THE OPERATION CONCEPT OF SARAF

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Abstract

The Soreq Applied Research Accelerator Facility (SARAF) is based on a 5 - 40 MeV, 0.04 - 2 mA proton/deuteron RF superconducting linear accelerator, which is under construction at Soreq NRC and is planned to start generating a beam by the end of 2010. SARAF will be a multi-user facility, whose main activities will be neutron physics and applications, radio-pharmaceuticals development and production, and basic nuclear physics research. The operational concept of SARAF will be 'one target at a time' and during irradiation, appropriate shielding will enable preparation and maintenance at other stations. This paper presents the planned facility operation program, the planned operations group, the location and layout of the MCR and the architecture of the main control system, including its interfaces with safety and applications. For a technical status of the SARAF project, see [1].

THE OPERATION PROGRAM

SARAF will be a 'multi-user' facility but not a 'multi-tasking' one. Therefore, the operation program includes foreseen activities and change-over time between them.

In addition, the program takes into account maintenance periods. We expect annual, quarterly and monthly maintenance periods of four weeks, two weeks and 48 hours, respectively. These periods leave 6700 hours per year over a 40 week period. Given the expected 90% availability, we plan for 6000 beam hours per year.

A typical weekly operation plan includes about 150 available beam hours per week, distributed over several applications with various ion type, energy and current. Given approximately 3 transition hours between applications and a 30 hours weekend break, there is a total of about 100 hours of beam-on-target per week.

THE OPERATION GROUP

The size and staffing of the SARAF accelerator operation group fits the size and nature of the facility, which on the border between 'Commercial' and 'Government Laboratory' [2]. Each operator is expected to be on a supervisor or engineer level and have a general knowledge of the entire system. In addition, each operator has one primary and one (or more) secondary and tertiary expertise. As the facility matures, non-expert operators of technician level may be added. While in operation, there will probably be at least two operators per shift.

The anticipated expertises of the operators are:

- High power RF and high DC voltage and current.
- Electronics, computers, control and instrumentation.
- Ultra high vacuum.
- Cryogenics in the liquid helium range.
- Beam dynamics.
- Radiation safety.

During the commissioning and first use of Phase I (2007), the accelerator will be staffed by about 12 people, of whom half are researchers and half are engineers and technicians. In Phase II, this number may increase to 16, where the addition is probably in the operator/technician level. The detailed staffing plan for the SARAF accelerator is given in Table 1.

Table 1: The planned SARAF accelerator group

	Design	Design & Construct	Commission Phase I	Construct & Commission Phase II	Start operation
	2001-4	2004-5	2006	2007-9	2010
Management & Researchers	5.5	5.5	5.5	6.5	5.5
Engineers	2	5	5	5	4
Technicians	1.5	1.5	1.5	4	6.5
Total	9	12	12	15.5	16

THE MAIN CONTROL ROOM

The size, layout, location and safety zone of the main control room (MCR) in SARAF were designed in order to ensure optimal operation conditions. Regarding size and layout, the requirements were:

- Comfortable size for all monitors and controls.
- Easy access to all monitors and controls.
- Housing of two permanent operators + a few more in special occasions.
- Similar to other facilities of parallel size [3].

The MCR size is 5×10 m^2, with an adjacent 15 m^2 servers and controllers room. The location and safety zone of the MCR were dictated by:

- Proximity to frequently visited systems.
- Centrality and proximity to main entrance.
- Possibility for enlargement.
- External walls with windows.
- Minimization of safety zone change procedures.

The MCR is located near most of the accelerator instrumentation, and it is in the 'yellow zone' (controlled), where most of the accelerator instrumentation is. The accelerator is in the 'red zone' (restricted when beam is on) and the offices are in the 'green zone' (free). The layouts of the top floor of the SARAF building and of the Main Control Room are shown in Figs. 1 and 2, respectively.

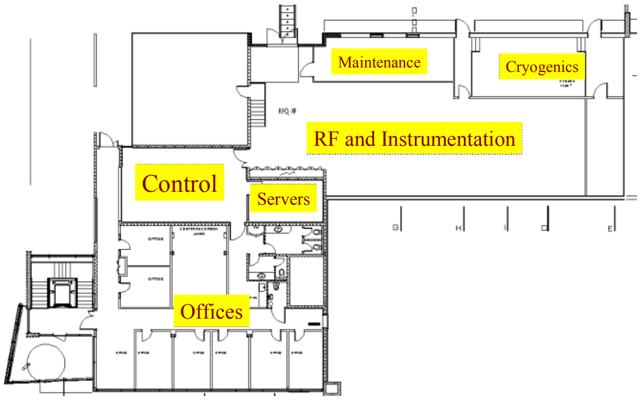

Figure 1: Layout of the top floor of the SARAF building. The Accelerator is located below the Maintenance and Cryogenics halls. The Targets Hall is further to the right.

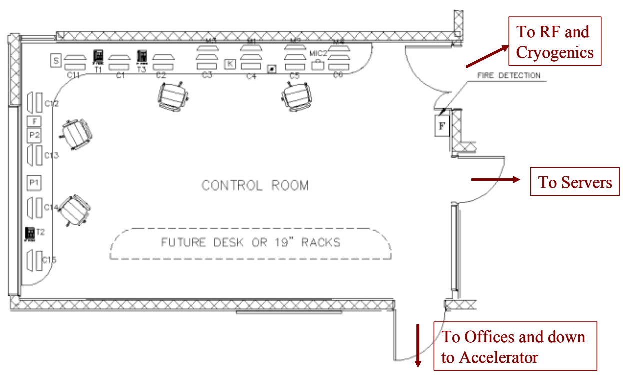

Figure 2: Layout of the MCR.

THE MAIN CONTROL SYSTEM

There were certain guidelines towards the realization of the Main Control System (MCS). We opted for a widely used commercial software package from an established company. The hardware (controllers, data acquisition cards, etc.) are also commercial, and incorporate the OPC standard, which is a universal protocol for hardware-software interfaces. It is advantageous to choose a company which produces both software and hardware. There is also a desire to minimize the types of hardware and software in the system. This has to be optimized with constraints that may be imposed by the many sub-contractors of the SARAF project, so we can settle for several types if inter-communication is possible.

The architecture of the MCS was chosen to be 'server-client'. This means that there is a central server whose sole purpose is to manage the hardware controllers and the MCS. The users operate the systems and run additional programs on client computers, which are networked only to the server, and not directly to the hardware. This architecture improves reliability, may provide redundancy and ensures that a crash in the client computer does not affect other clients, the server and the entire facility. The layout of the MCS architecture is shown in Fig. 3.

Based on the above guidelines, it was decided that the MCS software package will be Labview by National Instruments with a DSC module and an OPC server [4]. Labview is widely used, is flexible and scientifically oriented. In addition, client licenses do not depend on the amount of I/O. For hardware, we mainly use programmable logic controllers (PLC), of types FieldPoint, PXI from National Instruments [5] and S7,

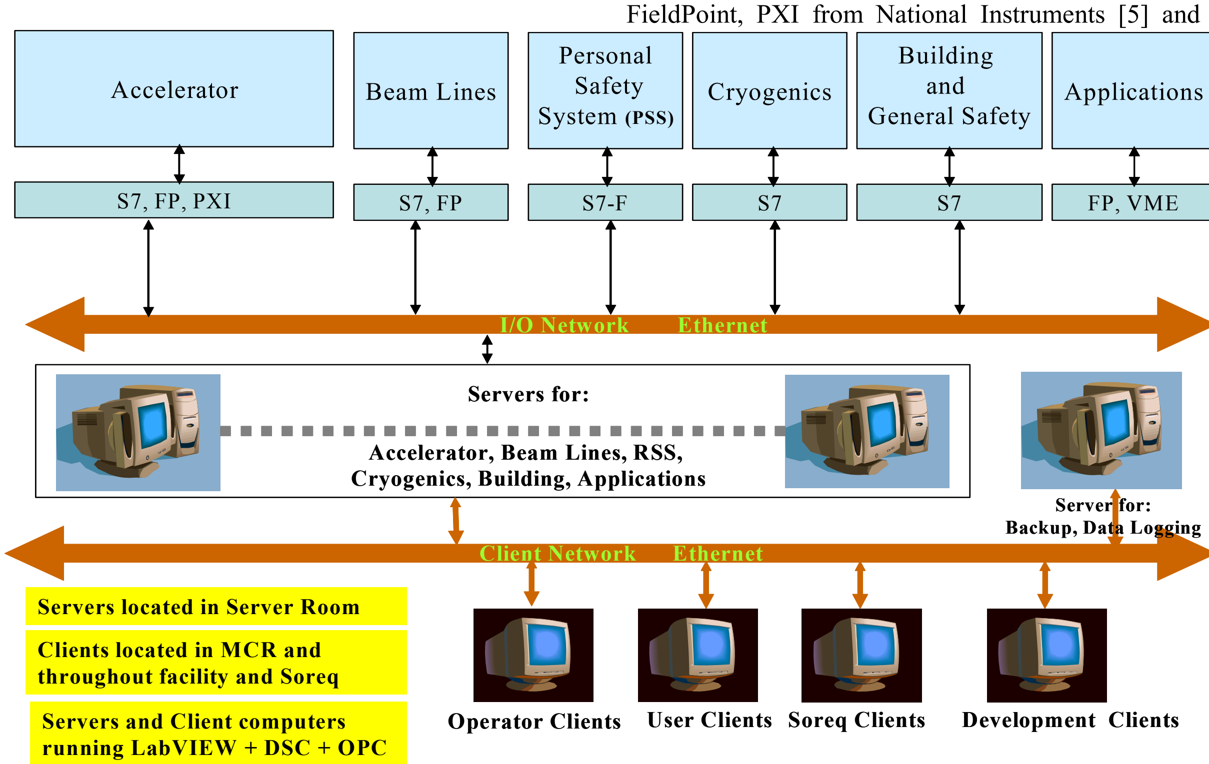

Figure 3: The architecture of the SARAF Main Control System.

S7-F from Siemens [6]. All types were chosen due to sub-contractors' constraints, they are all OPC compatible and S7-F is compatible with the international safety standard EN 954-1, Category 4. The network will be Ethernet and all the software will run on PCs with Microsoft Windows.

THE PERSONAL SAFETY SYSTEM

The personal safety concept of the SARAF accelerator is strongly inspired by the personal safety system (PSS) at the Paul Scherer Institute (PSI) accelerator [7, 8], where an accelerator with risks similar to SARAF is operated. In the following, we describe only the PSS of the accelerator. The PSS for the irradiation rooms is not designed yet. Regarding entry to the accelerator area (red zone), there are three safety statuses:

- Closed (red) - access is restricted and the accelerator may be on.
- Controlled (yellow) - access is controlled and the accelerator is off.
- Free (green) - access is free and the accelerator is of course off.

The safety status is displayed by 'traffic lights' throughout the building and on the MCS screens.

In yellow status, entry to the red zone is limited to six users and is done by a strict procedure, which involves communication with the MCR and removing a special safety key from the entry panel that disables accelerator operation. In green status, entry is not monitored.

The interface between the PSS and MCS is such that the accelerator can be operated and the beam can be generated only if the PSS provides a special 'enable' signal. This enable signal is dropped in the following cases:

- One of the red zone external doors is opened.
- One of the emergency buttons has been pushed.
- One of the special safety keys has been removed from the entry panel.
- The operators requested it via the MCS.

PSS Radiation readings above threshold do not drop the enable signal, but generate an alarm.

INTERFACE BETWEEN THE MCS AND THE APPLICATIONS

In principle, this interface will be quite loose, as the accelerator applications are getting the required beam from the accelerator, and should not be involved in the details of generating this beam. Nevertheless, certain information should be transferred. The MCS should give to the applications the following signals:

- Accelerator on or off.
- Beam to application is being tuned.
- Beam to application ready.
- Ion type.
- Beam current and energy according to the diagnostics closest to the application.
- Status of the accelerator's in-beam instrument (e.g. Faraday cup, gate valve) closest to the application.

The applications should send the following signals:

- Status of application's in-beam instrument closest to the application.
- Application is ready for beam.
- Application is at standby.
- Beam current at application.
- Emergency accelerator stop.

Feedback mechanisms are envisioned, where the energy and current at the application are set, and the MCS keeps them within a given range.

SUMMARY AND OUTLOOK

In this paper we presented the operation concept of SARAF, and the means with which this operation will be realized. The SARAF building, including the MCR is fully constructed, the MCS and PSS are fully designed and a significant part has been procured, programmed and installed. The operation group is starting to form and recently a few chief operators at the engineer level have been recruited and are participating in the system's installation and commissioning. Phase I of the project is due to be completed during 2007. Operation of Phase II is expected during 2010.

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