© 1971 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE.

ON THE CERN PS COMPUTER CONTROL SYSTEM

J.H.B. Madsen
CERN, Geneva, Switzerland

System Organization

The moderator of the panel discussion on computer control, K.B. Mallory, suggested examining the "Reasons for choosing the system we have". To make such an "examen de conscience" we start by giving our initial justifications - drawn up in early '66 - for buying a computer for the CERN PS. We expected to obtain with a control computer system: (i) an assistance to the PS Main Control Room (MCR) operators; (ii) an aid in performing studies on the accelerator; (iii) a possibility to optimize some accelerator processes. The fact that we were adding the computer to an operating accelerator had, on the one hand, the advantage of making an experimental approach possible but, on the other, we had the problem of integrating non-compatible systems with the computer. To overcome the latter problem, we produced a range of interface equipment for acquisition and control and constructed a digital transmission system (called STAR). The existence of the STAR, with which we can cover distances up to 2 km, enabled the linac controls people also to make use of the computer. The computer, an IBM 1800, was installed in a room next to the MCR. This layout proved to have many advantages, one being that the MCR staff can make small interventions, for example making "cold starts".

From the start of our project, we aimed at keeping the computer connected to the process all the time. As there are other tasks besides the execution of process jobs, such as developing and testing of new programs, we had to find a solution for our single computer system. This we found by using the IBM supplied Time Sharing Executive (TSX) system and by keeping the number of jobs done regularly each PS cycle low. The latter was achieved by avoiding too many jobs involving real-time processing and by observing the quality of the acceleration via some key data, making a more detailed study only upon detection of an error. The computer acts upon a process or a console interrupt, the former having a higher priority than the latter. For this reason, an operator requesting a process program may interrupt the off-line program work, thereby causing some annoyance to the programmers. Therefore, when considering the introduction of other applications for computer control - for the linac and the CERN PS Booster (PSB) - we realized that a simple extension of our single computer system, i.e. just more core storage, was not acceptable. A possible solution appeared feasible by adopting the Multiprogramming Operating Executive System (MPX) furnished by IBM. To implement the MPX, we expanded our core storage to 40 K. Fixed areas, 4 K each, are permanently attributed to each machine, the linac, PSB and CPS, ensuring in this way independence between users. The solution chosen was justified by considering that a multiple computer control system might demand more peripheral equipment, result in diversity of maintenance and software development and that the powerful computation facilities required by all users can be obtained with the single system. We also argued that due to the slow cycle time of the accelerators (typically 1 to 2 s), there is sufficient CPU time left on the single computer for non-process jobs.

When another computer application was required needing real-time work - the generation of about 30 analog functions for the PSB each cycle - we decided to confide this task to a small computer. This computer is linked to the IBM 1800 but data transmission between the two, if requested, takes place only during a specified moment in the cycle. The introduction of this computer in our "single computer system" illustrates our feeling that for regular real-time tasks dedicated computers can be more profitably used.

System Function

We keep the operator in charge of the functioning of the accelerator. For the moment we have no alternative as not all the controls of the accelerator are computer compatible yet. However, even with the hardware restriction removed, it seems more profitable to leave the human operator in command and we are following this line of approach for the PSB also. To enable this, we developed the application programs to be used via a program request panel and/or a simple dialogue with a keyboard and alpha-numerical display. There is a small number of programs which are executed in the first instance without interference by the operator. These programs concern the monitoring of the accelerator process by the computer. For example, each cycle the computer compares the ejection efficiency measured with a threshold value and acts upon an alarm if the situation becomes incorrect. Even for this application, we have learned that it is better to make it possible for the operator to interfere with the program since, if for some acknowledged reason the ejection efficiency is low, he should not be bothered by repetitive fault announcements. Our application programs are written in Assembler language and it is difficult for the accelerator operators to write a special program if they so wish. This restriction does not exist any longer for the acquisition of parameters as a special program permits anyone to compose his log in which some data treatment may be included.

The effort required to optimize even a part of the accelerator process is very appreciable indeed. For example, we have a program to optimize the radial harmonic dipole corrections to achieve a higher accelerated proton beam current. This program creates, with 24 individual powered dipoles, harmonic corrections of the closed orbit and the results obtained are very good. However, one man year was devoted to this task and we know also that there are many other conditions besides the one treated which equally well determine the injection conditions in the accelerator. Therefore we are inclined to start with simple supervisory programs. There are 50 ejection parameters acquired by the computer and another 50 concerning the ejected beam. The program indicates whether the settings are correct and also tells whether the quality of the ejected beam is still acceptable. Experience has shown that it is difficult to have a sufficiently developed acquisition of machine parameters to trace the cause of a change in quality in each case. This is mainly due to the fact that many of the parameters are pulsed and to correctly monitor the time-dependent parameters with the digital computer is expensive or time-consuming.

Summarizing, the hardware and software needed to monitor completely or to optimize parts of the accelerator process are substantial. It is therefore not surprising that at first we created programs which yield the most. They are: acquisition and data treatment programs (logs, statistics, variation logs - indicating changes from previous data) and specific programs concerned with beam or machine property measurements. The importance of the specific programs is higher than initially expected and is illustrated briefly by listing the measurements in which the computer plays an important role: the linac beam emittance and energy spread; injection capture efficiency, closed orbit, average mean radial beam position, beam density distribution; the apparent vacuum chamber aperture at injection; beam position and density distribution in the ejection magnets; the frequency analysis of the slow ejection burst waveform. The specific programs include the display of the results on a CRT, an alpha-numerical display or on simple nixie tubes.

The success of the specific programs should not let us forget that we have not yet been able to use the computer as controller of a process. As our processes have multi-variables, they do not seem attractive to handle but we may well have to make the step forward as high intensity operation imposes more stringent conditions.

The Man and the System

The computer is not yet an attractive tool for those people who only want to make use of the possibilities it offers occasionally. The effort involved in learning to programme in Assembler language is appreciable and some potential users stay away for this reason. We therefore follow with great interest the experiences gained with the use of interpreter type languages at other centres. There are other reasons why the computer is not yet a very popular tool. An important one is that we are not yet able to translate readily into digital form the analog information contained in the process signals. The accelerator physicist observing the instability of a proton bunch during acceleration will be happy with photographs of the sensor signals, photographs he can easily take himself. With such types of observations, a lot of work can be done. If, however, further and more accurate information has to be extracted from the sensor signal, he should then wish to perform these tasks with the computer. In the past, it was not always possible to provide the physicist with the tools to allow him to continue with his problem with little loss of time. We try to improve this situation by expanding our standard hardware equipment - for example for sampling pulsed signals - and to facilitate programming.

The problem of the man - computer interface has frequently preoccupied us. For calling standard programs - in general those providing assistance to the operation - we have retained the push-button selection panel. If a small dialogue is required for specifying certain options or data in the program, use is made of a keyboard and alpha-numerical display. Three independent displays will be used to serve the linac, PSB and CPS. The latter two will be located in the Main Control Room. We felt that using a single keyboard/display as interface with the computer would oblige us to concentrate all controls and analog observations into a too restricted area. If the setting-up, running-in, of an accelerator could become the job of a couple of people only, such an approach would then be favoured. However, we do not intend to impose such a situation as we want to keep a widespread interest amongst people

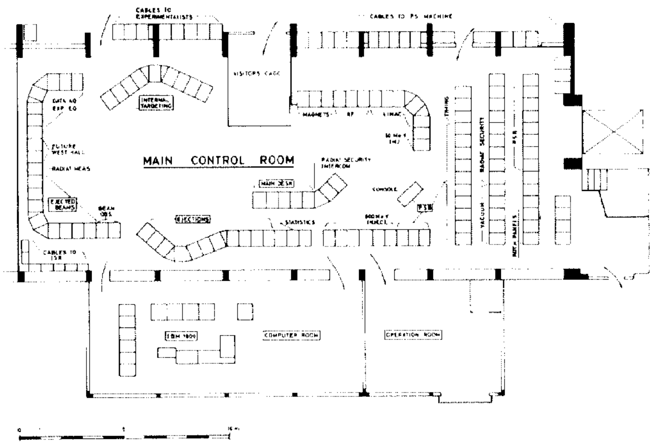

Fig.1 Layout of Main Control Room

and in consequence need to provide space for them in the MCR (see Fig.1). Also we have found that a lot of work can be done in parallel: improving injection conditions can be done at the same time as adjusting targeting and ejection.

Therefore, besides the keyboard/display we have other computer access points for controlling equipment and measuring parameters: consoles containing a selector panel, control buttons and a data display. The idea is that simple control functions can be done from the consoles while more complicated ones are reserved for the keyboard/display.

The Human Aspects in the Design of Computer Orientated Controls Systems

The overall control system is designed by people qualified in the controls field and knowledgeable in the possibilities of process control computers. Two problems can easily arise: at first a lack of experience on the part of the design people in the operating of an accelerator may result in a system not matched to the needs of the operating staff and, secondly, the individuals in charge of important items, such as the RF, may prefer to go their own way.

For the design of the PSB controls system we have tried, we think successfully, to overcome these problems by defining it from the start in close collaboration with the PSB project leaders (as with any other major machine system), by having included in the controls design team people with accelerator experience, by having proposals accepted by those who will run-in the accelerator and informing equipment designers, by the means of information meetings, discussions and reports, of the possibilities of computer orientated controls. Some considerable time was spent by the controls people on the information/public relations aspects, but we belive that such efforts are well spent.

Acknowledgement

I should like to acknowledge with thanks the participation in the design of the system, since its initial stages, of E. Asséo, H. van der Beken, and W. Remmer.