WHY CONTROL ROOM DESIGN IS CRITICAL FOR OPERATOR EFFECTIVENESS

White paper

- Improved operator performance
- Lower operational cost

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Industrial control rooms directly shape operator performance, safety, and reliability. This white paper synthesizes Human Factors research, industry standards, and real-world project outcomes to demonstrate how control room design reduces human error, lowers alarm loads, minimizes fatigue, and improves situational awareness, often delivering faster ROI than core automation upgrades. The paper is technology-agnostic and focuses on principles recognized across the industry.

Findings in this paper mainly draw from:
(1) international standards and recommended practices (e.g., ISO 11064, ISA-18.2/IEC 62682, API RP 1165, ISO 9241, NORSOK S-002)
(2) publications from Human Factors bodies and safety investigations (NASA TLX, HSE, CSB, NTSB/USCG reports); and
(3) aggregated outcomes from completed design projects and assessments. Where quantitative benchmarks are cited, sources are referenced in the References section.

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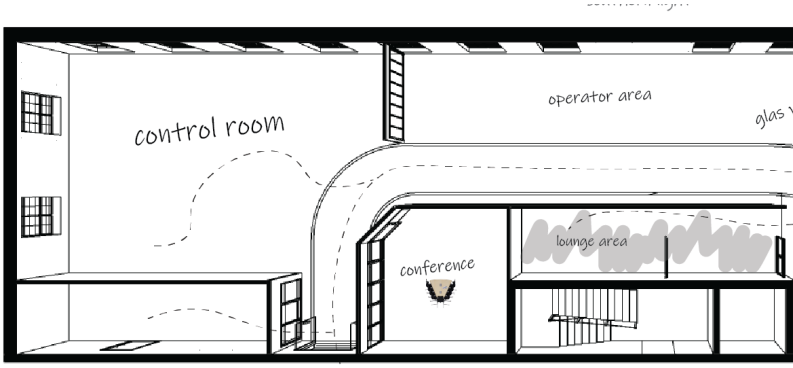


01

Human error is a primary performance risk

The global process industry loses approximately **5%** of annual production to unplanned downtime and quality losses.
Up to **80%** of these losses are preventable, and **~40%** are primarily attributable to operator error, rather than equipment failure.

Human error is strongly influenced by interface quality, layout, alarm handling, fatigue, and situational awareness – all direct outcomes of control room design.

02

Poor Alarm and Interface Design overwhelms operators

In many existing control rooms, operators receive more than **2,000** alarms per day, even during normal operation.
Human Factors research shows operators can only effectively manage a small fraction of this volume without performance degradation.

Industry standards such as **EEMUA 191** and **ISA-18.2** define acceptable alarm rates as: ≈6 alarms/hour for normal situations, ≤10 alarms per 10 minutes peak.

03

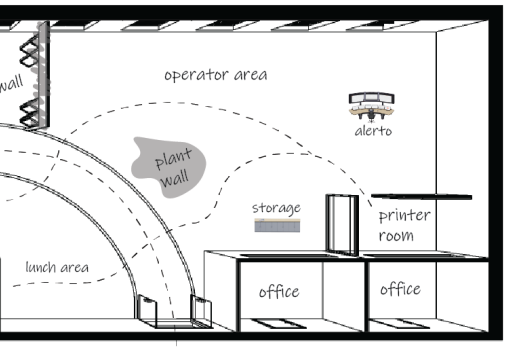
Ergonomic deficiencies directly increase fatigue and errors

Field studies in oil & gas control rooms show:

- **76%** of operators report chronic back pain.
- **~70%** suffer from Computer Vision Syndrome (eye strain, headaches, blurred vision)

These health issues are linked to poor workstation layout, screen positioning, lighting, and environmental conditions.

Fatigue and discomfort are proven contributors to slower reaction times and higher error rates, particularly during abnormal situations.



04

Control Room Design is a recognized safety factor

Major industrial accidents (e.g. Deepwater Horizon, Damascus Titan 2 missile explosion, Columbia Gas) repeatedly point towards poor control room interfaces, alarm overload, and layout deficiencies as contributing factors, and in some cases root-causes. Regulators and insurers increasingly treat compliance with human factors and ergonomic standards as good engineering practice, not optional guidance.

Failure to address control room ergonomics has led to enforced redesigns, legal claims, and regulatory findings.

05

Well-designed control rooms deliver measurable gains

Alarm rationalization and ergonomic redesign projects typically achieve:

- ≥50% reduction in alarm rates
- Faster detection of abnormal situations
- Improved operator confidence and consistency

These improvements are routinely achieved without changes to core automation, purely through better layout, information hierarchy, and workstation design.

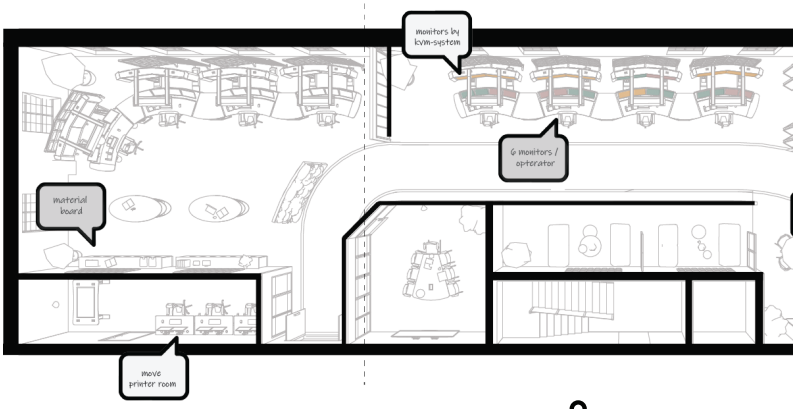
06

International standards explicitly link design to performance

ISO 11064 defines the purpose of control room design as:

- Reducing human error
- Improving operational efficiency
- Reducing fatigue and stress
- Enhancing safety and reliability

These are design objectives, not secondary benefits.



07

Attracting and retaining operators in today's market

The US Bureau of Labor Statistics projects the following:

- The average age of a control room operator is approximately 45 years old. In the broader energy industry, the U.S. Department of Labor has reported the average age of workers as over 50.
- Retirement projections: Industry reports indicate a significant "demographic time bomb" with estimates that half the workforce (over 500,000 workers across the entire energy sector) could retire in a 5–10-year period.
- Workforce size: The Bureau of Labor Statistics reported approximately 46,000 jobs for Power Plant Operators, Distributors and Dispatchers in 2024.
- Knowledge loss: a major concern is the loss of irreplaceable knowledge and experience as seasoned operators leave, posing a challenge
- for finding qualified replacements among younger generations.
- Projected to make up 74% of the workforce by 2030 Generation Z and Millennials are a defining force. It is important for a business to understand what matter to these generations to be able to effectively attract the new generations to the control room environment –
- design is critical.

08

Reduced physical footprint can be a huge cost saver

Minimalistic hardware setups reduce space

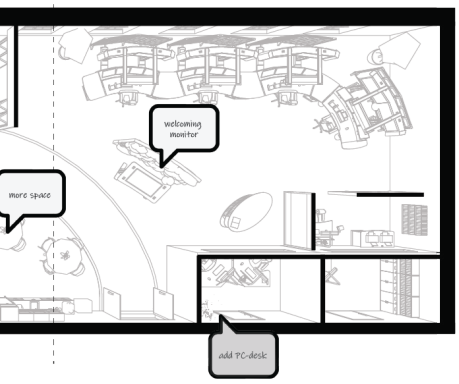
Modern control room design emphasizes minimizing on console equipment.

A streamlined hardware deployment, including IP KVM–based architectures, reduces the volume of devices within the room, which in turn reduces the required workstation footprint and overall room size. This approach results in a cleaner layout, and reduced space usage.

Remote equipment rooms free up floor space

Moving servers, processors, and heat generating devices into a centralized remote equipment room significantly reduces the space needed inside the main control room.

This not only shrinks the in-room footprint but also reduces cooling requirements and simplifies cable routing, lowering infrastructure costs.



09

Cost savings from efficient Space & Resource Management

Space-efficient design reduces construction and property costs. Control room consolidation, meaning merging multiple small control rooms into a single modernized space, has proven to reduce:

- Construction cost
- Lease or property footprint
- Redundant staffing and operational overhead

These savings have been documented in industry case studies presented at control room conferences. For a specific example, see Sample case study from existing client.

10

Cost savings from Operational Efficiency and Lifecycle Management

Modular and reconfigurable designs reduce future renovation costs. Future planning in the control room design, means layouts can change without major construction:

- Technology refresh cycles become cheaper, as an example, using networked KVM solutions, can give the possibility to extend the capabilities of the workstations, without adding more physical hardware.
- Scaling the room becomes cost neutral
- System integrations avoid costly rebuilds

This protects the investment and lowers total lifecycle cost.

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Environmental and sustainability savings (which also reduce OPEX)

Carbon footprint reduction correlates directly with cost savings, whether it be energy efficient lighting, HVAC, or minimalistic hardware, a properly designed control room can help reduce both carbon emissions and energy bills.

KVM over IP solutions can also reduce IT hardware cooling loads, contributing to lower consumption.

SAMPLE CASE STUDY FROM EXISTING CLIENT

Short project summary
Originally the site was managed by sixteen different control rooms, which were consolidated into one centralized control room (CCR), with the end goal of achieving safer operation and increasing productivity.

The original way of controlling the site led to lack of communication and misunderstanding that affected safe operation and reduced productivity.

In combination of a full analysis of HMI, Abnormal Situations Management, and Alarm Management, the end results demonstrated the value of proper control room designs.

Project scope
- Timeframe: 2008-2010 control room transformation program.
- Consolidation: Site went from **16** separate control rooms to **1** centralized control room.

Outcomes
- Total Recordable Incidents (TRI): reduced from **~ 6 to ~1**.
- Sick leave: reduced from **8% to ~4%**.
- Production volumes: increased by **~5%**.
- Hit rate: increased by **~10%**.
- Staffing level: reduced by **30%** (goal achieved).
- Financial impact: annual savings exceeded **$10,000,000**.

EXECUTIVE TAKEAWAY

Control room design has a measurable and direct impact on safety, performance, operator wellbeing, and long-term operational cost. A human-centered and ergonomically optimized environment reduces error, strengthens resilience, and helps attract the next generation of operators.

- Well-designed control rooms reduce human error, safety risk, and downtime
- Human-centered design improves performance, resilience, and decision quality.
- Ergonomics are increasingly essential to attract and retain operators.
- Smart design provides faster ROI and long-term lifecycle cost savings.

REFERENCES

(1) ARC Advisory Group https://www.arcweb.com/blog/ergonometrics-better-operator-ergonomics-increase-plant-kpis
(2) Per Lundmark, ABB Value Paper " Control room ergonomics with the operator in focus for an attractive collaborative environment"
(3) ABB White Paper " Alarm Management for SCADA control rooms"
(4) EEMUA Publication 191 (4th Ed.)
(5) ANSI/ISA 18.2 Management of Alarm Systems for Process Industries
(6) Ugada et al., "Ergonomics Evaluation of Control Room Operators" (2022)
(7) nature.com " Scientific Reports – Human factors challenges in process control rooms" (2025)
(8) IChemE / ABB Alarm Management Guidance
(9) EEMUA 191; ISA 18.2; IEC 62682
(10) ABB Alarm Management Case Evidence
(11) EEMUA 191; ISA 18.2; IEC 62682
(12) ABB Alarm Management Case Evidence
(13) Human Factors Engineering in Control Rooms "https://psychology.iresearchnet.com/articles/human-factors-engineering-and-the-design-of-control-rooms/"
(14) ISO 11064 Parts 1-7
(15) US Bureau of Labor and Statistics

ABB Control Room Solutions
Nils Jakobssonsgatan 5D
504 30 Borås
Sweden

new.abb.com/control-rooms

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