Velotic™

WHITEPAPER

Alarm overload is an engineering problem

How engineering teams can improve performance through better HMI/SCADA systems and alarm management.



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Executive summary

Key Takeaways

01 Alarm overload is not an operator issue – it is driven by system design and alarm strategy

02 Engineering teams define how alarms behave, how they are prioritized, and how they are presented

03 Poor alarm performance leads to slower response, increased risk, and inconsistent operations

04 Well-designed HMI/SCADA systems improve clarity, reduce noise, and enable faster, more effective decision-making

05 Alarm systems naturally drift over time without structured management and continuous improvement

06 Modern HMI/SCADA platforms enable more sustainable, data-driven approaches to alarm performance

07 Emerging AI and analytics capabilities are helping teams move from reactive response to deeper system understanding



Target audience

This paper is primarily designed for control systems engineers, SCADA engineers, and engineering teams responsible for designing, maintaining, and improving HMI/ SCADA systems and alarm performance. It is also relevant for operations and digital transformation leaders responsible for operational reliability, standardization, and system scalability.

Associated challenges:

Across these roles, several common challenges emerge:

- Alarm systems that generate high volumes of noise without clear prioritization
- Difficulty identifying root causes during abnormal conditions
- Inconsistent performance across teams, shifts, and sites
- High training effort due to complex or unintuitive system design
- Systems that degrade over time due to incremental changes and lack of structure

This paper outlines why these challenges occur, how to recognize them, and practical steps engineering teams can take to improve alarm performance and system usability.

The reality: alarm overload in modern operations

Across many industrial plants today, alarm overload is a common and persistent challenge. HMI/SCADA systems often contain hundreds or even thousands of configured alarms, with frequent alarm floods occurring during process disturbances or abnormal conditions.

In these environments, operators are expected to monitor, interpret, and respond to a constant stream of information. In practice, this leads to several common issues:

- Too many alarms to process in real time
- Unclear prioritization between critical and non-critical conditions
- Difficulty identifying the root cause of issues
- Alarms becoming background noise rather than actionable signals

As a result, operators often experience cognitive overload.

They are presented with large volumes of alarms and information, making it difficult to quickly identify what actually matters. In these situations, operators are often forced into reactive decision-making, responding under pressure rather than being supported by clear, structured system guidance. This means operators are often left to manage the consequences of how the system is designed.

In short, alarm overload is something operators experience – not something they create.



The misconception: treating alarm overload as an operator problem

Despite this, alarm overload is often framed as an operator issue. This shows up in a few common ways such as assuming:

> Operators need more training
> Operators are missing or overlooking critical alarms
> Operators are not responding appropriately to alarms

While these may touch on real symptoms, they do not address the root cause. This framing assumes that performance issues are driven primarily by human factors, rather than by the systems those operators rely on.

In reality, alarm performance is shaped upstream. The way alarms are configured, prioritized, and presented directly determines how usable the system is during real-world operations.

What looks like an operator issue is often a system design issue.

The root cause: alarm system design is the problem

Alarm performance is not random or purely operational. Alarm systems behave as they are designed, not necessarily as they are intended.

This behavior is the direct result of engineering decisions made during system design, configuration, and ongoing maintenance.

Engineering teams are responsible for:

Area	What it involves
Alarm configuration	Defining thresholds, limits, priorities, and suppression logic
Alarm rationalization	Removing unnecessary or duplicate alarms; aligning definitions with operational risk and standards such as ISA-18.2 and IEC 62682
HMI/SCADA design	Determining how alarms are displayed; ensuring visibility, context, and ease of navigation
Standardization	Maintaining consistency across systems and sites; using reusable templates and structured approaches
Continuous improvement	Analyzing historical alarm data; refining system behavior over time

> Together, these decisions define how alarms behave, how they are interpreted, and how effectively operators can respond.

The impact:



Why performance matters

When alarm performance is not actively managed, system behavior degrades in ways that directly impact operations. Poor alarm performance has direct and measurable consequences for industrial operations.

It can lead to:

- Slower response to abnormal conditions, increasing time to resolution
- Increased downtime from delayed or misdiagnosed issues
- Missed or delayed detection of critical events during alarm floods
- Inconsistent performance across shifts, teams, and sites
- Higher training costs driven by difficult-to-use alarm systems
- Increased safety and compliance risk due to alarm fatigue

These challenges make it harder for operators to quickly understand what is happening and respond effectively, ultimately increasing downtime, driving higher operational costs, and introducing greater safety and compliance risk.



What bad looks like

Consider a common scenario during a process upset. A piece of equipment begins to deviate from normal operating conditions, triggering a cascade of alarms within a short period of time.

Within minutes:

- Dozens of alarms are active, many of them related or redundant
- Priorities are unclear, making it difficult to determine where to focus
- Operators begin acknowledging alarms to manage the volume rather than take action

At this point, the underlying issue is still developing, but the system is no longer helping to diagnose it. Instead, it is adding noise.

As the situation continues:

- Time to identify the root cause increases
- The likelihood of misdiagnosis rises
- Small issues have more time to escalate into larger disruptions

Regardless of the outcome, the system has failed to support timely, effective decision-making when it mattered most. This is not an isolated failure. It is the predictable result of an alarm system that has become too complex and difficult to interpret under real operating conditions.



The value of strong alarm performance

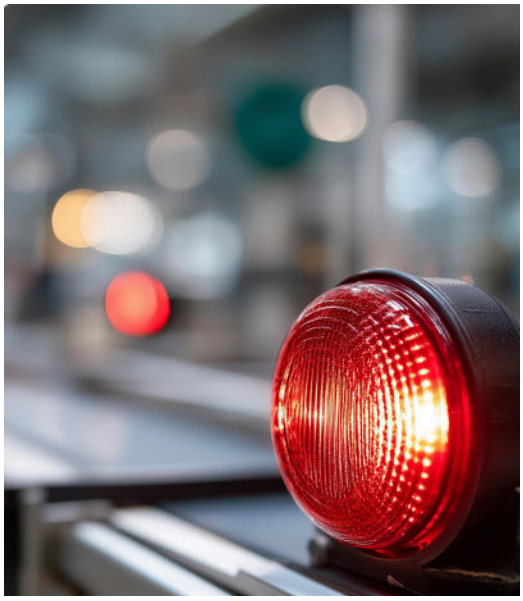
When alarm systems are well-designed and properly managed, the opposite is true. Operators respond faster, issues are diagnosed more accurately, and systems remain more stable during abnormal conditions.

Strong alarm performance enables:

- Faster response times and reduced time to resolution
- Quicker identification of root causes, minimizing production impact
- More stable and predictable operations with fewer disruptions
- Reduced alarm volume, allowing operators to focus on what matters
- Lower training burden through more intuitive system behavior
- Improved safety and reliability through clearer situational awareness

As organizations scale, alarm system complexity increases. Systems are replicated across lines, sites, and teams, and inconsistencies can begin to emerge. In these environments, well-designed and well managed alarm systems play an even more critical role, helping maintain clarity, consistency, and reliable performance across the organization.under real operating conditions.

How alarm systems drift over time



Even when alarm systems are well-designed initially, they rarely stay that way. As systems evolve, configurations change, expand, and accumulate – often without structured oversight.

Several common patterns contribute to this drift:

- Conservative alarm configuration creates excessive alarms
- Commissioning and testing introduce persistent alarm noise
- Limited cleanup occurs before systems go live
- Additional alarms are added over time as new needs are discovered
- Changes are made incrementally without structured rationalization

Over time, these patterns lead to systems that are more complex, less consistent, and harder to interpret during real operating conditions. This degradation is often gradual and difficult to detect until it begins to impact operations.

However, there are clear indicators that a system is no longer performing effectively:

- Frequent alarm floods during normal or expected conditions
- Alarm rates that exceed what operators can reasonably manage
- Large numbers of alarms acknowledged without action
- Repeated alarms tied to the same underlying issue
- Operators relying on memory or workarounds instead of system guidance
- Inconsistent alarm behavior across similar equipment or sites

These patterns are indicators that the system has drifted from its intended design and is no longer supporting effective decisionmaking. Recognizing these signals is the first step toward improving alarm performance.

Principles of effective alarm & HMI design

Addressing these challenges requires more than incremental fixes. It requires a structured approach to how alarms are designed, managed, and presented to operators. The following principles provide a practical framework for improving alarm performance and system usability.

Principle	What it Means	Outcome
High-Performance HMI Design	Clear visual hierarchy, focus on abnormal conditions, reduced cognitive load	Faster interpretation and improved operator response
Effective Alarm Management	Prioritize based on real risk, minimize nuisance alarms, define expected responses	Clearer prioritization and more actionable alarms
Context-Rich Visibility	Determining how alarms are displayed; ensuring visibility, context, and ease of navigation	Faster diagnosis and better decision-making
Standardization	Provide process conditions, historical trends, and related system context	Improved usability, scalability, and maintainability

Modern HMI/SCADA platforms increasingly incorporate these principles, improving usability, reducing training requirements, and enabling more consistent performance across operations

Practical steps: how engineers can improve alarm performance



While these principles provide a strong foundation, they must be applied in a structured and repeatable way to improve system performance. Engineering teams can take practical steps to translate these concepts into measurable improvements.

Step 1

Assess current alarm performance

The first step is understanding how the system behaves today. This includes reviewing alarm rates, identifying periods of alarm flooding, and determining how many alarms require action versus being acknowledged without response. Input from operators is essential, as it highlights usability gaps, trust issues, and areas where the system does not align with real-world workflows. In many cases, this initial assessment quickly reveals that a large portion of alarms do not drive meaningful action.

Step 2

Rationalize alarms

Rationalization ensures that each alarm has a clear purpose. This involves removing duplicates and low-value signals, aligning priorities with actual operational risk, and defining appropriate response expectations. The goal is to reduce noise while ensuring that meaningful conditions stand out and drive action.

Step 3

Improve HMI visibility

Interface design directly affects how quickly operators can interpret system conditions. Improving visibility means emphasizing what matters most, reducing unnecessary visual elements, and simplifying navigation between related information. A well-structured interface helps users quickly understand the situation and determine the next step.

Step 4

Add context to alarms

Alarms are more useful when paired with relevant context. Integrating trends, related tags, and system state information allows operators to move beyond reacting to individual signals and toward understanding the broader situation. This shortens diagnosis time and supports more informed decisions.

Step 5

Standardize design

Consistency is essential for usability and scalability. Establishing standard screen layouts, alarm structures, and design patterns reduces variability across systems and sites. It also simplifies training, ongoing maintenance, and the ability to replicate proven approaches..

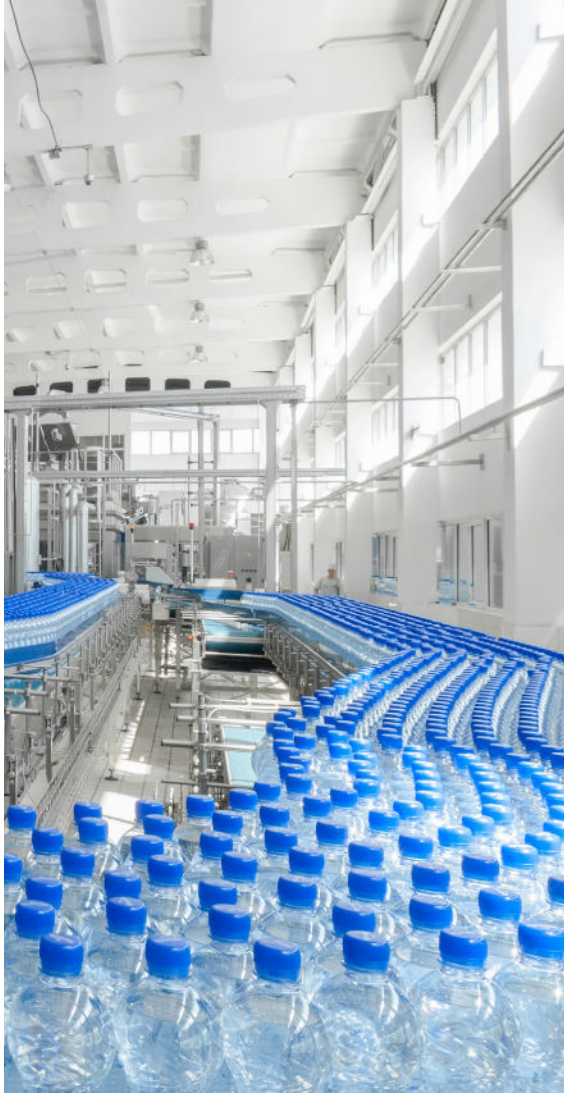
Step 6

Establish continuous alarm improvement

Alarm management requires ongoing attention. As systems evolve and processes change, configurations must be reviewed and refined. A structured approach to continuous improvement helps prevent gradual degradation and keeps system behavior aligned with operational needs.

In practice, these steps are effective, but they are also time-intensive and difficult to sustain manually. Maintaining consistency across systems and over long operational lifecycles requires ongoing effort and discipline.

Where to start



In most environments, improving alarm performance does not begin with a full system redesign. It starts with identifying a small number of high-impact issues and addressing them in a structured way.

A practical starting point is to focus on one system, production line, or area where alarm activity is highest. By reducing alarm volume, improving visibility, and aligning alarms with actual operational needs in that area, teams can quickly demonstrate value and build momentum for broader improvements.

Enabling better alarm performance with modern HMI/SCADA systems

Improving alarm performance is not just a matter of following best practices. It requires the ability to apply those practices consistently across systems and sustain them over time. This is where modernHMI/SCADA platforms play a critical role. They provide the structure,visibility, and control needed to implement these practices effectivelyand maintain them as systems evolve.

Proficy HMI/SCADA is designed to address these challenges directly. It brings together high-performance visualization, structured alarmmanagement, and integrated data capabilities to help engineering teams implement best practices and sustain them across systems, sites, and over time.

Proficy HMI/SCADA enables engineering teams to:

- Design interfaces that emphasize clarity, consistency, and situational awareness
- Implement structured alarm management with prioritization and control
- Standardize systems using reusable templates and centralized configuration
- Scale across environments using iFIX for fast development and efficient deployment
- Support large-scale, centralized, and multi-site operations with CIMPLICITY
- Extend visibility with integrated data and analytics through Proficy SCADA Ultimate
- Support continuous improvement through centralized updates and optimization

Proficy HMI/SCADA enables organizations to move beyond one-time improvements and establish a more consistent, scalable approach to alarm performance.

This helps teams maintain system quality over time, reduce variability across environments, and support more effective operator decision-making as operations grow more connected and distributed.

However, as organizations expand centralized visibility, remote access, cross-site integration, and analytics capabilities, modernization efforts must also account for operational security requirements.

Modernization and OT cybersecurity

As HMI/SCADA environments become more connected, cybersecurity becomes an essential part of modernization. Centralized visibility, remote access, cross-site data integration, and analytics can create new value, but they must be implemented with appropriate controls to help protect operational systems.

Engineering and operations teams should consider factors such as network segmentation, secure remote access, role-based access control, user authentication, patching strategy, and minimizing unnecessary exposure of OT assets.

Modern HMI/SCADA platforms should support this balance, helping organizations improve visibility and usability while maintaining operational control. Proficy HMI/SCADA supports flexible deployment architectures and secure industrial practices that help teams modernize systems without creating unnecessary risk.

These considerations are especially important in environments where organizations are modernizing incrementally across existing infrastructure rather than replacing systems outright.

Why your existing HMI/SCADA may not be enough

Most industrial organizations are not starting from scratch. They already operate HMI/SCADA systems across lines, sites, vendors, and generations of infrastructure.

But having HMI/SCADA in place does not necessarily mean alarm performance is optimized, operator visibility is consistent, or engineering teams have a scalable way to manage system behavior over time, especially across larger or evolving operations.



As environments grow more connected and distributed, many organizations struggle with:

- Inconsistent alarm and visualization standards across sites
- Limited centralized visibility into operational performance
- Difficulty scaling engineering practices across systems
- Siloed operational data that limits broader analysis and optimization
- Modernization efforts that require balancing new capabilities with existing infrastructure

Improving alarm performance does not necessarily require replacing existing control systems. In many environments, the priority is extending visibility, standardizing alarm and HMI practices, improving usability, and integrating operational data and analytics across existing infrastructure.

Proficy HMI/SCADA is designed to support these environments through open connectivity, centralized management capabilities, scalable visualization, and integrated operational data and analytics. This helps engineering teams standardize practices, improve visibility across distributed operations, and modernize incrementally while preserving existing investments.

Real world impact: case studies

These real-world implementations demonstrate how improved HMI/SCADA design and alarm management translate into measurable operational improvements using Proficy HMI/SCADA. While each environment is different, these examples highlight a common pattern: improving visibility and alarm performance leads to faster, more effective decisions during both normal operations and abnormal events.



Food & Beverage

Ocean Spray

Ocean Spray needed better visibility into production performance and operational trends across its processing environment. Using Proficy HMI/SCADA iFIX, the organization implemented centralized monitoring with integrated historical data, allowing engineers to analyze system behavior and identify improvement opportunities. This enabled more informed decision-making, improved operator visibility into system conditions, and increased overall operational efficiency.



Energy

Sentinel Energy Center

Sentinel Energy Center required a reliable way to manage complex startup procedures during grid outages. Proficy HMI/SCADA CIMPLICITY was used to develop custom HMI interfaces for its Black Start system, providing prioritized visibility into system status during critical transitions. This improved operator confidence and reduced risk during high pressure scenarios.



Transportation

Rail Transit Operator

A large rail transit operator lacked clear visibility across distributed infrastructure, making it difficult to diagnose and respond to issues quickly. By implementing Proficy HMI/SCADA iFIX for real-time monitoring and structured alarm management, the organization improved situational awareness across its network. This enabled faster issue diagnosis, improved response times during abnormal conditions, and more efficient system recovery.



Water & Wastewater

Racibórz Waterworks

Racibórz Waterworks was operating multiple fragmented SCADA systems, creating complexity and high infrastructure overhead. By consolidating these systems into a unified platform using Proficy HMI/SCADA iFIX, the organization reduced the number of SCADA servers by 50% while improving system reliability. Centralized monitoring and standardized interfaces also improved operational visibility, reduced system complexity, and enabled more consistent decision-making.

Across these examples, the pattern is consistent. With Proficy HMI/SCADA, engineering teams are better equipped to design alarm systems and interfaces with clarity, structure, and scalability, enabling improved visibility, faster response, and more reliable operations.

Looking ahead: from reactive alarms to intelligent, continuous optimization

Traditional alarm management relies on tag-based alarms, static thresholds, and periodic manual review. While foundational, these approaches are inherently limited. They offer little context, generate high volumes of noise, and make it difficult to identify underlying causes when issues occur. As systems evolve and complexity increases, these limitations become more pronounced.

A more modern approach focuses on continuous, data-driven improvement and a broader understanding of system behavior. Increasingly, this shift is being supported by AI and advanced analytics that can analyze patterns across alarms, process conditions, and historical performance.

This means moving beyond isolated alarms and instead:

- Analyzing relationships between alarms and process conditions
- Identifying patterns and recurring issues
- Understanding system-level behavior rather than isolated signals

This is an area of active innovation. Emerging approaches are bringing AI-driven assistance directly into SCADA environments, helping teams analyze alarm behavior, identify patterns, and uncover relationships that are difficult to detect through manual review alone. When grounded in real system context, these capabilities can support faster diagnosis, reduce alarm noise, and guide more effective system improvements over time.

Platforms like Proficy® from Velotic™ are advancing these capabilities to help engineering teams move toward a more continuous and data-driven approach to alarm management. Some of these capabilities are available today through industrial analytics and integrated operational data platforms. Others are evolving as AI capabilities become more tightly integrated into HMI/SCADA workflows.

Example: identifying system-level patterns earlier

In many cases, what appears to be a single alarm condition is actually a deviation from expected system performance. Consider a production line where throughput begins to drop. A low-speed alarm is triggered, followed by additional alarms related to flow rates and material levels. Individually, these signals point to localized issues. Together, they indicate a broader pattern driven by upstream constraints, equipment inefficiencies, or process variability.

In a more advanced environment, this pattern is surfaced early, before alarm volume escalates. Instead of reacting to a stream of disconnected alerts, operators see the shift as it happens: a gradual drop in upstream feed rate paired with small but persistent delays downstream, signaling a developing bottleneck.

With that visibility, operators can act immediately, stabilizing the system while the issue is still manageable, rather than chasing alarms after performance has already degraded. At the same time, engineers have the context to go deeper. They can trace how conditions evolved across the system and pinpoint contributing factors, such as supply variability, equipment running outside optimal ranges, or imbalance across the line.

This allows teams to move from reactive response to targeted intervention, rebalancing the line, adjusting control parameters, or resolving early-stage equipment issues before they escalate into downtime, quality loss, or broader disruption. Capabilities like these are increasingly being enabled through combinations of industrial analytics, historical data analysis, alarm pattern detection, and emerging AI-assisted workflows.

Conclusion: better systems start with better engineering

Alarm overload is not an operator issue. It is a system design and engineering challenge.

Engineering teams define how alarms behave, how they are presented, and how effectively operators can respond. When alarm systems are designed and managed with structure, context, and consistency, they enable faster decisions, more stable operations, and improved reliability.

As industrial environments become more complex and data-driven, alarm management is evolving from reactive response to continuous optimization. AI and advanced analytics are beginning to play a key role in this shift, helping teams identify patterns, reduce alarm noise, and improve decision-making. Organizations that adopt this approach are better positioned to improve clarity, respond more effectively, and maintain performance as systems scale.

Better operator outcomes don't happen by chance. They start with better engineering decisions, supported by the right systems and tools.

Learn More



Velotic™

Velotic™ is a leading independent industrial software company providing data-driven solutions that improve manufacturing efficiency, productivity, and operational insight. Serving customers across manufacturing, oil & gas, utilities, and infrastructure, the company generates more than $300 million in revenue. Velotic's portfolio, anchored by Proficy®, Kepware®, and ThingWorx®, supports the growing data and performance requirements of industrial operators globally, with an emphasis on AI-enabled manufacturing and industrial software.

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ThingWorx®

AIOT Engine and Tools
Highly scalable productivity & data suite

Kepware®

Data Aggregration & Abstraction
Foundation