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ORIGINAL ARTICLE

Decision-making in balancing fire safety hazards against security threats within the built environment

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Abstract

The built environment faces challenges from fire hazards and threats by malicious actors. Risks presented from these hazards and threats are managed through the practices of fire safety and physical security. Whilst distinct disciplines, both impact the built environment systems, resulting in potential conflict. To manage this conflict, a complex process is required. Through the framework of Governmentality, using a mixed methods approach, the study explored the process which fire safety engineers and security practitioners undertake to manage this conflict. The study produced a conceptual model that explains how practitioners operate and manage risk associated with fire safety hazards and security threats. The model indicates that the process for resolving conflicts is a dichotomy between physical security and fire safety, with fire safety being the most dominate and influential. Nevertheless, both fire safety and physical security are subservient to building regulations in this process; however unlike security, fire safety is codified through building regulations. *Risk assessment* and the *design process* are core processes, but only used in decision-making when there is conflict between the fire safety and physical security. Findings demonstrated that context remains static for greater threats, whereas context is dynamic for fire safety.

Keywords Physical security · Fire safety · Decision-making · Building regulation · Governmentality

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Introduction

The contemporary built environment provides the setting for many significant human activities, such as work, accommodation, and recreation, representing an important component of modern society. Nevertheless, the modern built environment faces innumerable challenges to its and its occupant's survival in the form of fire hazards and malicious threat actions. Risks presented by these distinct drivers are managed through the engineering practices of fire safety and physical security, with both discipline's strategies impacting on the built environment systems yet needing to comply with regulatory requirements set by governments.

A critical analysis of the modern built environment suggests that both fire safety and physical security share various engineering systems. For example, within buildings both fire safety and physical security are concerned with how occupants move through the building (egress/access control), the construction of the external walls for protection (fire ratings/blast ratings), and heating ventilating and air conditioning (smoke movement/contaminants) conditions. However, to achieve individual occupational objectives, differing management approaches to these building systems may be required that may be complimentary or incongruous to the other. For example, to meet egress requirements, all exit doors are required to open upon fire alarm activation, as opposed to lock on alarm, exposing one risk type in the mitigation of the other.

Consequently, these differing approaches to the operational design and management of such built environment systems potentially lead to design conflict. For example, the fire safety strategy may require all exit doors to unlock on activation of a fire alarm, facilitating occupant prompt egress during a fire event. In contrast, the security strategy may require the doors to remain locked from both directions to prevent a malicious intruder action. Such a strategy will also be dependent on the context setting of the environment, for example childcare versus prison. Adding to the built environment risk complexity is the fused safety and security threat concerns of malicious acts such as arson, which is a shared risk by both fire safety and physical security practitioners.

Historically, conflicts with fire safety and security, such as locked exits have contributed to large losses in life during major fires (Duval 2006), such as The Triangle Shirtwaist factory fire (Pence et al. 2003) or Cocoanut Grove fire (Reilly 1942). The shared risk of malicious acts, such as arson have also resulted in significant fires such as the South Korean Daegu subway fire (Gallagher 2003). Consequently, if fire safety and physical security are not balanced appropriately or considered, the built environment and its occupants may not be appropriately protected. To achieve a balanced outcome, a complex process is required by the built environment practitioners to protect society from an unacceptable level of danger.

Modern day building codes and standards, such as the Australian National Construction Code (NCC) or the United States International Building Code (IBC) and NFPA 101, account for these conflicts through specific provisions. These building codes have progressively evolved through reflection on fire disasters, but also technological, legal, and political reasons (Issacs 2018). Furthermore, modern building codes have incorporated performance-based designs, which allow for conflicts within the building design to be resolved through compliance to a performance criterion, as opposed to prescriptive requirements. Performance-based codes allow for a quicker response to changing conditions in the built environment (IRCC 2010). The development of performance codes has also resulted in various process driven models, to aid practitioners in achieving a balanced outcome, such as the International Fire Engineering Guidelines (IFEG) (Australian Government 2005).

The complexities of balancing the conflict between fire safety and physical security has also been explored by numerous authors and organisations (Stroik 1981; Garcia 2008; Craighead 2009), with Garcia (2008) previously characterizing it as a 'classic' conflict. Amongst the established literature which explores this issue, various models such as those produced by the UK Centre for the Protection of National Infrastructure (CPNI 2022) and Jacoby et al. (2016), have put forward guidance in this decision-making process. These models typically provide a normative approach to the issue, outlining an idealised process on how one should conduct themselves, which typically involves technical risk assessments and integration of the two disciplines.

Notwithstanding the established literature concerning this complexity, the current published literature fails to provide an evidence-based theory for explaining the process which practitioners undertake in balancing fire safety and physical security within the built environment. Consequently, this study explored the cognitive structure which practitioners undergo in balancing physical security and fire safety risk concerns in the modern built environment, including the decision factors, decision structure, and their contextual weighting. By describing the process at which practitioners undertake, better governance frameworks can be developed to manage these risks within the built environment, and a framework of decision-making developed to aid forensic review.

The underlying theory of governmentality

This study is primarily concerned with understanding the process which individual practitioners undertake in balancing social risks posed by fire hazards and security threats. The theoretical framework informing the study is based around the explanation on how society manages risks and as such, adopts the framework formed by governmentality (Foucault et al. 2009). The framework of governmentality can provide a lens on how society manages risks posed by fire hazards and security threats through direct and indirect government intervention, and how fire safety and physical security practitioners fit within this discourse.

The term 'governmentality' is a combination of *governance* and *mentality*, first introduced in 1957 by the semiologist Roland Barthes (Barthes and Lavers 1993). The term was later adopted by the philosopher Michel Foucault in his 1978 lecture series "Security, territory and population", as an alternative to Marxist theory to deal with issue of power and politics (O'Malley 2009a, p. 52).

The specific definition of governmentality is subject to debate, with Foucault not providing a single definition (Walters 2012); rather, referred to as the 'art of government' or the 'conduct of conduct' (Li 2007). However for the context of this study it can be seen as a neo-liberal approach to governance, which is based upon policy and strategies, which champions individual freedoms, whilst maximising personnel self-activation, with limited, but some state intervention (Lupton 2013).

An imbalance between fire safety and physical security within the built environment represents a problem for governments to resolve. From a governmentality perspective, this problem can be addressed through an assemblage of tactics, policy, strategies, and with the actualisation of the individuals, such as fire safety engineers and physical security practitioners.

Foucault does not mention how the term risk fits within the concept of Governmentality (Lupton 2013; Denney 2005). Consequently, the understanding of risk rationality within the framework of Governmentality has been developed by other scholars (see Ewald (1991), Rose (1999), Dean (1999). For the context of this study, risk was seen as a rationality or technology of government (O'Malley 2009b), which provides a way of ordering reality, making it calculable, used to achieve objectives and for governing the conduct of individuals.

Mitchell Dean developed a framework, referred to as 'analytics of government', which has been used by a number of researchers (see Winkel 2012; Russell and Frame 2013; Wishart 2015) to understand the elements of governance (Gouldson and Bebbington 2007). Under the framework, the system of governmentality comprises three elements; problematisation, regimes of governing, and utopian ideal, with regimes of governing further comprised four sub-elements. A description of each element, and any sub-elements, are described in Table 1. Although there is no clear methodological advice in the application of the framework (Oels 2005), researchers such as Wishart (2015) have used it as guidance in identifying the regimes of governance for complex issues.

For this study the analytics of government framework was used as the lens of governmentality, to analyse the governance structures between fire safety and physical security and to illuminate the process which practitioners undertake to manage fire and security risks. Each to meet their responsibilities, whilst achieving specific

Table 1 Elements of governmentality analysis

Problematisation	Identification of an issue to be governed
Regimes of governing or analytics of government	Visibilities—created by governance processes and by the use of particular governing or techniques
	Technologies—used to achieve the governance (and which may create visibilities, knowledge, and identities)
	Knowledge—generated by and used within governance processes
	Identities—which emerge from and support governance processes
Utopian ideal	The aim towards which governance is directed, as well as the belief that governance is made possible by a regime of governing

Adapted from (Gouldson and Bebbington 2007) and (Dean 2009) objectives of government. The methodology section provides details on how the framework has been incorporated as part of the analysis.

Methods

The study employed a mixed methods approach using a four-phase process (Fig. 1), with each phase feeding the proceeding phase. The methodological specifics were selected on the basis that they allowed for knowledge to be built based on what was uncovered sequentially. Consequently, Phases 1–3 were designed to build specific understandings of the cognitive process (factors, structure, influence) in the balancing of decisions between fire life safety and physical security, with the final phase interpreting this knowledge to develop assertions for testing amongst an expert focus

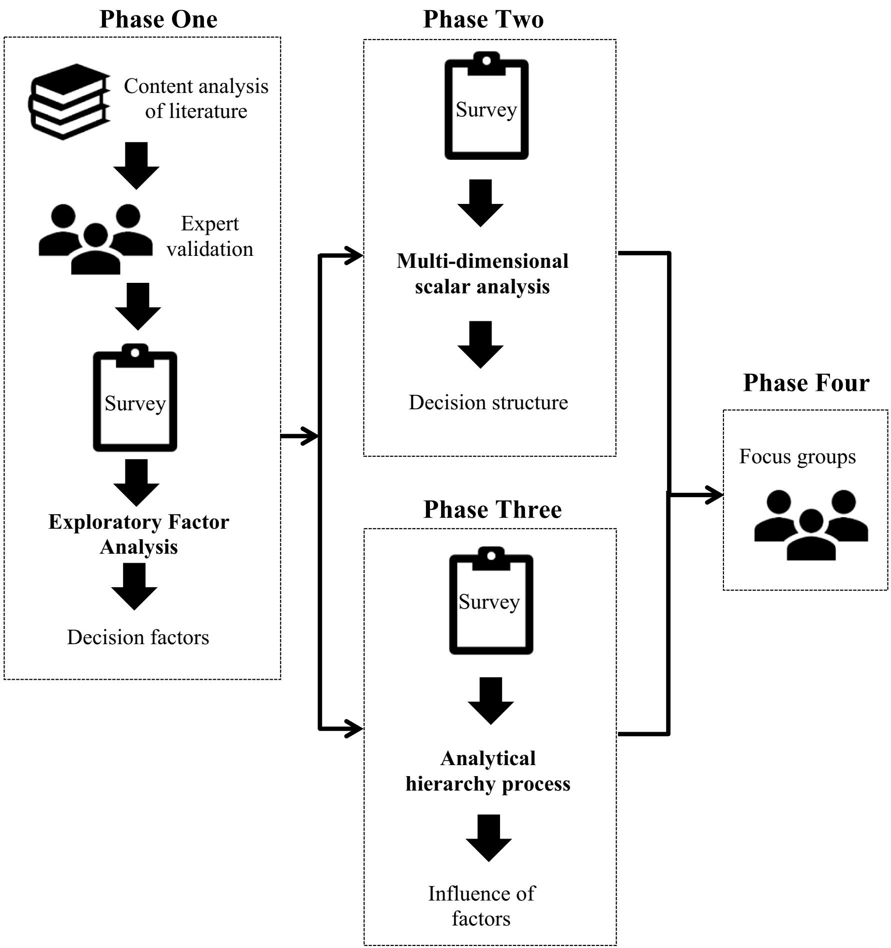


Fig. 1 Study design

group. Then, using the knowledge gained in the focus group, a conceptual model was then developed to provide a cognitive map capturing an ideal understanding of the decision process. This model and the individual phase outcomes were then used to inform a response to the different elements within the analytics of government framework.

Phase one—factor extraction and reduction

Phase one analysed texts across the two disciplines distinct written domains of fire safety and physical security. Content analysis, using word frequency and word co-occurrence counts, were conducted to extract a list of initial factors associated with risk decision-making. Independent experts from physical security and fire safety were then enlisted to review and validate the compiled co-occurrences as representing factors associated with discipline decision-making process.

Using the extracted factors, a survey was developed and administrated to physical security practitioners, fire safety engineers and other built environment practitioners to uncover how each factor influences their decision-making with respect to balancing fire safety and physical security. Exploratory Factor Analysis (EFA) was then undertaken on the survey results, to reduce the decision factors to a set of higher order factors.

Content analysis

The research premise in understanding current knowledge of balancing fire life safety and physical security was that the experts write the text books on any given subject matter. Consequently, the study commenced using factor analysis of published texts on physical security and fire life safety. Neuendorf (2017) succinctly describes content analysis as the "the systematic, objective, quantitative analysis of message characteristics". Content analysis was considered an appropriate approach, as it provided the ability to work directly on texts of human communication, written by the domain experts, whilst being systematic and flexible (Weber 1990; Schreier 2014) and quantifiable.

The output of the content analysis was then verified by independent physical security and fire safety experts. A questionnaire contained word co-occurrences associated with their discipline with a five-point Likert rating scale, questioning the influence each word has in the decision-making process associated with balancing fire safety and physical security in the built environment.

Exploratory factor analysis

Exploratory factor analysis (EFA) supported the understanding of the underlying factors and their interrelationship between the factors identified from the content analysis. EFA was used in the study to identify any underlying constructs, and also reduce the decision factors to a set of more manageable higher order factors.

	Unrelated 1	2	3	4	5	6	7	8	9	Highly related 10
Fire safety compared to fire scenario	○	○	○	○	○	○	○	○	○	○
Fire safety compared to physical security	○	○	○	○	○	○	○	○	○	○
Fire safety compared to security management	○	○	○	○	○	○	○	○	○	○
Fire safety compared to risk	○	○	○	○	○	○	○	○	○	○
Fire safety compared to risk assessment	○	○	○	○	○	○	○	○	○	○
Fire safety compared to building regulation	○	○	○	○	○	○	○	○	○	○

Fig. 2 EFA survey sample

An EFA survey instrument was developed based on the identified factors from the content analysis which were verified by the experts. To understand the participants attitude towards each factor and its influence, a five-point Likert rating was used for the survey. Participants indicated on the five-point scale how much influence a factor has in balancing fire safety and physical security. An example of the EFA survey is presented, showing only six of the total 15 factors (Fig. 2).

Phase two—cognitive structure

To understand how practitioners balance factors in the process of balancing fire safety and physical security, Phase two used Multi-Dimensional Scaling (MDS). MDS is a technique that allows for proximities of factors to be spatially represented, in which proximity represents how similar or dissimilar objects are in dimensional space (Kruskal and Wish 1978). MDS was selected over other methods as it allowed the visual representation as a cognitive map of underlying structures amongst complex data sets (Hout et al. 2013) or as noted by Borg and Groenen (2006), it represents ‘structure’ in the data. The method can also be used to uncover how people implicitly understand concepts.

The MDS survey instrument (Fig. 3) was based on the identified Phase one factors. To make the survey instrument more manageable, factors were limited to a maximum of eight. To achieve this reduced list of factors, a pre-defined selection criteria was applied. This criteria was based on the theory of professional work Abbott (1988), whether the factor was selected as representing diagnosis, inference or treatment. For the MDS survey instrument, participants indicated on a ten-point Likert scale how related each factor was with respect to decisions to balancing fire safety and physical security within the built environment.

Context was placed within the MDS survey by incorporating two separate settings, being a *high physical threat* and *low fire hazard* setting and a *low physical threat* and *high fire hazard setting*.

Phase three—factor influence

Phase three sought to uncover the influence of the identified factors in the process using Analytical Hierarchy Process (AHP). AHP is a widely used multiple criteria

Fig. 3 MDS survey

decision-making tool, described by Saaty (2008) as a "measurement through pairwise comparisons and relies on the judgement of experts to derive priority scales", where priority scales represent the level of priority represented by a factor. For the study, AHP was only used to evaluate the weighting of the factors and note any alternatives, therefore leading to a more simplified process.

AHP instrument

An AHP survey instrument was administered to practitioners to obtain their input values. Participants were provided with a nine point pairwise comparison between each factor, using the Saaty scale (Saaty 2001) and based on the Super Decisions software (Creative Decision Foundation 2012). An example of the AHP survey is presented, showing only nine of the total 28 comparison items (Fig. 4).

Context was placed within the AHP survey by incorporating the two separate context settings, similar to MDS instrument. Furthermore, to make the AHP survey more manageable, the survey criteria was limited to a maximum of eight factors, including all four factors from Phase two and four separate factors from Phase one.

There are no minimum sample size requirement for judging the AHP pairwise comparisons, and a single judge can suffice; however, this depends on the nature and context of the problem (Thomas and Mujgan Sağır 2015). For the purposes of this study, each survey instrument was issued to a separate survey group representing a different fire hazard and security threat context.

Phase four—decision-making validation

Using focus groups, Phase four sought to validate or question previous phase outcomes and provide an enriched understanding of the process which practitioners undertake to balance fire safety and physical security within the built environment. Drawing on the work of Liamputtong (2011), the focus groups were used to establish

With respect to balancing fire safety and physical security for a ***high physical threat / low fire hazard*** *environment, compare the importance of each of the following factors ?*

Highlight in yellow one number per row using the scale

1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

	A		A extremely more important			A strongly more important				A and B equally important				B strongly more important			B extremely more important		B
1	Fire safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Physical security
2	Fire safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Risk assessment
3	Fire safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Flame spread
4	Fire safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Intrusion detection
5	Fire safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sprinkler system
6	Fire safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Detector
7	Fire safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Building regulation
8	Physical security	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Risk assessment
9	Physical security	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Flame spread

Fig. 4 AHP survey sample

if there was a divergence between what was identified through the previous phases, and what people do in practice through the presentation of assertions for testing.

Analytics of government

The model produced from the phases was then used to responds to the specific elements of the analytics of government framework. Specific questions were developed for the model to respond to each element (refer to Table 2).

Analysis

Analysis is presented in-line with the applied four phases of the study.

Phase one—factor extraction

Phase one applied context analysis to selected domain texts and Exploratory Factor Analysis (EFA) conducted using an EFA survey instrument on participants. The intent of this phase was to extract and select the most significant factors in process when balancing fire safety and physical security.

Content analysis

Content analysis used a convenience sample of specific texts from the two domains across fire safety and physical security. The first set of texts were considered relevant for compliance within the regulatory domain, whilst the second encompassed texts which were considered to summarise the domain's body of knowledge (Table 3).

Word frequency and word co-occurrence counts were conducted on each text (Table 3), using WORDij (Danowski 1992). Common occurring words and those which were considered to have no sematic meaning with respect to the study were

Table 2 Elements of governmentality analysis

Element	Question
Problematisation	how do practitioners conduct themselves in balancing fire safety and physical security within the built environment?
Regimes of governing or analytics of government	Visibilities—how are things made visible by the governing activities?
	Technologies—how are mechanisms, procedures, instruments, tactics, techniques, technologies and vocabularies used to establish rule?
	Knowledge—How are forms of thought, knowledge, expertise, strategies, means of calculation, or rationality employed in practices of governing?
	Identities—how are the identities of fire safety and physical security formed when achieving a balance?
Utopian ideal	How is the utopian ideal identified?

Table 3 Content analysis domain texts

Fire safety	Physical security
Regulatory domain	
National Construction Code Volume One 2019 (Australian Building Codes Board 2019)	The protective security policy framework—policy 15 (Australian Government 2019b)
International fire safety engineering guidelines (Australian Government 2005)	The protective security policy framework—policy 16 (Australian Government 2019c)
Manual of fire protection engineering (Department of Defence 2020)	
National Construction Code fire engineering handbook (Australian Government 2019a)	
Body of knowledge	
SFPE Handbook of fire protection (5th ed.) (Hurley 2016)	ASIS Physical Security (ASIS International 2015)
	Handbook of Security Second edition (Gill 2014)

removed. Given that the word-occurrences would formulate the proceeding survey instruments for the proceeding phases, a limit of 30 keywords and word co-occurrences were extracted for each discipline.

Tables 4 and 5 represent the consolidated list of words or factors for the fire safety and physical security corpus following content analysis.

To ensure reliability, judgments by independent experts were assessed using the interrater reliability method (Holsti 1969). Although there is no accepted guide on

Table 4 List of factors (alphabetical order), fire safety

Building class	Flame spread
Building code	Hazard
Prescriptive requirements	Life safety
Design fire	Performance requirements
Fire engineering	Risk analysis
Fire protection	Risk assessment
Fire risk	Smoke control
Fire safety	Smoke layer
Fire scenarios	Suppression system

Table 5 List of factors (alphabetical order), physical security

Access control	Security management
Corporate security	Security measures
Crime security	Security staff
Detection systems	Security products
Intrusion systems	Security risk
Physical security	Security services
Risk assessment	Security systems
Risk management	Security technology
Security industry	Threat
Access control	Security management

how to interpret the reliability coefficients, Fleiss et al. (2003) suggests coefficients of between 0.75 and 0.8 indicate high reliability, whereas Krippendorff (2013) suggest values in excess of 0.8 should be considered. Observed amongst the experts were measures of 0.80 (fire safety corpus) and 0.77 (physical security corpus), which were considered to demonstrate consistency.

Exploratory factor analysis

Prior to undertaking the Exploratory Factor Analysis (EFA), the data was screened for suitability, which included checking linearity, examination of the correlation matrix, confirming statistical significance through Bartlett's test of Sphericity, inter correlations using the KMO test and determining the measure of sample adequacy MSA for each individual item. Linearity of the factors was confirmed via visually examining various scatter plots between each factor (Goodwin and Leech 2006), based on this review, the factors appeared to be linearly related.

The phase one survey was issued to six separate survey groups, with 30 responses received from fire safety engineers ($n=13$), physical security practitioners ($n=12$), building surveyors ($n=2$), architects ($n=1$) and project managers ($n=2$).

The correlation matrix for each group was examined to confirm whether factors were not sufficiently correlated ($r<0.3$) or too highly correlated ($r \geq 0.8$). The Factors of smoke control and smoke layer, along with security measures and crime security, were found to be highly correlated ($r \geq 0.8$), indicating a problem with multicollinearity. Such correlation would suggest that these factors are viewed as the same item by participants and could therefore be collapsed into a single factor.

Although considered subjective, numerous factors were found to have correlations exceeding 0.3, indicating that EFA was appropriate. Then, noting the limited population size, and for the purpose of the study, eight of the factors with high correlations were examined (Table 6).

Using Principal Factor Analysis (PFA), with both the Olbimin and Varimax rotations provided satisfactory results (Table 7). Loadings (how strongly the factor influences the measured item) were reasonable high between the factors and measured items (0.409 to 0.919). A cut-off for the factor loadings of 0.4 was used, which according to Pett et al. (2003) is considered acceptable.

Factor 1 was represented by three items, all of which were associated with fire safety (Table 5). Factor 2 was represented by three items, which were associated with physical security. Factor three was represented by three items, which were associated with building regulation. The factor 'sprinkler systems' loaded on Factor 1 and Factor 3. It was noted that items which load strongly on multiple factors could

Table 6 Selected factors

Security management	Prescriptive building codes
Building class	Flame spread
Sprinkler systems	Crime security
Access control	Fire scenario

Table 7 PAF, using Varimax rotation

Item	Factor		
	1	2	3
	Fire safety	Security	Building regulation
Security management		.615	
Prescriptive building codes			.721
Building class			.591
Flame spread	.919		
Sprinkler systems	.409		.425
Crime security		.832	
Access control		.590	
Fire scenario	.727		

be problematic, as this may cause confusion in results (Pett et al. 2003). Conceptually this makes sense, as the 'sprinkler systems' factor is shared between fire safety and building regulation.

In addition, factors associated with risk (risk assessment and risk management) were included to explore if these would form a separate factor (Table 8). To meet the required KMO statistics and Bartlett's test factors the concepts of 'prescriptive building codes' and 'building class' were removed.

Noting the sample sizes for individual survey groups, a KMO value or Bartlett's Test of Sphericity did not meet the acceptable values; however, a combined population KMO (0.602) indicated mediocre result. MSA was determined by reviewing the diagonals on the anti-image correlation matrix, with values between 0.450 and 0.754, indicating the results as satisfactory.

Factor reliability was assessed through the Cronbach's Alpha index, with values above 0.70 generally considered sufficiently reliable (Taber 2018). All factor produced an 'acceptable' to 'good' value (factor 1 $\alpha = 0.790$; factor 2 $\alpha = 0.702$; factor

Table 8 PFA using Varimax rotation with factors associated with risk

Item	Factor		
	1	2	3
	Fire safety	Risk	Security
Security management			.575
Flame spread	.835		
Sprinkler systems	.444		
Crime security			.711
Access control			.755
Fire scenario	.870		
Risk assessment		.784	
Risk management		.878	

3 α = 0.899). Validity of the survey instrument was assessed on face and content validity. Face validity was assessed through the respondents of the survey, where no concerns were raised regarding the survey questions.

The results provide evidence that the use of EFA is appropriate for the study, and that the factors identified in Phase One can be represented by 3–4 underlying high-order factors referred to as *fire safety*, *security*, *building regulation* and *risk*.

Phase two—decision-making structure

Phase Two applied a Multi-Dimensional Scalar (MDS) survey instrument to participants. The intent was to uncover the decision-making structure used by experts when balancing fire safety and physical security.

The MDS survey was applied to two separate groups, each representing a different context (high security threat/low fire hazard context and low security threat/high fire hazard context). Group A consisted of fire safety engineers (n = 4) and physical security practitioners (n = 4). Group B consisted of fire safety engineers (n = 4), and physical security practitioners (n = 4).

Four separate spatial proximity matrices were constructed, using the mean MDS survey data. The mean data had the MDS ALSCAL (Alternative Least Square Scaling) algorithm applied, producing four separate two-dimensional spatial maps of the decision-making process (Figs. 5, 6, 7, and 8). The results of the MDS analysis produced a consistent and coherent spatial structure amongst all groups, which can be described with physical security factors located to the left of the map, fire safety and building regulation factors to the right, with risk central. The only significant difference was amongst the physical security practitioners of survey group A (Fig. 6), where risk was not central but located in the lower left quadrant.

The stress values were all determined to be less than 0.1 (STRESS = 0.022 RSQ = 0.99, STRESS = 0.08 RSQ = 0.95, STRESS = 0.015 RSQ = 0.99,

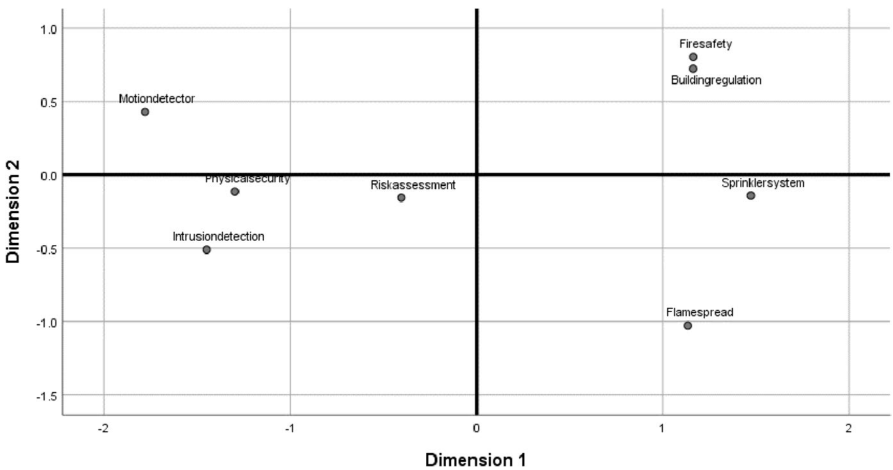


Fig. 5 Fire safety engineers, MDS group A—high physical threat/low fire hazard

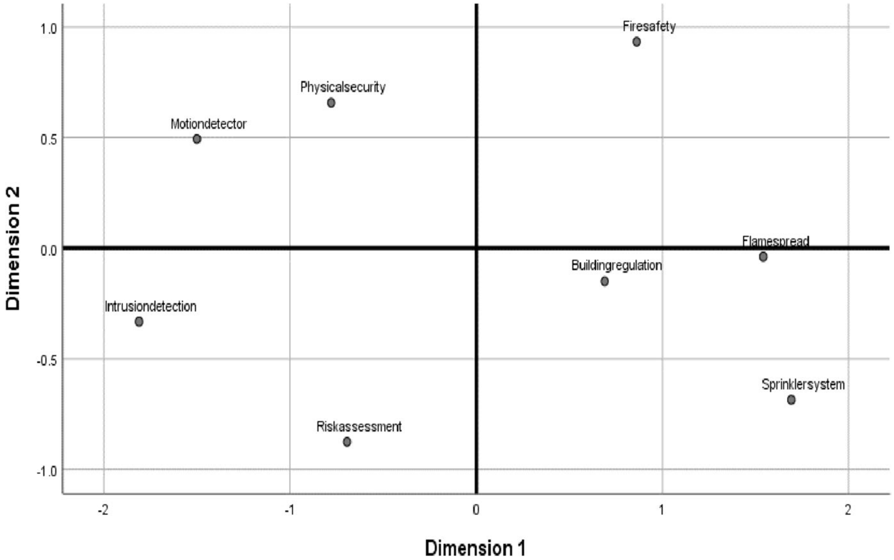


Fig. 6 Physical security, MDS group A—high physical threat/low fire hazard

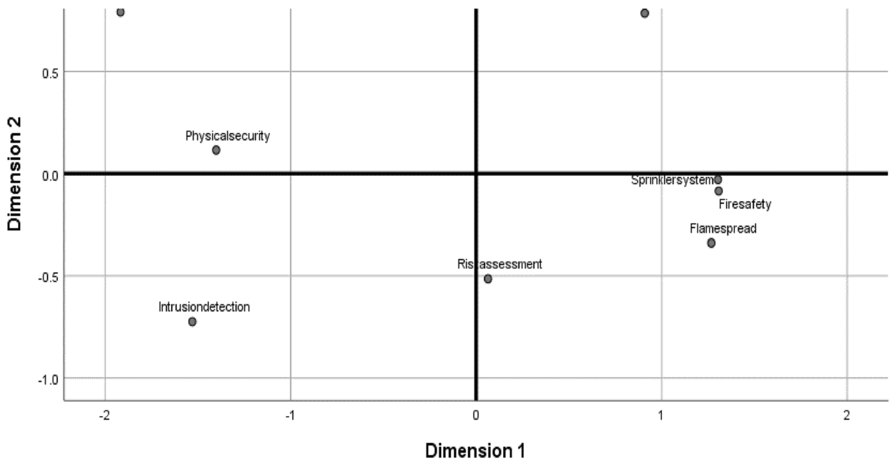


Fig. 7 Fire safety engineers, MDS group B—low physical threat/high fire hazard

STRESS = 0.06 RSQ = 0.96) indicating a desirable result (Kruskal and Wish 1978). Reliability for each MDS survey data group were also tested using Cronbach's Alpha, producing an acceptable result for all sets with the exception of Group A/fire safety (Group A (security $\alpha = 0.73$), Group B (fire safety $\alpha = 0.84$, security $\alpha = 0.89$)). In order to achieve an acceptable Cronbach's Alpha ($\alpha > 0.7$) for Group A/fire safety, a number of items had to be removed.

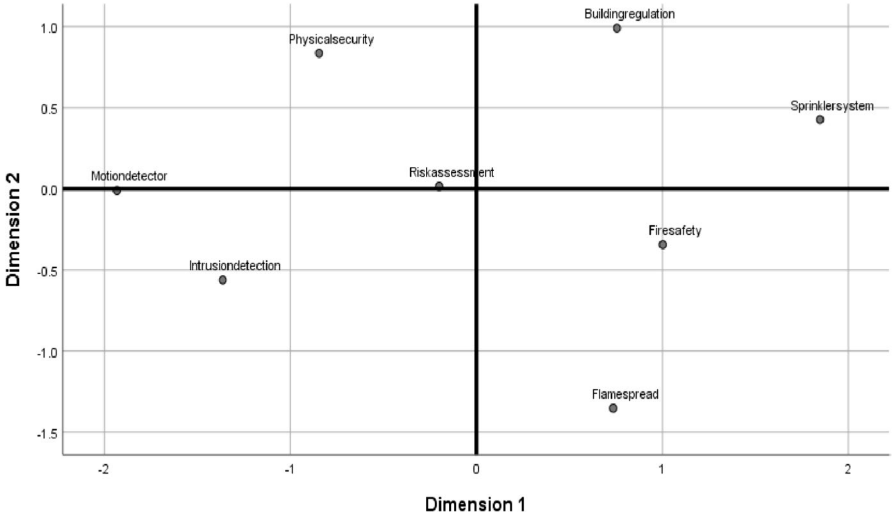


Fig. 8 Physical security, MDS group B—low physical threat/high fire hazard

Face validity was assessed through responses to a final question on the survey which asked how difficult the survey was to complete. The results of the MDS survey indicated that the majority of participants found the survey suitable. Content validity was considered using industry experts who conducted a formal review (physical security n = 2, fire safety n = 1).

Phase three—factor influence

Phase Three applied an Analytical Hierarchy Process (AHP) survey instrument across two groups to determine factor significance in decision-making when balancing fire safety and physical security. Groups A (n = 2) and B (n = 2) surveys each consisted of a fire safety engineer (n = 1), and a physical security practitioner (n = 1).

The group data were aggregated by calculating the geometric mean of the pairwise comparison in accordance with the aggregation of individual judgement (AIJ) method. These data values were entered in the Super Decision programme via the questionnaire mode and where decimal aggregations occurred, values were rounded to the closest integer (Mu and Pereyra-Rojas 2018).

Survey group A high physical threat/low fire hazard context factor ranking and weighting was identified (Table 9). Fire safety (47%) was the highest weighting factor, followed by risk assessment (18%), flame spread (13%), building regulation (7%) and then physical security (6%).

Survey group B—low physical threat/high fire hazard context factor ranking and weighting was identified (Table 10). Fire safety (24%) was the highest weighting variable, followed by sprinkler system (25%), risk assessment (24%), flame spread (16%), intrusion detection (5%).

Table 9 Factor ranking and weights—high physical threat/low fire safety context

Factor	Ranking	Weight (%)
Fire safety	1	47
Risk assessment	2	18
Flame spread	3	13
Building regulation	4	7
Physical security	5	6
Intrusion detection	6	5
Sprinkler system	7	2
Motion detector	8	2

Table 10 Factor ranking and weights—low physical threat/high fire safety context

Factor	Ranking	Weight (%)
Fire safety	1	24
Sprinkler system	2	24
Risk assessment	3	16
Flame spread	4	13
Intrusion detection	5	5
Motion detector	6	5
Physical security	7	5
Building regulation	8	4

Table 11 Phase four assertions

No	Description
1	Conflict between fire safety and physical security is centred around access and egress
2	Factors considered in the decision-making process are primarily derived from building regulations
3	The design process and risk assessment are a central driver to the decision-making process between fire safety and physical security
4	Building regulation sets how risk is considered for fire safety, but not physical security
5	There is a gap in managing the social risk associated with malicious threats within the built environment

From the results it is evident that fire safety is dominate regardless of context; however, the reason for this was not clear and explored as part of the Phase four focus group.

Phase four—decision-making validation

Phase Four used a focus group aligned to assertions (Table 11) to validate the previous phases and provide an understanding of pragmatic decision-making when balancing fire safety and physical security. The assertions were developed from the literature review and reflection on the outcomes of the previous phases as thematic outcomes to be tested.

For the focus group, experts (n = 3) were selected using purposive sampling, comprising two fire engineers and one physical security expert. The focus group was audio recorded and transcribed, supported by written notes taken by an independent note-taker. At the end of the focus group, participants were also asked to narrate any further comments regarding the topic and questions. These comments were recorded and formed part of the final analysis. Data were thematically reviewed to formulate a response to each of the assertions.

Each assertion was tested through a series of questions. Assertion one indicated that the decision-making structure used to balance physical security and fire safety within the built environment was primarily associated with the concepts of access and egress. This assertion was well supported by the group, noting that whilst there was little consensus amongst the experts on other areas of the built environment this position achieved group consensus.

Assertion two tested the finding that factors considered in the decision-making process are primarily derived from building regulations. There was strong support amongst the group supporting this assertion as a starting point; however, they considered other factors associated with one's own professional decision-making need also be considered. Consequently, this assertion was only partially accepted.

Assertion three indicated that risk was a central driver to the process between fire safety and physical security. Again, this assertion was not fully accepted. Across the group it was recognised that the design process is central to the process, rather than risk assessment. However, they noted that where the design process produces multiple options, risk assessments could be, and are used as a decision tool. In this instance, risk assessments could be considered central to the process in balancing fire safety and physical security, either through a formal assessment or through other means. However, of further note, the experts were unanimous in their concerns associated with the application of risk assessments, due to their subjectivity, tokenism, timing and completion in 'silos'.

Assertion four indicated that building regulation sets how risk is considered for fire safety by governments, but not physical security. The experts strongly supported this finding, noting that physical security cannot be regulated in a similar manner, due to its more abstract nature and relationship with society.

Assertion five indicated there is a gap in managing the social risk associated with malicious threats within the built environment. This assertion was well supported across the group, noting that malicious acts such as arson are credible risks within the built environment, however due to the difficulty in understanding community expectations it is unknown if they are adequately addressed. Furthermore, the experts were unanimous in that these types of risks cannot be addressed through additional regulation which can be considered a technology of government within the framework of governmentality.

Focus group interpretation

The focus group uncovered that at the centre of the decision-making process between fire safety and physical security is the design process. The focus groups described the design process as representing a pragmatic mechanism for achieving a balance between physical security and fire safety, which includes implicit factors such as communication, interaction between disciplines and changes in the design, with a strong drive towards meeting building code requirements. The focus group did acknowledge that where the design process fails to produce tangible decisions, formal risk assessments should then be used, and are used to balance decision-making. In this instance risk, understood through the practice of risk assessments, could also be considered as central to the process along with the design process, signifying a strong relationship between these two factors.

The focus group also provided further understanding into the influence of fire safety and physical security in the decision-making process. It was found that building regulation sets how risk is viewed for fire safety and more importantly, skews it in the decision-making process. However as physical security cannot be regulated to the same extent as fire safety, due to its nature and relationship with society, this lack of regulation impacts its influence, dampening it, in the decision-making process. The significance of this phase was uncovering a deeper understanding and the associated intricacies of the cognitive structure used by practitioners.

Study interpretation and discussion

The study findings led to the development of an indicative conceptual model for understanding the cognitive process which building practitioners undergo to manage fire safety and physical security within the built environment. This model depicts the relationships between higher order factors, their interrelationships, the modality of risk, and the influence and hegemony of fire safety.

Decision-making factors

Within this conceptual model, decision-making is structured around five separate higher order factors, being: *assessment of risk*, *building regulation*, *design process*, *fire safety* and *physical security*.

These identified factors partially aligned with Cohn (1981), who established a hierarchal decisions in resolving conflicts in design that comprised *building code objectives*, *fire protection*, *accident prevention, physical security, health protection* and *structural safety*. A key distinction between Cohn's work and the current study was the inclusion of broader factors not associated with fire safety or physical security, such as *structural safety*. However, such a distinction is less surprising considering the intent of the study was to consider fire safety and physical security.

Relationship between decision-making factors

Within this decision-making process, the relationship between these higher superordinate factors can be described as a dichotomy between physical security and fire safety, in which concepts such as risk assessment and the design process are located intermediately. For high threat settings, the concept of risk assessment gravitates closer to physical security, compared to a low threat setting. Building regulation sits closer to fire safety, signifying a stronger relationship compared to physical security, which is even more significant under a low fire hazard setting. Figures 9 and 10 provides an iteration of the conceptual model overlayed with the MDS maps, with the factors distributed to reflect this relationship, whereby closer proximity implies greater similarity.

Such a dichotomous relationship between physical security and fire safety, with risk centrally located or sitting between these two dichotomous concepts, is supported by Dodd (2004) who found that professionals view safety and security in a similar fashion with both having common and uncommon aspects. The centrality of risk in this relationship is further supported by Brooks and Coole (2019), who identify that both physical security and fire safety are different disciplines, yet both share similarities such as risk theory and risk management.

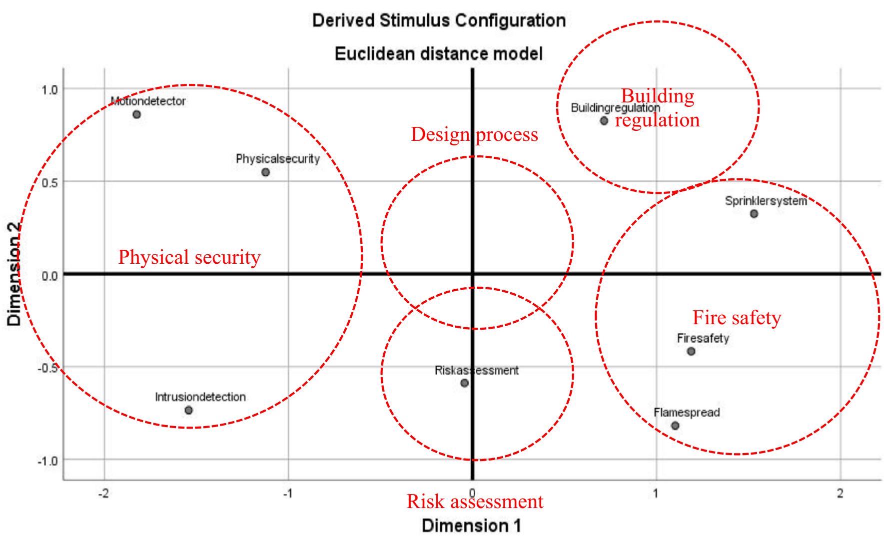


Fig. 9 Relationship between factors—low threat/high fire hazard

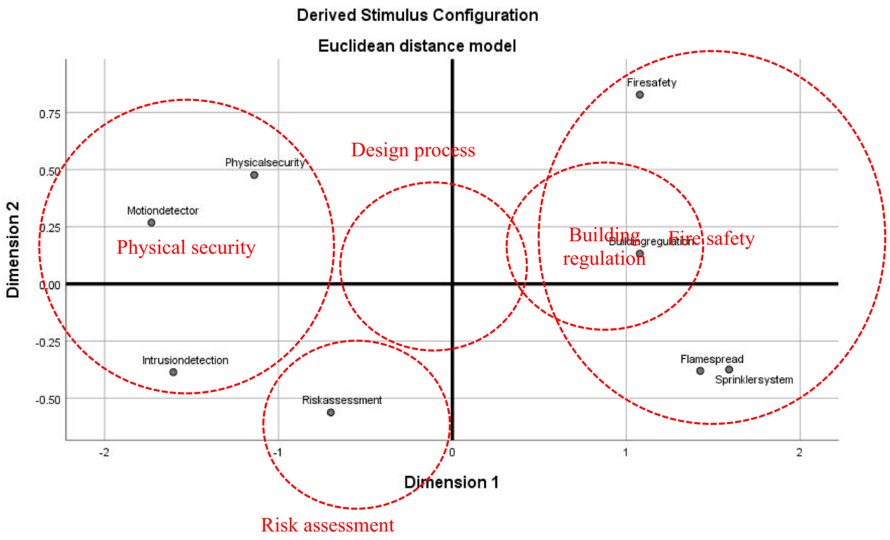


Fig. 10 Relationship between factors—high threat/low fire hazard

Modality of risk

The assessment of risks was identified as a central factor during the initial stages of the study, yet its centrality was later discounted by the experts due to its ambiguous and impractical nature. However, it was acknowledged by the experts that where the design process fails to produce tangible or final decisions, formal risk assessments should then be used, and are used within decision-making. Such a finding reinforced the validity of their central placement in the decision structure, as demonstrated during the initial stages of the study. Furthermore, the design process can be seen as a process to manage risk within the project more broadly.

The switching nature between the design process and risk assessment leads to a modality with increasing complexities, where alternative modes are selected depending on the situational complexity. Figures 11 and 12 provides an updated iteration of the conceptual model with the modality of risk included. Where complexity increases in decision-making, the balance between physical security and fire safety switches from a design process to formal risk assessment. Such modality between the design process and risk assessment fits within the work of both Garcia (2008) and Jacoby et al. (2016), who describe a process which requires increasing complex processes where initial design mechanisms fail.

Influence and hegemony of fire safety

Within decision-making, each identified factor and higher order factor will have differing magnitudes of influence depending on the setting and context. The study findings indicated that practitioners view fire safety as holding the greatest influence regardless of context, followed by risk assessment, influenced by the regulatory

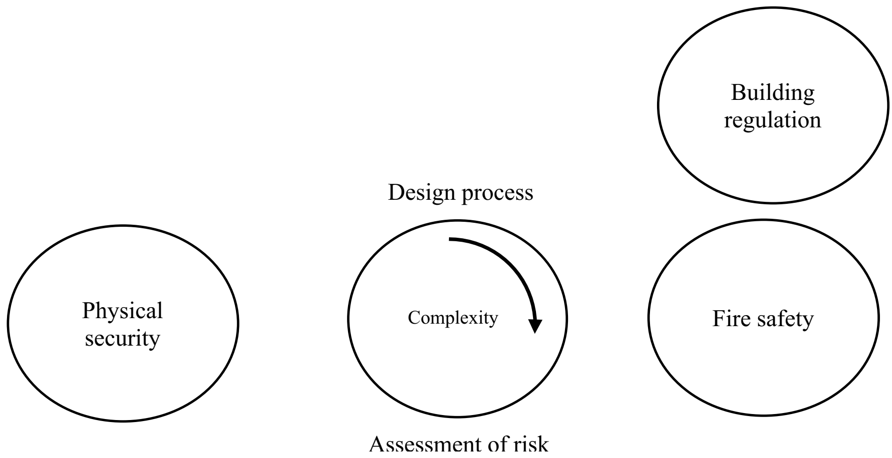


Fig. 11 Modality of risk—low threat/high fire hazard

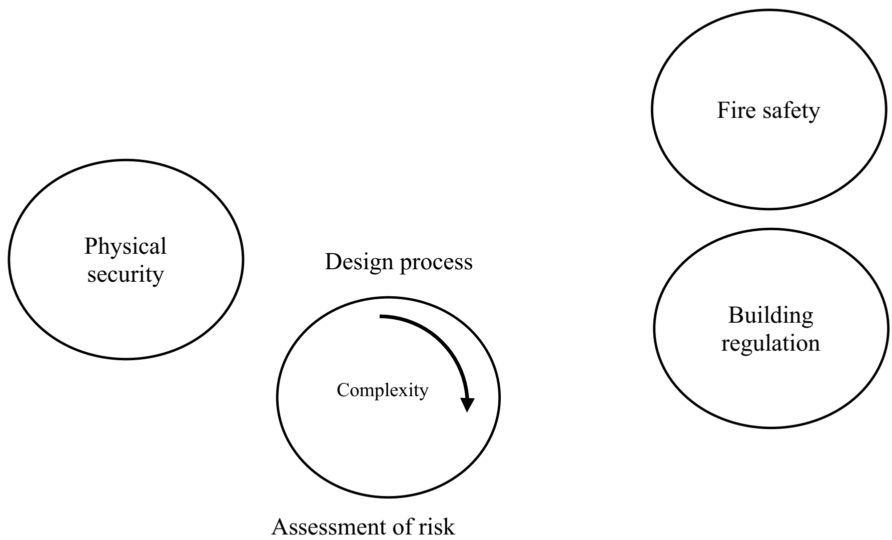


Fig. 12 Modality of risk—high threat/low fire hazard

approach to the management of such social risk, as per governmentality. Physical security has limited influence, which only increases minimally with an increased in threat context. The study found mixed results with building regulations, which was found to not be as influential as fire safety.

Fire safety's influence is reinforced by the literature, which generally emphasizes fire safety as the dominate factor when balanced against physical security (Cohn (1981); Craighead (2009); Mózer et al. (2014)). Figures 13 and 14 provides an iteration of the conceptual model with the inclusion of influence, where the higher order

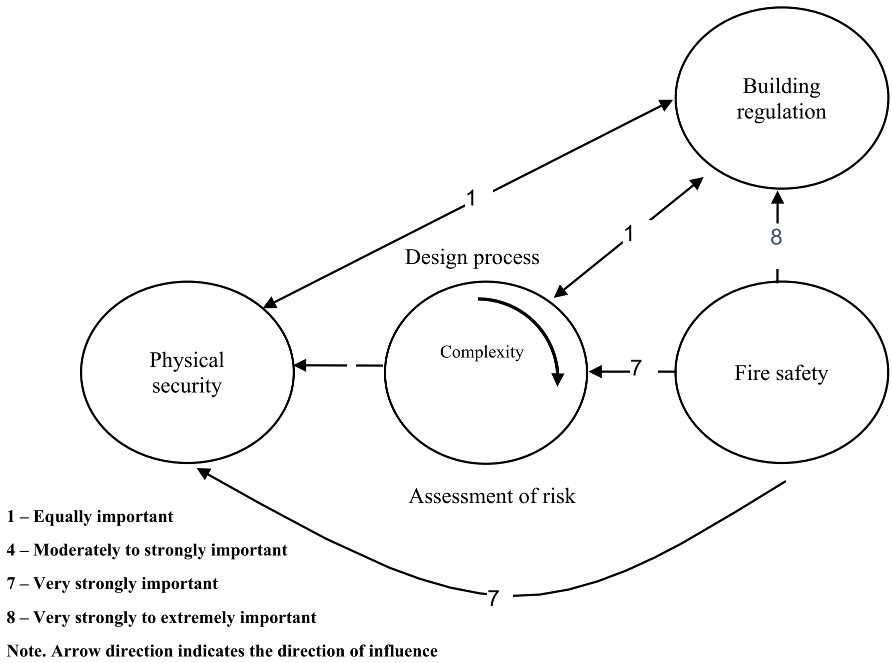


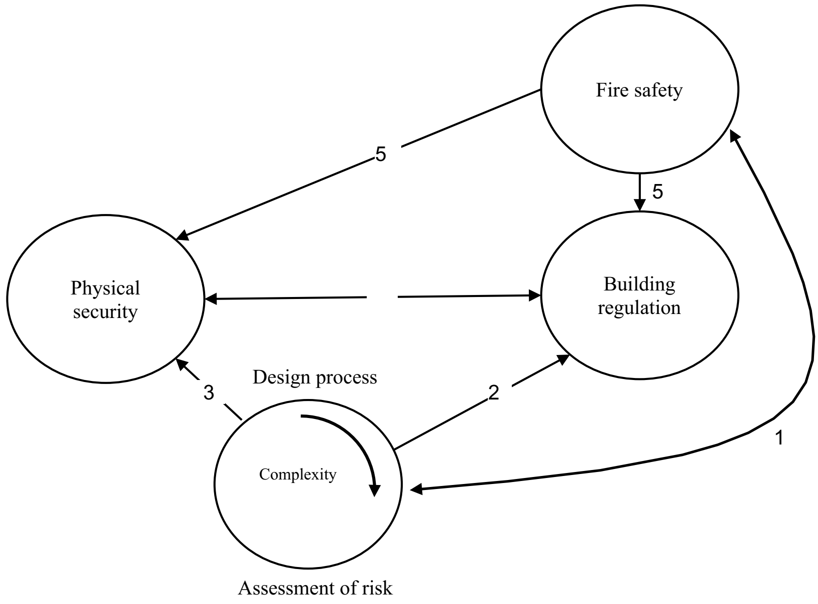
Fig. 13 Structure of high-order factors considered within the decision-making process (high security threat/low fire hazard)

factors are interconnected with one another through directional arrows. The numerical values associated with each arrowhead indicate the importance of the factor in comparison to the connected factor (based on the AHP analysis), where the arrowhead direction indicates the direction of influence.

The relationship between fire safety and building regulation is supported by the graphical relationship presented in the MDS maps of proximity. When measured and compared to the other factors, building regulations were not identified as being a dominate influential factor; however, the underlying driving influence associated with building regulations was reinforced by the focus group experts. As one participant stated, "regulation drives it". Such a finding is consistent with Cohn (1981), who believed that fire safety compared to physical security is held in a higher regard by public officials due to the standardization in building codes, where standardization represents an instrument of control and guideline for behaviour and used for the management of risk (Olsen et al. 2020).

Context and malicious risks

Throughout the study, a reoccurring comment from practitioners was the importance of context and how it may impact decision-making. The impact of context was tested in two separate approaches, through the use of differing threat and hazard survey



1 – Equally important

4 – Moderately to strongly important

7 – Very strongly important

8 – Very strongly to extremely important

Note. Arrow direction indicates the direction of influence

Fig. 14 Structure of high-order factors considered within the decision-making process (low security threat/high fire hazard)

settings. These comparisons demonstrated that the structure of decision-making is dynamic for fire safety but static for physical security, with the influence of the variables and superordinate factors dynamic for both disciplines. With an increased fire hazard setting, fire safety and the concepts of risk and building regulation became more influential in the decision-making process, with the influence of the physical security factors remaining relatively static. This aspect suggests that the influence of factors associated with fire safety are more dynamic, compared to the factors associated with physical security which remain relatively stationary. Such an understanding of fire safety and physical security is significant, as change in context is not covered by various authors (see Cohn (1981) Garcia (2008) Craighead (2009), Mózer et al. (2014), Perdikaris (2014), Jacoby et al. (2016)).

Malicious risks such as arson are a shared risk between fire safety and physical security and will therefore form part of this built environment decision-making process. Although data within Australia is limited, arson has been the cause of a large number of high profile fires involving multiple deaths within the Australian built environment, thereby suggesting the risk is credible (Australian Government

2019d). Outcomes of the focus group indicated that these risks were considered credible, but unknown it is unknown if they are adequately addressed. The focus group also indicated that these types of risks cannot be addressed through additional regulation.

Analytics of government

Using the study findings the specific elements within the analytics of government framework were addressed.

Problematisation

Gouldson and Bebbington (2007) describes problematisation as "the identification of an issue to be governed (for example, a particular environmental risk) which would lead to a particular practice or set of practices being problematised (for example, the corporate activities that generate such risks)."(p. 13).

The issue in this instance is adequately dealing with fire and security risks within the built environment. Government relies on an adequate balance be achieved through the conduct of design professionals, such as fire safety engineers and physical security practitioners. The study highlights that the problematisation is the adequacy of this conduct in achieving an appropriate balance. The study has outlined that there are issues with this balance, in that there is a bias towards fire safety and malicious risks may not be adequately addressed.

Fields of visibility

The study indicates that the governing activities make compliance with normative requirements of fire safety paramount, in contrast with dealing with security threats. When balancing fire safety and physical security, practitioners will utilise the design process and risk assessments.

What is not made visible, is how practitioners should work together in addressing joint risks such as malicious acts.

Technical aspects

Different types of governmentalities will utilise different technologies to accomplish governance, such as law or technologies of performance (Oels 2005). The current study identifies a number of technologies in the governance of physical security practitioners and fire safety engineers.

In achieving a balance between physical security and fire safety, the assessment of risk has been identified as a central technology. Such risk assessment aligns within the perspective of governmentality where risk is seen as a central technology of governance (O'Malley 2016), which acts as a means of directing power through the deployment of tools such as risk assessment and risk communication (Hrnqvist 2010).

Apart from risk, both disciplines also rely on other technologies as part of their governance, including prescriptive norms (through regulation and building codes), surveillance (registration of practitioners), regulation, etc. The outcomes of the study indicates that fire safety sits closer to technologies such as regulation and building codes, which provide it greater dominance in the balancing of the two disciplines. This view is supported by the study outcomes, in particular the focus group which noted a strong drive towards compliance with building regulations.

The outcomes of the study indicate that physical security within the built environment is unable to be regulated as liberally as fire safety, due to its impact on society. Such a view aligned with Lupton (2013) who noted as the crisis of neo-liberalism, or a paradox (Mouffe 2009), whereby governments need to balance between governing too much or too little to deal with unexpected risks, where risk management may impact on fundamental liberties and basic rights of citizens. Notwithstanding such a view, there are examples within the Australian built environment where security is regulated, for example residential tenancies, work health and safety, aviation, government buildings and maritime. However, despite the existence of such regulations, security does not sit within a regulatory focused domain compared to fire safety. Where security is regulated, it is within a defined context as opposed to a broader built environment regulatory regime.

Malicious acts, such as arson, appear to be governed by security and fire safety using what could be best described as best practice guidance, neo-liberal approach. The requirement to address arson is not explicitly codified. As identified in the focus group this is problematic and potentially creates a gap in dealing within these types of risks.

Forms of knowledge

The study shows that fire safety sits closer to codification of rules and laws, in comparison to physical security. Codification of a law provides a number of advantages, including certainty, acceptance amongst contemporary society, accessibility and compactness, can be reviewed, and involves community in its development (Leslie George 1967). From a perspective of governmentality, an increased codification provides greater clarity or direction in how one should conduct themselves. Key to Foucault's interpretation of power, is the concept of power knowledge, which centres around power being materialised through the acceptance of 'truths' through knowledge, and scientific understanding (Nickolas 2019). In this instance, it is argued that building regulations represents greater accepted 'truths and greater direction in how one should behave, through increased codification. Although there are many directions and levels to this power relationship, it is argued that the dominance and power of fire safety is materialised through the knowledge and greater acceptance of 'truths' through greater codification in building regulations.

Forms of identify

Although the study did not specifically review the identities of each discipline, on face value based on the literature review, screening of participants qualifications and also interaction with the participants, differences in identifies was reviewed. Within the Australian building literature, the identity of fire engineering appeared to be more clearly defined in comparison to physical security practitioners. Furthermore, interaction of participants and feedback indicated that the role of a physical security practitioner was largely unknown amongst fire safety engineer's participants. In contrast, the physical security practitioners appeared to understand the role of fire safety engineers. Furthermore, the role of a fire safety engineer is highlighted within some of the physical security literature, for example HB 188. Although the study, did not explore the impact of this difference in identify, it raises the question, on if it has an impact on the balancing of the two within the built environment.

Utopian Ideal

In context of the current study, a utopian ideal is that fire safety hazards and security threats are balanced to achieve optimum safety for the built environment. In context of the current study, evidence indicates that this is not being achieved, as there is a bias towards fire safety, and concerns in addressing shared risks such as malicious acts.

Limitations

There are several important limitations associated with this study, which are proposed to be improved for a future larger study. First, the sample sizes for surveys associated with the EFA and MDS analysis did not meet the desired criteria. Furthermore, the AHP analysis applied a single data point for each context/discipline setting. Although this impacts validity, the results are considered to demonstrate feasibility of the study and also supported by the various phases. Secondly, the regulatory literature analysed was geared towards the Australian built environment and did not include internally regulatory building codes or standards.

Conclusion

The built environment faces many fire hazards and malicious actor threats, managed through the practice of fire safety and physical security. Nevertheless, both practice areas impact on the built environment systems, and can conflict with each other. Consequently, to manage conflict, decisions in balancing fire safety and physical security are required, where decision factors and their weighting are not well researched and understood in the literature.

Through Governmentality, the study sort to understand the process of balancing fire safety and physical security. Findings indicate that this process can be described as a dichotomy between physical security and fire safety, with concepts such as *risk assessment* and *design process* having a strong interrelationship between the distinct engineering disciplines centrally. Furthermore, practitioners consider fire safety has the greatest influence, followed by risk assessment, building regulation and last, physical security. Seated within a regulatory environment, fire safety factors are more dominate then physical security; however, both fire safety and physical security are subservient to building regulations in this decision-making process.

Findings have provided an understanding in how practitioners manage risk within the built environment. Such views can provide an understanding on how practitioners operate in the built environment, thereby creating an opportunity to improve the regulatory systems in managing social risks associated with fire hazards and physical security threats. More studies are needed to understand how practitioners deal with other aspects in the decision-making process within the built environment.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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