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SPECIFICATION FOR A DISPLAY CONSOLE WITH ELECTRONIC AND PROJECTED DISPLAYS

NOVEMBER 1966

J. Mitchell
G. C. Kinney

Prepared for

DEPUTY FOR ENGINEERING AND TECHNOLOGY
DIRECTORATE OF COMPUTERS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

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Project 508G and
Project 7030

Prepared by

THE MITRE CORPORATION
Bedford, Massachusetts

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FOREWORD

Some of the credit for this work goes to M. DiBartolomeis who prepared most of sections 3.2 and 3.3 and parts of section 4.

Note also that sections 1 and 2 of the specification have not been written. Preparation of these sections is quite routine as long as careful attention is paid to the choice of referenced documents.

ABSTRACT

The specification for a console sets forth requirements for displays electronically generated from digital data supplied by a computer or the operator and for displays generated by optical projection from film chips. The requirements are stated quantitatively, with tolerances, in a manner readily susceptible to verification by test procedures which are standard or are explained in detail. Means for verifying all requirements are given. This specification may serve as a model for display equipment specifications although a number of questionable areas are pointed out and the detailed requirements will depend upon the particular applications.

REVIEW AND APPROVAL

This technical report has been reviewed and is approved.

CHARLES A. LAUSTRUP
Colonel, USAF
Director of Computers

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SECTION I

INTRODUCTION

The body of this document contains a specification for a console capable of presenting, on a CRT phosphor, displays derived from digital data and displays optically projected from film chips through the rear of the CRT. The display may be shown individually or several displays may be superimposed. The digital data may be supplied by an associated computer or by the operator. The operator is provided with an extensive set of controls for generating displays even in the absence of a computer and for communicating with a computer when one is present. He also has a set of indicator lights to show him the status of the console and of the system.

This specification was originally written to replace an inadequate specification for Operations Control Consoles. Although it was not used for this purpose, it has been published to show how a reasonable specification for display equipment could be written. It is recognized that the requirements of this specification are not all that could be desired. In particular, the following requirements should probably be changed as indicated.

a. The methods of conducting legibility and discriminability tests are being improved constantly. Future specifications should include these improvements.

b. It is not established that optical projection is the best approach for displaying reference data (e.g., maps) superimposed on electronically generated displays. Other systems have successfully used closed circuit television for this purpose, and means of generating such displays from digital data may yet be developed.

c. The details of how the interrupt capability is to be implemented should be more explicit. Interrupts are not normally possible through the 1414 I/O synchronizer specified.

d. The character set has been chosen for mathematical work; other character sets may be more desirable for other applications.

e. The requirement for straight vectors, while reasonable, needs more clearly stated methods of measurement; the measurement procedure is certainly troublesome and should be received.

f. The number and variety of controls and indicators requires more study. One existing system, at the RAND Corporation, uses only a single pushbutton in addition to a switch on the electronic stylus (RAND Tablet), and is able to handle both alphanumerics and graphics. The console specified herein has over 100 controls and indicators; perhaps the functions of many of these could be performed using "light" switches and indicators displayed on the CRT.

g. The magnification and off-centering requirement may be unnecessarily expensive.

SECTION II

SPECIFICATION FOR CONSOLE

3.1.1 Functional Characteristics

The Operations Control Console shall provide visual images on the surface of a CRT from both an electronic display generator and a projection display generator. It shall provide controls enabling the operator to modify the display and to communicate with an associated computer. The computer shall be able to modify the display and communicate with the operator.

The electronic display generator shall use digital data, received from either computer or operator and stored in a memory, to regenerate displays containing alphanumeric characters, and vectors, circles and points.

The projection display generator shall select a film slide from a magazine and optically project the image of this slide superimposed on the image generated electronically.

The operator's controls shall enable him to modify the display by deleting, adding, and changing displayed items. He shall also be able to interrupt the associated computer in order to transmit display data, requests for more or different data, or commands to the computer program.

The computer shall be able to send data to the console memory for display and shall control certain indicators on the console. It shall also be able to receive data from the console memory, from operator-controlled keys, and from status indicators in the console. The computer shall be connected to the console through an interface unit which shall not be a physical part of the console. This arrangement will facilitate attachment to a variety of computers through different interface units.

3.1.1.1 Primary Performance Characteristics

3.1.1.1.1 Display Surface

The display surface for both electronic and projection displays shall be the screen of a CRT. The display area useable for electronic display shall be not less than ten (10) inches by ten (10) inches and preferably not less than twelve (12) inches by twelve (12) inches. The useable area for the projection display shall have the same dimensions as for the electronic display, within plus or minus 1 percent.

The surface of the CRT, its implosion shield, and of any other surfaces between the phosphor and the observer shall be treated so as to reduce specular reflections and emitted electromagnetic radiation. The anti-reflective treatment of the surface nearest the observer shall be equivalent to the HEA coating of the Optical Coating Laboratory sufficient to meet the requirements of section 3.1.1.1.3.1. The emitted radiation shall comply with the requirements of section 3.3.9.

Choice of a phosphor for the CRT shall be subject to the approval of the contracting officer.

3.1.1.1.2 Electronic Display Data

3.1.1.1.2.1 Positioning and Point Display

The console shall be able to display symbols at any position defined by the intersections of 512 vertical and 512 horizontal lines, each set of lines equally spaced so as to fill the horizontal (X) and vertical (Y) dimensions of the useable display area, respectively.

The origin of the coordinate system shall be the lower left corner of the useable area.

It shall be possible to display points at any one of the 512 x 512 intersections of the coordinate grid defined above. The distances measured horizontally and vertically between two displayed points, having coordinates $\left(X_1, Y_1\right)$, and $\left(X_2, Y_2\right)$, shall be

$$\left|\frac{X_2 - X_1}{511}\right| \times D_x \quad \text{and} \quad \left|\frac{Y_2 - Y_1}{511}\right| \times D_y ,$$

within plus or minus 1 percent, respectively. The terms D_x and D_y represent the horizontal and vertical dimensions of the useable area, and the two points may be any two within the coordinate system, each coordinate value (c) meeting the requirement $0 \leqq C < 512$.

3.1.1.1.2.2 Alphanumeric and Special Characters

3.1.1.1.2.2.1 Displayable Characters

The console shall be able to simultaneously display at least 63 different alphanumeric and special characters. These characters shall be as follows:

Upper case alphabet A-Z	26
Numerals Ø → 9	10
Punctuation . , ; : () [ ] ? ' '	11
Mathematical - + = > < → ↑ ← ↓	9
Special $ / \ * % Δ ∇	7
	63

Since the set of 63 symbols specified above is not sufficient for all tasks that will be performed with this console, it is required

that other symbols, presently unspecified, be available. This capability may be achieved either by providing for a maximum of 127 symbols (using a 7-bit symbol code), or by making provision for the rapid and economical change in the appearance of at least 20 symbols (not including the alphanumerics). For example, the code which normally requires the display of, say, "$", may call for the display of, say, "&." Such a change is preferably accomplished by changes in the data stored in the console memory rather than by changes in equipment.

3.1.1.1.2.2.2 Character Size

There shall be two sizes of characters simultaneously displayable. The larger size shall be two (2), plus or minus 10 percent, times larger than the smaller. The size of the characters shall be adjustable by a maintenance adjustment. The range of adjustment for the height of the smaller characters shall be between a minimum of not more than 0.1 inch and a maximum of not less than 0.2 inch; character width shall be adjustable from less than 0.08 to more than 0.15 inches.

3.1.1.1.2.2.3 Character Display Formats

In a series of displayed characters, the first symbol space (see 6.1.1) shall be located at explicitly specified X and Y coordinates; either the center or the lower left corner of the symbol space may be so located. Successive characters whose codes are given without explicit coordinate data shall be displayed a fixed increment to the right of the previous character; this increment shall be twice as great for the larger characters as for the smaller. The increment shall be automatically generated and shall not be explicitly coded for each character. A series of characters so specified is termed a "string."

When the row of characters thus formed is about to extend beyond the useable display area, the next character shall be displayed a fixed increment (dependent upon character size) below this row and at the left side of the useable area, unless explicit coordinate data are supplied. If such a row would fall below the useable display area, then the top row in the useable area shall be used.

Provision shall be made to permit the magnitude of the horizontal and vertical increments to be changed by a simple maintenance procedure or by a change in data stored in the console.

3.1.1.1.2.2.4 Legibility Requirements

It is necessary to guard against deficiencies in the legibility of alphanumeric and special characters appearing on the display surface. This section specifies the requirements for acceptable speed and error tolerance with which human viewers must identify displayed symbols appearing alone and in groups. Section 6.1 provides definitions of some of the terms used, procedures for selecting and training subjects, and general information on test data collection and summarization. Section 4.1.3.4 describes the test procedures which shall be used.

The alphanumeric and special characters tested shall be of a height subtending an angle of from 14 to 18 minutes of arc at the eye of the subject.

The test shall be conducted at both minimum and maximum settings of the operator's brightness control. The requirements apply to symbols shown at all points in the useable display area.

In a legibility test conducted on the alphanumeric characters alone (26 upper case alphabetic letters and 10 numerals), the

total errors (non-diagonal matrix cell entries) shall not exceed 3 percent of the total number of showings. No non-diagonal cell entry shall be greater than 3 and no diagonal cell entry shall be less than 46. (Section 4.1.3.4.1 gives the number of subjects and number of showings to be used.) Should any symbol fail to meet the requirement for matrix cell entry values, the test may be rerun after symbol modifications are approved by procuring activity. The legibility requirement shall be met for both isolated symbols and for symbols appearing in groups as defined in the test requirements of section 4.1.3.4.

These legibility requirements shall also be met when the projection display (section 3.1.1.1.4) is turned on. For this requirement, the brightness of the display screen resulting from the projected display shall be in the range of 6 to 8 ft. Lamberts. The projected display shall be of uniform brightness such as may be achieved with an appropriate neutral density film chip of uniform photographic density.

The special symbols shall meet a similar legibility requirement, where the permissible total number of errors is the integer which is equal to or less than 3 percent of the total number of showings in the test. At the option of the procuring activity, those symbols which are unlikely to be confused in context, e.g., "(" and ")" may be deleted from the test.

The alphabetic characters shall meet a word legibility test as specified in 4.1.3.4, such that no subject shall make more than 7 errors in identification and all subjects shall make fewer than 31 errors, or, if the alternative reading time test is used, the average reaction time shall be equal to or less than 0.60 second and no subject's average shall exceed 0.85 second.

3.1.1.1.2.3 Vectors

A vector shall be a straight line on the CRT; it shall not deviate by more than 2 percent of its length or 0.05 inch, whichever is greater, from a straight line drawn between points having the same coordinates data as the origin and termination of the vector. Vectors shall be of two types which may differ in width, brightness, or construction (e.g., dotted or solid). Vector types shall be discriminable, one from the other, according to the requirements of section 3.1.1.1.2.4.1. The console shall be capable of drawing vectors between any two of the coordinate positions defined in section 3.1.1.1.2.1. It shall be possible to draw a series of connected vectors by specifying an origin for the first followed by a series of end points for the successive, connecting vectors. A series of vectors so specified is termed a "vector string."

Vector stroke width shall be not more than that used for the smaller character size, plus or minus 30 percent.

3.1.1.1.2.4 Circles

The console shall be capable of displaying circles. The distance of any point on the circle from a point displayed at the center of the circle shall be equal to the nominal radius of the circle within plus or minus 5 percent or 0.02 inch, whichever is greater. The console shall be capable of displaying sixty-four (64) sizes of circles varying in diameter from 0.1 to 6.5 inches in increments of 0.1 inch. Circles of two different types shall be displayable, where the types differ in the same way as the vector types. Circle line width shall be the same as vector stroke width, plus or minus 10 percent, as measured with the same techniques.

A circle shall be displayed given the coordinates of its center and the desired radius (or diameter).

3.1.1.1.2.4.1 Line Type Discriminability

The two line types specified in the last two paragraphs shall be discriminable according to the requirement of this paragraph. The two available types of lines shall be clearly discriminable, one from the other. In attempting to identify line types using the procedures of section 4.1.3.4.2, no subject shall make more than one error in identification of each line type, and the total number of errors shall be less than 5 percent of the total number of showings.

3.1.1.1.3 Electronic Display Characteristics

For all specified measurements of brightness or illumination, the contractor shall demonstrate, and at all times use, a method of measurement acceptable to the contracting agency. The use of electronic, electrical or visual photometers without demonstration of adequate calibration is unacceptable. For example, Spectra Brightness Spot Meters and Pritchard Photometers, used to measure the brightness of small areas or symbols on the CRT, shall be demonstrated to yield identical values when reading the brightness of a known source of larger area and to have equivalent optical energy distribution through an appropriate aperture in an opaque mask, where the mask is illuminated so as to be the equivalent in brightness and spectral energy distribution of the surrounds of the small area or symbol on the CRT. Visual.photometers, such as the MacBeth Illuminometer, are acceptable provided that the measured values offered as meeting the specification shall be the mean of three consecutive readings made by each of no less than three and no more than five observers with normal vision, corrected or uncorrected. Repeated readings are permissible

by any one observer who shows a personal mean value within 10 percent of the mean established for the three, four, or five qualified observers previously offered.

The brightness of symbols displayed on the console shall be at least sufficient to meet the requirements of sections 3.1.1.1.2.2.4 and 3.1.1.1.2.4.1. Maximum available brightness shall be not less than 20 ft. Lamberts. Brightness shall be variable by the display operator between the limits of 5 ft. Lamberts and the maximum; it is undesirable for the operator to be able to extinguish the display.

With no display appearing on the screen, its brightness (with 8 foot-candles of incident white light) shall be no more than 1 ft. Lambert.

At any setting of the brightness control, no displayed symbol shall have a brightness less than seventy (70) percent of the brightness of the brightest symbol, where all brightness measurements are made with a Pritchard meter at a constant distance from the CRT on the normal to the CRT at the symbol.

The display shall be fast enough to generate within 1/60 second the number of displayed items of each type indicated in the following sub-paragraphs. (These numbers are mutually exclusive; it is not necessary to generate the sum total of all of these numbers in 1/60 second):

a. 3000 alphanumeric and/or special characters in a text format;

b. 125 circles of any size;

c. 500 connected vectors having a total length of at least 1500 inches;

d. 250 unconnected vectors having a total length of at least 750 inches;

e. 500 points;

f. 500 alphanumeric and/or special characters, each individually positioned; and

g. proportional combinations of any of the above.

Displays containing data in amounts up to these quantities shall be regenerated a constant number of times per second, but not less than 60 times per second.

3.1.1.1.4 Projection Display Data

The projection display shall be capable of presenting rear-projected images on the CRT screen, derived from both black and white and from color film slides. Throughout the useable display area common to both display generation systems, the image projected shall register to within 1 percent of the full-scale dimensions of this area; points having the same coordinates shall be displayed within 1 percent of the area's dimensions of each other.

3.1.1.1.4.1 Legibility Requirement

Images presented by means of the projection display shall meet the same legibility requirements as those presented by the electronic display for characters of the same size.

3.1.1.1.5 Projection Display Characteristics

The brightness available from the projection display shall be sufficient to meet the requirements of section 3.1.1.1.4.1. Maximum available brightness shall be at least 80 ft. Lamberts, with no

film in the projection station. The brightness of the projected image shall be variable down to 1/8 of maximum or 10 ft. Lamberts, whichever is less; the brightness control may be either continuous or stepped by factors of two (plus or minus 20 percent) for each available step.

When observed from a distance of thirty (30) inches from the CRT on the normal to its center, the brightness of any point within the useable area of the projection display shall be less than 1/2 the maximum brightness observable from this position, with no film in the projection station.

The resolution of the projected image shall be at least 125 line pairs per inch, determined by projecting a standard photographic resolution chart into the CRT screen and visually examining the displayed image.

3.1.1.1.6 Operation Functions

The operator shall have available to him controls for generating, modifying, and deleting displays, whether or not the console is connected to an external computer. These controls shall include an alphanumeric keyboard for the entry of alphanumeric and digital data, a set of keys for generating graphic displays, a set of keys for manipulating displayed data, a lightgun for identifying displayed items, and a position identifying device for locating positions on the face of the CRT.

The operator shall have controls available for communicating with a computer connected to the console. These controls shall include a set of keys whose system function will be determined by the computer program as well as the lightgun for identifying displayed items and the position identifying device.

The operator shall have on the console's front panel a set of indicator lights controlled by the computer for showing him the status of the system.

3.1.1.1.6.1 Display Generation Functions

The operator shall be able to command the display of a point at any position in the display area by specifying 'Point' and specifying the coordinates with his position-identifying device or, digitally, by using the alphanumeric keyboard or an auxiliary numeric keyboard. The point shall appear on the screen, at the designated location, as soon as the location designation is complete.

The operator shall be able to command the display of vectors. He shall be able to designate any position on the display area as the origin of a vector and any other position, or series of positions, as end points to generate a single vector or a series of connected vectors. He shall also be able to select the line type to be shown. In specifying these points, he shall be able to use either his position-identifying device or the numeric keyboard. Each vector shall appear as soon as its end point is specified. Termination of a series of vectors shall be effective upon the start of some other operation.

The operator shall be able to command the display of circles, entering the required circle size either from the numeric keyboard or from a set of switches chosen for this purpose (one or the other means shall be provided; not both) and entering the coordinates of the center of the circle using either the position sensing device or the numeric keyboard (both means shall be provided). The circle shall appear as soon as its center coordinates are supplied.

The operator shall be able to command the display of individual characters by specifying a position, as above, and a character, using the alphanumeric keyboard. He shall also be able to call for the display of rows of characters by specifying an initial position, as above, and then simply entering successive characters from the alphanumeric keyboard, each character being displayed one position to the right of the previous, as soon as it is selected. During the process of entering characters, a marker symbol shall be displayed under or over the location in which the next character will appear on the screen (in the next character space to the right of the previous character or at the left of the row next below the present row).

The operator shall be provided with keys to control the motion of this marker symbol. He shall be able to advance (space) forward, backspace, advance downward a row at a time (index), advance to the beginning of the next lower row (carriage return effect), and backspace a row at a time (reverse index). Each of these controls shall permit not one-step incremental spacing at a time but, if depressed more firmly, shall permit motion to be repetitive at a rate of ten (10) to twenty (20) steps per second.

The operator shall have available a mode of operation which will facilitate his ability to enter data from the alphanumeric keyboard into spaces left in messages sent by the computer. Operation of the space marker key, or a special key reserved for this use, shall advance the marker to the next space, in a message designated as available for the insertion of data. As before, he may enter data into the character string; such data shall remain visually different from the remainder of the display to permit the operator to see easily what he has inserted. Upon completion of such entries, it is anticipated that the operator will request the computer to read the inserted data.

The entry of a string of alphanumeric characters shall be terminated by some other operator action.

The operator shall be able to enter data into the console memory from a punched paper tape reader, or equivalent, which shall be part of the console system

3.1.1.1.6.2 Display Manipulation Functions

The operator shall be able to manipulate displayed items as described in the following paragraphs.

3.1.1.1.6.2.1 Erase

The operator shall be able to erase individually displayed items, strings of connected items (vectors or characters), or the entire display. He will identify the item or string to be erased by using the lightgun. If any member of a string is so identified, the whole string shall be erased. Portions of the display, other than the item or string erased, shall be unaffected.

3.1.1.1.6.2.2 Delete

The operator shall be able to delete an individually displayed item in a string of items, designating the item to be deleted with the lightgun or the marker symbol. The displayed items remaining in the string shall be readjusted to compensate for the deleted symbol (i.e., if a vector is deleted, its end point shall be discarded and a new vector drawn from its origin to the next end point; and, if a character is deleted, all subsequent characters shall shift one place left to close up the gap).

3.1.1.1.6.2.3 Magnification

The operator shall be able to simultaneously scale both the electronic and projection displays by factors of 2^n and to

simultaneously displace the center of the resultant display independently in each direction by amounts $\pm m.2^{-n}$ ($m = 0, 1, \ldots, n$), where n is an integer equal to zero, and one (1) at least. Such scaling shall not affect the spacing between characters in a string or their size. Nor will such scaling affect the registration requirement of section 3.1.1.1.4.

3.1.1.1.6.2.4 Move

The operator shall be able to change the position of any displayed symbol, or string of symbols, by identifying the symbol(s) to be moved and identifying a new position with either the position identification device or the numeric keyboard. A whole string shall be moved if one of its members is identified in this manner.

3.1.1.1.6.2.5 Repeat

The operator shall be able to produce copies of displayed items or strings by designating the item or a member of the string to be reproduced and designating a position for the copy. Both the original, in its original position, and the copy, in the designated position, shall then be displayed.

3.1.1.1.6.2.6 Slide Selection

The operator shall be able to command the display of any slide within the magazine mounted in the projector by specifying its number either with the numeric keyboard or a set of special switches (one or the other shall be useable, not both).

3.1.1.1.6.2.7 Display Selection

The console memory shall be capable of storing at least four complete displays, each having the display capacity specified in section 3.1.1.1.3, together with the necessary control data to permit the

operator and computer functions specified in sections 3.1.1.1.6 and 3.1.1.1.7, It is desirable that the subdivision of the memory into different displays be flexible in the sense that the capability exists for storing at least two full displays, or a larger number of smaller displays, the division between blocks of display data being determined by data stored in the console memory.

The operator shall have facilities for selecting, for display, any of the blocks of display data in the memory core.

3.1.1.1.6.3 Computer Communication Functions

3.1.1.1.6.3.1 Interrupts

The display operator shall be able to send interrupts to the associated computer. Several of the console controls shall be capable of generating such interrupts, but which devices are capable at any given instant shall be a function of the state of the system. The computer shall be able to enable and disable the interrupt capability of these controls, and the operator shall be able to disable them. For example, the lightgun shall be capable of generating an interrupt when enabled by the computer program, but the operator shall have the ability to prevent the interrupt should he wish to use the lightgun for one of the display generation functions described above.

Actions consequent upon an interrupt are determined by the computer program.

3.1.1.1.6.3.2 Input Keyboard

The operator shall be provided with a keyboard containing not less than 25 keys. The settings of these keys shall be available to the computer for transfer to its program. The functions of the keys are dependent upon the computer program; they shall not have any fixed console functions.

The keys shall be labelled to indicate their program-defined function to the operator; the computer program shall be able to sense which set of labels is in use by the operator in order to determine how the program should react. These labels shall be readily replaceable by the operator. The system shall permit the use of at least 63 different sets of labels for the keys.

The keys or their labels shall be individually illuminated, and these lights shall be under control of the computer program so that the program may direct the operator's attention to a selected set of functions available to him.

The keys shall be capable of generating interrupts to the computer when operated; the enabling of the interrupt capability shall be independently set for each key by the computer program. The operator shall not be able to prevent the transmittal of such an interrupt.

3.1.1.1.6.3.3 Lightgun

The operator shall be able to use the console's lightgun in order to identify any displayed symbol or string of symbols, to the computer. Used in this manner, the lightgun shall generate an interrupt to the computer when it is enabled by the program.

3.1.1.1.6.3.4 Marker

The marker symbol shall provide a method of identifying individual characters in a character string to the computer program. Insertion of the marker shall not, in itself, cause an interrupt.

3.1.1.1.7 Computer Functions

When the console is on-line to a computer, the computer shall, by transferring data to it, be able to effect a number of functions.

3.1.1.1.7.1 Electronic Display Generation and Control

Data from the computer shall be able to generate any display that the operator is able to generate (see section 3.1.1.1.6.1) and shall be able to perform any of the display manipulations that the operator can perform (section 3.1.1.1.6.2), using data transfers to replace the operator's manual actions.

3.1.1.1.7.2 Projection Display Control

The computer program shall be able to select any of the slides available in the film magazine for projection. It shall also be able to determine which slide is presently on display and which slide magazine is in the projector.

3.1.1.1.7.3 Console Status Control

The computer program shall be able to control the status of the console by starting and stopping either or both display generators, illuminating system status lights, and illuminating and controlling the use of the operator's computer input keyboard.

3.1.1.1.7.4 Blinking

The computer shall be able to make any symbol or string of symbols blink at a rate of about 2 cycles per second in order to draw the symbol(s) to the attention of the operator.

3.1.1.1.7.5 Existing Computer Programs

A number of display programs have been written for the 1410 computer. The console supplied under this procurement shall be capable of using these programs to generate the intended displays.

3.1.1.2 Secondary Performance Requirements

3.1.1.2.1 Film Slide Requirements

3.1.1.2.1.1 Film Chips

The projection display system shall be designed to handle a standard size of 70-mm film chips, and shall have a normal aperture (image size) of 80mm by 60mm. In order to meet the requirements of section 3.1.1.1.1., the projection system shall be capable of filling the useable display area, with the 60-mm square image in the center of the normal chip aperture. The image stored on the film chip shall be free of intended distortion, such as keystoning.

3.1.1.2.1.2 Film Chip Magazines

The set of film chips selectable by either computer or operator at any one time shall be stored in a magazine mounted in the projector system. The capacity of this magazine shall be at least 100 film chips.

The time required to display a new chip shall be less than 10 seconds, independent of the position of the chip in the magazine.

Film chip magazines shall be readily replaceable. It shall require no more than 20 seconds for a skilled operator to interchange magazines.

During the time that a film chip is being changed, the projection display shall be blanked so that no motion of the projected display is visible to the user.

3.1.1.2.2 Detailed Requirements for Operator Controls

3.1.1.2.2.1 Alphanumeric Keyboard

The alphanumeric keyboard shall have the dimensions and key arrangement typical of an office typewriter.

3.1.1.2.2.2 Lightgun

The lightgun, which may be more pencil-shaped than gun-shaped, shall be a lightweight, hand-held instrument connected to the console by a lightweight and flexible cable. In use it shall project an aiming mark onto the CRT phosphor. This aiming mark shall clearly indicate the area on the phosphor which the lightgun "sees" (i.e., the area within which displayed items can be detected).

When used to identify a displayed symbol or string, operation of a "trigger" on the gun shall be required in order to enable the detection logic. When a detection is made with the lightgun enabled, the symbol detected (or the string, if a member of a string was detected) shall change in visual appearance in order to show the operator what has been detected. The change may, for example, be an increase in brightness to a clearly discriminable level, or a blinking action, at a rate clearly discriminable from the blinking specified in section 3.1.1.1.6.2.4. The change shall be momentary or shall continue until a subsequent operator action; the operator shall be able to choose which of these changes shall occur.

3.1.1.2.2.3 Position Identifying Device

The operator must be able to identify, to the console and to the computer program, positions on the face of the CRT, whether or not displayed symbols are shown at that position. The position-identifying device may be a displayed cursor symbol, which the operator can position

anywhere in the useable display area by means of a tracking ball, or equivalent. When it is positioned to the operator's satisfaction, it shall indicate to the console that this is the position of interest. Alternatively, the position-identifying device may be the lightgun (pencil) used in a position mode.

Use of the position-identifying device should not affect the appearance of the other displayed items, except to the extent that a displayed symbol used by this device (such as a cursor symbol) may overlap other displayed items.

The operator shall be able to identify any position on the CRT face within an average time of less than 2 seconds, where he starts his operation in the same location (e.g., the lower left corner) each time he attempts an identification.

3.1.1.2.3 System Status Indicators

The console shall have a set of 25 to 30 indicating lights which shall be turned on and off under the control of the computer program.

3.1.1.2.4 Modes of Operation

Four modes of console operation are required as follows.

3.1.1.2.4.1 Off

The main circuit breaker is open.

3.1.1.2.4.2 Off-Line

This mode of operation is available whenever the OFF/STANDBY/OPERATE switch (see section 3.1.1.2.5) is in the OPERATE mode and the console is not in the process of receiving data from, or transferring data to, the computer. It may even be completely

disconnected from the computer. In this mode, all of the requirements of section 3.1.1.1.1 through 3.1.1.1.6, inclusive, shall be met.

3.1.1.2.4.3 Input

The console is in the act of transferring data to the computer, such data transfers having been initiated by either the computer or the operator.

3.1.1.2.4.4 Output

The console is in the act of receiving data from the computer. Whenever the console enters Output Mode, a light on the console shall be illuminated and an alarm shall sound for 1 to 2 seconds. The light shall be extinguished when the operator takes any console action as defined in 3.1.1.1.6.

3.1.1.2.5 OFF/STANDBY/OPERATE Switch

The console shall be provided with a three-position key-operated switch. Operation of the switch in the counterclockwise direction (toward OFF) shall be possible without a key. Operation of the switch in the clockwise position shall be possible only with a key. It shall be possible to remove the key in any position of the switch.

When the switch is in the OFF position, the console shall be in the mode defined in 3.1.1.2.4.1 above.

When the switch is in the STANDBY position, the console shall be operable only in the Output Mode defined in 3.1.1.2.4.4, but all console power shall be on except for the high voltage power for the CRT and the projection lamp power.

If the console enters Output Mode while in the STANDBY condition, the light on the console front panel shall be illuminated and the alarm shall sound continuously until disengaged by the switch as it is turned to the OFF or OPERATE positions.

No operator inputs to the console memory or the computer shall be possible and no interrupts to the computer shall be possible in STANDBY.

When the switch is in the OPERATE position, any of the modes defined in sections 3.1.1.2.4.2, 3.1.1.2.4.3, and 3.1.1.2.4.4 shall be possible.

3.1.2 Operability

3.1.2.1 Reliability

Failure of the console is defined as any inability to meet the requirements of section 3.1.1.1 of this specification.

The mean Time Between Failures shall be not less than 300 hours.

3.1.2.1.1 Reliability Program

The contractor shall conduct a reliability program in accordance with the requirements of MIL-R-27542A, as modified below, in order to meet the MTBF requirement of section 3.1.2.1

Para. of MIL-R-27542A	Notes
2.1	Delete reference to MIL-W-9411. Change MIL-STD-803 to MIL-STD-803A-1.
3.2.2	Failure rate data and reliability estimating techniques shall be obtained from MIL-HDBK-217 and the RADC Reliability Notebook, PB 161894, wherever possible.
3.2.3	Delete. Note that the requirements of MIL-M-26512C, paragraph 3.6, allow for approved trade-off between reliability and maintainability.
3.3.2	The channels of communication between the reliability and maintainability organization(s) and design, test, and quality control engineering shall be described.
3.5.1.2	Delete.
3.5.1.3	Delete.
3.5.2	Delete.
3.5.4	Delete.
3.5.5	Details of subcontractor activities and relationships shall be included in the periodic progress reports required under paragraph 3.5.14.
3.5.6	Delete.
3.5.9	Degradation factors shall be developed and used, where applicable, in the mathematical models required by 3.2.2. The reliability requirement applies to installed, operational equipment.
3.5.10.2	The program plan shall describe the contractor's design review system.

3.5.10.4	A summary of the results of each review shall be included in each regular progress report.
3.5.11.1 through 3.5.11.4	Delete.
3.5.11.5	The program plan shall describe the contractor's change order system, especially the method for reliability and maintainability review.
3.5.12.c	Failure report summaries shall be included in the periodic reports required by paragraph 3.5.14. The summaries shall group and list failures by cause. Repetitive failures shall be identified and corrective action described.
3.5.13.1	Delete.
3.5.13.2	The reliability of the console(s) shall be demonstrated by operating one or more consoles for 600 hours in the expected environment. During this period, approved scheduled maintenance cycles shall be used. The reliability shall be considered adequately demonstrated if there is no more than one failure during this test. Acceptance, rework, or rejections shall be at the discretion of the procuring activity if there is more than one failure.
3.5.14	The interval between reliability status reports shall not exceed two months. Maintainability data and reports shall be related to and combined with reliability status reports. Repetition is to be avoided; loose leaf binding is preferred with only changes and additions submitted after the first report. The final report shall include (but not be limited to) the following items.

a. Predicted reliability and maintainability of the system.

b. Measured reliability and maintainability, with the appropriate level of confidence, including details of the demonstrations.

c. Summary of the R/M program through the course of the contract.

d. Conditions affecting R/M.

e. Features of the system which are weakest from the standpoint of R/M.

f. Methods for sustaining system R/M during use.

g. Recommendations for improvements.

h. Justification of the claimed Useful Life (see paragraph 3.1.2.3 of MIL-D-27948).

3.1.2.2 Maintainability

The console(s) shall be considered "available" if it is capable of meeting the requirements of section 3.1.1.1. The availability of the console(s) shall be not less than 0.987, where equation (7) of section 60.4.2.1 of MIL-M-26512C shall be used to determine availability. Maintenance personnel will be Air Force-5 level technicians under Air Force-7 level supervision. The criteria of MIL-STD-803A-1 shall be followed.

In order to achieve the required availability, the contractor shall conduct a Maintainability Program as required by MIL-M-26512C as modified below.

Para. of MIL-M-26512C	Notes
3.2	Quantitative evaluation is much preferred over qualitative. The values used to determine the optimum mix shall be presented and justified in the Reliability/Maintainability Program Plan and Reports.
3.4	Maintainability considerations shall be an integral part of the analysis required under Paragraph 3.2.2 of MIL-R-27542A and of the reports required under Paragraph 3.5.14 of MIL-R-27542A.
3.4.2.4	The maintainability program plan shall be a part of the R/M Program Plan. One maintainability analysis is required in this plan rather than the two suggested in Paragraphs 3.4.1 and 3.4.2 of MIL-M-26512C. The Program Plan shall include the elements required in 3.5.1.
3.5	These requirements are called out under the provisions of Paragraph 3.4.2.4 as amended above. Review and update shall be a part of the progress reports required under 3.5.14 or MIL-R-27542A.
3.5.1.j	See DD Form 1423.
3.6	Change "affect" to "effect" in the last line. The documentation and justification required shall be a part of the Progress Reports.
3.9	Change "affect" to "effect" in the second line.
4.2	Detailed plans for demonstrating maintainability as part of this test shall be submitted to the procuring contracting officer for approval.

30.3	The control points shall be: 1. Submission of R/M Program Plan. 2. Milestones established under 3.4 of MIL-R-27542A. 3. Detailed test plan and summary confirmation of maintainability to be submitted at least 90 days before the start of the R/M demonstration. 4. Final R/M test report submitted as a separate section of the Category I test report.
30.3.2	This is a continuous activity with milestones as noted above.
30.3.3	Delete.
30.3.4	The requirements of this paragraph shall be met at control point 3.
30.3.5	The requirements of this paragraph shall be met at control point 4.
40.1	Change "Control Point 4" to "control point 3".
40.2.2c	40.2.2d applies.
40.2.3.1	Delete.
40.2.4a	$K = 0.20$. $\emptyset = 1.282$.
50.2	Line 2, change M_{ct} to $\overline{M}_{ct}$. Line 3, change M_{pt} to $\overline{M}_{pt}$.
50.2.c	Use 8640 hours.

50.3.1 Delete. The upper limits of the computed means shall be used for $\overline{M}_{ct}$ and $\overline{M}_{pt}$. From these compute

$$f_c = \frac{8640 - \overline{M}_{ct} \cdot f_c - \overline{M}_{pt} \cdot f_p}{300}$$

obtaining f_p from the preventive maintenance schedule. Compute A_i using the equations in section 60.4.2.1. If A_i is greater than 0.987 and no preventive maintenance routine requires more than 30 minutes, then the equipment shall be considered ready for the maintainability tests required in section 4.1.4. If these requirements are not met, the decision to accept, reject, or require rework of the consoles shall lie with the procuring activity.

3.1.2.2.1 Maintenance and Repair Cycles

No preventive maintenance routine shall require more than half an hour.

3.1.2.2.2 Service and Access

The design of console and the interface unit shall permit ready access to circuit test points, pluggable circuits, and maintenance controls, both for routine and for corrective maintenance. Test points for all pluggable circuits shall be accessible without unplugging the circuit. Critical test points shall be brought out to one location - maintenance test panel - insofar as practical. Visual indication of the contents of critical digital registers shall be available on this test panel. Switches may be used to select one of several control flip-flops or registers at the test points and indicators. Such switching shall not disturb the state of the flip-flops.

The maintenance test panel shall also have facilities enabling a technician to operate the console manually, step by step in order to observe sequences of events in detail. There shall be provision for halting the operation of the console upon the occurrence of conditions which are considered especially significant in attempting to trace faulty operation. Such conditions may, for example, include the occurrence of a reference to a memory address selected by the technician or the occurrence of a memory data format selected by the technicians.

There shall be provision for marginal testing of the console logic by facilitating manual changes in power supply voltages.

3.1.2.2.2.1 Status Indicators and Tests

The console operator shall be provided with a set of lights which shall be illuminated upon the occurrence of certain failures in the console (e.g., power supply failure, memory timing failure). Occurrence of any of these failures shall also cause an alarm to sound until turned off by the operator. This alarm shall be clearly distinguishable from the alarm described, section 3.1.1.2.4.4. The operator shall also be provided with test controls which will enable him to carry out rapid confidence checks on the console's operation. These shall include a lamp-test switch to test all console lamps.

3.1.2.3 Useful Life

The useful life of the console shall be at least seven (7) years, assuming an average operating time of 100 hours per week. The design of the console shall facilitate its connection to different interface units to permit its operation with a variety of computers. The interface between console and interface unit shall be simple and independent of the computer associated with it.

3.1.2.4 Environmental

3.1.2.4.1 Ambient Temperature

Operating	$+10^{\circ}C$ to $+38^{\circ}C$.
Non-operating	$-35^{\circ}C$ to $+52^{\circ}C$.

3.1.2.4.2 Humidity

Operating	0% to 90% relative humidity.
Non-operating	0% to 100% relative humidity, including condensation. The console may be dried for four hours before turning it on subsequent to the occurrence of condensation.

3.1.2.4.3 Lighting

Operating	The console shall meet the requirements of section 3.1.1 in rooms with 40-foot candles of white incandescent or fluorescent light vertically incident 30 inches above the floor, measured with a cosine corrected meter.

3.1.2.5 Transportability

The console and interface units shall be transportable by either commercial or military carriers, including truck, rail, and air freight. Particularly fragile parts of the console may be packed separately for such shipment.

The console shall be provided with casters and a floor lock to facilitate its movement within a facility. It shall be possible to move the console and to interface units with a fork lift truck without crating them.

3.1.2.6 Human Performance

The design and arrangement of console controls and indicators shall facilitate the operator's performance of the functions specified in section 3.1.1.1. The design criteria of MIL-STD-803A-1 shall be followed.

3.1.2.7 Safety

3.1.2.7.1 Personnel Safety

The requirements of MIL-STD-803A-1, section 13, are a part of this specification.

3.1.2.7.2 Equipment Safety

The design of the console shall be such as to minimize the extent to which failure of one component or assembly causes failures of other components or assemblies.

3.1.2.8 Noise

The noise levels produced by the console and interface units shall not exceed those specified in MIL-E-4158C, section 3.2.10, condition C.

3.2 Definition

3.2.1 Interface Requirements

Initially, the Operations Control Console shall interface electrically and functionally with an IBM 1410 computer. Two or more consoles shall operate with the IBM 1410 computer through the IBM 1414-1 or 1414-7 I/O Synchronizer. The Console Interface Buffer (CIB), to be provided by the

contractor, shall provide the required interface between the I/O Synchronizer and the computer. The CIB shall appear as an IBM 729 IV tape unit to the 1414 I/O Synchronizer. A description of the 1414 I/O Synchronizer interface is given in IBM Reference Manual, 1414 Input-Output Synchronizer.

It shall be possible to use the consoles with other computers (e.g., IBM System/360 models) through new or modified CIB's. The console shall be capable of handling data rates up to a maximum of three (3) million bits per second.

3.2.1.1 Schematic Arrangement

A block diagram of the 1410 Computer/OCC configuration is shown in Figure 1. Each CIB shall be capable of accommodating at least two consoles.

The CIB's shall be connected to the 1414 much as the 729 Type IV tape units are connected to the 1414.

3.2.1.2 Detailed Interface Definition

3.2.1.2.1 General

Each CIB shall provide intermediate buffering between the 1414 I/O Synchronizer and the consoles, and shall provide electrical connections for at least two OCC's. Each OCC shall be capable of operation up to 500 feet from the CIB. The cable and cable connectors between the 1414 I/O Synchronizer and the CIB shall be provided by the contractor. The cable length and type of connectors will be specified by the procuring activity at the time of the Development Engineering Inspection (DEI). This cable length will not exceed 100 feet.

3.2.1.2.2 Prime Power

Prime power to the console and CIB will be provided to the facility which will house the computer-console system. The prime power will be 3-phase, 120 volts (± 10%) line to neutral, 60 (± 3%) hertz.

Power dissipation in the console and CIB shall not exceed 3000 watts.

The contractor shall supply the power cable and connectors. Cable length and type of cable connectors will be specified by the procuring activity at the time of the Development Engineering Inspection (DEI).

3.2.1.2.3 Cooling

The console and CIB shall draw in room ambient air for cooling and shall dissipate no more than (10,500) BTU/hr into the facility cooling system. The quantity of room ambient air required for cooling shall not exceed 500 CFM, with inlet air temperature of 72°F and outlet air temperature of not more than 100°F.

3.2.1.2.4 Electrical Interface

The CIB shall transfer data between the 1410 computer and the console at a rate of 62,500 characters per second. This interface shall transfer data in parallel groups of seven bits, where six bits contain data and the seventh bit is an odd parity bit for the parallel group.

In the output mode, the CIB shall use the clock pulses (Write Pulses) from the I/O Synchronizer to stroke the contents of the Write Buses into a register. Data transfer from the console to the computer shall be controlled by a clock in the CIB or OCC. A detailed description of the I/O

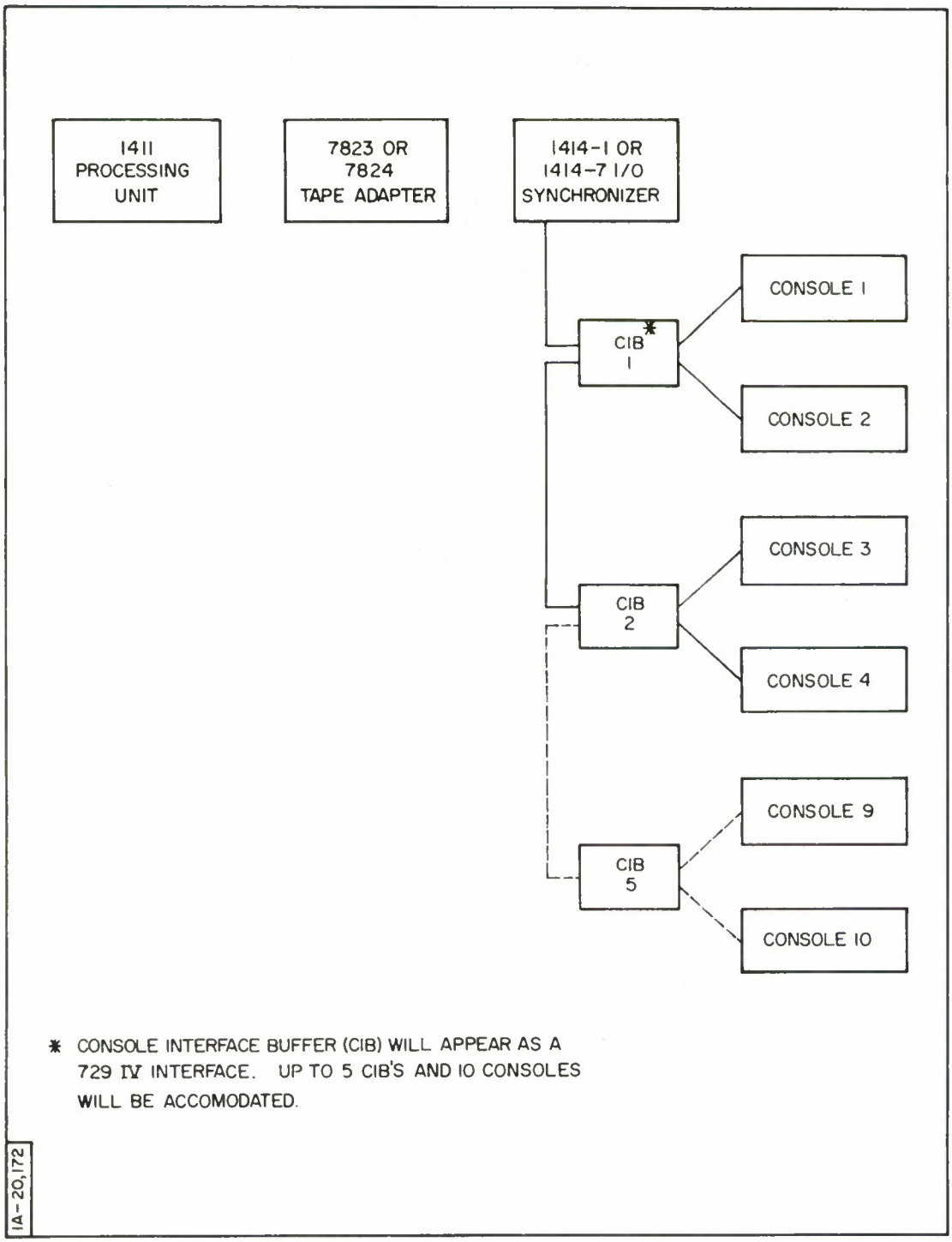

Figure 1. Equipment Configuration and Interface

Synchronizer electrical operation is given in the IBM Customer Engineering Instruction – Reference for the 1414 Input-Output Synchronizer (Models 1, 2, and 7).

The number and descriptions of the electrical interface lines and cables required between the 1414 I/O Synchronizer and the console shall be determined by the contractor and shall meet the requirements of data transfer as described in this specification.

The interface unit shall be compatible with the 1414 I/O Synchronizer signals, timing, and logic.

3.2.1.2.5 Parity Generation and Checking

Parity shall be checked by the console on all data transfers from computer to console. Each character [parallel seven- (7) bit group of bits] transferred from console to computer shall include an odd parity bit. A parity error symbol shall be displayed in any position, where the identity of a symbol destined for that position is indeterminate because of a detected parity error or illegal operation of the keyboards. The parity symbol shall be intermittently displayed at a 5 to 10 cps rate with a 50-percent duty cycle.

3.2.2 Component Identification

3.2.3.1 Government Furnished Property

1. (List computer programs to be provided to contractor.)

2. Sample film chips for projector.

3.3 Design and Construction

The console shall be designed and constructed for use in ground-based, fixed installations that provide a reasonable degree of environmental control.

Specification MIL-E-4158C shall be the guide for the design and construction. However, the requirements for environmental conditions specified in section 3.1.2.2.4 and other design requirements specified elsewhere in this document shall not be compromised.

3.3.1 General Design Features

The general design features of the console shall be consistent with the practices set forth in AFSCM 80-5 and MIL-STD-803A-1.

The console shall be contained in one (1) cabinet, with the exception of the Console Interface Buffer (CIB) which shall be contained in one (1) cabinet. It shall be possible to transport the console cabinet and the CIB through 36-inch wide doorways without console or CIB disassembly.

With the exception of the CRT, solid-state circuits shall be used throughout the design of the console, including the CIB.

3.3.1.1 Physical Design

3.3.1.1.1 Console Cabinet

The console cabinet shall meet the following physical requirements.

a. Maximum Size: Sixty-one (61) inches high by fifty (50) inches by thirty-five (35) inches (not including working shelf holding the several keyboards and other controls). The control panel shall extend no more than eighteen (18) inches from the front of the cabinet, and may be retractable or removable in order to meet the requirements of 3.3.1.

b. Maximum Weight: Fourteen hundred (1400) pounds.

3.3.1.1.2 CIB (Console Interface Buffer) Cabinet

The Console Interface Buffer cabinet shall meet the following physical requirements.

a. Maximum Size: Thirty-six (36) inches high by twenty-four (24) inches wide by twenty-four (24) inches deep.

b. Maximum Weight: One hundred and seventy-five (175) pounds.

3.3.1.1.3 Floor Loading

Floor loading for the console and CIB cabinets shall not exceed four hundred and fifty (450) pounds for any floor caster.

3.3.1.2.3 Access Panels

The design shall provide for access on all four sides of the console and at least the front and rear of the CIB for normal maintenance and serving functions. The access panels shall be easily removable.

3.3.1.3 Finish and Color

Finishes on the console and CIB cabinets shall be in accordance with MIL-F-14072. Exterior finishes shall be as described below.

a. All exterior surfaces and keyboard areas, exclusive of the display framing areas, shall be finished in accordance with FED-STD-595. The finish number, luster, and gloss factors will be provided to the contractor for the Development Engineering Inspection.

b. The display framing areas shall be black anodized, dull finish.

3.3.2 Selection of Specifications and Standards

All standards and specifications to be used in the construction of the console and CIB shall be those established and/or approved for use by the USAF. The specifications and standards for materials, parts, and processes

not specified herein shall be in accordance with the order of preference stated in MIL-STD-143.

3.3.3 Materials, Parts, and Processes

The materials, parts and processes shall be as specified herein. Materials used in the console and CIB shall conform to the requirements of paragraph 3.4 of MIL-E-4158C. Parts used in the console and CIB shall be selected in conformance with the requirements of paragraph 3.3 of MIL-E-4158C. Processes used in the fabrication of the console and CIB shall conform to paragraph 3.5 of MIL-E-4158C, with the exception of paragraph 3.5.7.3 therein.

Materials and parts not covered by applicable specification shall be the best commercial quality, the lightest practicable weight, and suitable for the purpose.

3.3.4 Standard and Commercial Parts

The requirements of MIL-E-4158C, paragraph 3.3, are a part of this specification. Where Qualified Products List (QPL) parts are not available or suitable, high-quality commercial parts shall be used after approval by the procuring activity on the suitability of such commercial parts.

3.3.5 Moisture and Fungus Resistance

The requirements of MIL-E-4158C, paragraph 3.2.26, are a part of this specification. Materials that are not nutrients for fungus shall be used wherever possible. If it is necessary to use nutrient materials, and the requirements of MIL-E-4158C are not applicable, prior approval of the procuring activity for their use is required. These nutrient materials shall be treated by a method which will render the resulting exposed surface fungus-resistant.

3.3.6 Corrosion of Metal Parts

Dissimilar metals shall not be used in intimate contact unless suitably protected against electrolytic corrosion. Surfaces of metal parts shall be given a protective finish against corrosion wherever necessary.

Materials subject to oxidation and corrosion shall be treated as follows.

a. Stainless Steel - All stainless steel shall be passivated.

b. Non-Stainless Steel - Non-stainless steel shall receive a coat of primer/sealer and be covered with a finish coat of paint.

c. Aluminum - Aluminum shall be treated with either an anodized or an irridite coating. When irridite is used, the part shall receive a primer and finish coat of paint, if required.

d. Copper - All exposed copper shall be tinned.

3.3.7 Interchangeability and Replaceability

Interchangeability and replaceability requirements defined in MIL-D-70327, paragraph 6.3.14, are a part of this specification.

3.3.8 Workmanship

The equipment, including all parts and accessories, shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts and assemblies, welding and brazing, plating, painting, riveting, machine-screw assemblies, and freedom of parts from burrs and sharp edges.

3.3.9 Electromagnetic Interference

Electromagnetic fields generated by the console and CIB and the susceptibility of these equipments to external fields shall conform to the limits specified in MIL-STD-826, Class Gp.

As a design goal, electromagnetic fields radiated or conducted from these equipments shall conform to the requirements of FED-STD-222.

3.3.10 Identification and Marking

The console and CIB shall bear name plates in accordance with MIL-STD-16.

The requirements of ML-N-7513 are a part of this specification.

3.3.11 Storage

The console and CIB shall be storable in a manner suitable for shipment in accordance with Section 5 of this specification.

4.0 QUALITY ASSURANCE PROVISIONS

The contractor shall be responsible, except as noted, for the performance of all inspection requirements as specified herein. Except as otherwise specified, the contractor may utilize his own or any other inspection facilities and services acceptable to the procuring agency. Inspection records of examination and tests shall be kept complete and available as specified by the procuring agency.

The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to assure supplies and services conforming to prescribed requirements.

The inspection and testing of the console and interface buffer shall be classified acceptance testing within the framework of Category I and Category II testing.

4.1 Category I Test/Acceptance

The contractor shall establish an acceptance test program in accordance with the requirements of MIL-T-26673. The Category I testing shall be in accordance with a test plan and detailed test procedures to be supplied by the contractor and approved by the procuring agency. Category I tests will be witnessed by a Test Force prescribed by the procuring agency. This test plan and associated procedures shall include, but not be limited to, tests of the form and intent described in this section.

4.1.1 Engineering Test and Evaluation

4.1.1.1 Environmental Testing

High-temperature, low-temperature, and humidity tests shall be performed on the console and interface buffer in accordance with the procedures of MIL-STD-810. For the high-temperature test, the procedure described in Method 501 shall be followed, with the exception that the chamber temperature shall be raised to 52°C (125°F) and maintained at this temperature for four (4) hours. Then the chamber temperature shall be reduced to 38°C (100°F) and stabilized at this level. The equipment shall be operated at this temperature for two (2) hours.

Low-temperature testing shall be conducted as described in Method 502. The test chamber shall be maintained at a temperature of minus 35°C (-30°F) for a period of twelve (12) hours, with the apparatus in operable configuration but not operating. The chamber temperature shall then be returned to plus 10°C (50°F) and the equipment temperature stabilized

at this value. Successful operation of the equipment shall then be demonstrated for a period of two (2) hours.

Humidity testing shall be conducted as described in Method 507. Test-chamber temperature shall be raised to plus 52°C (125°F) over the stated two- (2) hour period and maintained at this temperature for two (2) hours. During a subsequent six- (6) hour period, the temperature shall be gradually reduced to the value stated in MIL-STD-810. This cycle shall be repeated once again for a total test time of twenty (20) hours. The console shall be operated at room conditions of temperature and humidity.

No altitude, salt fog, fungus, sunshine, rain, dust, or explosive atmosphere test is required. Vibration tests as described in Method 514, class 7 equipment, and shock tests as described in Method 516 may be imposed if the contracting agency technical personnel define a need for such tests during the course of the procurement.

4.1.2 Preliminary Qualification Tests

No preliminary qualification tests are required.

4.1.3 Formal Qualification Tests

Formal qualification tests shall start in the contractor's plant, with the requirements of 4.1.3.1 and 4.1.3.2 and 4.1.3.3 being fully met. Some of the requirements of 4.1.3.4 may be met by tests conducted in the contractor's plant, but the Procuring Activity may require that any or all the tests of Section 4.1.3.4 be performed at the intended installation sites. The procuring activity will make this determination upon evaluation of the contractor's recommendations called for in 4.1.3.4.

4.1.3.1 Inspection

The following requirements of Section 3.0 shall be verified by inspection of the equipment in the contractor's plant and before any of the tests of 4.1.3.4 are carried out.

Paragaraph	Item
3.1.2.2.2	Service and Access (in part, see also section 4.1.3.3)
3.1.2.5	Transportability (in part, see also section 4.1.3.3)
3.1.2.6	Human Performance
3.1.2.7	Safety
3.3.1	General Design Features
3.3.3	Materials, Parts and Processes
3.3.4	Standard and Commercial Parts
3.3.5	Moisture and Fungus Resistance
3.3.6	Corrosion of Metal Parts
3.3.7	Interchangeability and Replaceability
3.3.8	Workmanship
3.3.10	Identification and Marking

4.1.3.2 Analyses

Review of analytical data shall, in part, verify the Reliability and Maintainability requirements (see 4.1.4). The only other requirement which shall be verified by analysis is useful life (Paragraph 3.1.2.3). Support for the claimed useful life shall be provided in the Reliability/Maintainability Final Report.

4.1.3.3 Demonstration

The following requirements of Section 3 shall be verified to the extent indicated by demonstration before the tests in section 4.1.3.4 are performed. In performing this demonstration, the equipment shall be exercised in all its modes of display generation, using appropriate manual data inputs. The equipment shall qualitatively meet the requirements of the paragraphs referenced. In no sense does the performance of these demonstrations relieve the contractor from the performance of the tests of section 4.1.3.4.

Paragraph		Demonstration
3.1.1.1.2.1	Positioning and Point Display	The ability to present points anywhere in the 512 x 512 array.
3.1.1.1.2.2.1	Displayable Characters	Display of the full character set and the ability to change characters readily.
3.1.1.1.2.2.3	Character Display Formats	Automatic horizontal and vertical spacing and the ability to change the spacing.
3.1.1.1.2.3	Vectors	The ability to display vectors of arbitrary length, connected vectors, and the different line types available.
3.1.1.1.2.4	Circles	The ability to display circles of the specified sizes and line type.

Paragraph		Demonstration
3.1.1.1.4	Projection Display Data	The ability to project both color and black and white slides.
3.1.1.1.6	Operator Functions	All the requirements of this section.
3.1.1.1.7	Computer Functions	All the requirements of this section.
3.1.1.2.2.2	Light Gun	All the requirements of this section.
3.1.1.2.2.3	Position Identifying Device	All the requirements of this section.
3.1.1.2.3	Status Indicators	The operation of these indicators under program control.
3.1.1.2.5	OFF/STANDBY/OPERATE Switch	All the requirements of this section.
3.1.2.2.2	Service and Access	All the requirements of this section.
3.1.2.5	Transportability	The ability to move the equipment with a fork lift truck.
3.2.1.1	Schematic Arrangement	All the requirements of this section.

Paragraph		Demonstration
3.2.1.2.1	General	All the requirements of this section.
3.2.1.2.2	Prime Power	All the requirements of this section.
3.2.1.2.3	Cooling	All the requirements of this section.
3.2.1.2.5	Parity Generation and Checking	The ability to detect parity errors.

4.1.3.4 Test

All quantitative requirements of Section 3 shall be verified. Testing methods shall be recommended by the contractor, subject to procuring activity approval. The tests may be performed in any order and the equipment shall not be adjusted during or between tests, except as allowed by the approved maintenance procedures. The decision to accept, reject, or require appropriate rework, in the event the equipment fails to pass particular tests, rests with the procuring activity. The greatest emphasis will be placed upon those characteristics of the console which affect its usefulness – its legibility primarily, but also its brightness, contrast and sharpness.

For these performance tests, an IBM 1410 computer shall be integrated with one (1) console through a Computer Interface Buffer. If it is not feasible to obtain the computer, a computer simulator having interface characteristics similar to the IBM 1414-1 or -7 I/O Synchronizer may be used, upon prior approval of the procuring activity.

The following requirements of Section 3 shall be verified during the formal test program.

Paragraph		Item
3.1.1.1.1	Display Area	The size of the display area.
3.1.1.1.1.2.1	Positioning and Point Display	The linearity of the point display.
3.1.1.1.2.2.2	Character Size	Character height and width.
3.1.1.1.2.2.4	Legibility Requirements	Refer to section 4.1.3.4.1.
3.1.1.1.2.3	Vectors	Vector straightness shall be measured.
3.1.1.1.2.4	Circles	Size and circularity shall be tested.
3.1.1.1.2.4.1	Line Type Discriminability	Refer to section 4.1.3.4.2.
3.1.1.1.3	Electronic Display Characteristics	
3.1.1.1.4	Projection Display Data	Registration with electronic display.
3.1.1.1.4.1	Projection Legibility Requirement.	Refer to section 4.1.3.4.1.
3.1.1.1.5	Projection Display Characteristics	Brightness of the projected display.
3.1.1.2.4	Modes of Operation	Refer to section 4.1.3.4.4.
3.1.2.1	Reliability	Refer to section 4.1.4.
3.1.2.2	Maintainability	Refer to section 4.1.4.
3.1.2.8	Noise	

Paragraph		Item
3.2.1.2.4	Electrical Interface	Interface capabilities of the interface unit.
3.3.9	Electromagnetic Interference	Refer to section 4.1.5.

4.1.3.4.1 Legibility Test

The tests required to verify the performance of the console with respect to the requirements of section 3.1.1.1.2.2.4 and section 3.1.1.1.2.4.1 shall be conducted on five human subjects for each test with ten showings of each symbol to each subject. (See section 6.1 for further explanation.) All tests shall be conducted with an ambient illumination of 5-foot candles of white light (Standard Cool White Fluorescent) falling directly and uniformly on the display surface without specular reflectance of the light source to the viewer.

The procuring activity may require that the tests be performed with the symbol appearing at the fringes of the useful display area if there is doubt about the legibility of symbols appearing there.

4.1.3.4.1.1 Isolated Symbol Tests

Under the test conditions specified, a small fixation area or marker, slightly larger than the symbol space, shall be shown located so that the center of the fixation area shall coincide visually with the center of the symbol space in which the symbol is to be shown. When the subject has been warned and his eyes are fixed on the center of the fixation area, the fixation marker shall be removed and the symbol shall be flashed for 10-milliseconds, plus or minus 1-millisecond. The warning shall precede symbol exposure by 1 to 3 seconds, and shall be a constant time, ± 1/2 second, before

exposure. The symbol brightness shall reach full value, and shall decay to less than 1 percent of full value, with delays of less than 1-millisecond (if this is not possible, see section 4.1.3.4.1.3). The subject shall name the symbol just shown by reciting the name of one and only one symbol in the set of symbols being tested; i.e., there shall be no response other than one of the names of the 36 alphanumeric characters (during the test of alphanumeric characters). The subject's response shall be recorded along with the name of the symbol just shown. The symbols shall be shown one at a time, with a period of no less than 3 seconds between showings. The data shall be summarized in a matrix as described in section 6.1.2.4 and shall meet the error criteria stated in section 3.1.1.1.2.2.4.

4.1.3.4.1.2 Grouped Symbol Test

A series of tests shall be conducted in which the symbol being identified appears in all positions of a square format at least three symbols square with the horizontal and vertical inter-symbol spacing used to meet the requirements of section 3.1.1.1.2.2.3. The position in the format of the symbol being identified shall vary at random among all the positions in the format. If so desired, only the one symbol to be identified may be controlled in exposure time as specified in section 4.1.3.4.1.1. In this case, all other letters in the format shall appear and remain for 1 to 3 seconds before the symbol being tested is flashed. A fixation cue shall be provided in all of the grouped symbols tests; it is acceptable to show all of the format except for a blank space where the symbol to be shown will appear. The data will be summarized again in a matrix, and the same error criteria shall be met.

4.1.3.4.1.3 Alternative Procedures

If symbol brightness cannot be controlled as required in section 4.1.3.4.1.1, either of the following procedures may be substituted.

4.1.3.4.1.3.1 View Box Procedure

The view box equipment is described in section 6.1.2.6. With this equipment the test shall be conducted as specified above, using the shutter to control the symbol exposure time.

4.1.3.4.1.3.2 Blanking Pattern Procedure

The symbol may be removed from view if the phosphor decay is not fast enough, or if other considerations so dictate, by turning it off and then obliterating its decaying image with a solid or double cross-hatched pattern of rectangular shape and large enough to completely overlay the largest symbol being tested. The blanking pattern shall be at least as bright as the symbol's greatest brightness during symbol exposure and shall have the onset characteristics specified for the symbol above, but may have a longer decay time. The blanking pattern shall be turned on 40, ± 5, milliseconds after the symbol is turned on, and shall be displayed at maximum brightness for 30, ± 10, milliseconds.

4.1.3.4.1.4 Word Recognition Tests

Either of the word recognition test procedures may be used. The words to be used are given in section 10.1.

4.1.3.4.1.4.1 Controlled Exposure Time

Subject selection and positioning shall be the same as for the single symbol tests above. As before, the subject will be given a fixation point, or area, on which to fix his eyes immediately before the word to be read is shown. Each word shall be shown with the middle letter visually coincident with the center of the fixation area or point. The subject shall be warned of word occurrence at least 1, and no more than 3, seconds early; the delay between warning and showing shall be held as nearly constant as is feasible

and shall vary no more than ± 1/2 second from the average delay. All of the words in the list provided shall be used once each, in random fashion with respect to alphabetic order.

The brightness of the letters in the word shall reach full value, and shall decay to less than 1 percent of full value, with delays of less than 1 millisecond. The symbols shall be shown at full brightness for 50 milliseconds, ± 5 milliseconds. The time interval between successive words shall be between 5 and 20 seconds. The subject shall speak each word aloud and the observer will record each word as spoken, asking for spelling in the case of ambiguity. The subject shall not see the words before they are shown as part of the test and shall in no way be informed of the word identities beforehand. He shall be told that all words are five-letter, commonly seen, words and that he is to fix his eyes according to the instructions and not attempt to move them during word exposure. He may, in cases of doubt, guess the word identity. Error scores shall meet the criteria of section 3.1.1.1.2.2.4.

4.1.3.4.1.4.2 Reading Time

Under the same conditions as in section 4.1.3.4.1.4.1, the subject shall read each word aloud as quickly as possible after its appearance. The time between onset of the exposure and the onset of his voice shall be recorded automatically. A voice-operated relay, or equivalent, shall operate with known delays in a timing circuit so that the actual reading time is determinate. The word shall disappear within 100 milliseconds after the subject's response.

The subject may be given five to ten words for practice before the test data are taken, and the remainder of the list of words shall be

used for data collection. The subject may be coached during the practice to make his responses faster and less variable.

Reaction times shall meet the criteria of section 3.1.1.1.2.2.4.

4.1.3.4.2 Line Type Discrimination Test Procedures

The test procedure essentially consists of showing one line at a time in an unpredictable sequence and requiring the subject to identify the line type. Five subjects shall be used for each test, and each subject shall be shown each line type ten times. Procedures for selecting the subjects are the same as for the legibility tests. As for the legibility tests, the subject shall be warned and a fixation area provided before the line to be identified is shown.

4.1.3.4.2.1 Central Viewing

The lines of each type shall be shown in two different lengths, 1 and 3 inches approximately, and in three orientations, horizontal, vertical, and slanting at about 45° from the vertical in either or both directions. Each line shall be centered on the fixation point or within the fixation area. Upon completion of the line exposure, the subject shall call out the name of one of the line types and shall make no other response. The line shall reach full brightness and decay to less than 1 percent of full brightness, with delays of less than 1 millisecond. The line shall be at full brightness for 100 milliseconds, ±10 milliseconds, and shall disappear, or be obliterated, as required for the legibility tests above. The error criteria are specified in section 3.1.1.1.2.4.1.

4.1.3.4.2.2 Peripheral Viewing

In a second test, the vectors shall be used to draw squares or triangles, and the circles shall also be drawn. The line type with which the figure is drawn is the item to be identified by the subject. A small fixation area or point shall be provided. The circle to be shown shall have the center of the fixation area as its center and shall be 1 inch in diameter; the other figure shall circumscribe the circle. The two figures shall be shown in an unpredictable sequence, and the line type used shall occur also in an unpredictable sequence which is independent of the figure. The two figures, as well as the line types, shall occur with equal frequency.

The figure shall be exposed for 100 milliseconds, ±10 milliseconds, with the same onset and decay requirements as above.

The error criteria shall be as specified in section 3.1.1.1.2.4.1.

4.1.3.4.3 Display Characteristics

4.1.3.4.3.1 Electronic Display Content

Tests shall be performed to demonstrate the following performance characteristics of the Console Memory and electronic display:

a. storage and display of the items indicated in section 3.1.1.1.3;

b. correspondence of stored and displayed symbol data with the specified digital codes;

c. display of underline symbol together with any other symbol in the same symbol position without conflict or overlap;

d. readily distinguishable marker whose position corresponds to the symbol position at which the next write or erase function will be effective and which responds to control and switch actions as specified herein;

e. parity error symbol intermittently displayed at a rate providing a readily perceivable flicker; and

f. capability of data storage in the Console Memory for at least twenty-four (24) hours without operator or computer intervention.

4.1.3.4.3.2 Composite Electronic and Projector Display

Tests shall be performed to verify the composite display requirements specified in section 3.1.1.2.1.3. Specifically, tests shall be as follows.

1. Composite electronic and projector displays shall appear on a common display surface within size and registration tolerances specified in Section 3. The registration between electronic data and projector display shall be verified by using the projector display to present a ten (10) by ten (10), uniformly spaced, array of squares, each 2 percent of the useable display area on a side. The array shall fill the display screen dimensions. Simultaneously, the digital data shall specify the display of a ten (10) by ten (10) array of points programmed, with uniform digital increments, to lie at the centers of the 100 squares. All points shall lie within the squares. This test shall be repeated using ten (10) different background displays and ten (10) freshly generated digital displays. The test shall be passed all ten (10) times.

2. Display of the composite display shall be within time requirements specified in section 3.1.1.2.1.2. Blink time, the interval between removing one (1) projector display and presenting the next, may be

measured with a light-sensing device connected to a timer or oscilloscope. Blink time shall be measured at least twenty (20) times and shall not exceed ten (10) seconds.

4.1.3.4.4 Modes of Operation

1. The three (3) modes of operation - input, output, and off-line - shall be demonstrated by specific operator actions. The proper state of console controls and indicators in each mode shall be verified.

2. Message transfer to and from the computer (or simulator) in accordance with specified formats, data transfer rates, and transfer functions under control of clock pulses shall be demonstrated.

3. Transmission of data from a selected section of Console Memory to the computer without affecting the content of Console Memory, except where required, shall be demonstrated.

4. Generation and transmission of console control messages to the computer as specified herein shall be demonstrated.

5. Reception of control or data messages from the computer in response to a computer-originated control signal, and storage of received messages in the selected section of the Console Memory and its display on the electronic display shall be demonstrated.

6. Status of controls and indicators shall be updated upon receipt of control messages from the computer.

4.1.4 Reliability of Maintainability

Reliability and maintainability tests shall be conducted as required by MIL-R-27542A, paragraph 3.5.13.2, as modified by the specification (section 3.1.2.1). Quantitative maintainability shall be demonstrated and evaluated.

For the maintainability test, the manner in which faults to be simulated are determined and the caliber of contractor test personnel used for the tests shall be approved by the procuring activity prior to the test.

4.1.5 Interference Testing

The console and Console Interface Buffer shall be tested to verify compliance with MIL-STD-826, Class Gp, as specified in section 3.3.9.

4.1.6 Previous Acceptance or Approval

Previous acceptance or approval of material by the procuring agency shall, in no case, be construed as a guarantee of the acceptance of the finished product.

4.1.7 Test Coordination

The contractor shall supply recommended procedures and methods for testing and inspecting the console to the procuring agency not less than thirty (30) days prior to the start of testing.

4.2 Installation/Integration/Category II Tests

The equipment shall be integrated with the appropriate system CEI's at its emplacement site and given all performance tests necessary to confirm that the equipment meets the performance requirements specified herein.

5.0 PREPARATION FOR DELIVERY

Preparation for delivery shall be in accordance with the instruction of the procuring agency.

6.0 NOTES

6.1 Supplemental Information

6.1.1 Definitions

A symbol space is the rectangular area which circumscribes the symbol. For alphanumerics, the letter W or M shall be taken as the letter defining the standard symbol space. The center of a symbol space is a point of intersection of its two diagonals.

A display element is any item such as a line, mark or dot which is not an alphanumeric symbol or a special symbol; the term is used for brevity.

A line type consists of a kind of line identified by, say, a particular construction (solid, dotted, broken, etc.), brightness and width. Thus, if there are two brightnesses of lines, two widths with each brightness, and three constructions with each width and brightness, then there are 12 (2 x 2 x 3) line types.

A format is a group of letters arranged in a more or less fixed or standard pattern, such as a matrix of letters with four rows of three letters each.

6.1.2. Conduct of Legibility Tests

Each subject used in the tests must have 20/20 vision, corrected or uncorrected, no marked phoria, be free of astigmatism, and pass all acuity tests with each eye alone. He shall not be permitted to wear corneal contact lenses during a test or during visual screening tests.

A subject who served in one test may also serve in one or more other tests.

If, in any test, the total number of permissible errors is equalled or exceeded by one subject, that subject may be discarded for purposes of the test and another subject used instead. Any subject discarded in one test shall not be used in another test.

6.1.2.2 Subject Training

All subjects shall be provided with a set of named illustrations, clearly drawn to scale, of all symbols or display elements whose legibility is being tested (except for words in the word tests, which he shall not be shown). Each subject shall be given time to study the illustrations until the name of each symbol or element is memorized. If necessary, during the test, in order to prevent confusion or hesitation of the subject, he may be permitted to to point to the symbol he believes to have just been shown, using the set of illustrations provided, instead of responding orally, unless the subject's reaction time is being recorded.

6.1.2.3 Physical Placement and Treatment of Subjects

During all tests, the subject's head will be in a fixed position with respect to the display surface. A chin rest, forehead rest, or other means may be used to control the position and orientation of the subject's head and eyes. The line-of-sight shall be perpendicular, ±10 degrees, to the plane tangential to the display surface at that point on the surface where the symbol or word is to appear and shall pass through this point. The subject's eyes shall be at normal viewing distance, as defined by the buyer, ±10 percent.

The data from each subject, for each test, shall be obtained at a single sitting, uninterrupted by failure of the equipment or delays for adjustment or maintenance. Should any test be so interrupted, it shall be completely redone from its original starting point, and the data from the interrupted test shall be discarded.

If the number of permutations and combinations of the symbols and elements being tested in one test require that the subject remain seated and attentive for more than 20 minutes, the test shall be divided into sub-parts of nearly equal size and duration so that the duration of any sub-part

does not exceed 20 minutes. There shall be a rest period of at least 10 minutes between sub-parts. No subject shall make more than four sub-part tests in a day nor shall his total test time, including rests between runs, be more than 2 hours in a day.

If an attempt to show a symbol or element fails due to causes such as the subject's inattention or failure to fix his eyes in time, that symbol shall be shown again at some later portion of the test. The subject shall not know when failures occur or when symbols will be repeated.

No subject shall be informed of his success or lack of success in the test until all data have been gathered from that subject.

In all tests, each subject shall be given the tests independently, each without any cue, either before or during his tests, as to the performance or the responses of the other subjects.

6.1.2.4 Test Data – Single Symbol Tests

In each test, all symbols or elements shall be shown in an unpredictable sequence, as defined for each test, except that each symbol shall be shown exactly ten times and no one symbol or element shall appear more than three times in succession more than once in a test.

If the symbols or elements are being displayed on a phosphor whose brightness decay rate is such that the symbol just shown at a particular location has not decayed to less than 1 percent of its original brightness at the end of the interval between trials (not less than 3 seconds), the next symbol to be tested shall be shown on a fresh area of the surface.

During single symbol tests, the subjects name the symbol seen, and their responses are recorded, along with the correct name of the symbol which has been shown. Since each symbol is shown ten times, there

are 10n showings per subject, where n is the number of symbols being tested. Five subjects are used for each test and so there are a total of 50n showings. The test data is summarized in an n x n matrix whose rows represent the symbols shown and whose columns represent the symbols called out by the subjects. If there are no errors, each entry along the diagonal of the matrix will be 50 and all other matrix cells will be 0. Error criteria are specified by requiring that no diagonal entries be less than 46, no non-diagonal entries be greater than 3, and that the total of all non-diagonal entries not exceed 3 percent of the total number of showings.

6.1.2.5 Basis for Error Criteria

The error criteria specified for the alphanumeric symbol legibility tests in section 3.1.1.1.2.2.4 are based on a font having a height-to-width ratio of approximately 4/3, a stroke width of approximately 1/6 to 1/10 of the symbol height, zero slant on all symbols, and no serifs except as required for the letter "I" and the numeral "1". The horizontal spacing between the centers of adjacent symbol spaces is assumed to be 1.5 times the symbol height (proportional spacing would be better), and the vertical spacing between rows is assumed to be approximately 1.75 times the symbol height.

6.1.2.6 Viewing Box Equipment

In case the display equipment under test is not modifiable so as to provide the required control over the exposure time of words or single symbols, an alternative device is suggested. The device is sketched in Figure 1 and consists of a beam-splitter (preferably one with high transmittance) imposed between the subject's eyes and the display screen. The beam-splitter is enclosed in a specially shaped box in order to shield the surface of the beam-splitter from stray light, thus providing control over the brightness and

contrast of display and background. The eye end of the box, and the exit ends, may be partly occluded with appropriate baffles to restrict the view to the areas of interest, and to further exclude stray light. The distance from the eyes, at X-X in the figure, and the screen shall be as stated in 6.1.2.3 and equal to the distance from X-X to S'. The background screen may be partially lighted by lamps at L in order to provide the desired brightness for the fixation area or point.

A suitable shutter mechanism at T-T provides control over the exposure time of the material being shown on the screen. Such a mechanism may be a revolving disc with a pie-wedge piece removed whose passage past the eyes provides the desired exposure time. The brightness of the screen may be modified so that the images seen at X-X through the beam-splitter are at normal brightness. (The beam-splitter produces an unavoidable loss of brightness of the material being viewed through it, and compensation for this loss is permissible.) The subjects should be comfortably seated at all times during the test, and shielding screen should be provided to prevent their viewing the display screen except through the beam-splitter.

10.1 List of Words for Recognition Test

The following list of 117 words are the words to be used in the word recognition test of section 4.1.3.4. They are chosen from a list of commonly encountered words.

ABIDE	CRUST	ONION	SPRAY
ABUSE	DITCH	OUNCE	STAIN
ACTOR	DRAMA	OUTER	STALK
ADAPT	DRANK	PEACH	STING
ADORE	DRIED	PERCH	SUNNY
AGONY	DRILL	PERIL	SWAMP
ALTAR	DROOP	PHONE	SWARM

AMAZE
AMPLE
ANKLE
ARRAY
BARON
BASIN
BERRY
BLUSH
BORNE
BOUGH
BRAKE
BRAND
BROOD
CABLE
CARVE
CHOKE
DRUNK
DWARF
ELBOW
EQUIP
FATAL
FOLLY
FRIAR
FROWN
GEESE
GLARE
GLIDE
HELLO
HOUND
JOLLY
LEGAL
LEMON
PIANO
PILOT
PINCH
PLUCK
QUEST
RANCH
REALM
REBEL
RIDER
ROUSE
RURAL
SALAD
SAUCE
SCENT
SHAFT
SIXTH
SWEAR
SWUNG
TEMPT
TENTH
THIEF
THORN
THUMB
TOAST
TRAMP
TREAD
TRUCK
UPSET
VAGUE
VAPOR
VITAL
WEAVE

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13. ABSTRACT

The specification for a console sets forth requirements for displays electronically generated from digital data supplied by a computer or the operator and for displays generated by optical projection from film chips. The requirements are stated quantitatively, with tolerances, in a manner readily susceptible to verification by test procedures which are standard or are explained in detail. Means for verifying all requirements are given. This specification may serve as a model for display equipment specifications although a number of questionable areas are pointed out and the detailed requirements will depend upon the particular applications.

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
COMPUTER DISPLAY CONSOLE						
Electronic, Proposed Specification for,						
Projected, Proposed Specification for,						

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