

Upgrading of the U-70 complex controls

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The 70 GeV accelerator complex in IHEP has been in operation since 1967. Its control system was originally oriented on remote manual control. Some computer-based control subsystems created subsequently have different structures and use obsolete computers. To provide better availability and reliability and to reduce maintenance costs a system upgrade is unavoidable. The paper describes the upgrade plan and the basic solutions adopted. As an example of the approach to the new control system structure the ejection system is described.

1. INTRODUCTION

The 70 GeV accelerator complex consists of a 30 MeV linac, a 1.5 GeV booster, the main proton synchrotron ring (U-70), slow and fast ejection systems and proton and secondary beam channels (fig. 1). The booster (and hence the linac) is a fast cycling machine which works in a batch mode (up to 32 pulses per batch with a 60 ms period). The accelerating time is approximately 30 ms. Pulse to pulse modulation (PPM) is used to provide beams for two users - U-70 and an "internal" booster experimental facility. The U-70 magnetic field pulse has 2 flattops, the first for beam injection and second for beam extraction. The cycle duration is less than 10s, including a 2.6s rise time. The fast ejection system can be triggered 3 times during a cycle, extracting from 1 to 29 bunches per shot. The ejection energy range is 30 to 70 GeV. The slow ejection system can extract a debunched beam up to one second in duration. There are special modes of operation such as using internal targets and slow non-resonant ejection. During a run all these modes of beam extraction may be used in any preprogrammed combination.

The complex has been used for about 30 years for partial physics. Except for the booster, which was added in 1985 with computerized control, the other installations of the complex had originally only remote manual control. Their computer-based control systems were developed independently from each other and at different times. To use the complex as an injector for UNK, the Beam Transfer Line (BTL) was constructed in 1993 with its own control system [1,2]. The U-70 complex has no general control system and its individual technical systems are controlled from the Local Control Rooms (LCR) situated in different buildings. The LCRs exchange a limited number of operational data in a non-modern way (fig 2). This leads to difficulties in system maintenance and development.

2. PRESENT STATUS OF CONTROLS

The current status of the controls of the U-70 complex may be summarized as follows:

- the computerized control of the U-70 technical systems is based on obsolete computing means (EC1010, E-60, SM1420, SM1810.XX, etc.)
- the hardware of the U-70 complex individual control systems consists of a great variety of methods of construction and standards, and the software is written in different languages and works under different operating environments
- a significant part of the U-70 technical systems equipment is still controlled manually.

3. UPGRADE PLAN

The upgrade of the U-70 complex control system will take about 3-4 years and comprise the following list of tasks:

- the replacement of the obsolete computers, providing new MCR consoles and local access from technical systems
- putting into operation a control network
- the replacement of old electronics and hence the development and production of electronic modules to modern standards
- adaptation of those technical components which now have only manual control into the computer system
- re-engineering of all control system software.

The U-70 complex is a running machine and the upgrade of its control system must be done without serious disruption of its high energy particle physics program.

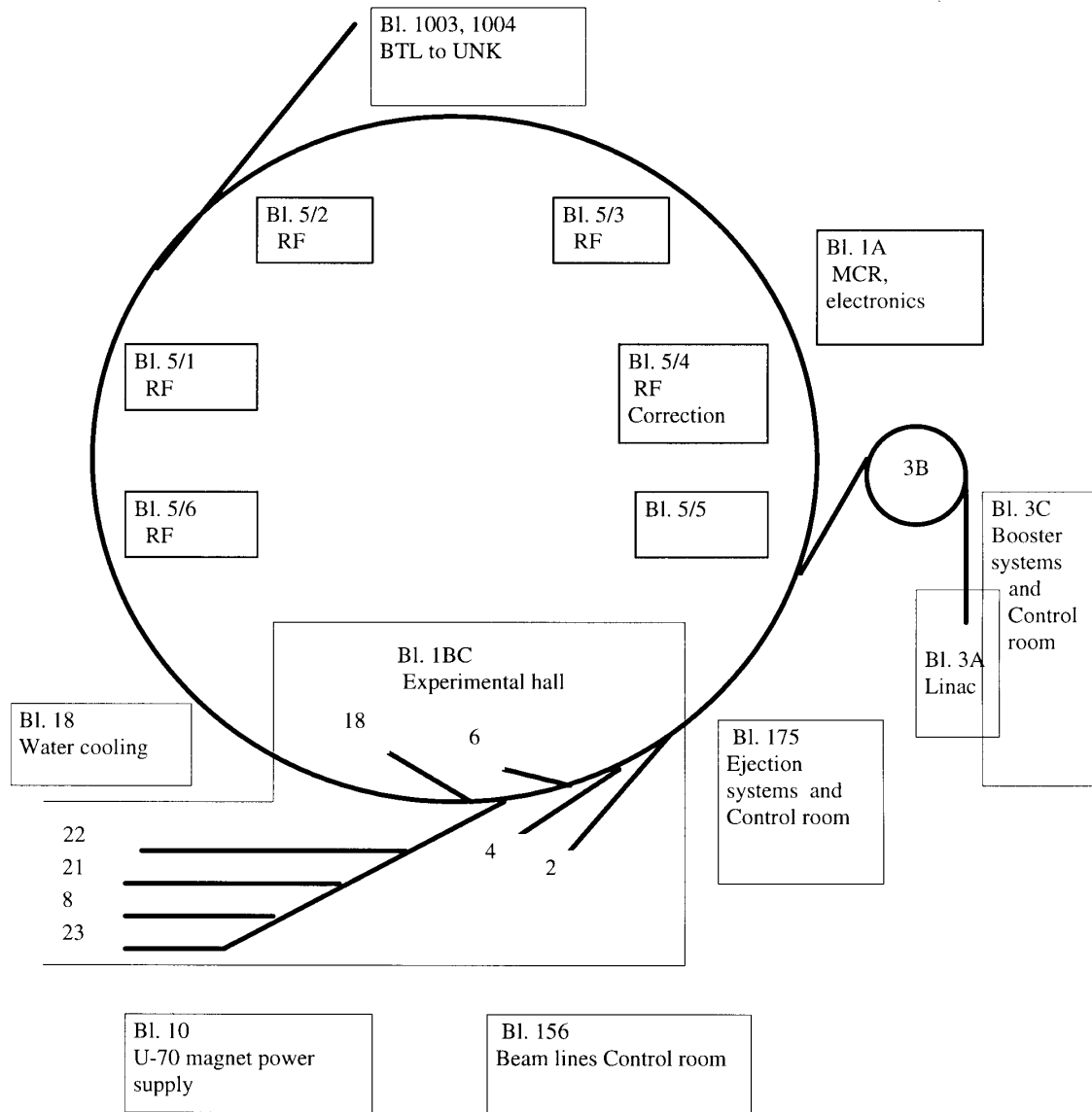


Fig.1. Technological buildings of the U-70 complex

3.1. Architecture

We intend to use the results of the UNK Control System upper-level design as much as possible. In particular the new Control System of the U-70 Complex is planned to have the same architecture (“standard” three levels) and to contain the same hardware/software components as were chosen or developed for the UNK Control System [3]. However the final decision concerning the components will be taken after their reliability and speed tests at the U-70 complex under actual working conditions have been completed. Together with Work Stations and X-terminals the 16 PCs with MS DOS will be used as operator consoles on the upper level of control system as a cost-effective measure. Some of these PCs will act as front end computers (FEC).

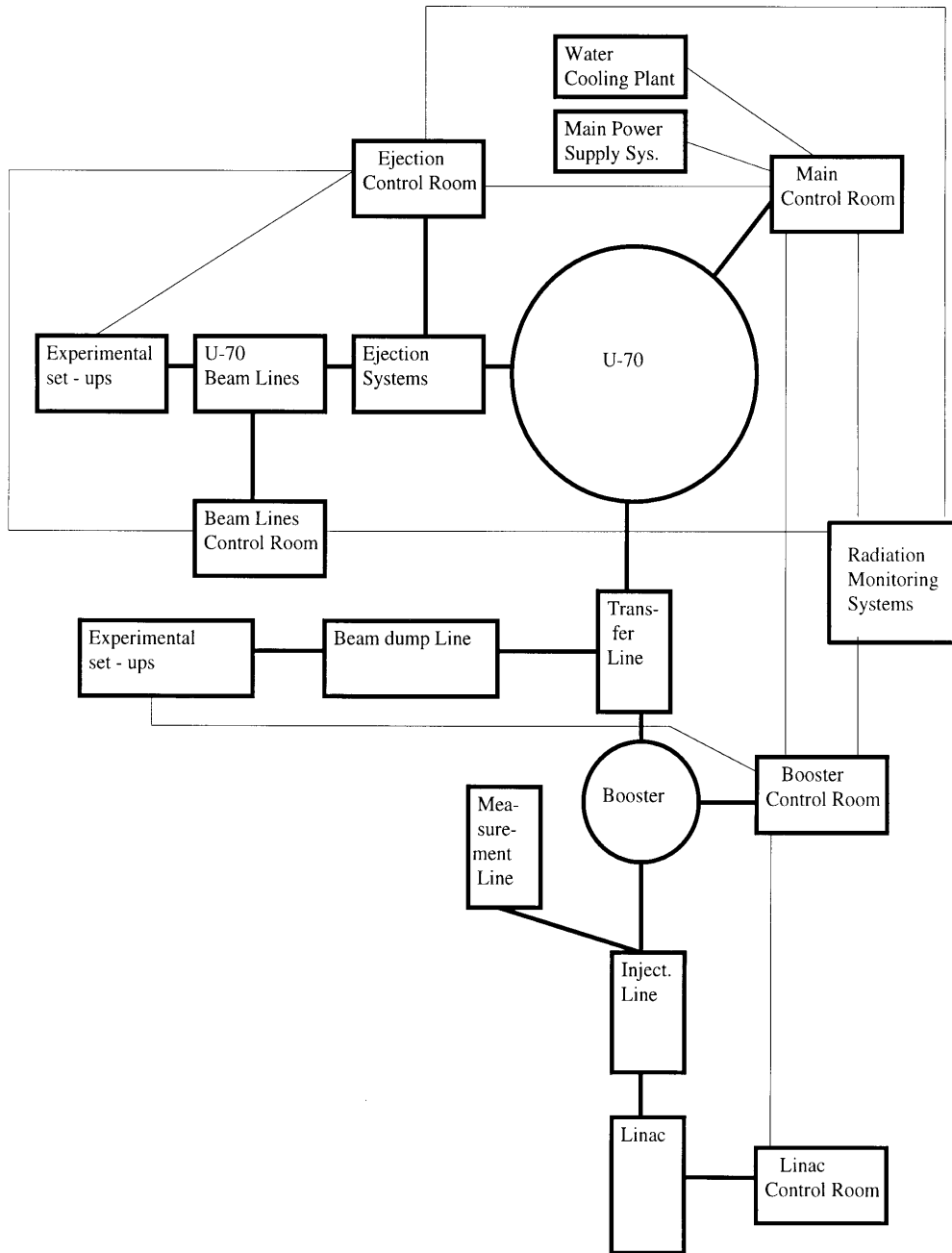


Fig.2. Cabling between Control Rooms

3.2. Controls network

The Ethernet-based controls network infrastructure (fig. 3) currently covers the most important sites: the U70 MCR, the Booster CR, the U70 beam extraction controls, the two local control rooms for U70 beam lines and the UNK BTL controls.

Each site has one or several “access points” (multiport repeater) to which computers are connected. Sites are separated by bridges. This control network is connected with the OEA development platform network, in order to provide computing resources and services, including access to the IHEP campus network.

The controls network infrastructure is not yet completed and must be extended to a few more sites. In addition a separation from the office network has to be made to make control more reliable.

3.3. Equipment controllers (EC)

A typical EC (total number is more than 70) is a Euromechanics crate with a Multibus I compatible backplane bus. An EC contains a single board computer (PC-16) based on a microprocessor similar to the Intel 8086 and a field bus interface (MIL 1553). As a first step most of old electronics made in SUMMA (CAMAC) will be controlled via a branch driver in the EC. Later, the SUMMA crates will be replaced with specific I/O cards in the same EC. EC's based on the Intel 8031 and 8051 microprocessors embedded in technical equipment will be used. for some subsystems (i.e. Power Supply).

3.4. Software

The software for the new control system will be based on the well known standards and protocols accepted for the UNK controls project:

- Unix and/or Unix-like operating system
- C programming language
- TCP/IP communication packages
- X-Windows and OSF Motif as the basis of the MMI
- Oracle DBMS and related tools

In addition, we plan to use the equipment access library which was developed for the UNK project [4,5], a home-made real time DBMS - SSUDA which provides a 3-D table structure for dynamic data storage, and also several home-made tools developed to simplify operator interface creation in applications [6].

4. CURRENT ACTIVITY EXAMPLES

4.1. Ejection system

Parts of the control electronics for the ejection systems were designed at various times by various organizations (CERN, IHEP, MRTI). Part of the equipment is still operated manually, the rest has control based on obsolete computers “Electronika-60” (like LSI-11) and SM1420 (like PDP-11). As a result we have now a conglomeration of various styles, configurations and standards. The following table illustrates the volume and diversity of the existing control equipment:

Mechanics and standards

Type	NIM	“Vishnia”	SUMMA	non-standard
Number of Crates	81	31	6	22
Number of Module Types	105	51	20	6

The new control system for the ejection complex will present a homogeneous structure of 8 functional subsystems integrated by fieldbus and FEC (fig.4). It will provide computerized control for all the extraction equipment. The EC I/O modules are connected to the controlled equipment either directly or through adaptation electronics. Some of the control and measurement procedures have to be synchronized with the beam structure. For this purpose a special RF generator (RFG) forms a so-called RF-train of pulses linked to the bunches. The RFG uses 2 input signals which

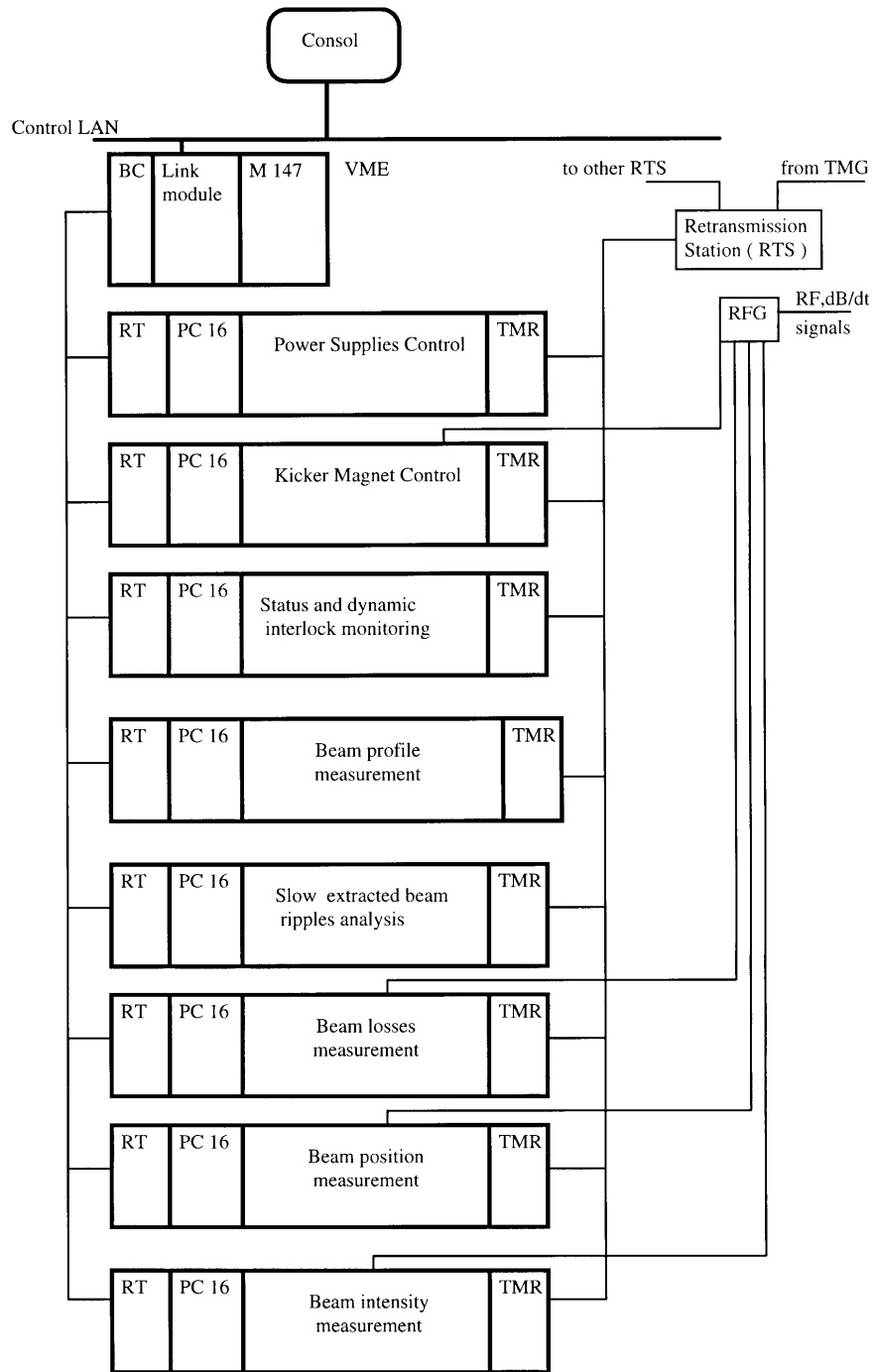


Fig.4. Ejection upgraded control system

are proportional to the accelerating RF voltage and the main magnetic field derivative (dB/dt). The different types of control hardware needed have been estimated to be the following:

- EC (Euromechanics crates).....8
- EC module types.....11
- adaptive electronics (small size crates).....17
- adaptive electronics module types.....8

Such a great decrease of the volume and diversity of the control electronics will simplify the maintenance and reduce its cost.

At present about 80% of the module types are developed and ready for serial manufacture. This year two ECs for power supply control and beam profile measurement are being assembled and will be installed in the ejection system LCR. Next year we plan to assemble three ECs, leaving the rest for 1997. The commissioning of the ECs and the control system as a whole will be carried out during the shut-down of 1996-1997. The completion of the upgrade design is planned to be in the middle of 1998.

4.2. General timing system

The existing U-70 general timing system was built in 1967. It generates and distributes a few pulses called the T-train and the B-train for common use ("cycle start", "reset", etc.). Each of these pulses and trains is transmitted from the MCR to users by means of individual distribution channels. To produce all necessary pulses locally, a large number of scalars is used. The new timing system is based on the technical solution designed for UNK and presented at this conference in detail [7]. The basic principle of the system is time-division multiplexing, which provides efficient utilization of the transmission cabling and the electronics. The main components of the system are the: timing message generator (TMG), timing message receiver (TMR) and multimode timer (MMT). The TMG forms the stream of encoded input information and sends it into the common transmission channel with the rate of up to 10 timing messages/ms. There are four sources of timing information: a 1kHz clock, preprogrammed events written in buffer memory, possible external pulses and 16-bit input data (number of cycles, astronomical time, current values of main magnetic field and beam intensity, etc.). The TMR decodes and processes the input information: it extracts the 1kHz clock, converts the event codes to output pulses and to interrupt request signals, writes down the new 16-bit data in dedicated registers. The multimode timer (MMT) can be programmed to produce both up to 6 pulses delayed with respect to the trigger and up to 3 pulse batches with programmed parameters. At present all the main components of the system have been designed. A segment of the new timing system was tested under actual working conditions and good results were obtained. This year two sets of the timing equipment will be installed in the booster and ejection systems. The installation of the new timing system design will be carried out gradually, depending on the readiness of the control subsystems, and completed in 1997.

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