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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

Keyboard Cathode Ray Tube State-of-the-Art Review

Systems Development Office

Systems Plans and Design Division

SILVER SPRING, MD.

July 1971

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681.3	Data processing machines and equipment
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ABSTRACT

This report contains descriptive information on keyboard cathode ray tube (KCRT) display devices and points out specific design questions and problems that must be resolved to achieve successful implementation. Computer-programming support required to use the KCRT is also discussed.

Potential applications of the KCRT in the National Weather Service include: a request/reply system to enable forecasters to obtain more rapid and direct access to observational data and prior forecasts, a system to revise forecasts and to transmit them to the communication networks, a request/reply system for use in pilot weather briefing, and computer monitoring of observations in relation to forecasts.

A summary chart of characteristics of 44 different devices is given and a glossary of KCRT terms is included.

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KEYBOARD CATHODE RAY TUBE STATE-OF-THE-ART REVIEW

SUMMARY

The Systems Development Office, as part of its Field Station Automation Program, has collected information on keyboard cathode ray tube (KCRT) display devices. The purpose of this document is to make this information available to other National Weather Service (NWS) offices.

Background

Display device technology is growing rapidly. In the past 5 years over 100 new display devices have been introduced on the commercial market. In part, this is a consequence of advances in computer capabilities for handling the processing and communications for multiple on-line users. Many characteristics of third-generation computers (e.g., multiprogramming, mass data storage, data structures and data management techniques, and variety of input/output channels) have made it possible for diverse users of information to communicate directly and simultaneously with the computer and to obtain the information they require via real-time techniques.

Because of the generality and power of these real-time computer system capabilities, many diverse applications have been and are being developed (e.g., management information, order entry, engineering, instruction, library browsing, military command and control). Display devices reflect this diversity of application; that is, a wide variety of capabilities and characteristics in display devices are presently on the market. Selection of the proper KCRT device for a given application and environment involves complex tradeoffs and other detailed design questions.

There are two primary reasons for this complexity of selection and design. First, the KCRT device is only one component of a complex man-machine system involving many interdependent hardware, software, data, and communications components. Second, the KCRT device must be compatible with the skills, tasks, needs, and environment of the human operator or user.

Applications

KCRTs have been proposed in conjunction with a number of Weather Service data handling applications. Forecasters need more rapid and direct access to observation data and prior forecasts. A request/reply system involving a computerized data base and KCRTs is a likely solution to this need. In such a system, observation and forecast data would be stored and updated either centrally, regionally, or locally in computerized files. The forecasters' KCRTs would be tied in via communications lines to the computers. A suitably programmed computer would manage the communications, interpret requests for information, retrieve appropriate data from the files, and transmit information to the forecaster.

When composing, editing, and transmitting his forecast, the forecaster might use the KCRT to call up a previous forecast, enter the new or revised information, and transmit to the communications network. Storage and retrieval of the forecasts might be implemented by a stand-alone local system, or they might be accomplished as part of a larger data retrieval system.

KCRTs have been proposed in conjunction with pilot weather-briefing applications. This application is similar to the forecaster's request/reply system, except that the conversation between computer and briefer (or pilot) would be specially tailored to the pilot briefing requirements. This implies that special computer programs for computation and data search/retrieval would be a component of the system. Of course KCRTs are only one alternative in such an application; teletypewriters would also be considered as request/reply communication devices.

Computer monitoring of observation data in relation to forecasts has also been suggested. In this case, the KCRT would be used to display exception messages to forecasters and other users of such information. Again, the KCRT is not a necessary component of the application. Forecast exception or verification notices could also be transmitted to teletypewriters. The key components in this application would be the computerized data base of up-to-the-minute observation data and the programs which perform the monitoring and execute decision rules about conditions which require an exception notice.

Each application or combination of applications has associated with it a particular set of requirements for KCRT capabilities. Each also has a particular set of requirements for total system capabilities--computer, data base, communications, and human operator. There are, in addition, certain requirements which are general to all Weather Service applications. For example, some Weather Service applications involve the display of special weather symbols. Also, if a KCRT is intended to be compatible with existing Weather Service teletypewriter communications networks, it must transmit the special five-level Baudot communications code of those networks.

Contents

This report contains descriptive information about KCRTs and discusses their role in a total information system. It describes the basic characteristics of the operation of a KCRT and the wide range of capabilities currently found on commercially available devices. These capabilities are explained in terms of their potential significance to Weather Service applications.

The report points out the specific design questions and problems that require resolution in order to achieve a successful implementation of KCRT technology in WSFOs. Stress is placed on the necessity of tradeoff analysis when selecting those capabilities of a KCRT that are important to a particular application. The tradeoffs discussed involve cost, performance, and human factors.

One section of the report is devoted to the computer-programming support that is required to utilize the KCRT. This discussion is written in such a way that the reader who is unfamiliar with computer programming will obtain

a basic understanding of the support functions performed within the computer. A number of potential Weather Service applications of the KCRT are explored, and the manual and machine tasks under a KCRT operation are described briefly. Important design questions are highlighted.

Two useful references are provided. Appendix A is a summary chart of the characteristics of 44 different devices in terms of factors of interest in Weather Service applications. Appendix B is a glossary of KCRT terms which will enhance communications with personnel who are expert in using KCRTs.

1. INTRODUCTION

The Systems Development Office, as part of its Field Station Automation Program, has collected information on display devices that may be useful to others. Information has been collected on a variety of display devices that have a range of capabilities for manipulating and displaying data, and covers the characteristics, special features, and support requirements of these devices.

This paper focuses exclusively on keyboard cathode ray tube (KCRT) display devices which allow the operator to play an active role in the handling of data. The operator may enter, retrieve, or alter data. Display devices, such as large-screen wall displays which permit only passive observation, are excluded.

The broad spectrum of keyboard display device capabilities is described, but is restricted to those found on commercially available devices. The internal operation of the device is presented only as background information. The basic functional capabilities of KCRTs are described, and the wide ranges of optional capabilities found on different devices are explained in the context of their use. The basic functions involve such items as screen characteristics, device speed, memory type, and standard keyboard controls. The optional capabilities include such items as light gun, special keyboard functions, and editing features.

The discussion includes supporting hardware and software requirements necessary for KCRT use. These requirements vary, based upon application and the particular specifications of a given manufacturer's device.

2. KCRT DISPLAY COMPONENTS AND CAPABILITIES

This section describes basic KCRT characteristics including scan, memory, character generation, and control functions.

2.1 The Screen

Characteristics of the KCRT screen include:

- Physical viewing area and color
- Screen size
- Screen addressing.

The physical viewing area (measured diagonally) ranges from three to twenty-four inches. The area may be squared, or it may be a rectangle with the larger dimension arranged either vertically or horizontally. Choice of physical size and shape depends on the conditions under which the device is used; the most common viewing areas range from eight to twelve inches measured diagonally.

Color of screen (background) varies, but the most common is a dark background with light characters.

The operable screen size is generally referred to as the number of characters per line, number of lines, and number of characters per screen. For instance, the Burroughs B9352 display has two options: 40 to 80 characters per line and 24 to 12 lines, respectively.

The screen-addressing capability of a KCRT is an important factor for many KCRT applications. Screen addressing refers to the ability to output information from the computer to a specific area of the screen. For instance, the IBM 2260 has an optional line-addressing feature that allows the computer to start the output message on a particular screen line. Another technique divides the screen into two parts, with each part separately addressable. This technique is commonly referred to as a "split-screen" feature.

Another technique enables the programmer to divide the screen into a variable number of blocks where the screen positions forming a block need not be contiguous. The Sanders 720 operates in this manner as could any programmable CRT (as via Data Disc 6600 system). A disadvantage is the user's difficulty in "knowing" which block he is in.

The flexibility which can be obtained in displaying information is directly related to the flexibility of the addressing scheme. For instance, the split-screen technique of the Control Data 200 User Terminal provides greater flexibility than a basic KCRT, which begins all output messages at the top screen line. When a message is received by a terminal, it overwrites the material currently appearing on the screen.

The flexibility of the KCRT operator in entering information is also related to the screen-addressing capability. For instance, one block may be

designated as active, i.e., the operator may key in information using the keyboard console. A second block may be designated as passive, i.e., only information from the central computer is displayed, and the operator cannot enter data in the block. It should be noted that not all alphanumeric display terminals which provide split-screen operations have the active and passive capability.

2.2 Memory

KCRTs are buffered devices. The buffer is a component that stores data sent to, or received from, the computer. It is a temporary memory, in that the information is only held until the next transmission to or from the KCRT.

Temporary storage (memory) is necessary because of the manner in which the characters are displayed. Characters are made visible on the screen by the motion of an electronic beam striking the phosphorescent coating on the inside of the cathode ray tube. Because the phosphorescent glow fades rapidly, it is necessary to refresh, or retrace, each character to prevent it from disappearing from the screen. Hence, a temporary storage device is necessary.

The KCRT memory should not be confused with auxiliary storage such as a tape cassette, which may be a component of a KCRT configuration. Auxiliary storage provides a medium for permanent or semipermanent data storage, while the KCRT memory is strictly temporary in nature. Auxiliary storage is discussed in section 2.5.

Buffered devices allow faster data transmission rates than unbuffered devices. The transmission rate may equal the rate at which the buffer can be filled. Teletypewriters are unbuffered devices, partially explaining why communications with teletypewriter are slower than those with display devices.

There are two basic types of memories: random access and time sequential. In a fixed (random access) memory the characters are often stationary, and there is often a direct correspondence between memory position and screen position; that is, positions on the screen that appear as blanks or "white space" use memory positions. Various graphic KCRTs, however, do not have correspondence between memory locations and screen positions so that screen character capacity can exceed the number of memory locations.

Circular memory is a simpler, less flexible form of memory where data continually recirculate and each character passes through the beam-positioning circuitry. Its main disadvantage is that a character can be altered only at specific times, placing a severe constraint on updating circuitry because the screen size is larger than the memory size. As a result, it is possible to achieve more flexibility in arranging the characters on the screen. This flexibility results from an ability to allow for space between columns, and space between lines, without using up valuable memory characters.

Some displays store the final image (say a 500-by 500-resolution image) on a circular disc memory. This eliminates the need for regeneration of the

final image from the character string at rates of 50/sec or so, that is, the image is simply repetitively reread from the spinning memory.

2.3 Character Generation

Because of its ability to display high-speed electronic signals, the cathode ray tube is a natural choice for displaying the output from digital computers. Since it is not limited by mechanical design constraints such as those of printers, the KCRT, with appropriate buffers, can display information at speeds commensurate with the inherent computer data rate. This advantage of speed is particularly important in applications requiring frequent man-machine interaction.

To use the KCRT in such applications, computer information in digital form must be transformed into analog signals. These signals will provide a display of special symbols, other characters, and line segments. In strobe-type KCRTs, the electron beam is first deflected to a point on the face of the cathode ray tube at which the character is to appear. The character is then written by controlling the incremental horizontal and vertical deflections of the beam. Individual character-writing techniques vary only in the methods used to control these quantities and the specific timing-control mechanism.

In video (T V -raster type) displays, the beam follows the same path over the whole screen, independent of the data to be presented. Video displays are far superior to strobe displays due to the low cost and reliability of the beam-moving circuitry. However, video displays place a heavier load on the character-decoding circuitry because of the need to have character data properly ordered and rapidly decoded in order to modulate the beam as it passes the desired screen location of the character.

Character Generation Techniques

The usual method of character generation is dot matrix or by stroke patterns within a matrix. Where characters are generated by dot patterns, the beam intensity is turned on (at points within the matrix) for selected dots that form the character and is turned off for those dots that do not form the character. Important to consider is the resolution of the character, that is, how many dots wide and tall, 5 by 7 or 7 by 10 being common sizes.

In stroke-pattern generators, the possible configuration of each character is also formable within a matrix, but the matrix can be turned on with strokes (line segments) in a combination of horizontal, vertical, or diagonal positions. The electron beam is intensified by intensity-control signals for those strokes that form the character. Each stroke is generated during one clock-pulse time interval, and time is allowed between successive strokes. Often the quality of stroke characters is poor because the short strokes are usually restricted to straight lines.

Vector generators may be distinguished from stroke generators in that the movement of the beam is not restricted to the matrix of a single character. Vector generators operate on line definitions which are translated into beam-

control signals. The beam-control signals then create the defined line on the screen by incrementing the beam between successive coordinates until the output pattern is completed. The main limitation of vector generators in KCRTs, which require regeneration of the vectors 30 to 60 times per second, is the limited number of vectors that can be drawn at a time.

Another method of vector generation is for the beam to be swept in a curve directly to the designated end point with a defined beginning and ending slope. With vector generation, a desired character that is not a part of the character generator's repertoire can be created by computer programming of the desired character configuration to be drawn.

2.4 Character Set, Keyboard, and Control Functions

The character set of a KCRT consists of alphanumerics, special symbols, and control characters. The special symbols consist of those found on the normal typewriter keyboard. The control characters are used by the computer to communicate with the display device to activate its control functions. They are also used by the device to communicate control functions to the computer; the RETRANSMIT function is an example of this.

Control characters may be embedded in a message to cause such functions as character blinking, displacement in the y-direction for subscripts and superscripts change of color, change of intensity, carriage return, tab movement, x- and y- location of next character, etc. There are also a number of control characters that are used for data transmission control, such as START OF MESSAGE, END OF MESSAGE, END OF ADDRESS.

The maximum character set is determined by the transmission code level. The ASCII code is an eight-level code, of which seven are used for data and the eighth is used for parity. This code has a maximum set of 128 characters (or 256 if parity is not used).

For any character set, some characters are display characters and some are nondisplay characters. The control characters are generally the nondisplay characters. Most characters in time sequential memories (circular) occupy a position in the KCRT memory, whether or not they are displayed on the screen (start of message, end of message, etc., do not). In those devices in which the screen positions have a one-to-one correspondence with the memory, the nondisplay characters usually do not subtract from the number of characters that can be displayed on the screen since many only control where the other characters are to be stored (and displayed).

For some uses of KCRT devices in the National Weather Service, special weather symbols are desirable. These symbols are not available in the repertoire of the character of most KCRT "off-the-shelf" hardware. Special hardware modification would be required for most manufacturers' devices.

KCRT Keyboard

The standard keyboard of a KCRT is similar in some respects to the familiar typewriter and different in others. The keyboard has the same

general layout; however, it provides only capital letters. The shift control key sets a mode for special characters. There are a number of other control keys which are located adjacent to the main keyboard layout. These control keys fall into two classes: (1) standard terminal control keys, and (2) special function keys. The first class of keys controls hardware features of the KCRT device, while the second controls application features.

The special function keys, in turn, consist of two kinds: fixed function and variable function. A variable function keyboard contains an array of variable function keys which may be alternatively interpreted according to a selected mode of operation. The mode of operation is determined by placing a labeled plastic overlay over the keys. In addition to labeling distinct functions, each overlay is perforated with a unique combination of holes or punches. When it is in place, the computer receives a coded bit pattern that tells it which set of variable functions is operable.

These and other considerations show that the KCRT keyboard is more complex, and, therefore, more difficult to use than either a typewriter or a teletypewriter keyboard. These problems can be mediated with careful keyboard design based on an analysis of the applications to be processed. Special keyboard design becomes cost-effective as more terminals are brought into the system.

KCRT Control Functions

There are three principal categories of control functions:

- Cursor control
- Screen controls
- Communication controls.

The cursor control determines the location of a cross-hair pattern or positional indicator (such as an underscore). The current position of the cursor is the position where the next keyed character will appear on the screen. Its movement can be controlled either by the operator or by the computer program. When controlled by the operator, several details may be considered. In alphanumeric KCRTs, the horizontal and vertical movement of the cursor is controlled by one or more cursor control keys, depending on the manufacturer's design. In graphic KCRTs (where vector generators are used), the movement of the cursor is often controlled by a "joy stick" mounted independently (see appendix B).

Another form of cursor control is a light gun or light pen which is a pointer, held by the operator, that can be directed to any location on the screen. This rapidly moves the cursor to the location thus designated by the operator. (The light gun has other uses, e.g., to select an item from a list on the screen or to draw diagrams on the screen.)

The screen controls include viewing controls and data controls. Viewing controls are analogous to the intensity (brightness) and contrast controls on a television set. Glare is a resultant factor of these two settings in con-

junction with the color of the screen. The glare problem may become critical with prolonged use of the KCRT.

The screen-data controls perform editing operations. The simplest KCRTs have key controls to erase one or more characters or lines of data, or completely clear the screen. More elaborate keyboards also have features that allow the insertion of data without having to re-key an entire data block. Data having material deleted from it can be closed automatically to permit a uniform presentation of data. These features provide a powerful capability, but they may also lead to inadvertent errors. Therefore, special operator training becomes vital, as do keyboard design considerations. For instance, the keyboard can be designed so that two keys must be depressed simultaneously to activate certain editing functions. This helps avoid such serious errors as deleting or "losing" an entire message.

The third category of KCRT control functions involves controls for communication between the terminal and the central processor. These controls can be in the form of lights, keys, switches, or alarms. For instance, the send/receive mode probably would be a control light that indicates the state of the device. An alarm bell might be used to attract the operator's attention to the fact that a message was about to be transmitted to the KCRT. All KCRTs have a SEND control key; activating this alerts the computer that the KCRT is ready to transmit a message to it for processing. The actual mechanisms used for controlling the transmission of messages between the CPU and multiple KCRTs are an important design matter. (This is discussed in section 5.)

Experience gained from previous experiments conducted by the Systems Development Office shows that operators will use the KCRT controls in unexpected ways. For example, depressing the HOME key (which moves the cursor to its home position on the screen) can clear the screen under certain conditions. Another problem is operator concern over whether the device has responded to his command; for instance, he may push the SEND key several times to assure himself that the message will be transmitted. This may cause unpredictable results in the computer processing.

2.5 Hard Copy and Other Auxiliary Devices

The basic design philosophy of a KCRT device is that its output data are used in real-time and hard copy is not created. One of the guiding forces of application design, therefore, is to store information (e.g., weather observation data) in the computer until called for by a KCRT operator. Because of this, KCRTs are not built with printout capability as an integral part of the device. Printers are available that can be connected to the KCRT, the most common of which is the Teletype Model 33RO (receive only). Another type of hard-copy printer is the Teletype Inktronic RO set. The latter is an on-line high-speed printer which prints from electrically charged ink particles that are fired from control nozzles onto regular teletypewriter paper. The device is compatible with five-level and ASCII codes.

Hard-copy printout is initiated by the operator using a special control key. Current KCRTs do not provide for automatic computer output to the printer through the KCRT.

Depending on various manufacturers' KCRT models, other auxiliary devices are available for the creation of hard copy either when transmitting data, receiving data, or preparing data for off-line use. Some of these devices include: magnetic tape cassette reader/recorder, paper tape reader/punch (send/receive), paper tape reader/paper tape punch, and digital cassette recorder. Although a given manufacturer may have only one or two standard attachments, connection of these devices to the KCRT is not difficult, and most can be installed upon request.

2.6 KCRT Device Characteristics Summary

To show the range of characteristics of KCRT devices, a summary chart is given in appendix A to this document. This chart is not exhaustive; for instance, it shows 44 devices while there are over 100 alphanumeric devices alone on the market. For the most part, it is adapted from a compilation made by the Systems Development Office, Equipment Development Laboratory, in June 1970.

3. DISPLAY HARDWARE CONFIGURATION

The KCRT is used in systems involving a computer. This is in contrast to the teletypewriter which is often used in communications purely for transmitting messages from point to point. The unique capabilities of the KCRT are one part of a total system, including the operator, the KCRT, and the computer, where the information system operates as a closed loop. The human operator at the terminal closes the loop formed by the input channels to the computer, the computer itself, and the output channels from the computer to his terminal. Such an information loop--where a KCRT is utilized--is cost-effective only if real-time processing in interactive mode is the primary requirement. An exception might occur where a KCRT is utilized for the principal purpose of rapid data entry to the CPU, with the screen serving in a verification and editing capacity.

Three basic arrangements in which KCRTs might be utilized are:

1. Stand-alone minicomputer,
2. On-line to remote computer, and
3. Computer network.

3.1 Stand-Alone Minicomputer

The KCRT requires the services of a computer to utilize its capabilities. The availability of minicomputers makes possible a relatively inexpensive configuration where one or more KCRTs are connected to a local minicomputer. This configuration is often called "stand alone" because neither the KCRT nor the minicomputer is necessarily tied directly into a communications network or a larger computer.

The minicomputer is characterized by its smallness (desk size), but in terms of processing speeds, it competes with medium-scale computers. However, the memory space is much less, and the minicomputers employ a smaller variety of peripheral devices than do larger computers.

The user generally provides nearly all of the programming for the minicomputer. The cost of programming for any one local minicomputer would be minimized if any identical local configurations were used in the Weather Service since all offices would use the same programs.

The main disadvantage of the stand-alone minicomputer configuration in the Weather Service is the inability to communicate directly with other offices or data bases. Also, it does not reduce the volume of teletypewriter input data to WSFOs. Paper tape from the teletype networks, however, could be used as input to the minicomputers to update a small local data base (e.g., of observation data).

3.2 On-line to Remote Computer

This configuration is a complex arrangement. The KCRT is usually used in this way when there is a large, centralized data base being shared by a

number of remote locations. (The question of whether to have a centralized data base or a number of local data bases is a major design consideration.)

An example of a large, centralized data base is one formed by weather observation data being sent to the National Meteorological Center for use in producing numerical weather charts. The charts, an output from the centralized data base, possibly could be displayed on graphic KCRTs, but for optimal use may require a display device with a larger screen size.

A variation would be to have a local stand-alone (minicomputer) configuration in which the minicomputer is tied into a large central computer. This type of arrangement might be considered a video display system for national weather charts. The central computer would generate the weather charts and transmit them in slowed-down video form to the local configuration including minicomputer, buffer, and video disk. The charts could then be retrieved selectively through the KCRT.

The connection of a KCRT to a central computer requires careful consideration of their compatibility. The interpretation of the KCRT's code must be compatible with operating system software of the central computer; in other words, the meanings of coded signals recognized by the KCRT must be the same as those recognized by the computer's software. As an example, the KCRT may use a certain bit representation to indicate a DATA FORMAT ON condition, but this bit representation might mean ABORT TRANSMISSION to the computer's software. Even though two KCRTs may use the same code structure (e.g., ASCII), one may be compatible and the other incompatible with a particular computer's software.

A wide variety of KCRTs are manufactured by firms which do not manufacture central processors. A number of these manufacturers construct their KCRT models to be compatible with the computers of other manufacturers, while others provide interface software to make them compatible. Sometimes, however, such compatibility, while being professed, may not be fully operable. Claims of KCRT-computer compatibility in the case of two different manufacturers should be investigated and confirmed by other users.

Another important consideration of compatibility in the weather information system is the hardware compatibility of the KCRT equipment with the existing communications network.

The three main properties of hardware compatibility are:

- Code structure
- Transmission rate
- Transmission mode (simplex, half-duplex, full duplex).

Code Structure

The National Weather Service communications network uses five-level code. Most KCRTs, however, have been designed to operate only with an eight-level code. These off-the-shelf KCRTs cannot be used with the present network

without a hardware modification.

The problem can be resolved with a code conversion mechanism (black box), but at additional cost except in a system like the Data Disc 6600 where a minicomputer acts as interface between terminal and central computer. That is, there are a few KCRTs that operate through a programmable controller. In this instance, there would be no additional cost for code conversion, because it is accomplished through a programming routine. However, these systems are usually economical only when there is a cluster of terminals served by one minicomputer.

Transmission Rate

Communication-channel transmission rates vary depending on the type of channel. There are three basic categories of channels: subvoice band, voice band, and wideband. Their line-speed ranges are as follows:

Subvoice band	45-200 bits per second (bps)
(Teletype ASR 33)	(110 bps)
Voice band	600-4,800 bps
Wideband	19,000-500,000 bps

The KCRTs themselves vary in the speeds at which they operate. The most common range is between 1,200 and 2,400 bits per second, which makes them incompatible with most NWS teletypewriter networks. There are some KCRT models, such as the Burroughs Input and Display System, that operate both in the subvoice and the voice range. Operating in the subvoice range, such equipment would be compatible with current NWS teletypewriter equipment; at a future date, when such compatibility is no longer a factor, conversion to the higher speed could be accomplished at little or no cost.

Transmission Mode

There are three modes of transmission:

(1) Simplex--lines that can transmit only in one direction.

(2) Half-duplex--lines that can transmit in two directions (between two points), but only in one direction at a time.

(3) Duplex (Full duplex)--lines that can transmit in both directions simultaneously.

Most KCRTs are designed to operate in a half-duplex mode. This is because KCRTs provide only one buffer; therefore, messages cannot be received and sent simultaneously. Some large terminals have separate buffers for separate devices which are connected to them as part of one station; in general, the full-duplex mode is provided for these terminals.

3.3 Computer Network

The use of KCRTs in a computer network is the most complex of the three

basic arrangements in which they can be utilized. This arrangement is used primarily for a large information system which is geographically dispersed. In the weather information system, regional data bases may be created for special purposes, such as regional/state/local forecast preparation. These regional data bases could be stored within a network of computers.

Configuration

Thus far, this report has discussed only KCRTs connected to a central computer, not in a network, but in a many-to-one configuration.

Another possibility is to establish regional computers which serve a number of field offices. Many KCRTs would be connected to one of the regional computers (normally medium-size computers), while the regional computers would be connected to one another by wideband (high-speed) transmission lines. This approach can be carried a step further by placing small satellite computers (minicomputers) in the field offices. The latter configuration further reduces the transmission mileage that may be required.

The main design question when considering satellite configuration is the allocation of functions between the various computers in the network. The allocation of functions will determine where various portions of the data base will be stored in the network.

Not all KCRT functions require processing on a computer with large storage; some forecasting support tasks could be handled on the field office satellite. Forecast composition is a prime example. Depending on size of the data base, request/reply for observation data and forecasts could also be handled locally.

Multiple computers provide one method of reliability in a network where one computer can assume the workload of another in an emergency. Normally, in a situation where a single computer drives one or more KCRTs, a failure in the central computer will force all of the connected KCRTs out of service until repairs can be completed. However, if the KCRTs are connected in a network to two or more computers, and the computers are programmed to provide the service, then one computer can serve as the backup for another. A failure in one computer is detected by the system, whereupon the other computer steps into the network and continues to perform the interactive functions with the connected KCRTs. Because it is not usually cost-effective for a backup computer to stand idle during normal operations, it is usually set up to perform tasks of lower priority. When called upon for backup functions, the second computer usually is forced to drop this low priority work. Airline reservation systems are examples of this type of operation. Typically, an airline reservation system has two large-scale computers and several hundred KCRTs.

4. COST AND TRADEOFF FACTORS

The purpose of this section is to give the reader some information in the following areas:

- Guidelines on the cost range of current-generation KCRT equipment
- The manufacturers' pricing structures
- Tradeoff considerations between various KCRT models
- A macro-level analysis, comparing teletypewriter-like devices with the KCRT.

4.1 KCRT Hardware Cost Ranges

The KCRT equipment is composed of a number of components that are separately priced. The keyboard units and the CRT unit, although they are usually parts of the same piece of equipment, are often considered separate for pricing purposes (they may be constructed as two pieces of equipment and sit in different positions on the table). The special features of the KCRT, such as a light gun, a joy-stick cursor control, and the special editing features, usually are priced separately.

One very important component is the terminal controller. This is a separate piece of equipment. Depending on the particular device, multiple display units may be connected to the terminal controller, or each display unit may be independent and contain its own control logic. The terminal controller may contain buffer storage (memory) and logic circuitry used with it to regenerate the display. Various manufacturers' controllers vary in the number of KCRTs they can serve--the usual number is from four to 20.

Some illustrative ranges of manufacturers' purchase-price structures for KCRT equipment are shown below:

Stand-Alone Unit (CRT, keyboard, and built-in control logic):
$3,000-$10,000

Separate Pricing:

a. Terminal controller unit (capable of servicing four or eight CRTs): $6,000-$9,000

b. CRT (purchased with terminal controller): $1,500-$3,000

d. Keyboard unit: $300-$700

For example, eight KCRTs may be attached to a terminal controller with a price structure as follows:

$	7,500	Controller (serving eight CRTs)
	16,000	Eight CRTs
	4,000	Eight keyboards
$	27,500	

Thus, the price of each of the eight KCRTs is $3,437.50.

Considerable effort has gone into engineering development so that future-generation KCRTs will drop substantially in cost. Primary areas of development are memory, such as plasma tube display in which the memory is in the face of the screen, and circuitry, such as LSI (large-scale integration) and TTL (transistor-transistor-logic).

Another important area of cost reduction in the use of display equipment is the utilization of video display technology. A video display (ordinary television set), coupled with a keyboard, can be produced for prices well under those of current KCRTs.

4.2 Cost Tradeoffs and Comparison of Teletypewriter-like Devices with KCRTs

There are several important trade-off considerations when selecting a KCRT. One is the cost of special features versus ease of operation on the part of the operator. For example, the inclusion of a light pen greatly facilitates cursor movement, although the increase in cost may be hundreds of dollars.

Another tradeoff situation is cost versus reliability. This subject is of particular importance with KCRT alternatives because of their complexity. The first impression is that more costly equipment will perform with greater reliability, but the gain could be nullified if the complexity of the equipment is also increased. Displays using TV-raster techniques are both more reliable and less expensive than strobe KCRTs.

A third consideration is the cost of error-detection capability versus system reliability (data integrity).

A teletypewriter is often considered as an alternative to a KCRT. They have certain similar functions: both have keyboard data-entry capability and both can be used as computer input-output terminals. The primary difference is speed. Teletypewriters are limited in speed due to mechanical limitations and usually lack of buffering. The KCRT also has editing features, vector generation, and other graphic capabilities which the teletypewriter does not possess.

There is a price differential of about three-to-one between KCRT equipment and teletypewriter equipment. Thus, the justification for the KCRT must be based upon its application advantages.

5. PROGRAMMING THE KCRT

The KCRT operates under programming control that may be classified broadly into communications software and applications software. The communications software is concerned with control of the external environment (the KCRT stations and the communications network). The applications software performs the internal processing of messages and presents responses to the communications software for output to the appropriate KCRTs.

5.1 Communications Software

The communications software performs many functions in the interaction of the KCRT with the central processor. The communications are accomplished through a set of commands recognized by both the computer and the KCRT. The KCRT must know when the computer is ready to accept messages or when the computer wants to send a message; the computer must know if the KCRT will accept messages or has a message to send.

There are numerous requirements for special commands such as an ABORT command in which a previously sent message is cancelled. Some of the most basic functions are highlighted below:

Polling

The most common function that is performed by communications software is polling. This is a function in which the KCRTs are interrogated on a periodic basis to determine if any messages are awaiting transmission. The communications software could be programmed to look up the terminal address in a polling table and to send a special polling character to the KCRT. The KCRT will respond with a START OF MESSAGE or signal signifying NO MESSAGE. The polling table must be updated as terminals are added or removed from the system (even on a temporary basis).

Message Queuing

A basic function of all communications software is message queuing. The messages arrive at the central processor unevenly. Some messages cannot be processed immediately, which means they must be placed in a queue. In a similar manner, the output message may have to go into a destination queue. There may be special requirements for processing messages out of their normal order, based upon their priority class.

The development of programming routines for queue management requires special skills. There is also the further consideration of the interface of the communications software with the operating system that is controlling the central computer operation. The on-line application may be sharing the computer with other applications, and another application program may have a priority designation higher than the one given to the program using the KCRTs.

Message Routing

A common function of the communications software is message routing. A message from one point may go to all points on the network after processing, or it may go only to selected points. A message may have to be rerouted to a different station because a KCRT has been placed on the inactive list. The programming complexity of this function depends on the complexity of the message traffic patterns.

Special Programming

The communications software will contain special routines that must be provided to take advantage of unique KCRT features. For instance, a device may have a scrolling capability(see appendix B)where new information is continually presented and old information is removed from the screen. On the UNIVAC Uniscope 300, the programming routine must give the command to the KCRT to delete the first or the last line, and the hardware automatically causes the remaining lines to move up or down to fill the void. The programming routine would then enter a new line.

5.2 Applications Software

The application programming requirements depend upon the nature of the task and the availability of standard routines to perform the tasks. Standard routines are sometimes provided by manufacturers to perform functions common to many applications. For example, a generalized routine may be available that retrieves a display format from a library of formats and presents it to the operator to fill in the variable data.

Special programming routines must be written to handle tasks that are specific or unique to a particular application. The application programming may be a minor cost or a major cost depending on the complexity of application programming requirements.

A typical task to be programmed would be message translation. A message may enter the computer in a relatively free format. An application requiring computer processing of the message content would first require the message to undergo a syntax analysis.

In certain KCRT configurations, the application programming is hardwired into the equipment. For example, format retrieval functions can be hardwired into a microprocessor controlling a group of KCRTs.

6. HUMAN FACTORS AND APPLICATION DESIGN TRADEOFFS

There are important human factor considerations concerned with the use of a KCRT. First, the problem of operator frustration must be considered. The computer system, for example, may generate an error message that the operator finds incomprehensible, with the result that he would be unsure whether to move on to the next input or to search for errors in the input still on the KCRT screen. Also, the operator can be quickly frustrated with his own performance, as he may find the experience of using an unfamiliar KCRT keyboard unpleasant. This raises the important consideration of adequate training to use the device.

Another factor concerns human physical limitations. An operator spending a number of work hours in front of a KCRT may experience eye strain although the screen characteristics of the KCRT may minimize this outcome. The most important screen characteristic is the resolution of the image as measured by the display viewer's ability to discriminate fine detail. Subsumed under this are brightness and contrast.

Another important factor is the stability of the image produced by the KCRT. This stability is determined by the frequency with which the electron beam refreshes the screen, combined with the type of phorphorus used.

The most satisfactory approach to coping with human factor problems is through careful function allocation. A sample listing of first-level functions includes:

- Data collection
- Data input
- Data storage
- Data retrieval
- Data dissemination
- Man-machine communications.

These functions are defined iteratively, progressing from general to specific statements. A second-level function definition for data input, for example, might include:

- Message identification
- Data field identification
- Data formatting
- Cursor control
- Data keying
- Editing and error correction
- Verification
- End-of-message indication.

The functional statements focus on the requirements. These requirements guide the selection of a specific system configuration from all alternative configurations. The actual process is best described in terms of considering application design tradeoffs during the process of function allocation.

6.1 Application Design Tradeoffs

The preceding sections indicate the range and variety of factors involved in selection of KCRT hardware for a given application and system environment. Selection of a particular KCRT device for an application is primarily a matter of tradeoffs in the allocation of functions. In any KCRT application, there are a number of functions to be performed. These functions may be totally or partially allocated to man, hardware, or software. The tradeoff is then made in terms of design and development costs, operational costs, output accuracy, and reliability.

Usually, design in favor of one factor will imply costs in another. For example, an inquiry capability which is extremely simple and flexible from the human operator's standpoint will imply costly and complex computer programming. Similarly, selection of standard off-the-shelf keyboard hardware may require far less development cost and hardware cost, but the tradeoff may be in lower operator efficiency or accuracy, or in higher training costs.

The following illustrate some of the application design tradeoffs from a KCRT-capabilities viewpoint.

CRT Screen

Tradeoffs in screen size are fairly straightforward. If the maximum number of characters per message can be predicted, screen size in total characters can be selected on that basis. However, the definition of what constitutes a separate "message" can often be based on tradeoffs of hardware, software, and human factors. Messages can be designed to use more than one CRT "page "(see appendix B), for example. This will entail costs in computer software to control paging. If number of characters per line on the CRT screen is not compatible with the application data or the operator's accustomed style, the tradeoff will occur in the area of operator training or frustration.

Hardware capabilities for screen addressing have direct implications for programming complexity and human factors. For example, a conversational-type inquiry may be extremely complex to implement if the screen may be addressed only at the beginning (top line).

Where standard formats are required, for example, in some forecasts, the operator's job is simplified by having the capability to separate the screen into "active" versus "passive" blocks, corresponding to fixed format data versus variable (operator-entered) data.

Memory Size

The CRT memory performs the function of storing data. Some CRTs

have been designed so that the memory can store, say, two or three "pages" of data. In the case of multipage messages, this would make communications line utilization more efficient. Also, because CRT hardware is performing the paging function, the central computer does not need to perform this function. The tradeoff implies higher CRT hardware costs and less flexibility in application message design with computer-controlled paging. (An exception may be the Data Disc 6600 where a mini-disc is available for intermediate buffering of more than one page sent from the central system.)

Character Set and Emphasis Indicators

Compromises are often made in the CRT character set because of the seemingly high cost of tailoring a character set to the requirements of the application. Usually the human factors and programming cost of these compromises are greater than anticipated. Any deviations from the character set, which is natural to the application data (such as weather symbols), imply costs in operator training and accuracy.

Lack of emphasis indicators (underline, uppercase and lowercase, blinking, etc.) may force applications into an awkward or unusual presentation of information. However, data which in the past has been transmitted via teletypewriter in the Weather Service may not buffer because readers are accustomed to lack of emphasis features.

Keyboard

Keyboard design is one of the most straightforward illustrations of the tradeoffs among human, machine, and programming factors. Ease of training and operation, accuracy, and efficiency from a human factors standpoint are always acquired at the expense of hardware cost and programming complexity. Usually, hardware costs of a keyboard modification or design are known prior to selection of the device, whereas accuracy and time costs in human operation are not known.

Total investment in interactive communications systems involving KCRTs is generally high enough to justify preliminary experiments to collect data on human factors costs. Such experiments as the "CRT Typewriter Experiment"[1] can provide information on critical human factors and can lead to suggestions of alternative functional allocations not previously considered. In that study, for example, the alternative of using specially trained and skilled KCRT operators in place of forecasters was suggested. That alternative would, of course, have to be compared to the cost of designing and purchasing keyboards more suitable for use by forecasters.

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[1]Hoehne, Walter E., "Final Report--CRT Typewriter Experiment," Report 3, Functional Experimentation and Test Branch, Test and Evaluation Laboratory, Systems Development Office, ESSA Weather Bureau, February 1970.

7. WEATHER SERVICE KCRT APPLICATIONS

There are several potential applications of KCRTs in Weather Service Forecast Offices (WSFO). The principal applications support tasks performed by forecasters.

Applications discussed in this section include:

- Selective recall of observation data
- Selective recall of forecasts
- Selective display of weather maps
- Forecast composition
- Pilot weather briefing.

Purposes of this section are to describe briefly the ways in which KCRTs might be applied and to identify the major questions that must be resolved when designing the systems and selecting hardware. While each application is discussed separately, the reader should keep in mind that several combined applications may use the same KCRT. The applications designer may, in this instance, make certain compromises in systems design and KCRT selection to accommodate several applications. (It should be noted that the KCRT, as such, is not essential to these applications--for most, teletypewriter devices would be alternative solutions.)

Selective Recall of Weather Observation Data

The forecaster frequently needs to recall or retrieve weather observation data. The KCRT may be used to automate the often time-consuming task of locating teletypewriter hard copy containing the appropriate information. The man-machine interface through the KCRT is shown in figure 1. The information flow is illustrative only and does not represent a preferred or optimal information flow for this application.

The forecaster enters the observation query through the KCRT keyboard. Special function keys might be provided on the keyboard--e.g., keys representing weather observation points most frequently requested. The computer will poll the terminal, then accept and store the request. The computer then searches the data base, retrieves the requested observations, and formats the message. The formatted reply is then transmitted to the KCRT which originated the request.

Some design considerations involve the location(s) of the computer and data base and the nature of the request permitted. Requests permitted are highly dependent on organization of the data base. The major search key could be time of observation or the observation station identification code. There are questions concerning the length of time that past observations could remain in the data base and method of updating the data base. There are questions as to whether all weather observations should be accessible to each WSFO or only the ones frequently recalled by that Office.

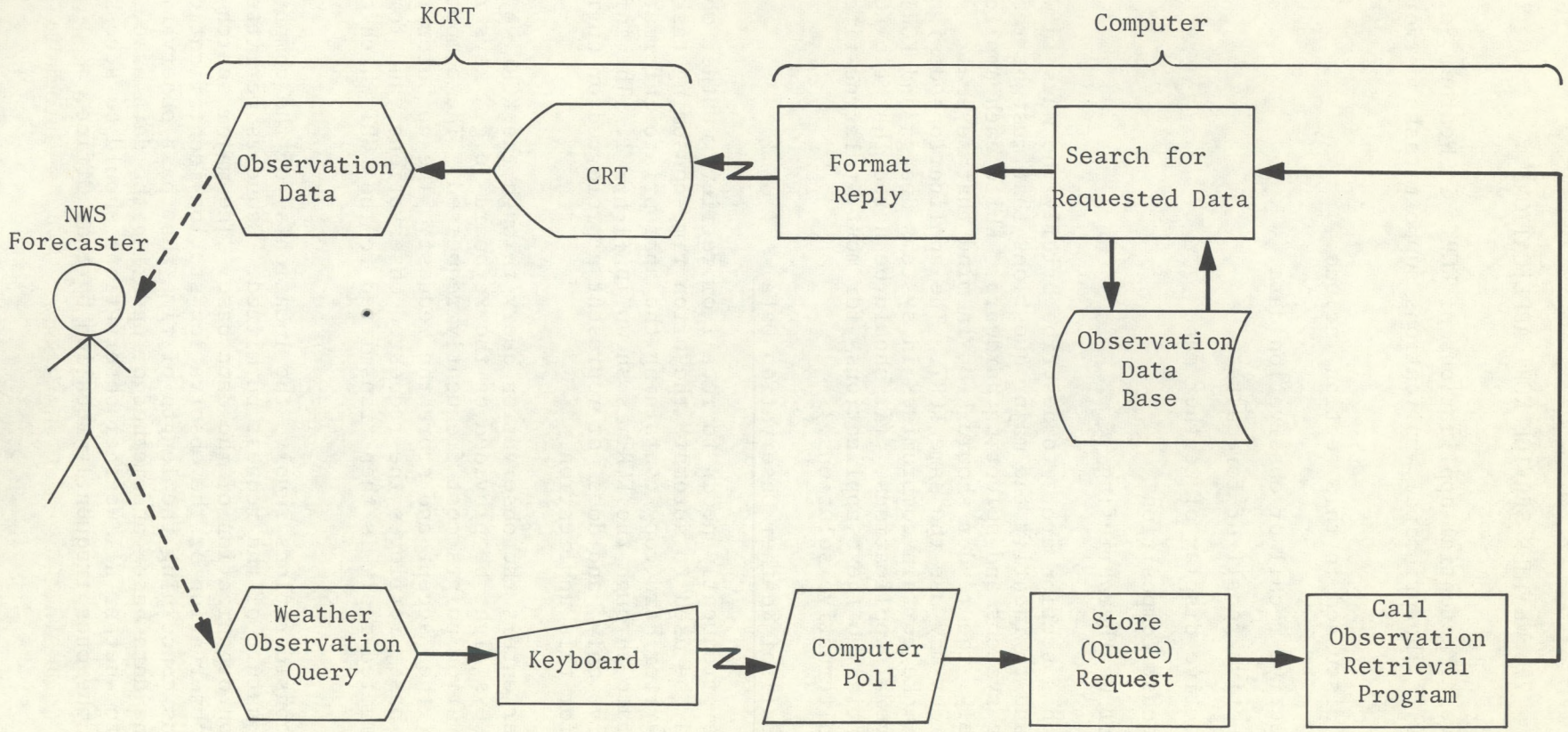

Figure 1.-- Man-machine interface through a KCRT for weather observation data recall.

Selective Recall of Forecasts

There are many different reasons for a forecaster to require access to forecasts. A newly arrived forecaster must familiarize himself with his predecessor's forecast. The forecaster will review forecasts from other areas to help form an initial conceptualization of weather trends. Also forecasts will be recalled by the forecaster for monitoring, amending, and composing new forecasts.

This application of the KCRT is similar in character to the observation data application. There are, however, special considerations to be taken into account when creating the data base structure. The structure must accommodate both public-area and aviation-point forecasts. A search strategy must be created for the retrieval of the forecast, and a programming algorithm developed to perform the retrieval function.

Weather Map Display

One of the most critical aspects of the forecaster's job is the formulation of a composite picture of the weather. The forecaster performing this task studies varying numbers of weather maps. The application of KCRTs to the display of weather maps introduces requirements not found in the applications involving alphanumeric data. Sophisticated software is required to perform such operations as overlaying one map on another. The capability for focusing in one region, with a "blow up" of that area, requires special support software.

Another major consideration for this kind of application is communication facilities. A large number of data points must be transmitted to form a weather map display. High-speed transmission lines are necessary to enable the map to appear on the screen rapidly.

The special function keys on the keyboard could be assigned to different types of maps. The forecaster could then retrieve the desired map by depressing a single key. The light pen could be used to designate a specific area of the map for a "blow up."

Forecast Composition

This application of the KCRT uses some of the most distinctive features of the device. The KCRT is unique in the ability it provides for manipulating alphanumeric text. The forecast composition task involves several functions which might be supported by the KCRT. These include:

(1) Retrieval of previous forecast or format

(2) Modification of previous forecast

(3) Forecast composition

(4) Transmission over communications network.

The first function, retrieval of previous forecast, can be handled in several ways: (1) manual retrieval of hard copy, (2) semiautomatic

retrieval using a tape cassette, and (3) automatic retrieval with computer program. The cost of the equipment would have to be weighed against the ease of operation and time saving.

Operator frustration caused by idiosyncrasies in the keyboard operation must be considered. The standard keyboard may be less than ideal for the type of input data that will be entered. A tradeoff exists between using the standard keyboard and incurring special development costs for a keyboard designed to provide "fail-safe" operation for a particular application.

The last function, communicating the forecast over the teletypewriter network, may be accommodated in three ways: (1) the message is retyped by a communicator from a hard copy, (2) the message is manually interfaced with the network through KCRT paper-tape output, or (3) the KCRT is physically connected to the network.

Pilot Weather Briefing

Pilot weather briefings are still an important activity at many NWS locations. An automated retrieval system using the KCRT has potential for making this activity more effective and efficient. The KCRT is an ideal device for man-machine interaction. The KCRT operator (in this case, the observer/briefer) may interact in a near conversational form directly with the computer. The information flow through such a system is represented in figure 2. The application design is illustrative only and should be considered along with alternative designs.

First, the briefer calls up on the CRT screen the briefing request format (step 1). Then, the briefer fills in the required information, thereby specifying the particular details of the flight for which the briefing is desired (step 2). An input communications program polls the KCRT and accepts the request into the central computer. A pilot-briefing program examines the request, searches the appropriate files, and responds with the weather data required (step 3). The information is stacked in an output queue. A split second later an output communications program formats the output data and transmits them to the KCRT, whereupon they are displayed on the CRT screen (step 4).

This application requires special computer facilities. The computer and data base are being shared by many users simultaneously. The conversation between the operator and computer is controlled by special software. The operators have a special language with which to communicate with the machine; e.g., a briefer may wish to inquire about the status of his briefing request.

Reliability is an overriding concern in request/retrieval systems. In a real-time system, there are many users that are dependent on the continuous operation of the computer they share. One approach to enhancing the reliability of the system is to design fallback operations. For example, if the pilot-briefings system is designed using regional computers, each region could be designed to accommodate requests from other regions during emergencies.

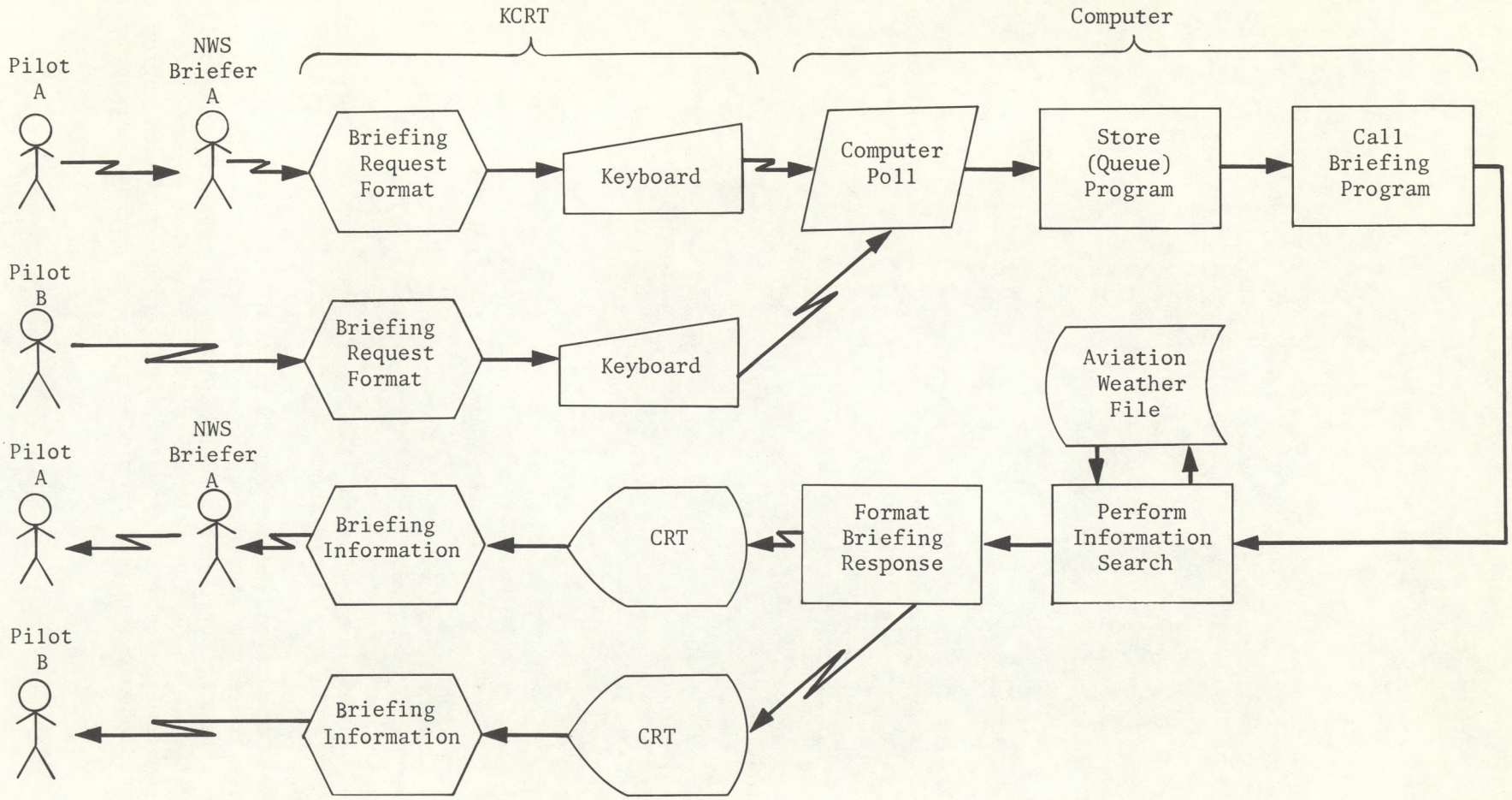

Figure 2.-- Man-machine interaction information flow--Weather Service pilot briefing.

APPENDIX A

KCRT COMPARISON CHART

KCRT Comparison Chart

MANUFACTURER	ALPHACOM	AMERICAN TERMINAL SYSTEMS	ATLANTIC TECHNOLOGY CORP.	BEEHIVE ELECTROTECH
MODEL	DW-33	767-40		Alpha 105
CHARACTER CAPACITY				
DISPLAYED	1800	2400	1920	1600
SEPARATE PAGE STORED?	NO	NO	NO	NO
CHARACTER FORMATION	5x7 Dot Matrix	9x14 Filled Stroke	15 Cursive Stroke Max.	5x7 Dot Matrix
CHARACTER SIZE (HXW)	0.13" x 0.09"	0.14" x 0.10"	0.18" x 0.12"	0.18" x 0.13"
VIEWING AREA (diagonal)	11"	12"	15"	11"
EDITING FUNCTIONS				
INSERT/DELETE:				
CHARACTER	YES	YES	YES	YES
LINE	YES	YES	NO	YES
TEXT EXPAND/CLOSE	YES	YES	YES	Line Page Edit
OUTPUT CODE	ASCII	ASCII	ASCII	ASCII
OUTPUT INTERFACE (direct to TTY-33 ASR)	YES	YES	YES	Optional
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED	Magnetic Tape Cassette	Magnetic Tape I/O; Paper Tape	NO	Magnetic Tape Cassette (Protected Field)
COST	$1500	$800		$2000
CHARACTER SET	64 char. ASCII	64 char. ASCII	64 char. ASCII	64 char. ASCII
COST/12 SPEC. CHARS.:				
ONE TIME (est.)	$2000	$2500	$3000	No Estimate Available
SUBSEQUENT (est.)	NONE	NONE	NONE	No Estimate Available
DATA OUTPUT SPEED (serial processing)	110 Baud (standard)	75-9600 Baud	110 Baud from TTY Buffer	110-2400 Baud
TYPE OF HARD COPY OUTPUT	IF[2] to TTY 33	Modified IBM Selectric		IF to TTY 33
INTERFACE/DEVICE COST	NONE	$3000		NONE
[1] PRICE	$3495	$3900	$14,000 (Display; ROM; Print Adaptor/Conv.)	$4995
DELIVERY (w/Spec.Chars.)	1-3 mos.	3 mos.	4 mos. minimum	Not Given

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER	BUNKER-RAMO	BURROUGHS	CANADIAN WESTINGHOUSE	COMPUTER COMMUNICATIONS, INC.
MODEL	2206/17	Input & Display System	WAND	CC-30
CHARACTER CAPACITY				
DISPLAYED	960	1020, 508, or 252 in	1050	960
SEPARATE PAGE STORED?	NO	? 2000 positions	Optional	NO
CHARACTER FORMATION	5x7 Dot Matrix	Stroke		5x7 Dot Matrix
CHARACTER SIZE (HXW)	1/8" - 1/4" x 4/3 ratio			0.187" x 0.156"
VIEWING AREA (diagonal)	Variable (small)	12" x 9" (WxH)		12"
EDITING FUNCTIONS				Edit by Typing over
INSERT/DELETE:				
CHARACTER	YES	Optional	NO	
LINE	NO	Optional	NO	
TEXT EXPAND/CLOSE	YES		N/A	
OUTPUT CODE	Computer Interface only	ASCII	ASCII or Baudot	ASCII
OUTPUT INTERFACE (direct to TTY-33, ASR)	YES	YES		Mod. CC-308 to TTY ($1600)
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED		NO (w/o Computer)		NO
COST				
CHARACTER SET	64 char. ASCII	64 char. ASCII		64 char. ASCII
COST/12 SPEC. CHARS.:	Not Available			
ONE TIME (est.)				$700
SUBSEQUENT (est.)				NONE
DATA OUTPUT SPEED (serial processing)	110, 150, 300 Baud	150-4800 Baud		110 Baud w/Converter (Mod. CC-308)
TYPE OF HARD COPY OUTPUT	IF to TTY 33/35, KSR/ASR/RO	IF to TTY 33 RO, 1 per Controller		Electrostatic Printer, 300 cps
INTERFACE/DEVICE COST				$7500
[1] PRICE		$13,000 (w/Control I)		$9145 (w/CC-308 IF)
DELIVERY (w/Spec.Chars.)				3 mos.

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER	COMPUTER CONSOLES, INC.	COMPUTER OPTICS	COMPUTER TERMINAL CORP.	CONRAC CORP.
MODEL	724-2	CO:70	Datapoint 3300	201 Data Display Term.
CHARACTER CAPACITY				
DISPLAYED	1920	3000	1800	960
SEPARATE PAGE STORED?	Optional	NO	NO	NO
CHARACTER FORMATION	5.7 Dot Matrix	16x18 Dot Matrix	5x7 Dot Matrix	5x7 Dot Matrix
CHARACTER SIZE (HXW)	Size is fn Screen Size	0.18" x 0.09"	0.16" x 0.11"	1/4" x 3/16"
VIEWING AREA (diagonal)		7.5" x 9.5"	12"	14"
EDITING FUNCTIONS				Edit by Typing over
INSERT/DELETE:				
CHARACTER	YES	YES	w/Mag. Tape Accessory	
LINE	YES	Optional	w/Mag. Tape Accessory	
TEXT EXPAND/CLOSE	YES	YES		
OUTPUT CODE	ASCII or Baudot	ASCII	ASCII	ASCII
OUTPUT INTERFACE (direct to TTY-33 ASR)	Paper Tape to ASR 28	Punch Tape	YES	Optional
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED	Format Mag. Tape (100 formats)	Mag. Tape Optional (Protected Field)	Mag. Tape Unit	Mag. Tape Input or RS 232-B (Protected Field)
COST	$9000		$2250	
CHARACTER SET	64 char. ASCII	88ch.ASCII(Selectric KB)	64 char. ASCII	64 char. ASCII
COST/12 SPEC. CHARS.:	Need formal request for price.			
ONE TIME (est.)		$12 per character	$10 per character	$1000
SUBSEQUENT (est.)		NONE	NONE	NONE
DATA OUTPUT SPEED (serial processing)	110 Baud (75 possible)	2400 Baud (No 110)	110-2400 Baud	110 Baud
TYPE OF HARD COPY OUTPUT	Selectric Typewriter (15 cps)	"VIP" (300 cps)	Printer (30 cps)	IF to TTY 33
INTERFACE/DEVICE COST	$4500	$2400	$3600	
[1] PRICE	$10,500	$7875	$4625	$3500
DELIVERY (w/Spec.Chars.)	4 mos.	4 mos.	1-3 mos.	3 mos. at least

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER MODEL	COURIER TERMINAL SYSTEMS Executerm 1	DELTA DATA SYSTEMS Telterm 2	DELTA SYSTEMS Delta 1	DIGITAL EQUIPMENT CORP.
CHARACTER CAPACITY DISPLAYED SEPARATE PAGE STORED?	 512 NO	 2160 Paging	 960 NO	DOES NOT MANUFACTURE ITS OWN CRT
CHARACTER FORMATION CHARACTER SIZE (HXW) VIEWING AREA (diagonal)	7x8 Dot Matrix 0.14" x 0.11" 4.8" x 6.4"	7x9 Dot Matrix 9/32" x 7/32" 14"	5x7 Dot Matrix ? 12"	
EDITING FUNCTIONS INSERT/DELETE: CHARACTER LINE TEXT EXPAND/CLOSE	 YES YES YES	 YES YES YES	 Optional Optional YES	
OUTPUT CODE OUTPUT INTERFACE (direct to TTY-33 ASR)	ASCII YES	ASCII Optional ($1000)	ASCII Optional ($1000)	
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED COST	NO	Mag. Tape (Protected Field) $1900	Mag. Tape Cassette No. 4001 (Protected Field) $4175	
CHARACTER SET COST/12 SPEC. CHARS.: ONE TIME (est.) SUBSEQUENT (est.)	64 char. ASCII Unknown	64 char. ASCII $2000 $600	64 char. ASCII $2000 $600	
DATA OUTPUT SPEED (serial processing) TYPE OF HARD COPY OUTPUT INTERFACE/DEVICE COST	110-1200 Baud Execuprint (11 cps) $2150	110-9600 Baud Telterm Printer $3500	110 Baud Character Printer (30 cps) $4000	
[1] PRICE	$3800	$3500	$5500	
DELIVERY (w/Spec.Chars.)	1 mo. (w/o spec. char.)	4-5 mos.	4-5 mos.	

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER	DIGITAL SCIENTIFIC	FOTO-MEM, INC.	GENERAL AUTOMATION, INC.	GENERAL DYNAMICS
MODEL	2101	Foto-Vision II		Datagraphix 1110
CHARACTER CAPACITY				
DISPLAYED	800	1440	1030	1030
SEPARATE PAGE STORED?	NO	NO		NO
CHARACTER FORMATION	5x7 Dot Matrix	10x14 Dot Matrix	Computer-compatible only	"Charactron" Beam Extrusion
CHARACTER SIZE (HXW)	Size is fn Screen Size	3/16" x 1/8"		0.125" x 0.07"
VIEWING AREA (diagonal)		10"		10" x 10"
EDITING FUNCTIONS				
INSERT/DELETE:				
CHARACTER	YES	YES		YES
LINE	NO	YES		YES
TEXT EXPAND/CLOSE	NO	YES		YES
OUTPUT CODE	ASCII	ASCII		ASCII
OUTPUT INTERFACE (direct to TTY-33 ASR)	YES	YES		301 Bell Dataphone
CANNED FORMAT CAPABILITY--	NO	Need Minicomputer with Mag. Tape or Paper Tape Input		NO
ACCESSORIES NEEDED				
COST				
CHARACTER SET	64 char. ASCII	64 char. ASCII		64 char. ASCII
COST/12 SPEC. CHARS.:	Unknown	Unknown		
ONE TIME (est.)				$1000
SUBSEQUENT (est.)				NONE
DATA OUTPUT SPEED (serial processing)	110, 1200, 2400, 4800 Baud	110-600 Baud		1200 Baud (standard)
TYPE OF HARD COPY OUTPUT	IF to TTY 33	IF to TTY 33		NONE
INTERFACE/DEVICE COST	NONE	NONE		
[1] PRICE	$2900 (w/o Display)	$2430		$7000
DELIVERY (w/Spec.Chars.)	4 mos. (w/o spec.char.)	?		3 mos.

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER MODEL	GENERAL ELECTRIC Datanet 765	HAZELTINE 2000	HONEYWELL VIP 2323	IMLAC Model PDS-1 Minicomputer with Light Pen Optional
CHARACTER CAPACITY DISPLAYED SEPARATE PAGE STORED?	 1012 NO	 1998 NO	 960 NO	 1200 NO
CHARACTER FORMATION CHARACTER SIZE (HXW) VIEWING AREA (diagonal)	5x7 Dot Matrix 0.19" x 0.14" 14"	5x7 Dot Matrix ? 12"	Computer-compatible only	7x9 Stroke Matrix, No Max. 0.125" x 0.10" 14"
EDITING FUNCTIONS INSERT/DELETE: CHARACTER LINE TEXT EXPAND/CLOSE	Edit by Typing over	 YES YES YES		 YES YES YES
OUTPUT CODE OUTPUT INTERFACE (direct to TTY-33 ASR)	ASCII YES	ASCII YES		ASCII or Baudot ASR 28
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED COST	?	Mag. Tape Cassette (Protected Field)		Complete Format Capability
CHARACTER SET COST/12 SPEC. CHARS.: ONE TIME (est.) SUBSEQUENT (est.)	64 char. ASCII $500-$1000 per char. NONE	64 char. ASCII N/A		ASCII or Baudot Cost of Key Changes
DATA OUTPUT SPEED (serial processing) TYPE OF HARD COPY OUTPUT INTERFACE/DEVICE COST	1200 Baud Page Print Adaptor to TTY 33 $610	110, 150, 300, 600, 1200 Baud Printer (Speed up to 300 Baud)		Adjustable to any Speed IF to TTY 33 or 28
[1] PRICE	$4605	$2995		$9800
DELIVERY (w/Spec.Chars.)	6 mos.	1-3 mos.		3 mos.

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER	IBM	INFOTON	INTERNATIONAL COMPUTER TERMINAL	LOGITRON
MODEL	2260 Display Station	Vista 2D	SPD 10/20 Minicomputer	Logiport/1
CHARACTER CAPACITY				
DISPLAYED	240, 480, 960	1280	1920	512
SEPARATE PAGE STORED?	NO	NO	NO	NO
CHARACTER FORMATION	5x7 Dot Matrix	5x7 Dot Matrix	7x10 Dot Matrix	5x7 Dot Matrix
CHARACTER SIZE (HXW)		0.15" x 0.10"	0.10" x 0.07"	0.22 x 0.14"
VIEWING AREA (diagonal)	9" x 4"	12"	12"	7" x 5"
EDITING FUNCTIONS				Edit by Typing over
INSERT/DELETE:				
CHARACTER	?	YES	YES	
LINE	NO	YES	YES	
TEXT EXPAND/CLOSE	NO	YES	Programmable	
OUTPUT CODE	ASCII	ASCII	ASCII or Baudot	ASCII
OUTPUT INTERFACE (direct to TTY-33 ASR)	IBM 1053 Mod. 4	RS 232 or TTY 33	RS 232 or TTY 33/28	RS 232-B or TTY 33
CANNED FORMAT CAPABILITY--	NO (w/o Computer)	Mag. Tape Cassette I/O (Protected Field)	Mag. Tape; Paper Tape (Programmed)	NO (Protected Field)
ACCESSORIES NEEDED				
COST		$2000	$1900	
CHARACTER SET	88 char. ASCII	64 char. ASCII	64 char. ASCII	64 char. ASCII
COST/12 SPEC. CHARS.:				N/A
ONE TIME (est.)		$3000	$1000 (ROM Change)	
SUBSEQUENT (est.)		$100	NONE	
DATA OUTPUT SPEED (serial processing)	1200, 2400 bps	110-2400 Baud	45-4800 Baud	110, 300 Baud (switch selectable)
TYPE OF HARD COPY OUTPUT	IBM 1053 Mod. 4 only	Printer (speeds to 30 cps)	Printer (30 cps)	IF to TTY 33
INTERFACE/DEVICE COST	$2000		$200	
[1] PRICE	$19,770 (w/Control Mod.1, A/N KB, Printer)	$2995 (basic)	$9000	$2950
DELIVERY (w/Spec.Chars.)		3 mos.	4 mos.	1 mo.

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER	MARK COMPUTER	MEGADATA	PHILCO FORD CORP.	PHOTOPHYSICS
MODEL	DD 70 L	S/R 1023	Military-oriented; not price competitive	45
CHARACTER CAPACITY				
DISPLAYED	1024	1440		1000
SEPARATE PAGE STORED?	NO	YES (Mod. 2023)		NO
CHARACTER FORMATION	5x7 Dot Matrix	5x7 Dot Matrix		5x7 Dot Matrix
CHARACTER SIZE (HXW)	0.13" x 0.08"	?		0.125" x 0.10"
VIEWING AREA (diagonal)	12"	12"		9"
EDITING FUNCTIONS				
INSERT/DELETE:				
CHARACTER	YES	YES		YES
LINE	YES	YES		YES
TEXT EXPAND/CLOSE	YES	YES		YES
OUTPUT CODE	ASCII	ASCII		ASCII
OUTPUT INTERFACE (direct to TTY-33 ASR)	RS 232-B or TTY 33	RS 232-B or TTY 33		RS 232-C or TTY 33
CANNED FORMAT CAPABILITY--	Minicomputer Needed	Mag. Tape Cassette		Mag. Tape Cassette
ACCESSORIES NEEDED				
COST		$900		$2900
CHARACTER SET	64 char. ASCII	64 char. ASCII		64 char. ASCII
COST/12 SPEC. CHARS.:	Unknown			
ONE TIME (est.)		$2000 (standard option)		$2000
SUBSEQUENT (est.)		$500		NONE
DATA OUTPUT SPEED (serial processing)	110 Baud	110, 150, 300 Baud (switch selectable)		110-1200 Baud (switch selectable)
TYPE OF HARD COPY OUTPUT	Line Printer	IF to TTY 33		Photographic Internal to Machine
INTERFACE/DEVICE COST	$12,000			NONE
[1] PRICE	$4440	$4500(1023);$5500(2023)		$8000
DELIVERY (w/Spec.Chars.)	5 mos.	70 days		3 mos.

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER	RAYTHEON	RCA	RCA	SANDERS ASSOCIATES
MODEL	DIDS 402	70/756-31 or 752	DIVCON	5700 Display System 720
CHARACTER CAPACITY DISPLAYED SEPARATE PAGE STORED?	520, 1040, 1470	1134 NO	2048	1024 NO
CHARACTER FORMATION	Monoscope	Template Monoscope	NOT SUITABLE FOR OUR APPLICATION	Stroke (16 max.)
CHARACTER SIZE (HXW)	0.17" x 0.14"	0.12" x 0.085"		Adj. 0.18" x 0.12"
VIEWING AREA (diagonal)	8.5" x 6.5"	5.5" x 8"		9.5" x 7"
EDITING FUNCTIONS INSERT/DELETE: CHARACTER LINE TEXT EXPAND/CLOSE	 YES YES YES	 YES YES YES		 YES YES YES
OUTPUT CODE	ASCII	ASCII	ASCII	ASCII or Baudot
OUTPUT INTERFACE (direct to TTY-33 ASR)	201 Bell Dataphone	Optional ($1700)		ASR 28
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED COST		NO (w/o Computer)		Paper Tape Reader (not available)
CHARACTER SET	64 char. ASCII	64 char. ASCII		64 char. ASCII
COST/12 SPEC. CHARS.: ONE TIME (est.) SUBSEQUENT (est.)		 $4375 $50		Not Displayable with Their Matrix
DATA OUTPUT SPEED (serial processing)	1200, 2400 Baud	110 Baud		110 or 75 Baud (switch selectable)
TYPE OF HARD COPY OUTPUT	TTY 33 RO Adaptor	IF to TTY 33		IF to TTY 28
INTERFACE/DEVICE COST	$4200	NONE		NONE
[1] PRICE	$7260	$8325		$17,000
DELIVERY (w/Spec.Chars.)		3 mos. at least		3 mos. at least

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER	SPIRAS SYSTEMS, INC.	SUGARMAN LABS, INC.	TEC LITE	TELEMATION
MODEL	DBEC-1000-TY	Video T-6	460	TCG-1440
CHARACTER CAPACITY				
DISPLAYED	1200	1600	1000	560
SEPARATE PAGE STORED?	NO	Optional ($500)	NO	NO
CHARACTER FORMATION	Template Monoscope	5x7 Dot Matrix	5x7 Dot Matrix	Raster Scan (equiv. to 7x13 Dot Matrix)
CHARACTER SIZE (HXW)	0.13" x 0.10"	0.21" x 0.09"	0.18" x 0.12"	Size is fn Screen Size
VIEWING AREA (diagonal)	12"	14"	12"	14"
EDITING FUNCTIONS				
INSERT/DELETE:				
CHARACTER	YES	YES	YES	YES
LINE	YES	YES	YES	YES
TEXT EXPAND/CLOSE	YES	YES	YES	YES
OUTPUT CODE	ASCII	ASCII	ASCII	ASCII
OUTPUT INTERFACE (direct to TTY-33 ASR)	RS 232-B	YES	YES	Convertible to ($1500)
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED	Mag. Tape Interface (Protected Format)	Mag. Tape Cassette (Protected Field)	Mag. Tape Interface (Not Available)	Mag. Interface (Not Available)
COST		$1000		
CHARACTER SET	64 char. ASCII	128 char. ASCII	64 char. ASCII	64 char. ASCII
COST/12 SPEC. CHARS.:				
ONE TIME (est.)	$2500 (Spec. Monoscope)	$3000	$1200	$2000
SUBSEQUENT (est.)	NONE	NONE	NONE	NONE
DATA OUTPUT SPEED (serial processing)	110-1200 Baud (switch selectable)	110-2400 Baud (switch selectable)	110 Baud (standard)	110 Baud
TYPE OF HARD COPY OUTPUT	IF to TTY 33	IF to TTY 33	Similar to TTY 33	IF to TTY 33
INTERFACE/DEVICE COST	NONE	NONE	$275	NONE
[1] PRICE	$4995	$3900	$2400	$11,245
DELIVERY (w/Spec.Chars.)	3 mos.	3 mos.	3-4 mos.	4 mos. at least

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

KCRT Comparison Chart

MANUFACTURER MODEL	ULTRONIC Videomaster 7000	UNIVAC Uniscope 100	UNIVAC Uniscope 300	VIDEO SYSTEMS CORP. VST 2000
CHARACTER CAPACITY DISPLAYED SEPARATE PAGE STORED?	 960 NO	 1024, 960, 512, 480	 1024, 512	 1296 YES
CHARACTER FORMATION CHARACTER SIZE (HXW) VIEWING AREA (diagonal)	Computer-compatible only, Polled Terminal	Closed Stroke (8 max.) 10" x 5"	Stroke 10" x 5"	5x7 Dot Matrix 0.20" x 0.10" 10.5" x 8"
EDITING FUNCTIONS INSERT/DELETE: CHARACTER LINE TEXT EXPAND/CLOSE		 YES NO	Scrolling Feature YES YES	 YES Line Erase, not Insert NO
OUTPUT CODE OUTPUT INTERFACE (direct to TTY-33 ASR)	ASCII	Modified 7-level ASCII YES	Modified 7-level ASCII NO	ASCII YES
CANNED FORMAT CAPABILITY-- ACCESSORIES NEEDED COST		NO (w/o Computer)	NO (w/o Computer)	NO
CHARACTER SET COST/12 SPEC. CHARS.: ONE TIME (est.) SUBSEQUENT (est.)			96 char. ASCII	64 char. ASCII NO
DATA OUTPUT SPEED (serial processing) TYPE OF HARD COPY OUTPUT INTERFACE/DEVICE COST		2400 bps (leased) UNIVAC Comm. Output Printer; TTY 33/35	2400 bps (leased) NONE	110-2400 Baud IF to TTY 33 NONE
[1] PRICE		$2950 - $3450	$15,140 (Single-Station Display)	$2870
DELIVERY (w/Spec.Chars.)				Stock (std. unit)

[1] Prices exclusive of special characters, hard copy, and external format equipment.

[2] IF = Interface.

APPENDIX B

SPECIAL GLOSSARY OF TERMS RELATED TO KCRT DISPLAYS AND THEIR USE

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ASCII	(American Standard Code for Information Interchange), a data transmission code having eight bit positions per character.
baud	Unit of signaling speed. The speed in bauds is the number of discrete conditions or signal events per second. If each signal event represents only one bit condition, baud is the same as bits per second.
Baudot code	A data transmission code having five bit positions per character.
block	A type of screen addressing in which the screen may be divided into logical "blocks" which are separately addressable; data in the blocks need not be physically contiguous.
buffer (KCRT)	Temporary storage for data being transmitted to or from the KCRT.
character set	The set of numeric, alphabetic, symbols, and control characters recognized by a KCRT's hardware.
control keys	Keyboard keys which control KCRT hardware operations. Examples are vertical tab, horizontal tab, and new line.
cursor	Special character which may appear on a KCRT as a pointer, usually in connection with some interactive facility; indicates the character position into or from which the next character of data will be moved.
data base	Collection of information stored on a computer storage device in a manner that allows rapid retrieval.
dot matrix	Method of character generation where characters are generated by dot patterns within a matrix of dots.
electron beam	Accelerated and focused stream of electrons emitted from a cathode which impacts the phospher-coated surface of a KCRT to form a spot of light.
format	A prescribed form for entering or presenting information.

function keys	Programmable keys of a KCRT that send special characters to the computer, which in turn executes a pre-programmed function.
home	Upper left-most screen position.
joy stick	A small straight stick or hemisphere control that activates screen movements. A joy stick, depending on its implementation, can cause the rotation of a picture or the movement of the cursor.
KCRT	Keyboard cathode ray tube device.
light gun, light pen	Hand-held device which activates selected screen operations; employs a small photocell or fiber optic bundle.
many-to-one	Transfer of information from many sending locations to one receiving location.
memory (KCRT)	See buffer.
off-line	Remote stations not directly connected to an information loop; off-line from the main processing.
on-line	Remote stations connected directly to a computer through a communications channel or line.
page	All the data displayed on the CRT screen at one time.
paging	A function performed either through hardware or software in which more than one page of data is associated to form a logical message.
screen addressing	Means whereby data may be transmitted to specific places on the KCRT screen. Coordinates, line number, block, or sections are examples.
screen size	Size of the CRT screen in terms of number of characters displayed, characters per line, and lines per screen.
scrolling	A technique in which data are continually rolled onto the screen. The basic purpose is for rapid scan of information.
split screen	A type of screen addressing in which the screen is "split" into two logical portions, each of which is addressable.

strobe KCRTs	The class of KCRTs that direct a beam momentarily to one point, in distinction with the TV-raster-class KCRTs where the beam continuously moves across scan lines.
stroke pattern	Method of character generation in which each character's configuration is formable within a matrix; the matrix can be turned on with strokes in a combination of horizontal, vertical, or diagonal positions.
vector generator	Hardware line generator which operates on line definitions translated into beam-control signals.
viewing area	Physical dimensions of the CRT screen, usually measured diagonally.

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