FUTURE AGS CONTROL STATIONS

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I.   Introduction

Discussions with numerous staff members have made it apparent that con-
siderable interest and need exist for a new generation of computer inter-
face for AGS operators. This note is an attempt to organize some thoughts
pertinent to implementing such a new interface. I intend that it should
stimulate discussion, possibly controversy, and alert those interested in
the matter that ideas and suggestions are welcome. In the following dis-
cussion, I shall mainly use the term "control station" in preference to
the overly pompous "Operator-Computer Interface".

Section II describes a control station in terms of its functional
characteristics. Section III rehearses the arguments for implementing a
new design of control station. Section IV constitutes a laundry list of
virtues a control station should possess. Finally, Section V embodies
my proposal for a station design. In addition, Appendix A describes the
present control stations in the Main Control Room. Readers familiar with
the topics of Sections II and III may skip these, as Sections IV and V are
for the most part self-contained.

II.   Functions of AGS Operator-Computer Interface

The functions of the AGS Operator-Computer Interface are described
here in terms of operating requirements. Appendix A describes in some detail
the current Main Control Room (MCR) control stations. It may be noted in

passing that the primary AGS control program, AGAST, will function in what is
called teletype mode, i.e., a mode requiring none of the MCR special facili-
ties and which permits commands to be typed in at any computer terminal; in
principle then, the AGS has a large number of potential operator consoles.
In practice, teletype-mode AGAST has found few customers. One must conclude:
a) that the apparently minor hardship of typing commands (rather than set-
ting a cursor and pushing a button) presents a significant barrier to the
casual user and especially the novice user; and/or b) the process of page
updating on a scrolled CRT screen is painfully slow.

A control station requires first an interactive alphanumeric display
for presentation of tabular and menu-style information and a user-controlled
cursor on the display for selection of menu items. An array of button-style
switches is required for use in conjunction with menu items on the display.
In typical usage, the menu item provides a noun and the button provides a
verb, the pair then constituting an operator command.

One usually also requires a general purpose computer terminal for the
use of the operator. In practice one would employ this terminal to initiate
the programs which support the interactive facilities. Finally, a graphic
display device, although not indispensable, can be of immense value in
presenting large volumes of readbacks in quickly digested form and in com-
paring a vector of readbacks with standard or archived values. The graphic
display may, in fact, be the same device as the computer terminal or the
alphanumeric display. One may optionally require additional non-interactive
alphanumeric displays for the presentation of status conditions, alarm mes-
sages, etc; some have termed these displays as "comfort displays".

III. Why A New Control Station

The reasons for desiring a new style control station can be sorted into
a few general categories: a need for additional control stations; a need
for new or enhanced features at the control stations; dissatisfaction with
the performance of the current stations; and maintenance problems with the
current stations.

The interactive displays of the current MCR control stations, the
TEC's (cf Appendix A), limit a control station to one interactive page of
40 characters by 24 lines. Considerable sentiment has been voiced by users
of the control stations that multiple interactive pages would considerably
enhance the utility of a control station.   Likewise,

it has been held that multi-color interactive display consoles could be
used to good advantage in presenting additional information via the ad-
ditional dimension of color.

The I/O bus hardware interfaces to the PDP-10 for the current MCR con-
trol station hardware, the TEC's, TED's and CIA's, are local special designs,
plugged directly into the PDP-10 I/O bus; they are high speed parallel
interfaces, providing very fast service for the user, but constrained to
be very close to their controlled hardware. There has been a demand for
additional control stations, notably at the linac among others, and we may
certainly expect ISABELLE to require at least one control station. These
new control stations would be physically remote from the PDP-10; the present
type of control station can be used at a remote location only with heavy
modification of the hardware. In any case, the present hardware interfaces
can support neither additional control stations nor additional interactive
displays. To provide additional displays and/or stations, additional inter-
faces would have to be built, as well as additional crates for the PDP-10
I/O bus to contain these interfaces. Before such a heavy program of con-
struction is undertaken, prudence alone would dictate a reevaluation of the
current design, which can be characterized as geriatric.

The age of the current hardware argues not only against expanding the
design, but also for replacing the existing control stations with more mod-
ern equipment. The TEC's/TED's are older, expensive devices, state-of-the-
art when acquired but no longer so, and keeping them in repair has become
expensive (compared to the cost of newer display modules of similar function-
ality). The CIA panels have been a continuing problem; there were four
built, of which three currently still exist, not all alike. They have indi-
vidual quirks which we have tolerated, more or less gracefully. In any
case, the trackballs incorporated in them have begun to deteriorate. Main-
tenance of the CIA panels has always been difficult and arduous, especially
as they are directly interfaced to the PDP-10 I/O bus and hence often
require the dedication of the PDP-10 to the maintenance task. The CIA panels
are the strongest argument to retire the current interface hardware.

Finally, the current design requires PDP-10 intervention to maintain
the TEC cursor, generating multiple interrupts each time the operator rolls the
CIA trackball. These interrupts are serviced by custom system software, link-
ing the CIA service routine to the TEC service routine. This software support
of the TEC cursor can produce high instantaneous demand

on PDP-10 resources, which was tolerable on a lightly loaded system, but
which in the current environment is extremely tedious. Moreover, the
CIA-TEC service routine linkage has proved to be rather buggy, and since
its introduction has yet to be made truly satisfactory.

IV. Laundry List of Station Attributes

We list here some potentially attractive properties of control stations,
for the sake of identifying problems to be solved in the design of a con-
trol station and to provide criteria by which to judge a suggested station
design. It is entirely possible that any particular item on the list may
not be included in the final design, or may be optional. These attributes
may be properties of the global station design (G), the interactive alpha-
numeric display (I) or some other feature of the station (O). The follow-
ing list is only vaguely ordered, mainly proceeding from the general to the
particular.

Modularity (G)--It is desirable that as much as possible, special
        features such as color displays, multiple displays or graphic
        displays be modular units that can be added to a station without
        major revision of the hardware already present or of the soft-
        ware support for the station. Likewise, it s probable that MCR
        stations may require more extensive facilities than remote sta-
        tions such as the linac; one set of software should support all
        stations. The basic hardware complement for a station should also
        be modular, not monolithic.

Commercial Acquisition (G)--As much as possible of the hardware should
        be standard commercial units. Reliability is higher, development
        times are shorter, repair and expansion easier and documentation
        better.

Expandability (G)--The design should not limit the installation of
        additional stations, either at the same or other locations.
        Likewise, additional facilities at existing stations should be
        easy to install.

Remote Stations (G)--The design should not discriminate against in-
        stallation of control stations at locations remote from the MCR.

Station Intelligence (G)--Many of these properties imply some level of
    independent intelligence in the control station. Specifically
    requiring such intelligence, in the form of a station processor,
    can enable the transfer of some program content from the PDP-10
    to the station (such as display formatting or generation). Such
    off-loading of the PDP-10 is desirable in general (since the
    PDP-10 has become rather heavily loaded), may well contribute
    to lengthening the useful life of the PDP-10 as the control com-
    puter, and may be crucial as the number of control stations increases.

Loosely Coupled to PDP-10 (G)--The coupling of the control station to
    the PDP-10 control computer should be loose, i.e., easily dis-
    connected without prejudice to either the PDP-10 or the station.
    This condition is to be contrasted to the present control station
    hardware installed directly on the PDP-10 I/O bus. This property
    is essential to facilitate the maintenance and development of the
    control station.

High Data Rate (G)--The link between the PDP-10 and the station should
    be high speed and should consist of not more than one PDP-10 inter-
    face per station.

ISABELLE Compatibility (G)--The control station design should not be
    antagonistic to control concepts likely to be embedded in the
    ISABELLE control system.

Display Write-Speed (I)--The write-speed of the displays, especially
    the interactive alphanumeric display, should be very high. The
    operator should perceive screen update not as a process, but as
    an event. This requirement probably implies some kind of parallel
    interface for the display rather than a serial one.

RS170 Compatibility (I)--The displays (interactive alphanumeric, non-
    interactive alphanumeric and graphic) should be RS170 compatible.
    RS170 is the specification for composite video television signals.
    RS170 compatibility ensures that displays can be piped into the
    CCTV system and can be connected to the Versatec printer for hard
    copy generation.

Color Displays (I)--The design should neither preclude nor require
    color displays. Color should be an option, easily added and re-
    quiring no significant additional software support to implement.
    (Clearly, PDP-10 programs which support color displays require

special design.) Color displays may require some compromise
of RS170 compatibility.

Display Size (GI)--The quest for multiple interactive alphanumeric
   pages can be addressed through multiple pages within one display.
   Displays of 80 characters by 24 lines are common; 80 character by
   48 line displays are available, but suffer resolution problems.
   Since current interactive programs generate display pages of 40
   characters by 24 lines, such display consoles could support respec-
   tively two or four interactive pages.

Independent Cursor Maintenance (OI)--Cursor maintenance on interactive
   displays should require no support from the PDP-10. Station
   maintenance of the cursor should be true even, and especially,
   in the case of multiple interactive pages (the presumption here
   is that a single button array and a single cursor are being
   used to service multiple interactive pages). This attribute
   especially requires independent station intelligence.

Flexible Button Presentation (O)--The array of button switches available
   to the operator should remain as flexible as possible. The CIA
   consoles by contrast are relatively inflexible, a problem compounded
   by the poor allocation of functions between soft and hard buttons.
   The button arrays should be almost all "soft" buttons, i.e., have
   functions and labels assigned by the computer. In this way maxi-
   mum utility of the buttons is provided for all programs, button
   arrangement/rearrangement remains flexible and labels can be
   guaranteed always to reflect button function. This requirement,
   in conjunction with the desire for multiple interactive pages,
   again argues strongly for independent station intelligence.

Comfort Displays (O)--Additional comfort displays should be easily in-
   stalled, at any station, with minimum disruption to the system.

Graphics (O)--Graphics displays should be available but optional. Re-
   taining the graphics option should not require additional expense
   until the option is installed. Graphics displays should also
   be high speed devices. Graphics support should not impose heavy
   PDP-10 loading.

V. Suggested Station Design

In this section, a specific design for a station is suggested. Essentially all the previously listed virtues are retained. Before proceeding with the details of the design, some general comments are in order about the choice of interactive alphanumeric display.

Three basic types of interactive alphanumeric displays exist. (1) One can use a standard CRT computer terminal, with a serial link to the PDP-10 or station processor and with a keyboard. A large variety of such hardware is available, in color and monochrome, several with internal microprocessor. Common problems with this approach are slow write-speeds due to the serial interface, an undesired keyboard (which frequently cannot be removed) and awkward cursor control. (2) A number of graphics display systems are available with sophisticated internal graphics processing support, providing both color and monochrome displays. Typically these systems are designed to support heavy graphics usage and are overpriced for an application intended mainly to display alphanumeric data. If, however, we knew that we would ultimately be doing heavy graphics display work, especially in color, these systems would be the least expensive approach. In our present environment, these systems are too expensive and sacrifice considerable modularity. (3) There are a few varieties of display systems available with parallel computer connections and little or no native intelligence. I have sought a display of the third type, with RS170 compatibility, with color and graphics as options and with flexible cursor control.

The suggested station design has a processor for each station or local group of stations. An LSI-11 is well matched to the requirements. Thus, one LSI-11 would service all MCR stations, one would be at linac, one at ISABELLE, etc. The size of the LSI-11 could be adapted to the number of stations it was required to service. It would also be possible to employ more than one LSI-11 to service the MCR stations if the loading of the station processor were high or if extreme reliability were desired; such a requirement seems unlikely. Communication between the PDP-10 and the station processor would by by the same technique used between the PDP-10 and the PDP-8's. The RF-10 cards required on the PDP-10 side are a local design, but have been heavily utilized in large numbers and are well debugged. Similar interfaces have been locally designed for the PDP-8 and

Unibus PDP-11. We would require the design of such an interface for the Q-bus LSI-11. This interface, termed an RFV11, is the only significant locally built component in this station design. This communications link is high speed (about 0.5 megabaud), highly noise immune and reliable at the required distances (e.g., the existing link between the PDP-8 at the linac and the PDP-10).

The interactive alphanumeric display would be generated by a card called a "video-ram" by the manufacturer. This card plugs into the LSI-11 backplane and appears to the computer to be memory and is accessible to the computer at memory speeds. The card also contains a CRT controller which has parellel access to the on-board memory and which generates an RS170-compatible composite video signal displaying the memory contents as ASCII characters. The generation of the video display imposes absolutely no load on the LSI-11. The display size is 24 lines by 80 characters; the character set is 128 characters, including upper and lower case and a variety of crude graphics characters and can be changed by replacing a PROM on the video-ram card. The characters can be displayed in white-on-black or black-on-white. Three cards can be ganged together to generate separate red-green-blue signals for a color display if desired. A separate card is available for graphics display, with selectable resolutions of 256 x 256, 256 x 512, 512 x 512 or 256 x 1024 points. This card can drive a separate display or can be ganged with an alphanumeric video-ram to generate a common RS170 signal containing both the graphics and alphanumeric information.

Two separate pages of 24 lines by 40 characters could be maintained by the station processor on the interactive display, each page assigned to a separate job in the PDP-10. The station processor would appear to the PDP-10 system as a multi-user device, much as the PDP-8's currently do. The display could maintain one page in black-on-white, the other in white-on-black. The station processor could maintain the cursor on the screen, for example, by blinking the appropriate character or setting it to inverse video. The station processor could even maintain multiple interactive displays for each station, if two pages were found inadequate. Additional video-rams could be used as non-interactive comfort displays as required.

Separate video monitors are required in this scheme, just as they are at present. Such monitors can thus be procured separately from the video-ram.

Monochrome or color monitors can be used, with the video-rams reconfigured
as appropriate. In each case, we retain the option of choosing a monitor
of the desired resolution.

Cursor control can be accomplished with a separate joystick or track-
ball. Joysticks have a price advantage, and if properly selected, provide
all the functionality of a trackball and can be used interchangably with a
trackball. One would use a "displacement" joystick, one that returns to
the center position when released and controls the cursor velocity rather
than position. The most atractive approach is to have the joystick output
consist of a pulse train, just as a trackball output does, to provide maxi-
mum flexibility in choosing one option or the other. Finally, the joy-
stick should be proportional, that is, the cursor velocity would depend
on how far from the center position the joystick were pushed.

The button array for the operator would be maintained on a touch-sensi-
tive video display. The video signal would be generated by a video-ram
as already discussed. The most reasonable touch sensitive display system
provides a 4 x 4 array of screen areas, or "buttons", plus 7 off-screen
buttons. In this type of system, the 16 "soft" buttons can be labeled by
the computer program to reflect the function currently assigned by the program.
The 7 "hard" buttons should be assigned functions that are truly invariant
as far as can be practically foreseen, e.g., such functions as "Next Page"
or "Previous Page". The soft buttons can be relabeled by the station pro-
cessor as the operator selects one or the other of the interactive pages.
Moreover, the station processor can support use of the display as a number
pad to enter values into a numeric register, much as the CIA panel does,
but supported by software. Thus the station supports a separate set of
buttons and a separate numeric register for each interactive page/program.

With multiple interactive pages, the operator can "talk" to only one
program at a time, as determined by which interactive page the cursor is
located on. One would assign one of the "hard" buttons the function of
changing the cursor from the current page to the other page. The station
processor would remember the location of the cursor on each page and page
switches could be made without losing the cursor position.

Although the touch sensitive display discussed is designed for CAMAC
usage, its interface signals are TTL and straightforward to handle. The
cursor and touch sensitive display can be interfaced to the LSI-11 via a

standard DEC parallel interface card, the DRV11, with little more design effort than a card or chassis to match cable connectors and provide appropriate DC power supplies. Thus the total complement of equipment for a station consists of the station processor and its RFV11 link to the PDP-10, a pair (or more) of video-rams and the DRV11 interface to a joystick (or trackball) and touch sensitive display, plus a video monitor.

Appendix A

Present Control Stations

For the sake of readers unfamiliar with them, we describe the current MCR control station facilities. There are three control stations, essentially identical. At each station the general purpose computer terminal is provided by a Tektronix terminal (4006 or 4010 model), which also provides a graphics display facility. A second "blind" terminal is provided at each station, which produces a composite video signal displaying the user-computer dialogue for display on a small video monitor. A toggle switch permits the keyboard of the Tektronix terminal to double as keyboard for the blind terminal. The blind terminals are used to run the OPSER program which permits a user to control multiple programs from a single terminal, via the subjob technique.

The interactive alphanumeric display is a 24 line by 40 character TEC display station, with a custom parallel interface to the PDP-10. One such interface supports three TEC's. The TEC is located in the computer room and generates a composite video signal displayed at the station on a 9" video monitor.

Each station has a so-called "CIA" panel which provides a trackball for control of the TEC cursor, an array of buttons and a 12-bit numeric register and number pad. A custom interface for the PDP-10 can support four such CIA panels. The PDP-10 system service routine for the CIA's detects trackball movements and through hooks to the TEC service routine generates cursor motion on the TEC's. The CIA panel provides 13 "hard" buttons with permanently assigned functions and 8 "soft" buttons identified only by numbers from 1 to 8. Labels on the TEC display advise the operator of the functions currently assigned by the program to the "soft" buttons.

An additional three TEC's are available for use in a non-interactive mode. These are used as comfort displays and are assigned not to a particular station, but rather to certain "watchdog" programs running in the PDP-10. For purposes of distinction, these TEC's are referred to as TED's.

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