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Interactive Design Center

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Abstract

Sandia's advanced computing resources provide researchers, engineers and analysts with the ability to develop and render highly detailed large-scale models and simulations. To take full advantage of these multi-million data point visualizations, display systems with comparable pixel counts are needed. The Interactive Design Center (IDC) is a second generation visualization theater designed to meet this need. The main display integrates twenty-seven projectors in a 9-wide by 3-high array with a total display resolution of more than 35 million pixels. Six individual SmartBoard displays offer interactive capabilities that include on-screen annotation and touch panel control of the facility's display systems. This report details the design, implementation and operation of this innovative facility.

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Acronyms

ASC	Advanced Simulation and Computing Program
AV	Audio-Visual
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DISL	Distributed Information Systems Laboratory
DLP	Digital Light Processing
DOE	Department of Energy
DVI	Digital Visual Interface
IDC	Interactive Design Center
ISDN	Integrated Services Digital Network
GB	Gigabyte
HVAC	Heating, Ventilation and Air Conditioning
IP	Internet Protocol
KVM	Keyboard-Video-Mouse
LCD	Liquid Crystal Display
MB	Megabyte
PC	Personal Computer
RAM	Random Access Memory
SCN	Sandia Classified Network
SGI	Silicon Graphics, Inc.
SRN	Sandia Restricted Network
STK	Satellite Toolkit Software
NNSA	National Nuclear Security Administration
VDC	Visualization Design Center
VGA	Video Graphics Array
VTR	Vault-Type Room

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1 Introduction

The Interactive Design Center (IDC) is Sandia/California's premiere facility for viewing high resolution computer-generated graphics. Funded by the National Nuclear Security Administration's (NNSA) Advanced Simulation and Computing (ASC) Program and opened in January 2005, the IDC provides a visualization environment where designers, engineers and analysts work interactively to develop and modify weapons designs. The high-fidelity display systems, coupled with advanced computational platforms, enable users to view, discuss and easily comprehend complex large-scale weapons models and simulations in real time.

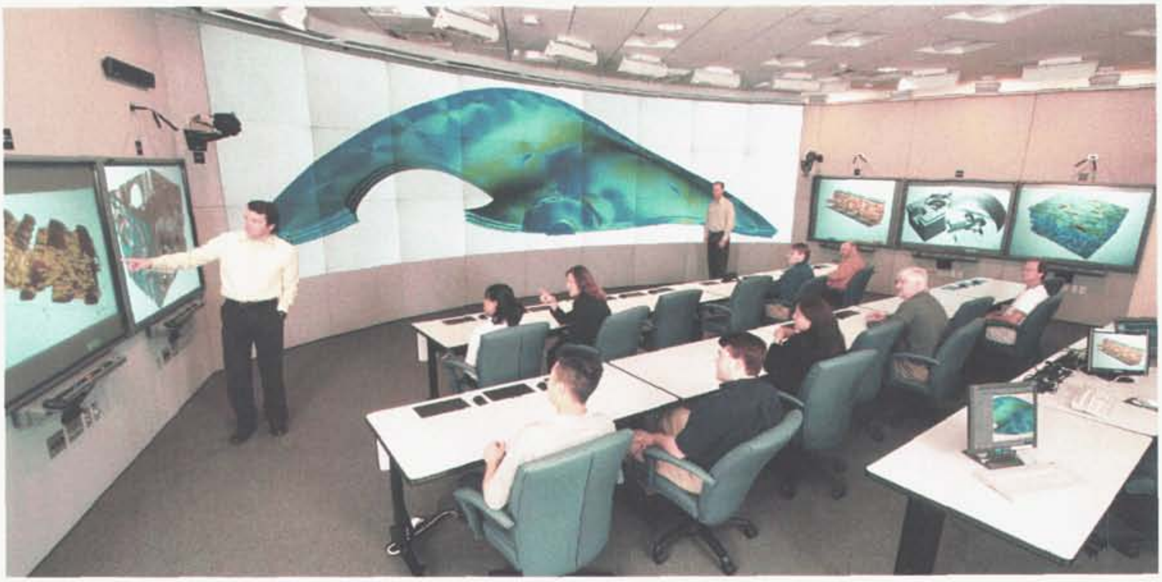

Figure 1. The IDC display theater.

The IDC's primary application is the visualization of complex multi-megabit data sets on a large, high fidelity display system. Desktop displays have limited size and resolution which limit the viewer's ability to discern small details. By comparison, the IDC's thirty foot wide main display has over 35 million pixels to show extremely fine detail in highly complex models and simulations. As these details become apparent, design team members are better able to comprehend their designs, thus reducing design iterations and cycle time. Additionally, design teams may incorporate remote participants with the IDC's integrated videoconferencing systems and collaboration tools.

The IDC supports a wide variety of other customer applications with its flexible audio-visual (AV) system design. A video processor enables the simultaneous display of up to twenty separate inputs in scalable display windows across the main display array. Six ancillary SmartBoard displays complement the main display. They can be used as simple display screens or as interactive touch-screen systems for presentations and on-screen note taking. Two of these displays also have on-demand touch panel control overlays that give users control of all of the IDC's AV system functions at these locations. Tabletop touch panels can be used separately or in combination with the on-screen control interfaces. Another interactive feature gives users the ability to control any of the in-house computers by connecting a single keyboard and mouse at one of the many tabletop and wall ports located throughout the facility.

The IDC supports both classified and unclassified computing applications. Two 80-processor Linux graphics computing clusters, two 16-processor Silicon Graphics servers, and 18 Windows™ personal computers power the IDC's visualization environment. Users may integrate their own laptop computers into the display systems and Sandia networks through the aforementioned tabletop ports.

While the IDC is designed for several specific customer applications, it is also designed for flexibility to meet changing customer needs and to adapt to changes in operational security rules. Expected customer applications include:

- Classified cluster visualization of large-scale weapons models and simulations
- Nuclear weapons design reviews
- Unclassified cluster simulations of fluid dynamics
- Homeland defense threat scenarios and first responder exercises
- Visualization of real-time telemetry data from weapons tests

2 Background

The objective of the ASC Program is to ensure the safety, reliability and performance of the nuclear weapons stockpile in the absence of nuclear testing. "The need to predict the behavior of nuclear devices using simulation must be met as long as nuclear security is a national priority."[1] Sandia's Distributed Information Systems Laboratory (DISL) is a critical element of the ASC strategy to develop and deploy information systems technologies into the nuclear weapons complex. DISL provides work environments for research, development, prototyping and deployment of distributed computing and collaborative engineering solutions. DISL facilitates the transformation of the engineering environment by integrating high fidelity modeling and simulation, and seamless access to information into a routine way of doing business.[2]

The design and construction of DISL provided an opportunity for the development of Sandia/CA's second major visualization facility, the Interactive Design Center (IDC). The Visualization Design Center (VDC), Sandia/CA's first visualization environment, served as the foundation for the design of the IDC. The VDC was designed as an immersive visualization theater with a front-projected, curved screen display system with three CRT projectors. Two multi-pipe SGI graphics servers ran visualization applications.

Figure 2. The Distributed Information Systems Laboratory.

Figure 3. The Visualization Design Center.

[1] "ASC Strategy - The Next Ten Years", NA-ASC-100R-04-Vol.1-Rev.0, August 2004, http://www.sandia.gov/NNSA/ASC/pubs/pdfs/Strat10yr_MT.pdf.

[2] "Distributed Information Systems Laboratory (DISL) dedicated at Sandia/California", Sandia National Laboratories/CA press release, 6/10/04, http://www.sandia.gov/news-center/news-releases/2004/comp-soft-math/disl-dedication.html.

The VDC's value to weapons programs was validated through a number of case studies including design reviews and flight test simulations.[3] Over its six year course of operation, the primary display system was upgraded with digital light processing (DLP) projection technology. A rear projection 4x3 display array using LCD projectors was added to support two 16-node Linux graphics clusters.

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[3] J. A. Friesen, et al., "Visualization Design Environment", Sandia National Laboratories SAND99-8455, May 1999.

3 IDC Design

A preliminary design process began in 2001. Because the implementation of the IDC would not occur for three years, no attempt was made to define the design of the IDC at that point. The expectation was that any design developed at that time would be outdated by the time of implementation due to improvements in computational and display technologies. As a result, the objectives were limited to securing a location and defining the infrastructure requirements to minimize rework at a later date. The final design process was intentionally delayed to take advantage of the latest developments in computer and display system technologies.

3.1 Preliminary Facility Design

The IDC Design Team worked with Sandia Facilities staff to locate the best available space within the tentative DISL building plan. Although a large open space on the first floor with 14'-16' ceiling height and a suspended floor was desired, the best available space was restricted in both height and continuous open space. Ceiling height was 16', but the HVAC ducting and a desired 12" raised floor reduced the floor-to-ceiling height to 11'. Two vertical support columns located within the 80'x45' space restricted design flexibility and could not be relocated. A preliminary design consisting of a main display theater with rear projected display technology and two computer server rooms was developed (Figure 4). The server room sizes were based on the expectation that each would house a computing cluster with up to sixty-four nodes. The sixteen node graphics cluster operating in the VDC at the time required three full size equipment racks, suggesting that the IDC server rooms would have as many as twelve cluster racks, plus additional racks for the audio-visual (AV) systems.

The display walls in the main theater were merely penciled in as place holders. The knowledge gained from operating the VDC led the IDC Team to believe the ultimate IDC configuration would consist of some number of rear projected displays around the perimeter of an inner wall. Ongoing research of display technologies was planned to help develop ideas for a future final design. Simple ceiling light fixtures were included with the understanding that they would be replaced by a more complex lighting design as part of the AV system integration.

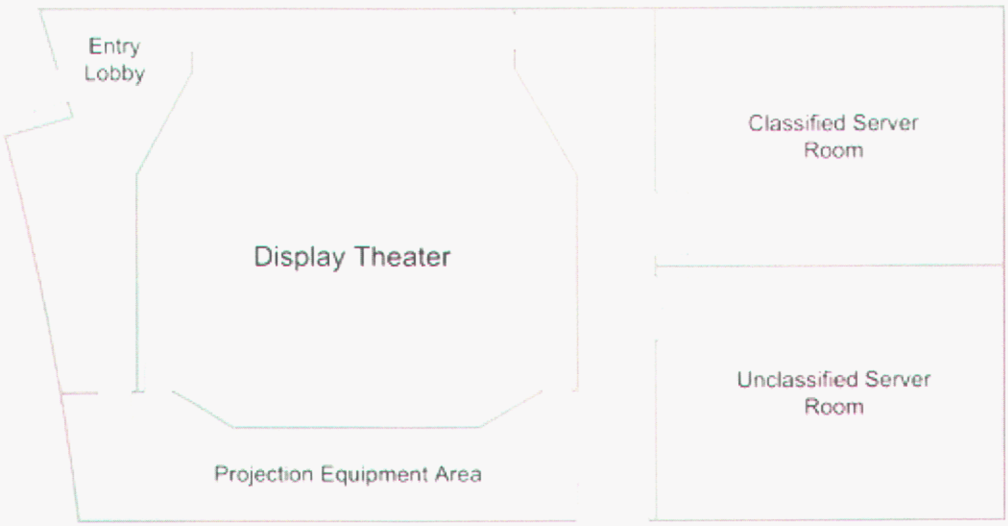

Figure 4. The preliminary IDC facility design.

The impending finalization of the DISL building design drove the need to quantify electrical service and HVAC requirements. The current VDC needs and best-guess projections for future AV and computing systems were the basis for setting the IDC requirements.

3.2 IDC Design Criteria

The second phase of the IDC design process commenced in mid-2003 as the construction of DISL began. The IDC Team polled VDC customers to find out what current and additional capabilities would benefit their programs, and what type of applications they anticipated in the coming years. Lessons learned from operating VDC were combined with customer input to develop the IDC design criteria:

- IDC will have multiple uses and a diverse customer base.
- Base the design on immediate needs, but keep it highly flexible to meet unanticipated future customer needs and wants.
- Customers want numerous system capabilities with a simple operating system.
- Provide a capability for scalable, multiple source display for information-rich presentations and collaborations.
- Provide additional interactive and collaborative systems to enhance meetings and design reviews.
- Simultaneous display of classified and unclassified computing systems is essential.
- Classified and unclassified videoconference capabilities are needed.
- Provide connectivity for user laptops, both to the AV display system and Sandia's classified and unclassified networks as allowed by current and future computer security rules.
- The touch panel user interface must be clear and intuitive.

- The design must meet all current technical and computer security requirements and be adaptable as those requirements change.
- The lighting system must support all proposed applications for the facility.
- The facility should accommodate approximately 25 people seated at tables.
- Provide a buffer between the entry door and the display theater to minimize security risk during classified meetings and presentations.

The IDC Team also relied on VDC experiences to establish technical criteria to use in the selection of display systems:

- Consistent image calibration and color balance are priorities for minimizing visual distractions in display arrays.
- Edge matched display arrays are preferable to edge blended displays.
- Black bead diffusion screen systems provide a wider angle of view with no brightness hot spots than standard diffusion screens. The trade-off is a slight loss of image detail that is undetectable except at very close distance viewing.
- The focal length of the black bead screen must be closely matched to the projector-to-screen distance to avoid image degradation.
- A tiled screen system provides more design flexibility than a solid-sheet diffusion screen.
- Display systems should not be lower than approximately 30" above the floor. Images projected below this height cannot be seen by anyone seated behind the first row of tables or chairs.

Because the IDC was funded by the ASC Program, supporting ASC activities had to be the primary design goal and cluster-based visualization was considered the primary application. The fundamental objective was to provide a high pixel count, high quality display system that would match the multi-mega pixel image output of the graphics clusters. Throughout the design process, when trade-offs between capability and performance had to be made, cluster visualization took precedence. The challenge for the IDC Team was to incorporate as many capabilities and features as possible without adversely affecting the system's operational performance and user interface.

3.3 Design Process

Although the IDC Team members had gained considerable experience building, operating and upgrading the VDC, they chose to employ Charles M. Salter and Associates as design consultants to assist in the development of the IDC's AV system design. The team was confident that advance planning would result in a clearly defined project that would produce lower, more accurate bids from AV system integrators and would reduce the potential for contract disputes during the system integration.

Two choices are typically available for the AV system integration with a project of this nature:

- *Design/Build* is a process where an AV integrator is hired to both develop a system design and then build it. General design criteria and system requirements are stated, but the integrator generally has the freedom to meet those requirements using the products and design of their choice.
- *Build to Specification* is a process where an integrator is hired to build a system exactly as specified in a contract. The system design is provided and most or all system components are specified.

Sandia/CA's first visualization facility, the VDC, was constructed as a design/build project and there were some positives, but many negatives with the process. The IDC Team felt the best way to ensure the success of the IDC was to develop a detailed AV system design and bid it out as a build-to-specification contract.

Working from the premise that the facility should be a room-within-a-room with rear projected displays across multiple walls, the Salter consultants used the IDC Team's design concepts and developed a variety of design concepts for consideration (Figure 5). Ultimately, the best solution was a main display array consisting of an as yet undefined number of projectors working together to display output from the graphics clusters, complemented by a number of individual displays for collaborative and presentation applications.

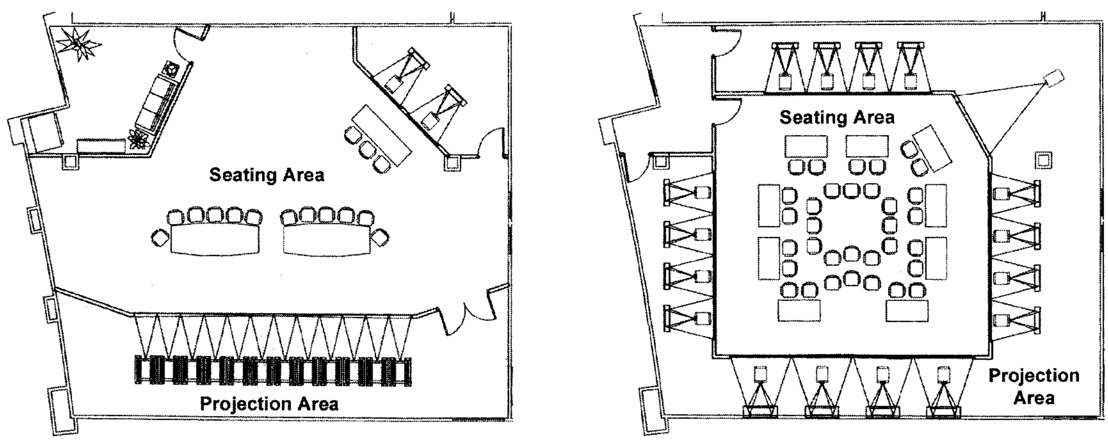

Figure 5. Two display theater design concepts.

3.4 Final Design

The final AV system design had two immediate constraints: The aforementioned spatial constraints of the location, and the limits of the fixed budget that had been established several years prior when the DISL building budget was finalized. The spatial constraints limited the size of the main display array and the budget limited the choices for the type of projection system that could be used. The total project budget was $3.2M, which would fund both the AV system integration and the purchase of two cluster computing systems. A target budget of $2.4M was established for the AV system integration.

The configuration of the facility was another factor that dictated the final design. The two server rooms had been partitioned from the main display area when the building was constructed. That left an area of approximately 50'x 45' feet for the display theater and projection systems, minus a small entry lobby designed to buffer the display theater from the main entry door.

Display Systems

To maximize the size of the main display array, provide a number of ancillary displays, and comfortably seat 25 people at tables, a faceted main screen array was considered. By offsetting each screen column of the main display by seven degrees, all of these objectives were achieved (Figure 6).

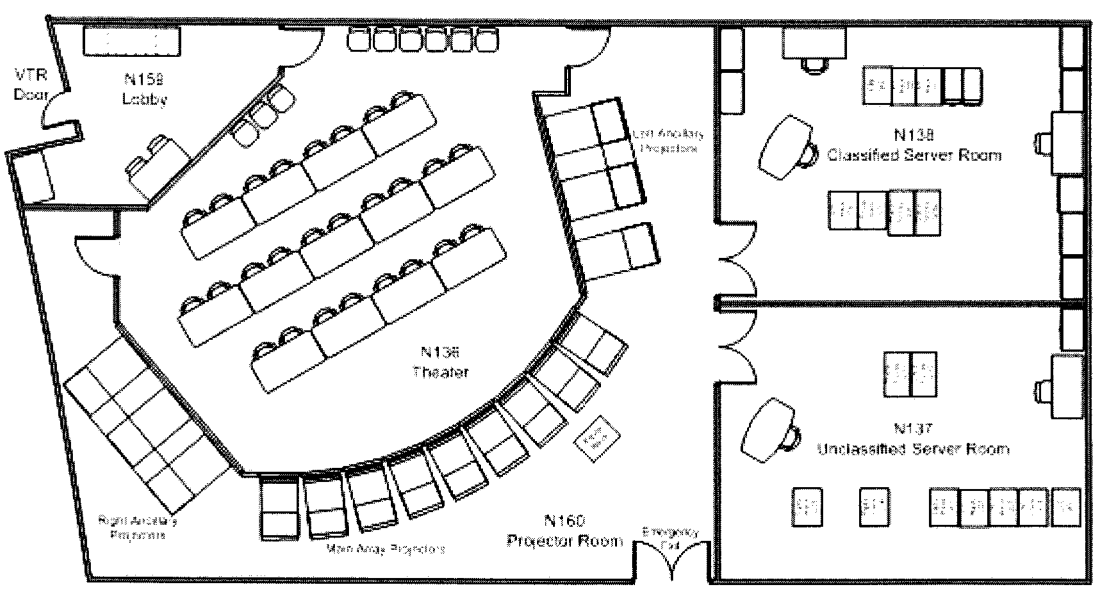

Figure 6. The final IDC facility design.

The dimensions of the main display system were dictated by several factors. The resolution of the graphics cards for the cluster nodes would be 1280x1024 pixels, requiring a screen aspect ratio of 5:4 for one-to-one pixel mapping and maximum image resolution. As stated in the design criteria, the bottom of the display should be approximately 30" up from the floor. Subtracting that 30" and another 6" for ceiling clearance left 8' for the display height. A system with twenty-seven 50" (diagonal) screens in a 9-wide by 3-high array was selected as the best fit for the space (Figure 7).

Figure 7. The IDC main display array.

Budget considerations dictated the type of projectors for the main array. Although 3-chip digital light processing (DLP) projectors were the preferred choice, they were cost prohibitive. An affordable solution was to use less expensive single-chip DLP projectors. The trade-off was reduced image quality, potential "strobing" effects from the spinning color wheel used with single-chip DLP projectors, greater variation in color balance between projectors, and no stereo imaging capability. However, the IDC Team felt this was the best solution within the budget constraint. One solution that was considered was to integrate a small number of 3-chip projectors with a majority of single-chip projectors to provide a limited stereo display capability. The Team was advised by the manufacturer that the 3-chip projectors would not match the single-chips in either image quality or color balance. Because this configuration would be detrimental to cluster visualization across the full array, the idea was rejected.

The remaining available space to either side of the main display dictated the number and dimensions of the ancillary displays. Three 72" (diagonal) displays on each side would provide additional display surfaces with interactive and collaborative capabilities. SmartBoard screen systems were selected for their integrated touch screen feature. The projector selected was a single-chip DLP with twice the luminance output of the main array projectors. Because the image is projected onto a larger screen, the apparent brightness would be comparable for all displays.

Audio-Visual System Infrastructure

The IDC's basic AV design concept is fairly simple: The video and audio outputs from computers and video sources are connected to the input side of a matrix switch and the display systems are connected to the output side of the switch (Figure 8). Users select a source and the desired display from a touch panel control system, which in turn directs the switch to make the connections. The integration of multiple computational platforms and video playback devices with a video processor and interactive and collaborative tools substantially increases the system complexity. Patch panel systems are installed to break the audio and video signal paths for classified sources and the videoconferencing systems when they are not in use to satisfy Sandia computer security requirements.

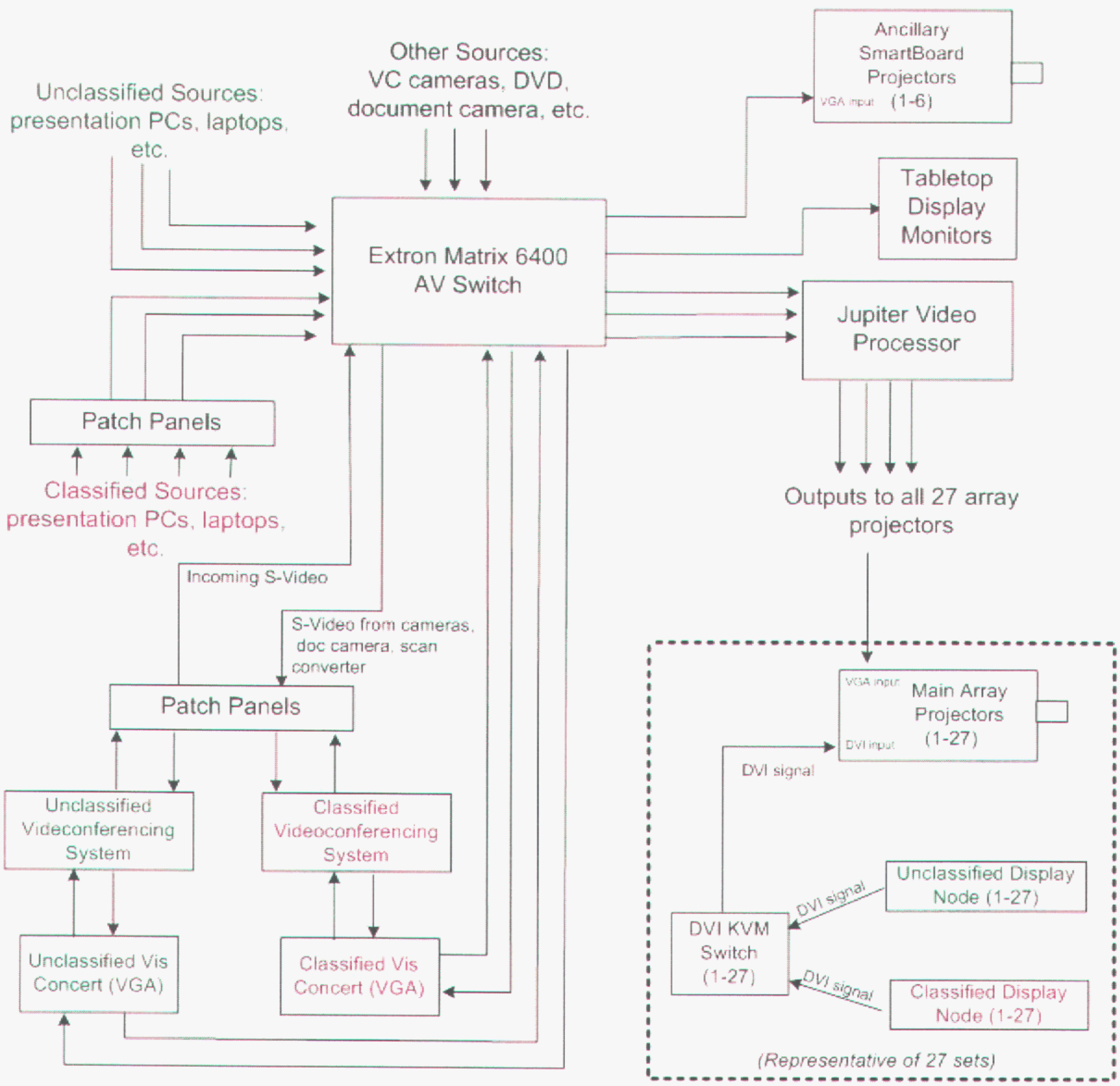

Figure 8. IDC audio-visual signal diagram.

The main display array is used in two distinctly different display modes:

- Cluster visualization: Each of the twenty-seven projectors displays the digital video output from one of twenty-seven display nodes from either the classified or the unclassified computational cluster, creating a single composite image on the array.
- Video processor: The analog video outputs from the SGI servers, PCs, laptops and video playback devices are routed through an analog video processor, scaled to the desired size, and placed in multiple display windows on the main display array.

These two distinct display modes facilitate the design goals of high quality cluster visualization and display system flexibility.

Cluster Visualization

Each of the two computational clusters has forty processing nodes, including twenty-seven "display" nodes that generate images for the main display array's twenty-seven projectors. Software applications such as ParaView, Chromium and EnSight distribute processing tasks to the cluster's individual display nodes to speed the rendering process so that data-intensive simulations can be viewed at "real-time' playback frame rates.

Cluster visualization applications take full advantage of the high resolution of the main display array. Each cluster display node generates a 1280x1024 pixel image, matching the display resolution of each projector. Using all twenty-seven display nodes and projectors displays a single composite image with 35.4 million pixel resolution.

To achieve the best display quality for cluster visualization, the digital video interface (DVI) output of each display node is routed into the DVI input on one of the array projectors. Maintaining a digital signal path minimizes the introduction of signal noise that can degrade the image. However, each projector has only one DVI input. To accommodate the DVI signals from both the classified and unclassified clusters within the confines of Sandia computer security rules, KVM switches are used between the display nodes and the main display array projectors. Each of the 2-input, 1-output KVM switches has one classified and one unclassified display node as the inputs, with the output connected to an array projector. A user can easily switch the display between the classified and unclassified clusters by switching the input selection on the KVM switches.

Video Processor

For applications other than cluster visualization, a Jupiter Fusion 980 video processor is used to display analog computer and video sources in multiple, scalable display windows on the main display array. This capability enables users to simultaneously display from one to twenty different images in variable sized windows across the array. Although the video processor scales and processes these lower resolution images to produce good quality projected images, they are none the less limited by the output resolution of the computer or video source, typically 1280x1024 or 1024x768 pixels for computers, and S-video resolution for video sources.

Crestron Touch Panel Program Development

A major task undertaken by the Salter consultants was the development of the Crestron touch panel user interface and program code. The IDC Team wanted to maintain the same look and feel of the VDC user interface for the convenience of customers and the IDC support staff. The consultants used the VDC interface as a starting point and incorporated all of the IDC's additional features and capabilities in the IDC design. A highly detailed touch panel logic diagram and prototype graphics for each touch panel menu were developed for the AV system integration contract.

System Specification

The development of a detailed design specification for bidding the system integration contract completed the IDC AV system design process. The specification included:

- A detailed description of the required system components and their functions.
- The AV integrator's responsibilities.
- Quality assurance requirements.
- Required submittals and sign-offs.
- Warranty requirements.
- A listing of virtually every product and component to be used for the installation.
- Installation and programming requirements.
- Acceptance testing requirements.
- Documentation, training and support service requirements.
- A comprehensive set of system layout and wiring diagrams.

Integrators were informed that the winning bidder would be provided with a copy of the preliminary touch panel code upon the award of the contract.

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4 IDC Implementation

The IDC implementation phase began with the AV integration contract bid process and concluded with the completion of the AV and computer system installations. Throughout the course of the project, the IDC Team worked closely with the Sandia Safety, Security and Facilities staffs to ensure a safe and secure workplace.

4.1 AV System Integration Bid Process

The IDC Team, in conjunction with Sandia Purchasing, determined that a best price bid process would be the preferred method for selecting an AV integrator to construct the IDC. A pre-bid conference was conducted at Sandia/CA for potential bidders. Team members presented an overview of the system design and requirements, answered questions, and conducted a tour of the IDC location in DISL. The Team provided an explanation of the technical evaluation and contract award processes, and the requirements for submitting a bid. These requirements restricted the bidders to only those with experience with comparable AV system installations, and those who were authorized dealers for the primary display systems and other major system elements.

The pre-bid process limited the number of qualified bids received to four, all from large AV systems integrators with substantial experience. Because all of the bidders met the required criteria, the contract was awarded to the lowest bidder, SPL Integrated Solutions. SPL's bid was $1.88M, significantly lower than the $2.4M conservatively estimated by the Salter consultants.

4.2 AV System Integration

An aggressive integration timetable was a contract requirement. The goal was to complete the IDC in time for the building dedication, scheduled for June, 2004. An unforeseen delay due to infrastructure upgrades had an immediate impact on the schedule. The electrical service and HVAC requirements for IDC had been established several years prior, based on the VDC's configuration and best guess projections for changes in technologies. The expectation at that time was that IDC would have 12-15 display systems and the computational clusters would increase in size by a factor of 2-4. The inclusion of 33 high-output projectors and dual processing cluster nodes dramatically increased the IDC's electrical and cooling requirements. The modifications to the IDC's infrastructure needed to accommodate the higher electrical loads and cooling requirements delayed the start of the AV integration by three months.

Once the AV system integration process began, it proceeded slowly at first and then accelerated once the display systems were delivered. The number of design changes required "in the field" was minimal due to the level of effort expended on system specification and testing prior to the contract award. Problems that did arise were solved by negotiation between the IDC Team and SPL staff.

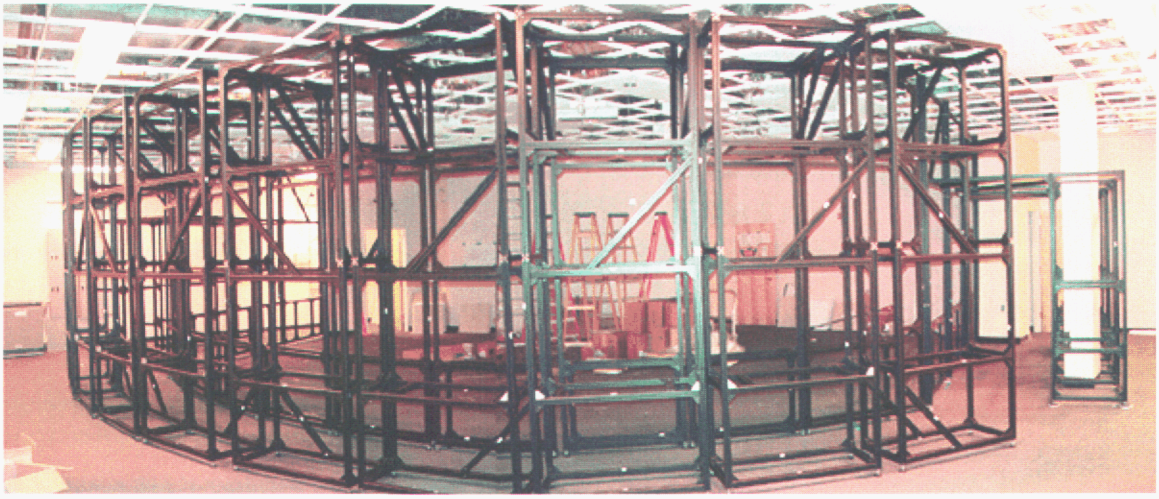

Figure 9. Back view of the main display array screen structure during installation.

The most complex and demanding task of the integration was the installation of the main display array. Although the screen manufacturer's staff had claimed to have considerable experience with this type of installation, it quickly became apparent to the IDC Team that this was a unique system that would challenge the capabilities of the manufacturer's field engineers. The seven degree offset for each 3-screen column required precision placement to meet the stringent requirements of the contract specification (Figure 9). A minimal tolerance was required to ensure that image alignment between adjacent screens would be +/- 1/2 pixel. This requirement was achieved after considerable effort on the part of the field engineers.

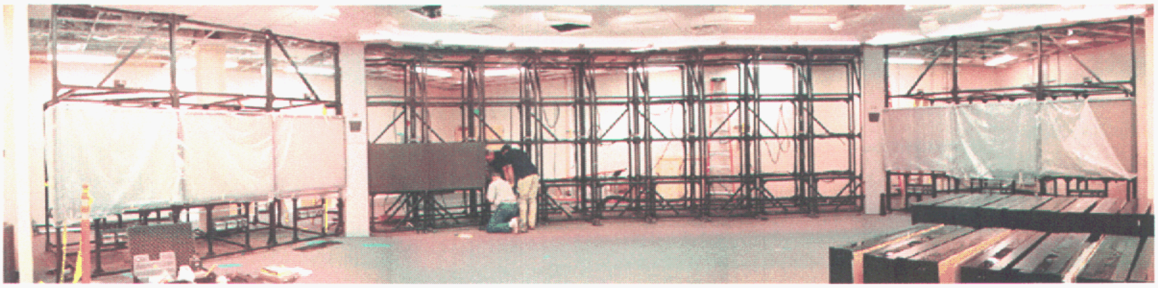

Figure 10. Christie Digital field engineers installing the main display array screens.

Several change orders were required through the course of the project. Most changes were at the request of the IDC Team to accommodate minor design changes and product substitutions made possible by new technology. The only major change was a relocation of the cluster display nodes. The original plan had called for all of the cluster display nodes to be located in equipment racks next to the main display projectors. The DVI output of the nodes provides a superior image when connected directly to the DVI input of the projectors. The longest DVI cables available at the time of the original design were 5M copper cables, requiring the co-location of the nodes and projectors. After the contract award and before the start of the integration, the IDC Team became aware of and tested a 30M Pacific Cable fiber optic DVI extender that would allow the cluster nodes to be located in the server rooms, as originally envisioned the IDC designs. The implementation of this design change no longer required the nodes to be distributed among eight separate racks around the projectors. All of the display nodes of each cluster could be grouped in the server rooms with the processing nodes in just two racks per cluster. This simplified cluster installation and would facilitate more convenient system upgrades and maintenance. It also eliminated an emergency egress path issue that was caused by placing equipment racks in the limited space between the projector structure and the adjacent wall.

Several requirements included in the integration contract contributed to a smooth installation process. They include:

- Submittals to and approvals by the Sandia delegated contract representative for every product to be used by the integrator.
- Approval for any product substitution and design change.
- Submittal of seismic restraint system designs by a licensed structural engineer with approval by Sandia Facilities.
- Submittal of a safety plan with approval by the DISL building manager.

The AV system integration was completed outside of the original timeline, but within the IDC Team's expected timetable as adjusted for the delays caused by Sandia's infrastructure modifications. Including change orders, the total integration cost was $2.05M, nearly 15% below the $2.4M (conservative) cost projection developed by the Salter design consultants.

4.3 Lighting System Design and Installation

The IDC lighting system was designed with the assistance of Lumenworks, Inc. lighting consultants. The IDC Team's past experience with the VDC demonstrated the difficulties caused by trying to support multiple capabilities and applications without a flexible lighting system to support them.

The following list of specific lighting applications was developed for the design:

- Full-room uniform lighting for general purpose applications
- Theater-style lighting for visualization applications
- Presentation lighting for speakers at the front of the main display
- Presentation lighting for speakers at the right ancillary screens
- Videoconferencing lighting for the full room
- Videoconferencing lighting for the area close to the right ancillary screens

A major obstacle with the IDC design was the limited ceiling space available. A design goal was to use all recessed fixtures rather than surface mounted ones. However, in many areas there was little or no space between the ceiling tiles and the HVAC ducting and other utilities. As a result, a combination of recessed and surface mounted fixtures was required.

Another complication was the need to incorporate the design around the existing HVAC vents, fire sprinklers and smoke detectors already installed in the suspended ceiling tiles. Finally, the light fixture locations also had to be integrated with the twenty-two audio playback speakers. The front and center surround speakers created the most difficulty, as their locations had little flexibility and had to be located in the areas of highest light fixture density (Figure 11).

The Lumenworks consultants evaluated the system needs and physical restrictions and developed a detailed lighting system specification that included fixture types, bulb wattage and color temperature, light locations, and system controller details. The lighting system was installed under the same Sandia task order contract that was used for other electrical system modifications in DISL. The IDC Team's lighting design consultant worked with the electrical contractor throughout the process of acquiring, installing and programming the system.

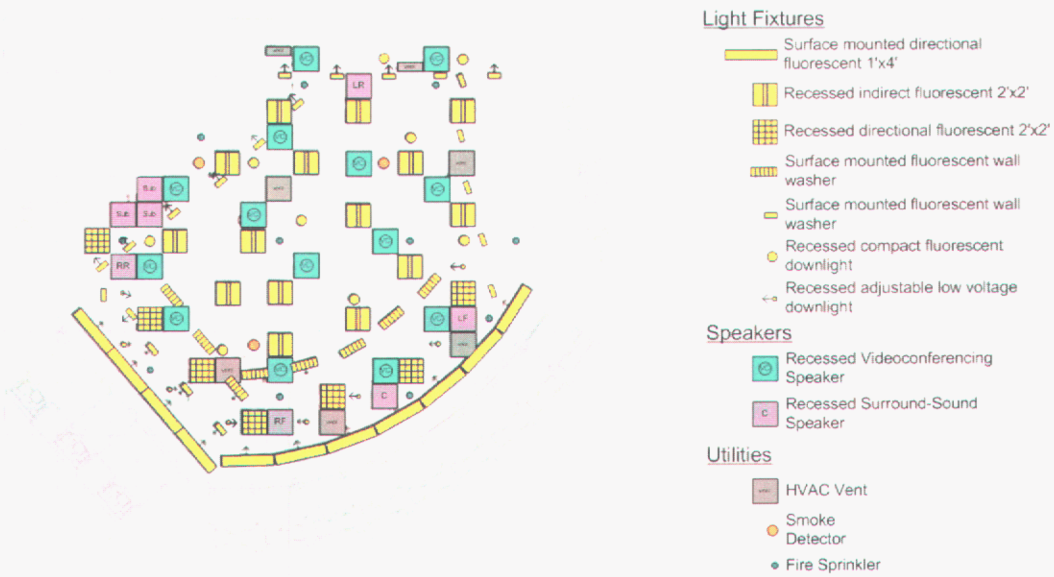

Figure 11. IDC reflected ceiling plan.

5 IDC Description

The elements that comprise the IDC include the physical facility and utilities, the display systems and AV infrastructure, and the computing resources. Many systems are integrated to create a user-friendly facility with many capabilities to serve a variety of current and future customer applications. The primary system components are described in this section.

5.1 Facility Description

The IDC consists of five rooms: a main display theater; a projection room; a classified server room; an unclassified server room; and an entry lobby. The entire facility is an access-controlled vault-type room (VTR). The classified server room houses all of the classified computing systems, the videoconferencing systems, and audio and video patch panels for the classified system connections. Access to this server room is limited to a small number of staff who use and maintain the facility.

Figure 12. The unclassified server room.

The display theater's primary seating configuration uses 13 tables with 2 chairs at each table. Another 10 chairs can be comfortably positioned along the rear walls. This layout provides all participants with views of all displays. Removing the tables and arranging chairs in an auditiorium layout will accommodate 48 people. However, the complexity of disconnecting and reconnecting the table cable assemblies while maintaining required wiring separations makes seating reconfiguration an onerous task.

5.2 Display, Computational and Support System Descriptions

The IDC's display systems and computational resources are integrated through a number of support systems and operated with a touch panel control system. Descriptions of the major components and systems follow.

Main Display Array

The main display array consists of a support structure, twenty-seven screen modules and twenty-seven projectors. The structure's 2"x2" extruded aluminum frame is secured with seismic restraints to maintain screen alignment. The screen modules are Christie Digital Reflex II Screen Can Assemblies assembled in a 9-wide by 3-high array. Each 3-screen column is offset from the adjacent columns by 7 degrees to arc the structure a total of 56 degrees from end to end to conform the display to the IDC's primary seating configuration.

Each screen assembly has a 51.25" (diagonal) dual element screen. The rear element is a Fresnel lens that collimates the light from the projector for uniform light distribution across the screen. The front element is a black bead diffuser that scatters the collimated light to provide wide viewing angles. A Christie Digital RPMS-500xe DLP projector is paired with each screen assembly. Each projector has 1280x1024 pixel resolution for a combined display array resolution of 35 million pixels.

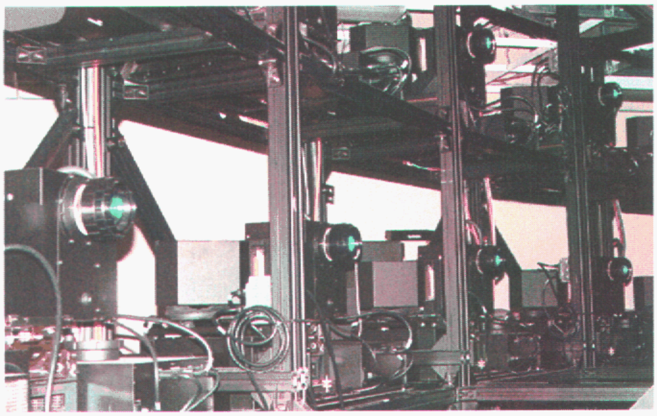

Figure 13. Christie Digital RPMS-500xe main display array projectors.

Ancillary Displays

Six ancillary displays provide additional display capability that can be used in conjunction with the main display array or for stand-alone applications. Each ancillary display has a 72" (diagonal) Smart Technologies "SmartBoard" diffusion screen and a rear projected Christie Digital DS30W DLP projector (Figure 14).

The SmartBoard screens provide on-screen touch control and writing capability within a variety of software applications such as Microsoft PowerPoint. The content on the SmartBoards, including annotations, can be simultaneously displayed on the main display array to enhance a presentation (Figure 15). Each SmartBoard is tied to a dedicated PC that runs the SmartBoard software and other applications. Users can display the dedicated PC when SmartBoard functions are required, or they can display other in-house computer, laptop or video source without the SmartBoard functionality. To enable SmartBoard functions for both classified and unclassified applications, four displays use unclassified dedicated PCs and the other two use classified PCs.

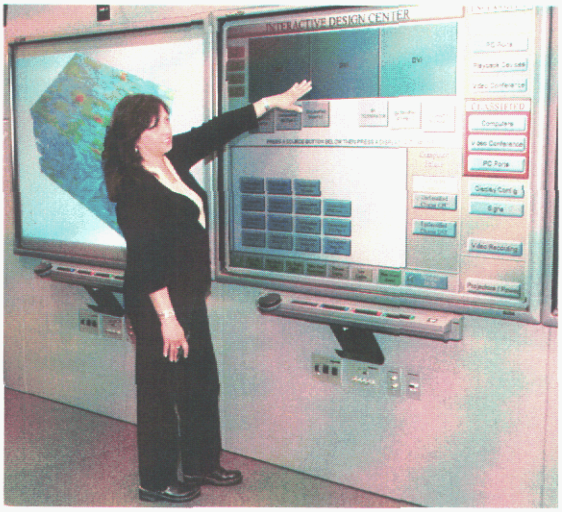

Figure 14. SmartBoard display with on-screen touch panel control interface.

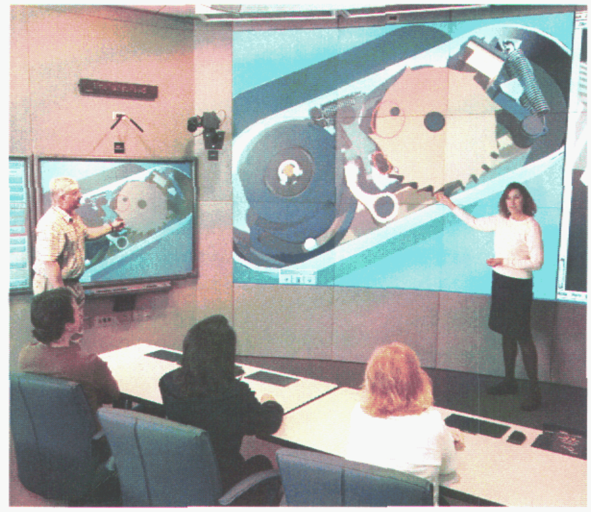

Figure 15. Image annotation using an ancillary SmartBoard display.

For added system flexibility, two of the ancillary displays use Crestron DVP-4 systems to integrate a touch panel overlay onto the screen. Selecting the overlay turns the display into a large touch panel for controlling all of the IDC's display system functions. Users can toggle between the touch panel and a projected source by an on-screen button touch.

Two separate displays have Boeckeler Systems telestrators integrated with the SmartBoard to enable simple on-screen touch-and-draw telestration over any displayed image. Unlike SmartBoard applications, which are limited to programs running on a dedicated PC linked to the SmartBoard, these telestrators are independent overlays that work with images displayed from any computer or video source. However, because the telestrator is not tied to a PC, annotations cannot be captured and saved to file which is a feature of the SmartBoard applications.

GraphStream Computational Clusters

The IDC's primary application is for displaying high resolution models and simulations generated by classified and unclassified graphics computing clusters. Each GraphStream Linux cluster has 40 nodes with dual Opteron 246 2-GHz processors with 4 GB RAM, an 80 GB hard drive, and Gigabit ethernet and Infiniband 4x high speed network interconnect. As previously described, each cluster has 13 processing nodes and 27 display nodes that also serve as processing nodes when they are not generating display images.

Figure 16. The GraphStream classified computational cluster, Gefen DVI switches, classified PCs and the AV patch panels.

Silicon Graphics Visualization Servers
The IDC has two identical SGI Onyx 350 visualization servers, one for classified and one for unclassified processing. Each system has 4 graphics pipes, 8 video channels, 16 CPUs, and16 GB of memory. They are used to run applications including EnSight (both client and server), ProEngineer and Satellite Toolkit (STK).

In-House PCs
The IDC has in-house PCs to support system operations and customer applications. The three categories are:

- General Purpose PCs: These are used to run a variety of applications to support presentations and general customer activities.
- SmartBoard PCs: Each of the six ancillary SmartBoard displays uses a dedicated PC for operation. These PCs can run presentation applications and software to support customer applications. Two of these PCs are classified and four are unclassified.
- Project PCs: For customers with on-going projects, PCs dedicated to running their applications can be installed for their use only.

Additional PCs can be installed as needed to meet customer needs. Customers can also run applications from their laptops by connecting to AV ports throughout the display theater.

Jupiter Video Processor

A Jupiter Fusion 980 analog video processor provides the ability to display multiple, scalable analog sources simultaneously on the main display array (Figure 17). In-house computers, video sources and user laptops are routed through an AV switch to the video processor, where they are scaled and placed in preset display layouts. The video processor's outputs are connected to the analog inputs on the main display projectors. All of the signal routing, layout selection and display functions are user-controlled through a Crestron touch panel interface.

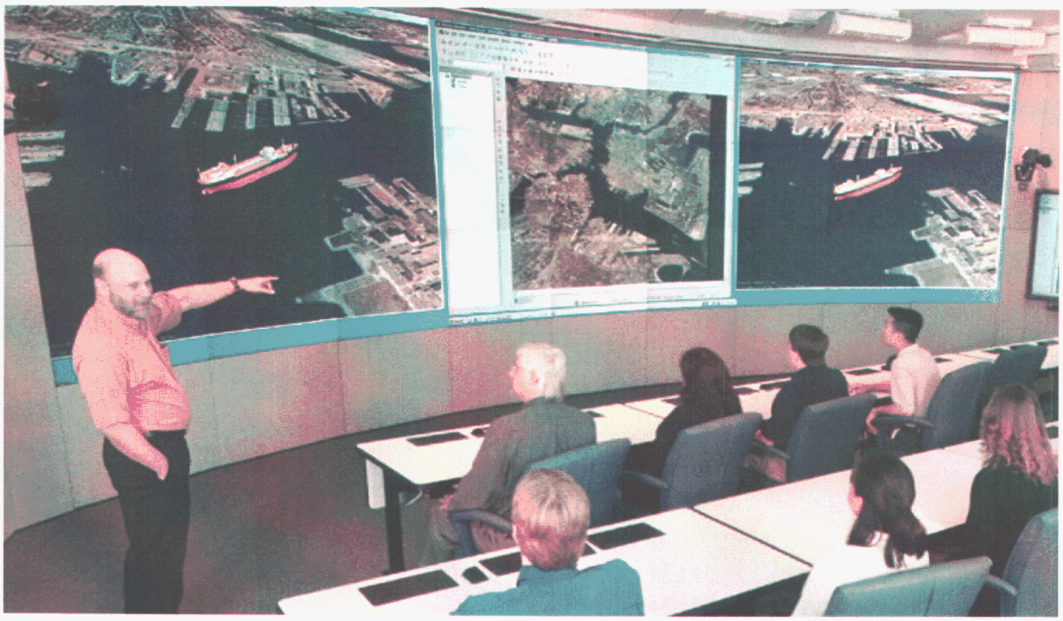

Figure 17. A multiple-source display configuration on the main display array.

The Jupiter video processor can display as many as 20 separate image windows simultaneously on the main display array. It can cleanly scale a computer's VGA image up to 4,000 x 3,000 pixels. Video sources can be scaled to 10,000 pixels. Users select preset display layouts from the touch panels and populate the display windows by selecting sources. Additional display layouts can be created as needed to support customer needs.

Extron Matrix 6400 AV Switch

With the exception of the DVI output from the cluster display nodes, audio and analog video from all in-house computers, video devices and audio-visual ports are routed into an Extron Matrix 6400 AV switch. The Crestron touch panel interface is used to direct the switch to route the sources to the main display array, ancillary displays, and video devices. The switch has the capacity for 64 inputs and 64 outputs.

Crestron Control System

The Crestron touch panel control system provides the user interface for controlling signal routing, display configuration, and individual component operation. The Crestron communicates with the AV switch, the projectors, the SmartBoards and other system components through an in-house RS-232 network. Users command the system from tabletop touch panels and the two SmartBoards with integrated on-screen touch panel overlays. For customers who routinely use the IDC with the same display configuration, the configuration can be stored and recalled as needed using configuration preset buttons.

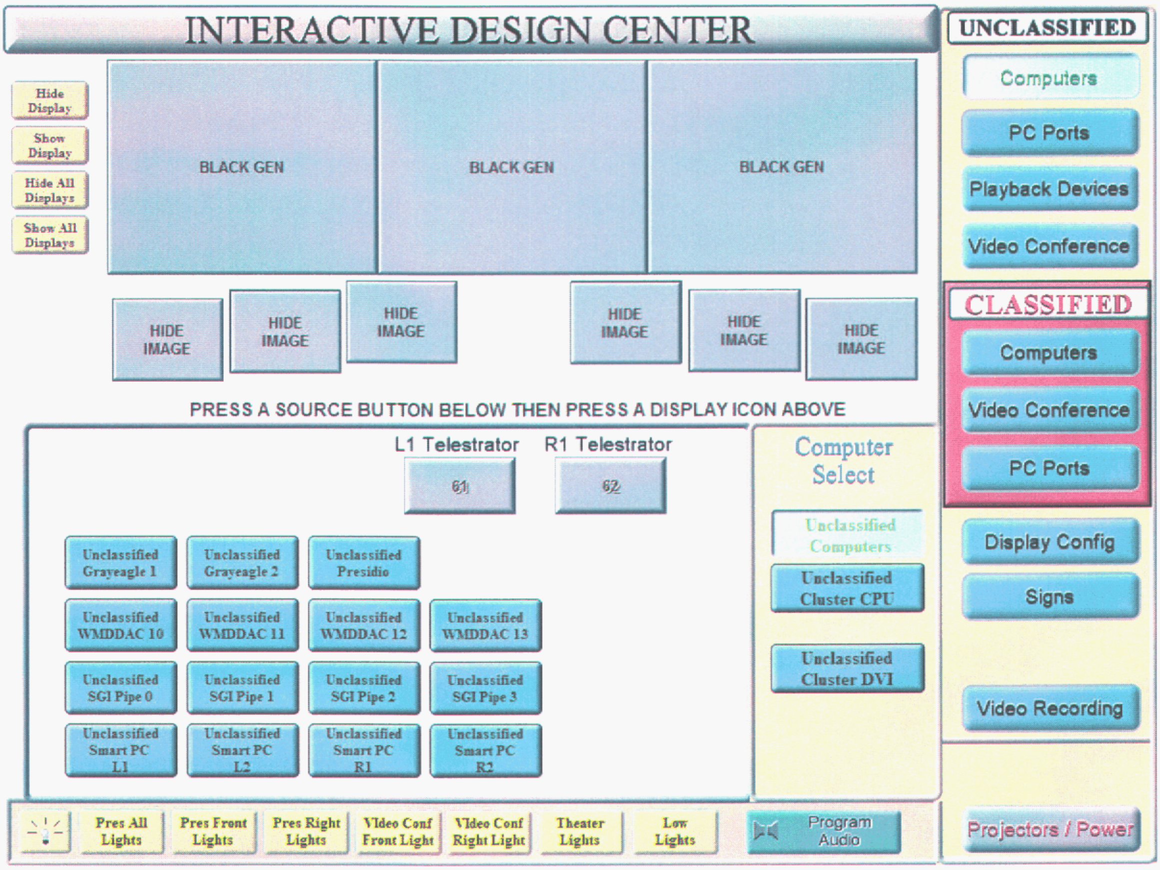

Figure 18. The unclassified computers touch panel menu page.

Some of the touch panel controls have password protection to restrict access to system configuration commands. This feature provides the IDC staff with access to these controls while preventing casual users from inadvertently reconfiguring system settings.

Audio-Visual Interface Ports

AV interface ports are used to connect laptops to the IDC's AV system. Located on eight of the tables and at seven wall plates, these ports connect the laptop VGA signals to the AV matrix switch where they can be sent to any display (Figure 19). Four tabletop ports can be used for either classified or unclassified laptops. This either/or capability is made possible by isolating the cabling from these ports to the AV matrix switch to maintain signal separation and avoid any signal crossover. The other twelve tabletop ports are for unclassified laptops only. Of the seven wall ports, four are dedicated to classified laptops and three are for unclassified laptops.

In addition to the laptop ports, there are a number of other connections at the table and wall plates, including:

- Keyboard, mouse and monitor connections to enable users to operate in-house computers from these locations. The IDC has two BlackBox Summit keyboard-video-mouse (KVM) switching systems, one for classified and one for unclassified computers. Each port is dedicated to either the classified or unclassified KVM system. A local monitor must be connected to display the KVM's on-screen menu for selecting the system to control.
- Network connections to enable users to network their laptops. Network connections are distinguished by using different connectors for classified and unclassified. SC fiber connectors are used for all classified and RJ-45 connectors are used for all unclassified connections. Media converters are provided as needed.
- A touch panel interface provides users the ability to place a touch panel control system monitor at various locations around the facility.
- 120-volt power outlets for laptops.

The tables with AV ports come in two configurations, one with unclassified connections and one with a combination of unclassified and classified connections. To facilitate the reconfiguration of the facility's table and chair layout, both table configurations use an umbilical cable system to connect the table ports to underfloor junction boxes. The cables from the table-mounted AV ports are routed down channels in the table legs in bundles to maintain separation as required. These cables pass through grommets or access hatches in floor tiles and are routed to junction boxes mounted on the sub-floor. Unclassified cable bundles use a unique multi-pin connector assembly to connect to the junction box. Classified cables use individual connectors at the box. This configuration prevents connection of unclassified cables to classified connectors, and vice versa.

Figure 19. Extron HSA-402 table-top audio-visual ports.

Polycom Videoconferencing Systems

The IDC has two Polycom VS4000 videoconferencing systems, one for classified and one for unclassified use. For transportation of video, the classified system uses an IP network through the Sandia Classified Network (SCN) and the unclassified system uses three ISDN lines. Both systems are capable of multi-point conferencing with up to three remote sites. The local and remote sites can be simultaneously displayed on the main display array using one of the Jupiter video processor's multi-window display configurations. Both systems use Visual Concert FX graphics converters for sending and receiving VGA computer signals between sites for high-quality display of presentations and other computer applications.

Five video cameras on pan and tilt mounts support videoconferencing applications. Omni-directional table-mounted microphones capture audio from seated videoconference participants. Additional wall-mounted microphones capture audio from presenters positioned at the ancillary displays. All videoconferencing system and camera functions are controlled from the touch panels.

Audio Reinforcement Systems

The IDC has a surround sound system to support audio from computers and video devices. The front, center and rear surround speakers are ceiling mounted, as are 3 sub-woofers. A separate passive matrix with 14 ceiling-mounted speakers reinforces audio for videoconferences.

Graphics Cluster Workstations

Each of the two server rooms has a workstation dedicated to the graphics cluster located in that room (Figure 20). These workstations enable IDC staff to interact with the clusters without being limited by, or having an impact on, activities in the display theater. Four administrative cluster nodes are displayed on LCD monitors at the workstation. A KVM switch routes control from any of the four nodes to the workstation's single keyboard and mouse.

Figure 20. The classified cluster workstation.

Lighting Control Zones

There are 20 separate light zones in the display theater. Eight preset lighting configurations can be recalled from the Crestron touch panel. A manual page on the touch panel allows individual control of all 20 zones with on/off buttons and a variable dimmer (Figure 21). The lighting matrix consists of 77 fixtures in 7 different fixture types and a Lite Touch control system.

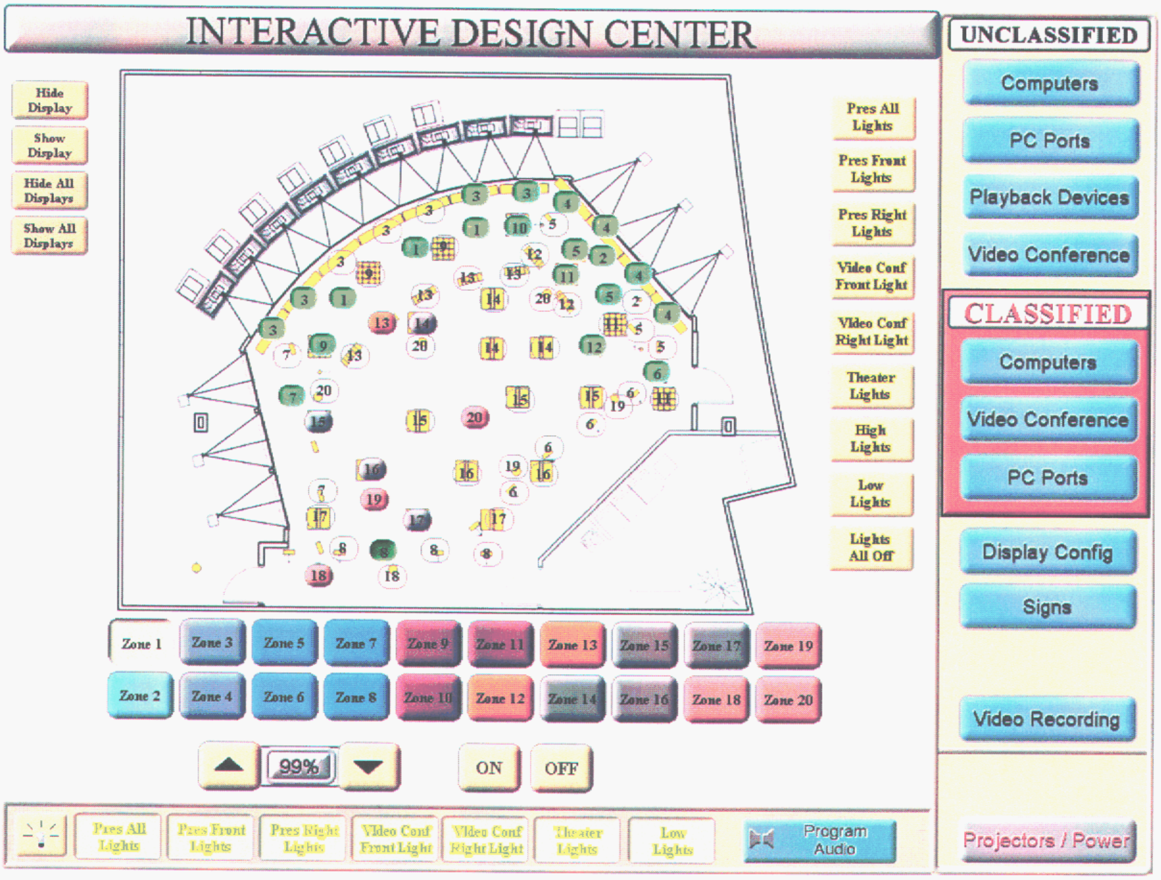

Figure 21. The manual lighting control touch panel menu.

5.3 Physical Security Features

As a combined classified-unclassified facility, many physical security requirements had to be implemented in the IDC to facilitate operational approval from both the Sandia Technical Security Department and DOE/NNSA. Descriptions of the relevant physical security features follow.

Cable Marking and Separation

All cables carrying audio and video signals throughout the IDC are marked and separated as required to meet transmission separation requirements between classified and unclassified signals. A system of under-floor cable trays is used to route and separate cables wherever possible (Figure 22).

Cable separations are maintained as required until the signals reach the Extron matrix switch. The switch is approved for simultaneous classified and unclassified use by DOE/NNSA. Because it acts as a diode to prevent signals on the output side from migrating back to the input side, cable separation is not required between the switch outputs and the display devices. The classified inputs on the matrix switch modules are grouped to maintain separation from unclassified cables at the connection points.

Classified cables are routed into the matrix switch on one side of the equipment rack and unclassified cables are routed in on the other.

There are several groups of "either/or" cables that may carry either classified or unclassified signals. These cables are marked as classified and isolated from other cable types. They include:

- Camera video and microphone audio cables, either of which may carry either classified or unclassified signals depending on which videoconferencing system is in use. These cables are grouped together, but isolated from all other types of cables between the devices and the matrix switch.

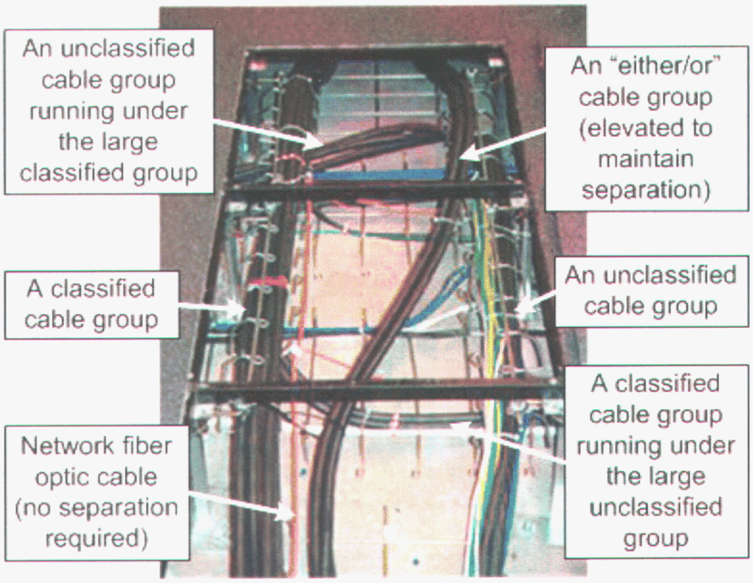

Figure 22. Under-floor cable tray system.

- The audio and video cables from the "either/or" laptop ports on the tables. Each set of audio/video cables is isolated from all other cables between the port and the matrix switch. This configuration allows the connection of either a classified or unclassified laptop at each of these ports, independent of one another.

Wiring from the tabletop ports to the under-floor boxes is accomplished with umbilical cable sets grouped by classification. Each of the two table legs has two wiring channels that are more than 2" apart, the minimum separation distance for classified cables. Because the classified fiber has no transmission vulnerability, it is grouped with unclassified cables. For the four "classified" tables, there are four separate groups, each routed through a channel in a leg:

- Classified cables (classified KVM)
- Unclassified cables (laptop port audio/video, power, and network fiber)
- Either/Or laptop cables (either/or laptop port audio/video)
- Either/Or audio cables (microphones)

The four "unclassified" tables have only two cable groups:

- Unclassified cables (laptop port audio/video, power, and network fiber)
- Either/Or audio cables (microphones)

The separate umbilical cables are routed from the table legs though openings in floor tiles to junction boxes mounted on the sub-floor (Figure 23). The connectors for the different classification cables are unique, preventing classified cables from attachment to unclassified connectors and vice versa. Two junction boxes are used for each table to maintain cable separations. Although this system of umbilical cables was designed to enable reconfiguration of the table locations, the process of doing so is very time consuming. The complex system of under-floor cable trays and the multiple groups of cables requires a slow and meticulous effort to ensure that all cable groups are properly separated and secured.

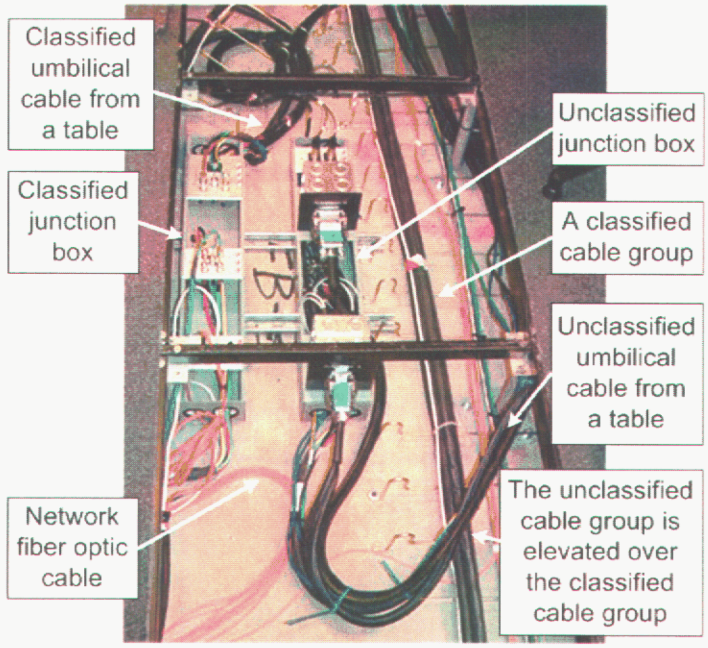

Figure 23. Table umbilical cables and junction boxes.

Physical Patching Systems

All classified in-house computers and both videoconferencing systems have physical breaks in their audio and video signal paths to the matrix switch, provided by either patch panels or approved KVM switches. When a classified device is to be used, patch cords are installed or the corresponding KVM switch is set to the classified input to send the device's video signals to the matrix switch. At the end of each work session, the patch cords are removed or the KVM switch is returned to the unclassified input to break the classified signal paths. These physical signal breaks ensure that no classified signals are routed to the matrix switch without specific intent. All of the patch panels and KVM switches for classified devices are located in the classified server room and access to this room is limited to authorized personnel only.

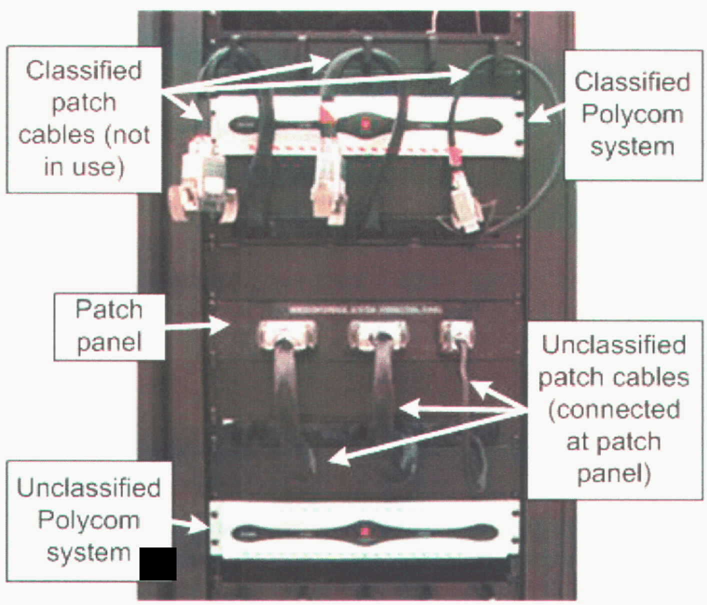

Figure 24. Videoconferencing systems and cable patch panel.

The touch panel menus are used as an administrative control for the routing of sources to displays. The classified touch panel menus provide buttons for selecting only classified sources or ports for display or routing to other classified devices such as the classified videoconference system. Likewise, the unclassified touch panel screens provide buttons for selecting only unclassified sources or ports for display and routing.

6 Lessons Learned

The IDC Team applied previous lessons learned from building and operating the VDC to the design and implementation of the IDC to improve the project's outcome. Several new lessons were learned through the IDC's integration phase and from initial customer use.

6.1 Security Issues

Meeting current and future security requirements must be a top priority throughout the facility design and development process. The IDC Team worked with Sandia Technical Security and Computer Security personnel from the early design stages to get clarification of requirements and tentative approval of system designs and proposed operating procedures. Although these tentative approvals could not guarantee that DOE/NNSA would ultimately approve the physical and computer security plans, they did provide a level of confidence that there would be few unexpected surprises when the facility was completed and ready for certification. These partnerships facilitated a relatively smooth approval process for the technical security certification of the IDC.

Computer Security Plan

Gaining certification for classified computing was far more difficult than the technical security certification. The IDC computer security plan had been reviewed by Sandia Computer Security and then submitted to and approved by DOE/NNSA as soon as the AV integration was completed. However, obtaining certification to begin processing classified information required the completion and implementation of a test plan for all of the classified computing systems. These tests could not be completed until all of the systems were fully operational. System problems with the classified and unclassified computing clusters delayed the IDC team from completing the tests for more than five months.

The installation of the computational clusters was not expected to present any major problems, as they would employ existing hardware and software. However, an unforeseen hardware problem prevented them from sustainable operation with Sandia's primary visualization software. As a result, considerable time and effort were required to identify and resolve the problem. Because the clusters, the other classified computers and all of the AV systems were included in the classified computing plan, this delay prevented the use of any of the IDC's display systems for classified presentations.

The IDC Team's intent was to have all IDC systems under a single master plan for convenience. However, the delay with the clusters impacted all systems and prevented customers from using the IDC for any classified applications pending the certification of the computer security plan. In retrospect, had the clusters been left out of the original computer security plan and later added as a system upgrade, the IDC would likely have been certified for processing and displaying classified information shortly after the AV integration was completed.

DVI Switches
Providing the capability for the simultaneous display of classified and unclassified computing systems presented a variety of technical and administrative challenges. For example, the IDC's AV system design relied on the use of a DVI switch to connect the unclassified and classified cluster display nodes to the single DVI input on each main display array projector. At the time of the design, no DVI switches had been approved for this type of application by DOE/NNSA. The process to test and approve the switch for this application would have to be conducted by Sandia Technical Security personnel and then certified by DOE/NNSA. There was no guarantee that the switch would be allowed, making this approach risky. On the other hand, if the switch were not approved, the cluster nodes could be connected to the projectors through analog connections. This would have provided a functional, albeit lower display quality, solution. Ultimately, the DVI switch was approved by DOE/NNSA and the design objectives were achieved. Taking the risk to implement the DVI switch was well worth the effort.

Seating Reconfiguration
The IDC is designed for easy reconfiguration of table and chair locations to support many different customer applications. Unfortunately, this flexibility is constrained by the security requirements for separating classified and unclassified wiring. By design, the umbilical cables that connect the tabletop AV ports to under floor junction boxes can be disconnected and tables can be relocated throughout the theater as needed. In practice, the complex maze of under floor cable trays used for maintaining cable separations for the hundreds of cables in different classification groups, combined with the locations of the floor boxes within the maze, makes reconfiguration a time consuming process. Many of the umbilicals have to be threaded over, under or around cable trays, floor boxes and power conduits, and must be secured to floor support posts to maintain the minimum required separation distances.

The reconfiguration was intended to be a simple process, but in reality, it is a labor intensive job requiring two people a half-day's effort. A fixed seating configuration was considered in the IDC design phase, but was rejected in favor of one that provided flexibility for different customer uses. In retrospect, the fixed configuration would have been the better choice and would have simplified some of the system wiring.

6.2 AV System Design Consultants
Employing the Salter design consultants added value to the IDC design process in several ways. They helped the IDC Team establish specific design criteria, from which they developed a variety of design concepts for consideration. They provided ongoing product and labor cost estimates that were essential for design decisions. They performed extensive product research, set up focused product demonstrations for primary system components, and prototyped some of more complex system integrations to validate designs. The detailed design specification they helped the IDC Team develop for bidding the AV integration contract greatly simplified that process. There were a few elements of the design that became impractical in the system integration, but they were resolved with relative ease. Taken in the context of the complex project and based on prior experience with the VDC, these were minor issues that were to be expected.

6.3 AV System Integration

The AV integrator, SPL, used sub-contractors for the majority of the IDC installation work. It became obvious fairly early into the project that the cabling sub-contractors were not well informed with regard to Sandia's unique cable separation requirements and other security-related design details. As a result, considerable rework (at SPL's expense) was required to correct a number of installation errors. This type of problem was eventually reduced by continuous oversight and involvement by the SPL project manager. This oversight was a requirement of the integration contract, but was not initially adhered to by SPL.

This example highlights the importance of the AV integrator's project manager for the complex IDC project. The AV system installation proceeded slowly and with a number of errors until the SPL project manager became fully involved in all aspects of the project. He partnered with the Sandia IDC project manager to fully understand the importance and complexity of the security issues and to ensure their implementation. He moved the project forward steadily and he contributed his technical expertise to solve a number of in-field design problems and to offer several unexpected system enhancements.

The complex integration of all of the AV display system components with the IDC's computing systems produced a number of problems that had not been anticipated or identified by prototyping efforts. Although many of the individual systems were evaluated during the design process, it was not possible to simulate the conditions of the complete IDC system and therefore, system performance did not always meet expectations.

An example was the integration of the touch panel overlay with the ancillary SmartBoard displays. The AV design consultants had demonstrated the viability of the system with a prototype mockup during the design phase. When installed by the AV integrator, the system had considerable time lag for redrawing the touch panel graphics whenever a different menu was selected. This lag was not occurring with the independent LCD desktop touch panels. The source of the delay was found to be the complex graphics that were used for the touch panels, which required a longer redraw time than the simpler graphics that were used for the consultants' prototype.

The IDC Team had planned for a post-installation problem solving phase to resolve issues such as the one just described. One of the keys to the Team's successful roll-out of the facility was the inclusion of this phase in the project timeline, which helped them avoid bowing to customer pressure to open the facility for immediate use when the installation was completed. The Team opened the IDC to only a few customers initially, which also provided the time for them to fully understand system features and capabilities, to understand how customers interact with the systems, and to learn how to effectively train customers to use the IDC to support their projects.

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7 Summary

The Interactive Design Center is a second generation visualization facility that meets Sandia's need for displaying ever-increasing large-scale data sets for improved comprehension of complex data. It incorporates the knowledge gained from building, operating and upgrading the Visualization Design Center over a six year period.

While the IDC will serve a broad customer base with diverse needs, its primary application is for cluster computing applications. Working in concert with the IDC's computational clusters and graphics servers, the 35 mega-pixel high-fidelity main display enables engineers and analysts to view and interact with highly complex weapons models and simulations in real-time. The ability to see and discuss design details and component interactions promotes shared understanding within design teams and can lead to reduced design iterations and significant project cost savings.

The IDC's analog video processor enables the simultaneous display of up to twenty separate computer or video sources on the main display. This makes the facility an ideal platform for applications such as Homeland Defense threat scenarios and simulation exercises, where the use of many data streams increases the realism of the exercise. For meetings and presentations, the IDC's interactive SmartBoard displays, telestrators, touch panels and other collaboration tools contribute to more effective communications.

Many design ideas were considered for the IDC. The final design was arrived at through a combination of factors including: the development of a specific list of design criteria; customer input; the IDC Team's experience from operating the VDC; ideas contributed by the audio-visual design consultants; the spatial limitations of the facility; and budgetary constraints. Because the primary application of the IDC was defined as cluster visualization, design decisions were made on the basis of whether they supported or detracted from that application. The goal was to add multiple system capabilities, providing they did not negatively impact the performance of the primary application. The IDC's flexible infrastructure was designed to support future customer needs and new technologies, and to facilitate changes to meet new security rules and regulations.

The IDC was designed for both classified and unclassified applications. To ensure operational approval by DOE/NNSA, the IDC Team worked with Sandia Technical Security and Computer Security staff throughout the design and integration phases of the project. The IDC team also worked closely with the system integrator throughout the installation process to verify that all cable and hardware separations, cable labeling, system documentation, and other security requirements were completed to DOE/NNSA specifications.

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Appendix A: References

All brand names and product names mentioned in this report are trademarks or registered trademarks of their respective companies.

Advanced Micro Devices, Inc. - http://www.amd.com/us-en/
Black Box Corporation - http://www.blackbox.com/
Boeckeler Instruments, Inc. - http://www.boeckeler.com/
Computational Engineering International (EnSight software) - http://www.ceintl.com/products/ensight.html
Christie Digital Systems, Inc. - http://www.christiedigital.com/
Chromium - http://chromium.sf.net/
Crestron Electronics, Inc. - http://www.crestron.com/
Extron Electronics - http://www.extron.com/
Gefen Inc. - http://www.gefen.com/
GraphStream, Inc. - http://www.graphstream.com/index.php
Jupiter Systems, Inc. - http://www.jupiter.com/
Linux - http://www.linux.com/
LiteTouch, Inc. - http://www.litetouch.com/
Microsoft Corporation - http://www.microsoft.com/
Pacific Custom Cable, Inc. - http://www.pacificcable.com/
ParaView - http://www.paraview.org/
Polycom, Inc. - http://www.polycom.com/home/
Silicon Graphics, Inc. - http://www.sgi.com/
Smart Technologies, Inc. - http://www.smarttech.com/

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Appendix B: Project Timeline

- DISL construction
  - 12/01: Design finalized 12/01
  - 6/02: Construction begins
  - 12/03: Construction completed
- IDC AV System Design
  - 3/02: Planning begins
  - 10/03: Design completed
- AV System Installation
  - 11/03: Pre-bid conference
  - 11/03: RFQ sent out
  - 1/04: Contract awarded
  - 3/04: Installation begins
  - 12/04: Installation completed
- Computational Cluster Installation
  - 6/04: Installation begins
  - 3/05: System fully operational

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Appendix C: Sandia/CA Project Personnel

IDC Project Manager:
Alan Pomplun
Visualization and Scientific Computing, Org. 8963

IDC Facility Technician:
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Visualization and Scientific Computing, Org. 8963

IDC Computational System Administrators
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Jan Nobel
Information Systems and Services, Org. 8945

8963 Department Manager:
Jerry Friesen
Visualization and Scientific Computing, Org. 8963

DISL Program Manager:
Dennis Beyer
Computer Sciences and Information Technologies, Org. 8900

DISL Building Project Manager:
Craig Taylor
Facilities Planning and Engineering, Org. 8512

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Appendix D: IDC Project Contractors

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www.cmsalter.com
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Lighting Consultant:
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3410 Lake Shore Ave. Suite 201
Oakland, CA 94610
510-835-2724
Project Engineer: Thomas Skradski

AV System Integration:
SPL Integrated Solutions
6920 Koll Center Parkway, Suite 215
Pleasanton, CA 94566
www.splis.com
Project Manager: Don Jenkins

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Appendix E: Technical Specifications for Primary AV Components

Main Display Array Projectors

Christie Digital RPMS-500xe:

Imaging Panel: DLP single-chip DMD
Resolution: 1280x1024 pixels (native)
Brightness Uniformity: >80%
Contrast Ratio: >500:1
Lamp: 500W Xenon
Output: 1200 lumens
Color Wheel: Six-segment
Lens: 1.25:1 (22mm)
Inputs: Analog RGBHV (1), DVI-D (1), YPbPR (1)
Control: RS-232

Main Display Array Screens

Christie Digital Reflex II Screen Can Assembly:

Screen: Dual element black bead diffusion screen
Focal length: 1100mm

Ancillary Display Projectors

Christie Digital DS30W:

Imaging Panel: DLP single-chip DMD
Resolution: 1280x1024 pixels (native)
Contrast Ratio: 1000:1
Lamp: 250W UHP
Output: 3000 lumens
Lens: 1:1 (17.9mm)
Inputs: Analog RGBHV (2), DVI-D (1), composite video, S-video, Component video
Control: RS-232

Ancillary Display Screens

Smart Technologies WRPSB 1810-DV:

Screen Type: In-wall, rear projection
Size: 72: diagonal
Sensors: Optical (3 video cameras)
Resolution: Supports projector resolutions up to 1600x1200 pixels
Screen Type: Matte finish diffusion screen
Computer Interface: USB

Video Processor

Jupiter Systems Fusion 980:

Processor: Dual Intel Xeon (3GHz)
Hard Drive: 36 GB Ultra 320 SCA-2 removable disk, 10K RPM
Graphics Memory: 32 MB SGRAM per graphics channel

Resolution: Up to 1600x1200 pixels per output channel
Color Depth: 16 or 32 bits per pixel
Input Channels: 20
Output channels: 28
Scaling and Display: RGB up to 4096x3072 pixel window
Control: RS-232

Matrix AV Switch
Extron Matrix 6400:
Bandwidth: 430 MHz (RGB), 150 MHz (video)
Inputs/Outputs: 64 RGB; 32 video; 32 audio
Crosstalk (RGB modules): -80dB @ 1MHz; -62 dB @ 10 MHz; -52 dB @ 30 MHz
Switching Speed: 200 ns (max.)
Control: RS-232 and RS-422

Touch Panel Control Systems
Crestron Rack2:
CPU: 32-bit Motorola 5407 ColdFire Processor
On-board Memory: 36MB
Y-Bus: 40 MB/s parallel communications
Z-Bus: 300 MB/s parallel communications
Ethernet: 10/100 BaseT Ethernet
Programming: SIMPL Windows
Communications: RS-232

Desktop Touch Panels
Crestron TPS-6000:
Screen: 15" active matrix color LCD
Resolution: 1024x768
CPU: 32-bit Motorola ColdFire Processor
Processing Speed: 63 MIPS
Memory: 16MB flash; 32MB DRAM
Touchscreen: Resistive membrane

Touch Panel/SmartBoard Interfaces
C2N-DVP4DI digital video processor:
CPU: 32-bit Motorola ColdFire Processor
Processing Speed: 257 MIPS
Memory: 4MB flash; 32MB SDRAM
Output Color Depth: 32 bits per pixel
Programming: SIMPL Windows

Telestrators
Boeckeler Pointmaker PVI-X90D telestrator:
  Resolution: Up to 1280x1024
  Video Bandwidth: 200 MHz

Matrix KVM Switches for In-House Computers
Black Box KV1503A ServSwitch Summit:
  Capacity: 64 CPUs; 16 user stations
  Resolution: Up to 1280x1024 @ 75Hz
  User Stations: KV1510A-R2 with PS/2 keyboard, monitor and mouse connections
  Distance: Up to 500 ft. over Cat-5 cable

DVI Switches
Gefen "the DVI Switcher":
  Switching: Two input, one output switch for keyboard, digital video and mouse
  Resolution: Up to 1920x1200 pixels
  Video Bandwidth: 1.65GHz
  Vertical Frequency Range: 60 Hz
  Inputs/Outputs: DVI-I input (2), DVI-I output (1)

DVI Extenders
Pacific Custom Cable OC-030X:
  Bandwidth: 1.25 GB/s
  Resolution: 1600x1200 pixels
  Fiber: H-PCF Multi-mode fiber
  Connector: DVI-D
  Length: 10M, 20M, 30M

AV Interfaces
Extron Hideaway HSA 402 tilting table box
Extron Extender AAP 70-147-12 wall mounted interface

Videoconferencing Systems and Components
Polycom VS-4000 videoconferencing system
  Video Resolution: CIF; 352x288 pixels (full-screen mode)
  Video Bandwidth: Up to 2 Mbps
  Audio: Full-duplex
  Multipoint Capability: Four video sites (IP, ISDN)
  Control: RS-232
Polycom Visual Concert FX graphics converter
  Output Resolution: 1024x768 pixels
Sony DXC-390 Camera
  Image Device: 1/3" type IT CCD 3-chip color
  Resolution: 768x494 pixels
Lenses: Fujinon T16x5.5DA-58
  Fujinon WCV-65 wide angle adapter

Lighting Controller

Lite Touch Compact CCU

Capacity: 40 keypads, 40 control modules

Control: RS-232

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