EVOLUTION OF THE ARGONNE TANDEM LINEAR ACCELERATOR SYSTEM (ATLAS) CONTROL SYSTEM*

M. Power, F. Munson, Argonne National Laboratory, Argonne, IL 60439, U.S.A.

Abstract

Given that the Argonne Tandem Linear Accelerator System (ATLAS) recently celebrated its 25th anniversary, this paper will explore the past, present, and future of the ATLAS Control System, and how it has evolved along with the accelerator and control system technology.

ATLAS as we know it today, originated with a Tandem Van de Graff in the 1960s. With the addition of the Booster section in the late 1970s, came the first computerized control. ATLAS itself was placed into service on June 25, 1985, and was the world's first superconducting linear accelerator for ions. Since its dedication as a National User Facility, more than a thousand experiments by more than 2,000 users world-wide, have taken advantage of the unique capabilities it provides.

Today, ATLAS continues to be a user facility for physicists who study the particles that form the heart of atoms. Its most recent addition, CARIBU (Californium Rare Isotope Breeder Upgrade), creates special beams that feed into ATLAS.

ATLAS is similar to a living organism, changing and responding to new technological challenges and research needs. As it continues to evolve, so does the control system: from the original days using a DEC PDP-11/34 computer and two CAMAC crates, to a DEC Alpha computer running Vsystem software and more than twenty CAMAC crates, to distributed computers and VME systems. Future upgrades are also in the planning stages that will continue to evolve the control system.

ATLAS' FIRST CONTROL SYSTEMS

In 1978 a proposal was submitted to create a super-conducting LINAC using seven groups of independently-phased split ring resonators, and called for a computer based control system. The proposal was to use a Digital Equipment Corporation (DEC) PDP 11/34 to "(1) set and monitor all parameters of resonators and solenoids, and to control long-term drifts, if any; (2) to monitor many sensors such as thermometers; (3) to automate the tuning operations" [1]. Figure 1 shows the original proposed design, using two CAMAC crates, two touch screen panels integrated with knob controls, and a numeric keypad as shown in Figure 2, and a raster display as operator interfaces. Control programs were written mostly in FORTRAN on the RSX/11 operating system. Some of this code is still in use today.

* This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

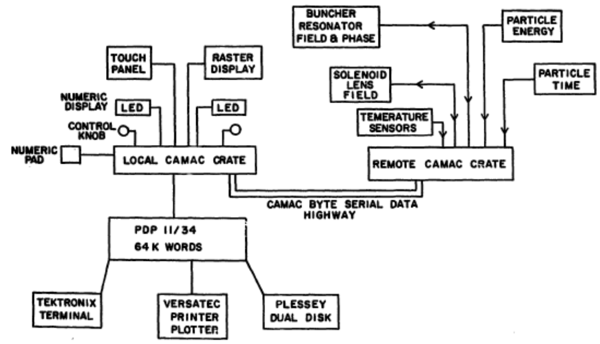

Figure 1: Original computer control system proposal.

Figure 2: Touch screen control board.

As the accelerator continued to expand, so did the control system to include three PDP 11 systems, each controlling part of the accelerator: the newly constructed Positive Ion Injector (PII), the primary accelerator section (Booster and ATLAS), and beamline devices. All three systems contained separate and isolated databases. More CAMAC hardware was added and separated into two serial highways [2]. Figure 3 shows the control room after the expansion.

Figure 3: Control Room circa 1985. The right (grey counter) is the accelerator control system including the original Booster and added ATLAS sections. The left (white counter) is the added beamline control system.

MAJOR UPGRADE

In the early nineties, plans to update the control system to create a more integrated and expandable system using newer technologies began to be discussed. Since there was a significant investment in the existing CAMAC hardware, it was decided to retain it, but the crates were reconfigured into a single serial highway. The multiple PDP 11 computers were replaced with a single DEC MicroVAX running VMS software, and an Ethernet based LAN was installed to interconnect the various display computers with the server. A third party software package, Vista Control Systems Vsystem, was chosen to provide an integrated database, graphical user interface, and hardware support [3]. Figure 4 depicts one of the new Vsystem displays.

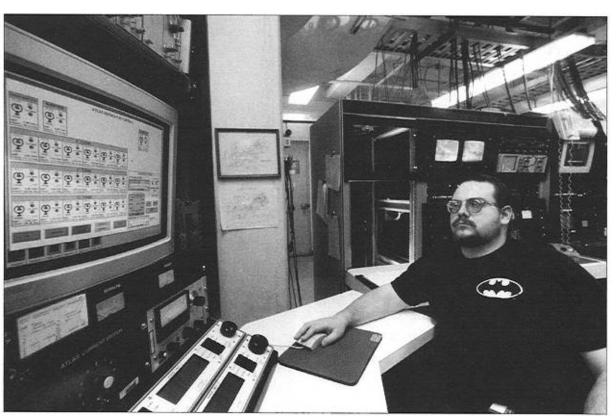

Figure 4: New Vsystem display in the Control Room.

Gradually, new pieces were phased into the system. The software written for the PDP 11 computers was transferred to the MicroVAX. Once the port was complete, a new DEC AlphaServer was purchased and replaced the MicroVAX. The AlphaServer was the core of the control system and contained the single link to the CAMAC serial highway and all the real time databases and displays. Various other Alpha workstations and PCs were used as operator workstations throughout the accelerator site. Figure 5 shows the conceptual layout of the upgraded control system.

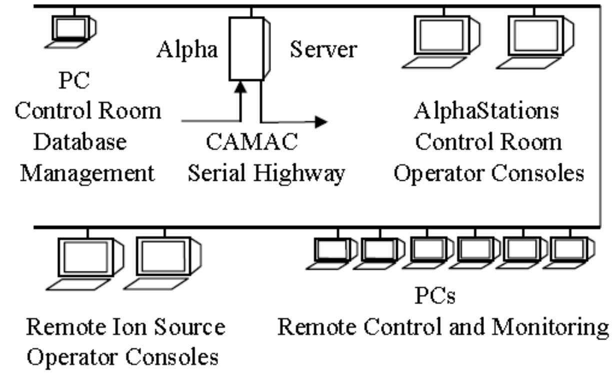

Figure 5: 1990's upgrade configuration.

Additionally, two relational databases were added to provide logging of system parameters and the ability to scale and reload control parameters into the real-time system for similar charge to mass ratios. This was accomplished by storing real-time data on the AlphaServer using Oracle RDB, and periodically transferring the data onto a remote PC located on the LAN. The PC software was written with Corel Paradox to store the data and provide an interface for the operations staff.

Another noteworthy accomplishment of this upgrade was that it was done for the most part online, simultaneous with the operation of the accelerator. The ported software control programs including Resonator and Solenoid Control, Autoscan, and Energy and Time Measurement applications are still in use today.

DISTRIBUTED SYSTEMS

As ATLAS would continue to grow, and with the understanding of the limitations of having a single point of failure with a single server and single CAMAC serial highway, efforts were made to implement a distributed system test case. The Vsystem software already supported distribution, and it was decided to move the cryogenics database to a distributed system. The cryogenics database and its related displays were copied to a PC with the Linux operating system running the Vsystem software. A PCI to CAMAC interface was installed, and the CAMAC crate was removed from the main serial highway and connected directly to the Linux PC. Figure 6 shows the new configuration [4].

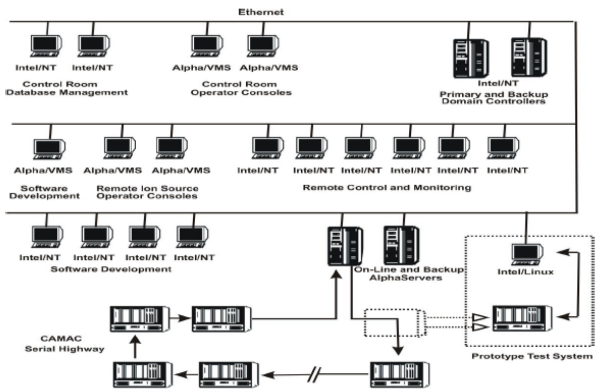

Figure 6: ATLAS control system with distributed I/O.

More recent accelerator upgrades including the new Charge Breeder and the addition of the CARIBU (Californium Rare Isotope Beam Upgrade) Source have increased the use of distributed processing. With increasing prices due to the low demand for CAMAC modules, additional hardware options have also been investigated. Two hardware options using Industry Packs have now been implemented. Four VME crates have been installed, and are controlled using Linux based PCs running the Vsystem software. A second option was initially installed on the source high voltage platforms. Two Hytec 9010 blade I/O controllers [5] were installed using the onboard Industry Pack support. These controllers also run the Vsystem software on Linux, and are excellent in areas where less I/O is needed. Due to problems with the 9010s caused by an occasional electromagnetic pulse due to high voltage arcing in these locations, the 9010s have been replaced with VME systems, but will be repurposed for use in other areas as the system continues to be distributed and offloaded from the DEC AlphaServer. Figure 7 shows the current control system configuration.

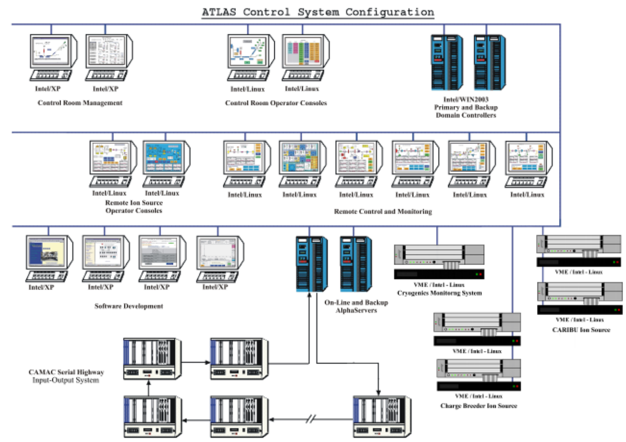

Figure 7: Current ATLAS Control System configuration.

FUTURE PLANS

ATLAS continues to evolve and expand, meeting the future needs of its users. Additional upgrade projects are currently underway and the control system will continue to evolve with the accelerator. Along with supporting additions and updates, future plans include further distribution of I/O processing and databases, and phasing out the DEC AlphaServer.

With the use of well tested and commercially available control system solutions, the ATLAS control system continues to be maintained by a very small staff.

REFERENCES

[1] Bollinger, L. M. et al., “ATLAS: A Proposal for a Precision Heavy Ion Accelerator at Argonne National Laboratory”, Argonne National Laboratory, 1978, ANL-78-XX-68.

[2] F. Munson, D. Quock, B. Chapin, and J. Figueroa, “Argonne’s ATLAS Control System Upgrade”, International Conference on Accelerator and Large Experimental Physics Control Systems, ICALEPCS ’99, Trieste, Italy, October 4-8, 1999.

[3] Vista Control Systems, Inc., Los Alamos, NM, USA.

[4] F. Munson, D. Quock, S. Dean, and K. Eder, “First Experiences Integrating PC Distributed I/O Into Argonne’s ATLAS Control System”, International Conference on Accelerator and Large Experimental Physics Control Systems, ICALEPCS 2001, San Jose, California, October 2001.

[5] Hytec Electronics LTD, Reading UK.