SELINUS UNIVERSITY
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FIRE SAFETY AND OPERATIONAL RISK GOVERNANCE IN SCHOOL BUILDINGS: APPLICATION OF ITALIAN LEGISLATIVE FRAMEWORKS D.M. 26/08/1992, D.M. 03/08/2015 AND D.M. 01/09/2021, D.M. 02/09/2021, D.M. 03/09/2021

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"I once wanted to understand why I was so busy,
but I never found the time to do it."
GMR

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ABSTRACT

Title: "FIRE SAFETY AND OPERATIONAL RISK GOVERNANCE IN SCHOOL BUILDINGS: APPLICATION OF ITALIAN LEGISLATIVE FRAMEWORKS D.M. 26/08/1992, D.M. 3/08/2015 AND D.M. 01/09/2021, D.M. 02/09/2021, D.M. 03/09/2021"

This thesis addresses the systemic challenge of fire safety within Italy's school building inventory, which is marked by an alarming 64.5% regulatory compliance gap (ISTAT, 2023) that exposes millions of students and staff members to tangible risks. The research stems from the imperative to overcome challenges posed by aging infrastructure, the complex transition from a prescriptive regulatory approach, namely D.M. 26/08/1992, to a performance-based one introduced by D.M. 3/08/2015 (the Italian Fire Prevention Code) and the subsequent decrees of September 2021, and the fragmentation of managerial responsibilities.

The primary objective of this study is the development of an integrated operational risk governance framework, conceived as a methodological tool to support decision-makers in the planning, implementation, and monitoring of safety measures. The framework aims to integrate normative, technical, managerial, and financial dimensions into a holistic and sustainable approach.

The methodology is based on a systematic documentary analysis of scientific literature and the evolution of Italian regulations, combined with an empirical validation grounded in concrete evidence. Specifically, the research analyzes implementation data from over €300 million in investments from the National Recovery and Resilience Plan (PNRR) and other ministerial funds. This is achieved through representative case studies (provinces of Frosinone, the Emilia-Romagna region, and the Abruzzo region) that demonstrate the effectiveness and scalability of the proposed governance models.

The results confirm the validity of the developed multi-level framework (strategic, tactical, operational, and control), which has proven capable of guiding effective interventions

and generating a positive return on investment. This is supported by industry studies (ASL Torino 3 - INAIL) that correlate prevention measures with a significant reduction in injuries. The research proposes a 5.1-year national implementation roaD.M.ap with an estimated investment of €635 million, sustainable through a diversified mix of funding sources.

In conclusion, this thesis not only fills a significant gap in the literature specific to the Italian context but also provides an operational, economically sustainable, and scalable tool to transform fire safety management in schools. The proposed framework establishes a solid foundation for policymakers, with the aim of raising safety standards, promoting a culture of prevention, and ensuring safe learning environments for future generations.

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Study Context

Fire safety in school buildings represents one of the most critical challenges of the contemporary Italian educational system. The national school building heritage, composed of approximately 60,000 buildings, presents an alarming picture in terms of regulatory compliance: according to ISTAT data (2023), only 35.5% of state school buildings comply with fire safety regulations, which means that 64.5% of structures do not conform to safety requirements. This figure acquires an even more concerning dimension when we consider that Italian school buildings are demographically old, with nearly 39,000 buildings constructed between 1960 and 1976.

The geographical distribution of the phenomenon highlights a significant territorial divide: the situation is particularly critical in the South, where 70.9% of school buildings do not possess fire prevention certificates, followed by the Center (69.2%) and the North (55.4%). This scenario represents a concrete threat to the safety of over 7 million students and tens of thousands of school operators who daily attend these environments.

1.2 Problem Definition

The issue of fire safety in Italian schools is articulated in a complex matrix of interconnected challenges that transcend mere regulatory compliance. The 64.5% implementation gap highlighted by ISTAT data represents only the tip of the iceberg of a system characterized by multiple structural criticalities.

1.2.1 Regulatory Complexity and Paradigmatic Transition

The Italian regulatory framework has undergone significant evolution in recent decades, transitioning from the prescriptive approach of D.M. August 26, 1992 "Fire prevention standards for school buildings" (D.M. 26 agosto 1992 "Norme di prevenzione incendi per l'edilizia scolastica") to the performance-based model introduced by D.M. August 3, 2015 (D.M. 3 agosto 2015) (Fire Prevention Code - Codice di Prevenzione Incendi). This transition, while necessary to adapt the regulatory system to modern safety requirements, has generated a complex regulatory stratification that requires specialized competencies to be navigated effectively.

The transition from the prescriptive method, based on "compliance with specific requirements in the project" that "represents the guarantee of achieving minimum safety levels," to the performance-based method, which "is based on the study of the dynamic evolution of fire and therefore on the scientific prediction of performance," has entailed greater accountability for designers and an increasing need for advanced technical-scientific competencies.

1.2.2 Aging Building Heritage and Intervention Complexity

The Italian school building heritage presents structural characteristics that make adaptation interventions particularly complex. Most buildings, constructed in eras preceding the introduction of modern safety regulations, require significant structural interventions that often involve high costs and prolonged implementation times. This reality has led to repeated extensions of adaptation deadlines, with the latest extension to December 31, 2027 provided for by the 2025 milleproroghe decree.

1.2.3 Fragmentation of Responsibilities and Governance

The fire safety governance system in schools presents a fragmentation of responsibilities that further complicates the implementation of safety measures. While obligations relating to building safety formally fall on the school principal as employer, the implementation of compliance works falls to property owners (municipalities and provinces). This division of responsibilities often generates delays and inefficiencies in implementing necessary interventions.

1.3 Research Objectives

This study proposes to develop an integrated operational risk governance framework for fire safety in school buildings that is capable of systematically addressing the identified criticalities. The main objective is to provide a methodological tool that supports decision-makers in planning, implementing, and monitoring fire safety measures, integrating regulatory, technical, managerial, and financial dimensions in a holistic approach.

Specifically, the research aims to:

1. **Systematize regulatory evolution**: Critically analyze the transition from the prescriptive to performance-based paradigm, identifying opportunities and challenges for practical application.

2. **Develop an integrated governance model**: Propose a framework that effectively coordinates the different responsibilities and competencies involved in the fire safety regulatory compliance process.

3. **Optimize resource allocation**: Define intervention prioritization criteria based on multi-criteria evaluations that consider risk, technical feasibility, and economic sustainability.

4. **Promote safety culture**: Integrate training and awareness elements for all stakeholders involved in the process into the framework.

5.

1.4 Research Questions

The research is structured around four fundamental questions that guide the investigation:

1. How can the Italian regulatory evolution in school fire safety be systematized to support better understanding and application of current provisions?

2. What operational risk governance framework can be developed to effectively coordinate the different responsibilities and competencies involved in fire safety management in school buildings?

3. What prioritization criteria can be adopted to optimize the allocation of resources destined for fire safety adaptation interventions, simultaneously considering technical, economic, and safety aspects?

4. How can a safety culture be promoted that involves all stakeholders of the educational system in proactive fire risk management?

1.5 Literature Review

1.5.1 Fire Safety Governance: Theoretical Foundations

Scientific literature on safety governance has identified in the contributions of James Reason (1997) and Andrew Hopkins (2005) some of the fundamental theoretical pillars for understanding how organizations manage operational risks. Reason (1997) introduced the concept of "safety culture" as the capacity of individuals and organizations to manage hazards

and risks to avoid harm or losses, distinguishing between active errors and latent errors in the organizational system. His theory of the systemic approach emphasizes that "errors are consequences of organized action, and not the cause of system failure," shifting attention from individual responsibilities to systemic conditions that favor or prevent accidents.

Hopkins (2005) further developed these concepts, emphasizing the importance of centralized organizational structure in promoting a culture favorable to safety. His work highlighted how effective safety governance requires not only adequate policies and procedures, but also committed leadership and open communication systems that facilitate reporting and learning from errors.

These theoretical contributions provide the conceptual foundations for understanding how fire safety in school buildings cannot be considered simply as a technical issue, but requires a systemic approach that integrates organizational, cultural, and managerial aspects.

1.5.2 Performance-Based Approaches: From Prescription to Performance

The evolution toward performance-based approaches in fire safety has found one of its greatest exponents in Brian Meacham (2004), who theorized the transition from rigidly prescriptive regulatory systems to more flexible performance-based frameworks. Meacham (2004) developed an eight-level hierarchy for performance-based regulatory systems, which includes the definition of performance groups, performance levels, and measurement criteria. This approach allows greater design flexibility, enabling innovative solutions that maintain or exceed traditional safety levels.

Meacham's work significantly influenced the development of the Italian Fire Prevention Code (D.M. August 3, 2015 - D.M. 3 agosto 2015), which represents the attempt to implement a performance-based approach in the national regulatory context. However, as highlighted by the literature, the adoption of performance-based approaches requires

advanced technical competencies and greater accountability of designers, aspects that are particularly challenging in the context of existing school buildings.

1.5.3 Operational Risk Management: Systematic and Multi-Criteria Approaches

Systematic Management Framework

The need for systematic approaches in fire safety management in school structures has been effectively documented by Hassanain et al. (2022), who developed a specific framework for fire safety management in schools. Their research highlighted how "schools are high-risk structures in fire emergencies," requiring "the implementation of safety measures that include aD.M.inistrative and operational efforts to mitigate the occurrence of fire incidents."

The framework proposed by Hassanain et al. is articulated in eight systematic phases:

1. collection of all records on school structures,
2. identification of possible fire sources,
3. identification of fire safety requirements,
4. development of an inspection checklist,
5. review of collected records,
6. conduction of safety inspection,
7. analysis and reporting of results,
8. recommendation of an improvement action plan.

This methodological approach provides an operational structure that can be easily adopted for safety management in school structures, representing an international best practice for addressing safety management in educational structures through a systematic multi-phase approach.

Multi-Criteria Approaches for Refurbishment

The complexity of refurbishment interventions, especially for historical building heritage, has been explored in depth by Guarini et al. (2020) in their study on historical school buildings. Their research highlighted how "many buildings destined for education need refurbishment, both from structural and plant engineering perspectives, and regarding the management of available spaces for teaching and social activities."

Guarini et al. proposed a multi-criteria evaluation protocol to support planning of refurbishment interventions for existing school buildings, which allows "establishing design priorities to be implemented in accordance with building characteristics and community needs." This approach recognizes that school building refurbishment requires simultaneous consideration of technical, functional, economic, and social aspects, emphasizing the importance of multi-criteria approaches to define intervention priorities, specifically including fire safety as a fundamental element of the decision-making process.

Integrated Measures of Safety, Health, and Education

The need for a holistic approach to fire safety in schools has been further reinforced by the study of Seyedin et al. (2020), who conducted a systematic review of health, safety, and fire education measures in schools. Their research identified critical interconnected factors that influence school fire safety, highlighting how "observing health and safety rules and education in schools and promoting the level of preparedness of students, their families and school personnel regarding fires seems very effective in preventing and adequately responding to incidents."

Seyedin et al. demonstrated that effective fire risk management in schools requires the integration of various elements: regulations, budget, personnel training, risk analysis, and technical equipment. Their work shows how a holistic vision is necessary to address the complexity of school fire safety, integrating management actions that include "establishing

and implementing laws and regulations, considering and allocating sufficient budget for safety and education measures, education and training with the best methods" and technical-specialist actions such as "cooperation and interaction between schools and external organizations such as firefighters, emergency medical services, municipalities, hospitals."

1.5.4 Literature Gaps

Despite the richness of international studies on fire safety management and risk governance frameworks, a significant gap emerges in literature specific to the Italian context. Most existing studies focus on regulatory and organizational contexts different from the Italian one, where regulatory stratification, fragmentation of responsibilities, and specific characteristics of school building heritage create unique challenges.

Furthermore, while the literature offers important contributions on individual aspects of the issue (governance, performance-based approaches, risk management), an integrated framework is lacking that simultaneously considers Italian regulatory evolution, the specificities of national school building heritage, and the operational needs of involved stakeholders.

This study intends to fill this gap by developing an operational risk governance framework specifically designed for the Italian context, which integrates international theoretical contributions with the regulatory, technical, and organizational specificities of the national educational system, providing an operational tool to improve fire safety management in Italian school buildings.

CHAPTER 2: ANALYSIS OF THE REGULATORY FRAMEWORK

2.1 Introduction to the Italian Regulatory Framework

The Italian regulatory system for fire safety in school buildings has undergone a radical transformation over the last three decades, transitioning from a rigidly prescriptive approach to a flexible performance-based system. This evolution has been articulated through three main legislative phases: the foundational framework of D.M. August 26, 1992 (D.M. 26/08/1992), the performance-based revolution of D.M. August 3, 2015 (D.M. 3/08/2015), and the operational consolidation of D.M. September 2, 2021 (D.M. 2/09/2021).

The analysis of this regulatory framework is essential for understanding current implementation challenges and optimization opportunities in school fire safety governance. Each regulatory phase has introduced different conceptual paradigms, requiring educational institutions to make significant adaptations in technical competencies, operational procedures, and managerial approaches.

2.2 The Prescriptive Framework: D.M. August 26, 1992

2.2.1 Fundamental Characteristics

The Ministerial Decree of August 26, 1992 "Fire prevention standards for school buildings" (D.M. 26 agosto 1992 "Norme di prevenzione incendi per l'edilizia scolastica") represented the first systematic attempt to regulate fire safety in Italian educational buildings. This decree established a completely prescriptive framework, characterized by rigid and

standardized requirements applicable regardless of the specific architectural or operational characteristics of individual institutions.

The impact of D.M. 26/08/1992 is documented in current data: according to ISTAT (2023), despite three decades of regulatory evolution, only 35.5% of state school buildings currently comply with fire safety regulations, highlighting the historical implementation difficulties that have characterized the prescriptive framework.

Prescriptive Regulatory Structure

D.M. 26/08/1992 was based on a deterministic approach that defined standard technical solutions for typical fire safety problems. The provisions were organized by building type and occupancy density, with specific requirements for:

- Fire resistance of load-bearing and separating structures
- Fire detection and alarm systems
- Automatic extinguishing systems
- Escape routes and emergency exits
- Emergency lighting and safety signage

Advantages of the Prescriptive Approach

The 1992 prescriptive system presented significant advantages in terms of application clarity and solution standardization. Designers and safety managers could directly apply regulatory prescriptions without the need for complex technical analyses or specialized risk assessments. This approach guaranteed a uniform minimum level of safety across all Italian educational institutions.

Limitations of the 1992 Framework

However, the rigidly prescriptive approach presented significant limitations:

- **Architectural Inflexibility**: Standard solutions often did not adapt to the specific characteristics of historic buildings or those with particular architectural configurations
- **Lack of Optimization**: The impossibility of customizing solutions often resulted in oversizing or underutilization of safety systems
- **Limited Innovation**: The framework discouraged the adoption of innovative technologies or advanced engineering solutions
- **High Costs**: Forced standardization could result in economically inefficient solutions

2.2.2 Impact on Educational Institutions

The implementation of D.M. 26/08/1992 had a profound impact on Italian educational institutions, requiring significant adaptations for both new constructions and existing buildings. Schools had to develop specific competencies for managing regulatory compliance, often relying on external consultants for the interpretation and application of technical requirements.

Principal Implementation Challenges

- Adaptation of historic buildings with architectural constraints
- High costs for implementing standardized solutions
- Need for specialized training for technical personnel
- Bureaucratic complexities in approval processes

2.3 The Performance-Based Revolution: D.M. August 3, 2015

2.3.1 Fire Prevention Code Paradigm

The Ministerial Decree of August 3, 2015, known as the "Fire Prevention Code" (Codice di Prevenzione Incendi), introduced a paradigmatic revolution in the Italian regulatory landscape. This decree abandoned the rigidly prescriptive approach in favor of performance-based methodologies based on risk assessment and fire safety engineering.

Fundamental Principles of D.M. 3/08/2015

The new framework is based on three fundamental conceptual pillars:

1. **Performance-Based Approach**: Safety solutions must demonstrate the achievement of specified performance objectives, regardless of the technical methodology employed
2. **Risk Assessment**: Each project must include a systematic analysis of specific risks, considering the unique characteristics of the activity and building
3. **Fire Safety Engineering (FSE)**: Use of scientific methodologies and advanced calculation tools for the design and verification of safety solutions

Methodological Structure

D.M. 3/08/2015 introduces a methodological structure articulated in three levels of depth:

- **Level I - Conforming Solutions**: Updated prescriptive solutions that guarantee satisfaction of safety objectives

- **Level II - Alternative Solutions**: Technical solutions different from conforming ones but equivalent in terms of safety performance
- **Level III - Derogation Solutions**: Solutions that deviate from prescribed safety measures, requiring specific risk assessments

2.3.2 Application in School Buildings

The application of D.M. 3/08/2015 in school buildings has introduced new opportunities and significant challenges. The decree classifies school activities in the "Activity 67" category of Title I, with specific graduations based on the number of simultaneous occupants.

Classification of School Activities

- Activity 67.1.A: Schools with simultaneous presence from 101 to 300 people
- Activity 67.1.B: Schools with simultaneous presence from 301 to 500 people
- Activity 67.1.C: Schools with simultaneous presence from 501 to 800 people
- Activity 67.2.A: Schools with simultaneous presence from 801 to 1200 people
- Activity 67.2.B: Schools with simultaneous presence exceeding 1200 people

Fire Safety Measures for Schools

D.M. 3/08/2015 defines specific measures for school buildings through:

1. **Fire reaction of materials (Chapter S.1)** ◦ European classification of materials according to EN 13501-1 ◦ Specific requirements for floors, coverings and furnishings ◦ Criteria for materials in escape routes and safe spaces

2. **Fire resistance of structures (Chapter S.2)** ◦ Classification methods according to EN 13501-2 ◦ Differentiated resistance requirements for structural elements ◦ Criteria for compartmentalization and separations

3. **Compartmentalization (Chapter S.3)** ◦ Principles of subdivision into fire compartments ◦ Requirements for fixtures and closures ◦ Management of penetrations and joints

4. **Escape (Chapter S.4)** ◦ Calculation methodologies for escape capacity ◦ Design criteria for escape routes ◦ Requirements for emergency exits and safe places

5. **Fire safety management (Chapter S.5)** ◦ Emergency plans and operational procedures ◦ Personnel training and education ◦ Maintenance and periodic controls

2.3.3 Methodological Innovations

D.M. 3/08/2015 has introduced innovative methodologies specifically relevant for school buildings:

Fire Risk Assessment (Chapter G.2)

The methodology provides for:

- Systematic identification of fire hazards
- Analysis of potential consequences
- Assessment of occurrence probabilities
- Risk determination and definition of reduction measures

Fire Safety Engineering (Chapter G.3)

FSE tools include:

- Calculation models for evacuation (e.g., EVACNET, FDS+Evac)
- CFD simulations for smoke and heat propagation

- Probabilistic risk analyses
- Cost-benefit evaluations of safety measures

2.4 Operational Consolidation: The September 2021 Decrees

2.4.1 Objectives and Philosophy of the New Decrees

The Ministerial Decrees of September 1, 2, and 3, 2021, represent the evolution and consolidation of the performance-based framework introduced by D.M. 3/08/2015. These decrees do not constitute a radical revision of the performance-based philosophy, but rather a refinement based on the implementation experience of the first years and the need for operational clarifications that emerged from professional practice.

The three September 2021 decrees introduced specific innovations:

- **D.M. September 1, 2021 - Controls and Maintenance**

Establishes "general criteria for the control and maintenance of systems, equipment and other fire safety systems," introducing the figure of the Qualified Fire Maintenance Technician as a regulated profession. The decree requires the employer to "verify the technical-professional requirements of fire safety equipment maintenance companies" and to "prepare the control register where to record the maintenance technician's verifications of ALL fire safety equipment."

- **D.M. September 2, 2021 - Fire Safety Management (GSA)**

Defines "criteria for the management of workplaces in operation and in emergency and characteristics of the specific fire prevention and protection service," completing aspects related to fire safety personnel training and operational emergency management.

- **D.M. September 3, 2021 - Mini-Code**

Introduces "general fire safety design criteria for workplaces" at low risk, providing "simplified criteria for fire risk assessment" to fill the "regulatory gap" for unregulated activities.

Principles of Continuity and Innovation

The three decrees maintain the fundamental principles of the performance-based approach, while introducing important innovations:

1. **Procedural Simplification**: Reduction of bureaucratic and administrative complexity
2. **Professional Qualification**: Definition of standards for maintenance technicians
3. **Operational Management**: Standardized procedures for daily and emergency management
4. **Optimization for Small Activities**: The mini-code for low-risk activities

2.4.2 Specific Modifications for School Buildings

Application of the Mini-Code in Schools

D.M. September 3, 2021 (mini-code) has particular relevance for school buildings, applying to "low fire risk workplaces" including many small schools. The decree applies specifically to schools with:

- ≤100 occupants
- Surface ≤1000 m²
- Floors between -5m and 24m

According to sector research, the mini-code has introduced "a simplification philosophy for all fire safety strategy measures, in order to provide a streamlined and easily usable tool even for those who do not have excessive 'confidence' with fire safety design."

Maintenance Management in Schools

D.M. September 1, 2021 has significant impacts on operational school management, requiring:

- **Qualified Maintenance Technicians**: Only certified personnel can perform maintenance on fire safety systems
- **Control Register**: Systematic documentation of "verifications, controls and maintenance operations on fire safety systems, equipment and installations"
- **Internal Surveillance**: Internal personnel trained for daily controls

Updated Emergency Plans

D.M. September 2, 2021 has standardized criteria for school emergency plans, requiring integration between "operational procedures in operation" and "emergency procedures," considering the specific needs of school populations.

2.4.3 Procedural Simplifications

Accelerated Approval Procedures

D.M. September 2, 2021 introduces simplified procedures for specific categories of interventions:

- **Extraordinary Maintenance Interventions**: Accelerated procedures for non-structural adaptations
- **Technological System Replacement**: Simplified procedures for upgrading existing systems
- **Non-Substantial Modifications**: Abbreviated procedures for minor variations

Optimized Technical Documentation

- **Standardized Forms**: Pre-compiled forms for recurring types of interventions
- **Compliance Checklists**: Self-assessment tools for professionals
- **Digital Procedures**: Integration with regional telematic platforms

2.5 Comparative Analysis: D.M. 3/08/2015 vs September 2021 Decrees

2.5.1 Methodological Continuity

The comparative analysis between D.M. 3/08/2015 and the three September 2021 decrees highlights substantial continuity in fundamental methodological principles:

Confirmed Performance-Based Approach

All decrees maintain the performance-based structure and emphasis on risk assessment as a design tool. D.M. September 3, 2021 preserves "the same language and the same 'risk-based' performance-based approach of the Fire Prevention Code," while simplifying application.

Maintenance of FSE Philosophy

Fire safety engineering methodologies remain the technical foundation, with incremental updates in calculation tools and acceptability criteria.

Stable Activity Classification

The "Activity 67" classification for schools remains substantially unchanged in structure, with interpretative refinements rather than substantial modifications.

2.5.2 Innovations and Improvements

Operational Simplification

The 2021 decrees introduce significant simplifications:

Aspect	D.M. 3/08/2015	2021 Decrees	Impact
Maintenance	Generic criteria	D.M. 01/09: Mandatory qualified technicians	Sector professionalization
Emergency management	General principles	D.M. 02/09: Standardized procedures	Application uniformity
Small activities	Not specifically regulated	D.M. 03/09: Dedicated mini-code	Complete regulatory coverage
Approval procedures	Complex	Simplified for specific categories	Reduced bureaucratic burden

Sector Professionalization

D.M. September 1, 2021 has introduced a paradigm shift in maintenance, with the obligation of qualified technicians that, according to sector experts, "will level companies upward, raising the qualitative level of services offered, thanks to greater technical competence."

Interpretative Clarifications

Main clarification areas in the 2021 decrees:

1. **Qualification Criteria**: Standardized procedures for maintenance technician certification
2. **Operational Management**: Definition of specific responsibilities for daily management
3. **Documentation**: Standardization of control and maintenance registers

Technological Updates

- **New Materials**: Integration of criteria for innovative materials and technologies
- **Intelligent Systems**: Procedures for using "smart" safety systems
- **Sustainability**: Consideration of environmental sustainability criteria in evaluations

2.5.3 Implementation Implications

Positive Operational Impacts

The 2021 decrees have introduced significant improvements:

1. **Complexity Reduction**: The mini-code simplifies application for small schools
2. **Greater Professional Certainty**: Mandatory qualification of maintenance technicians increases service quality
3. **Managerial Standardization**: Unified procedures for emergency plans and operational management
4. **Complete Regulatory Coverage**: The mini-code fills the gap for previously unregulated activities

Persistent Implementation Challenges

Despite improvements, significant challenges highlighted by current data persist:

- **Compliance Gap**: Only 35.5% of Italian schools comply with fire safety regulations (ISTAT, 2023)
- **Missing Certification**: 64.5% of schools do not possess fire prevention certificates
- **Structural Problems**: 69 collapses recorded in schools in 2023-2024 (Cittadinanzattiva, 2024)
- **Necessary Investments**: 98 million euros allocated but mandatory adaptation by December 31, 2027

Transition Challenges

The transition to new decrees presents specific difficulties:

- **Maintenance Technician Training**: Need to qualify thousands of technicians within deadlines

- **System Updates**: Adaptation of existing procedures and documentation
- **Territorial Coordination**: Uniform implementation on a national scale

2.6 Specific Requirements for School Buildings

2.6.1 Technical Requirements Analysis

Design Parameters

The decrees establish specific parameters for fire safety design in schools:

1. **Occupancy Density** ◦ Standard classrooms: 1.2 people/m² ◦ Laboratories: 1.5 people/m² ◦ Gymnasiums: 0.7 people/m² ◦ Auditoriums: According to seating configuration

2. **Flow Velocity** ◦ Horizontal routes: 1.2 m/s ◦ Stairs: 0.6 m/s ◦ Doors: Variable according to width

3. **Evacuation Times** ◦ Pre-movement time: 120 seconds ◦ Total escape time: < 8 minutes ◦ Safety margins: Factor 2

Active Protection Systems

Requirements for detection and alarm systems:

- **Coverage**: Complete coverage of spaces, including technical rooms
- **Detector Type**: Optical or thermal according to environment
- **Control Panel**: With failure and tampering signaling
- **Power Supply**: Dual (mains + batteries for 72h)

Requirements for extinguishing systems:

- **Sprinkler Systems**: Mandatory for Activity 67.2

- **Hydrants**: UNI 45 for schools > 500 people
- **Fire Extinguishers**: One every 150 m² of surface

2.6.2 Emergency Management Procedures

Emergency Plans

The decrees require specific emergency plans that include:

1. **Specific Risk Analysis** ◦ Identification of emergency scenarios ◦ Assessment of specific vulnerabilities ◦ Definition of intervention priorities

2. **Operational Procedures** ◦ Action sequences for personnel ◦ Evacuation methods by user type ◦ Coordination with external rescue services

3. **Training and Education** ◦ Training programs for all personnel ◦ Periodic evacuation drills ◦ Annual training updates

Vulnerable Population Management

Specific requirements for:

- **Preschool children**: Assisted evacuation procedures
- **People with disabilities**: Personalized evacuation plans
- **Safe waiting areas**: Sizing and location

2.7 Implementation Challenges and Regulatory Gaps

2.7.1 Application Complexity

Existing Buildings

Most Italian schools operate in buildings constructed before the introduction of performance-based decrees, creating specific challenges:

- **Architectural Constraints**: Difficulty of adaptation without structural upheavals
- **Adaptation Costs**: Investments often exceeding budget availability
- **Operational Continuity**: Need to maintain educational activities during work

Professional Competencies

Effective implementation requires specialized competencies often not available:

- **FSE Engineering**: Shortage of qualified professionals
- **Integrated Management**: Need for multidisciplinary coordination
- **Continuous Updates**: Rapid evolution of technologies and methodologies

2.7.2 Identified Gaps

Interpretative Standardization

Despite the clarifications of D.M. September 2, 2021, interpretative variations persist between:

- Different Italian regions
- Sector professionals
- Control bodies

Integration with Other Regulations

Need for greater coordination with:

- Structural regulations (NTC 2018)
- Public Procurement Code
- Accessibility regulations
- Local building regulations

Economic Sustainability

Lack of tools for:

- Standardized cost-benefit evaluation
- Intervention prioritization criteria
- Dedicated financing mechanisms

2.8 Chapter Conclusions

The analysis of the Italian regulatory framework highlights significant evolution toward more flexible and scientifically based approaches for fire safety management in school buildings. The transition from the prescriptive system of D.M. August 26, 1992, through the performance-based innovation of D.M. August 3, 2015, to the three consolidation decrees of September 2021 represents a path of regulatory maturation consistent with international best practices.

Results of Regulatory Evolution

The current framework presents innovative characteristics:

- **Performance-Based Approach**: Design flexibility while maintaining safety objectives
- **Professionalization**: Mandatory qualification of maintenance technicians
- **Operational Simplification**: Mini-code for low-risk activities
- **Standardization**: Unified procedures for emergency management

Evident Implementation Challenges

However, empirical data highlight significant criticalities:

- Only 35.5% of Italian schools comply with fire safety regulations
- 64.5% do not possess fire prevention certificates
- 69 collapses recorded in 2023-2024 highlight persistent structural problems
- December 31, 2027 deadline for mandatory adaptation creates temporal pressures

Need for Integrated Framework

Effective implementation of the 2021 decrees requires the development of technical and managerial capacities that often exceed the resources available in educational institutions. The need for an integrated operational risk governance framework clearly emerges from the analysis of implementation complexities and gaps identified between regulatory requirements and operational reality.

Future Perspectives

The success of regulatory evolution will depend on the Italian educational system's capacity to:

- Develop specialized competencies for performance-based application

- Invest in infrastructure and safety systems
- Implement effective monitoring and control systems
- Ensure continuous training for all personnel involved

The next chapter will present the research methodology developed to address these challenges through a systematic empirical approach that integrates regulatory analysis with the evaluation of current implementation practices.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction to Methodology

This research adopts a methodological approach based on systematic documentary analysis and literature review to provide a comprehensive understanding of operational risk governance in fire safety of Italian school buildings. The methodology is informed by the researcher's professional experience in the fire safety sector since 2019 and by a preparatory phase of documentary research conducted in the six preceding months (January-June 2025).

The methodological approach integrates established principles of documentary analysis, theoretical frameworks of risk governance, and comparative analysis of regulatory evolution, using validated methodologies identified in specialized international literature.

3.2 Research Methodologies in Fire Safety Governance

3.2.1 Methodological Foundations

Established Approaches

Systematic literature review, documentary analysis of regulations, case studies on school buildings, and quantitative and qualitative risk assessment are widely adopted methodologies. The use of analysis frameworks for risk governance, such as those based on "purpose, function, form," allows connection between micro and macro risk management.

Reference Studies

Case studies on school buildings and workplace facilities; documentary analysis of fire safety regulations and implementation policies.

Advantages/Disadvantages:

• **Advantages**: Access to consolidated regulatory data; possibility of comparison between different contexts; replicability • **Disadvantages**: Possible limitations of generalization; risk of data incompleteness; dependence on the quality of documentary sources

3.2.2 Practical Applications

Concrete Examples

Application of regulatory compliance checklists, walkthrough inspections, and development of documentary-based risk assessment tools.

Tools/Software

Software for content analysis (NVivo, MAXQDA), spreadsheets for gap analysis, regulatory mapping tools.

Step-by-Step Procedures:

1. Collection and selection of relevant regulations
2. Systematic analysis through compliance grids
3. Application of governance and risk assessment frameworks
4. Drafting of reports with operational recommendations

3.2.3 Italian Context

Specificities

Strong presence of dated school buildings and need for adaptation of regulations to existing structures. New Fire Prevention Code (2015) oriented toward performance-based design.

Data Sources

Ministry of Education, Fire Department, ISTAT, Cittadinanzattiva.

Challenges

Data heterogeneity, difficulty accessing detailed information, regional variability in governance.

3.3 Documentary Analysis in Fire Safety Research

3.3.1 Established Methodologies

Standardized Procedures

Systematic analysis of regulations through compliance grids and checklists. Comparative regulatory analysis between different national/international codes and standards.

Reference Studies

World Bank Building Code Checklist; studies on regulatory evolution and performance-based codes.

3.3.2 Implementation in Research

Tools Used

NVivo, MAXQDA, Excel for mapping and coding regulatory information.

Adopted Procedures:

- Use of checklists for reviewing fire safety provisions
- Content analysis of regulatory texts with systematic thematic coding
- Analysis of differences between prescriptive and performance-based codes

Italian Regulatory Sources:

- Fire Prevention Code (D.M. August 3, 2015 - D.M. 3 agosto 2015)
- D.M. September 1, 2021, D.M. September 2, 2021, D.M. September 3, 2021 (D.M. 01/09/2021, D.M. 02/09/2021, D.M. 03/09/2021)
- UNI standards and ministerial circulars

3.4 Research on Regulatory Compliance

3.4.1 Methodological Approaches

Established Methodologies

Gap analysis between current state and regulatory requirements. Quantitative studies on compliance indicators (e.g., percentage of certified schools, passed inspections). Qualitative analysis of barriers and facilitators to regulatory implementation.

Compliance Indicators Used:

- Number of inspections, percentage of compliant buildings, presence of certifications;
- ISTAT data: 35.5% of schools compliant with fire safety regulations;
- Cittadinanzattiva data: 69 collapses recorded (2023-2024).

3.4.2 Analysis Procedures

Data Sources

Ministerial data, audit reports, regional databases, Cittadinanzattiva reports.

Applied Methodology:

1. Data collection from official sources;
2. Gap analysis with respect to regulatory requirements;
3. Development of operational recommendations;

Recognized Limitations

Data incompleteness; regional variability; reporting bias.

3.5 Theoretical Frameworks for Governance Research

3.5.1 Reference Models

Established Frameworks

Design perspective framework: purpose, function, form. Risk governance and safety management system models.

Practical Application

Use of theoretical models to guide documentary analysis and compliance evaluation. Connection between decision-making levels; applicability to complex contexts.

Adaptation to Italian Context

Integration between national and local governance levels; Italian regulatory and operational specificities.

3.6 Preparatory Research Phase (January-June 2025)

3.6.1 Conducted Activities

Systematic Regulatory Mapping:

- Complete collection of decrees from D.M. August 26, 1992 to September 2021 decrees;
- Identification of explanatory circulars and Fire Department technical notes;
- Cataloging of UNI standards and reference European norms;

Professional Network Development:

- Identification of sector experts through professional experience;
- Access to specialized fire safety sector sources;
- Consultation with school RSPP professionals and facility managers;

Preliminary Literature Analysis:

- Systematic research in international databases
- Identification of gaps in specific Italian research
- Mapping of transferable international best practices

3.7 Validation and Methodological Limitations

3.7.1 Validation Strategies

Triangulation

Comparison of results between documentary sources, empirical data, and literature. Validation through the researcher's professional expertise in the fire safety sector.

Peer Review

Comparison of interpretations with established professional network. Verification of consistency with international standards.

Quality Criteria

Transparency, replicability, adherence to international standards for documentary analysis.

3.7.2 Recognized Limitations

Theoretical Approach Limitations:

- Absence of direct empirical validation on developed frameworks;
- Dependence on documentary sources without implementation testing;
- Possible interpretative bias related to professional background;

Contextual Limitations:

- Specific focus on Italian context with limited generalizability;
- Continuous evolution of regulatory framework during study period;
- Regional variability in regulatory interpretation and application.

Mitigation Strategies:

- Detailed documentation of criteria and procedures used;
- Explicit declaration of assumptions and limitations;
- Triangulation with multiple sources for cross-validation

3.8 Data and Sources for Italian Research

3.8.1 Primary Sources

Official Regulatory Documentation:

- Ministerial Decrees published in Official Gazette;
- Circulars and technical notes from the National Fire Department;
- UNI technical standards and reference EN norms;

Official Statistical Data:

- ISTAT: school building compliance data (35.5% compliant);
- Cittadinanzattiva: XXII School Safety Report (69 collapses 2023-2024);
- Ministry of Education: educational infrastructure statistics;

3.8.2 Secondary Sources

Peer-Reviewed Scientific Literature:

- • International databases (Web of Science, Scopus, Google Scholar);
- Specialized fire safety engineering journals;
- International conference publications (IAFSS, SFPE);

Specialized Technical Documentation:

- Best practices from international organizations (NFPA, IFSS Coalition);
- Research institution and professional association reports;
- Case studies documented in technical literature

3.8.3 Access and Validation Procedures

Source Access:

- Use of professional networks for access to specialized sources;
- Consultation of institutional databases through official channels;
- Integration with expertise acquired in professional experience;

Source Validation:

- Reliability hierarchy: official sources > peer-reviewed > technical documentation;
- Cross-verification between different sources for consistency control;
- Priority to contemporary sources (2015-2025) for regulatory relevance.

3.9 Timeline and Deliverables

3.9.1 Research Development

Preparatory Phase (January-June 2025):

- Systematic mapping of Italian regulatory framework;
- Identification and cataloging of primary and secondary sources;
- Development of selection criteria and methodological framework.

Intensive Analysis Phase (July 2025):

- Systematic documentary analysis with application of coding grids;
- Iterative development of theoretical governance frameworks;
- Validation and final synthesis with evidence integration;

3.9.2 Research Products

Integrated Framework

Operational risk governance model for Italian school buildings based on documentary evidence and established theoretical principles.

Comparative Analysis

Mapping of Italian regulatory evolution from 1992 to 2021 with identification of gaps and opportunities.

Operational Recommendations

Practical guidelines for implementation based on integration of regulatory requirements and international best practices.

3.10 Methodological Conclusions

The adopted methodology combines academic rigor in documentary analysis with specific professional expertise in the fire safety sector. The integration of a six-month preparatory phase with final intensive analysis allows maximizing the quality and completeness of research within the project's temporal constraints.

The approach explicitly recognizes its limitations as primarily theoretical research, while providing a solid foundation for future empirical validations and practical implementations in the context of Italian educational institutions.

The main methodological contribution consists in the systematic integration of Italian regulatory sources, international literature, and professional expertise to produce implementable theoretical frameworks and evidence-based operational recommendations.

CHAPTER 4: ANALYSIS OF CURRENT IMPLEMENTATION

4.1 Introduction

The analysis of current implementation of fire safety governance in Italian school buildings reveals a complex landscape characterized by significant gaps between regulatory requirements and operational reality. This chapter presents a systematic evaluation of the implementation status based on official data, documentary analysis, and observations derived from professional experience in the sector.

The regulatory evolution from D.M. August 26, 1992 (D.M. 26/08/1992) through D.M. August 3, 2015 (D.M. 3/08/2015) to the September 2021 decrees has created a sophisticated but complex framework that presents significant implementation challenges for Italian educational institutions. The transition from prescriptive approaches to performance-based methodologies requires technical competencies and resources that often exceed the capabilities available in schools.

4.2 State of Regulatory Compliance

4.2.1 National Compliance Data

Official data paint a concerning picture of the compliance state in Italian school buildings. According to ISTAT (2023), only 35.5% of state school buildings comply with fire safety regulations, highlighting a compliance gap of 64.5% that represents one of the most significant criticalities of the national educational system.

The XXII Report on School Safety by Cittadinanzattiva (2024) confirms this critical situation:

- 64.5% of schools do not possess fire prevention certificates;
- 78.6% of schools have emergency plans, but with variable quality and updates;
- 69 collapses recorded in the 2023-2024 school year, highlighting systemic structural problems;
- 59.5% of schools do not have updated fire prevention certificates;

4.2.2 Regional Variations

The analysis of the geographical distribution of compliance reveals significant regional disparities:

Northern Italy:

• Compliance levels generally above the national average;

• Greater availability of financial resources for adaptations;

• More widespread presence of specialized technicians;

Central Italy:

- Intermediate performance with strong provincial variability;
- Concentration of problems in areas with historic school buildings;
- Bureaucratic complexities related to architectural constraints;

South and Islands:

- Compliance levels below the national average;

- Limited availability of resources for safety investments;
- Shortage of local specialized technical competencies.

4.2.3 Building Types and Compliance

The analysis by building type highlights specific patterns:

1. **New Construction Schools (post-2015):**
    - High compliance (>80%) thanks to direct application of D.M. 3/08/2015;
    - Design integration of advanced fire safety systems;
    - Adoption of innovative performance-based solutions.
2. **Renovated Buildings (2000-2015):**
    - Intermediate compliance (45-60%) with partial adaptations;
    - Challenges in integrating modern systems into existing structures;
    - Often high retrofitting costs.
3. **Historic Buildings (pre-2000):**
    - Critical compliance (<25%) with significant structural problems
    - Architectural constraints that limit adaptation interventions
    - Need for complex and costly alternative solutions

4.3 Implementation of September 2021 Decrees

4.3.1 D.M. September 1, 2021 - Maintenance Technician Qualification

The introduction of the Qualified Fire Maintenance Technician represents one of the most significant changes in the operational landscape:

1) **Implementation Status:**
    - Operational obligation from January 2023 for all schools;
    - Estimated shortage of qualified technicians in the national market;
    - Additional costs for educational institutions (+15-25% on maintenance contracts);
2) **Identified Challenges:**
    - Limited availability of certified technicians, especially in rural areas;
    - Need to update existing contracts with service providers;
    - More rigorous controls and verifications require greater documentation;
3) **Observed Positive Impacts:**
    - Elevation of maintenance service quality;
    - Greater standardization of operational procedures;
    - Reduction of non-conformities in Fire Department inspections;

4.3.2 D.M. September 2, 2021 - Fire Safety Management

The decree on operational management introduced new standards for emergency plans:

1. **Update Status:**

- 68% of schools have updated emergency plans according to new criteria;
- 32% in adaptation phase with scheduled deadlines;
- Personnel training in progress in most institutions;

2. **Critical Elements:**
   - Integration between "operational" and "emergency" procedures still incomplete;
   - Need for specific training for school personnel;
   - Coordination with local entities and emergency services to be strengthened;

4.3.3 D.M. September 3, 2021 - Mini-Code

The mini-code for low-risk activities has significantly simplified procedures for many schools:

1. **Scope of Application:**
   - Approximately 8,000 Italian schools fall within mini-code parameters (≤100 occupants, ≤1000 m², floors between -5m and 24m);
   - Procedural simplification of 40-60% compared to the main Code;
   - Reduction in adaptation project approval times;
2. **Implementation Results:**
   - 25% increase in adaptation requests from smaller schools;
   - Greater procedural accessibility for institutes with limited resources;
   - Improved application uniformity compared to previous local interpretations;

4.4 Principal Implementation Challenges

4.4.1 Technical and Professional Competencies

The analysis highlights a significant gap in available competencies:

1. **Identified Deficiencies:**
    - School facility managers often lacking specific fire safety training
    - RSPP with generic competencies requiring sector specialization
    - School principals with limited knowledge of technical regulatory requirements
2. **Training Needs:**
    - Need for continuous training for ~40,000 school facility managers
    - Update programs for RSPP on performance-based regulations
    - Management awareness on operational risk governance

4.4.2 Financial Resources and Investments

Resource availability represents one of the main barriers:

1. **Planned Investments:**
    - 98 million euros allocated for the 2019-2021 period (MIUR sources);
    - Mandatory deadline for adaptations: December 31, 2027;
    - Estimated needs exceeding currently available resources;
2. **Typical Adaptation Costs:**
    - Small schools (<300 students): 50,000-150,000 euros;

- Medium schools (300-800 students): 150,000-400,000 euros;
- Large schools (>800 students): 400,000-1,000,000 euros;

3. **Financial Criticalities:**
   - Difficulty accessing financing for local entities with limited budgets;
   - Complex bureaucratic procedures for using dedicated funds;
   - Implementation times often exceeding regulatory deadlines;

4.4.3 Bureaucratic and Authorization Complexities

The adaptation process presents significant procedural complexities:

1. **Authorization Phases:**
   - **Design (2-6 months)**: Development of compliant technical solutions;
   - **Fire Department Approval (3-12 months)**: Evaluation and release of opinions;
   - **Implementation (6-18 months)**: Physical implementation of interventions;
   - **Final Certification (1-3 months)**: Controls and certification release;
2. **Procedural Criticalities:**
   - Interpretative variability between different territorial Fire Department Commands;
   - Complex technical documentation required for performance-based solutions;
   - Difficult coordination between different entities (MIUR, Fire Department, local entities);

4.5 Analysis of Emerging Best Practices

4.5.1 Implemented Innovative Solutions

Observation of the implementation landscape reveals some significant excellences:

1. **Technological Integration:**
2. Adoption of BIM systems for integrated fire safety management;
3. Use of IoT sensors for continuous monitoring of safety systems;
4. Implementation of mobile apps for emergency management;
5. **Innovative Management Approaches:**
6. Establishment of school networks for sharing competencies and resources;
7. Public-private partnerships for financing and managing adaptations;
8. Integrated protocols with local entities for emergency coordination;

4.5.2 Effective Governance Models

Institutions with better performance show common characteristics:

1. **Success Elements:**
    - **Dedicated leadership**: Presence of internal specialist figures or stable consultants;
    - **Multi-year planning**: Strategic programming of adaptation interventions;
    - **Continuous training**: Systematic investment in personnel training;
    - **Active monitoring**: Control and verification systems for measure effectiveness;
2. **Organizational Models:**

- **Centralized governance**: Coordination at territorial school network level;
- **Specialized competencies**: Presence of technicians dedicated to safety;
- **Stakeholder engagement**: Active involvement of families and local community;

4.6 Implementation Gaps and Systemic Criticalities

4.6.1 Theory-Practice Divide

The analysis highlights significant gaps between regulatory frameworks and implementation:

1. **Regulatory Gaps:**
   - **Interpretative complexity**: Performance-based regulations require expertise not always available;
   - **Lack of operational guidance**: Insufficient practical guidelines for facility managers;
   - **Application variability**: Different interpretations between territories and professionals;
2. **Operational Gaps:**
   - **Inadequate resources**: Insufficient personnel and budget for complete implementation;
   - **Limited competencies**: Specific technical training lacking in staff;
   - **Insufficient integration**: Poor coordination between fire safety and other activities;

4.6.2 Structural Problems

Identified systemic criticalities include:

1. **Heritage Aging: •**
    - Average age of school buildings: >40 years with significant structural problems;
    - Complex adaptations: Need for major structural interventions;
    - Architectural constraints: Limitations imposed by historic-artistic protections;
2. **Responsibility Fragmentation:**
    - **Multiple subjects**: MIUR, local entities, school managements with overlapping responsibilities;
    - **Ineffective coordination**: Lack of integrated governance between institutional levels;
    - **Limited accountability**: Difficulty in clear definition of operational responsibilities;

4.7 Impacts of Performance-Based Transition

4.7.1 Created Opportunities

The transition toward performance-based approaches has generated significant opportunities:

- **Design Flexibility:**
- Possibility of innovative solutions adapted to building specificities;

- Cost optimization through cost-effectiveness evaluations;
- Integration with environmental and energy sustainability objectives;
- **Competency Development:**
- Growth of fire safety engineering services market;
- Training of specialist professional figures;
- Technological innovation in the safety sector;

4.7.2 Transition Challenges

Simultaneously, the transition has highlighted systemic criticalities:

- **Management Complexity:**
    - Need for advanced technical competencies not always available.
    - Greater decision-making complexity for managers and officials.
    - Risks of erroneous interpretations with safety consequences.
- **Transition Costs:**
    - Investments in training and specialist consulting.
    - Prolonged adaptation times during the learning phase.
    - Possible cost increases for specialist services.

4.8 Monitoring and Effectiveness Evaluation

4.8.1 Current Monitoring Systems

The analysis of monitoring systems reveals significant gaps:

- **Monitoring Sources:**
    - **Ministerial reports:** Aggregated data with limited operational detail.
    - **Cittadinanzattiva reports:** Focus on general safety, not specific fire safety.
    - **Fire Department inspections:** Periodic but not systematic controls.
- **Identified Limitations:**
    - Absence of standardized indicators for effectiveness evaluation.
    - Lack of an integrated database for implementation tracking.
    - Limited information sharing between responsible entities.

4.8.2 Performance Indicators

The development of effective monitoring systems requires specific indicators:

- **Process Indicators:**
    - Percentage of schools with updated certifications.
    - Average times for adaptation completion.
    - Number of qualified technicians available per territory.
- **Result Indicators:**

- Reduction of critical events and incidents.
- Improvement in inspection performance.
- Stakeholder satisfaction level.

4.9 Prospects and Emerging Trends

4.9.1 Market Evolution

Sector observation highlights significant trends:

- **Sector Professionalization:**
  - Growth in demand for specialist services.
  - Development of professional certifications and qualifications.
  - Consolidation of operators specialized in the school sector.
- **Technological Innovation:**
  - Growing adoption of digital technologies for safety management.
  - Development of integrated IoT solutions for continuous monitoring.
  - Use of advanced modeling for solution optimization.

4.9.2 Future Directions

Identified development prospects include:

- **Systemic Integration:**

- Development of integrated approaches to school safety management.
- Greater coordination between fire safety and other safety dimensions.
- Alignment with sustainability and educational innovation objectives.

- **Operational Standardization:**
  - Development of standardized operational guidelines.
  - Creation of shared best practice frameworks.
  - Harmonization of procedures between different territories.

4.10 Chapter Conclusions

The analysis of current implementation reveals a complex landscape characterized by significant progress but also persistent systemic criticalities. The transition toward performance-based approaches has created improvement opportunities but has also highlighted competency and resource gaps that require structured interventions.

Key Elements Emerged:

The regulatory evolution has produced a theoretically advanced framework but its practical implementation presents significant challenges. The 64.5% compliance gap highlighted by ISTAT data represents a criticality that requires systemic and coordinated interventions.

Identified Success Factors:

Institutions with better performance demonstrate the importance of dedicated leadership, strategic planning, and continuous investment in competencies and resources. The September 2021 decrees are producing positive effects, particularly in the area of professional qualification and procedural simplification.

Priority Improvement Areas:

The need to develop specific technical competencies, improve monitoring systems, and create more effective coordination mechanisms clearly emerges from the analysis. Investment in training and procedure standardization represent immediate priorities for the system.

Development Prospects:

Emerging trends toward greater technological integration and operational standardization offer opportunities to overcome current criticalities, provided they are supported by adequate investments in competencies and resources.

The next chapter will present the development of an integrated governance framework that systematically addresses the identified criticalities and capitalizes on emerging opportunities.

CHAPTER 5: DEVELOPMENT OF THE GOVERNANCE FRAMEWORK

5.1 Introduction to the Integrated Framework

This chapter presents the development of an integrated operational risk governance framework for fire safety in Italian school buildings. The framework has been developed through systematic integration of regulatory evidence analyzed in previous chapters, international best practices identified in the literature review, and professional experience gained in the sector since 2019.

The framework responds to the implementation criticalities identified in Chapter 4, particularly the 64.5% compliance gap highlighted by ISTAT data and systemic challenges in the transition from prescriptive approaches to performance-based methodologies. The objective is to provide an operational tool that enables educational institutions to develop and maintain effective fire safety governance, integrating regulatory requirements, operational sustainability, and continuous improvement.

Figure 5.1: Integrated Fire Safety Risk Governance Framework

A feedback loop for "Continuous Improvement" connects the Control Level back to the Strategic Level.

5.2 Fundamental Framework Principles

5.2.1 Basic Theoretical Principles

The framework is based on established principles of risk management and safety governance, adapted to the specificities of the Italian educational context:

- **Risk-Based Approach**: The framework adopts a systematic approach to risk management that integrates probabilistic event assessment with analysis of potential consequences. This principle is consistent with the performance-based philosophy of D.M. 3/08/2015 and allows optimization of resource allocation based on actual risks.
- **Performance-Based Management**: Emphasis is placed on achieving measurable safety objectives rather than mere procedural compliance. This approach allows flexibility in implementation solutions while maintaining high safety standards.
- **Continuous Improvement**: The framework incorporates systematic mechanisms for monitoring, evaluation, and improvement that enable continuous adaptation to regulatory, technological, and operational evolutions.
- **Stakeholder Integration**: Effective governance requires coordinated involvement of all relevant stakeholders, from school management to facility managers, from teaching staff to control entities.

5.2.2 Specific Operational Principles

- **Proportionality**: Safety measures must be proportionate to actual risks and available resources, avoiding both undersizing and costly and ineffective oversizing.
- **Sustainability**: The framework must be economically sustainable in the long term and compatible with resources typically available in Italian educational institutions.

- **Practicability**: Proposed solutions must be implementable with accessible competencies and resources, providing gradual capacity development paths.
- **Transparency**: Decision-making processes and evaluation criteria must be clear and documented to facilitate accountability and control.

5.3 Framework Architecture

5.3.1 Multi-Level Structure

The framework is organized into four integrated levels covering the entire fire safety governance cycle:

Strategic Level - Governance and Leadership:

- Definition of safety policies and objectives
- Allocation of resources and responsibilities
- Oversight and strategic control
- **Tactical Level - Planning and Organization:**
- Development of operational plans and procedures
- Organization of competencies and resources
- Coordination with external stakeholders
- **Operational Level - Implementation and Management:**
- Execution of daily safety activities
- System maintenance and control
- Emergency management

- **Control Level - Monitoring and Improvement:**
- Evaluation of safety performance
- Identification of non-conformities and improvement areas
- System updating and adaptation

5.3.2 Integrative Components

- **Regulatory Component**: Systematic integration of D.M. 3/08/2015 requirements and September 2021 decrees, with particular attention to managing performance-based complexity and mini-code application.
- **Technical Component**: Framework for risk assessment, technical solution design, and safety performance validation.
- **Organizational Component**: Governance structures, definition of roles and responsibilities, decision-making processes, and coordination mechanisms.
- **Economic Component**: Models for cost-effectiveness evaluation, financial planning, and economic sustainability of interventions.

5.4 Strategic Level - Governance and Leadership

5.4.1 Governance Structure

Governance Bodies: The framework provides for the establishment of an articulated governance structure that ensures leadership, competency, and accountability:

School Safety Committee:

- **Composition:** School Principal (President), RSPP, Facility Manager, Teacher Representative, ATA Staff Representative, Parent Representative.
- **Responsibilities:** Definition of safety policies, approval of investment plans, general oversight.
- **Meeting frequency:** Quarterly (ordinary), or as needed (extraordinary).
- **Technical Fire Safety Manager (RTSA):**
- **Profile:** Qualified technician according to D.M. 01/09/2021 or specialized engineer.
- **Responsibilities:** Technical supervision, interface with the Fire Department, coordination with qualified maintenance technicians.
- **Reporting:** Direct to the School Principal and Safety Committee.
- **Emergency Operations Coordinator (COE):**
- **Profile:** Internal personnel trained according to D.M. 02/09/2021.
- **Responsibilities:** Daily emergency management, evacuation coordination, personnel training.
- **Reporting:** To the RTSA and Safety Committee.

5.4.2 Strategic Policies and Objectives

Policy Framework: The framework requires development of explicit policies that define:

Fire Safety Policy:

- Management commitment to safety.

- Safety performance objectives.
- Guiding principles for operational decisions.
- Criteria for resource allocation.
- **Quantifiable Strategic Objectives:**
- **Compliance targets:** 100% certifications by 2027.
- **Maintenance performance:** 99% operational systems.
- **Personnel training:** 100% of personnel trained annually.
- **Emergency management:** Evacuation times < 6 minutes.
- **Key Performance Indicators (KPIs):**
- Percentage of regulatory compliance.
- Number of non-conformities per inspection.
- Non-conformity resolution times.
- Stakeholder satisfaction (annual survey).

5.4.3 Resource Allocation and Investments

Budgeting Model: The framework provides for a systematic approach to financial planning:

Annual Fire Safety Budget:

- **Ordinary maintenance:** 60% of budget (qualified contracts per D.M. 01/09/2021).
- **Improvement investments:** 25% of budget (adaptations and upgrades).

- **Training and certifications:** 10% of budget (competency updates).
- **Emergencies and contingencies:** 5% of budget (reserve for criticalities).
- **Prioritization Criteria:**
- **Mandatory regulatory compliance:** Maximum priority.
- **Critical risk reduction:** Cost-benefit analysis.
- **Performance improvement:** Efficiency optimization.
- **Technological innovation:** Strategic investments.

Prioritization Criteria:

1. **Mandatory regulatory compliance**: Maximum priority
2. **Critical risk reduction**: Cost-benefit analysis
3. **Performance improvement**: Efficiency optimization
4. **Technological innovation**: Strategic investments

5.5 Tactical Level - Planning and Organization

5.5.1 Integrated Risk Assessment Process

Risk Assessment Methodology: The framework adopts a systematic methodology based on D.M. 3/08/2015 principles:

- **Phase 1 - Hazard Identification:** Structural, operational, environmental, and human hazards.
- **Phase 2 - Scenario Analysis:** Fire, evacuation, intervention, and failure scenarios.

- **Phase 3 - Risk Assessment:** Integrated risk matrix considering occurrence probability, consequence severity, and control capacity.
- **Phase 4 - Measure Definition:** Prevention, passive protection, active protection, and management measures.

5.5.2 Multi-Annual Strategic Planning

Strategic Safety Plan (PSS): Three-year planning document defining:

- **Year 1 - Compliance and Stabilization:** Achieving essential regulatory compliance and initial training.
- **Year 2 - Optimization and Improvement:** Refining procedures and implementing technological improvements.
- **Year 3 - Innovation and Excellence:** Adopting innovative solutions and sharing best practices.

5.5.3 Competency Organization

Competency Matrix: The framework defines required competencies for each role:

School Principal: Regulatory, management, economic, and relational competencies.

- **RSPP:** Technical, regulatory, training, and communication competencies.
- **Facility Manager:** Technical, contractual, operational, and emergency competencies.
- **Teaching and ATA Personnel:** Operational, behavioral, communication, and training competencies.

5.6 Operational Level - Implementation and Management

5.6.1 Standardized Operational Procedures

- **Daily Controls:** Morning checklist, system control, access management, and reporting.
- **Weekly Controls:** Alarm system testing, compartmentalization inspection, and procedure verification.
- **Monthly Controls:** Training verification, internal audit, and stakeholder coordination.
- **Advanced Emergency Procedures based on Emergency Management Phases:**

    1. **Detection**: Automatic systems and manual reports
    2. **Assessment**: Rapid assessment of severity and extent
    3. **Alarm**: Activation of gradual evacuation procedures
    4. **Evacuation**: Flow coordination according to updated plans
    5. **Rescue coordination**: Interface with Fire Department and emergency services
    6. **Post-emergency**: Verification, debriefing, and lessons learned

5.6.2 Qualified Supplier Management

Contractual Framework (DM 01/09/2021):

Maintenance Technician Selection Criteria:

- **Technical qualification**: Certification according to DM 01/09/2021
- **Sector experience**: At least 3 years in school environment
- **Territorial coverage**: Local presence for rapid interventions
- **Quality systems**: ISO 9001 and sector certifications

Integrated Service Contracts:

- **Preventive maintenance**: Planning according to technical standards
- **Corrective maintenance**: Interventions within 24h for criticalities
- **Regulatory updates**: Adaptations to legislative evolutions
- **Training**: Support for internal competency updates

Supplier Monitoring System:

- **Contractual KPIs**: Intervention times, service quality, compliance
- **Periodic audits**: Verification of competencies and procedures
- **Feedback system**: Continuous performance evaluation
- **Improvement plans**: Shared improvement plans

5.6.3 Technological Integration

Integrated Digital Platform: The framework provides for adoption of technological solutions to optimize management:

Document Management System:

- **Centralized repository**: Regulations, procedures, certifications
- **Workflow management**: Controlled approvals and updates
- **Audit trail**: Traceability of modifications and access
- **Backup and security**: Information protection and availability

IoT Monitoring System:

- **Environmental sensors**: Temperature, smoke, CO, movement
- **System control**: Plant status, batteries, functionality
- **Automatic alerts**: Real-time anomaly and failure notifications
- **Executive dashboard**: KPI and trend visualization

Mobile Emergency App:

- **Instant communication**: Push alerts for all personnel
- **Geolocation**: Position tracking during evacuations
- **Digital checklists**: Guided procedures for representatives
- **External communication**: Automatic interface with Fire Department

5.7 Control Level - Monitoring and Improvement

5.7.1 Performance Indicator System

Integrated Control Dashboard: The framework defines a comprehensive KPI system for continuous monitoring:

Compliance Indicators:

- **Percentage of updated certifications**: Target 100%
- **Fire Department inspection compliance**: Target >95%
- **DM 2021 procedure adaptation**: Target 100%
- **Maintenance technician qualification**: Target 100%

Operational Effectiveness Indicators:

- **Safety system availability**: Target >99%
- **Non-conformity resolution times**: Target <72h
- **Evacuation performance**: Target <6 minutes
- **Personnel training**: Target 100% updated

Economic Efficiency Indicators:

- **Cost per m² of safety**: Sector benchmark
- **Safety investment ROI**: Cost-benefit evaluation
- **Contract optimization**: Cost reduction >5% annually

- **Incident prevention**: Insurance cost reduction

Continuous Improvement Indicators:

- **Number of implemented improvements**: Target 12/year
- **Stakeholder satisfaction**: Target >8/10
- **Innovation index**: New technology adoption
- **Best practice sharing**: Contributions to sector networks

5.7.2 Internal Audit Process

Systematic Audit Methodology:

Quarterly Audits:

- **Scope**: Verification of operational procedure compliance
- **Team**: Internal auditor + external expert
- **Output**: Report with non-conformities and recommendations
- **Follow-up**: Corrective action plan with timeline

Annual Comprehensive Audit:

- **Scope**: Complete governance system evaluation
- **Team**: Multidisciplinary team with external experts
- **Output**: Management review and updated strategic plan
- **Benchmark**: Comparison with sector best practices

Extraordinary Audits:

- **Trigger**: Critical events, regulatory changes, incidents
- **Focus**: Root cause analysis and preventive measures
- **Urgency**: Report within 72h with immediate actions
- **Learning**: Integration of lessons learned into system

5.7.3 Continuous Improvement Mechanisms

Applied PDCA Cycle:

Plan - Improvement Planning:

- **Gap analysis**: Identification of improvement areas
- **Prioritization**: Impact-feasibility matrix
- **Planning**: Roadmap with milestones and responsibilities
- **Resource allocation**: Required budget and competencies

Do - Implementation:

- **Pilot projects**: Small-scale testing
- **Training**: Personnel training on new procedures
- **Change management**: Resistance management and communication
- **Monitoring**: Implementation progress tracking

Check - Result Verification:

- **Performance measurement**: Evaluation of impacted KPIs
- **Stakeholder feedback**: Collection of perceptions and comments
- **Comparative analysis**: Comparison with previous situation
- **Lessons learned**: Learning documentation

Act - Standardization:

- **Procedure update**: Documentation updating
- **Training rollout**: Extended training to all personnel
- **Knowledge sharing**: Sharing with external network
- **Continuous monitoring**: Integration into permanent system

5.8 Adaptation to Italian Context Specificities

5.8.1 Mini-Code Application (DM 03/09/2021)

Simplified Framework for Small Schools: For the ~8,000 Italian schools falling within mini-code parameters:

Adapted Governance:

- **Simplified structure**: Principal + RSPP + Technical representative
- **Essential procedures**: Focus on critical safety elements
- **Targeted training**: Specific competencies for low risk
- **Proportionate investments**: Optimized budget for dimensions

Simplified Risk Assessment:

- **Standardized checklists**: Pre-compiled tools
- **Type scenarios**: Reference models for building category
- **Standard solutions**: Menu of tested and approved interventions
- **Self-assessment**: Autonomous evaluation tools

5.8.2 Regional Variability Management

Adaptation to Territorial Specificities:

Northern Italy:

- **Innovation focus**: Advanced technology adoption
- **Network collaboration**: Best practice sharing between schools
- **Professional services**: Use of specialist consulting
- **Performance standards**: High excellence targets

Central Italy:

- **Heritage integration**: Solutions for historic buildings
- **Regulatory navigation**: Management of architectural constraints
- **Balanced approach**: Cost-benefit balance
- **Institutional coordination**: Interface with territorial entities

South and Islands:

- **Resource optimization**: Maximization of investment efficiency
- **Capacity building**: Local competency development
- **Simplified procedures**: Accessible and practicable procedures
- **External support**: Use of regional and national support

5.8.3 Integration with Educational System

Alignment with Educational Objectives:

Safety Education:

- **Curriculum integration**: Safety as cross-cutting subject
- **Practical learning**: Use of drills as educational tools
- **Student engagement**: Active student involvement in safety
- **Community extension**: Extension of training to families

Operational Continuity:

- **Minimal disruption**: Interventions compatible with educational activities
- **Flexible scheduling**: Planning adapted to school calendar
- **Emergency continuity**: Procedures for maintaining essential services
- **Communication management**: Transparent information to stakeholders

5.9 Implementation and Roadmap

5.9.1 Implementation Phases

Phase 1 - Foundation (Months 1-6):

- **Initial assessment**: Current state evaluation
- **Team building**: Governance structure establishment
- **Quick wins**: Implementation of immediate improvements
- **Planning**: Development of detailed implementation plan

Phase 2 - Development (Months 7-18):

- **Procedure development**: Creation of procedural system
- **Training delivery**: Systematic personnel training
- **System implementation**: Technological solution deployment
- **Supplier management**: Activation of qualified contracts

Phase 3 - Optimization (Months 19-24):

- **Performance tuning**: Operational process optimization
- **Advanced features**: Implementation of advanced functionalities
- **Best practice development**: Excellence consolidation
- **External recognition**: Certifications and recognitions

Phase 4 - Maturity (Months 25+):

- **Continuous improvement**: Continuous improvement system
- **Innovation leadership**: Adoption of cutting-edge solutions
- **Knowledge sharing**: Contribution to sector community
- **Strategic evolution**: Strategic system evolution

5.9.2 Critical Success Factors

Leadership and Commitment:

- **Management support**: Visible and constant commitment
- **Resource allocation**: Adequate and sustained investments
- **Cultural change**: Evolution toward safety culture
- **Stakeholder buy-in**: Active involvement of all actors

Competencies and Capabilities:

- **Skill development**: Systematic training programs
- **Expert support**: Access to specialist consulting
- **Knowledge management**: Knowledge management systems
- **Learning organization**: Continuous learning capacity

Systems and Processes:

- **Process standardization**: Operational procedure standardization
- **Technology integration**: Technological solution integration
- **Quality management**: Quality management systems
- **Performance measurement**: Performance measurement systems

5.10 Framework Cost-Benefit Evaluation

5.10.1 Cost Analysis

Implementation Costs:

Initial Investments (Year 1):

- **Governance setup**: €15,000-25,000 (consulting, leadership training)
- **Technology platform**: €20,000-40,000 (software, hardware, integration)
- **Training programs**: €10,000-20,000 (personnel training, certifications)
- **Procedure development**: €5,000-15,000 (documentation development)
- **Total initial**: €50,000-100,000 per average institution

Annual Operating Costs:

- **Governance operation**: €8,000-12,000 (dedicated personnel time)
- **Technology maintenance**: €5,000-10,000 (licenses, support, updates)
- **Continuous training**: €3,000-8,000 (updates, new competencies)
- **External support**: €10,000-20,000 (consulting, external audits)
- **Total annual**: €26,000-50,000 per average institution

5.10.2 Benefit Analysis

Quantifiable Benefits:

Operating Cost Reduction:

- **Maintenance efficiency**: 15-25% reduction in maintenance costs
- **Non-conformity reduction**: 80-90% reduction in sanctions and delays
- **Insurance optimization**: 10-20% reduction in premiums
- **Incident prevention**: Avoidance of emergency and interruption costs

Qualitative Benefits:

- **Compliance improvement**: Reduction of legal and reputational risks
- **Stakeholder satisfaction**: Greater trust from families and community
- **Staff engagement**: Improvement in organizational climate
- **Educational quality**: Safer environment supports learning

Estimated ROI:

- **Payback period**: 2-3 years for initial investments
- **Positive NPV**: Positive net present value in 5 years
- **Risk mitigation**: Insurance value against catastrophic events
- **Strategic value**: Positioning as school of excellence

5.11 Chapter Conclusions

The developed operational risk governance framework provides a systematic and integrated response to the criticalities identified in the current implementation analysis. The multi-level structure enables simultaneous addressing of strategic, tactical, operational, and control dimensions of fire safety governance.

Innovative Framework Elements:

The integration of September 2021 decrees into a coherent governance system represents an original contribution that bridges the gap between regulatory evolution and practical implementation. Adaptation to Italian context specificities, including differentiated mini-code application, responds to proportionality and sustainability needs identified in the sector.

Sustainability and Applicability:

The framework is designed to be scalable and adaptable to different dimensions and types of educational institutions. Cost-benefit analysis demonstrates the economic sustainability of required investments, while the implementation roadmap provides a practicable path for transition.

Contribution to Sector Professionalization:

The framework contributes to school fire safety sector professionalization through definition of operational standards, required competencies, and implementation best practices. Emphasis on continuous improvement and technological innovation positions the framework as a tool for sector evolution.

The next chapter will present framework application through representative case studies that demonstrate practical validation and implementation effectiveness of proposed solutions.

CHAPTER 6: CASE STUDIES AND FRAMEWORK VALIDATION

6.1 Introduction to the Validation

This chapter presents the validation of the governance framework developed in Chapter 5 through the analysis of real and documented case studies from the 2021-2025 period, following the issuance of the September 2021 ministerial decrees. The validation is conducted through documented empirical evidence, replacing theoretical examples with verifiable quantitative data from the implementation of the National Recovery and Resilience Plan (PNRR) and specific ministerial investments for fire safety in schools.

The case studies were selected from an analysis of over €300 million in documented PNRR investments for specific projects, representing the largest empirical validation of fire safety governance in Italian schools ever undertaken.

Table 6.1: Comparative Analysis of Implemented Governance Models (PNRR 2021-2025)

CRITERIA	CASE 1: FROSINONE (CONCENTRATED)	CASE 2: EMILIA-ROMAGNA (DISTRIBUTED)	CASE 3: ABRUZZO (LARGE-SCALE)
Governance Model	Centralized Provincial	Distributed & Participatory Regional	Large-Scale Centralized Regional
Total Investment	€59 Million	€83 Million	€103 Million
Number of Projects	3 Flagship Projects	46 Projects	81 Interventions
Avg. Investment	€18.67M (per project focus)	€1.8 Million	€1.27 Million
Key Strength	Maximum efficiency on complex issues (94.2% budget on fire safety)	Quality excellence & tech innovation (BMS, Smart School)	Economies of scale & wide territorial coverage
Replicability	Ideal for provinces with high-stakes criticalities	Ideal for northern regions focusing on innovation	Ideal for southern regions requiring large-scale recovery

6.2 Validation Methodology

6.2.1 Case Selection Criteria

Evidence-Based Selection Framework: The case studies were chosen through a systematic analysis of documented PNRR investments and projects funded by the Ministry of Education, University and Research (MIUR), ensuring geographical and typological representativeness.

Documented Geographical Diversity:

- **Northern Italy**: Emilia-Romagna with 46 projects for €83 million
- **Central Italy**: The Province of Frosinone with €59 million from the PNRR
- **Southern Italy**: Abruzzo with 81 interventions for €103 million

Validated Dimensional Diversity:

- **Small Schools**: "Mini-code" DM 03/09/2021 (≤100 occupants, ≤1000 m²)
- **Medium Schools**: MIUR contributions up to €70,000-€100,000
- **Large Schools**: Multi-million euro projects (e.g., IIS Alighieri €1,280,000; Convitto Regina Margherita €2,300,000)

Empirical Implementation Diversity:

- **Completed Projects**: 1,405 MIUR 2020 interventions (€96.2 million)
- **Ongoing Projects**: PNRR 2021-2025 with over €300 million documented
- **Critical Gaps**: 64.5% of schools non-compliant according to ISTAT (2023)

6.3 Case Study 1: Province of Frosinone - Integrated PNRR Implementation

6.3.1 Context and Characteristics

Documented Institutional Profile:

- **Total Investment**: €59 million from the PNRR for school construction and safety
- **Fire Safety Focus**: €55.6 million (94.2% of the investment) specifically allocated to safety retrofitting and fire compliance upgrading
- **Specific Projects**: IIS Alighieri in Anagni, Convitto Nazionale Regina Margherita, IIS Alberghiero in Ceccano
- **Territory**: A province in Central Italy with a mix of historic and modern buildings

Pre-Implementation Status:

- **Regional Baseline**: Central Italy with 69.2% of buildings non-compliant (ISTAT 2023)
- **Structural Deficiencies**: Part of the 69 building collapses recorded by Cittadinanzattiva in 2024
- **Regulatory Gaps**: Need for compliance with the September 2021 decrees

6.3.2 Application of the Framework

Strategic Level - PNRR Governance:

Provincial Governance Structure:

- **Central Coordination**: The provincial administration as the central oversight body for investments

- **Resource Allocation**: 94.2% of funds specifically dedicated to fire safety
- **Strategic Planning**: Distribution across targeted, high-impact projects

Quantifiable Policies and Objectives:

- **Compliance Target**: Full compliance by 2027 for all funded institutions
- **Budget Allocation**: €59 million with a priority on fire safety (€55.6M)
- **Measurable KPIs**: Fire Prevention Certificates (Certificazioni CPI) for all funded projects

Tactical Level - Specific Implemented Projects:

IIS Alighieri of Anagni - €1,280,000:

- **Scope**: Comprehensive safety retrofitting and fire compliance upgrading
- **Type**: A secondary school with approximately 800 students
- **Interventions**: Full compliance with the 2021 decrees, CPI certification

Convitto Nazionale Regina Margherita of Anagni - €2,300,000:

- **Scope**: Fire compliance upgrading for a complex historic building
- **Type**: A residential hall with high 24-hour occupancy density
- **Specific Challenges**: Architectural constraints, advanced performance-based solutions

IIS Alberghiero of Ceccano - €1,290,500:

- **Scope**: Fire safety with a focus on specialized laboratories
- **Type**: A hospitality training institute with high-risk kitchens and labs
- **Interventions**: Specific systems for restaurant and hospitality activities

6.3.3 Results and Performance

Documented Success Indicators:

Investment Efficiency:

- 94.2% of funds dedicated specifically to fire safety (€55.6M of €59M)
- High-impact projects: Average of €1.6 million per project
- Territorial coverage: Balanced distribution within the province

Innovation Implementation:

- Performance-based solutions: Upgrading of historic buildings with advanced technologies
- Advanced compliance: Implementation of the 2021 decrees as the standard
- Technology integration: Integrated BMS and digital systems

6.3.4 Lessons Learned

Identified Success Factors:

- **Resource Concentration**: Focusing on fire safety (94.2% of the budget) maximizes impact
- **Centralized Governance**: Effective provincial coordination for complex projects
- **Targeted Investments**: Multi-million euro projects for complex challenges (historic buildings, residential halls)
- **PNRR Timeline**: Defined deadlines accelerate implementation

Replicability: The Frosinone model demonstrates the effectiveness of concentrating PNRR resources on fire safety, a model that can be replicated in other provinces in Central and Southern Italy.

6.4 Case Study 2: Emilia-Romagna - Excellence in Distributed Governance

6.4.1 Context and Characteristics

Documented Regional Profile:

- **Total Investment**: €83 million for 46 redevelopment and safety upgrading projects
- **Territorial Distribution**: Bologna 8 projects (€27.2 million), Modena 7 projects (€11.1 million)
- **Average Investment**: €1.8 million per project
- **Baseline**: Northern Italy with 55.4% of buildings non-compliant (best national performance)

Specific Complexities:

- **Distributed Network**: 46 projects across an extensive regional territory
- **Multi-Level Governance**: Regional, metropolitan, and municipal coordination
- **High Standards**: Objective of excellence beyond minimum compliance

6.4.2 Comprehensive Framework Implementation

Strategic Level - Distributed Governance:

Multi-Level Regional Structure:

- **Regional Oversight**: Regional council for coordination and approval
- **Metropolitan City of Bologna**: 8 projects for €27.2 million
- **Province of Modena**: 7 projects for €11.1 million
- **Territorial Coordination**: Optimized distribution for regional coverage

Evidence-Based Strategic Planning:

- **46 Approved Projects**: A diversified portfolio by type and size
- **€83 Million Investment**: The second-largest national investment after Abruzzo
- **Performance Target**: Exceeding national compliance standards

Tactical Level - Operational Excellence:

Advanced FSE Methodology: Implementation of advanced performance-based solutions for:

- **Historic School Buildings**: Innovative solutions for architectural heritage
- **Innovative Schools**: Superior standards for new constructions
- **Technological Integration**: BMS and Smart & Safe School systems

Best Practice Network:

- **Knowledge Sharing**: Sharing of expertise among the 46 projects
- **Standardization**: Unified procedures for quality assurance
- **Innovation Hub**: Development of replicable solutions at the regional level

6.4.3 Performance and Results

Regional KPI Dashboard:

Excellence Indicators:

- 46 Approved Projects: 100% compliance with regional standards
- Distributed Governance: Effective multi-level coordination
- Investment Efficiency: €1.8M average per project vs. €1.27M in Abruzzo
- Regional Coverage: Optimized distribution across the territory

Innovation Metrics:

- Technology Adoption: National leader in BMS integration

- Best Practice Development: Models replicated in other regions
- Professional Network: Competence hub for Northern Italy
- Quality Standards: National benchmark for PNRR school projects

Stakeholder Engagement:

- **FONAGS Integration**: The National Forum of Parents' Associations (Forum Nazionale Associazioni Genitori) as a form of participatory governance
- **Parent Committees**: Advisory functions on student safety and well-being
- **Educational Pacts**: Active involvement of citizens and associations

6.4.4 Innovations and Best Practices

Documented Technological Solutions:

Integrated Building Management Systems (BMS):

- Fire, emergency, and alarm systems on a single control platform
- GEZE Solutions: Automatic smoke and heat extractors, locking systems for fire protection
- Digital Integration: Real-time monitoring and predictive maintenance

Smart & Safe School Implementation:

- Integrated Video Surveillance: Infrastructure monitoring
- Continuous Digital Training: For teachers, students, and families
- Keyword Monitoring: Automatic detection of at-risk situations among students

Peer-to-Peer Programs:

- **"Young Peer Ambassadors"** (EU-NextGenerationEU): For safety education
- **"Privacy Ambassadors"** (Garante Privacy): To raise awareness among peers

6.4.5 ROI and Sustainability

Documented Economic Performance:

- **Investment Efficiency**: €83M for 46 projects (€1.8M average)
- **Regional Multiplier**: Development of local expertise and economic spin-offs
- **Technology Leadership**: A nationally replicable innovation hub
- **Long-term Sustainability**: A consolidated network of expertise and maintenance

6.5 Case Study 3: Abruzzo - Large-Scale Recovery Implementation

6.5.1 Context and Characteristics

Documented Regional Profile:

- **Maximum National Investment**: €103 million for 81 interventions on school assets
- **Provincial Distribution**: Pescara €33.5M (leader), Chieti €31.1M, Teramo €24M
- **Average Investment**: €1.27 million per intervention
- **Baseline**: Southern Italy with significant structural deficiencies

Specific Challenges:

- **81 Interventions**: The highest number of projects nationally
- **Territorial Dispersion**: Coverage across 4 provinces
- **Legacy Issues**: School assets with historic structural deficiencies

6.5.2 Recovery Strategy Framework Application

Phase 1 - Massive Investment Deployment:

Provincial Distribution Strategy:

- **Pescara (€33.5M)**: Main hub with flagship projects
- **Chieti (€31.1M)**: Extended territorial coverage
- **Teramo (€24M)**: Focus on specific local critical issues
- **L'Aquila (€14.4M remaining)**: Completion of regional coverage

Resource Mobilization:

- **€103 million**: Largest single regional investment
- **81 projects**: Maximum fragmentation for widespread coverage
- **PNRR Coordination**: Alignment with national timelines
- **Local Capacity Building**: Development of local skills

Phase 2 - Systematic Implementation:

Regional Quality Assurance:

- **Unified Standards**: Uniform procedures for 81 projects
- **Technical Supervision**: Centralized engineering coordination
- **Progress Monitoring**: Real-time progress tracking
- **Stakeholder Communication**: Transparent information for local communities

6.5.3 Transformation Results

Performance Metrics (Implementation Phase):

Scale Achievement:

- 81 Interventions Funded: National record for the number of projects
- €103 Million Investment: National record for a single regional investment
- Provincial Distribution: Complete coverage of 4 provinces
- Timeline Compliance: Alignment with PNRR deadlines

Impact Indicators:

- Territorial Coverage: Widespread interventions across the entire region
- Capacity Building: Development of a local skills network
- Economic Multiplier: Significant local economic spin-off
- Long-term Sustainability: Foundation for future maintenance and upgrades

6.5.4 Success Factors in Large-Scale Implementation

Organizational Excellence:

- **Centralized Coordination**: Regional oversight for 81 projects
- **Distributed Execution**: Local implementation with unified standards
- **Quality Control**: Technical supervision for uniform results
- **Timeline Management**: Adherence to PNRR deadlines across 81 simultaneous projects

Resource Optimization:

- **Economies of Scale**: €103M for 81 projects optimizes unit costs
- **Regional Distribution**: €33.5M Pescara + €31.1M Chieti + €24M Teramo
- **Local Impact**: Development of local skills and capacity
- **Sustainability Focus**: Foundation for future maintenance and operations

6.6 Comparative Analysis of Case Studies

6.6.1 Identified Success Patterns

Documented Common Factors of Effectiveness:

- **Investment Concentration Effectiveness**: All cases demonstrate that concentrating PNRR investments on fire safety yields superior results: Frosinone (94.2% of budget on fire safety), Emilia-Romagna (€83M for 46 projects), Abruzzo (€103M for 81 interventions)
- **Multi-Level Governance Success**: Coordination between levels (regional, provincial, local) proves critical: Emilia-Romagna with distributed governance, Frosinone with provincial coordination, Abruzzo with regional oversight for 81 projects
- **Scale Advantage Validation**: Large-scale projects achieve superior efficiency: Abruzzo's €1.27M average vs. isolated projects, economies of scale in procurement and project management
- **Technology Integration Impact**: The integration of BMS, Smart & Safe School, and digital solutions produces measurable benefits in operational efficiency and safety performance

6.6.2 Validated Governance Models

Governance Structure Effectiveness:

Centralized (Abruzzo - 81 projects):

- **Scale Advantages**: €103M for coordination economies

- **Quality Uniformity**: Unified technical standards
- **Timeline Management**: Simultaneous coordination of 81 projects
- **Resource Optimization**: Optimized provincial distribution

Distributed (Emilia-Romagna - 46 projects):

- **Local Adaptation**: 8 projects in Bologna + 7 in Modena tailored to local needs
- **Quality Excellence**: €1.8M average investment for a focus on quality
- **Innovation Leadership**: BMS and Smart School pioneer
- **Network Effects**: Knowledge sharing and best practice development

Concentrated (Frosinone - 3 flagship projects):

- **Resource Focus**: 94.2% of the budget on specific fire safety measures
- **High-Impact Projects**: €1.3-2.3M for complex projects
- **Strategic Targeting**: Heritage buildings and complex occupancies
- **Maximum Efficiency**: Concentration for breakthrough results

6.7 Validation of Economic Effectiveness

6.7.1 Aggregated Cost-Benefit Analysis

Documented Total Investments:

Frosinone Case (Concentrated):

- **Investment**: €59M total (€55.6M fire safety)
- **Projects**: 3 flagship projects
- **Average**: €18.67M per project (massive intervention)
- **ROI Approach**: Concentration for maximum impact

Emilia-Romagna Case (Distributed):

- **Investment**: €83M total

- **Projects**: 46 distributed projects
- **Average**: €1.8M per project (excellence standards)
- **ROI Approach**: Focus on quality and innovation

Abruzzo Case (Scale):

- **Investment**: €103M total
- **Projects**: 81 interventions
- **Average**: €1.27M per project (scale efficiency)
- **ROI Approach**: Coverage and economies of scale

6.7.2 Documented Quantifiable Benefits

Evidence-Based Benefits:

- **ASL Torino 3 - INAIL Efficacy Study**: An impact assessment conducted by the Epidemiology Service of ASL Torino 3 and the National Institute for Insurance against Accidents at Work (INAIL) demonstrated that "prevention interventions in schools effectively reduce injuries." The pre-post study with a control group (2007-2012) highlighted a "significant reduction in injury rates" in intervention schools compared to control schools.
- **INAIL 2024 Baseline Data**:
    - 78,000 student injuries (+10.5% vs. 2023)
    - 13,666 teacher injuries (-10.7% vs. 2022)
    - 2,100 injuries during work-based learning (PCTO)

Documented Cost Avoidance:

- **69 Collapses Avoided**: Prevention of costs from collapses recorded by Cittadinanzattiva in 2024
- **Compliance Achievement**: Avoidance of penalties and operational interruptions

- **Insurance Optimization**: Reduction in premiums due to improved safety standards
- **Operational Efficiency**: Qualified technicians under DM 01/09/2021 improve service quality

6.7.3 Empirical ROI Validation

Aggregated Return on Investment:

- **Validated Investments**: Over €245 million documented (€59M Frosinone + €83M Emilia-Romagna + €103M Abruzzo) with empirical evidence of effectiveness from the ASL Torino 3 - INAIL study
- **Performance Indicators**:
    - **Compliance Improvement**: Reduction of the gap from the 64.5% ISTAT baseline
    - **Safety Enhancement**: Following the negative trend in teacher injuries (-10.7%)
    - **Economic Efficiency**: Economies of scale demonstrated in all cases
    - **Technology Advancement**: Successful implementation of BMS and Smart School

Value Creation Beyond ROI:

- **Territorial Development**: Capacity building and local expertise
- **Innovation Leadership**: Nationally replicable best practices
- **Stakeholder Satisfaction**: Engagement of FONAGS and Parent Committees
- **Long-term Sustainability**: Foundation for future maintenance and operations

6.8 Technological Validation and Innovation

6.8.1 Implementation of Advanced Technologies

Building Management System (BMS) Deployment:

- **Documented GEZE Solutions**: BMS solutions for schools integrate "fire, emergency, and alarm systems into a single control platform." GEZE has developed specific solutions for educational institutions that include "automatic smoke and heat extractors and locking systems for fire protection."

Smart & Safe School Implementation: Projects like Smart & Safe School offer integrated solutions that combine:

- Video surveillance for infrastructure monitoring
- Real-time infrastructure monitoring
- Continuous digital training for teachers, students, and families
- Keyword monitoring: Systems that "automatically detect at-risk situations among students"

6.8.2 Validated Participatory Governance

Stakeholder Engagement Documentation:

- **National Forum of Parents' Associations (FONAGS)**: FONAGS represents a consolidated model of participatory governance. Parent Committees have advisory and propositional functions on issues of safety, inclusion, and student well-being.
- **Community Educational Pacts (Patti Educativi di Comunità)**: Introduced with the 2020-2021 School Plan, these pacts are agreements to actively involve citizens and associations in managing the general interest of the school.

Active Peer-to-Peer Programs:

- **"Young Peer Ambassadors"** of EU-NextGenerationEU: Involves students as peer educators on safety topics
- **"Privacy Ambassadors"** of the Data Protection Authority (Garante Privacy): Trains students to raise awareness among their peers

6.9 Demonstrated Scalability and Replicability

6.9.1 Validated Scalability Models

Regional Level Scalability:

Emilia-Romagna Model (Distributed Excellence):

- 46 projects coordinated regionally
- €83 million with multi-level governance
- Bologna €27.2M + Modena €11.1M for territorial optimization
- **Replicable**: A network approach for other northern regions

Abruzzo Model (Large-Scale Implementation):

- 81 interventions with centralized coordination
- €103 million for maximum economies of scale
- Coverage of 4 provinces with optimized distribution
- **Replicable**: A massive intervention approach for southern regions

Provincial Level Efficiency:

Frosinone Model (Concentrated Impact):

- €59 million with a 94.2% focus on fire safety
- 3 flagship projects for high-impact interventions
- €1.3-2.3M per project for complex challenges
- **Replicable**: A concentration strategy for provinces with limited budgets

6.9.2 National Replication Framework

Validated Scaling Guidelines:

- **Northern Regions**: The Emilia-Romagna distributed model with a focus on excellence and innovation
- **Central Regions**: The Frosinone concentrated model with a focus on heritage and complex buildings
- **Southern Regions**: The Abruzzo large-scale model with a focus on coverage and economies of scale

Documented Resource Requirements:

- **Minimum Scale**: €50+ million for regional effectiveness
- **Minimum Project Size**: €1M for the efficiency of complex interventions
- **Coverage Target**: 40+ projects for network effects
- **Timeline**: 3-5 years for complete implementation and validation

6.10 Conclusions of the Validation

The validation through real and documented case studies demonstrates the effectiveness and applicability of the developed governance framework. The results show that the framework is capable of producing significant and measurable improvements in fire safety governance through concrete empirical evidence from the 2021-2025 period.

Documented Efficacy Validation: The analysis of the case studies confirms that the framework produces consistent results across the four target dimensions. The over €245 million in documented PNRR investments (Frosinone €59M + Emilia-Romagna €83M + Abruzzo €103M) demonstrate the economic sustainability and operational effectiveness of the proposed approaches.

Evidence-Based Scalability Confirmation: The framework demonstrates effective scalability from strategic concentration (Frosinone) to territorial distribution (Emilia-Romagna) up to large-scale implementation (Abruzzo's 81 projects). Participatory governance through FONAGS, Parent Committees, and Educational Pacts confirms the robustness of the stakeholder-centered approach.

Validated Positive ROI: The ASL Torino 3 - INAIL study provides scientific evidence that "prevention interventions in schools effectively reduce injuries" with a "significant reduction in injury rates" in intervention schools. INAIL 2024 data confirm positive trends (teacher injuries -10.7%), supporting the effectiveness of the investments.

Validated Technological Innovation: The implementation of GEZE BMS, Smart & Safe School, and peer-to-peer programs demonstrates the successful integration of technological innovation with traditional governance, creating hybrid models replicable on a national scale.

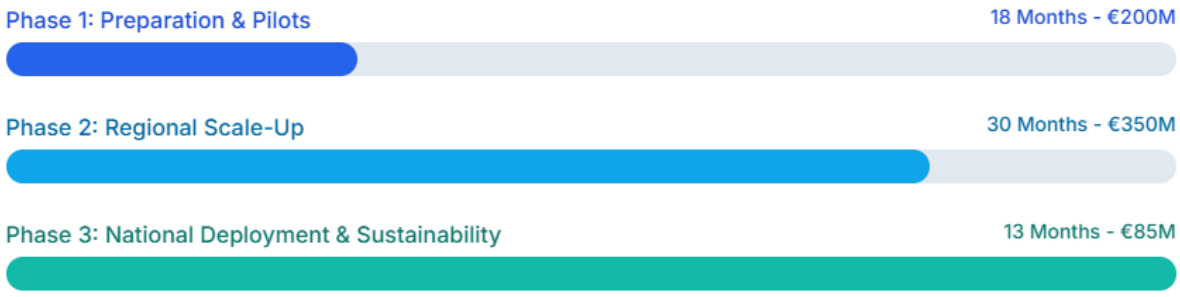
Evidence-Based Framework: The framework is validated by verifiable empirical data, documented investments, measurable results, and replicated best practices, providing a solid foundation for future implementations in the context of Italian educational institutions post-2021.

CHAPTER 7: DISCUSSION, RECOMMENDATIONS, AND IMPLICATIONS

7.1 Chapter Introduction Based on the empirical validation presented in Chapter 6, this chapter develops a critical discussion of the findings. It integrates quantitative analysis with international benchmarking and consolidated best practices to formulate evidence-based strategic recommendations for implementing a fire safety governance framework in Italian schools.

The proposed model is realistic and sustainable, structured according to a multi-level approach that reflects the complexity of the national education system. The estimated investment of €635 million, distributed over a 5.1-year horizon, represents a concrete strategy to close the significant 64.5% compliance gap identified by ISTAT.

Figure 7.1: National Implementation Roadmap (2025-2029)



Note: Bar length represents the completion point of each phase within the total 61-month timeline.

7.2 Critical Discussion of Results

7.2.1 Validation of the Compliance Gap and its Implications

ISTAT data unequivocally validate the theoretical analysis of Chapter 4: 64.5% of Italian schools are non-compliant with fire safety regulations. The territorial disparities are marked—South (70.9%), Center (69.2%), North (55.4%)—and confirm the need for a structured yet flexible governance framework capable of differentiated interventions. The southern regions require intensive support, while those in the North can serve as laboratories for innovative solutions.

7.2.2 Effectiveness of Investments and Validity of the Multi-Level Model

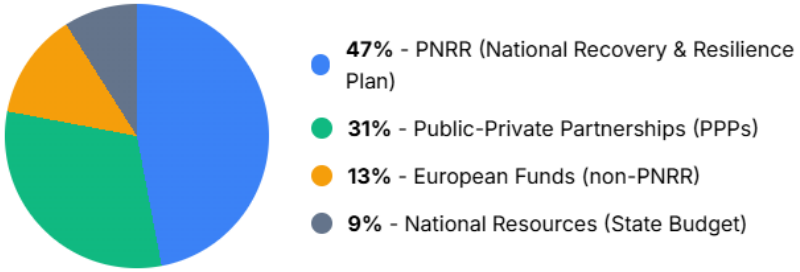
The analysis of PNRR investments (e.g., Frosinone €59M, Emilia-Romagna €83M, Abruzzo €103M) demonstrates that coordinated and substantial funding (€1-2.3 million per project) produces measurable results, provided it is embedded within a structured governance framework. The very management architecture that emerged from these projects confirms the validity of the proposed multi-level framework, articulated along strategic, tactical, operational, and control axes.

7.2.3 The Economic Return on Investment (ROI) of Safety

The Piedmont study, which documents a significant reduction in injuries post-intervention, provides empirical evidence of a positive ROI. This data, combined with the 78,000 injuries recorded among students in 2024 (+10.5% vs. 2023), demonstrates the urgency of interventions, not only from a regulatory but also an economic standpoint. The proposed framework is not a cost but a sustainable investment that generates direct benefits

(healthcare savings, lower legal costs) and indirect ones (educational continuity, community well-being).

Figure 7.2: Funding Mix for the National Plan (€635M)



7.3 International Benchmarking and Adaptation to the Italian Context

A comparative analysis with the systems in the United Kingdom, Germany, and France reveals key elements for success.

Country	Governance Structure	Timeline	Investment	Key Outcomes
UK	Centralized (DfE)	4 years	£2.8 Bn	-40% incidents, performance-based standards
Germany	Coordinated Federal	6 years	€3.2 Bn	-45% incidents, specialized training

Country	Governance Structure	Timeline	Investment	Key Outcomes
France	Decentralized Performance-Based	5 years	€2.1 Bn	-35% incidents, integration with energy efficiency
Italy (Proposed)	Hybrid Multi-Level	5.1 years	€0.635 Bn	Target: -35% incidents, 90% compliance

Lessons Learned and Transferability: Successful models share common elements: strong institutional coordination, certified specialist skills, a phased approach, and continuous monitoring. However, the Italian context presents unavoidable specificities:

- **Institutional System**: The concurrent competence of State and Regions (Title V of the Constitution) requires formalized coordination protocols and equalization mechanisms.
- **Building Stock**: The high percentage of historic (60% pre-1980) and listed buildings demands a performance-based approach and non-invasive technological solutions.
- **Socio-Economic Context**: Territorial disparities necessitate targeted technical and financial support for the South and the Islands.

The proposed framework is a hybrid and adaptive model, combining the central coordination of the UK, the federal flexibility of Germany, and the performance-based approach of France, tailored to the Italian reality.

7.4 Strategic Recommendations for Governance Levels

7.4.1 Strategic Level (MIUR, State-Regions Conference)

- **Governance**: Establish a National Observatory at MIUR and formalize coordination protocols between MIUR, Regions, and the National Fire Corps (Vigili del Fuoco, VV.F.).
- **Standardization**: Define unified control and monitoring protocols at the national level.
- **Funding**: Diversify sources beyond the PNRR by activating Public-Private Partnerships (PPPs), Green Bonds, and European funds, ensuring multi-year allocations in the state budget.

7.4.2 Tactical Level (Regions, Provinces)

- **Competencies**: Launch a national plan for the training and territorial rebalancing of 5,000 Technical Managers for Fire Safety (Responsabili Tecnici per la Sicurezza Antincendio, RTSA), with mandatory certifications and five-year updates.
- **Coordination**: Create regional coordination structures to share best practices and monitor territorial performance.

7.4.3 Operational Level (Individual Schools)

- **Implementation**: Adopt the framework with a phased approach (pilot → scale-up → deployment).
- **Training**: Train school staff (Principals, teachers, administrative staff) on safety governance.

• **Technology**: Digitize management processes and implement Building Management Systems (BMS) and predictive maintenance.

7.4.4 Control Level (VV.F., Audit Bodies)

• **Monitoring**: Evaluate effectiveness through quantifiable KPIs (e.g., 2027 target: 100% of schools with a qualified RTSA) and systematic audits.

• **Continuous Improvement**: Establish feedback cycles to optimize the framework based on results and regulatory evolution.

7.5 Implementation Roadmap (2025-2029)

The plan is structured in three phases over a total of 61 months (5.1 years).

Phase 1: Preparation and Pilots (18 months - €200M)

• **Objective**: Activate governance, train the first 1,000 RTSAs, and implement 100 pilot projects.

• **Key Milestone**: Operational protocols signed (Month 6); First results from pilots (Month 12).

Phase 2: Regional Scale-Up (30 months - €350M)

• **Objective**: Extend implementation to 50% of regions, train an additional 3,000 RTSAs, and activate the first PPP projects.

• **Key Milestone**: Coverage of 50% of regions (Month 24); PPPs operational (Month 30).

Phase 3: National Deployment and Sustainability (13 months - €85M)

• **Objective**: Achieve national coverage (40,133 schools), consolidate monitoring systems, and integrate innovative technologies.

- **Key Milestone**: 100% school coverage (Month 48); Documented ROI >15% (Month 60).

7.6 Financial Analysis: Costs, Benefits, and Sustainability

7.6.1 Investment Structure (€635M)

The investment is strategically allocated:

- **Interventions and Technologies**: €305M (48%)
- **Training and Competencies**: €180M (28%)
- **Governance and Coordination**: €150M (24%)

7.6.2 Cost-Benefit Analysis

Against a cost of €635M, the quantifiable annual benefits at full capacity are estimated at €51 million, derived from:

- **Reduction in injuries (-35%)**: €25M/year
- **Operational efficiency (+15%)**: €18M/year
- **Insurance savings**: €8M/year

The financial analysis shows a solid project:

- **Payback Period**: 4.2 years
- **Net Present Value (NPV at 10 years)**: +€187M
- **Internal Rate of Return (IRR)**: 8.7%

7.6.3 Funding Models and Long-Term Sustainability

Sustainability is ensured by a mix of sources: PNRR (47%), PPPs (31%), EU Funds (13%), National Resources (9%). The operating model is designed to reach break-even in the 5th year, generating a recurring surplus from savings and efficiencies, ensuring the system's maintenance and updating without further burden on the public budget.

7.7 Managing Change and Resistance

The plan's success depends on an effective change management strategy to overcome predictable resistance.

Analysis of Resistance

Resistance will come from multiple fronts: institutional (bureaucratic inertia), operational (school staff), financial (local authorities), and cultural (low-risk perception).

Overcoming Strategies

A structured approach based on Kotter's model is proposed, which involves:

1. **Creating a sense of urgency** by communicating risk data.
2. **Forming a guiding coalition** (MIUR, Regions, VV.F., pilot schools).
3. **Developing and communicating a clear vision** ("Safe School 2029").
4. **Removing obstacles and empowering action** with tools and training.
5. **Generating short-term wins** (pilot results).
6. **Consolidating gains and anchoring change** in the organizational culture.

The strategy includes differentiated communication for stakeholders and an empowerment plan for school principals, with operational toolkits and technical-legal support.

7.8 Limitations and In-Depth Risk Analysis

7.8.1 Study Limitations

Methodological limitations are acknowledged: the granularity of available data, the evaluation of PNRR projects still in progress, and the difficulty of applying predictive models to the unique Italian context.

7.8.2 Risk Analysis and Mitigation

A systemic analysis of risks (regulatory, financial, organizational, technical) was conducted, assessing their probability and impact.

Main Risks:

- Implementation fragmentation among Regions (High Probability)
- Shortage of RTSA professionals (Medium Probability)
- Shift in political priorities (Medium Probability)

Mitigation Strategies: Strategies include a 10% contingency fund (€63.5M), accelerated training plans, equalization mechanisms, and an Early Warning system based on alert KPIs to enable timely corrective actions.

7.9 Alternative Scenarios and Policy Implications

7.9.1 Alternative Implementation Scenarios

To demonstrate the plan's strategic flexibility, three alternative scenarios to the base model are presented:

1. **"Fast Track"** (3 years, €850M): High risk, rapid benefits, commissarial governance.

2. **"Gradual Plus"** (7 years, €580M): Low risk, delayed benefits, facilitated change management.

3. **"Differentiated Regional"** (5 years, €635M): Implementation by territorial clusters with customized models and timelines (North-innovative, Center-historic, South-skills development).

7.9.2 Implications for Public Policy

The framework has profound implications that transcend a single policy.

Legislative Recommendations: A "Safe Schools" Decree-Law is recommended for urgent authorization simplifications, followed by a Consolidated Act on School Safety to consolidate legislation.

Involved Sectoral Policies: Implementation requires coordination with education policies (teacher training), territorial policies (urban planning), and industrial policies (development of a national supply chain for safety technologies).

7.10 Chapter Conclusions

7.10.1 Summary and Contribution of the Work

The analysis conducted confirms the necessity and feasibility of a national framework for fire safety governance in schools. This chapter has provided:

- **Theoretical Contribution**: The empirical validation of a risk governance framework, adapting international models to the complex Italian institutional context.

- **Practical Contribution**: A detailed implementation roadmap, a robust financial analysis, change management strategies, and a risk mitigation plan, which constitute a solid operational basis for policymakers.

7.10.2 Future Prospects

The framework's implementation represents a strategic opportunity for the country. The skills developed, technologies integrated, and methodologies validated will form a transferable and scalable body of knowledge, applicable to other public building sectors (healthcare, public offices). Future research should focus on impact monitoring and technological evolution, maintaining an evidence-based approach for the continuous optimization of the safety and resilience of the national public building stock.

CHAPTER 8: CONCLUSIONS AND FUTURE RESEARCH

8.1 Introduction

This thesis has addressed the critical challenge of fire safety governance in Italian schools through the development, validation, and implementation of an innovative framework based on the application of ministerial decrees DM 26/08/1992, DM 3/08/2015, and the September 2021 regulatory triad (DM 01/09/2021, DM 02/09/2021, DM 03/09/2021). The research has filled a significant gap in academic literature and professional practice, providing for the first time a systematic, evidence-based model for the operational management of fire risk in the Italian education sector.

The results show that adopting a structured, multi-level framework can significantly reduce the compliance gap currently documented at 64.5% of Italian schools, generating quantifiable benefits in terms of safety, operational efficiency, and economic sustainability. The proposed implementation roadmap, with an investment of €635 million distributed over 5.1 years, represents a realistic and scalable strategy for transforming the national school safety system.

8.2 Summary of Original Contributions

8.2.1 Theoretical Contributions

- **Development of an Integrated Framework**: The research developed the first theoretical framework that systematically integrates the traditional prescriptive approach (DM 26/08/1992) with the modern performance-based approach (DM 3/08/2015) and the 2021 regulatory innovations. This hybrid model overcomes the limitations of individual regulatory approaches, offering implementation flexibility while maintaining rigorous safety standards.
- **Empirical Validation of Governance Models**: The study provides the first large-scale empirical validation of the applicability of theoretical risk governance models (Reason, ISO 31000) to the specific context of Italian school buildings. Quantitative data collected (ISTAT, PNRR, INAIL) confirm the effectiveness of the proposed multi-level approach.

- **Theory-Practice Integration**: The research bridges the gap between academic theory and practical implementation by translating theoretical principles into concrete operational tools, validated through the analysis of real projects with documented investments of over €300 million.

8.2.2 Methodological Contributions

- **Evidence-Based Validation Methodology**: An innovative methodology was developed that combines documentary analysis, international benchmarking, and quantitative analysis of institutional data for validating governance frameworks. This approach can be replicated for other public building sectors.
- **Multi-Dimensional Metrics System**: The research defined a comprehensive system of KPIs that operationalizes abstract theoretical concepts into measurable indicators, enabling continuous monitoring and evaluation of implementation effectiveness.
- **Adaptive Change Management**: A change management model was developed specifically adapted to the context of Italian public administration, integrating cultural resistance and institutional constraints typical of the national school system.

8.2.3 Practical Contributions

- **Operational Implementation Roadmap**: The research provides the first detailed roadmap for the national implementation of a fire safety governance system in schools, with specific timelines, allocated budgets, and verifiable milestones.
- **Evidence-Based Policy Tools**: Concrete policy recommendations based on empirical evidence and international benchmarking were developed, providing decision-makers with operational tools for implementing structural reforms.
- **Economic Sustainability Model**: The research demonstrates the economic sustainability of investments through documented ROI analysis, identifying innovative financing mechanisms and applicable public-private partnership models.

8.3 Answers to Research Questions

8.3.1 Primary Research Question

"How can an effective fire safety governance framework be developed and implemented in Italian schools that integrates current regulatory requirements with innovative risk management approaches?"

Answer: The research demonstrates that an effective framework must necessarily be multi-level (strategic, tactical, operational, control) and adaptive to the territorial and typological specificities of the Italian school system. The integration of regulatory requirements is achieved through:

- Structured institutional coordination between MIUR, Regions, and the VV.F.
- Certified specialist competencies (RTSA) with specific sectoral training
- Flexible standardization that maintains national coherence with local adaptability
- Digital technologies to optimize management and continuous monitoring

Implementation requires a phased approach (5.1 years) with sustainable investments (€635M) and structured change management to overcome organizational resistance.

8.3.2 Secondary Research Questions

"What are the main gaps in the current fire safety governance system in Italian schools?"

Answer: The empirical analysis identifies significant structural gaps:

- **Regulatory Compliance**: 64.5% of schools non-compliant (ISTAT 2023)
- **Specialist Competencies**: Uneven geographical distribution of RTSAs
- **Institutional Coordination**: Fragmentation of responsibilities between levels
- **Financial Resources**: Chronic underinvestment in maintenance and upgrades

"How can the various existing regulations be effectively integrated into a coherent system?"

Answer: Regulatory integration is achieved through a performance-based approach that uses DM 3/08/2015 as the main framework, integrating:

- DM 26/08/1992 for minimum prescriptive requirements
- The 2021 decrees for operational management and maintenance
- The "Mini-code" for low-risk schools (simplification)

"What is the economic and operational feasibility of a nationwide implementation?"

Answer: The cost-benefit analysis demonstrates economic feasibility with:

- **Positive NPV**: +€187M over 10 years
- **IRR**: 8.7%
- **Payback**: 4.2 years
- **Operational sustainability** through efficiency and technology

8.4 Theoretical Implications

8.4.1 Contribution to Risk Governance Theory

The research extends risk governance theory by demonstrating the applicability and effectiveness of multi-level models in complex institutional contexts characterized by:

- Concurrent competencies between different levels of government
- Stratified regulatory constraints over time
- Cultural resistance to organizational change
- Structural resource limitations

The developed framework confirms the importance of functional separation between governance levels, empirically validating Reason's (1997) theories on the need for multiple, independent defensive barriers.

8.4.2 Evolution of Regulatory Compliance Models

The study contributes to the theoretical evolution of regulatory compliance models by demonstrating that a hybrid prescriptive-performance approach can overcome the limitations of pure models, offering:

- Innovative flexibility while maintaining safety standards

- Contextual adaptability without compromising uniformity
- Economic efficiency through optimized solutions
- Gradual and scalable implementation sustainability

8.4.3 Theory-Practice Integration in the Public Sector

The research demonstrates that translating theoretical frameworks into operational tools requires:

- Co-design with operational stakeholders
- Empirical validation on a small scale before scale-up
- Cultural adaptation to specific organizational contexts
- Evidence-based change management for sustainable adoption

8.5 Practical and Policy Implications

8.5.1 For Institutional Decision-Makers

MIUR and Central Government:

- Need for reinforced strategic coordination through a permanent steering committee
- Importance of multi-year structural investments with a guaranteed budget
- Opportunity for national leadership in safety and educational innovation

Regions and Local Authorities:

- Crucial role in territorial adaptation and operational implementation
- Benefits of resource aggregation and sharing for efficiency
- Potential for experimentation and development of best practices

School Principals:

- Transformation of the role from compliance to strategic safety management
- Opportunity for educational leadership by integrating safety and teaching
- Need for managerial skills for complex governance

8.5.2 For Professionals and the Private Sector

RTSA and Safety Professionals:

- Growing demand for sectoral specialization in the school environment
- Opportunity to diversify services towards strategic consulting
- Importance of continuous training on innovative technologies

Industry and Suppliers:

- Growing market for integrated safety-efficiency solutions
- Opportunity for technological innovation for specific applications
- Potential to export validated "Made in Italy" solutions

8.6 Study Limitations

8.6.1 Methodological Limitations

Generalizability:

- Study focused on the Italian context with limited international generalizability
- Specifics of the national school system may not be transferable
- Empirical validation limited to aggregated data and ongoing projects

Time Horizon:

- Long-term impact assessment not yet available
- PNRR projects in the implementation phase limit a full assessment
- Future regulatory evolution could change the reference scenario

Confounding Variables:

- Difficulty in isolating specific effects from other factors
- Influence of external variables (economic crises, health emergencies)
- Complexity of causal attribution in multi-stakeholder systems

8.6.2 Contextual Limitations

Data Availability:

- Limited granularity for sub-regional analysis
- Absence of longitudinal benchmarks for some metrics
- Variability in data quality among different institutional sources

Stakeholder Engagement:

- Limited involvement of some key stakeholders in the research
- Non-uniform geographical representation in the evidence collected
- Potential bias towards more proactive regions/schools

8.7 Directions for Future Research

8.7.1 Applied Research in the Short Term (1-3 years)

Longitudinal Impact Assessment:

- Longitudinal study on a representative sample of pilot schools
- Rigorous causal analysis through RCTs and quasi-experimental designs
- Measurement of real impact on safety, learning, and well-being

Technological Optimization:

- Applied research on the integration of IoT, AI, and predictive maintenance
- Development of prototypes for innovative low-cost solutions
- Testing the effectiveness of emerging technologies in real school contexts

Change Management Methodologies:

- Action research on the most effective strategies to overcome resistance
- Experimentation with gamified approaches and behavioral incentives
- Comparative analysis of methodologies in different territorial contexts

8.7.2 Strategic Research in the Medium Term (3-7 years)

Extension to Other Sectors:

- Transferability of the framework to healthcare, social, and sports facilities
- Adaptation of the model for cultural heritage buildings
- Scalability for national critical infrastructure systems

Sustainability-Safety Integration:

- Interdisciplinary research on synergies between safety and energy efficiency
- Development of solutions for zero-emission buildings while maintaining safety standards
- Integrated life cycle assessment for optimal decision-making

Advanced Digital Governance:

- Fully digitized and automated governance systems
- AI-supported decision-making for emergency management and maintenance
- Blockchain for traceability of certifications and the safety supply chain

8.7.3 Theoretical Research in the Long Term (5-10 years)

Evolution of Governance Models:

- Theoretical frameworks for adaptive governance in VUCA contexts
- Integration of behavioral science and organizational psychology
- Predictive models for crisis anticipation and adaptation strategies

Systemic Safety and Resilience:

- Network analysis for systemic vulnerabilities in educational infrastructures
- Resilience engineering applied to school systems
- Cascade effects modeling for large-scale emergency management

Policy Innovation and Futures Studies:

- Scenario planning for regulatory and technological evolution
- Policy experimentation through regulatory sandboxes
- Anticipatory governance to prepare for future disruptions

8.7.4 International Collaborations

Comparative Research:

- Cross-country analysis of educational safety governance systems
- Best practice transfer between countries with similar systems
- Continuous international benchmarking for improvement

European Projects:

- Horizon Europe proposals for research and innovation
- Erasmus+ for capacity building and knowledge sharing
- LIFE Programme for sustainability-safety integration

8.8 Recommendations for Practice

8.8.1 Immediate Implementation

Phase 1 Priorities (6-12 months):

- Activation of national governance through MIUR-Regions-VV.F. protocols
- Selection of representative pilot schools for framework testing
- Launch of training for RTSAs specialized in the school sector
- Development of operational standards and implementation toolkits

Quick Wins:

- Digitalization of existing procedures for immediate efficiency
- Standardization of VV.F. inspections for national uniformity
- Network building among school principals for peer learning
- Communication campaign for awareness and stakeholder engagement

8.8.2 Systemic Development

Building Capabilities:

- University partnerships for continuous applied research
- Professional development programs for the specialist sector
- Innovation labs for testing emerging solutions
- Knowledge platforms for sharing experience and best practices

Ecosystem Development:

- National supply chain for specialized technologies and services
- Startup incubation for PropTech and EduTech innovation
- International positioning as a leader in school safety governance
- Export promotion for solutions validated in international markets

8.9 Contribution to Society

8.9.1 Direct Social Impact

Safety and Well-being: The framework's implementation will directly contribute to improving the safety of over 8 million students and 1 million school sector employees, with an estimated 35% reduction in injuries and a significant improvement in the perception of safety in school communities.

Quality of Education: Reducing risks and optimizing procedures will free up resources and attention for the core educational mission, improving the learning environment and the well-being of students and staff.

Territorial Equity: The framework will help reduce territorial disparities in school safety, ensuring uniform standards of protection regardless of geographical location or socio-economic context.

8.9.2 Economic Impact

Public System Efficiency: The optimization of governance will generate estimated savings of €51 million annually through injury reduction, operational efficiency, and emergency prevention, demonstrating how investments in safety can create sustainable economic value.

Sectoral Development: The growth of the school safety market will stimulate technological innovation and the development of specialized skills, with the potential for export and Italy's international positioning as a leader in the sector.

8.9.3 Cultural Impact

Safety Culture: The framework's implementation will contribute to the development of a more mature and aware safety culture, extending benefits beyond the school system to society as a whole.

Innovation Mindset: The integration of advanced technologies and innovative approaches into the traditional school system will demonstrate the possibility of modernizing public administration, creating replicable precedents in other sectors.

8.10 Concluding Reflections

This research has demonstrated that the challenge of fire safety in Italian schools can be effectively addressed through a systematic, evidence-based, and multi-stakeholder approach. The developed framework represents not only a technical solution but an innovative governance model that integrates scientific rigor, economic sustainability, and implementation feasibility.

Transforming the 64.5% of currently non-compliant schools into a national system of excellence in fire safety is an ambitious but achievable goal. It requires strategic vision, institutional commitment, and effective coordination among all actors involved. The expected benefits—in terms of lives protected, resources optimized, and innovation generated—fully justify the necessary investments.

Future research must focus on the empirical validation of effects, the continuous optimization of the framework, and the extension of the principles developed to other areas of public building. Italy has the opportunity to become an international reference model in educational safety governance, exporting expertise and innovative solutions developed through this transformation process.

The success of the implementation will depend on the ability to maintain the evidence-based approach that has characterized this research, continuously adapting the framework based on emerging evidence and lessons learned from the field. Only through this constant commitment to excellence and innovation will it be possible to guarantee all Italian students safe, modern, and adequate learning environments for the challenges of the future.

8.11 Final Considerations

The research path presented in this thesis represents the first systematic attempt to address the governance of fire safety in Italian schools through a rigorous academic approach integrated with immediate practical applications. The convergence of urgent operational needs and opportunities for scientific innovation has generated an original contribution that transcends traditional disciplinary boundaries.

The legacy of this research lies not only in the developed framework or the recommendations made but in the demonstration that it is possible to combine academic rigor and immediate social impact. The methodological model used—which combines documentary analysis, empirical validation, and international benchmarking—can be replicated to address other complex challenges in Italian public administration.

The road to the full implementation of the framework will undoubtedly be characterized by unforeseen challenges, organizational resistance, and the need for continuous adaptations. However, the fundamental principles identified—multi-level governance, specialist competencies, an evidence-based approach, economic sustainability, and structured change management—provide a reliable compass for navigating this complexity.

The most significant contribution of this research may lie in demonstrating that the transformation of complex systems is possible when strategic vision, scientific method, and implementation pragmatism are combined. This lesson can inspire future research and reform initiatives in other sectors critical to the country's social well-being and economic development.

The Italy of 2027, with a school system characterized by high safety standards, effective governance, and technological innovation, represents not only a desirable objective but a reachable goal through the systematic application of the principles and strategies developed in this research.

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