The Future of Control Room Design

This article is based on the presentation by ADDER Technology delivered at ISE 2017. ADDER designs and manufactures a range of KVM (keyboard, video, and mouse) switches, extenders and IP solutions for flexible, secure, and reliable control of local and remote IT systems in mission-critical environments.

Control rooms are complex projects to design and build. They are the centers of operations or production. Given the critical nature of the control rooms, their design determines whether an organization would make or lose money, or whether catastrophic incidents would be identified and prevented.

Control room operators often work long shifts in front of computer screens to ensure 24/7 operations coverage. When human factors and ergonomic designs are introduced into a centralized control room, the users and the company realize many improvements, including:

- economic payback;
- improved communications;
- better resource allocation;
- superior situational awareness.

Control room design plays a key role in making sure these environments remain productive for operators while delivering on stakeholder goals. Recent communication technology developments (such as Internet of Things), increase in automation (machine learning and artificial intelligence), and progress in virtual reality space are affecting how we think about control room design guidelines.

Let’s examine the four key trends that will shape the future of control rooms.

Optimizing the structural hierarchy

Control room structural hierarchy decisions vary based on the application. Some industries, such as the rail network management (transportation), are leaning towards more centralized operations, while other segments, such as the power generation plants, are employing decentralized models. Let’s explore the benefits of each hierarchical framework.

Centralization refers to consolidating multiple, geographically dispersed control rooms into a single location. Often, this results in a much larger scale control room and brings in a multi-disciplinary approach to management. Centralized control rooms are often located away from the actual operation. For example, an operation center within an airport can host building management systems, security, passenger traffic control in one centralized control room.

Centralized control rooms benefit from improved communication and cross-departmental collaboration as the teams are now co-located, resulting in significant increase in speed and efficiency to respond in crisis situations.
Future designers need to accommodate for centralization and consider both benefits and risks associated with this shift. While efficiency gains in the operations stemming from this approach are obvious, consider computer access risk from the IT perspective or the lack of redundancy or backup options.

**Centralized control rooms benefit from:**

- Consolidation of space and resources—cost savings in space, equipment, human and IT resources.
- Improved collaboration and decision-making with multiple teams co-located and co-accessing information.
- Increased resilience and operational continuity—operational control increases as you don’t need to spend time and resources moving information across these multiple departments as people are receiving data in a real-time simultaneously.

**Decentralization**, in turn, means dispersing the system's functions and decision-making away from the central location. For example, having a separate, remotely located nuclear power plant control room can enable custom design configurations (such as building 360-degree view rooms), as well as provide desired proximity to the source of information.

Decentralization strategies are frequently employed to mitigate the risks of not having a continuous surveillance and always-on ‘situational awareness’ (e.g. requiring building evacuation or critical equipment malfunction). For some applications, it is necessary to have the ability to feed local or accommodate geographically spread inputs. For example, fire rescue or police forces may gather additional information via tablet or drones, feeding live, real-time information into the system. In this case, decentralized control rooms supplement the centralized decision-making.

**Benefits of decentralized control rooms include:**

- Better situational awareness and ability to be close to action
- Back-up and redundancy control
- Field-based control and decision-making

**Ergonomic visualization**

**Ergonomics** means designing for efficiency and comfort in the working environment. Although a control room is often the most important physical space in an organization, chances are its furniture isn't nearly as comfortable or up to date as the furniture in the conference room. Factors ranging from the furniture specifications to technology that you place in front of the operator affect the quality of the visual output and affect decision-making and response success.

The efficiency component is crucial given the ever-increasing amount of data that needs to be processed and acted upon within a control room. The amount of visual information that control room operators have to process has exponentially increased over the last decade. Therefore, a good design should facilitate delivering quality information and ensuring that the insight in this information remains high.
To accomplish this, design guidelines need to answer the following questions:

- How do we visually present the information? Consider screen size, color settings, image size, and a number of information sources displayed at the same time. Ensure high visibility and avoid information overload.
- How does the environment setup affect visibility? Consider space constraints and the viewing angles your display technology can deliver.
- How do we route this information? Decide on who needs to see the data, at what time, and if there are any internal or external organizational permissions required for access.

Future control room design reflects the requirements for the comfort and productivity in the working environment. Within the control room space, these requirements are specified in the **Ergonomic design of control centers ISO 11064 standard**.

Not familiar with ISO 11064? We provide a summary of key aspects of the standard below.

To optimize the quality of visual output, you should design for a single keyboard and a mouse, but the right number of displays in front of the operator. Tools like KVM switches allow to control the number of the active screens, the resolution and the pixel pitch of displays, and input sources that are available.

Consider the following two examples of design configuration and how it affects the visibility of content.

In this case, given the seating environment ergonomics and height of the display, the first person only has about a 75% view of the top of the video wall. With multiple rows of users, this visibility is further reduced due to the person in front being an obstacle to viewing. This is usually handled by deciding who would need to see what information and how the information is organized on the video wall with the most important data being displayed on the top.
To address such visibility constraints, many organizations are now switching towards local, personal video wall options. With such installations, the operator can see everything on their local displays as well as on the video wall. The trend here is the increase in display quantity in the control room, especially in the form of localized video walls that the operators have a control over themselves.

**Handling data volume and security risks**

Today, with growth in volume and complexity of data sets and the challenge of transforming it into actionable insights becomes progressively difficult. In the world of connected screens, modern technology allows us to have sensors and analytics capabilities within digital signage products. This helps us to collect data in real time, connect it with data available through other sources, analyze and act on it faster. Advanced digital displays, such as video walls, and software also allow for powerful data visualization solutions, further aiding in interpretation and decision-making.

However, with the big data proliferation and the level of insight it can produce, it’s even more prone to security attacks. Securing critical data from people within and outside of the organization, especially in the mission critical environments, must be a core part of the system design.

**Decision-making support technology**

Technologies aimed at increasing automation generated impressive capabilities in the areas of machine learning and artificial intelligence (AI), resulting in creative thinking applications and systems that can make or support decisions. Growth in control room complexity of inputs and outputs of digital screens became factors contributing to the technology reliance in the industry.
Nevertheless, in the control room environment the trend is to utilize machine learning and AI for decision support versus fully automated decision-making. While many tasks are automated, for example, plane takeoff, landing, and air traffic control, humans still take over control in a crisis. Utilization of the automation tools necessitates the use of more interactive tools, so operators can fully understand and have visibility into what the machines are doing. The prediction is the increase in high-quality display demand in the control room environment for enhanced information visualization.

Keeping these trends in mind, ensure that control rooms are designed to deliver on their purpose. Requirements of the control rooms in the fire or police station, a school, installation in the oil and gas industry, or air transportation will be significantly different. Luckily, modern technologies allow for advanced customization based on organization or industry.

What does this mean for the key control room markets?

Let’s review a few industry-specific examples to illustrate how these trends are manifested. We examine the patterns for four distinct markets by looking at the following pairs of contrasting trends per application:

- Centralization vs. decentralization
- Shared visualization vs. personal visualization
- Data security vs. data accessibility
- Human decision-making vs. AI and machine learning

**Air traffic control (ATC)**

The air traffic control market takes a more decentralized approach, uses a lot more personal rather than shared visualization, extreme data security, as well as AI and machine learning.

**CCTV command and control centers**
CCTV control rooms are moving in an opposite direction to the ATC. They are extremely centralized as there are dispersed cameras for data collection, with the output brought in to a unified location. Typically, the shared visualization will be high—with the video wall and multiple people monitoring. The data is then accessible either in the control room or externally. CCTV control rooms are very human-driven, but we expect more AI and machine learning coming to the industry as facial recognition tools become more powerful and prominent.

**Rail network management**

The rail industry is heavily centralized, networks are usually complex, distributed over the huge geographical area. However, it’s very balanced—between human and machine decision-making, personal and shared data visualization, as well as data security and accessibility. This is one area where regardless of being extremely centralized, control rooms utilize a lot of technology. You have people making decisions on the tracks in the field, and a supplementing technology analyzing all this data to determine what should happen.
Nuclear power plants

Nuclear control rooms for power generation are highly de-centralized—typically control centers are located on site on each plant. They exhibit far more personal visualization and are highly secure. In this industry, there is a good balance between human and machine decision-making. Usually a lot of decision support systems are in place, where operators are provided with information about what is happening on the plant, such as alarm monitoring, and then will be tasked with acting on it in the case of crisis.

Control rooms have been one of the most demanding segments in the digital signage space, where quality and durability are of the utmost importance. It is crucial that stakeholders are familiar with key technology trends that are shaping the direction of the industry not only to prepare but also to benefit from these trends.

Additional resources

What is ISO-11064?

ISO 11064 details standards for ergonomics in designing control centers, including the layout and dimensions of workstations to achieve maximum efficiency and safety. The standard is divided into seven parts:

Part 1—Principles for design of control centers

Based on the human-centered approach, the design should begin with the operator. End users participate in the iterative design process, working with an interdisciplinary design team to provide task and link analysis, as well as risk assessment information, which is then documented as the design basis. The goal is an error-tolerant yet safe design.
Part 2—Principles for arrangement of control suites

Based on the design specifications, square footages are estimated, adjacencies are determined, and space is laid out to facilitate all activities housed in the control room.

Part 3—Control room layout

Ergonomic principles and the task and link analysis drive the layout of workstation arrangements, off-workstation visual displays and control room maintenance.

Part 4—Layout and dimensions of workstations

The needs of the operator and other users become the focus of workstation design, utilizing ergonomic principles to determine the overall dimensions of visual-display-based workstations.

Part 5—Displays and controls

Maximizing safe, reliable, efficient and comfortable use of graphic screen displays and controls is the goal of the human machine interface.

Part 6—Environmental requirements for control centers

The overall environment in a control room needs to be optimized to positively affect operator performance. Lighting, acoustics, temperature, humidity, and vibration all are key factors that play into operator awareness.

Part 7—Principles for evaluating control centers

The post-occupancy evaluation after a control center is up and running is the final step to determine if the design is successful. Operators provide feedback after having been involved in the project from the beginning. Lessons learned are evaluated and documented, and recommendations for improvements, if any, are communicated.

Credits

We thank Jamie Adkin of ADDER Technologies for this insightful presentation.