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# Physical Security Barrier Selection: A Decision Support Analysis

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# PHYSICAL SECURITY BARRIER SELECTION: A DECISION SUPPORT ANALYSIS

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**Abstract**
Physical security controls aim to reduce risk through their ability to systematically deter, or detect, delay and respond against deviant acts within a risk context. Holistically the aim is to increase the difficulty and risks while reducing the rewards associated with an act of deviance as captured in Clarke's Situational Crime Prevention (SCP) framework. The efficacious implementation of such controls commensurate with the risk context requires a considered undertaking referred as informed decision-making. Informed decision-making is effective when a suitable choice is made accordant with base rate data that achieves its defined objectives within costs versus benefits framework. The study examined the feasibility of developing a decision support tool to enhance the selection of a suitable barrier fence system, in-line with defence in depth to increase the efforts and risks, and reduce the rewards associated with unlawful access. The study found that a decision support tool can be developed comprising of the various contextual inputs and their relationships in achieving a contextually suitable barrier fence system, as a result enhancing the selection of situational crime prevention elements.

**Keywords**
Security risk management, Physical security, Decision making, Utility function.

## INTRODUCTION

Physical security is concerned with physical measures designed to safeguard personnel, prevent unauthorized access to equipment, installations, material and documents as well as protection against espionage, sabotage, damage and theft (Browning, 2008, p. 1; Field Manual, 2001, p.47; GAO, 2004, p. 3). The characteristics of physical security controls include measures for deterrence, detection, delay and response elements to mitigate risks and enhance operational effectiveness (ASIS, 2009, p. 10; Royal Canadian Mounted Police, 2004, p. 1; Standards Australia, 2006, pp. 60-63) by increasing the difficulty and risks, and reducing the rewards as captured in Clarke's Situational Crime Prevention (SCP) framework (Lab, 2013, pp. 216-219). This framework arguably provides a rubric to engage in the professional tasks of diagnosis, inference and treatment as they relate to solving a security or crime risk problem. Detailed knowledge across the rubric's constituent strategies can facilitate the inference process leading to enhanced decision making in the face of a range of alternative options.

Informed decision-making occurs across all professional domains. For physical security, the aim of such decision-making is towards implementing security controls, which efficaciously reduce risk and facilitate organizational objectives in sector-specific and dynamic environments that are cost effective accordant with the economic law of diminishing returns (Broekhuis & Vos, 2003; Series 3, n.d.).

The study examined the feasibility of developing a decision support tool to enhance the selection of a suitable barrier fence system, in-line with defence in depth to increase the efforts and risks, and reduce the rewards associated with unlawful access. The study found that a decision support tool could be developed that considers the various contextual inputs and their relationships in achieving a contextually suitable barrier fence system. By comparing a set of alternative constituent elements systematically within the security risk and environmental context, findings showed that the decision making process in the form of a decision matrix can guide the selection process.

**DEVELOPMENT AND USE OF DECISION MAKING TOOLS FOR PERIMETER BARRIER EVALUATION**

In the security domain, decision-making is reflected through security risk management, towards developing a constructed understanding of the nature of uncertainty on objectives. This constructed understanding aims to facilitate more informed decision-making and offers capacity to exploit opportunities, whilst minimizing harms that threaten an organization (Standards Australia, 2006, pp. 6-10). Such an approach is documented as a formal systematic process that includes identifying exposure to risk, evaluating methods to manage risk, applying treatment strategies, ongoing performance monitoring of strategies and employing necessary feedback to adjust strategies where necessary (Hatfield & Hipel cited in Coole, 2010, p.1).

Security risk management emphasizes the key elements of organizational security controls that contribute to the management of risk via their ability to deter, detect, delay, respond and recover from damages (Coole, 2010, p. 2; Standards Australia, 2006, p. 63). As follows, acceptable risks are a combination of unique elements within each risk, with decisions based on the costs-benefit analysis of protecting assets in relation to assessed risk level, for corresponding levels of treatment controls (Burns-Howell, Cordier & Erikson, cited in Coole, 2010, p. 2). Here, the implementation of physical security controls aims to reduce offending opportunities, which in accordance with Situational Crime Prevention (SCP) can be targeted towards increasing the level of difficulty through target hardening, increasing the risks through surveillance and reducing rewards. SCP can be executed in accordance with the theory of defence in depth (Coole, Corkill & Woodward, 2012), which links layered security elements into a system incorporating people, technology, barriers and procedures to ensure a holistic and functional protective posture (Smith, 2003, p. 8). This approach arguably applies a body of relevant knowledge to inform the risk reduction decision process.

Informed decision processes aim to deliver effective risk based choices along with enhanced operational effectiveness (Coole, 2010, p. 2). As part of the informed decision making process, selective or support tools in other disciplines and industries have been developed including the areas of agriculture, utilities, economics and psychology (CSIRO, 2013; Palaniappan, Lang & Gleick, 2008). Such tools are a synthesis of the best available science and management knowledge, brought together to assist in the decision making process as many of these tools are based on computer models. For example, in agriculture the tools provide timely and valuable information to better understand farm and land management systems. MetAccess™ uses daily climate records to assist farmers in estimating probable weather conditions at critical times in their production cycles; selecting from a range of alternative crop and pasture varieties according to likely weather conditions (CSIRO, 2013).

Furthermore, within utilities field, the decision-making tools help address technological needs, guiding practitioners to the most appropriate water and sanitation solutions (Brikké & Bredero, 2003). These tools provide essential information on the types of water-supply and sanitation technologies available, including descriptions of their operation and maintenance requirements (Palaniappan, Lang & Gleick, 2008). Software such as WAWTTAR - Water and Wastewater Treatment Technologies Appropriate for Reuse Model is a Microsoft Windows based program, designed to assist engineers, planners and decision makers in improving their strategies for sustainable water and sanitation coverage, while minimizing impacts on water resources (Finney & Gearheart, 2004).

In security domain, the decision tools have been developed with many focused towards identifying and evaluating risk, rather than the selection of efficacious reduction controls. For example, Riskware (2013) is a software program based on Microsoft NET technology that assists to identify and access, control and manage potential impacts to the organization, using risk management according to AS/NZS ISO 31000:2009. In addition, Estimated Adversary Sequence Interruption (EASI) model is a quantitative decision support tool used in the security domain. EASI represents a systems commissioning or operational macro-state level, and can be used to inform the probability of interrupting (Pi) an adversary in a layered defense, towards ensuring that constituent decisions combine to achieve a defined system objective for the security plan (Garcia, 2001).

Consistent with other domains, the aim is to develop a broader suite of tools for security risk management beyond risk identification software or total system synthesis (EASI), focusing on the constituent selection. Such tools would enable decision makers to compare their multiple treatment alternatives concurrently and facilitate an enhanced risk treatment decision through the elimination of options that are not contextually suitable, producing an optimal business solution (Business Analysis Made Easy: Decision Making, 2012). In many domains, such tools are often reflected as a decision matrix; where traditionally elements represent the values for each possible alternative in a range, to select the best alternative in terms of the highest probability of success within a context (Brachinger & Monney, n.d.). Therefore, decision makers must have the means to identify essential criteria and integrate them into a model that will facilitate their assessment and prioritization to enable informed, cost-effective decision choices within a context ("Business Analysis Made Easy: Decision Making," 2012).

**Study Objectives**

The study sought to develop a decision support tool for selecting physical barrier elements among possible alternatives for controlling access to a protected site. The tool presents the various contextual inputs and their relations required for comparing a set of alternative barrier options to facilitate enhanced decision-making within this protective context. Therefore, the study posed the following Research Questions:

1. What criteria can be used for an evaluation process of security barrier fences?
2. Can a decision support tool be developed through a literature critique to aid in the selection of barrier fence construction elements within context of asset protection?

**UNDERLYING THEORY**

Decision theories focus towards explaining how people *do* make decisions (descriptive), or prescribing how people *should* make decisions (prescriptive) (Grant & Van Zandt, 2007, p. 2). Therefore, the study drew on the principles of Expected Utility Theory (ETU) (Bernoulli, 1738; Grant & Van Zandt, 2007) and Innovation Theory (Clarke, 1995) to understand, examine and map the representation of the various feature inputs and their organisation most suitable for comparing a set of alternative product constituent elements in barrier fence design. Such mapping allows a means of expressing how barrier fence decisions *should* be developed (Bernoulli, 1738; Clarke, 1995; Fishburn, 1970; Mongin, 1997).

The word utility is generally associated or synonymous with a benefit property, advantage, good or happiness with relation to assets or an object (Kapteyn, 1985, p. 1). For this reason Expected Utility Theory (EUT) considers that a decision maker chooses between numerous alternatives by comparing their expected utility values. In traditional EUT models, weighted sums are obtained by adding the utility values of potential outcomes multiplied by the likelihood of success to produce a desirable decision position (Bernoulli, 1738). Therefore, the expectation is considered with respect to the selected, well-defined norms or criteria of probability and utility function of the alternatives (Fishburn, 1970; Mongin, 1997). The utility criterion considers the expected utility in terms of benefit or functionality for each alternative product element and provides an indication of that alternative accordant with the highest expected value (benefit/functionality) ("Decision Theory" n.d.; Weber & Coskunoglu, 1990, p.311).

Innovation theory describes and categorizes objectives, and perceived, contextual influencing factors that lead to successful adoptions or implementation of products or individual product elements within organizational decision frameworks (Marshal & Rossman, 1999, p. 50), as a dynamic multilevel process (Marshal & Rossman, 1999, p. 49). The innovation-decision making process is also realized through a cost-benefit analysis with major obstacle being uncertainty where an innovation, with all things considered, has the potential to enhance utility (Clarke, 1995). As a consequence, expected utility and innovation theory provided the theoretical frame for exploring decision making within the physical security domain to achieve an optimal solution based on individual characteristics of a range of solution options.

## DECISION MAKING

Decision making derives from prior preferences and expectations about consequences, directed by considerable individual and organizational constrains on realizing an optimal solution (March, 1991). According to March (1991) decisions often stem from logic of suitability rather than consequential choices and so Wallenius, et al. (2008) recognizes that a decision maker chooses one or a subset of a set of alternatives evaluated on the basis of two or more criteria or attributes. Conceptually, the decision maker acts to maximize utility or value function that depends on the criteria or attributes and in cases of uncertainty, maximize the expected value of utility function.

Giere (1991) articulates that decision problems involve a set of options, possible courses of action and a set of possible consequences of alternative options represented as a matrix. Traditionally, the elements of the matrix are composed in pairs consisting of one option and one possible consequence labeled outcomes and signify achieving a particular consequence having chosen a specified course of action. The representation of value denotes a rank ordering of the outcomes according to their relative importance or desirability (Giere, 1991, p.187). Subsequently, a decision matrix provides the means of systematic resources or numerical modeling used to evaluate and prioritize a list of options against criteria, with the highest ranking option designated as the most suitable solution. The options are compared rationally and logically, with the pros and cons being listed and ranked in importance.

### Security Decision Making

Currently, a decision tool for assessing and rating the construction elements for intruder resistance for physical security control barriers is defined in Standards Australia AS3555.1 (2003). The construction elements for intruder resistance include walls, floors and ceilings used in commercial or domestic premises, along with inferred attacks types and evaluation of working time required for breaching each element. The Standard also offers a destructive testing of these elements. However, the testing does not provide a conclusive indication of the most appropriate barrier or elements for a security context as it provides a working delay time only against defined threat scenarios and does not consider other variables that interact with any barrier elements decision. Consequently, the Standard cannot facilitate the determination and evaluation of alternative criteria for selecting security barrier products or elements within any given corporation, industrial or domestic context (Standards Australia, 2003, p. 2).

## METHODOLOGY

The study employed a qualitative action research approach to investigate the fusing of decision making literature and research within the domain of physical security for the selection of barrier fence elements. Such fusion was achieved by using a literature critique in an annotated bibliography format (N=26), to identify patterns and themes or relationships among patterns and themes in the reviewed data corpus (McMillan & Schumacher 1993, p. 479), which were fused to produce a single source planning tool (Figure.1).

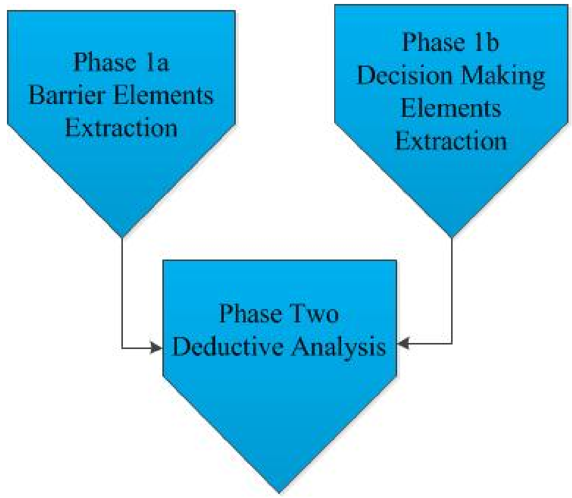


*Figure.1: Study phases and analysis*

**Analysis**

The study drew on an interpretative inductive approach through thematic analysis for identifying, analysing, and reporting patterns and themes within the reviewed literature. Accordant with the works of Spradley (1979), hierarchical taxonomic tables (folk taxonomy) were then developed where data was organized according to its perceived relationships with other data, where deductively sets of subcategory (subordinate) data fell beneath a certain higher category (superordinate), and that category fell beneath an even higher level category. Johnson and Christensen (2004, p. 511) explain the study adopted process with a fruit analogy:

> *"In the case of fruit, some possible subcategories are oranges, grapefruit, kiwi, apples and bananas. These are all subcategories because they are part of or types of the higher level category called fruit. Yet the category of fruit maybe the subcategory of a higher category called food group. Systems of categories such as this are called hierarchies because they are layered or fall into different levels".*

Such taxonomies are a means of expressing through inference how the elements of a domain are internally organized, and are represented by different levels with superordinate and subordinate relations which unless explored remain tacitly below the surface (Spradley, 1979, pp. 137-138).

**BARRIER AND DECISION MAKING ELEMENTS**

Study Phase.1a and Phase.1b extracted the barrier and decision constituents. The thematic analysis identified the following categories within the specifics of physical security barriers consisting of: attack types, environmental conditions, supplementary fixings, progression impediment, fence cost and legal requirements. The subsequent categories further formed integral part of the resulting themes: defined threat, effectiveness, barrier design, deterrence, and delay time with difficulty level.
In response to research question 1, the review found that the threat of scaling or climbing was a salient factor in barrier fence selection, with scaling or climbing occurring 77 times across the reviewed texts. Consistent with this criteria topping was another input factor occurring saliently across the reviewed texts, occurring 74 times, these criteria were supported by height as a decision factor, occurring 53 times. In addition, the ability of the barrier to support detection was another significant decision factor, with detection occurring 51 times throughout the reviewed texts. Deterrence as a value occurred 47 times throughout the sampled text and was followed by delay or delay time as another salient factor in barrier selection, occurring 39 times across the reviewed texts. Finally, the threat of cutting was another salient design consideration, occurring 33 times across the reviewed texts.

The extracted key words provided the functional utility inputs associated with a contextually suitable barrier fence to be taken forward to develop a phase hierarchical taxonomic table of barrier selection constituent elements and their relationships with other constituent elements. Table.1 indicates the relationships between the descriptive key words, particular categories and themes with defined threat and context as the drivers for evaluation and selection of physical security barriers.

| | | | | | |
|---|---|---|---|---|---|
| Defined Threat | Attack Types | | | | [32]Scaling, [34]Climbing, |
| | | | | | [33]Jumping, |
| | | | | | [35]Tunneling, |
| | | | | | [36]Cutting, |
| | | | | | [37]Vehicle penetration/breach/crash, |
| | | | | | [39]Crawling, |
| | | | | | [40]Ramming, |
| | Barrier Design | Fence Cost | | | [5]Cost, |
| | | | | | [7]Degradation, |
| | | | | | [8]Maintenance, |
| | | | | | [9]Material elements, |
| | | | | | [23]Instalation, |
| | | | | | [28]Deterioration, |
| | | Environmental Conditions | | | [17]Soil, |
| | | | | | [18]Terrain, |
| | | | | | [19]Climate, |
| | | | | | [29]Nature, |
| | | | | | [14]Landscape, |
| | | Legal Requirements | | | [6]Social acceptability, |
| | | | | | [27]Location, |
| | | | | | [30]Safety, |
| | | Effectiveness | Delay time | Supplementary Fixings | [24]Toppings, |
| | | | | | [25]Top Guard, |
| | | | | | [31]Detection, |
| | | | | Progression Impediments | [4]Height, |
| | | Deterrence | | | [11]Barrier foundation, |
| | | | | | [12]Placement, |
| | | | Difficulty level | | [13]Structure, |
| | | | | | [16]Stand-off distance, |
| | | | | | [22]Construction, |
| | | | | | [26]Clear Zone, |

*Table.1: Taxonomy of Physical Security Barrier Characteristics*

The decision making extraction revealed constituents of decision making (Table.2), where within the reviewed text the concept of probability in terms of success was the salient variable considered, occurring 89 times across the reviewed text. The concept of probability was supported by preferences in terms of choice options, occurring 24 times across the reviewed texts. Value was also a salient decision element occurring 43 times throughout the reviewed text, as was utility or utility function, occurring 31 times throughout the reviewed texts. Combined these extracted key words provided the decision making principles associated with a contextually optimal solution to be taken forward to develop a phase hierarchical taxonomic table of decision making constituent factors and their relationships with other constituent factors towards achieving an optimal decision.

<table>
<tr><td rowspan="5">Context</td><td rowspan="5">Expected Utility Objective</td><td rowspan="3">Cultural Bias</td><td>Organizational objectives</td><td rowspan="4">Probability Distribution</td><td rowspan="5">[x]Expected utility,<br>[k]Expert knowledge/Knowledge<br>[g]Utility/ [w]Utility function,<br>[f]Value,<br>[d]Cost-nonfinancial,<br>[l]Decision weights/Weighting,</td></tr>
<tr><td>Objective function</td></tr>
<tr><td>Feasibility</td></tr>
<tr><td>Preferences</td><td>Effectiveness</td></tr>
<tr><td>Cost-Benefit</td><td>Highest Expected Value</td><td>Attributes of Alternatives</td></tr>
</table>

*Table.2: Taxonomy of Organizational Decision Making*

**Deductive Analysis**

In response to research question 2, the study Phase.2 identified and extracted consistent criteria and their relations, with the processes required for objectively evaluating decision options in security barrier fence selection. As physical security is embodied within systematic measures of deterrence, detection and delay (Defence in Depth), along with security risk management, the security barrier decision making process is integrated into the evaluation of each alternative (Table.3). The distributed representations of designated utility, the evaluation criteria signify meaning not represented by a single symbolic unit (individual criterion) rather summarize meaning from the interaction of a set of units (criteria in matrix). Effective decision making should consider the alternative options, their organization and weighting in terms of utility function for the decision objective.

| | | | Barrier design | | | | | | | Difficulty | | Effectiveness | | Cost | | | Feasibility |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Material Elements | Height | Toppings | Supplementary Fittings | | | Foundation | Delay sec. | Rating A/S | Threat | Deterrence | Per linear meter | Installation | Maintenance | |
| | | | | | | Energy Systems | Detection | Surveillance | | | | | | | | | |
| Attack Types | | Climbing | | | | | | | | | | | | | | | |
| | | Jumping | | | | | | | | | | | | | | | |
| | | Tunneling | | | | | | | | | | | | | | | |
| | | Cutting | | | | | | | | | | | | | | | |
| | | Vehicle | | | | | | | | | | | | | | | |
| Environmental Conditions | | Terrain | | | | | | | | | | | | | | | |
| | Soil | Sand | | | | | | | | | | | | | | | |
| | | Clay | | | | | | | | | | | | | | | |
| | | Rock | | | | | | | | | | | | | | | |
| | Climate | Cyclone | | | | | | | | | | | | | | | |
| | | Rain Fall | | | | | | | | | | | | | | | |
| | | Heat | | | | | | | | | | | | | | | |
| | | Salt | | | | | | | | | | | | | | | |
| Legal Concerns | | Safety | | | | | | | | | | | | | | | |
| | | Social Acceptability | | | | | | | | | | | | | | | |
| | | Location | | | | | | | | | | | | | | | |
| Progression Impediments | | Structural | | | | | | | | | | | | | | | |
| | | Natural | | | | | | | | | | | | | | | |
| | | Clear zone | | | | | | | | | | | | | | | |
| | | Stand-off Distance | | | | | | | | | | | | | | | |

*Table.3: Barrier Fence Decision Matrix*

**PHYSICAL BARRIER DECISION MAKING TOOL**
The study objective considered security's lack of functional treatment decision support tools. As such, it aimed to investigate the salient, constituent component criteria, combined to produce a contextually suitable barrier system organized in such a way so that an informed decision can be achieved. Such a barrier selection tool, if effective, should produce a system of sound construction for the context, support risk reduction through its targeted features in relation to the defined threat, consider additional elements required or desired including intrusion detection support and surveillance requirements, be socially acceptable and cost effective within the security risk context.

The selection of barrier elements is often conducted at the project design phase, sometimes many years before a project is realized. Consequently, barrier selection must be undertaken accordant to some predefined base rate data that sets a baseline where standards can be grounded from. What is more, during the project development life cycle some stakeholders seek to implement changes in either barrier construction or fittings, resulting in a variation to contract and cost overrun for that constituent, sometimes due to wants rather than needs. As such, an appropriate decision support tool becomes an essential component of the project documentation, clearly highlighting and formally documenting why design decisions were made. The decision support tool provides a project baseline, where variations can be contextually considered in relation to the original planning decisions. Additionally, the decision support tool delivers a documental means to separate wants from needs within the barrier system, where environmental or threat changes can be directly mapped to the original decision and proposed changes mapped to environmental or threat changes.

Furthermore, functional decision tools have been developed in other domains. For security, most decision tools relate to risk but do not facilitate the selection of components to reduce risk. The study identified the specific criteria (Table.3) required for an effective evaluation of security barrier elements in risk reduction. Such criteria were extracted, cognizant of the systematic application of deterrence, detection, delay and response (Defence-in-depth) used to achieve a state of effective security. The security decision-making process was integrated into the evaluation accordant with each alternative, as they combine to produce a barrier system.

The study outcomes highlighted the salient choice criteria, their relationships and the characteristics to be met for the security project context. Here, the established criteria denote the designated utility (organizational context) and so influence the alternatives to be considered for an optimal outcome within the relevant protective project.

For that reason, the Security Barrier Decision Matrix (Table.3) becomes the means of systematically modeling a decision making process by creating a logical evaluation path. Thus, such a path structures decision making in a way that enables clear identification and justification of various contextual inputs required for element selection among alternative products. In addition, for later reviews that lead to a change in design due to altered actual or perceived need, changing contextual threats and other factors that could alter, the path provides a benchmark to understand how and why such a barriers design was reached.

**LIMITATIONS**
The study included a number of limitations. Firstly, with qualitative research the researcher is the main data collection instrument, as a result, beliefs, values, predispositions may have influenced the extraction and analysis process (Hughes, 2006). Secondly, the data corpus (N=26) was a limited sample in terms of the potential broader literature, with six documents forming the data set of decision making and 20 reviewed documents forming the data set for specifics of physical security barrier selection where time constraints limited a broader literature extraction. Thirdly, the matrix was subjected to expert review but it was not subjected to a broad sample of security experts for validation. Conversely, the aim of the study was to inform of the salient, constituent elements and their organisation in terms of optimal decision making, where the reviewed data corpus along with

expert review provided for this evaluation. The development of a suite of decision support tools is an iterative process. As such, the study sought to establish the first iteration towards the development of a more refined tool through further research.

**FURTHER RESEARCH**

The study recommends undertaking further research in the area of decision support tools for enhanced security decision making. This should include fusing a broad depth of literature which is supported through expert interviews and further refinement through trial evaluations. Given the financial costs and potential consequences of poor decision making within security domain, it is essential for security to mature as an established science; therefore researchers must pursue more functional tools. Such tools should facilitate the employment of criminology and security theory with best practice principles into effective security risk management decision making.

**CONCLUSION**

The study sought to explore whether a decision support tool, based on the available literature, could be developed to aid in the selection of barrier fence construction elements within context of asset protection as first iteration. Findings indicate that both decision making literature and barrier elements can be combined and organized in such a manner to facilitate enhanced barrier fence elements decision making. Outcomes included a series of criteria inputs, organized systematically to enhance the project evaluation process for selecting optimal fence elements to mitigate risk and facilitate organizational objectives for sector-specific, dynamic environment to safeguard people, process and technology. The study established the feasibility of researching to develop a series of decision support tools for physical security treatment controls.

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