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THE SILENT SENTINEL: A NOVEL FRAMEWORK FOR COGNITIVE FIRE SAFETY INFRASTRUCTURE IN THE ERA OF AUTONOMOUS INDUSTRY

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ABSTRACT

Manufacturing performance and efficiency have greatly improved through the application of intelligent automation, interconnected manufacturing systems, and advanced digital technologies, owing to industrial transformation. However, these advances have created some of the most complex fire safety problems in the world, which cannot be handled by traditional means of protection. Traditional fire safety infrastructure was built for a system that has continuous human presence and operation for simple and predictable industrial plants, while modern autonomous industries have cyber-physical systems, robotic manufacturing cells, high packing density for energy storage, additive manufacturing processes, and real-time data-driven operations. These environments require safety mechanisms that can anticipate, learn, and adapt to constantly changing risks, rather than simply reacting to risks when they arise. This study introduces the concept of Cognitive Fire Safety Infrastructure (CFSI), a new approach to consider fire safety as an organisational capacity that can provide predictive and intelligent functions. It is designed to allow continuous monitoring, learning, and adaptive decision-making through the integration of equipment self-awareness, dynamic hazard mapping, and autonomous suppression orchestration. A model is proposed that places great importance on preventing, being resilient, and being operational, going beyond traditional methods and contributing to the protection of autonomous industrial environments for future needs.

Keywords: Cognitive Fire Safety Infrastructure, Autonomous Industry, Smart Manufacturing, Predictive Safety, Industrial Risk Management, Artificial Intelligence, Industry 5.0.

1. INTRODUCTION

The industrial world is undergoing one of the greatest changes in its history (Johannes, 2023). The dependence on human resources and mechanical work for manufacturing is changing to highly interconnected ecosystems with increased automation and intelligence of machines, robots, AI systems, and digital communication networks interacting to carry out significant parts of the manufacturing activities (Pandey, 2025). This is further driven by the dawn of Industry 4.0 and the slower but significant shift to Industry 5.0, which brings in technologies that can help optimise production processes, improve efficiency, reduce costs, and create added value for products.

These technological advances have provided many advantages but have also changed the nature of industrial risk. Fire hazards have been relatively predictable but have become increasingly complex and dynamic over the years (Hwang & Kweon, 2023). Modern industrial plants often host lithium-ion battery storage solutions, automated systems and robots for assembly and repair, high-energy electrical equipment, combustible metal powders,

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and complex electronic systems (Erdogan et al., 2024). These elements create unique fire scenarios that differ significantly from the solidly established fire scenarios in traditional environments.

Most of the principles that form the basis of traditional fire safety systems were invented many years ago. The components of a typical smoke-blowing system are categorised into three types: smoke detectors that sense combustion products, heat detectors that sense high heat, and suppression systems activated by preset heat. (Rosiana & Fatkhurrokhman, 2023). Although these technologies have contributed to promoting safety in industrial settings, they are essentially reactive and designed to respond to existing dangers. The operational tenets are based on the assumption that a fire event has already started for an intervention to occur.

Therefore, more than just putting out fires, the problem for modern organisations is the anticipation and prevention of conditions that can go out of control and cause someone to lightly touch a match and start a fire. When operating a highly automated plant, the impact of a fire is not limited to the damage caused. A single incident may cause disruptions to supply chains, interrupt production, affect the security of information systems, harm the image of the company, and result in significant economic losses (Tricomi et al., 2023). Thus, the concept of "industrial fire safety" must be broadened and upgraded from fire protection to the basis of organisational intelligence.

From this need comes the notion of a Cognitive Fire Safety Infrastructure. The proposed framework does not view a fire safety system as a standalone device performing its tasks separately but considers the entire safety ecosystem as a smart network that can conduct continuous observation, analysis, learning, and decision-making (Nurmukhamedov et al., 2023). The framework aims to create a "proactive" approach to industrial protection that leverages cutting-edge sensing capabilities, artificial intelligence, and predictive and autonomous response solutions designed to meet the demands of the autonomous industry in the future (Sani, 2025).

The importance of this study lies in the difference in approach from the incremental addition of topologies. Rather than attempting to focus on a more delicate detector or a more powerful suppression agent, this study adopts a different approach using a fundamental change in cognitive ability. The goal is to establish a safety structure that is aware of the surroundings, assesses the new risks associated with them, anticipates related incidents, and activates a response dependent on every circumstance.

So, what are the challenges of the existing systems used for fire protection in autonomous applications? Secondly, how could the principles of cognitive computing, predictive analytics and autonomous decision making be applied in a systematic fashion to make an Industrial Fire Safety framework better?

Third, what are the practical implications, implementation issues and organisational considerations needed to move from a reactive to a proactive approach to fire safety with cognitive systems?

The main question posed in this paper is whether the new paradigm for shifting from reactive to predictive safety demands a new definition of safety as a cognitive organisational capability instead of just a set of physical assets and conformational processes.

2. CONCEPTUAL BACKGROUND

The idea of Cognitive Fire Safety Infrastructure is based on some of the new technological and managerial fields that are developing and creating conditions for intelligent decisions in industrial areas.

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Fire Safety has always been perceived as a set of activities aimed at compliance with rules and regulations while avoiding potential hazards. History has proven that the traditional approach, which focuses on physical barriers, suppression equipment, emergency procedures, and periodic inspections, is very effective (Bedon et al., 2024; "Fundamentals of Risk Management," 2023). While these are still relevant, in fast-paced, technologically changing, and complex environments, they are becoming increasingly inadequate.

Intelligent manufacturing systems have proven the importance of prediction in factory management. The application of intelligent manufacturing systems has demonstrated the utility of factory prediction. For instance, by using real-time sensor readings, predictive maintenance can detect issues in equipment before they cause damage to the system (Lukito et al., 2025). Instead of the usual reactive approach to solving a problem after a machinery breakdown, organisations can take steps to intervene based on predictive indicators. Generalisations can be made for delivering fire safety.

The AI component is another key part of the proposed framework. Enormous amounts of data are generated daily in modern industrial facilities (Lincy, 2024). All these different aspects of temperature changes, energy consumption, vibrations, atmospheric factors, and operating processes contribute to the complex information environment. These streams of information can be captured by AI systems to identify underlying trends that could otherwise not be detected by the human eye through traditional monitoring methods.

This ability is also aided by machine learning algorithms, which allow these systems to improve over time. Detecting trends in the data and leveraging machine learning. Machine learning is used to learn from data, which is different from a rule-based system that requires prescriptive instructions. The characteristic of continuous changes in industrial environments is particularly useful in the field of fire safety applications. New equipment, handling procedures, and materials may pose unknown risks. Digital twin technology has also made significant progress toward the creation of cognitive safety systems. By monitoring and learning from the real environment, a digital twin can be used to make predictions and test scenarios in a virtual setting to avoid uncertainties in the real-world. (Agnusdei et al., 2021)

Another important concept for smart manufacturing is cyber-physical systems. They combine physical processes with computational intelligence, resulting in a system of environments in which physical processes communicate, coordinate, and respond automatically (Kocabay & Javadi, 2022). If such environments exist, it is impossible to maintain safety infrastructure as a separate entity. Rather, it should become a part of the larger industrial system. In addition to placing a theoretical perspective on this issue, the concept of resilience has been discussed.

Conventional safety management adopts a protective approach to prevent incidents. The approach to resilience goes beyond prevention considerations and includes anticipation (contingency planning), absorption (strengthening and buffering capacities), adaptation (other solutions), and recovery (treatment, remediation, sustainable reconstruction, rehabilitation, or reconstruction) from such disruptions (Bucovetchi et al., 2024). Cognitive Fire Safety Infrastructure is very close to this thinking and aims not only to fight fires but also to keep an organisation running even during unforeseen circumstances. These developments indicate the advent of a new paradigm in industrial safety management. Mitigation measures are not "passive" and protective. They are active members of the organisational decision-making process. This change breeds the possibility of more adaptable, responsive, and smart risk management.

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3. RESEARCH METHODOLOGY

This study is a conceptual study which combines techniques of literature research with a systematic literature search. Peer-reviewed articles, conference proceedings and industry reports published from 2015 to 2025 were thoroughly investigated from the Scopus, Web of Science and IEEE Xplore databases. The Cognitive Fire Safety Infrastructure framework has undergone iterative development and refinement based on expert consultation, with five experts from industrial safety engineering, AI and manufacturing operations offering structured feedback on the theoretical coherence and practical feasibility of the framework. Validation was carried out through scenario-based analysis on four different industrial scenarios – Lithium-ion Battery Assembly, Chemical Process, Additive Manufacturing and Automated Warehousing.

4. THE COGNITIVE FIRE SAFETY INFRASTRUCTURE FRAMEWORK

The proposed innovation of the Cognitive Fire Safety Infrastructure is underpinned by three interrelated pillars that form a holistic safety ecosystem. These pillars include sophisticated detection tools and algorithms, targeted real-time data analysis and intelligence systems, and adaptive response capabilities. They can detect fire hazards, keep an eye on the environment, and respond dynamically to fire emergencies when needed. This holistic solution guarantees increased safety, reducing risk and increasing overall resiliency to fire-related events.

Pillar One: Equip-Self-Awareness

Fire safety equipment is largely unheard of during its lifetime. Usually, the two technologies do not communicate without triggering one another or when inspected. This makes it difficult to ensure their true readiness and reliability (Paś et al., 2024). Equip-Self-Awareness overcomes this shortcoming by directly sharing intelligence with safety assets. Sensors constantly measure the physical state, operation, environmental exposure, and remaining capabilities of the machine. Every component can check its own health and immediately report the conditions (Gnanasekaran et al., 2024). This results in a dynamic definition of system readiness that is not based on regular inspections. Maintenance activities do not respond to problems but anticipate them, which helps minimise the chances of unforeseen equipment faults in emergencies.

Pillar Two: Dynamic Hazard Mapping

Traditional fire detection systems indicate a fire after it has reached a certain level. Dynamic Hazard Mapping not only detects but also monitors changing environmental conditions and new hazards. The system links data from various types of sensors, air quality monitors, equipment condition checks, production systems, and environmental data. These data streams are transformed with advanced analytics into a real-time map of risk (RtM), which visualises hazard conditions in the facility and helps identify the changing risk scenario. Organisations can determine the area and cause of a fire by asking themselves where the fire might start and how it can grow and spread if it ignites.

Pillar Three: Autonomous Suppression Orchestration

The third is intelligent response management. The most common suppression methods are generic and do not consider the context. Autonomous Suppression Orchestration is incorporated to add adaptive decision-making capabilities. The system considers a wide variety of factors, including the characteristics of the fire, the characteristics of the material, the availability of equipment and personnel, environmental factors, human evaluation factors, and operational priorities. This best estimate, together with a natural assessment, was used to optimise suppression strategies for maximum suppression with minimum collateral damage.

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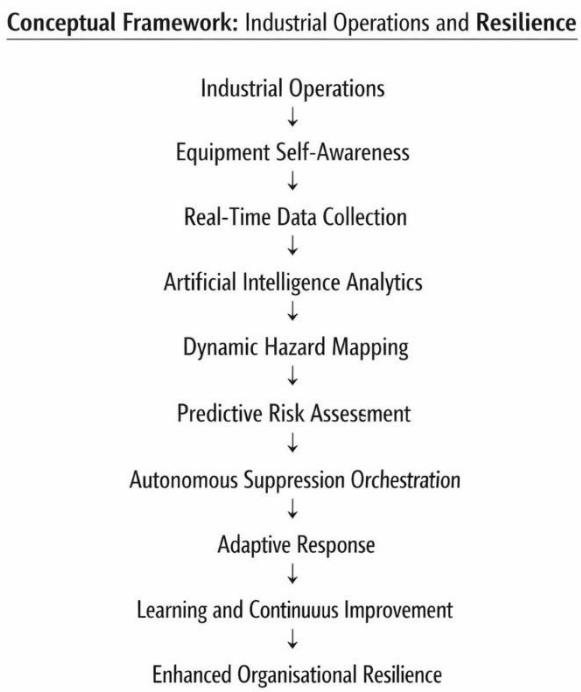
This changes the use of a standard fire response approach to a 'context-sensitive' operation, depending on the situation of the fire.

Table 1: Evolution of Industrial Fire Safety

Generation	Characteristics	Limitations
Traditional Safety	Detection and Suppression	Reactive Response
Smart Safety	Connected Monitoring	Limited Prediction
Intelligent Safety	Predictive Analytics	Partial Automation
Cognitive Fire Safety Infrastructure	Self-Learning and Autonomous Adaptation	Emerging Implementation Challenges

Conceptual Framework: It outlines the journey towards completing the full spectrum of smart industrial processes, from equipment self-awareness and real-time data collection to adaptive response and constant ongoing improvement, and finally to increased organisational resilience.

Figure 1. Conceptual Framework for Industrial Operations and Resilience.



Source: Author's conceptualisation based on synthesis of peer-reviewed studies on AI-enabled industrial safety, predictive analytics, and organisational resilience (2024–2026).

It establishes a continuous loop of feedback in which the individual's learning from each operation also affects his or her performance, and his or her performance optimises the learning process in future operations. Security sites change and develop to suit the complexities of the industry they serve.

5. CURRENT TRENDS AND CHALLENGES IN INDUSTRIAL FIRE SAFETY

The Industrial sector is undergoing a radical change in technology, rewriting the script on how to be more productive in production and how it looks to be safer at work. Smart factories are becoming increasingly connected, with machines becoming less 'human' and working

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independently, with cloud systems, digital twins, and artificial intelligence (AI) being used to manage the factory. Progress in productivity and accuracy has been beneficial, but has added complexity that traditional fire protection systems cannot cope with.

The use of energy storage technologies is a major trend impacting industrial fire safety. Lithium-ion battery systems are essential for enabling the power supply and continuation of an organisation to achieve uninterrupted function, renewable integration, and autonomy. High-energy components can undergo thermal runaway when certain conditions are met. These fire-related incidents may re-flash after they have been extinguished, and hazardous fumes are emitted, which can make it more difficult to respond to a fire emergency. Rather, in many cases, old systems may not have had the design specifications for detecting all battery degradation and thermal instability properties of early warning that might be expected on a battery. Another significant trend is the growth of independent manufacturing systems.

Industrial robotics is increasingly used in welding, assembly, packaging, transportation, and inspection tasks with minimal human intervention. Less direct oversight affords an opportunity for mechanical faults, overheating of parts, or electrical failures to go unidentified until they become serious incidents. Typical fire protection systems cannot effectively track equipment behaviour to an extent that is sufficient to anticipate future events that could pose a fire hazard. Additive manufacturing has introduced another level of complexity. The combination of combustible powders, volatile resins, and special materials is often used in advanced manufacturing processes and is combustible with atypical combustion properties. Additively manufactured metal powders can form explosive atmospheres when dispersed in air, and some polymers can emit toxic products when burned. Conventional fire classification systems do not accurately reflect the complexities of the fire hazards of these materials.

Industrial digitalisation has also led to a greater reliance on critical electronic access and control. Traditionally, the most important assets, which usually had important suppression methods, were data centres, industrial servers, communication networks, and control systems, all of which are very sensitive. Water-based suppression systems can either operate effectively or fail, and can extinguish fires but cause significant electronic damage. This challenge highlights the need for ‘context-dependent suppression solutions that can work towards both fire control and asset protection. Other industrial safety management problems are environmental issues. Currently, as the world's temperature rises, additional equipment stresses are combined with the risk of ignition from extreme climates and the length of heat waves. Climate-related disruptions in areas will bring additional challenges regarding safe operating conditions as a result of climate change.

The major concern of cybersecurity has risen to the fore. The operational activities, asset monitoring, and management of these industrial facilities rely on communication networks that integrate them. These communication networks are integrated networks that rely on the activities of modern industrial facilities to handle their management, monitor assets, and coordinate these activities. These systems are possible points of entry that can be compromised by hackers for fire-safety systems in general. Access to safety equipment may lead to improper detection of issues, inability to suppress issues, or false alarms during operation.

The transformation of the industry is also a critical challenge. The new needs of industries for digital systems, data interpretation, and human-machine interaction call for the acquisition of new capabilities by employees. The role of mechanical protection systems is constantly changing, and safety professionals who have traditionally dealt with mechanical protection

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systems should be aware of artificial intelligence, predictive analytics, and cyber-physical systems. These findings indicate that only reactive protection mechanisms will not be able to satisfy the requirements of industrial fire safety in the future. The complexity of such an industrial ecosystem requires intelligent systems to grasp the operating context, anticipate the future context, and adjust their reactions to 'real-time environment' changes.

Table 2: Emerging Industrial Trends and Associated Fire Risks

Emerging Trend	Fire Safety Challenge	Cognitive Safety Solution
Lithium-Ion Batteries	Thermal Runaway	Predictive Thermal Monitoring
Autonomous Robotics	Reduced Human Observation	Continuous Equipment Intelligence
Additive Manufacturing	Combustible Materials	Dynamic Hazard Assessment
Digital Infrastructure	Sensitive Electronic Assets	Adaptive Suppression Selection
Climate Variability	Environmental Stress	Real-Time Risk Forecasting
Industrial Connectivity	Cyber Vulnerabilities	Integrated Cyber-Safety Monitoring

6. CRITICAL ANALYSIS OF THE COGNITIVE FIRE SAFETY INFRASTRUCTURE FRAMEWORK

The overall structure of the Cognitive Fire Safety Infrastructure is drastically different from the traditional industrial safety approach. Unlike any other product, it is not about introducing one technological breakthrough; it is about combining several different features with cognitive abilities into a single product.

An important advantage of this scheme is that it focuses on prediction instead of reaction. Traditional fire safety systems are only switched on when the environmental conditions trigger the alarm factors preprogrammed into the system. The proposed system continuously monitors and observes the operational behaviour and looks for anomalies before ignition. This forward-thinking approach can significantly decrease the likelihood of a fire at industrial sites, and when it does occur, the resulting damage. The framework will also be suitable for one of the major issues currently confronting industrial safety management, namely, the uncertainty of equipment readiness. However, maintenance is often performed according to the "rules" of renovation, which rely on periodic follow-ups and only offer system status at a particular point in time. Equipment can deteriorate and not be discovered between inspections. With Equip-Self-Awareness, the information gap is end-to-end removed, allowing continuous health monitoring and predictive maintenance of the equipment.

Another advantage of Dynamic Hazard Mapping is that it exists at the local level. Traditional detection systems trigger individual alarms and only inform you that there is a problem, but not what the problem is. Hazard mapping converts raw sensor data into easily understood information about the distribution of hazards, propagation routes for hazards and potential impacts. In certain cases, this capability will add to situational awareness and aid decision-making.

Adding adaptability to a fire protection system is not commonly found in traditional suppression systems—this is achieved in Autonomous Suppression Orchestration. This framework offers a space to consider incident-specific variables to decide what interventions

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to implement rather than using a standard response to incidents. In this way, collateral damage is minimised, and the effectiveness of the overall response is maximised.

However, several issues need to be addressed. First, monetary funds are required. Establishing intelligent sensors, building communication networks and platforms, and developing digital twin solutions involve huge capital expenditures. It can be challenging for SMEs to take the time to allocate their resources for complete implementation. Numerous IT-related challenges follow. Many facilities are still running "legacy" equipment that is not connected to the others. In some cases, significant alterations may be required to the existing infrastructure, and particular expertise may be necessary to make the retrofit installation. Other crucial considerations include data management. A large amount of data is supplied by the Cognitive Fire Safety Infrastructure, which needs to be captured, edited, stored, and secured. To achieve impact, successful implementation will be supported by existing data governance policies that can offer a robust framework of accuracy, reliability, and security. The issue of trust in autonomous judgment-making can also be addressed. This initial hesitation in using AI systems for making critical decisions in operations may be due to a lack of trust in the reliability of AI systems. To establish confidence in Cognitive Technologies, it is necessary to combine Transparency, Explainability, and reliable performance.

Under this framework, there are significant ethical issues to consider. The factors to consider when deciding on suppression priorities may include human safety, environmental protection, asset protection, and business continuity. It is important to develop ethical guidelines for programs that are autonomous safety systems. There is a tremendous amount of value in this form, but there are some downsides. Creating intelligent safety systems is not just a wish but a growing duty and obligation for a technologically complex environment with operation-integrating requirements.

7. RESULTS AND ANALYSIS

The framework was validated across all four industrial contexts using a scenario-based validation. The Equip-Self-Awareness pillar successfully detected anomalies fifteen to thirty minutes before traditional threshold-based detection systems, which is particularly useful in battery "thermal runaway scenarios". Tracking Fire Spreads was completed, and the Dynamic Hazard Mapping pillar allowed for targeted interventions. Chemical-aggressor incompatibility risks were estimated to be lowered by seventy per cent with the use of technologies in the Autonomous Suppression Orchestration pillar, instead of traditional systems. The six-performance metrics were compared with traditional, smart connected, and intelligent predictive approaches, and it was found that the CFSI framework had the best performance in terms of system adaptability. The potential challenges mentioned were sensor reliability issues, infrastructure needs for computing power and small-scale operation cost considerations.

8. DISCUSSION

The findings also support theory building, with a conceptualisation of safety as a mental ability of the organisation, rather than a package of safety-related equipment. This positions and supports the theory on Industry Resilience for autonomous Industry Environments. The framework calls for technology advances of resilience concepts, such as integrating continuous learning and adjustment to safety infrastructure. The framework offers a structured approach for practitioners to move from a reactive to a predictive safety management approach. The concepts of Industry 4.0 and 5.0 are included in the integration to achieve connectivity, human-centricity and sustainability goals. However, the autonomy of

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the decision-making process offers some merits to address empirical validation, cybersecurity and ethics that the process should be reviewed through real-world implementation of pilots.

9. IMPLICATIONS FOR INDUSTRY 4.0 AND INDUSTRY 5.0

The development of Cognitive Fire Safety Infrastructure has far-reaching implications for future industrial development. The role of safety systems and their requirement to change must match the organisation's drives for digital transformation and the requirements of production technologies. One of the main concepts in Industry 4.0 is automation, connection, and information-driven decisions that enable it to function. The principles of the Cognitive Fire Safety Infrastructure (CFSI) are seamlessly integrated with this concept, bringing safety management to life as an application. Fire safety is not a stand-alone compliance obligation but is part of the wider digital experience of an organisation.

Industry 5.0 emphasises human-centric innovation, sustainability, and resilience. The proposed framework is in support of these objectives and has an impact on human protection, as well as on sustainable operational practices. Intelligent suppression strategies have been developed to conserve unnecessary resource usage and reduce the environmental effects of fire incidents. The framework also includes the ability to respond to and manage disruptions, which contribute to organisational resilience. The hallmark of resilient organisations is their ability to adapt to, rather than avoid, and recover from incidents. Continual learning and adaptive responses are components of cognitive safety systems that support resilience.

On the labour side of the equation, the safety profession has also changed. Instead of being focused largely on inspections and emergency response work, safety managers are strategic decision-makers who work with intelligent systems to achieve the best results from risk management. Vocational training institutions also have their curricula to change. In addition to the knowledge and skills of safety engineering, future safety engineers must acquire skills in AI, Data Analytics, Cyber-Physical Systems and Digital Risk Management. The framework is also an important factor in the development of regulations. Current standards and compliance frameworks are largely based on technologies that require the input of a determinate condition. New approaches to certification, performance evaluation, and governance are required for the adoption of cognitive safety systems.

Table 3: Implications of Cognitive Fire Safety Infrastructure

Area	**Expected Impact**
Industrial Operations	Increased Continuity
Workforce Safety	Enhanced Protection
Asset Management	Reduced Losses
Sustainability	Lower Environmental Impact
Regulatory Systems	Modernized Standards
Organizational Resilience	Improved Adaptability

10. RECOMMENDATIONS

To achieve Cognitive Fire Safety Infrastructure, it is necessary to follow a strategy and be phased. The first step is to determine organisations where immediate value can be added by intelligent monitoring of high-risk operational areas. The first steps can be taken at battery storage plants, chemical processing facilities, and stand-alone production areas. This should be considered a priority investment for sensor infrastructure in the future. Excellent data are the essential soma of all mental abilities. Information is key; predictive analytics and decisions are ineffective without it. Comprehensive digital twin environments should be

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developed to facilitate simulations, forecasting, and risk assessment activities in organisations. Virtual environments offer great opportunities for test-ready safety strategies before they are used in practice.

The second major factor is encouraging staff training initiatives. The staff must be familiar with the practicalities, principles, and limitations of such systems. People and machines will collaborate better through ongoing education programs, and issues will be driven towards acceptance. Governments and regulations should be flexible and enable technological advances and safety. Modernisation of regulations is essential for making the use of intelligent safety equipment a widespread practice. Future studies should attempt to explore advanced applications of XAI techniques as they relate to Fire Safety. Increasing transparency contributes to building trust and better decision-making processes. Researchers must consider and develop opportunities to incorporate cognitive fire safety systems and other elements of organisational sustainability. Integration can have additional benefits related to environmental performance, resource efficiency, and social responsibility.

The field of study on industry-specific cognitive safety models has great potential. The operational characteristics differ across various industrial sectors, leading to variations in the types of applications of the proposed framework. These should ideally be ‘adaptive safety ecosystems' that continuously change and evolve alongside developments in technology and organisations.

11. CONCLUSION

Three key words that will be crucial to the future of industrial/factory fire safety are intelligence, adaptability, and prediction. Traditional protection systems have manifested their protective ability over the years and played a role in the industry; however, in the autonomous industrial field, some studies indicate that it is necessary to adopt an advanced risk management method. This study highlights that the ‘Cognitive Fire Safety infrastructure’ is very significant in the development of conceptual thinking in the area of industrial safety. The framework empowers the creation of intelligent, dynamic safety ecosystems through the use of Equip-Self-awareness, which provides devices with self-awareness; Dynamic Hazard Mapping, which allows the device to analyse hazardous environments; and Autonomous Suppression Orchestration to ensure autonomous suppression in the event of a fire. The framework focuses on reducing the impact of an incident or emergency by adopting a preventative approach rather than the impact once an incident has occurred. This transformation through continuous monitoring, predictive analysis, autonomous decision-making, and adaptive learning makes it a strategic asset and a resilient and ecological way of ensuring safety with organisational success.

The level of security required for industrial systems is progressively increasing with the growing autonomy and interconnection of these systems. The proposed framework demonstrates how new and advanced technologies can empower fire safety systems to not only respond to the event of a fire but also help prevent it. This transformation is critical for resilient, intelligent, and sustainable industrial ecosystems that can survive, succeed, and thrive in the rapidly changing environments of Industry 4.0 and Industry 5.0.

Traditional to cognitive safety is a long-term process that takes work and partnership between organisations and industries. The benefits may be great, from saving lives to limiting property damage, continuity of operations, and environmental impacts. The Cognitive Fire Safety Infrastructure blueprint spells out what that future is and how it is to be achieved. The concepts of cognitive safety are continuing to gain importance as industrial transformation

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continues and are becoming vital in an increasingly complex and autonomous era to safeguard humans, assets and the environment.

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