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TWO YEARS OF EXPERIENCE WITH THE PETRA CONTROL SYSTEM

Machine - Control - Group MKR

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TWO YEARS OF EXPERIENCE WITH THE PETRA CONTROL SYSTEM

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Deutsches Elektronen-Synchrotron DESY
Hamburg , Germany

1. Summary

PETRA control system experience after March '79 is reported. We discuss system structure influence on reliability , flexibility , maintainability , and the development of correlated functions , task allocation , and intertask communication. Operational aspects of man-machine communication , man-machine interface as well as interactive language approaches are presented.

2. Control System Layout

The PETRA Control System [FR 79] was designed for operating under worst case conditions , which occur during the setup phase and the detecting of malfunctions . The main design criteria were :

- control system division into main accelerator tasks such as magnets & monitors , RF , vacuum , LINAC , PIA , etc.
- central location of control room and all computers
- simple and reliable remote electronics distributed around the ring
- well defined hardware and software building blocks :

2.1. Hardware

- Equipment Control Modules (ECM) serving one piece of equipment each in all digital and/or analog functions
- serial data link via SEDAC [FRE79]
- task dedicated computers
- man-machine interface via PADAC [HOC79]
- operator console devices (TV, ball, touch-panel etc.)

2.2. Software

- Equipment Control Functions to control one type of process element
- multi device operating functions
- SINTRAN-III operating system [NORSK] & process dependent extensions
- POCAL (NODAL dialect [MCC78]) as conventional interactive language
- operating programs

Currently , the system is comprised of 1300 ECMs , 6 operator consoles connected to 5 task dedicated computers .

3. System Structure Influence

After having provided the basis for setup and commissioning of PETRA , the control system matured into the operational stage . During two years of experience , the functional separation of the task dedicated system has retained validicity . Intertask communication needs are still limited to a handful of parameters .

3.1. Maintainability

Because of its structure , the control system as a whole requires no scheduled maintenance periods . Building blocks are exchanged only if they fail . Faulty ECMs are diagnosed by the equipment control functions and can be replaced by any member of the operating crew, while faults in the computer hardware or software require expert help.Normal repair action is building block replacement at any level.Failure of a system node should only disturb the system below that node in system hierarchy; hardware design permits the exchange of an ECM without disturbing other ECM in the same SEDAC crate.

We have established the following meantime between failures (MTBF)

individual ECM:	>> 2 years
SEDAC system:	>20 months
PADAC modules:	>20 months
computers (mainly disk trouble):	> 4 months

meantime to repair (MTTR) :

ECM exchange:	<10 min
computer switchover:	~30 min.

Future implementations of SEDAC systems will favor a polling scheme of "hot" status bits over the current request scheme with its inherent geographic priority.

Redundancy provides error checking at all levels and graceful degradation. System restart after power fail (black-out) requires 30 minutes.

3.3.Flexibility / Adaptability

The PETRA control system has been expanded to include the accelerators LINAC ,PIA and the DORIS , PETRA beam lines. Incorporation of existing and running processes has been done by installing consoles in parallel to those in the central control room adjacent to the old local controls and step by step transfer of functions to the new system.

Re-allocation of control tasks has been performed by physical transfer of all required building blocks to the new task.

4. Operation

Experience has shown that software production and software use do not overlap. Despite over use of a simple to learn interactive language, 'non-programmers' have done programming only during the prototype testing phase of their ECMs'. Operating crews, even if they are programmers, prefer to use existing software instead of adapting it to their specific needs. During hectic machine physics shifts, computing demands change at a pace too rapid even for experienced programmers to cope with, and the control system tool repertoire is expanded to include paper, pencil, and pocket calculator.

On the other hand, implementation of different control algorithms, information display, and human interaction is greatly enhanced by the use of an instantly executed interactive computer language.

Speed of execution has demanded the transfer of several control programs from the interpretative level to assembler subroutines. Since this 'compilation by hand' has to be done by an expert, it will generate well structured and optimized software, taking into account the experience gained while the program was executed interpretatively.
Among other tasks collection and processing of operational data for equipment and machine statistics were advanced. Fig. 1 illustrates the overall performance of PETRA. It displays 10 days of the October '80 run in the 2 * 18 GeV region.

4.1. Man Machine Interface

Since displays and standardized interaction tools are presenting the process to the operator in a uniform way, efforts have to be made to provide the operator with a "feel" of the process and confidence in the control system:

- live displays, trend displays
- redundant information
- information displayed without interaction which can be surveyed at a glance.

With computer generated TV pictures, color is used as a third dimension:the color of displayed items conveys status information to the experienced viewer, while the novice can still interpret what he sees at first glance.

Fig 2 depicts the current control room setup with the increased number of live displays and RGB monitors . It includes :

- 5 consoles
- ~ 30 computer generated RGB and TV displays
- ~ 20 CCTV displays

5. Software Management

PETRA control system software was written by a small, close unit group. This kept software development overhead to a minimum.The integration of the software necessary to handle the process interface required changes in the vendor's operating system, research and dependeuce on a specific release of the operating system.Improved versions of the control system software are implemented twice a year.

6. Energy Saving Concepts

In three ways, the control system helps to minimize power cost per physics event:

1. injector accelerator duty cycle reduction This requires automated control cycles and good reproducibility in order to minimize turn on times
2. accelerator turn off during power peak rate period, again is a function of turn on time
3. beam quality improvement to enhance the luminosity/power ratio.

As an example, conversion of beam line controls will be paid for by the power saved during a single year.

7. Future Plans

Future plans include: Integration of the control of all accelerators , beamlines , and supporting services into a unified system with only one central control room to minimize operator manpower.Currently, the synchroton is being converted to the PETRA control standard .

Addition of front-end microcomputers for routine control tasks and increased TV-picture generation. [HOC81]

Installation of a fast packet switching network between all control room computers to permit common operation of all systems from one console during production runs. [FRE81]

8. References

[FRE79] The Serial Data Aquisition System at PETRA ; H.Frese, G.Hochweller ; IEEE NS Vol.26 No.3 June 1979

[HOC79] Tools for Man-Machine Interaction in the PETRA Control System ; G.Hochweller , H.Frese ; IEEE NS Vol.26 No.3 June 1979

[FR 79] First Experience with the PETRA Control System; G.Frese et al. ; IEEE NS Vol.26, No.3 , June 1979

[MCC78] The NODAL System for the SPS; M.C.Crowley-Milling, G.Shering; CERN 78-07

[NORSK] Norsk Data , Box 4 Lindeberg gard , Oslo , Norway

[FRE81] FPSS - A Fast Packet Switching System ; H.Frese et al.; these proceedings

[HOC81] PADAC Multi-Micro Computers , Basic Building Blocks for Future Control Systems; G.Hochweller et al. ; these proceedings

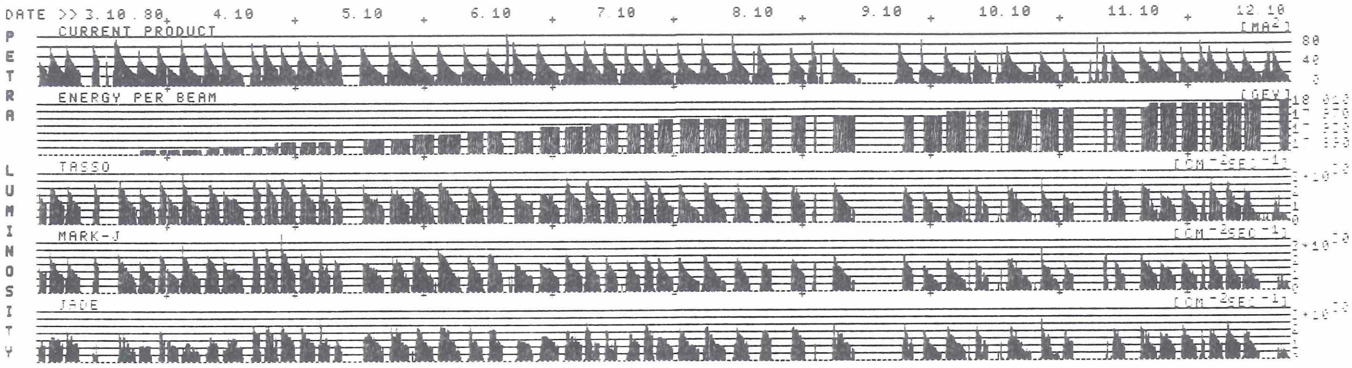

FIG.1 - PETRA MACHINE STATISTICS -
10 DAYS OF THE OCTOBER RUN IN THE 2 * 18 GeV REGION

The upper trace of Fig. 1 portraits the product of the colliding beam currents versus ten day's of this run.

Trace two shows the energy scan with a slope of ~ 10 MeV per day. (PETRA was running close to its upper energy limit)

The three lower histograms demonstrate the luminosity gain at three of four interaction points. The peak luminosity was slightly higher as the plotted 15 minute average values. The data from the JADE interaction point are reduced by the dead time of the luminosity detector.

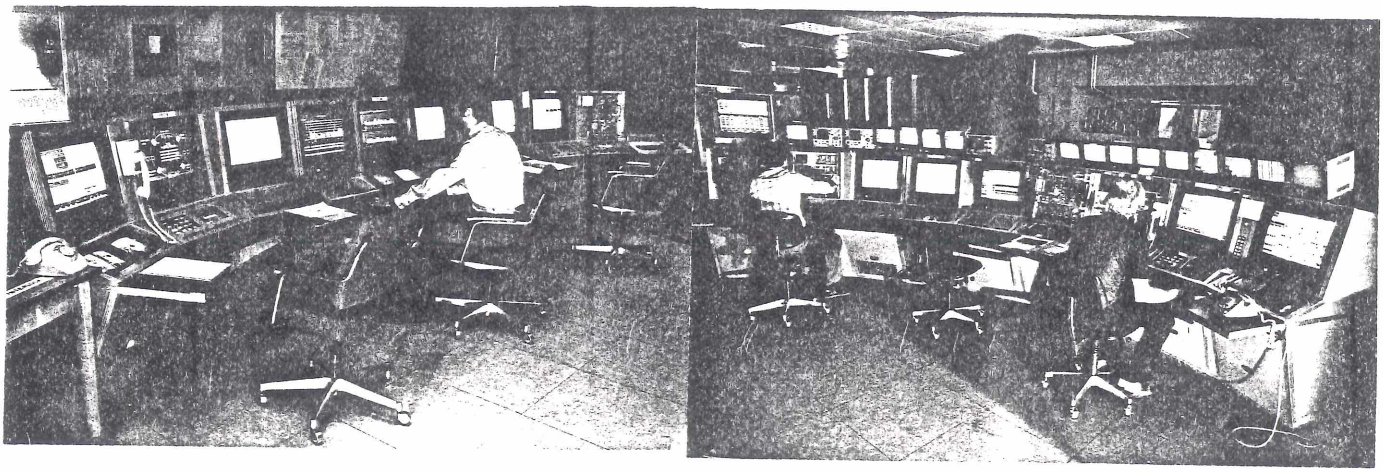

FIG.2 - THE CENTRAL CONTROL ROOM -

During the October run three operators handled from this room

- the 400 MeV positron linear accelerator LINAC II
- the 400 MeV positron intensity accumulator PIA include the beam lines
- the 19 GeV storage ring PETRA.