

# DESIGN AND EVOLUTION OF THE OSPS OPERATOR INTERFACE

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Human factors requirements have strongly influenced the design of OSPS operator terminals. This article describes the OSPS operator interface design, and several features that have been incorporated to improve operator performance from the perspectives of process, implementation, and the operator terminal. The article also presents a discussion of implementing the design on the video display terminal (VDT), combined services terminal (CST), and intelligent communication workstation (ICW).

## Introduction

The goals of simultaneously satisfying end user needs, enhancing service flexibility, increasing operator efficiency, and offering the latest technology have provided the core challenge in the design of OSPS operator terminals. These terminals have been designed to handle calls requiring an operator, and to accommodate the flow of calls through the system. The design includes information entry flexibility and operator and system control.

A study of existing terminals during early OSPS development found that no completely satisfactory terminal was commercially available. Therefore, the decision was made to develop a custom terminal, which came to be known as the OSPS video display terminal (VDT). In periodically re-examining this decision throughout OSPS development, expanding the product to include terminals—based on personal computer (PC) technology—was deemed desirable because of improvements in commercially available products. Therefore, the OSPS VDT's functionality was extended to two PC-based products: the combined services terminal (CST) for the North American market, and the intelligent communication workstation (ICW) for the international market.

These terminals and their interface—i.e., the type of hardware needed, and means of communication between the operator and OSPS—improve the operator's ability to interact with customers, process information supplied by the operator equipment, and make the procedural decisions needed to handle calls.

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### Operator Interface Design Process

Many factors needed to be considered in designing the operator interface (Figure 1 shows the design process flowchart). A fundamental consideration was the existing operator services base, i.e., the type of activities that operators routinely do. Operator handling of a typical call includes, but is not limited to, the following functions:

- Identifying the type of billing for a call
- Controlling verbal communications with various parties, e.g., to confirm acceptance of billing on a collect call
- Querying a database, e.g., to obtain a charge quotation
- Visually monitoring the status of a call
- Observing system feedback
- Responding to customer, operator, or system errors
- Recording other details for a "call ticket record," e.g., data describing transmission difficulties encountered by a caller.

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Because these tasks are varied and complex, the ergonomic guidelines described below have been developed. These guidelines, coupled with market input, telephone service provider input, operator input, hardware criteria, and cost considerations, have framed the design of the operator interface. This design has been produced by an operator interface design team consisting of members representing human factors engineering, planning, systems engineering, and hardware and software development. The team derived design requirements through the process identified in Figure 1, examining each call capability to be provided and determining how it would be implemented through the operator interface. Prototype development and evaluation—including human factors trials with experienced operators—were done during design phases to involve end users actively as early as possible and to continue their participation.

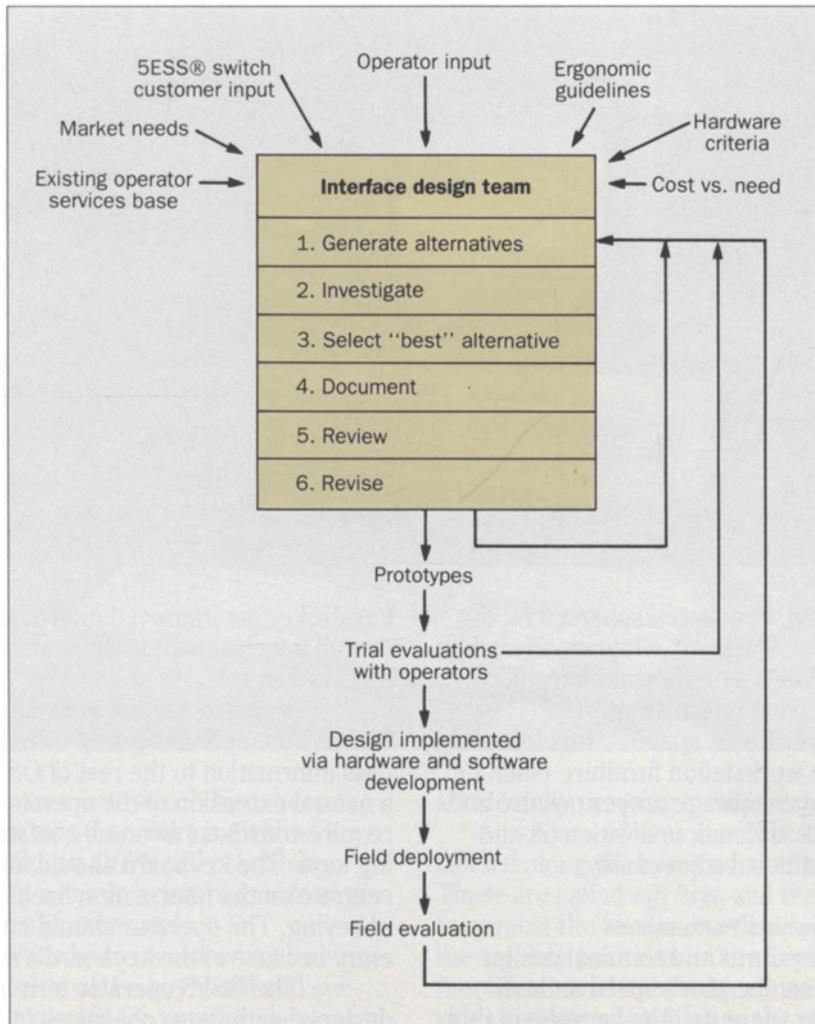
Workstation prototypes, operator interviews, time and motion keyboard evaluations, and simulated call handling work environment studies provided feedback to enable the operator interface design to evolve to its

present form. This design was implemented through hardware and software development. Later feedback from OSPS development and studies at field sites deploying OSPS were used to verify the interface design and to suggest design changes.

### Ergonomic Guidelines for Designing the Operator Interface

The operator interface design team developed a set of guidelines that helped direct VDT, CST, and ICW designers toward an ergonomically sound final operator terminal design. These guidelines included:

- User Comfort and Data Entry
  - Designing the physical components of the operator terminal for user comfort, and to minimize visual fatigue over long periods of use
  - Using local terminal intelligence to provide immediate visual feedback to keyboard entries to minimize keying delays
  - Using a standard procedure to enter alphanumeric data into displayed fields, and for editing data within fields
  - Allowing a flexible order of data entry to accommodate the various ways callers may request service
- Keyboard
  - Making frequently used keys the easiest to reach, and assigning less frequently used keys to soft key locations
  - Using keys that activate the desired function with a single keystroke
  - Arranging keys and displayed information into color-coded functional groupings to make them easier to locate
- Screen Layout and Display
  - Avoiding cluttered displays
  - Entering call processing data via screen "forms," and arranging data fields on the forms into functional areas to make them easy to locate
  - Using software-defined display windows to allow less frequently used data to be organized on sep-



**Figure 1. Design process flowchart.**

- arate “pages” that are accessible to the operator
- Using graphics to represent call connection status in an easy-to-understand format
- Using larger text, color coding, and reverse video to alert the operator to areas of the display that need immediate attention.

These guidelines resulted in a terminal design that uses local intelligence to minimize response time, a high refresh rate monitor to provide a flicker-free positive video display (dark characters on a light background) that reduces visible reflections, and a custom keyboard to provide special keys grouped by function

**Figure 2. OSPS CST display and keyboard.**



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and color. To display sharp, easy-to-read characters, the VDT uses a high-resolution black-and-white monitor; the CST and ICW design includes a high-resolution color monitor to display color-coded information.

All OSPS terminals are compatible with commercially available adjustable workstation furniture (such furniture is recommended to encourage proper posture and prevent fatigue). Monitors are equipped with a tilt-and-swivel mechanism for additional adjustability.

#### **Maximizing the OSPS Operator's Performance**

Call handling procedures and terminal design play an important role in an operator's speed and efficiency in processing caller requests. Any increase in this area translates into improved call processing throughput for the entire OSPS office. Therefore, the OSPS operator interface has been carefully designed to maximize the speed and accuracy of information flow.

The following sections describe how the operator interface guidelines noted in the previous section were used to maximize the OSPS operator's call processing abilities. These guidelines translate into minimized

keystrokes, an improved information display, and an overall improvement in the interface between operator and system.

**Minimizing Keystrokes During Call Handling.** The keyboard is the operator's only communication channel to pass information to the rest of OSPS. Ideally, it should be a natural extension of the operator's fingers and not require conscious awareness of moving hands or pressing keys. The keyboard should allow the operator to concentrate on the information itself, not on the physical act of keying. The operator should not have to slow down data entry because of the keyboard's mechanical limitations.

The OSPS operator terminal keyboards were designed with these objectives in mind. For example, the VDT keyboard shown in Figure 2 was designed specifically to provide the functions and data entry capabilities needed for the toll and assistance application in North America.

As a rule, the more keystrokes needed to send commands to the OSPS switch, the longer it will take for the operator to process a call and the more chances for keying errors to occur. Therefore, command entry has



**Figure 3. OSPA ICW display and keyboard.**

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been designed to use *function keys*, which have been arranged in *color-coded* groups that make individual keys faster to locate. Frequently, an OSPA call processing function may be done with a single keystroke instead of multicharacter alphanumeric commands.

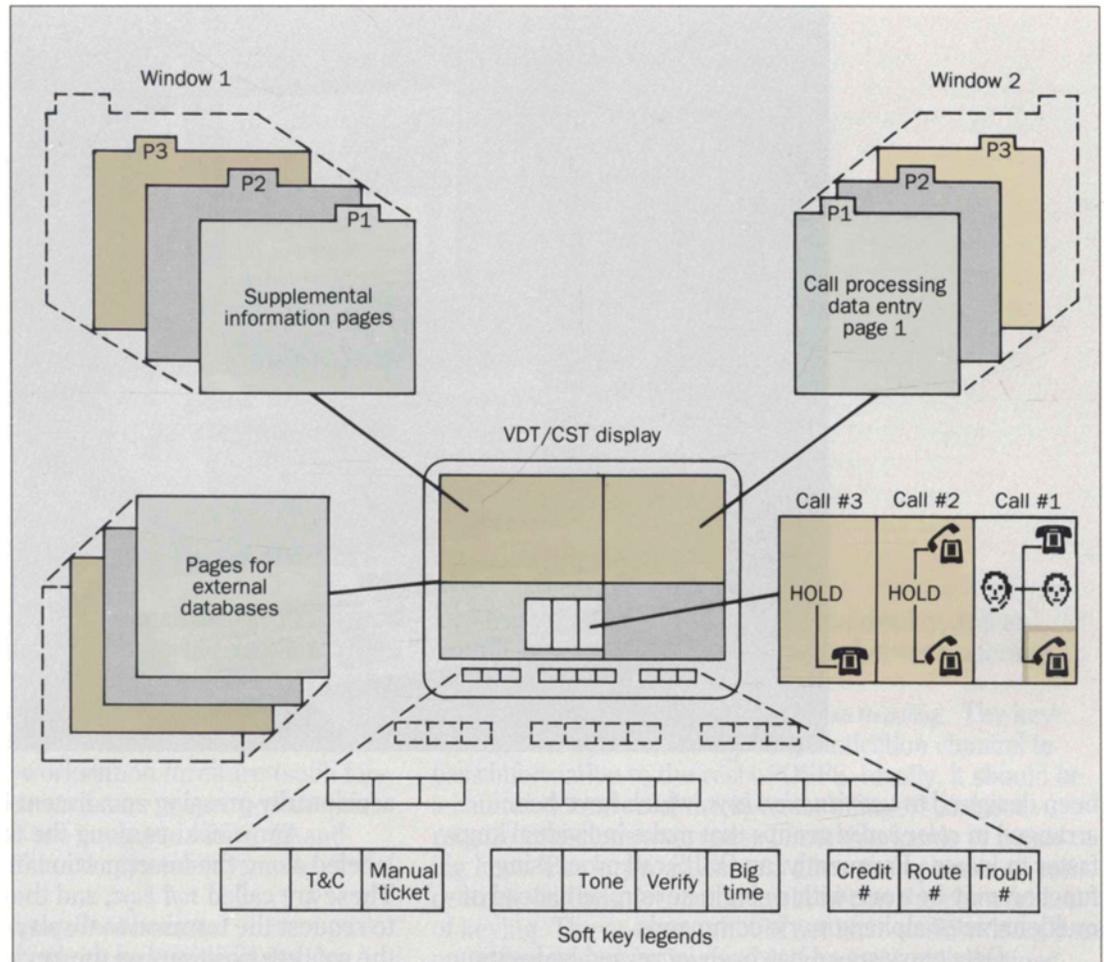
Data entry speed has been increased by locating the digit pad on the right side of the keyboard and surrounding it by function keys used for numeric data entry, reducing the hand motion required. The alphabetic keyboard uses the standard Sholes (QWERTY) arrangement, allowing operators trained in touch-typing to enter alphabetic data faster.

Keys that are accessed frequently have been made larger to make them easier "targets" for the operators' fingers. Certain keys have been also located at the corners of key groupings to reduce the possibility of

accidentally pressing an adjacent key.

A row of keys along the top of the keyboard is labeled along the lower portion of the screen display. These are called *soft keys*, and they allow OSPA software to request the terminal to display labels corresponding to the soft key positions on the keyboard. Infrequently used functions have been assigned to soft keys, which provides an elegant solution to the problem of providing keys for these functions. Other uses of soft keys include application-specific keys, such as the special charge categories for inter-administration calling and the Chinese character editing functions shown in Figure 3, used in some international markets. Several rows of soft key labels typically are available to the operator; the operator may scroll through these rows to search for a particular label. Without the soft keys, many more

**Figure 4. OSPS display layout.**



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function keys would have been required, resulting in a larger and more complicated keyboard. They also provide a means to add functions later without keyboard redesign.

For the North American Market, programmable *macro keys* have been placed on the keyboard. These allow OSPS office personnel to write *macros*, i.e., a sequence of often-used keystrokes represented by one

key. Frequently entered phone numbers or emergency agency numbers may be assigned to these keys for faster data entry without requiring the operator to look up the number every time it is needed.

**Displaying Information to the Operator.** Information displayed on the operator's terminal must be easy to understand and must allow the operator to make quick, accurate judgments when deciding the best way to pro-

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cess a caller's request for operator service. The OSPS operator terminal displays a form, containing only pertinent call information, an enhancement over the paper tickets once used to record call billing information manually, which did not prompt the operator to obtain only significant information. Figure 2 shows an OSPS CST display for North American toll and assistance call processing.

Because operators frequently look back and forth between the keyboard and display while processing a call, the most significant and frequently needed call data have been located on the *lower portion* of the display. This design strategy minimizes the amount of operator head and eye movement during call handling when looking at the keyboard and the screen.

Less important and less frequently needed data are displayed in two "windows" located at the left and right upper quadrants of the call processing display. Each window may hold several "pages" of call information, with labeled tabs identifying each page; two or more pages in one window resemble layers of index cards. A simple key action allows the operator to step through each page in a window to locate the desired one. When none of the information applies to a call, the operator cannot access the pages, and their tabs do not appear on the window. However, when call processing requires it, the display windows provide a way to make more data accessible to the operator without degrading screen readability. This design also allows OSPS to group data on function-oriented pages to help operators understand and use data. An example of this is the international market VIT<sup>1</sup>, where an on-line aid is supplied for finding information about other countries' numbering plans, etc. Figure 4 shows how the pages of these two windows relate to the rest of the call processing display.

In North American market applications, the terminal also has a third window overlaying the entire display and allowing the operator access to external databases. (This allows the CST access to a Directory Assistance database, for example.)<sup>1</sup> As with the other

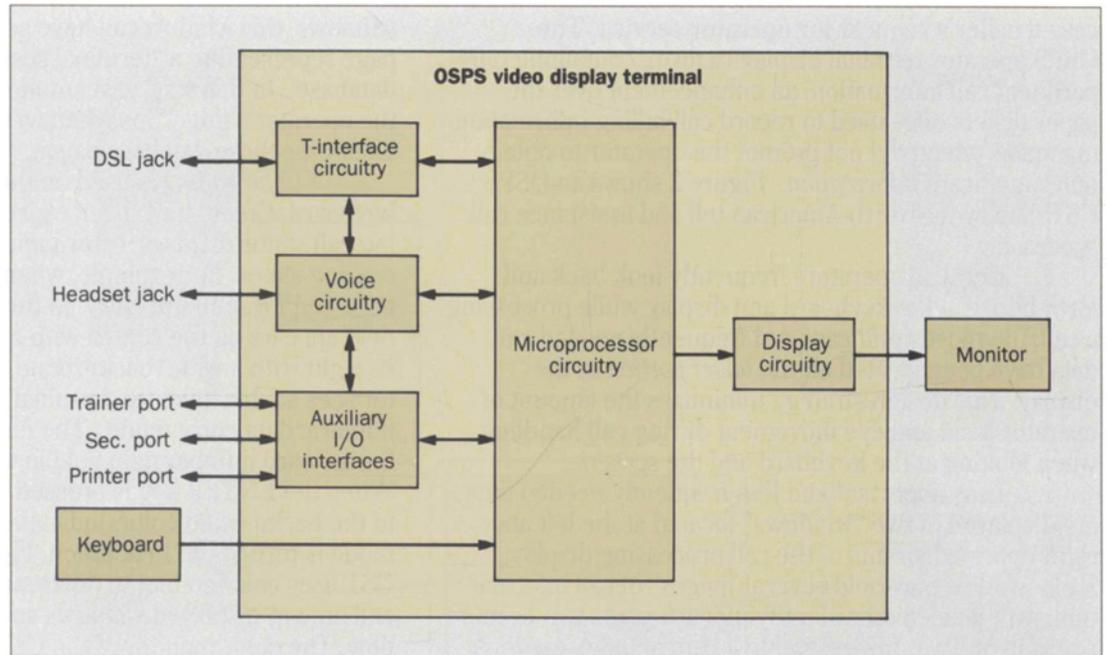
windows, this window can have several pages, with each page representing a "terminal session" with a different database. In this way, vast amounts of information are at the operator's fingertips whenever it is needed. Figure 4 illustrates these database pages.

*Color-coding* is used on the display as well as the keyboard. Colors have been especially useful in identifying call status displays, error indications, and data processing states. For example, when a data entry field is accessed for numeric entry on the VDT, a label for the field appears on the screen with a data field displayed to its right with a white background. Whenever the operator sees such a field, the terminal is clearly in an alphanumeric data entry mode. The display in Figure 2 shows the forward number data field in the data entry mode. When the ENTER key is pressed, the white field returns to the background color, indicating that the data entry mode is turned off. In addition, Figure 3 shows how the CST uses color-coding to differentiate visually between and among displayed windows and pages within a window. The color monitor of the CST and ICW provides a full range of colors; the VDT's black-and-white monitor provides gray tones for color-coding.

Graphic characters show the status of any parties connected to a call, including the status of the operator, up to three external parties, and an additional operator, who may be added for help. Some examples of party status include on-hook, off-hook, split (i.e., speaking and receiving voice path connection are temporarily disabled), and muted (i.e., only the speaking connection is temporarily disabled). Figure 4 shows a second operator connected to two parties, one on-hook and the other off-hook and also split (shown with a tan background). This pictorial representation of call status quickly conveys to the operator the status of connections for up to three calls with minimal chance of confusion.

**Designing Operator-System Interactions.** For every function keyed by the operator, OSPS operator terminal local intelligence provides an immediate response via the display, informing the operator that the terminal regis-

**Figure 5. OSPA VDT architecture.**



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tered the key depression, regardless of system response time. Although some operator-system interactions are complex, each has been designed to minimize key-strokes while adhering to the design guidelines. These operations often involve several function keys, and may cause data in other areas of the display to be updated automatically. For example, in the North American market, changing the caller's requested number could invalidate a previously established interexchange carrier for this call. The operator must quickly and clearly be notified of this invalid state. And the operator's procedure for correcting this problem (e.g., by changing the carrier or the number to be called) must be flexible enough to cope with miskeyed digits or callers who change their request.

As a result, error displays pinpoint the suspected source of the error so the operator can quickly correct the problem. Error messages are displayed in reverse video

(dark background and white characters) to alert the operator, and are worded to describe the problem. If the system detects invalid data, it sets the field to reverse video.

To enter data and correct errors, the operator terminal provides data editing features that give the operator a choice of:

- Deleting an entire data field
- Progressively backspacing and deleting individual characters from the end of the field
- Moving the cursor and overwriting specific characters anywhere in a data field.

Also, for the North American market, to accommodate callers who forget to mention the area code for the phone number, the operator may add the area code to the *end* of a phone number in a data field. OSPA will then automatically reformat that number and display it with the area code *first*.

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To allow the operator to use the display and keyboard as an integrated unit, the data fields on the call processing display and the function keys used to access them have corresponding locations. For example, fields associated with function keys on the right of the keyboard appear on the right of the display, while call indicators associated with keys on the left side of the keyboard appear on the left side of the display. Most of the data fields requiring numeric entry appear on the right side of the display to correspond to the location of the digit pad on the right side of the keyboard.

Another feature designed to save operator time is generation of a paper ticket for calls with unusual billing conditions or for emergency calls. With one keystroke, the operator can request a printout of the pertinent call details, eliminating the need to hand-copy this information during the call. The printout includes the call date and time, the telephone numbers used, and several free-format detail fields (e.g., the names and addresses of the parties).

#### **OSPS Terminal Implementation**

In addition to the ergonomic criteria already mentioned, OSPS terminal design needed to provide several hardware interfaces, including:

- An ISDN T-interface<sup>2</sup> for voice and packet-switched data communications with the switch.
- Additional interface ports for voice and data communications with the OSPS trainer—a stand-alone call simulator used to support operator training.
- An operator headset interface for voice-path communications with the switch. This interface includes voice processing hardware to provide local volume control, voice-switched attenuation, automatic gain control (AGC), local generation of signaling tones, and detection of plug-in and plug-out.

Based on these requirements, the OSPS VDT has been designed as a custom terminal with the architecture shown in Figure 5. The microprocessor chosen was the Intel 80186, equipped with 256 kbytes of erasable

programmable read-only memory (EPROM) for program storage and 64 kbytes of static random-access memory (RAM) for dynamic data and video memory. The EPROM also contains custom alphanumeric and graphic icon fonts. As the core of the voice processing circuitry, the VDT uses a digital signal processor (DSP), the AT&T DSP20.

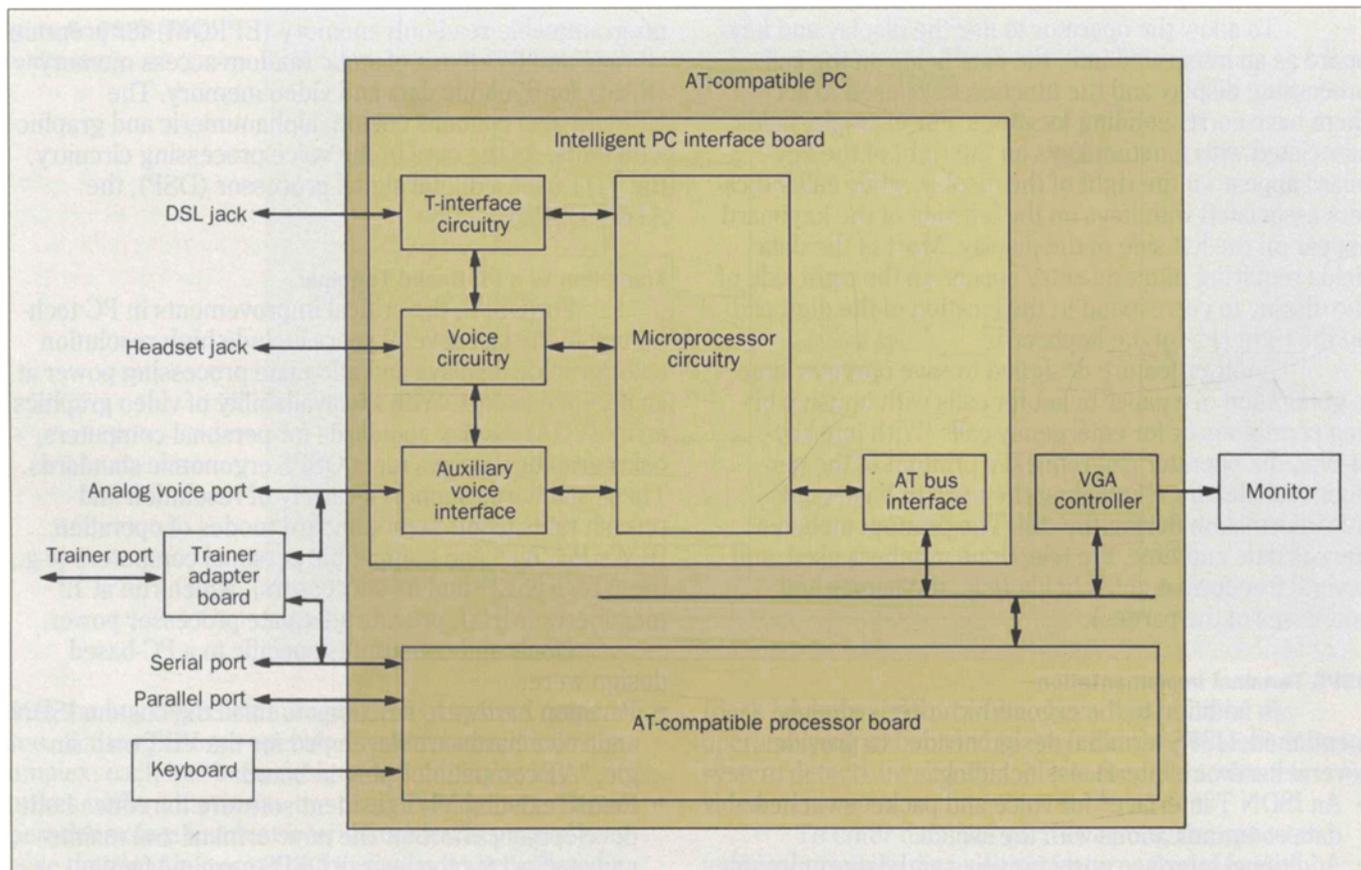
#### **Transition to a PC-Based Terminal**

For OSPS, the critical improvements in PC technology in the last several years include high resolution color graphic displays and adequate processing power at an acceptable cost. With the availability of video graphics array (VGA) display standards for personal computers, color graphic displays meet OSPS ergonomic standards. These standards support a variety of resolution and refresh rates using their standard modes of operation. IBM's PC/AT<sup>®</sup> and compatible personal computers (e.g., the AT&T 6312<sup>®</sup> and its successors), which run at 12 megahertz (MHz), provide adequate processor power.

Goals and constraints specific to a PC-based design were:

- Partition hardware functions to fit all the custom ISDN and voice hardware developed for the VDT on a single, "AT-compatible" plug-in board.
- Re-use existing VDT resident software to reduce both development effort for the new terminal and maintenance effort for the overall OSPS terminal family.
- Minimize costs for the new terminals so they do not exceed those of the VDT.
- Maintain overall performance for the new terminal to match the VDT's.
- Provide interfaces to the 5ESS<sup>™</sup> switch and to the operator trainer to match the VDT's.
- Provide a general purpose analog audio port for interfacing to external devices.
- Insulate the operators from personal computer software or operations detail.

In addition, to improve user friendliness, the local maintenance interface design uses pull-down



**Figure 6. OSPS PC-based terminal architecture.**

menus, which provide all the functionality present on the VDT, plus initialization for new features, such as the macro keys and color selection.

#### **CST and ICW Architecture**

The design of the CST and ICW splits the operator terminal functionality between the PC processor unit and an intelligent PC interface board (IPIB) (see Figure 6). In this design, the PC processor unit provides the

intelligence and memory for display and key processing for several applications. It also includes hardware to interface with the keyboard, serial devices, a printer, and a VGA-compatible monitor. Human factors studies recommend selecting monitors with acceptable brightness, color trueness, dot pitch, and adjustable tilt-and-swivel to minimize visual fatigue.

To augment these features, the software has been written to configure the monitor to run at a 68 hertz (Hz) refresh rate to minimize perceptible flicker. A resolution of 640 by 480 pixels was chosen for the necessary

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visual quality and compatibility with all standard VGA modes of operation. (A *pixel* is the smallest display element on a video display screen, usually a dot or cluster of dots.) A screen saver feature has been included to prolong monitor life. To improve response time and reliability, and to decrease noise levels, the PC's disk is used only for initialization. During operation all software and data are stored in the PC memory.

The IPIB board provides the specialized hardware for the CST's and ICW's ISDN termination and headset interface. It also adds an auxiliary audio port and circuitry to interface to the bus of the PC host. Devices on the IPIB do voice processing and protocol processing functions. To minimize software development, the IPIB processor is compatible with the VDT's; however, the IPIB uses a 12 MHz Intel 80C186 to improve performance, instead of the 8 MHz Intel 80186 used in the VDT. The DSP has been upgraded to an AT&T DSP16 to provide additional processing power for potential new features. To support desirable test configurations for system lab and factory testing, the ISDN T-interface device has been updated to an AT&T T7253. For compatibility with the existing VDT trainer interfaces, the electrical format of IPIB voice and data interfaces requires an external trainer adapter board. The IPIB software—downloaded from the PC host during terminal initialization—is completely RAM-based to simplify program updates when doing generic retrofits, providing new features, or resolving field problems.

#### **Evolutionary Capabilities and Special Applications**

With the increased flexibility of the PC architecture, new features are expected to be incorporated without requiring hardware redesign. Examples of potential features include adding local printing capability or providing a direct interface to local area networks for electronic program updates or database access. Users could customize the operator interface or change screen parameters—such as field layout or colors—to meet their specialized needs. The PC architecture also may

allow implementing new features, such as using third-party software or provisioning terminal-resident databases.

The ability to enter and display Chinese characters for the Taiwan market is the first of these new features. The Chinese character feature shows how the design of operator and system interactions are intertwined with the capabilities of the switch and terminal.

Operators need access to about 20,000 Chinese characters, stored in a terminal-resident database. After selecting an ICW character data field, the operator may choose to enter a Chinese character input mode, invoking a standard character entry method used in Taiwan. For each character, a special phoneme data field appears in which the operator enters several phonetic characters related to the first Chinese character desired. The ICW searches the database for all characters matching this phoneme; those that match are displayed as a numbered list on a page in the upper left window of the call processing display. The operator then uses the digit pad to select the correct Chinese character. The phoneme entry with a quick local database search provides an easy way to access one character out of many that cannot be assigned to individual keys. Figure 3 shows the ICW with the display in the Chinese character entry mode.

Because the terminal is built using a standard PC architecture, a commercial memory expansion board, containing the character database, may be used to provide the feature-specific memory without requiring any terminal hardware redesign. The PC's bit-mapped display is flexible enough to accommodate the additional page for presenting the Chinese characters to the operator.

#### **Summary**

This article has described the OSPS operator interface design from the perspectives of process, implementation, and operator terminal. Implementation of the design on the VDT, CST, and ICW was also discussed. The resulting robust operator interface affords substantial flexibility to meet future user needs. The results of

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research and development in the areas of operator services, ergonomics, and technology advances have been applied to provide the most current, full-featured operator workstation.

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Biographies (continued)

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