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# THE MAIN OPERATOR CONSOLES OF THE PS ACCELERATOR COMPLEX

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## Abstract

The operator interface of the PS control system consists of 7 large general purpose consoles in the Main Control Room with, in addition, 2 other ones, more compact, fully software compatible and mobile, near clusters of process equipment. The paper describes the consoles and discusses the major design options and their impact.


## Introduction

The CERN Proton Synchrotron (CPS) complex of particle accelerators provides particle beams of various types to different experiments and to other accelerators in a Pulse-to-pulse Modulation mode. This group of accelerators has a control system[1] that is based on a network of minicomputers. The currently running accelerators have a basic cycle of about one second for injection, acceleration and ejection. During some dead time between cycles, control and acquisition of machine parameters must be done.

The accelerator operators, machine experimenters and control specialists use groups of consoles either in a central control room or close to the equipment in local equipment rooms.[2]

## General Description from User Point of View

For the user, a console looks like a group of 4 specialized workstations :

(i) the alarms station,
(ii) the analog observation,
(iii) the video observation,
(iv) the main control working place.

The alarm system uses one large video colour display, split in two parts, one for general overview of alarms, the other for detailed information about system or equipment status. The interaction is done through a touch-panel with 16 programmable buttons.

The analog observation station has 4 oscilloscopes (2 are digital) and the signals are provided by 8 analog channels. The choice of the signal is made in a tree structure on two touch-panels. Two trigger channels are available. They are selected from a large number of key machine pulses on a touch-panel. Up to 3 variable delays, derived from machine standard pulse trains, RF trains and miocroseconds can be cascaded in order to make the actual scope trigger. A beam event related pulse can also be used. Selection of pulses and trains are made on a dedicated touch-panel, the delays are ajusted with 2 x 3 sets of 5 up-down buttons.

The video station has 4 black and white standard video monitors. They display images either from video generators of the computers and microprocessors or from video cameras looking at scintillator screens. Selection of video signals is made in a tree structure, on a touch-panel.

The main operation station consists of two large displays, one colour video, one high resolution graphics (1022 x 1022), and interaction devices. The latter include:

(i) a keyboard,
(ii) two touch-panels,
(iii) a 4 knob device,
(iv) a tracker ball,
(v) a set of dedicated action push-buttons.

The virtual accelerator visibility[3] is provided by the so-called Tree touch panel which supervises all control activities of the console and does the dynamic connections to the proccess. Up to 5 display programs can concurrently generate repetitive displays according to the choice of the operator. Typically, these are beam related and/or status displays of large equipment. They work together with screen interaction programs with tracker ball and keyboard. These interaction programs may also use the second touch-panel for specification of working conditions. The 4 knob systems (which include rotating buttons, up-down digital buttons, touch-panel and video display) are mainly used for direct control of machine parameters, which are attached to it by the Tree touch-panel facility. The high degree of parallelism allows the operator to compose his control procedures and displays in a flexible way.[3]

## Design Objectives

The major design objectives are discussed here, how they were implemented, and what their actual use is. An overall appreciation of advantages of the major options is given in order to help designers of new control consoles to make their principal decisions. Only what is directly relevant for any other designer of control systems is discussed.

Overall objectives are to provide an integrated and homogeneous controls system with well pre-defined visibility structure of the process[4] and some flexibility for quick prototyping of new control procedures. A particular goal is to be able to follow the machine cycle of about one second, which is very close to human reaction time.

Derived objectives for the operators consoles were:
(i) general purpose consoles;
(ii) simultaneous visibility of various types of control information: analogue signals, video signals, alarms and detection of systems anomalies, and computer aided control procedure display;
(iii) independant interaction with the various supervisors of control information without interference with main control procedures;
(iv) direct access to the interpretative control language Nodal[5] from the control desk keyboard.

## Brief Description of Current Implementation

The current implementation[6] is the result of these objectives modulated by various constraints. The more drastic constraints for the design were:
(i) the operating system of the computers (SINTRAN III) which was at the time of the design (1978-79) very efficient for memory management but poor in program-to-program communication facilities;
(ii) the state of hardware technology especially in the field of display devices.

The topology used for the consoles was based on two simple principles:
(i) absolutely no direct connections between accelerator equipment and consoles, especially for analogue and video signals and for scope triggers;
(ii) all console equipment is under software control, and connections with the process must be done dynamically by software.

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This topology ensures that consoles are really general-purpose control facilities, consequently that every control activity can be done from any console.

Hardware Solution

The consoles are made of three clusters of equipment
(i) console computer and its peripherals;
(ii) CAMAC interface, related signal adaptation and transceiver equipment, signal multiplexing equipment for the scope triggers:
(iii) the console desk.
The two first clusters are located in the computer room.

Standard TV monitors were chosen for all displays, except for the graphic display. High resolution TV graphics were not available in 1978/79 for a moderate price.

The general layout of the console is shown in Fig. 1.

Fig. 1 Main Control Room Console

Software Solution

The major aim of the console system software layout was the safety of operation. This was even more necessary by the direct availability of the Nodal interpreter on the console, which allows any sort of untested actions. In this context protection of the console system software is needed in order to ensure the operators a safe use of the console and to give to software developers reasonably comfortable facilities without too much risk of catastrophic software corruption during debugging time of a new facility.

The main options chosen to ensure this safe use were:
- all I/O to and from console equipment go through the standard mechanism of operating system service requests. This gives a complete separation of hardware action from user programs and gives a general way of hardware clean-up in case of abnormal end of user programs.
- suppress any possible deadlock cases during input operations from console interactive devices. Intrinsically, input from interactive devices cannot be supervised by a time-out mechanism. We therefore have chosen to distribute in a fixed and pre-defined manner the console interactive devices between five classes of programs, and only one program can be active at a time in one class.

The classes of interactive programs reflect directly the various activities on a console.

Three of them correspond to specialised systems:
(i) analogue signals and trigger scopes allocation and adjustment;
(ii) video signals allocation;
(iii) alarms and survey system display and interaction.

The two last ones are more general facilities:
(i) the main interactive facility with the class of the normal application programs;
(ii) the supervisor which provides the Tree structured visibility of the process to the user[4].

An open class of non interactive programs, without the restriction of only one being active at a given time, provides the flexibility of multi-programs which build concurrently a display. This feature is especially used by a pipe-line facility in order to update directly from the process computer repetitive display.[6]

To provide this facility of concurrent access to display, a multi-channel property was given to software drivers of the console displays. One of these channels with special properties, allowing direct interaction with the screen content by keyboard or cursor, is statically allocated to the dedicated interactive class.

A 16 bit microprocessor (TMS99000) in CAMAC is used as a graphics processor to provide a high level of graphics privimitives without too much load on the console computer itself. The communication protocol between the console computer and the graphics processor allows a high degree of parallel processing, reducing the execution time of user programs.

The console software includes a number of dedicated programs for automatic restart of the system, management of disc resources and for automatic distribution and installation of new process over all consoles through the computer network.

A suite of programs provides a complete facility for very global to very detailed checks of software and hardware console components.

Experience and Evolution

The first operational console was given to application programmers in Autumn 1979, the first batch of three consoles came into operation during 1980. Since then four more consoles have been added to the central facilities and two local consoles were put in the equipment room (Booster observation room and radiofrequency room). A control room general facilities system was added also, mainly for logging, display hardcopy and archives.

The high degree of console software reliability, reached very quickly after start-up of console, gave confidence to the user.

The major evolution of the console was led in the field of:
(i) local consoles;
(ii) increasing performances;
(iii) dedicated and fast procedures for very often used software features;
(iv) facilities for debugging, installation and updating of user software.

The local consoles (Fig. 2) are a compact version of the central consoles without analogue and video observation facilities. From the software point of view they are completely equivalent to the central consoles.

The increase of console performances was ach-

Fig. 2 Local Console

ieved mainly by addition of dedicated high performance tools which benefits of new features of the successive releases of the operation system and by using new computer hardware. A factor of three in console performances was thus gained.

## Experience and Possible Medium-term Improvements

Emphasized are the high benefit options in our initial design but also those which had painful consequences for the users.

General purpose consoles is certainly the option which gives the largest benefit. At the design time we expected benefits in the field of homogeneity, which is true because it enforces the standardization of software, and for the multiple-access to the same process for the operators. Experience shows that the greater benefit of this facility is for the software developers. It gives the flexibility to test and debug new software pieces from any console and to be sure that it will run correctly on all the consoles.

The penalty for that is an increase in price of the console due to multiplexing of everything.

The choice of the software compatible local console is also very useful. It gives local access to all control facilities for a nul software price. This is very convenient for the running-in time of new equipment and gives exchange of knowledge between the equipment designer and the operators easy.

A very appreciated feature is the large number of concurrent displays and interaction tools on the console.

The interpretive language Nodal, directly available from the console, is an essential facility for quick prototyping of control procedure and for the daily management of the console resources.

The price of this facility is the need of a high level of software protection which decreases flexibility in application programs organisation.

For the long term, the worst option was to give to the application software too much visibility of the specific features of the display hardware. This put a curb on using new display technologies which are very attractive and powerful.

The too rigid allocation of interactive tools to the various classes of programs, which is a consequence of software protection against untested actions, induces complications on some software components. A compromise between the facility of doing everything immediately through the interpreter and more flexibility in application software organisation will be a much better solution.

The two fields of evolution foreseen are in integration of new displays technology and in more computer aid for using the new digital scopes for observation of single phenomena and for signal processing.

The rapid development in graphics workstations, built with high resolution TV technlogy, very powerful interaction and multi-windowing facility, are a challenge for new thoughts on console facilities.

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