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# The Replacement of Touch-Terminal Consoles of the CERN Antiproton Accumulator Complex (AAC) by Office PC's As Well As X-Windows Based Workstations

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## *Abstract*

With aging hardware and expensive maintenance and replacement possibilities, it was decided to upgrade the AAC touch terminal consoles with modern hardware. With significant amount of operational application software developed with touch terminals over 10 years, the philosophy adopted was to attempt a total emulation of these console functions of touch actions, graphics display as well as simple keyboard terminal entry onto the front-end computer controlling the AAC. The PC based emulation by mouse and multiple windows under MS-DOS and later, under the Windows 3 environment was realized relatively quickly; the next stage was therefore to do the same on the Unix platform using software based on X-windows. The communications channel was established using the TCP/IP socket library. This paper reviews this work up to the operational implementation for routine control room usage for both these solutions.


## INTRODUCTION

The CERN Antiproton Accumulator Complex (AAC) is composed of two circular, concentric ring accelerators and an antiproton production area (see Fig. 1). The inner ring, the Antiproton Accumulator (AA) was commissioned in 1980 while the outer, Collector ring (AC) was brought into operation in 1987 to permit an order of magnitude increase in the antiproton flux. The AA was conceived initially as an experiment and was built and commissioned in record time while the CERN PS Complex of accelerators was undergoing major changes from rudimentary to modern computer controls. For reasons of time and financial expediency, it was considered necessary to have cheap operator interaction means available for the AA commissioning, with simple to use interpreter (Nodal) based facilities. The Touch Terminals [1, 2], developed and used for the CERN-SPS control room were ideally suited for this role [3]. The controls system provided the necessary facilities to connect the Touch Terminals to the equipment. The AA controls system and its extension and upgrade in 1986 has been amply described elsewhere [4, 5].

## THE PRESENT TOUCH TERMINALS

The Touch Terminal (TT) is a specially configured mini-CAMAC crate with a microprocessor and special modules to drive a touch button screen, a graphics and character display screen and is connected to the front-end computer which controls the equipment via CAMAC Serial highways. Communication between the computer and the TT is by means of the standard current loop serial interface. The microprocessor controller in the TT is programmed to be transparent to the front-end computer terminal driver. However, it also detects or inserts certain "escape sequences" enabling the simple touch button functions like LEGEND, BUTTON etc. and graphic monitor functions like VECT, TEXT and so forth. Hence, the TT simply appears as a standard terminal to the controls computer but provides powerful interaction facilities with equipment. For the antiproton improvement programme at CERN and in preparation for the construction/commissioning of the AC ring in 1986-87, the TT's were upgraded to a Motorola 68000 based microprocessor, permitting colour alphanumeric and graphic facilities as well as higher terminal speeds. This, together with a faster front-end computer, has permitted up to five operational TT's for the AAC since 1986.

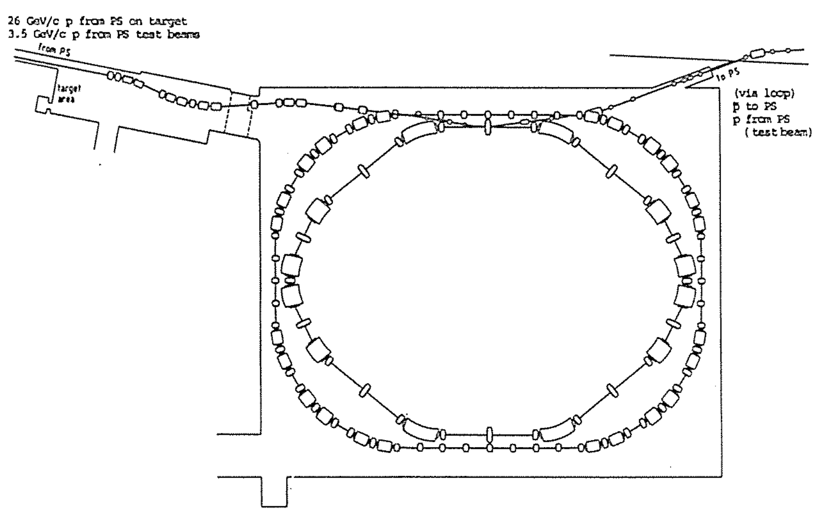


Fig. 1. General layout (magnetic elements only) of the Antiproton Accumulator Complex (AAC): outer ring - Antiproton Collector (AC), inner ring - Antiproton Accumulator (AA).

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## Goals and Needs for Touch Terminal Replacement

In the years 1988-89, it was increasingly clear that the mini-CAMAC crate based TT's, although cheap compared to the conventional fully-fledged minicomputer based operator consoles, were at least a factor three more expensive than a modern, commercial office Personal Computer (PC). With limited spare hardware and expensive repair/maintenance possibilities, it was obvious that the TT's, thanks to the simplicity of usage and direct connection to the front-end computer, could be replaced by a powerful PC using a standard VGA or super-VGA (1024 × 768 pixels) graphics card and ethernet, TCP/IP links.

With vast and running investment in thousands of lines of application software and very limited annual accelerator shutdown time (< two months every winter), the primary goal was to literally emulate the complete TT facilities on a PC, using multiple windows to provide the pseudo-touch (click by mouse on touch area), graphics window and the terminal keyboard echo window. The accelerator dependent applications suite of programs [6] and automated processes in the AAC represent a large number of man-years of software refinement and effort and CERN's ongoing physics programmes did not have the resources to make any extensive alterations or modifications; hence the original applications code had to run on the new PC-based TT as well as being transparent to the old TT's at the same time. This cohabitation of the new with the old and a graceful transition during the normal accelerator running (>6000 hours/year) was an important issue that precipitated the idea of a fully-fledged TT Emulator.

At the same time, the CERN management had mooted the idea to dismantle the AAC and re-assemble it in the USSR at the UNK complex, with a view to collaborate and continue the proton-antiproton Collider programme in the TeV range. It was considered essential that the hardware and software be maintainable for several years if this move did occur [7]; the PC-based Emulator fitted this criterion ideally.

With the adapting of the PS Complex controls system to industry standards and trends at least at the operator interaction level, the TT Emulator also needed to work under a modern RISC architecture workstation, running UNIX, X-Windows and MOTIF tool kit. In this manner the AAC could converge to the same chosen standard interaction means as the rest of the PS complex as well as SPS-LEP. Hence an ultimate aim was also to be able to do this, based on DEC-3100 workstations.

## Emulator Description and PC-based Facilities

The Emulator work commenced in early 1990 using an office Olivetti 386 PC running MS-DOS as a target system. The PS Division has a network of office PC's, connected via ethernet and the controls computer are also interconnected via ethernet and TCP/IP protocols to the office network. Figure 2 illustrates a simple schematic layout of this connection to the AA front-end computer controlling both the AA and AC rings. The Emulator task was developed such that it automatically establishes a two-way socket stream (telnet) to the AA computer at start-up, using the low-level suite of TCP/IP socket library routines. Immediately afterwards, remote log-in is carried out and the necessary procedures are automatically established to access real-time Nodal facilities, permitting full

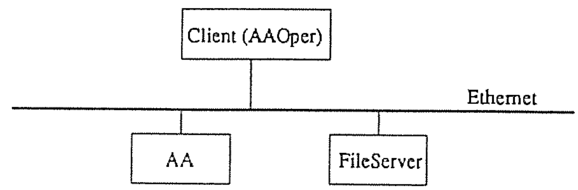


Fig. 2 : Network layout

accelerator control. This then establishes the identical environment under which the existing TT's run. Subsequently, the Emulator creates the three windows on the single PC screen emulating the three screens of the TT namely, the touch screen, the graphics/alphanumeric display screen and the terminal VDU. Having established the communications, log-in and respective emulated windows, the main function of the emulator reduces to the correct detection, interpretation, re-direction to the right window and insertion of byte streams and 'escape sequences', just as was done by the TT microprocessor. An essential difference of course was that the created pseudo-touch buttons on the touch window have to be clicked by the mouse; this and other features like the moving, re-sizing and automatic re-scaling of every window and provision of essential services like the hard-copy printout of any window, graceful exit, etc meant that a continual scan of the keyboard, mouse and communications input buffer (TCP/IP) is necessary in the main loop of the Emulator. Initially, the DOS-based Emulator was developed in Microsoft 'C' and used a self-written graphical window manager for this application. This has been replaced to run under MS-Windows 3.0, using the standard tools available under Windows 3.0 and including the Software Development Kit (SDK) for Windows. The Windows version permits increased flexibility and compatibility with normal Windows 3.0 applications and uses interrupts for keyboard and mouse instead of a continual scan. Using a high resolution graphics board and a larger screen, two concurrent Touch Terminals can be run on the same PC. Figure 3 shows the schematic Emulator layout in the current PC environment and the respective links. Figure 4 illustrates a typical PC three-window Emulator screen dump, as used by an accelerator application program.

## Facilities on DEC-3100 Workstations

The success of the PC-based Emulator augured well for next stage of the project to have the same facilities on a DEC-3100 workstation running Ultrix. The PS Complex has

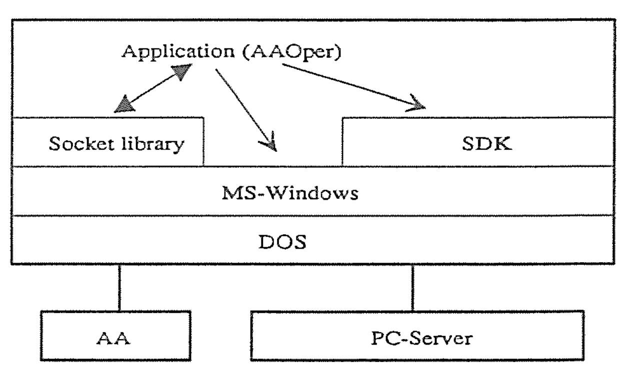


Fig. 3 : Software levels for Windows 3 (PC)

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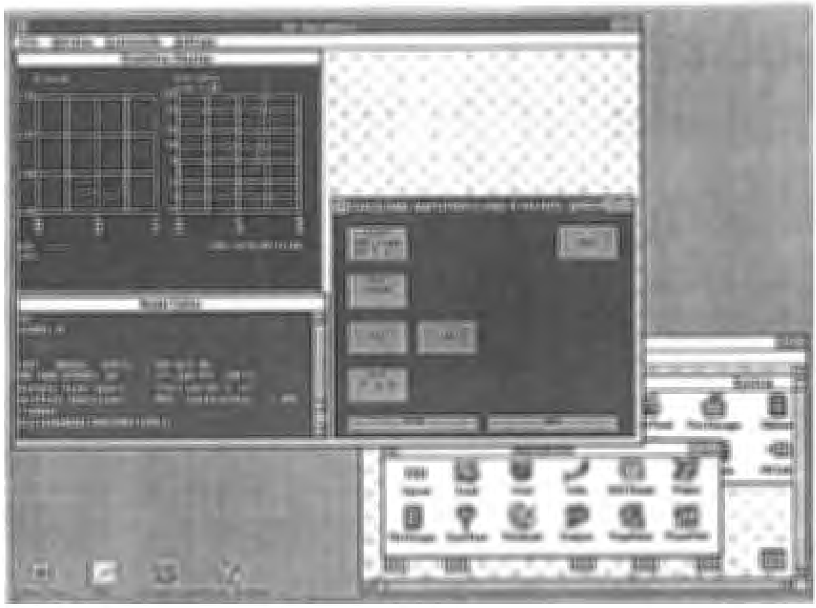

Fig. 4. Emulator running under Windows 3 on a PC.

standardized on this hardware recently, together with the X-11 library and MOTIF tool kit at the intermediate level. The Emulator was specified to use the full client-server relationships based on these protocols on top of the TCP/IP socket library implementation for the communication link as in the PC case. Figure 5 shows a schematic layout and interconnection of the Emulator software on a DEC-3100 workstation. The DEC-3100 workstation provides increased speed due to the RISC architecture; it also has a larger screen as a standard compared to a normal office PC, providing high resolution, convenience and ease-of-use for the three window TT emulation. Much of the low-level source code was ported from the PC-Emulator to the DEC-3100. Figure 6 shows the screen output of the complete three-window emulator running an operational application program on DEC-3100 workstation.

## CHARACTER AND GRAPHICS FACILITIES

The Emulator package uses the original definitions for the character and graphics facilities as were defined for the TT [8, 9]. In the TT, the high-level commands to draw characters, vectors, circles, polygons, etc. are broken down into individual

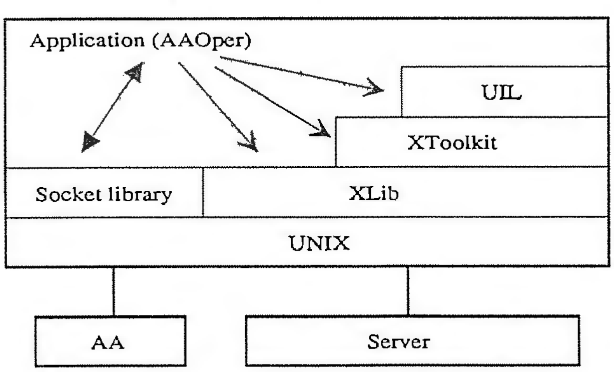


Fig. 5 : Software levels for X-Windows (Unix)

dot commands which are then output to the display through the Display Memory (DIME) module. Hence, for the Emulator, the essential task was to convert the character and graphics escape sequences into C-language based calls for both the PC or the DEC-3100. The major difference is due to the fact that since multiple windows are needed for creating the pseudo-touch panel, graphics display and the terminal-echo, respective memory buffers are required and used at every instance such that correct re-size, re-direction or hide/expose events can take place for each window. For the graphics window, separate memory buffers are required for both the graphics and text information. The graphics display continues to support a resolution of 768 × 576 pixels while for the character display, the standard size text is supported for 24 lines with 64 characters, reduced to 12 × 32 for large size text. Full technical details of all the definitions and additional features of the Emulator are given elsewhere [10].

## PORTING APPLICATION PROGRAMS AND PERFORMANCE

The whole suite of accelerator dependent application programs and procedures for the AAC Complex have undergone the ultimate trial in usage from both the PC or the DEC-3100 workstations, without needing any changes. In fact, the original three TT's in the local control room have not been decommisssioned from use, hence the *de facto* cohabitation is an absolute necessity. Maintenance of a unique set of accelerator application programs limits the software interventions to this level only, independent of the three variants (TT, PC or DEC-3100) possible at the operator interaction level. The application programs have been routinely used for accelerator operations by the shift crew on both the Emulators. While there may be little difference between a PC or DEC-3100 based Emulator, the operators have experienced a considerable improvement in speed over the old TT's. The aspects of window hard-copy and multiple window printouts on a single page have provided an improved facility, highly appreciated as a paper-saving, ecological solution.

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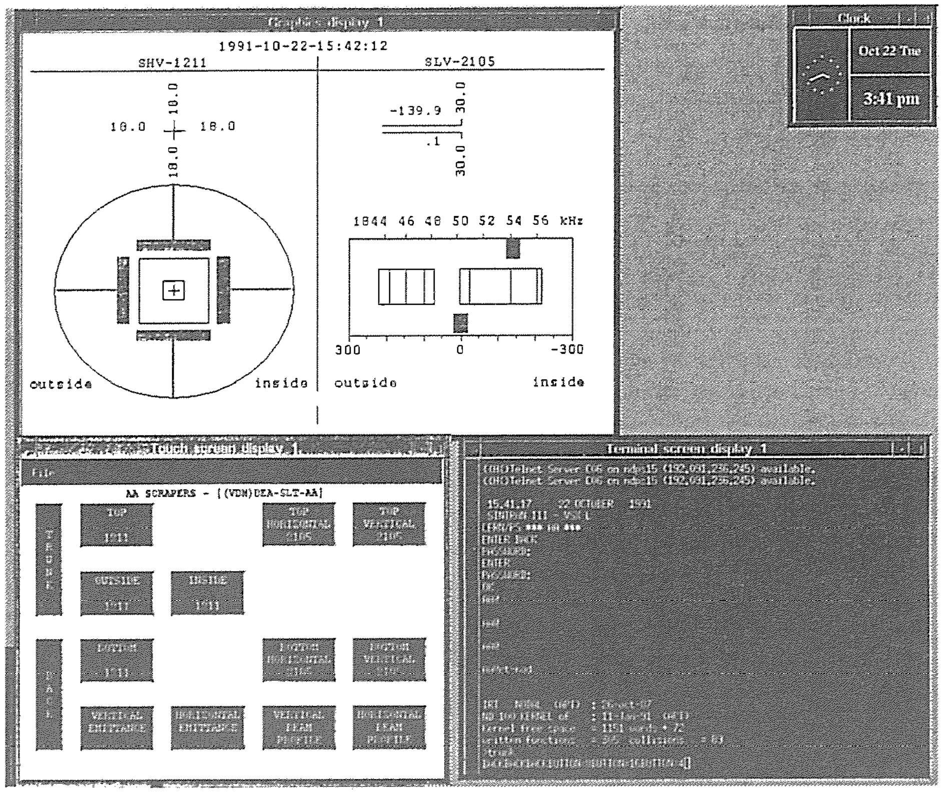


Fig. 6. Emulator running on a DEC-3100 Workstation.

While the Emulator benefits from the modern ethernet TCP/IP links, the response time is dependent to a large extent on the front-end Norsk-Data controls computer; however, for the final display features and facilities, the modern graphics hardware and software provide a large factor of improvement in speed. Overall, the net effect is a factor three gain in speed over the terminal connection TT's in the main control room and factor ten gain in the local control room.

## Conclusions

The Emulator has been put into routine operation using both the DEC-3100 and the Windows 3 PC environment. There has been a total and welcome acceptance of these facilities by the operations crew without any great need for additional training on usage; the latter aspect permitted installation and usage even during normal accelerator runs for physics.

Within the usual accelerator shutdown constraints and planned hardware maintenance, upgrades and spending profiles over several years, the Emulator has provided a tremendous bonus in permitting multivendor modern hardware and software to be successfully introduced in parallel with the partial and graceful de-commissioning of existing, aging TT's. The ethernet links across the accelerator laboratory and offices permits further advantage in ease of accelerator supervision and initial trouble-shooting, without recourse to urgent visits to the control room.

For the future, since the Emulator package permits the use of up to two concurrent consoles on the same, larger screen workstation, a significant amount of flexibility and substantial saving in hardware is possible in the local control room; a graceful de-commissioning of the three old-style TT's has been planned over the next two years, to be replaced by a pair of Emulator workstations, each running two concurrent consoles.

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