Fire Safety Technology: "The Future of Fire, New technology and Challenges with Implementation"

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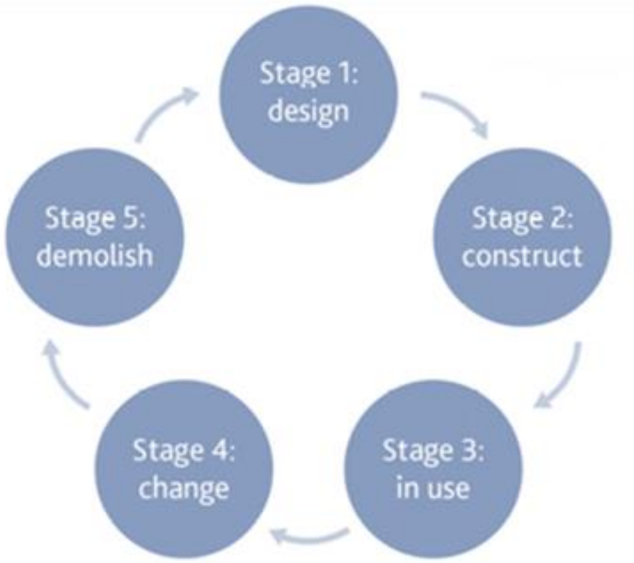
Fire Safety Is Changing

- Complex buildings & energy systems
- AI, IoT & smart infrastructure Driving
- Maintenance Digitisation, Drive for increased system reliability & Oversight Data-driven decision making
- New technology fire systems/approaches (eg Li-Ion)
- Limits of traditional prescriptive systems

Regulatory Framework

- NCC & AFEG as governing framework
- Standards AS1670, AS1530, AS1851 etc
- Technology must align with lifecycle



AFEG - Fire Safety Sub-Systems

Fire Safety interacts across six sub-systems (AFEG).

Understanding how new technology interacts with the sub-systems requires considering, if used as part of the fire safety approach.

<u>Examples of Sub-System Integration</u>

Detection and alarm:

Smart sensors feed data into BIM and digital twins for real-time risk assessment.

Suppression Systems:

Robotics and automated suppression units can be modelled as part of performance solutions for high-risk zones.

Smoke Control:

IoT-driven fans and dampers adjust dynamically based on sensor feedback during a fire event.

Egress:

Dynamic signage and AI-guided evacuation routes adapt to real-time conditions.

Icon	Sub-system
	Sub-system A SS-A Fire initiation & development & control (see Appendix A.1)
	Sub-system B SS-B Smoke development, spread & control (see Appendix A.2)
	Sub-system C SS-C Fire spread, impact & control (see Appendix A.3)
	Sub-system D SS-D Fire detection, warning & suppression (see Appendix A.4)
	Sub-system E SS-E Occupant evacuation & control (see Appendix A.5)
	Sub-system F SS-F Fire services intervention (see Appendix A.6)

Why Technology Is Being Introduced Now

Traditional fire systems:

- Highly proven
- Strong statistical backing
- Supported by decades of testing

New technology is driven by:

- Smart buildings
- Higher asset values
- Data centres and new energy risks

Shift from:

Static assumptions at design stage to Dynamic verification across the building life

Technology in the AFEG Design Process

Hazard Identification

- IoT sensors provide:
  - ✓ Real-time occupancy levels
  - ✓ Environmental conditions
  - ✓ System condition data

Scenario Development

- Digital twins simulate:
  - ✓ Multiple fire scenarios
  - ✓ Different occupant behavior's
  - ✓ System degradations

Outcome

- Better definition of design fires
- Stronger justification of assumptions

Evolution of Analytical Methods

Fire & Smoke Modelling

- CFD now enhanced with:
  - ✓ Real sensor data
  - ✓ Continuous validation of models

Evacuation Modeling

- AI improves:
  - ✓ Human behavior representation
  - ✓ Mobility-impaired modelling
  - ✓ Crowd dynamics

Verification

- Performance is no longer “assumed”
- Systems verified continuously through data

Technology in the AFEG Lifecycle

Documentation and Compliance

Blockchain:

- Immutable records of maintenance, commissioning, and performance tests align with AFEG's emphasis on transparency and auditability.

Digital Reporting*:*

- Automated compliance checks and smart contracts ensure adherence to NCC objectives.

Future AFEG Integration

- Moves from static design assumptions to adaptive, data-driven fire safety strategies.
- Enhance verification and validation through continuous monitoring and simulation.
- Supports regulatory confidence with transparent, traceable performance evidence.

AI Opportunities & Risks

- Improved prediction & modelling
- Black-box & liability risks
- Engineer accountability remains

AI tools lack the methodological transparency of FDS and other physics-based models, creating risks when signing off on designs. The legal profession/courts are likely to reject expert declarations containing AI-generated fabricated citations, which places liability on professional engineers.

Case Study: Fire Door Monitoring

Engineering Principles

- Applying Fire Engineering using AFEG
- Using AI for statistical analysis
- Understanding Reliability
- Probability of Successful operation increases ~80% → ~96% ?
- Traditional inspection limits
- IoT monitoring improves reliability

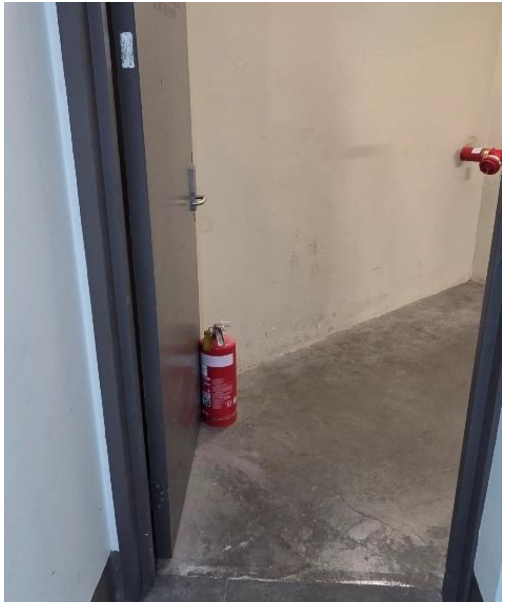
Case Study: Fire Door Monitoring

How Real Time Monitoring Improves Fire Door Success Probability

A fire door typically fails in real buildings due to:

- Being propped open
- Closer or latch failure that goes unnoticed
- Misalignment from building movement
- Damaged or missing smoke seals
- Lack of maintenance visibility

Real time monitoring addresses these failure modes.



Major Reduction in Obstruction Risk

Monitoring obstructions allows the following alerts:

- “door held open too long”, or
- “door not closed”, or
- “unauthorised wedging”

Fire Door Reliability

Effectiveness = Efficacy x Reliability
(ef-ih-kuh-see)
(The ability to produce a desired or intended result)

Fire Door monitoring modifies the reliability of the Fire Door System.

The reliability of a Fire Door can be determined via the following:

- P(success) = P(closer operates) × P(latch operates) × P(door unobstructed) × P(seals intact) × P(fire resistance maintained)
- Example (Source of Data not stipulated):
    - Closer works: 0.97
    - Latch engages: 0.95
    - Door unobstructed: 0.90
    - Seals intact: 0.98
    - Fire resistance maintained: 0.995

Concept	Meaning	Fire Door Example
Efficacy	Maximum performance under test conditions	Passed AS1530.4 test for 120 minutes integrity
Effectiveness	Actual performance in a real building	Keeps smoke and fire out during an actual fire, assuming proper installation
Reliability	Consistency of performance over time	Door self-closes properly every day without being wedged open or damaged

Fire Door Reliability

Overall probability of success (**without monitoring**)

P(Success) = 0.97 × 0.95 × 0.90 × 0.98 × 0.995 0.995≈ 0.80 **(80%)**

Overall probability of success (**with monitoring**)

P(Success) = 0.995 × 0.985 × 0.98 × 0.995 × 0.995 ≈ 0.96 **(96%)**

AI generated Monte Carlo analysis

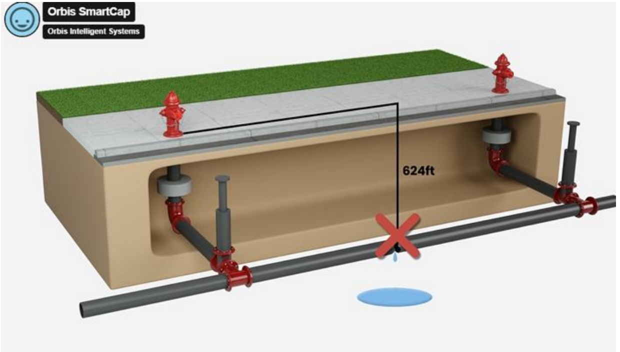
- Overall success ≈ 0.81 (81%)
- 90th percentile ≈ 0.89
- % of scenarios ≥ 0.90 success = 3.2%

Factor	Before	After Monitoring
Closer works	0.97	0.995
Latch engages	0.95	0.985
Unobstructed	0.90	0.98
Seals intact	0.98	0.995
Fire resistance OK	0.995	0.995

**The reliability of the Fire Door monitoring system is difficult to quantify given the lack of data on the efficacy or reliability of the system itself – lack of test standards.

Smart Suppression & Detection

- Smart extinguishers
- Enhanced alarm networks
- Wet fire Pressure & flow diagnostics



Smart Fire Extinguishers

Trigger Events

Pressure Loss
Fault notification when extinguisher loses pressure beyond factory set threshold

Pin-Pull / Tamper
Issue of Pre-Alarm Event if extinguisher is armed and ready for discharge

Battery Voltage Low
Issues a fault notification with low voltage issues

Extinguisher moved
Fault notification when disengaged
Normal location event when reinstated to normal

Obstruction Sensor
If extinguisher is obstructed a notification will be sent on a daily heartbeat

Benefits

Standards Compliance
Electronic monitoring compliant with SS578

Maintenance Efficiency
Reduction of on-site manual maintenance frequency and the validation of on-site maintenance

Real-Time Alerts
Real time monitoring and notification / messaging to FireM

Tamper Protection
Theft notification, obstruction and pin-pull monitoring

Lithium-Ion Fire Challenges

- New hazards
- NTA (Netherlands) 8133 tested extinguishers
- Australian compliance gaps (No Class L)

Efficacy - can only be determined to a recognised benchmark or test which is usually a test certificate from an approved testing authority.

Concept	Meaning	Fire Extinguisher Example
Efficacy	Maximum performance under test conditions	Fire is suppressed. Extinguisher operates. Eg compliance with performance standard AS1841
Effectiveness (successful suppression)	Actual performance in a real fire	Supresses/Extinguish Fire
Reliability	Consistency of performance over time	AS1851 dictates maintenance requirements. Extinguisher regularly serviced. Note that only 6 monthly service requirements under AS1851. Other International standards require monthly visual.

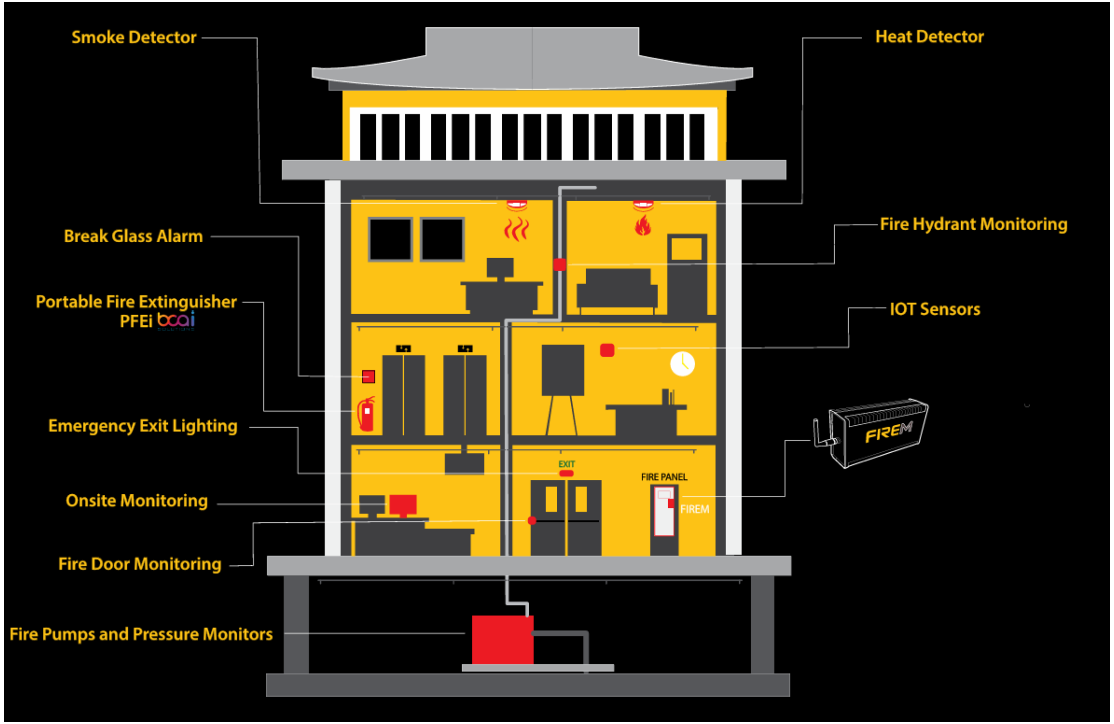
Remote Monitoring & Response

Remote management allows for quick adjustments and updates to fire safety protocols based on evolving threats or changes in occupancy patterns.

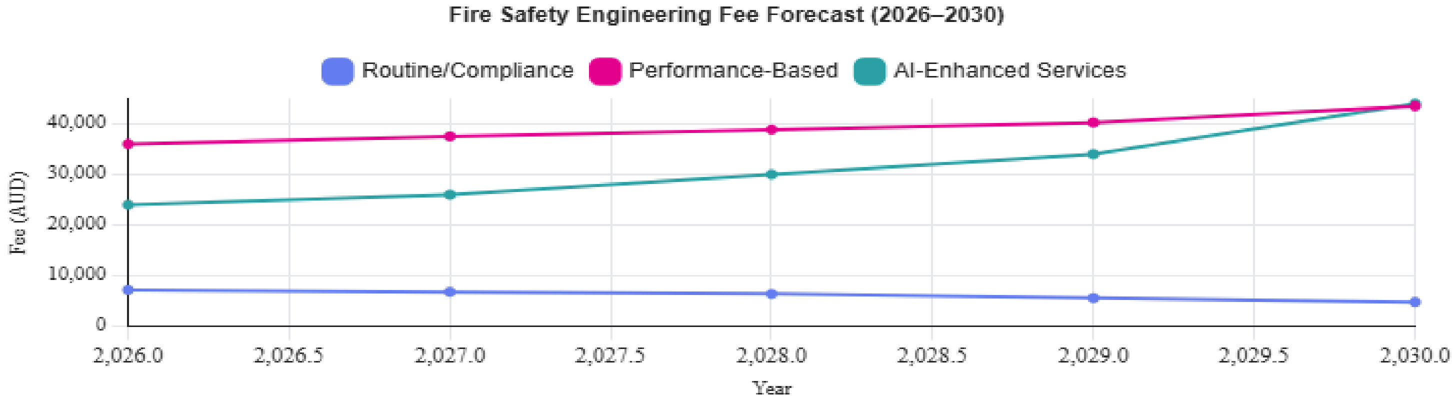
Platform e.g. FireM, Nimbus (Ampac) or Honeywell (CLSS) provide oversight and maintenance reporting.

Improved emergency response pin pointing Fire Alarm locations for fast incident response.

Improved maintenance reporting, critical fault notifications



AI Impact on Design Services

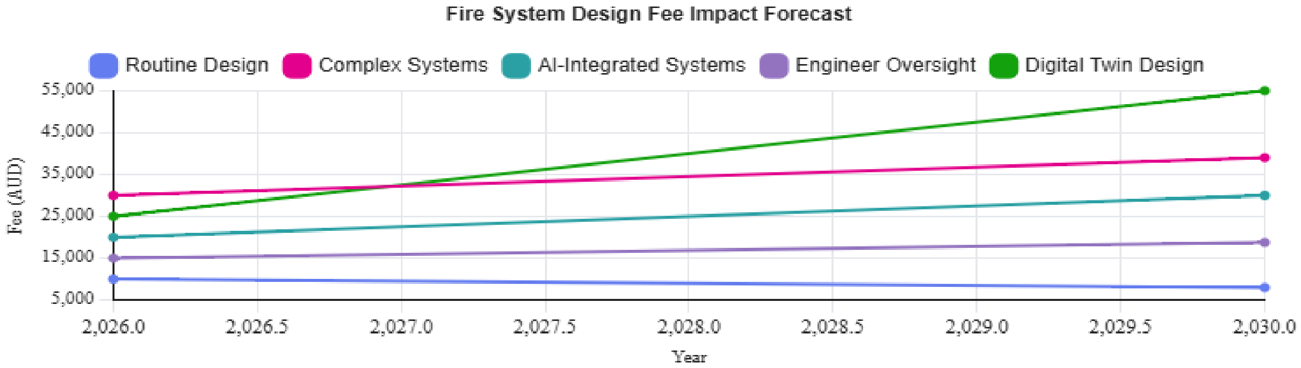


Routine/low complexity work becomes cheaper (AI automation & client price pressure): AI is already reducing labor costs for data analysis and routine tasks in consulting, leading to lower billable-hour justification.

Expert judgement, verification, and sign off becomes more expensive (liability increases): AI black box risks and legal cases rejecting AI generated errors increase responsibility on licensed professionals.

AI enabled services (digital twins, predictive modelling, outcomes-based pricing): Consulting sectors adopting AI are shifting from hourly billing to outcomes-based pricing, increasing revenue potential for data verified value delivery.

AI Impact on Design Services



System Type	Fee Trend	Client Benefit
Traditional / Routine Systems	↓ Slightly lower	Lower design cost due to automation
Complex Multi-Trade Systems	↑ Moderate increase	Better coordination, fewer errors
AI-Integrated Systems	↑ Significant increase	Faster detection, reduced downtime
Engineer-off-Record Certification	↑ Moderate increase	Regulatory assurance & liability protection
Digital Twin & Next-Gen Systems	↑ Major increase	Real-time risk insight & lifecycle optimization

Key Takeaways

- Embed tech using AFEG principles
- Understand the risks of applying new technology systems and engineering approaches
- Enhance — don't replace traditional fire systems
- Maintain professional judgement