

# THE APPLICATION OF LINUX "SOFT" IOCS FOR STATUS SUMMARIES AT THE SPALLATION NEUTRON SOURCE \*

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## ABSTRACT

In order to respond quickly to changes that occur in a complex set of machinery, operators need to be able to tell at a glance where there may be trouble. A "soft IOC" is one of a collection of supervisory processes that require no I/O hardware except for network access, sharing a single Linux processor. Soft IOCs behave very much like conventional VME- or PC-based input-output controllers (IOCs). The supervisory processes that collect and pre-process information from all parts of the accelerator system are obvious applications for soft IOCs. At the Spallation Neutron Source (SNS) soft IOCs have been used in many data collection and summarization applications, including the RF systems, the cryogenic system and the control system itself. We describe each application and our operational experience with it.

## PROJECT DESCRIPTION

The SNS project is a partnership involving six DOE national laboratories: Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos and Oak Ridge. The status of the project is described in more detail on the web [1] and elsewhere [2].

## SOFT IOC DEFINITION AND PROCEDURES

Soft IOCs run using the EPICS (Experimental Physics and Industrial Control System) IOC shell [3]. At SNS, we use ProcServ, a process manager developed locally [4], to run soft IOCs and sequencers in the background. ProcServ allows a background process to run without creating a security hole, and allows IOC engineers to connect, control, monitor and restart soft IOCs using "telnet".

We have defined a structure similar to that we use for our traditional vxWorks IOCs to keep the software as uniform as possible for ease of maintenance. Operational soft IOCs are run by a common username so that they are no longer owned by a single engineer and can be maintained by others as well. The "IxRestart" and "IxRestartDev" scripts start soft IOCs under the soft IOC user either from the standard defined production area or from the development area respectively. While the soft IOC can be restarted by control-X under telnet if it is running well enough to respond to telnet and if the file location of the start-up script has not changed, these scripts can be used to change versions – or, analogously to a traditional IOC that needs a hard reboot, to kill and restart the process when it is no longer running well enough to perform a soft reboot. "IxRestart" and "IxRestartDev" assume that there are start-up scripts with specific names in the directory for the soft IOC, which is named to match the soft IOC and is located in a common IOC directory. The start-up scripts change to the appropriate directory and use ProcServ to start the iocCore binary with the appropriate command file.

We have developed a rudimentary IOC health module that defines heartbeats, start-up locations, reboot times and other useful information so that soft IOCs can be monitored almost like vxWorks IOCs. (See fig. 3.)

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Soft IOCs make it possible to define summaries giving upper-level views of the accelerator structure without disturbing the operating low-level systems. This is invaluable when making enhancements to a system while the equipment is being installed and tested. Soft IOCs reboot rapidly, so changes to these systems are less likely to impact operations even in the case of systems in constant use.

### RF SUMMARY

Top-level system summaries involve bringing together status indications and analog readings from different low-level processors. Many of the colored indicators in figure 1 display calculation process variables in soft IOCs summarizing data from a number of low-level traditional IOCs. Many of those indicators allow operators to get to engineering screens so they can investigate equipment problems easily. Operators and equipment engineers can keep track of the maintenance condition of system components using string process variables and soft status indicator process variables in soft IOCs. Changes to the maintenance status indicators and strings are sent automatically to our electronic log.

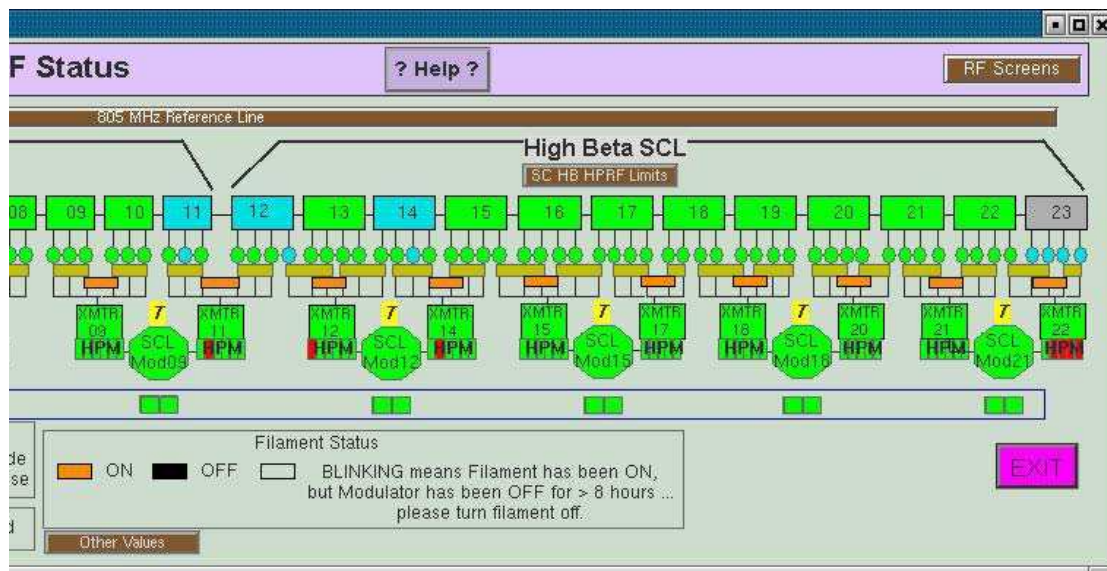
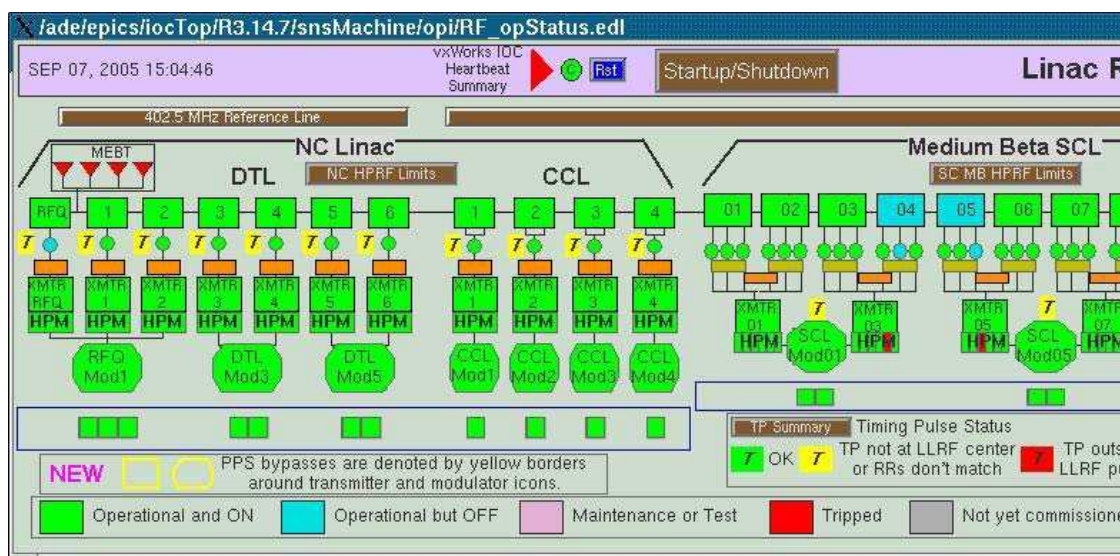


Figure 1: Linac RF Status Summary. Operators can see at a glance the status of the RF system.

## CRYOGENIC ALARM SUMMARY

Because the cryogenic alarms were not well-defined when the main cold box and gas management systems first became operational, the alarm summaries were moved to a soft IOC where they could be changed more easily. For example, devices could be added as they became operational, and process variable names from other systems could be changed. Once again, many of the indicators on the top-level cryogenic alarm screen (fig. 2) display the states of summary calculations served as process variables from the alarm soft IOCs. The brown related display buttons beside the status indicators bring up screens with details about the components.

The screenshot shows a window titled "X:/ade/epics/iocTop/R3.14.7/linac/cryo/cryo-latest/opi/Cryo\_mainAlarms.edi" with a timestamp of "SEP 07, 2005 15:06:41". The main title is "0.1 Main Alarm Screen" and there is a button for "0.9 Cryo Overview". A central warning box says "Call Cryogenic Coordinator if Continuously Red for 3 Minutes".

The screen is divided into several sections:

- Central Helium Liquefier Building:**
  - CHL Compressors: Active
  - CHL Recovery: Active
  - CHL Contamination: INACTIVE
  - 4K Cold Box: Active
  - CHL Turbines: Active
  - CHL 7000 L Dewar: Active
  - 2 K Cold Box Cold Compressors: Active
  - 2 K Cold Box LN Dewar Level: Active
  - CHL Water Pressure: Active
- ICS - Cryogenic Control System:**
  - CHL IOCs: Active
  - CHL PLCs: Active
  - SCL IOCs: Active
  - SCL PLCs: Active
- Cryogenic Heartbeat:** A blue heart icon with "EPICS" text next to it.
- ODH Alarms:** A button next to the label.
- Transfer Line and Cryomodules:**
  - Transfer Line: Active
  - Cryomodule: INACTIVE

An "EXIT" button is located in the bottom right corner.

Figure 2: Cryogenic Main Alarm Screen. The cryogenic operator can see problems in the cryogenic systems very quickly.

### IOC SNAPSHOT

A soft IOC is used to keep track of the heartbeats of all of the IOCs in the control system, including other soft IOCs. Whenever an IOC goes down or loses its network connection, the circle indicating its current status goes red. A second status shows latched status, so that IOC engineers can keep track of problems that have affected their IOCs. As in the RF systems, strings and soft status indicators are provided to allow operators and equipment engineers to keep track of the maintenance condition of IOCs. Changes to IOC status strings are sent automatically to the electronic log, and are typically used to document IOC reboots. The brown label is a related display button that brings up a menu of IOC status screens; the scroll icon (usually green for operating IOCs) includes a related display button that brings up the engineering status strings.

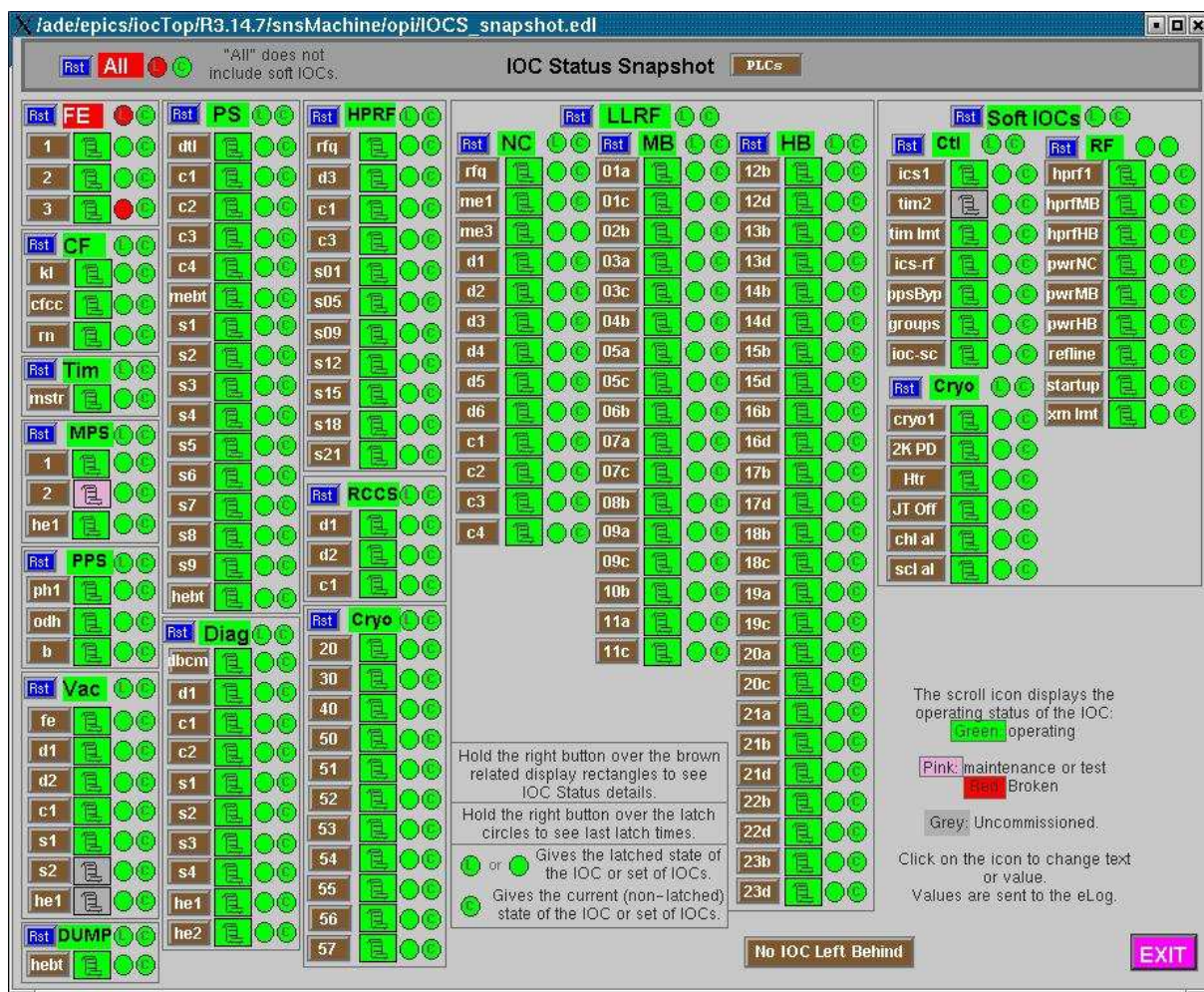


Figure 3: IOC Snapshot Screen. Operators and controls engineers can respond quickly to problems in the IOCs and the networks that connect them.

### OPERATING EXPERIENCE

Our experience with soft IOCs has been generally very positive. The ease with which they can be restarted to improve the programs and databases has been invaluable in developing systems. A few things do not work quite the same as traditional IOCs. The SNS standard IOC set-up involved loading the shared database definition and software libraries at run time; in soft IOCs, database definition and software libraries need to be included at compile time. Problems arose in sequences that did not arise in the same sequences when running on traditional IOCs. For example, sometimes process variables have not changed at the expected time. Channel access connection problems have been observed on rare occasions, particularly when process variables have not changed for long periods of time. In spite

of these problems, soft IOCs have multiplied in our control system, including summaries, start-up and shutdown applications [5], as well as data servers for pure Ethernet devices.

Our main soft IOC server is running 25 soft IOCs under Linux 2.4 and mostly EPICS 3.14.7, serving 17500 EPICS process variables with 1200 sequences and 3500 threads. The system CPU stays at around 85% idle. With 2 GB of memory, this server has not used swap space since the last reboot – thus, it has not run out of memory in 355 days.

Server	Soft IOC Count	PV Count	Thread Count	Sequence Count
Main server	25	17465	3569	1188
Cryogenic server	6	2686	557	76
Vacuum server	10	1830	300	10
Totals	41	21981	4426	1274

Table 1: Soft IOC usage.

## PLANNED IMPROVEMENTS

We plan to implement the facility to log output that goes to the soft IOC console as is done using the `iocConsole` program at SLAC and ASD [6]. More soft IOC status information such as channel access connection information could be useful.

We plan to have a Linux server for each major subsystem to provide for scalability and reliability. For example, a reboot of the cryogenic soft IOC Linux server does not bring down the vacuum soft IOC server. The soft IOCs are not running on a real-time operating system, so we cannot rely on them for time-critical/deterministic applications [7]. The EPICS developers are working to improve this with task priorities – however, for the applications described above, the response has been satisfactory.

## REFERENCES

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