CEBAF CONTROL ROOM RENOVATION*

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Abstract

The Machine Control Center (MCC) at Jefferson Lab's Continuous Electron Beam Accelerator Facility (CEBAF) was initially constructed in the early 1990s and based on proven technology of that era. Through our experience over the last 15 years and in our planning for the facility's 12 GeV upgrade we reevaluated the control room environment to capitalize on emerging visualization and display technologies and improve workflow processes and ergonomic attributes. This effort also sets the foundation for the redevelopment of the accelerator's control system to deliver high reliability performance with improvements in beam specifications management and information flow. The complete renovation was performed over a three-week maintenance period with no interruption to beam operations. We present the results of this effort.

INTRODUCTION

The MCC has served as the focal point for CEBAF operations since its construction in the early 1990s. The original control room layout consisted of a U-shaped array of 20 full-height equipment racks (figure 1) that housed analog electronics and 3 tiers of large form-factor CRT monitors and computers. A continuous low-depth non-adjustable work surface was bolted to the racks to hold keyboards and mice. A large table dominated the room to hold binders and beamline drawings. The MCC staff, consisting of a shift supervisor, two operators and specialists, operated the accelerator from these rack spaces.

Figure 1: Large equipment racks bearing LCD monitors comprised the main Operations workspace.

A separate bank of equipment racks (figure 2) housed the Safety System controls and CRT monitors, which were located at the opposite end of the control, room and separate from the primary accelerator controls. This console also had a non-ergonomic countertop bolted to the racks to create a worksurface. The depth of the desktop surface prevented staff from reaching the Safety System key controls and access buttons from a seated position.

Figure 2: Safety System racks and small CRT monitors for managing accesses just visible at the far end of the console.

A large portion of the MCC was dominated by a separate walled space called the fishbowl (figure 3). Scientific and engineering staff used this area to monitor system performance independent of the main control room staff.

Figure 3: Fishbowl for support staff computing.

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Motivation for Change

The original raised floor tiles and rail system in the control room were made of zinc-clad concrete and had deteriorated during 15 years of operations to the point that the floor system had failed. A complete replacement of the tiles and grid was necessary which would require the dismantling of all rack systems within the control room.

Poor marks in ergonomics from two independent assessments were also a factor in the decision to redesign the space. The studies cited the facility for excessive noise, non-adjustable work surfaces, inadequate temperature control and poor sight lines to the upper tier of system status displays.

Workflow dynamics needed improvement as well. It was often difficult for the shift supervisor or Crew Chief to oversee operations due to the cramped space and distribution of small displays. Scientific and engineering support staff were often tasked with performing their system analysis from the adjacent fishbowl. This separation from the main control room staff was not conducive to efficient operations and made communication difficult. The location of the Safety System console at the far end of the space also provided operational inefficiencies.

The CEBAF physics program is a dynamic enterprise calling for frequent energy and pass changes (table 1). Our operational efficiency in making these transitions of the machine setup is an important component of our program.

Over the first 15 years of operating the facility we slowly replaced existing rack mounted equipment with more compact solutions and replaced much of the analog hardware with digital solutions or relocated these systems to the outlying service buildings. This reduction in effective use of the existing rack systems coupled with significant ergonomic shortfalls, failure of the raised-floor system and a general desire to improve the operability and workflow dynamics of the facility prompted the redesign.

A team of Accelerator Division and Facilities staff was formed to analyze emerging technologies and workplace solutions in the summer of 2003. Over the next six months a renovation plan was developed and then approved by laboratory management for implementation over the summer of 2004.

Table 1: Frequent Energy and Pass Changes

Change	FY04	FY03	FY02	FY01	FY00	Totals
Linac	4	9	5	7	8	33
Hall A	6	25	15	24	18	88
Hall B	5	9	5	11	11	41
Hall C	6	7	4	14	11	42
Totals	21	50	29	56	48	204

TRANSFORMATION

The MCC renovation was an extensive undertaking touching all aspects of control room technology. These changes were precipitated by thoughtful consideration of all of the possibilities by a team of Controls System Administrators, Operations Staff, Engineers, Technicians and Staff Scientists and then validated by a peer review process. In the end the original space was gutted from floor to ceiling and everything replaced with new systems with the work accomplished in two phases and without interruption to the physics program.

Phase I July 2004

The first phase of the renovation was performed over the 4th of July weekend and concentrated on upgrades to the acoustic ceiling, lighting and HVAC systems as well as demolition of the fishbowl area.

The original ceiling tiles were replaced with a superior acoustic system to solve the noise problem. The ceiling was also raised an inch in the whole space and 11 inches in the central area to accommodate a new display system. The resulting improvement in sound quality in the space was immediately apparent.

Figure 4: Phase I complete showing the new lighting solution and acoustic ceiling tiles.

As can be seen from the previous figures, the original space had a low ceiling populated with standard fluorescent direct lighting solutions, which made the space appear cramped and harshly lit. The new design uses indirect fixtures in conjunction with the new ceiling tiles to provide a uniform lighting profile. This technique eliminates shadowing and monitor glare. The bulbs were specified to have a color rendition index greater than 90, which makes the space appear sunlit.

The HVAC system was part of a poorly regulated and shared equipment room system that fed cold air from below the raised flooring. The new ducting is now contained in the ceiling and fed from an independent and well-regulated HVAC system.

Phase II August 2004

During our summer shutdown we began the second phase of the project, which consisted of a complete removal of all remaining equipment. A temporary MCC was established to provide support for downtime activities around the machine. All computer systems and equipment racks, the raised flooring system, and five generations of network and telephone cabling were then removed in preparation for the new installation (figure 5).

Figure 5: Demolition completed after first two days of the second phase. New network drops are visible as well as the fire-suppression system.

We completed the renovation over the next 18 days and brought the new control room online prior to the end of our shutdown period. The new facility includes ergonomic workspaces, a large-format display wall, new computer equipment, new voice and data lines, improved analog and video switching systems and many other improvements. The final result is shown below giving a feel for the scope of work performed (figure 6).

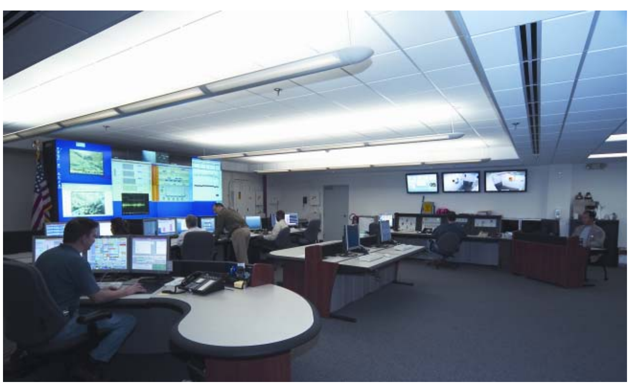

Figure 6: New space showing ergonomic workstations, main DLP display wall at left and three Safety System displays positioned across the room.

Workstation Layout

The new control room layout is depicted in figure 7 and was developed after careful consideration of people and information flow. The design team monitored the existing control room space to ascertain how it was being used and misused in this regard. We also visited a number of other control centers to gather ideas. Our new layout is a result of this research.

At the top left corner we placed our three remaining equipment racks to house oscilloscopes, analog and video switching hardware and servers for control of the main display wall and to provide access to PC sessions via Metaframe servers.

We positioned the Crew Chief at the left side of the facility with a clear view of the space and of all displays. They are also in the best position to monitor traffic as it enters the control room. Their workspace has a single keyboard and mouse connected to a triple-headed HP B2000 workstation and an adjustable worksurface. The end of this console is designed to support small discussions that are facilitated by a white board on the left wall.

The main 22’ console at the top of the picture is for Accelerator Operators and Principal Investigators. This worksurface is situated directly in front of the main display wall, which is described in the next section. All workspaces have the same computer resources as the crew chief and the center positions have adjustable work surfaces.

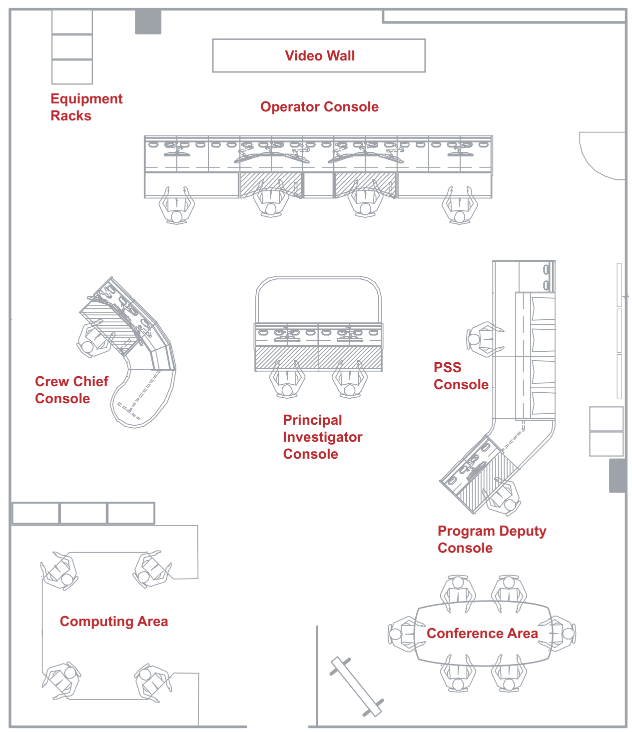

Figure 7: New control room layout.

The center workspace is for additional support staff and has single monitors connected to HP B2000 workstations and adjustable worksurfaces. Accelerator scientists and engineering support staff typically occupy this space.

Our Safety System console occupies the right hand side of the layout and is in easy reach of the Accelerator Operator. Three new 42” LCD and plasma displays are mounted on the right-hand wall to depict system status and video feeds from accelerator access points and are easily visible from anywhere in the control room. We have installed new switching hardware that allows for multiplexing up to 16 video displays on one of the plasma screens. The balance of the PSS workstation contains key switch and push-button controls for operating the safety system.

Adjacent to the Safety System console is our Program Deputy (PD) station. The PD is responsible for scheduling accelerator activities over a two-week period. Their workspace is positioned to provide a view of the main display wall and to allow easy access to the corner conference area that is used for planning and program development. The workspace has a single monitor connected to an HP B2000 workstation.

In the lower left corner we retained the computing space that was served by the original fishbowl but we left the space open to the main control room. This allows for close collaboration with support staff.

And finally on the lower right side of the layout we have a conference area to support discussions of machine operations and to hold shift turnover meetings between support staff and control room staff.

Display Wall

Our old array of 21” monitors has been replaced by a seamless configuration of 8-50” DLP™ rear-projection cubes from Christie Digital™. Each XGA cube has an independent projection engine providing a native resolution of 1024 x 768 pixels. With our 2x4 stacked array of 50”-diagonal displays we have a total resolution of 4096 x 1536 pixels spanning a 5 ft. tall by 13 ft. 4 in. wide display system. A schematic representation of DLP™ technology is shown in figure 5. These displays are designed for demanding control room environments and provide high brightness clear digital images of accelerator control screens, video inputs, RGB windows, and satellite feeds.

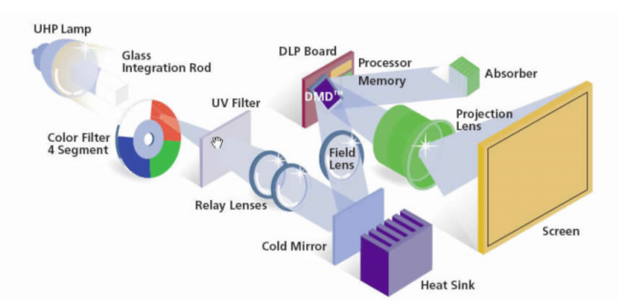

Figure 8: Display Wall projection engine.

The Display Wall offers a unique perspective on machine operations and provides for:

- Integration of all status information to one display.
- Improved oversight capability for Crew Chief.
- All beamlines to be viewed simultaneously to facilitate tuning of accelerator.
- A viewable and controllable environment from anywhere in the room.
- A single focal point for Operators and support staff
- A focal point for visitors minimizing the need to shutdown the accelerator for tours

Display Wall Environment

The CEBAF control system utilizes EPICS on a unix platform. We use Exceed™ running on a pair of HP B2600 servers to bring the X environment to the video wall’s desktop. All control screens are hosted by these servers and displayed on the wall.

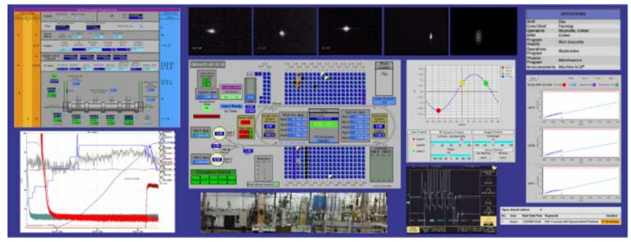

Figure 9: Typical display wall layout showing versatility of system.

The accelerator utilizes video data to display beam quality information from synchrotron light monitors/interferometers, viewers and other devices. Presently we can display up to eight of these images at one time anywhere on the wall at arbitrary sizes. We pass all accelerator video through a switcher system to manage the signal paths.

We send RGB data to the wall from a pair of oscilloscopes and video digitizers for display on the wall. All 4 inputs can be displayed at the same time.

Two satellite feeds are available for display and are connected to two of the controller’s S-video inputs for monitoring emergency management stations.

VNC Display Wall Control

The control room operator can use the local keyboard and mouse to interact with the video wall computer. In addition we have developed VNC clients to allow remote control from any of the workstations in the control room. Three clients were developed. The “control wall” application allows one to share the keyboard and mouse actions with any other user who is running “control wall”. The “take wall” application provides the user with exclusive control of the wall. If one user is already using the wall their session is terminated by the new user. The “view wall” application allows any user to display the wall on their local desktop.

CONCLUSION

An extensive renovation of the Jefferson Lab CEBAF control room was completed in the summer of 2004. The work completely transformed the space into a state-of-the-art control room facility with all aspects of the space undergoing change. We look forward to the continued development of this work environment and in collaborating with other laboratories on future projects.