which there are but two possible alternatives; e.g., the binary number system using 2 as its base and using only the digits 0 and 1.

APPENDIX D. GLOSSARY.

Term	Definition
Bit	A binary digit; hence, a unit of data in binary notation. In the binary numbering system, only two marks (0 and 1) are used. Each of these marks is called a binary digit.
Brevity	Information presented to the operator or entered by the operator that is grouped into short, readily understandable units.
Buffer	An area of computer memory for temporary storage of an input or output record.
Byte	A generic term to indicate a measurable portion of consecutive binary digits; e.g., on an 8-bit byte, it is considered as a unit of memory size.
Cancel	A capability that regenerates (or re-initializes) the current display without processing any entries or changes made by the user.
Cathode Ray Terminal (CRT)	A terminal which has a keyboard for data input and a display screen. Also used to describe a type of terminal in which an electronic vacuum tube energizes phosphors on a screen.
Central Processing Unit (CPU)	The unit of a computing system that contains the circuits that control and perform the execution of instructions.
Character	The actual or coded representation of a digit, letter, or special symbol but not a space.
Code	A system of symbols and rules for use in representing information.
Command	A pulse, signal, or set of signals that occur in a computer as the result of an instruction and which initiate one step in the process of executing the instruction. From the user's perspective, the instruction or request used to initiate a computer action.
Command Language	A type of dialogue in which the user formulates control entries with minimal prompting by the computer.
Command Stacking	The process of queuing up multiple commands before execution. The computer then executes the commands in sequence without requiring any interaction by the operator.

APPENDIX D. GLOSSARY.

Term	Definition
Communication	The process of transferring information in the various media from one point, person, or device to another.
Compatibility	When a system is able to work together with the workspace, input and output devices, and software to accommodate the user needs.
Computer	A device capable of accepting information applying prescribed processes to the information and supplying the results of these processes. It usually consists of input and output devices storage arithmetic and logical units and a control unit.
Control Action	An action taken by the user to alter the state of the system.
CRT-ARI	A cathode ray tube used for indicating the azimuth and range of a target. It is typically used on radar systems and used to be called PPI (plane position indicator).
Cursor	The cursor on the video display terminal (VDT) screen is a position-marking symbol, such as solid block or underscore. It may blink or be brighter than other symbols to identify its location easily. It shows the "current" item for attention, which may designate a displayed item. The cursor may be positioned under computer control or moved by the user through the keyboard.
Data	A general term used to denote any or all facts, numbers, letters, and symbols that refer to or describe an object, idea, condition, situation, or other factors. It connects basic elements of information which can be processed or produced by a computer. Sometimes data are considered to be expressible only in numerical form, but information is not so limited.
Data Processing	Any procedure for receiving information and producing a specific result, and also the rearrangement and refinement of raw data into a form suitable for further use. The preparation of source media which contain data or basic elements of information, and the handling of such data according to precise rules of procedure to accomplish such operations as classifying, sorting, calculating, summarizing, and recording.
Database	The collection of information or data that is stored in the central computer for relatively long periods of time.

APPENDIX D. GLOSSARY.

Term	Definition
Database Management	A systematic approach to storing, updating, and retrieval of information stored as data items, usually in the form of records in a file, where many users, or even many remote installations, will use common data banks.
Data Display	Output of data from a computer to its users, it is generally visual output, but it may be qualified to indicate a different modality, such as an "auditory display".
Data Entry	User input of data from paper documents to computer-based records for computer processing.
Data Field	An area of the display screen reserved for user entry of a data item.
Debug	To locate and correct any errors in a computer program, or to detect and correct malfunctions in the computer itself. If mistakes are revealed, they must be traced to their source and corrected.
Default Value	A predetermined, frequently used, value for a data or control entry, intended to reduce required user action.
Delete	The ability to remove extraneous or erroneous material from screen or memory, simultaneously eliminating the gaps which would otherwise be formed.
Delimiter	A special character used to denote a boundary between adjacent syntactic components of a program; for example, a slash (/).
Dialogue	A structured series of interchanges between a user and a computer terminal. They can be computer-initiated, e.g., question and answer, or user-initiated, or command language.
Digit, Binary	A whole number in the binary scale of notation; this digit may only be 0 (zero) or 1 (one). It may be equivalent to an "on" or "off" condition, a "yes" or a "no," etc. The word "bit" is a contraction of binary digit.

APPENDIX D. GLOSSARY.

Term	Definition
Disk	A circular metal plate with magnetic material on both sides, continuously rotated for reading or writing by means of one or more read/write heads mounted on movable or fixed arms; disks may be permanently mounted on a shaft, or as a package, they may be removable and others placed on the shaft.
Diskette	A thin flexible platter (floppy disk) coated with magnetic material used as the storage medium in a floppy disk.
Display Coding	A means of highlighting displayed segments such that one segment is differentiated from other segments.
Dot Matrix Characters	Are character images on a CRT display screen that are represented by rectangular cells composed of dots arranged in rows and columns from which characters can be composed by causing some of the dots to glow, while permitting others to remain dark.
Enter	An explicit user action that affects computer processing of user entries. For example, after typing a series of numbers, a user might press a specially marked ENTER key that will add them to a data base, subject to data validation.
Feedback	A response from the system which informs the user of the status of the current request or command.
Field	A set of characters of fixed or variable length that form a single unit of data entry.
File	A collection of related records treated as a unit. In a computer system, a file can exist on magnetic tape, disk, punched paper tape, punched cards, or as an accumulation of information in system memory. A file can contain data, programs, or both.
Fixed Function Key	A function key that is not readily changeable.
Flexibility	A system is flexible to the degree that individual differences in skill are encompassed to ensure optimal performance of all users under all anticipated conditions.

APPENDIX D. GLOSSARY.

Term	Definition
Flicker	The sensation of brightness or color variation caused by the perceived dimming and brightening of the character images as they are refreshed on the display screen.
Format	A predetermined arrangement of characters, fields, lines, punctuation, and page numbers.
Formatting	The structuring of the display screen into protected and accessible areas within which various actions can be performed in fields.
Glare	A visual condition caused by excessive luminance variations within the field of vision, e.g., when bright sources of light such as windows or lamps or their reflected images fall in the line of sight.
Graphic Display	A display of data in the form of lines, shapes, and symbols such as graphs, histograms, maps, etc.
Hard Copy	A printed paper copy of the information displayed on the display screen.
Hardware	The physical equipment which makes up a computer system, e.g., CPU, terminals, and other input/output (I/O) and storage devices, as opposed to the programming software.
Help	A capability that displays information upon user request for on-line guidance. HELP may inform a user generally about system capabilities, or may provide more specific guidance on what to enter in the field currently indicated by the cursor.
Hierarchical	Arranged in a set of levels; tree-structured.
Illuminance	The amount of light falling on a surface. It is measured in units of Lux (lx) or foot candles (ft-C).
Input	The information or data transferred, or to be transferred, from an external storage medium into the internal storage of the computer.
Input Devices	Devices that convert facts into electronic impulses.

APPENDIX D. GLOSSARY.

Term	Definition
Input/Output	Commonly called I/O and a general term for equipment used to communicate with a computer and the data involved in such communication.
Insert Area	The physical area of the screen where data are displayed prior to entry into the data base.
Instruction	A coded program step that tells the computer what to do for a single operation in a program.
Interface	An electronic device which enables one piece of equipment to communicate with or control another.
Joystick	A movable handle which a human operator may grasp and rotate to a limited extent in one or more degrees of freedom, and whose variable position or applied force is measured and results in commands to a control system. Isotonic joysticks operate by displacement and isometric joysticks operate by applied force, not movement.
Keyboard	Any computer input device that utilizes keys. This includes alphanumeric keyboards, keypads, and control panels composed of legend switches.
Keypad	A small keyboard or section of a keyboard containing a smaller number of keys, generally those used on simple calculators. These 10-, 12-, or l6-key units are often the simplest input devices to microcomputers or function as an extension of ASCII keyboards to permit more extensive computational capability.
Label	One or more characters used to identify a statement or an item of data in a computer program.
Languages	A software framework of commands for writing a program.
Luminance	The amount of light emitted by a light source. It is measured in candela per square meter (cd/m^2) or foot lamberts (ft-L).

APPENDIX D. GLOSSARY.

Term	Definition
Memory	The part of a computer, internal to the CPU, where programs and data are stored.
Menu	A collection of items, e.g., a list or directory of the contents of a given file, from which the operator may select. The selection may be made by entering a code, word, or number associated with the selection.
Numeric Keypad	An arrangement of the 10 numeric keys in the standard telephone arrangement 1, 2, 3 across top row; 4, 5, 6 in second row; 7, 8, 9 in third row; with 0 on the bottom row.
Output	The result of a computer program action that is sent to a display, printer, or other device.
Output Devices	The part of a machine that translates the electrical impulses representing data processed by the machine into permanent results such as printed forms, punched cards, and magnetic writing on tape or disk.
Page	The information appearing at one time on a single display screen.
Parameter	A quantity, or constant, whose value varies with the circumstances of its application. A quantity with variable values used in determining other variables.
Phosphor	A coating of luminescent material which emits visible light when struck by a beam of electrons within an evacuated glass tube such as a CRT.
Program	A set of instructions for handling data that is input into the system. Level “a” is the language used to write programs. Level “b” is programs combined to handle a specific application.
Real Time	A speed sufficient to give an answer within the actual time the problem must be solved.
Record	A set of one or more consecutive fields on a related subject, as an employee's payroll record. Although a record need not be a block in length, such an arrangement is often useful.

APPENDIX D. GLOSSARY.

Term	Definition
Reflectance	The ratio between the quantity of light that is reflected from a given surface and the total quantity of light that is incident on the same surface.
Reflected Glare	A glare condition caused by the reflection of bright sources of light, like windows, etc., from illuminated surfaces within the field of vision.
Refresh	A technique used to regularly energize the phosphor coating in the CRT in order to ensure an apparently continuous and stable, but in fact transient image.
Refresh Rate	The frequency with which the image on the face of the CRT is refreshed.
Response Time	The elapsed time between the generation of an inquiry at a data terminal and the receipt of the response at the same terminal.
Scrolling	Where information is recalled from the display memory and displayed on the CRT. There are three basic types of scrolling: line, screen, and page. In line scrolling, the information is updated on the screen one line at a time. In screen scrolling, information is updated for the visible screen. If the system is designed properly, a part of the old screen remains as a reference. In page scrolling, an entire page is updated. A page is usually more information than is visible to the operator on the display.
Software	The term for all programs that run on the computer.
Storage	A device capable of receiving data, retaining them for an indefinite period of time, and supplying them upon command.
System	A computer plus its output devices, input devices, connectors, modems, and software.
Tabular Display	Data presented in row/column format.
Terminal	An input/output (I/O) device for transmitting or receiving data on a communication line. Data are usually entered via a keyboard, and are usually displayed via a video screen or printer.

APPENDIX D. GLOSSARY.

Term	Definition
User	Any person who uses an information system in performing his/her job.
Variable	A quantity that can assume any of a given set of values.
Variable Function Key	A function key that is readily changeable, e.g., keys that are displayed electronically on a CRT.
Word/Byte/Nibble	Terms that are often misused in describing microprocessor data. For a specific microprocessor, a word is the number of bits associated with the instruction or data length. This can be 4 bits, 8 bits, 16 bits, etc., depending on the machine. A byte specifically refers to an 8-bit word; a byte can be manipulated by a 4-, 8-, or l6-bit microprocessor. For example, instructions are often provided to deal with byte data in 4-or l6-bit processors. This is called byte handling, and is independent of the natural word size of the machine. A nibble is 4 bits, and it takes 2 nibbles to make a byte. Nibble (or 4-bit) control can be found on many 8-bit word machines as well as one some 16-bit machines. Four-bit operations are usually associated with hexadecimal (HEX) or binary coded decimal (BCD) operations.
Workload Reasonability	A system has a reasonable workload to the extent that the tasks required by the operator are within the operator's capability and require the operator to perform a useful, meaningful role.

APPENDIX E. ABBREVIATIONS.

AEC	U.S. Army Evaluation Center
ALU	Arithmetic and Logic Unit
ASCII	American Standard Code for Information Exchange
ATEC	U.S. Army Test and Evaluation Command
BCD	binary coded decimal
cd/m^2	candela per square meter
cm	Centimeter
CPU	central processing unit
CRT	cathode ray tube
dB	Decibel
DT	developmental testing
DTP	Detailed Test Plan
ECWCS	Extreme Cold Weather Clothing System
EPROM	erasable programmable read-only memory
EWI	Electronic Warfare Intelligence
ft-C	foot candles
ft	foot
ft-L	foot lamberts
ft-lbs	foot pounds
HEDGE	Human Factors Engineering Data Guide for Evaluation
HEX	hexadecimal
HFE	human factors engineering
HRPP	Human Resource Protection Plan
Hz	hertz
I/O	input/output
in-lbs	inch pounds
ITOP	International Test Operations Test Procedure
LED	light emitting diode
lx	Lux

APPENDIX E. ABBREVIATIONS.

MIL-HDBK	Military Handbook
MIL-STD	Military Standard
mm	millimeter
MOS	military occupational specialty
MPU	micro-processing unit
MTBF	mean time between failures
NA	not applicable
NASA	National Aeronautics and Space Administration
NBC	nuclear, biological, chemical
N m	Newton meter
oz.	ounce
PPI	plane position indicator
PROM	programmable read-only memory
ROM	read-only memory
rpm	revolutions per minute
SCI	Soldier-computer interface
SEP	System Evaluation Plan
SME	subject matter expert
SOMTE	Soldier, Operator, Maintainer, Test and Evaluation
SR	Safety Release
TIR	test incident report
TLX	Task Load Index
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee
VDT	video display terminal
VDU	visual display unit

APPENDIX F. CHECKLIST IDENTIFICATION AID.

Purpose: This form is to be used in conjunction with Table 3 of this TOP, during the identification of design checklists and checklist sections.

Directions: For each classification listed in Table 3 that is applicable to the test item, mark off the corresponding checklist numbers and section letters on the list presented below. Once you have marked off a number, it is not necessary to mark it off again. At the conclusion, there should be a comprehensive list of those checklists that are applicable to the test item.

CHECKLIST NUMBERS

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23

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APPENDIX H. APPROVAL AUTHORITY.

CSTE-TM 27 January 2015

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 01-1-059A, Soldier-Computer Interface, Approved for Publication

1. TOP 01-1-059A, Soldier-Computer Interface, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

The material in this TOP is intended to provide guidance for the planning and conduct of a human factors engineering assessment of the Soldier-computer interface, during developmental testing. The procedures and criteria contained herein will assess the adequacy of those aspects of the software, hardware, and workspace design for the test function of operability that influence operator performance in a computer-based system.

2. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: U.S. Army Electronic Proving Ground, 2000 Arizona Street, Fort Huachuca, Arizona 85613-7063 Additional copies can be requested through the following website: http://www.atec.army.mil/publications/topsindex.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.