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"The Efficient Relationship between Residual Security Risk and Security Investment for Maritime Port Facilities"

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Abstract

The research employs an adaptive cross-disciplinary research strategy in an industrial example to address port facilities' inability to assess whether their security systems are efficient. The research combines a twin-pronged approach of first, adapting Markowitz (1952) theory of portfolio selection from the field of finance to maritime port security to examine each port facility's security systems as a portfolio; and secondly, through portfolio optimization to construct the optimum theoretical portfolio of security systems drawn from a number of different port facilities owned by Dubai Ports World. The research builds on the existing literature and proposes new definitions of security, port security, port security risk and port security risk management. The research also develops a model of port security risk based on Willis et al's (2005) definition of terrorist risk. Furthermore, the research builds on the work of Gleason (1980) and examines terrorist attacks on ports and on shipping in ports between 1968 and 2007 and shows, using the Kolmogorov-Smirnov test, that they follow a Poisson distribution. The contribution which the research makes is in terms of adapting Markowitz (1952) theory to the port security environment; and the modelling and measurement of the impact of the introduction of new port security technology, changes in background port security threat levels and for the planning of port security in Greenfield sites. Furthermore, the adaptive approach of the research is generalisable to all nodes in the supply chain and is not limited to port facilities alone.

Keywords

Security; port security; port security risk; port security risk management; terrorism; efficient frontier; portfolio selection theory; portfolio analysis; ISPS Code; port facility security officer; company security officer; benefit-cost analysis; residual security risk; expected loss.

Structure of the Thesis

The thesis consists of seven chapters and is structured as follows. Chapter one begins with an introduction which contains a statement of the research problem; the purpose and rationale behind the research; and a summary of the research. Chapter two contains a review of the literature and is focused on port security; port security risk; port security risk management; contemporary port security initiatives and their costs; and portfolio theory. Chapter three describes the research strategy; and the research design and methodology. Chapter four describes the model of port security risk and shows how portfolio optimization and the application of Markowitz theory of portfolio selection can be applied to port facilities' security systems. Chapter five sets out the empirical findings based on the theoretical models advanced in chapter four. Chapter six contains the discussion and describes the contribution and the scope for further research. Finally, the conclusion follows in chapter seven.

Chapter 1 - Introduction

1.1 Statement of the Research Problem

Port facilities around the world have been subjected to international port facility and supply chain security initiatives in the wake of the 11 September 2001 (9/11) attacks on New York and Washington. These initiatives include, among others, the International Maritime Organisation's International Ship and Port Facility Security (ISPS) Code, the United States' Container Security Initiative (CSI) and the Customs-Trade Partnership Against Terrorism (C-TPAT) Initiative (Peck, 2006; Bichou, 2004; Barnes & Oloruntoba, 2005; Price, 2004; Raymond, 2006; Stasinopoulos, 2003). This has resulted in significant investment in security systems by companies in the supply chain (Bichou, 2004; Farrow & Shapiro, 2009) and in port facilities in particular (Dekker & Stevens, 2007).

According to Sheffi (2001), companies in the supply chain must determine how to balance the costs and benefits of security needs and how to do so in the most efficient manner. Closs and McGarrell (2004) state that enhanced supply chain security is expected with no increase in cost. According to Haubrich (2006), the substantial investments in security made by democracies around the world after 9/11 merit closer scrutiny given that efficiency is an increasingly important criterion by which the success of public policy is being judged. The predominant security initiative which internationally trading port facilities have been subjected to is the ISPS Code, which was introduced into European Union legislation in the form of EC Regulation 725/2004 (Dekker & Stevens, 2007; Anyanova, 2007). U.S. implementation of the ISPS Code was accomplished through the Maritime Transportation Security Act (MTSA) 2002 (Helmick, 2008). The main provisions of the ISPS Code came into force on 1 July 2004, eighteen months after the ISPS Code was introduced by the IMO's Diplomatic Conference of 12-14 December 2002 by amending the International Convention on the Saving of Life at Sea (SOLAS) 1974 by the addition of a new chapter XI-2. The speed with which the port and maritime security initiatives came into force means that it is unlikely that the ports industry were able to evaluate the benefit-costs of the various industry security solutions on offer or the amended working practices which needed to be adopted in order to comply with the

provisions of the ISPS Code. Therefore, the problem which the research aims to address is the determination by ISPS Code compliant port facilities of whether they have been able to discover the efficient relationship between security and cost.

1.2 Purpose of the Research

The purpose of the research is to discover the efficient relationship between residual security risk and security investment for maritime port facilities. No new theory will be generated but the research undergoes an adaptive cross-disciplinary research approach to generate the Markowitz risk-return efficient frontier which is generalisable to all nodes in the supply chain, not limited to maritime port facilities.

1.3 Rationale

According to Stock (1997, p515), "much of logistics research has its roots in theories borrowed from more established disciplines." Stock (1997, p524) identifies Markowitz theory of portfolio selection as one which could be applied to logistics applications which include budgeting, company performance and logistics decision making. Goankar & Viswanadham (2004) have successfully adopted Markowitz theory to supply chain research for the purpose of managing a portfolio of suppliers, though their strategic level deviation management model does not extend to matters of security. The research aims to extend this cross-disciplinary research by incorporating port facilities' security performance and investments as inputs to the Markowitz theory.

The research addresses part of Juttner et al's (2003, p208) agenda for future research in supply chain risk management by defining the risk concept and mitigating risks for the supply chain, specifically with an emphasis on port security.

Williams et al (2008, p255) highlight the gaps in academic knowledge of supply chain security (SCS), in particular they refer to the lack of quantitative research in the field.

Finally, Helmick (2008) concludes that much work remains to be done to create a framework for maritime security research that is truly risk-based and that effectively engages stakeholders.

1.4 Summary of the Research

The research proposes to solve the problem of the inability of port facilities to assess whether they have discovered the efficient relationship between port security residual risk and security investment following the introduction of the ISPS Code in the wake of the 11th September 2001 terrorist attacks on New York and Washington. The research employs an adaptive cross-disciplinary research strategy in an industrial example to examine the phenomenon of security in the maritime port facility environment, framed in Juttner et al's (2003) model of supply chain risk management.

The literature review begins by examining the origins of security and proposes new definitions for security, port security and port security risk before conducting a review of the literature on port security risk management; port security investments; port security incident costs; and benefit-cost analysis.

The literature on port security risk management prompts a further investigation of risk assessment; risk sources; risk consequences; and risk drivers. The review of port security risk mitigating strategies introduces the key security initiatives: the ISPS Code and the MTSA and includes other global and local relevant contemporary security initiatives. The literature review concludes with an examination of portfolio selection theory and efficient frontiers and draws some parallels between portfolio theory and port security investment.

The research design describes how the main research question is broken down into two questions which prompt a further five questions. The main research question is: how can ISPS Code compliant port facilities discover the efficient relationship between residual security risk and security investment? In order to tackle the main research question, it is necessary to discover first, what is meant by an ISPS Code compliant port facility and secondly, to assess how the efficient relationship between residual security risk and security investment can be calculated. While the first part involves an examination of the regulatory requirements of the ISPS Code, the second part is addressed by asking a further five questions:

1) What are the security threats to the port facility and what are their probabilities?
2) What are the estimated gross losses to the port facility following each prescribed security threat?
3) What do the security systems consist of in each port facility?

4) How well do the port security systems perform in the face of the prescribed security threats?
5) What are the port security systems' costs?

The research design subsequently lists the data sources and collection methods in order to address each of the five questions which are concerned with a port facility's security threats; the estimated gross losses following the prescribed security threats; the security systems in the port facility; how well the security systems perform; and the size of the security investment.

The research then develops a model of port security risk, based on Willis et al (2005) definition of terrorism risk and continues the work of Gleason (1980) but for terrorist attacks against ports or against shipping in ports from 1968 to 2007 with interesting results: they resemble a Poisson distribution, as confirmed by the Kolmogorov-Smirnov test.

The research findings capture an array of data beginning with the estimated gross losses to the port facilities from the seven prescribed security incidents, chosen from a combination of the literature and input from Dubai Ports World's security specialists. Figures for each port facility are presented for the expected physical damage and business interruption from the prescribed security incidents and combined with the data from the Lloyd's Terrorism Underwriter, also a figure for the gross expected loss to the port facility. With this is combined the data from the interviews with the Company Security Officers on their subjective assessments of the performances of the security systems to calculate the port facilities' residual security risks (in US$).

At this juncture two port security ratios are calculated: the benefit-cost ratio which calculates by how much the residual security risk is reduced for every $1 invested in security; and the residual risk : expected loss ratio which depicts how well the port facility's security system performs against the prescribed security incidents. The data for the six port facilities is presented in turn and the results are then summarised to examine the performances (mean and standard deviation) of the security systems; a comparison of the benefit-cost ratios; and the residual risk : expected loss ratios.

The research methodology follows a twin-pronged approach to the discovery of the efficient relationship between residual security risk and security investment in port facilities. The first approach entails applying Markowitz (1952) theory of portfolio selection individually to the port facilities. Subsequently, the portfolio optimization

approach employs an analysis of the performances of the 216 possible different combinations of the three security systems across the six port facilities.

The application of the Markowitz (1952) approach shows how, for each port facility's portfolio of security systems, the expected performance-standard deviation efficient frontier can be constructed and when combined with the model for port security risk, can be used to reduce residual risk efficiently. The portfolio optimization approach is also used to generate a solution to the relationship between residual security risk and security investment. Subsequently, a comparison is made of how effective the two approaches are in reducing port security risk, with some interesting results.

The main limitation in the research is that the prescribed security incidents are limited to acts of terrorism owing to constraints on the type of data available from the Lloyd's Insurance Market.

The contribution of the research is four-fold. First, the research adapts Markowitz theory from the field of finance to the field of port security. Secondly, the methods can be employed in the development of Greenfield sites to guide a Company Security Officer to implement a security system which best suits his/her requirements in terms of both residual security risk and security investment and to do so efficiently. Thirdly, the proposed introduction of new port security technology with an enhanced performance in an existing port facility can be modelled to learn the extent to which the residual security risk might be reduced, for a new given level of security investment. Fourthly, a change in the background security threat to a port facility can be quantified in terms of a change to the residual security risk.

The research was conducted over a period of three years and involved making four visits to the offices of Dubai Ports World in Jebel Ali, UAE. The first three visits were essential in laying the groundwork for the final visit when much of the subjective data was collected. The security sensitive nature of much of the data collected has resulted in the need to cloak the data and the results in this research.

Chapter 2 - Literature Review

The literature review begins by tracing the origin of security and proposing a new definition of port security. The concepts of port security risk and port security risk management are then developed and subsequently framed in Juttner et al's (2003) model of supply chain risk management with a discussion on port security risk sources, risk consequences, risk drivers and risk mitigating strategies. The discussion addresses some of the threats that ports face and their potential consequences followed by an overview of contemporary maritime and supply chain security initiatives with a discussion of the ISPS Code and the U.S. Maritime Transportation Security Act (MTSA). Next, the literature review addresses the costs of implementing the ISPS Code, the costs of potential port security incidents and techniques for carrying out port security benefit-cost analysis. The literature review concludes with a discussion of portfolio selection theory and draws some parallels between port security investment and portfolio investment.

2.1 Port security

In trying to arrive at a definition of port security it is suitable to begin with some origins of the term 'security' from the social science literature. The definition of security is then considered in the context of the supply chain security literature and is subsequently refined in order to arrive at a suitable definition of port security.

Maslow (1942) describes security as a "feeling of safety; rare feelings of threat or danger". Maslow (1942) includes security as a basic human need, together with safety, in his hierarchy of needs model. Baldwin (2005) defines security as 'the absence of threat' and Buzan (1991, p19) includes such definitions as 'relative freedom from harmful threats' and 'absence of threats to acquired values'.

Williams et al (2008, p258) describe how the origin of security stems from individual level theories in sociology and psychology. Fischer and Green (2004, p21) state that security "implies a stable, relatively predictable environment in which an individual or group may pursue its ends without disruption or harm and without fear or disturbance or inquiry." Robinson's (2008, p188) definition of security is that it

"implies freedom from threat" and "one's desire not merely to be free from threat but to feel free."

Combining Maslow (1942), Baldwin (2005), Buzan (1991) and Robinson (2008), security can be defined as the absence of and/or the perception of the absence of threat. Thus an individual who is surrounded by threats but has taken steps to reduce the threats may feel secure. Conversely, an individual who does not feel secure but who is not surrounded by any threats is in effect secure. This concept is important because different individuals (with the appropriate security knowledge and experience) when questioned about the security of a port facility, may have differing views in terms of their own perceptions as to both the threats that the port facility faces and how effectively existing security measures address the threats.

Here it is also important to distinguish between security and security measures: security measures are the measures (personnel, procedures and technology) required to achieve the absence of and/or the perception of the absence of threat.

Given that ports are considered to be nodes in a supply chain network (Yap & Lam, 2004), it is necessary when developing the definition of port security to examine the literature on supply chain security (SCS).

Williams et al (2008, p256) state that few formal definitions can be found in the literature and draw their definition of SCS from Closs and McGarrell's (2004, p8) definition of SCS management. The Closs and McGarrell (2004, p8) definition is: "the application of policies, procedures and technology to protect supply chain assets (product, facilities, equipment, information and personnel) from theft, damage, or terrorism and to prevent the introduction of unauthorised contraband, people or weapons of mass destruction (WMD) into the supply chain." In pursuit of a definition of port security it would be easy simply to substitute 'port' for 'supply chain'. However, this would not distinguish between port security and port security management, in the way that Williams et at (2008) do not distinguish between SCS and SCS management. Furthermore, this would limit the definition simply to the port's assets and exclude cargoes and, specifically, the ship-port interface which the ISPS Code seeks to protect. Also, the Closs and McGarrell (2004) definition is in some ways too specific in its reference to terrorism and weapons of mass destruction given that by naming threats they run the risk of excluding others such as sabotage or criminal damage arising from strikes and riots by locked out workers (see Miller, 1994, p452 for a fuller description of named threats to ports covered by marine

insurance). The ISPS Code does not single out terrorism as a threat per se but refers to measures which provide protection from security incidents (which include terrorism), while the MTSA refers specifically to the threat of terrorism in the maritime domain. This is understandable given that the MTSA was drafted in the United States in the wake of the attacks on 9/11. However, the MTSA focus on terrorism also potentially excludes other forms of unauthorised acts such as maritime fraud, which is included in Regulation (EC) No. 725/2004. Furthermore, the focus on WMD appears to be centred more on the United States, specifically in consideration of containerised trade (Harrald et al, 2004; Gerencser et al, 2003).

Therefore, it would be appropriate to amend the named threats in the Closs and McGarrell (2004) definition to 'unauthorised acts', which is wider in scope. 'Unauthorised acts' is chosen in preference to 'illegal acts' in order to avoid any confusion arising from differing definitions of legality between jurisdictions.

The proposed definition for port security is: the absence of and/or the perception of the absence of threat to port facility assets, cargoes and the ship-port interface from unauthorised acts. From this, it follows that port security management is: the application of measures (personnel, procedures and technology) to reduce the threat and/or the perception of threat to port facility assets, cargoes and the ship-port interface from unauthorised acts. The choice of words is significant for while it may be preferable to try to eliminate threats rather than to reduce them, it will never be possible to eliminate all security threats absolutely (Price, 2004, p335).

2.2 Port security risk

As risk is present in all walks of daily life, it is logical that an extensive literature exists on the subject. Whether considering individuals' attitudes to risk and decision making under uncertainty (Kahnemann and Tversky, 1979), or risk as a factor in decision making (March and Shapira, 1987), the interpretation of risk varies from person to person. Definitions of risk also vary according to the discipline in which the discussion is framed, be it supply chain (Rao and Goldsby, 2009; Christopher, 2005; Juttner et al, 2003; Zsidisin et al, 2004; Chopra and Sodhi, 2004), supply chain security (Williams et al, 2008), port security (Bichou, 2004, 2009; Talas and Menachof, 2009), terrorism (Sheffi, 2001; Woo, 2003; Raymond, 2006; Price, 2004,

Willis et al, 2005; Greenberg et al, 2006), sociology and psychology (Heimer, 1988) or more established disciplines such as economics, finance or management (Juttner et al, 2003). Rao and Goldsby (2009) present selected definitions of risk from the literature including from Lowrance (1980) "risk is a measure of the probability and severity of adverse effects" and Yates and Stone (1992) "risk is an inherently subjective construct that deals with the possibility of loss."

Definitions of risk relevant to this study can be found in Robinson (2008), March and Shapira (1987), Bedford and Cooke (2001), Markowitz (1952), Broder (2006), Greenberg et al (2006), Price (2004) and Willis et al (2005). Robinson (2008, p182) describes risk from a security perspective as "the probability that harm may result from a given threat." March and Shapira (1987, p1404) review managerial perspectives on risk and risk taking and define risk as "reflecting variation in the distribution of possible outcomes, their likelihoods and their subjective values." Bedford and Cooke's (1996) analysis of probabilistic risk analysis describes risk as having two particular elements: hazard and uncertainty. Markowitz (1952, p89) describes risk as "variance of return." Broder (2006, p3) describes risk as "the uncertainty of financial loss, the variations between actual and expected results or the probability that a loss has occurred or will occur." Greenberg et al (2006, p143) state that terrorism risk "does not exist without existence of threat, the presence of vulnerability and the potential for consequences." Price (2004, p335) claims that ports (in the context of terrorism) are actually faced with uncertainty, not risk because uncertainty implies that while the range of events is known, the associated probabilities of each type of event are not. To an insurance underwriter, risk can represent not only the vessel, aircraft or property under consideration for insurance (Broder, 2006, p3) but also the product of the probability of the occurrence of an insured event and the financial consequences of such an event. Willis et al (2005) describe terrorism risk as consisting of the product of threat, vulnerability and consequence: where threat is the probability that an attack occurs; vulnerability is the probability that an attack results in damage, given that an attack has occurred; and consequence is the expected damage, given that an attack has occurred which resulted in damage. Drawing on this definition and the definitions by Robinson (2008), Broder (2006) and Bedford and Cooke (2001), the proposed definition for port security risk is: the product of the probability of a threat to port facility assets, cargoes

and the ship-port interface which may give rise to a loss and the size of the financial consequences that might follow.

2.3 Port security risk management

Williams et al (2008) present a comprehensive overview and research agenda for supply chain security. They categorise the literature into four organisational approaches to supply chain security: an intra-organisational approach, an inter-organisational approach, a combination of the two and an ignore approach. In the intra-organisational approach they discuss the security processes and technology used by companies to secure their supply chains and the scope for adopting a total quality management (TQM) or Six Sigma philosophy. The inter-organisational approach is focussed on organisational relationships with other supply chain members, public entities and competitors and some key contemporary supply chain security initiatives are listed. Furthermore, they propose an update to the Juttner et al (2003) model for supply chain risk management by adding an additional dimension to supply chain risk mitigating strategies which includes three of the above approaches (intra-organisational, inter-organisational and combination) to supply chain security. As this research is chiefly concerned with ports which have adopted the risk mitigating strategies as set out in the ISPS Code, it is also appropriate to frame the discussion on port security risk in Juttner et al's (2003) original four constructs of supply chain risk management: supply chain risk sources, risk consequences, risk drivers and risk mitigating strategies. However, the discussion begins by considering some methodologies for port security risk assessment.

2.3.1 Port security risk assessment

Bichou (2009, p116) describes the process of risk assessment as "the assessment of risk in terms of what can go wrong, the probability of it going wrong and the possible consequences." Drawing on the system safety literature he states that "the empiricist approach is to regard accidents as random events whose frequency is influenced by certain factors" and that under this approach the cause of an accident is a hazardous event. Bichou (2009, p117) classifies the major hazard analysis tools as either

sequence dependent or independent and following either consequence or cause analysis (see table 2.1).

	Consequence analysis	Cause analysis
Sequence dependent	Event Tree Analysis	Markov Process
Sequence independent	Failure Modes and Effects Analysis	Fault Tree Analysis

Table 2.1 – Major hazard analysis tools (source: Bichou, 2009)

Event tree analysis (ETA) and Failure Modes and Effects Analysis (FMEA) are two forms of hazard analysis which analyse the consequences of an event, whereas Fault Tree Analysis (FTA) and the Markov process analyse the causes of an event. Pyzdek (2003) describes FTA as providing a graphical representation of the events that might lead to failure. According to Bichou (2009), a shortcoming of FTA is the assumption that the sequence of causes of an incident is not relevant and that "where sequence does matter, Markov-chain techniques may be applied."

Bichou and Evans (2007) describe how precursor analysis combined with other techniques such as near-misses and probabilistic risk analysis provide an effective framework for risk assessment and risk management in the context of maritime security. They define 'precursor' as "any internal or external condition, event, sequence, or any combination of these that precedes and ultimately leads to adverse events." Bichou and Evans (2007) argue that the benefits from introducing programmes of security assessment based on precursor analysis include the identification of previously unknown failure modes (for FMEA analysis) and the analysis of the effectiveness of actions taken to reduce risk.

In addition to the risk assessment tools described by Bichou (2009), other industry-specific methods exist in the security field. One seaport-specific method of risk assessment can be found in the Navigation and Vessel Inspection Circular (NVIC) No. 11-02 dated 13 January 2003 issued by the United States Coast Guard. Enclosure 5 (Guidance on Assessing Facility Security Measures) includes a simplified risk-based security assessment methodology which seaports can conduct themselves in pursuit of their compliance with the requirements of the United States Maritime Transportation Security Act (2002).

Another industry-specific document which contains a methodology on risk assessment is the International Standard ISO 28001 (2007) "Security management systems for the supply chain — Best practices for implementing supply chain security, assessments and plans — Requirements and guidance."

Talas and Menachof (2009) developed a conceptual model for calculating a port facility's residual security risk. The conceptual model examines the following characteristics:

- the security threats that the port facility faces and their probabilities
- an estimate of the economic damage to the port facility from each prescribed security threat
- the port facility's security components and systems and their performance in the face of the potential security incidents
- the port facility's security components' costs.

Merrick and van Dorp (2006) describe a methodology for risk assessment in the maritime domain by developing a probabilistic risk framework for modelling collisions between a ferry and another vessel. In their model, the probability of a collision depends on triggering incidents and other criteria such as situation and the probability of the incident occurring given the situation. Merrick and van Dorp (2006) state that to perform an assessment of the risk of an accident using the model, each term in the probability model must be estimated. However, the complexity of the data which must be captured in order for the model to work may to be beyond the bounds of even the most experienced insurance underwriter and port security specialist.

2.3.2 Port security risk sources

Juttner et al (2003) describe supply chain risk sources as environmental (accidents, socio-political actions such as terrorism), organisational (labour, production uncertainties or IT-system uncertainties) or network-related (risks arising from interactions from companies within the supply chain.)

Environmental risk sources

The environmental risks that ports face include but are not limited to acts of terrorism. While the focus on terrorism appears to be uppermost in the literature, there are limited references to such attacks being directed at port facilities. Examples found in the literature include the incident in April 1996 when the Tamil Tigers launched an attack on the port of Colombo and succeeded in damaging three vessels(Aryasinha, 2001), including one belonging to the Van Ommeren shipping line which was insured by the author; in 2004 Jamaat al-Tawhid attacked the Khawr Al Amaya and Al Basrah oil facilities in Iraq and in the same year suicide bombers from Hamas and the al-Aqsa Martyr's Brigade launched an attack in the Port of Ashdod (Greenberg et al, 2006).

However, this gap in the literature on terrorist attacks against ports is addressed in some additional research which builds on Gleason's (1980) research on terrorist attacks against targets in the United States and is described in more detail in chapter four. Nevertheless, ports also face threats of unlawful entry and activity by thieves, smugglers and potential stowaways as well as individuals bent on destruction or the interruption of international trade on political or ideological grounds.

Prior to 9/11 the main threats to ports were considered to be from drug smuggling and organised crime. These threats resulted in the creation in the United States of the Business Anti-Smuggling Coalition (BASC), which has now been superceded by the Business Alliance for Secured Commerce, a security initiative initially aimed at reducing the risk of legitimate cargo being used by illegal organizations for the narcotics trade (Gutierrez et al, 2007). Nevertheless, the potential for terrorist attacks to disrupt ports and supply chains dominates the literature post-9/11. According to Raymond (2006, p242) ports are vulnerable to attack by terrorists: they are extensive in size and accessible by water and land. Furthermore, their accessibility impedes the deployment of the types of security measures that, for example, can be more readily deployed at airports. Bichou (2004) highlights the additional security threats that ports face due to their "close spatial interactions with large city-agglomerations and seashore tourist attractions." Table 2.2 lists examples of potential attack characteristics against US maritime targets (Parfomak and Fritelli, 2007).

Dimensions	Example Characteristics
Perpetrators	• Al Qaeda and affiliates • Islamist unaffiliated • Foreign nationalists • Disgruntled employees • Others
Objectives	• Mass casualties • Port facility Disruption • Trade disruption • Environmental damage
Locations	• 360+ U.S. ports • 165 foreign trade partners • 9 key shipping bottlenecks
Targets	• Military vessels • Cargo vessels • Fuel tankers • Ferries / cruise ships • Port facility Area populations • Ship channels • Port industrial plants • Offshore platforms
Tactics	• Explosives in suicide boats • Explosives in light aircraft • Ramming with vessels • Ship-launched missiles • Harbor mines • Underwater swimmers • Unmanned submarine bombs • Exploding fuel tankers • Explosives in cargo ships • WMDs in cargo ships

Table 2.2 – Example Maritime Attack Characteristics (source: Parfomak and Fritelli, 2007)

According to Nincic (2005, p623), the Sri Lankan Liberation Tigers of Tamil Eelam (LTTE), Hizballah, the Popular Front for the Liberation of Palestine, the Abu Sayyaf Group, Gama al-Islamiya, the Moro Islamic Liberation Front and the IRA are all believed to have varying levels of maritime expertise. According to Raymond (2006, p240), the terrorist groups that are known to have a maritime capability include "Polisario, the Abu Sayyaf Group, Palestinian groups, Al Qaeda, the Moro Islamic Liberation Front and the Liberation Tigers of Tamil Eelam." However, Raymond (2006, p244) points out that "in order to be considered a threat, it is not necessary for a terrorist group to have already carried out a maritime terrorist attack against shipping or port facilities."

With the potential for maritime terrorists to deploy a mothership with tenders, their geographic reach is, in theory, considerably extended from their homelands' territorial waters. Somali pirates are reported to use this mode of transport to attack ships hundreds of miles offshore[1] and the Mumbai bombers are rumoured to have arrived in Mumbai via inflatable boats from a highjacked fishing vessel, which was later found adrift with the body of a man onboard. [2]

Organisational risk sources

Organisational risk sources in port security stem chiefly from the security labour force and the operational aspects of security systems, including IT-systems. Examples of labour force risks include security guard manpower shortfalls and security guard violations. Security guard violations cover not only on-site breaches in working practices but include the unauthorised copying, lending or sale of security passes. According to Raymond (2006, p243), seafarer certificates can easily be forged and identity documents can be bought on the black market so it must follow that this can be done onshore as well. Operational aspects of security systems include failure by the security workforce to adhere to security procedures, failure of CCTV camera units, intruder detection devices, scanning equipment or any IT security system.

Network-related risks

Juttner et al (2003) describe network-related risk sources as those "which arise from interactions between organisations in the supply chain." Network-related security risks which ports face are those which had their origins in supply chain interactions and can result from the failure of any company's security systems or the exploitation of a security weakness. For example, in the containerised trade, the possibility of the introduction of a chemical, nuclear, biological or radiological (CNBR) device which is detonated in a port will have considerable consequences for the port facility As well as cause severe supply chain interruption. In the port security war game Gerencser et al (2003) showed that a dirty bomb, a conventional explosive device used to scatter nuclear or radiological material, found at the port of Los Angeles followed by the

[1] "Piracy off the Somali Coast: Workshop commissioned by the Special Representative of the Secretary General of the United Nations to Somalia", p19, Nairobi, 10-21 November 2008. Accessed 3/08/2009 at http://www.imcsnet.org/imcs/docs/somalia_piracy_intl_experts_report_consolidated.pdf

[2] Greenberg, M. 1/12/2008 "The Terror Attacks in Mumbai: Background, Operational Uniqueness and Implications", International Institute for Counter-Terrorism http://www.ict.org.il/NewsCommentaries/Commentaries/tabid/69/Articlsid/538/currentpage/3/Default.aspx

discovery of another shipped through the port of Savannah could ultimately lead to supply chain interruptions and stock market falls which could cause up to $68 billion in direct and indirect losses.

Other network-related risks include the use of the containerised trade to transport stowaways or even terrorists through ports and across national boundaries, as in the case of the suspected member of al-Qa'eda found on the quay in an Italian port in a container converted into a mobile hotel room (Raymond, 2006, p246; OECD, 2003).

2.3.3 Port security risk consequences

The consequences of port security risk events are typically negative and can be classified as direct or indirect losses. Direct losses include physical damage to port infrastructure. The disruption of port facility Activities resulting from direct losses will invariably lead to indirect losses such as business interruption through supply chain shocks, increased insurance costs and increased cost of working through the implementation of a tougher security regime which restricts cargo movements through the port. Details of empirical studies of port security risk consequences can be found later in this chapter under the section 'Port Security Incident Costs.'

2.3.4 Port security risk drivers

Juttner et al (2003, p205) describe how supply chain risk drivers "impact directly on network-related risk sources." Supply chain risk drivers such as globalisation of supply chains and the trend to outsourcing have their equivalents in their effect on network-related security risks. The globalisation of terrorist and criminal networks and the trend to outsourcing security in the supply chain act as potential port security risk drivers. Miller and Talas (2007) state that there are approximately twenty terrorist groups that have aligned themselves to al-Qaeda, signing up to Osama bin Laden's fatwa of November 2000 and in effect globalising bin Laden's terrorist organisation. In particular, the outsourcing of security in the supply chain can lead to a lack of transparency of implemented security measures and with it confidence in the third party provider of security. Security initiatives such as the ISPS Code and ISO 28000 are designed to counter this type of port security risk driver by introducing a given set of minimum security standards in a transparent manner. The importance of

identifying port security risk drivers becomes clear in the examination of port security vulnerability.

2.3.5 Port security vulnerability

Juttner et al (2003) describe supply chain vulnerability as "the propensity of risk sources and risk drivers to outweigh risk mitigating strategies, thus causing adverse supply chain consequences." Translating this to port security, a description of port security vulnerability can be the propensity of port security risk sources and risk drivers to outweigh port security risk mitigating strategies, thus causing adverse security events. Broder (2006) defines vulnerability as "the probability of failure and the probability of occurrence after countermeasures are implemented. It measures the likelihood of threat and its ability to cause damage." Willis et al (2005) describe vulnerability in terrorist context as the probability of an attack resulting in damage given that an attack occurs.

Considering the earlier proposed definition of port security risk, port security vulnerability can thus be defined as the product of the probability of a security event and the inability of a port's security systems to prevent the occurrence of the event. This definition is important because it forms one of the key parts of the methodology for the calculation of a port facility's residual security risk.

2.3.6 Port security risk mitigating strategies

Pinto and Talley (2006, p268) describe the security incident cycle of ports in four phases: prevention, detection, response and recovery. They describe prevention as barriers that deny terror plans and events; detection provides early apprehension; response pursues as event and mitigates its impact; and recovery involves the return to normal operations. The port security risk mitigating strategies in this research are concerned with the first two phases as described by Pinto and Talley (2006).

There are two key port security risk mitigating strategies which were introduced after 9/11. The main one is the ISPS Code introduced by the IMO at the Diplomatic Conference in December 2002. The other is the Maritime Transportation Security Act which was passed by the US Congress in November 2002 and relates to US port facilities, or facilities in US parlance. According to Bichou (2004, p323), the ISPS Code is "the most important global security initiative ever." The European Union

equivalent of the ISPS Code is Regulation (EC) No. 725/2004, which is largely a word-for-word reproduction of the ISPS Code. In the next section the key points of the ISPS Code and the MTSA are addressed and there follows a brief summary of other key supply chain security initiatives which also have a bearing on port security.

2.4 ISPS Code

The ISPS Code was drawn up by the IMO's Maritime Safety Committee and its Maritime Security Working Group in little over a year following the adoption of resolution A.924(22) on the review of measures and procedures to prevent acts of terrorism which threaten the security of passengers and crews and the safety of ships, in November 2001 (ISPS Code, 2003, p iii.) The ISPS Code was adopted on 12 December 2002 by the Conference of Contracting Governments to the International Convention for the Safety of Life at Sea (SOLAS) 1974 when the existing chapter XI was amended and re-identified as chapter XI-1 and a new chapter XI-2 was adopted on special measures to enhance maritime security. Amendments were also made to the existing SOLAS chapter V.

The ISPS Code is divided into two parts, A and B. Part A establishes the new international framework of measures to enhance maritime security by introducing mandatory provisions while part B provides non-compulsory guidance on the procedures to be undertaken in order to comply with the provisions of chapter XI-2 and of Part A of the ISPS Code (Bichou, 2004.) Certain countries, such as the European Union under EC Regulation 725/2004, have made compliance with part B of the ISPS Code mandatory through legislation (Dekker & Stevens, 2007; Anyanova, 2007).

The objectives of the ISPS Code are to enable the prevention and detection of security threats within an international framework; to establish roles and responsibilities; to enable the collection and exchange of security information; to provide a methodology for assessing security and to ensure that adequate security measures are in place. The objectives are to be achieved by the designation of appropriate personnel on each ship, in each port facility and in each shipping company, to prepare and to put into effect the approved security plans.

The ISPS Code is applicable to vessels engaged in international trade including passenger vessels with 12 or more berths, cargo vessels of 500 gross tonnes and over, mobile offshore drilling units and all port facilities serving such vessels engaged in international trade.

The ISPS Code definition of responsibilities determines the responsibilities of Contracting Governments, ship operators and port facility operators. Contracting Governments must identify the Designated Authority (for port facilities), set security levels, coordinate with port facility security officers and issue and inspect International Ship Security Certificates.

In turn, ship and port facility operators must designate the appropriate security officers and develop and implement the security plans. In addition, each Contracting Government (or a Recognised Security Organisation appointed by the Designated Authority) must carry out a Port Facility Security Assessment (PFSA) which will include the following elements (ISPS Code Part A.15.5):

- Identification and evaluation of important assets and infrastructure it is important to protect;
- Identification of possible threats to the assets and infrastructure and likelihood of their occurrence, in order to establish and prioritise security measures;
- Identification, selection and prioritisation of countermeasures and procedural changes and their level of effectiveness in reducing vulnerability; and
- Identification of weaknesses, including human factors, in the infrastructure, policies and procedures.

Each Contracting Government (or Recognised Security Organisation appointed by the Designated Authority) must then prepare a port facility security plan (PFSP) which addresses at least the security measures listed in ISPS Code Part A.16.3.

Against the background of the security measures described above, all port facilities and the relevant vessel types must also operate at one of three security levels, determined by their Contracting Government. Security level 1 is the level for which minimum appropriate protective security measures shall be maintained at all times. The following security-related activities in a port facility are mandated by the ISPS Code (Part A.14) at security level 1:

- Ensuring the performance of all port facility security duties

- Controlling access to the port facility
- Monitoring of the port facility, including anchoring and berthing areas
- Monitoring restricted access areas to ensure that only authorised persons have access
- Supervising the handling of cargo
- Supervising the handling of ship's stores
- Ensuring that security communication is readily available

At security level 2 additional protective measures, as detailed in the PFSP shall be implemented and maintained for a period of time as a result of a heightened risk of a security incident.

At security level 3 further specific protective measures, as detailed in the PFSP shall be implemented and maintained for a limited period of time when a security incident is probable or imminent, although it may not be possible to identify the specific target (Jones, 2006, p128).

Following the approval of the PFSA and the PFSP, including any amendments, the Statement of Compliance of a Port Facility is then issued by the Contracting Government (ISPS Code, B.16.54) for a period not exceeding five years.

2.5 Maritime Transportation Security Act (MTSA)

The MTSA is the US equivalent of the ISPS Code and in common with its international counterpart was implemented on 1 July 2004. It shares many commonalities with the ISPS Code but goes much deeper into specific requirements of securing the US maritime infrastructure (Jones, 2006, p99). The MTSA prescribes the formation of a national maritime security plan and advisory committee; area maritime transportation security plans and committees; vessel and (port) facility security plans; security incident response plans; the appointment and training of security personnel; and the development of specific sanctions against those who fail correctly to implement the Act. In line with the ISPS Code, the MTSA also establishes the three levels of security. Furthermore, the MTSA introduces additional security initiatives, the most significant of which are the Container Security Initiative (CSI) and the Customs-Trade Partnership Against Terrorsm (C-TPAT).

2.5.1 Container Security Initiative (CSI)

The Container Security Initiative was launched in 2002 with 20 of the world's largest container terminals and forms part of the US Maritime Transportation Security Act. By June 2003, 23 ports representing at least 60% of container imports to the United States had signed CSI agreements. In 2006, 43 ports with approximately 75% of cargo containers destined for US ports were part of the CSI scheme (Jones, 2006, p101). By September 2007 there were 55 CSI ports worldwide and in 2009 there were over 60 ports that were part of the scheme.

CSI addresses the threat to border security and global trade posed by the potential for terrorist use of a maritime container to deliver a weapon. CSI proposes a security regime to ensure all containers that pose a potential risk for terrorism are identified and inspected at foreign ports before they are placed on vessels destined for the United States. The United States' Customs and Border Protection Agency (CBP) has stationed multidisciplinary teams of U.S. officers from both CBP and Immigration and Customs Enforcement (ICE) to work together with host foreign government counterparts. Their mission is to target and pre-screen containers and to develop additional investigative leads related to the terrorist threat to cargo destined to the United States. The pre-screening of containers is assisted by the introduction in December 2002 of the Advanced Manifest Rule, or 24 Hour Rule.

Through CSI, CBP officers work with host customs administrations to establish security criteria for identifying high-risk containers. Those administrations use non-intrusive inspection (NII) and radiation detection technology to screen high-risk containers before they are shipped to US ports. CSI, a reciprocal program, offers its participant countries the opportunity to send their customs officers to major US ports to target ocean-going, containerized cargo to be exported to their countries. Likewise, CBP shares information on a bilateral basis with its CSI partners. Japan and Canada currently station their customs personnel in some US ports as part of the CSI program.

2.5.2 C-TPAT, Customs-Trade Partnership Against Terrorism[3]

C-TPAT is a Joint government-business initiative to build cooperative relationships that strengthen overall supply chain and border security. Central to the security vision of C-TPAT is the core principle of increased facilitation for legitimate business

[3] URL: http://www.cbp.gov/xp/cgov/import/commercial_enforcement/ctpat/ [accessed 17 March 2009]

entities that are compliant traders. Only importers and carriers based in the US were initially eligible to participate in the program and one of its main motivations is to protect US borders from terrorist attacks occasioned by goods entering the country.

2.5.3 C-TPAT and non-US Terminals

Under C-TPAT, foreign-based marine port facility authorities and terminal operators (MPTOs) may be eligible for membership of the C-TPAT scheme but only following an invitation from CBP to join. The terminal must handle cargo vessels departing to the US and have a designated company officer that will be the primary cargo security officer responsible for C-TPAT.

2.5.4 Requirements for C-TPAT membership

US and Foreign-based MPTOs must conduct a comprehensive assessment of their security practices based on C-TPAT minimum-security criteria. C-TPAT recognizes the complexity of MPTOs and endorses the application and implementation of security measures based upon risk. Therefore, the program allows for flexibility and the customization of security plans based on the C-TPAT member's business model, the port's geography, the commodities handled at the port facility and the terms and conditions of the lease agreement between the marine port facility authority and the terminal operator.

C-TPAT also recognizes the unique role and relationship between MPTOs situation regarding terminal operators who operate as tenants within a marine port. For C-TPAT purposes, each terminal operator must implement the C-TPAT security criteria within the physical area and processes within the terminal operator's area of control and responsibility. Where a does not control a specific process or element of the supply chain, such as a sea carrier, terminal operator or independent contractor, the marine port facility authority should work with these business partners to seek to ensure that pertinent security measures are in place and adhered to within the overall port.

2.6 Contemporary supply chain security initiatives

The following are other contemporary supply chain security initiatives which have a bearing on port security and will be described briefly in turn:

- BASC – Business Anti-Smuggling Coalition
- PIP – Partnership in Protection
- WCO Framework of Standards
- European Union AEO - Authorised Economic Operator
- TAPA – Transported Asset Protection Association
- StairSec
- Secured Export Partnership
- ISO 28000
- Advanced Cargo Information Initiatives

2.6.1 BASC, Business Alliance for Secured Commerce / (formerly: Business Anti-Smuggling Coalition) [4]

BASC is a cooperation program between the private sector and national and international organizations, created to promote a secure global supply chain. The main goal is to encourage within its membership the development and implementation of voluntary steps to address the risks of narcotics and merchandise smuggling through legitimate trade, as well as the threat of a disruption in the global economy brought about by terrorism.

BASC procedures require a security program which consists of a number of operating measures adopted to protect an organization, its assets, properties, employees and customers.

Factors to consider in preparing a security program include:

- Organizational security requirements
- Potential of the organization to meet those requirements
- The organization's vulnerability to current and future security risks
- Available options to the organization to cover its security needs

[4] URL: http://www.wbasco.org/english/documentos/bascstandards.pdf [accessed 17 March 2009]

Other important aspects that should be included in a Security Plan are:

- Clear definition of security methods.
- Written procedures for internal / external security notification.
- Mechanisms to establish accountability in case of theft or robbery.
- Handling of documents and files.
- Procedures for checking lighting and perimeter fencing.
- Procedures when closing facilities (doors, gates, windows, etc).
- Security systems to check entry and exit of people and /or vehicles.
- Procedures for handling cargo.
- Defined policies for external monitoring.
- Control and handling of keys and conducting periodic inventory checks.
- Policies and procedures for personnel hiring.
- Policies to be applied in criminal background checks.
- Procedures for obtaining photographs and fingerprints of all employees.
- Assignment of responsibilities of security personnel.

2.6.2 PIP, Partners in Protection[5]

PIP is designed to enlist the co-operation of private industry in efforts to enhance border security, combat organized crime and terrorism, increase awareness of customs compliance issues, and help detect and prevent contraband smuggling. This program does not have a "certification" component as such. Companies may be refused if they do not fulfill the requirements, but once accepted in the program they work together with Canadian Customs to improve their supply chain security, even though they will not get a certification as such. A PIP participant can apply for CSA (Customs Self-Assessment program) to expedite goods into Canada.

[5] URL: http://www.cbsa-asfc.gc.ca/security-securite/pip-pep/menu-eng.html [accessed 17 March 2009]

2.6.3 WCO Framework of Security standards to secure and facilitate global trade[6]

This is a framework of security standards developed by the World Customs Organization. It intends to provide a new and consolidated platform which will enhance world trade, ensure better security against terrorism, and increase the contribution of Customs and trade partners to the economic and social well-being of nations. It aims to improve the ability of customs to detect and deal with high-risk consignments and increase efficiency in the administration of goods, thereby expediting the clearance and release of goods. Specifically, the aims of the Framework are the following:

- Establish standards that provide supply chain security and facilitation at a global level to promote certainty and predictability
- Enable integrated supply chain management for all modes of transport
- Strengthen co-operation between customs administrations to improve their capability to detect high-risk consignments
- Strengthen customs/business co-operation
- Promote the seamless movement of goods through secure international trade supply chains

2.6.4 EU AEO, European Union Authorized Economic Operator[7]

This designates the status that Customs authorities from European member states should grant to reliable traders established in the European Community. AEOs will be able to benefit from facilitations for customs controls or simplifications for customs rules or both, depending on the type of AEO certificate. There are three certificate types:

- **Customs Simplifications.** AEOs will be entitled to benefit from simplifications provided for under the customs rules.
- **Security and Safety.** AEOs will be entitled to benefit from facilitations of customs controls relating to security and safety at the entry of the goods into

[6] URL: http://www.wcoomd.org/home.htm [accessed 17 March 2009]
[7] URL: http://ec.europa.eu/taxation_customs/customs/policy_issues/customs_security/index_en.htm#auth_eco [accessed 17 March 2009]

the customs territory of the Community, or when the goods leave the customs territory of the Community.

- **Customs Simplifications/Security and Safety.** AEOs will be entitled to benefit from both simplifications provided for under the customs rules and from facilitations of customs controls relating to security and safety (a combination of 1 and 2).

The main benefits of AEO status will not be realised until the requirements for pre-arrival and pre-departure are introduced in July 2009 and the changes linked to the Modernised Customs Code are introduced in 2010.

2.6.5 TAPA, Transported Asset Protection Association (formerly Technology Asset Protection Association[8])

This is an association of security professionals and related business partners from high technology companies who have been working together to address emerging security threats that are common to the technology industry and high-tech businesses. In recent years TAPA has added both an Asian and an EMEA chapter to the US original. The goals of TAPA include:

- Security of goods from theft
  - in transit
  - in-transit storage
  - warehousing
- Specifies minimum standards for security throughout the supply chain
- Describes methods for maintaining standards
- Includes process for TAPA certification
- TAPA suppliers must:
  - Have a security policy, procedures and plan
  - Submit to periodic audits and certification

[8] URL: http://www.tapaonline.org [accessed 17 March 2009]

2.6.6 StairSec[9]

This is a module introduced to the Swedish Customs program Stairway (originally created to facilitate customs processes for compliant traders). This module makes it possible to provide quality assurance for operators within the Stairway not only for quality in their customs routines but also for the security measures they have taken to prevent terrorists from using the operators commercial flow of goods for transporting weapons of mass destruction.

2.6.7 Secured Export Partnership[10]

It is designed to protect cargo against tampering, sabotage, smuggling of terrorists or terrorist-related goods, and other transnational crime, from the point of packing to delivery. Exporters from New Zealand are eligible and encouraged to participate: especially those moving goods to the US. The program emphasizes that security measures are customizable depending on the applicant's situation.

2.6.8 ISO 28000[11]

The International Standards organization has developed security standards aimed at becoming the global supply chain security standard program. It is intended to be in concert with and complementing the World Customs Organization's Framework of Security Standards and it does not attempt to cover specific Customs agency requirements. ISO 28000 was launched in November 2005 as a publically available specification and is now a fully-fledged ISO standard.

ISO 28000 is applicable to all sizes of organizations, from small to multinational, in manufacturing, service, storage or transportation at any stage of the production or supply chain that wishes to:

- establish, implement, maintain and improve a security management system;
- assure compliance with stated security management policy;
- demonstrate such compliance to others;

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[9] URL: http://www.tullverket.se/en/Business/the_stairsec/ [accessed 17 March 2009]
[10] URL: http://www.customs.govt.nz/exporters/Secure+Exports+Scheme.htm [accessed 17 March 2009]
[11] URL: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=41921 [accessed 17 March 2009]

- seek certification/registration of its security management system by an Accredited third party Certification Body; or
- make a self-determination and self-declaration of compliance with ISO 28000.

ISO 28000 is based on the format adopted by ISO 14000 owing to its risk-based approach to management systems and is based on the Plan-Do-Check-Act methodology:

- Plan: establish the objectives and processes necessary to deliver results in accordance with the organization's security policy
- Do: implement the processes
- Check: monitor and measure processes against security policy, objectives, targets, legal and other requirements, and report results
- Act: take actions to continually improve performance of the security management system

The supply chain security initiative "specifies the requirements for a security management system, including those aspects critical to security assurance of the supply chain. These aspects include, but are not limited to, financing, manufacturing, information management and the facilities for packing, storing and transferring goods between modes of transport facility And locations."

ISO 28000 relies on the principle of continual improvement through management review as shown in figure 2.1. The process begins with the setting out of the firm's security policy, followed by security risk assessment and planning, followed by the implementation and operation stage with checking and corrective action leading to a review by management and subsequent restatement of policy.

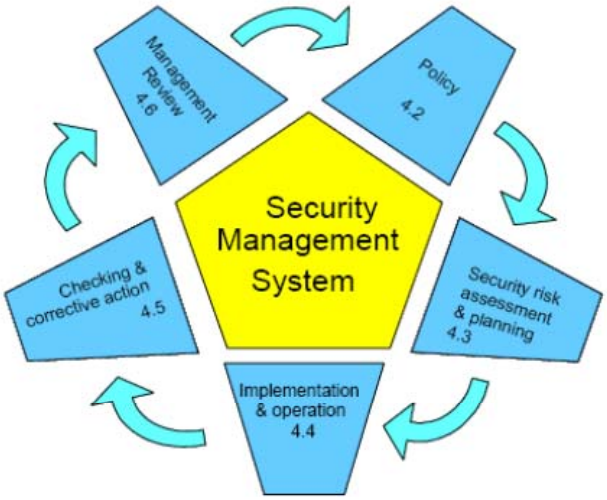


Figure 2.1. ISO 28000 security management system (source: ISO 28000)

The key sections in ISO 28000 are the security risk assessment process, the operational control process and the emergency preparedness process.

The security risk assessment process set out in 4.3.1 shall "….consider the likelihood of an event and all of its consequences which shall include physical failure threats and risks, such as functional failure, incidental damage, malicious damage or terrorist or criminal action….operational threats and risks etc." The emphasis is on identifying all of the threats to the organisation's supply chains, not only the upstream and downstream threats.

Section 4.4.6 'Operational Control' is concerned that the organisation shall ensure that the operations and activities listed in 4.4.6 a) to f) are carried out under specified conditions by "evaluating any threats posed from upstream supply chain activities and applying controls to mitigate these impacts to the organisation and other downstream supply chain operators."

Section 4.4.7 'emergency preparedness, response and security recovery', describes how the organisation shall "establish, implement and maintain appropriate plans and procedures to identify the potential for, and responses to, security incidents and emergency situations, and for preventing and mitigating the likely consequences that can be associated with them." The procedures are concerned with preventing and mitigating the likely consequences from any security incidents and emergency situations.

2.6.9 Advanced Cargo Information Requirements

The first mandatory advanced cargo information (ACI) requirement introduced in the wake of September 11th was the US Customs and Border Protection Advanced Manifest Rule, commonly known as the 24-hour Rule. The 24-hour rule requires sea carriers and NVOCCs (Non-Vessel Operating Common Carriers) to provide the US Customs and Border Protection Agency with detailed descriptions of the contents of sea containers bound for the United States 24 hours before the container is loaded on board a vessel. The rule allows US Customs officers to analyze the container content information and identify potential terrorist threats before the US -bound container is loaded at the foreign seaport, not after it arrives in a US port. The use of such vague cargo descriptions as "Freight-All-Kinds", "Said-To-Contain" or "General Merchandise," is no longer tolerated. Sea carriers and NVOCCs that violate the 24-hour rule 2003 receive "Do-Not-Load" messages. The "Do-Not Load" message instructs these parties not to load a specific container that has been found in violation of the 24-hour rule. Carriers and NVOCCs that disregard these "Do Not Load" messages (and load the cited container) are denied permission to unload this container at any US port.

The tightened reporting requirements for containerised cargo entering the United States as prescribed by the 24 hour rule has forced companies' supply chains towards greater functionality. To meet the 24 hour rule requirements, shipowners and other NVOCCs have extended their electronic commerce technologies by developing e-commerce portals through which their customers can communicate more easily their shipping information and giving customers the capability to manage their shipments by increasing visibility in their supply chains.

Since then, additional mandatory ACIs have been introduced in the United States, Mexico, Canada, the European Union, China and Japan. They are outlined below and the section concludes with a brief description of the United States' intention to scan 100% of inbound containers by 2012.

Importer Security Filing "10+2 Rule"

The Importer Security Filing (ISF), commonly known as the "10+2" initiative, is a Customs and Border Protection (CBP) regulation that requires importers and vessel

operating carriers to provide additional advance trade data to US CBP pursuant to Section 203 of the SAFE Port Act of 2006[12]. 10+2 is designed to build on the capability of CBP's automated targeting system (ATS) by helping to identify the entities involved in the supply chain and their locations as well as providing more detailed descriptions of the goods to be imported into the United States. The ten items to be transmitted to CBP by the importer, or their authorized agents no later than 24 hours before loading at the non-US port are:

- Manufacturer (or Supplier)
- Seller
- Buyer
- Ship to Party
- Container Stuffing Location
- Consolidator (Stuffer)
- Importer of Record/Foreign Trade Zone (FTZ) Applicant Identification Number
- Consignee Number(s)
- Country of Origin
- Commodity Harmonized Tariff Schedule of the United States (HTSUS) Number

The additional two items that must be submitted by the carrier, electronically to CBP, within 48 hours of the vessel departing from the last port, inbound US are:

- Vessel Stow Plan
- Container Status Messages

However, in the event of foreign cargoes remaining onboard or other transit cargoes, only the following five items need to be transmitted 24 hours before loading in the non-US port:

- Booking Party name/address
- Ship to Party

[12] URL: http://www.cbp.gov/linkhandler/cgov/trade/cargo_security/carriers/security_filing/ra.ctt/ra.pdf [accessed 29 January 2010]

- Commodity HTS-6
- Foreign Port of Unlading
- Place of Delivery

Mexico 24 hour rule

On 1 September 2007, Mexican Customs implemented a similar ACI system to the United States. The information which must be transmitted to Mexican Customs at least 24 hours before loading in the non-Mexican port is designed to be similar to that required by CBP and is as follows[13]:

- Name and complete address of the shipper, consignee and of the person who shall be notified of the arrival, as stated in the bill of lading. (When the consignee is labelled TO THE ORDER OF. the name of the Notify party must be declared.)
- Amount of the merchandise and measurement unit, if the merchandise is carried in containers, the amount and measurement unit shall also be specified as well for each container.
- Gross weight or volume of the merchandise. If the merchandise is carried in containers, the gross weight or volume shall be specified also for each container.
- Merchandise description, avoiding general descriptions that do not allow proper identification of the nature of the merchandise; such as "general cargo", "dry cargo", "chemicals", "perishable items", "bulk merchandise", "bulk minerals" ,"F.A.K.".
- Number, quantity and dimensions of containers.
- Seal number(s) for each container. (No slashes, no hyphen, neither blank spaces within seal number)
- Type of service contracted.
- In case of dangerous merchandise, state class, division and United Nations number, as well as a telephone number for emergencies.

[13] URL: http://www.hamburgsud.com/WWW/EN/Services_and_Offices/Regional_Information/Asia/Regional_Content/Microsoft_Word_-_NEW_24_HRS_REGULATION_FOR_MEXICO_sep_1_RAS.pdf [accessed 29 January 2010]

Canadian Advance Commercial Information

On 19 April 2004, the Canadian Border Services Agency introduced the advance commercial information programme which is similar to the US CBP 24 hour rule. requiring marine carriers to electronically transmit marine cargo data to the Canada Border Services Agency (**CBSA**) 24 hours prior to loading cargo at a foreign port.[14]

European Union Pre-Arrival and Pre-Departure

As of 1 July 2009, EU authorities required importers and exporters to lodge pre-arrival and pre-departure summary customs declarations up to 24 hours prior to exportation or importation, depending on the method of transportation. Thus, the European Union has become one of the few customs territories in the world requiring not only pre-arrival declarations but also pre-departure customs declarations. The new EU customs rules require pre-arrival and pre-departure declarations to be stored in electronic format for at least three years. Since many multinational companies will choose to centralise their electronic storage of these documents, they will have to carefully evaluate the applicable EU Member State's national legislation relating to data protection and retention. The AEO Security and Safety Certificate and AEO Customs and Security Certificate are aimed at lessening this burden by providing significant benefits with regard to pre-arrival and pre-departure declarations. Non-AEO entities have to provide pre-departure and pre-arrival declarations consisting of additional security-related information.[15]

Japan Advance Cargo Information

On 1 June 2007, Japan Customs introduced their advance cargo information for both marine and air cargoes. The required items include[16]:

- Shipping location and destination of cargo
- Marks, numbers, name and quantity of goods
- Address or place of residence, name or appellation and telephone number of consigner and consignee

[14] URL: http://www.cbsa-asfc.gc.ca/prog/aci-ipec/menu-eng.html#a1 [accessed 29 January 2010]
[15] URL: http://www.mwe.com/index.cfm/fuseaction/publications.nldetail/object_id/61581f82-7f64-4c88-b797-c2e63964ed1a.cfm [accessed 29 January 2010]
[16] URL: http://www.customs.go.jp/english/procedures/advance2_e/index_e.htm [accessed 29 January 2010]

China Advance Cargo Information

From 1 January 2009, Decree No. 172 of the General Administration of Customs of the People's Republic of China came into force "for the purposes of regulating the customs administration of manifests of inbound and outbound means of transport, facilitating international trade and ensuring international trade security." Under the measures, operators of inbound and outbound means of transport, non-vessel operating common carriers, freight forwarders, shipping agency companies are obliged to submit cargo manifests to Chinese Customs 24 hours prior to the loading of cargo.[17]

United States 100% Container Scanning 2012

The United States legislation "Implementing Recommendations of the 9/11 Commission Act of 2007" unilaterally introduced a 100% scanning requirement for US-bound maritime cargo at the point of export, to be implemented by 1 July 2012.[18] Pilot programmes for 100% scanning have been conducted in Southampton Container Terminal, UK; Qasim International Container Terminal in Karachi, Pakistan; and Cortes in the Honduras under the auspices of the Secure Freight Initiative which derived from the Security and Accountability For Every (SAFE) Port Act of 2006. While commentators disagree about the financial and security viability of 100% container scanning, ports should be aware that failure to comply with the legislation may put them at risk of being unable to export to the United States from 2012, though the legislation does allow for a period of up to two years in which the mandatory introduction may be delayed. Nevertheless, there is much opposition to the introduction of the legislation, particularly from the European Union, which is considering introducing a requirement for US ports to scan 100% of all containers bound for Europe.

[17] URL: http://english.customs.gov.cn/publish/portal191/tab3972/info162113.htm [accessed 29 January 2010]
[18] URL: http://www.gao.gov/new.items/d08126t.pdf [accessed 29 January 2010]

2.7 Port Security Costs

Estimates of the costs of the introduction of the ISPS Code can be found in Bichou (2004), Bichou and Evans (2007), OECD (2003), Dekker and Stevens (2007) and Benamara and Asariotis (2007). According to Bichou (2004), the US Coast Guard (USCG) estimated the cost implications of security compliance on US ports to be $1.1 billion for the first year and $656 million each year up to 2012. The OECD (2003) report on the global economic impacts of the new security measures estimated that more than $2 billion was required as an initial investment with 1$ billion annual expenditure for developing country ports alone. Table 2.3 summarises the research by USCG and OECD with regard to the costs of security compliance in ports.

	Nature of estimates	Initial costs	Annual costs
Port Facility Security Assessment	US port facility Costs (USCG)	23	1
	Global port facility Costs (OECD)	27.9	0.8
Port Facility Security Plan	US port facility Costs (USCG)	23	1
	Global port facility Costs (OECD)	27.9	0.8
Port Facility Security Officer	US port facility Costs (USCG)	335	335
	Global port facility Costs (OECD)	undetermined	undetermined
Security training/drills	US port facility Costs (USCG)	17	52
	Global port facility Costs (OECD)	undetermined	undetermined
Security staff/equipment	US port facility Costs (USCG)	565	146
	Global port facility Costs (OECD)	undetermined	undetermined
Total ISPS Code	US port facility Costs (USCG)	963	509
	Global port facility Costs (OECD)	undetermined	undetermined

Table 2.3 - Summary of OECD and USCG estimates of ISPS cost compliance for ports in US$million (source: Bichou, 2004)

Bichou (2004) states that there is no international benchmark for calculating ISPS costs among ports. Capital and operating costs vary significantly between ports which

makes it difficult to construct cost analyses on average-global approximations. He also states that security measures targeting ports differ by scope, nature and level of compliance and that the cost of compliance will therefore vary accordingly.

Bichou and Evans (2007) include data on UK and Australian ports. They report that in the UK, total initial costs for ISPS Code compliance for 430 port facilities was US$26 million with annual costs at US$2.5 million. In Australia, the Australian Government reported that total ISPS Code costs for 70 ports, in which there are a total of 300 port facilities and for 70 Australian-flagged vessels was US$240 million initially with annual costs of US$74 million. While it is not possible to compare directly the figures for the UK and Australia given that the Australians include the costs associated with ISPS Code compliance for 70 vessels in addition to the ports, the data presented by Bichou and Evans (2007) suggests that the Australian experience is considerably more costly than in the UK.

Dekker and Stevens (2007) carried out a survey of port facilities' security investments in EU Member States and EEA countries. Their results are based on a total of 27 port facilities based in six European ports: Klaipeda, Rotterdam, Amsterdam, Lisbon, Barcelona and Bilbao. The authors found that the average security investment per port facility was €464,000 and the average annual running cost was €234,000. The average security investment costs and running costs are clustered by type of port facility and are reproduced in table 2.4.

Port Security Costs	Dry Bulk	Liquid Bulk	Ro/Ro	Container	Cruise	Multi-purpose
Average investment costs (€1000s)	253	439	101	74	430	798
Average running costs (€1000s)	177	110	69	108	260	409

Table 2.4 - Average port security investment and running costs in a study of 27 EU Member States (source: Dekker and Stevens, 2007)

Benamara and Asariotis (2007) present the findings of the UNCTAD (2007) survey report which surveyed 55 ports in 28 countries. They found that the average initial cost per ISPS port facility for smaller respondent ports (with up to 10 port facilities) amounted to US$386,000 which was more than double the amount for larger respondent ports (US$181,000). The corresponding figures for the annual costs was

US$128,000 and US$81,000 for the smaller respondent ports and the larger respondent ports respectively.

2.8 Port Security Incident Costs

Greenberg et al (2006) describe how the economic consequences of a successful terrorist attack are likely to be large and widespread and that economic consequences of attacks on the container shipping system would have direct and indirect effects. The authors describe the direct effects as life and injury compensation, repair and replacement of port infrastructure and other public property, losses of cargo and damaged and destroyed private property. The indirect effects are a consequence of the role of the port in the supply chain: business interruption due to delayed or missing shipments, long term adjustments to the modified transport system, augmented security procedures and lost revenue to the port facility And to the public purse.

The OECD report (2003, p.19) describes how, after the attack on the tanker Limburg off Aden in November 2002, Yemeni terminals saw container throughput plummet from 43,000 TEU in September 2002 to 3,000 TEU in November 2002. This resulted largely from marine war underwriters' increased war additional premiums rising to as much as USD 300,000 per vessel call. The Yemeni government estimated that 3,000 workers were laid off and economic losses arising from the attack were running at USD 15,000,000 per month. The OECD Report (2003, p.20) also states that property damage from a terrorist attack to a modern 16 hectare container terminal could be as much as USD 32,000,000.

Farrow and Shapiro (2009) review the literature on the cost of potential terrorist attacks in the United States. They present estimates for the overall costs of various attack scenarios, some of which are based in ports. The authors' findings are reproduced in table 2.5.

Author	Attack	Cost Estimate
Gordon et al (2007)	Aviation system	$214 to $421 billion (not counting lives)
Rose, Oladosu, Liao (2007)	Los Angeles blackout	$2.8 to $20.5 billion, depending on resilience (defined by the author as ability to respond to attack)
Rosoff and Winterfeldt (2007)	Dirty bomb in ports of Los Angeles/Long Beach	$130 million to $100 billion, depending on the length of the shutdown
Gordon et al (2005)	Ports of Los Angeles / Long Beach	From $1.1 billion to $34 billion
Park (2008)	Dirty bomb in ports of Los Angeles/Long Beach	$34 billion in import/export losses. No estimate based on lives or property lost.
Cheng, Stough and Kocornik-Mina (2006)	Power plant attack in Washington DC	$1.18 billion
Abt (2005)	Bioterrorist attack	From $200 billion to $3 trillion; deaths from 500,000 to 30 million
Bae, Blaine and Bassok (2005)	Seattle highways	From $1.2 to $1.5 billion

Table 2.5 – Costs of various terrorist attack scenarios [source: Farrow and Shapiro, 2009]

While the OECD (2003) report focuses on Yemeni port terminals, the Farrow and Shapio (2009) review extends to the host country's economy and supply chains. In carrying out an analysis of the potential economic losses arising from port security incidents, it is important to distinguish between the two.

2.9 Port Security Benefit-Cost Analysis

Farrow and Shapiro (2009) summarize a benefit-cost framework for investing in security which is designed to be consistent with benefit-cost guidance from the US Office of Management and Budget (OMB). They define benefits as expected avoided costs which include elements of both probability and consequences. Farrow and Shapiro (2007, p4) also state that "if a system is resilient the cost avoided may be large with respect to several different types of attacks or types of hazards." They refer to a model developed by 'Risk Management Solutions', a private company, for insurance companies to use to measure the risk of terrorist attacks.

Willis and LaTourette (2008) describe a probabilistic risk modelling approach in break-even benefit-cost analysis which employs the Risk Management Solutions methodology. They describe how terrorism risk can be expressed in terms of the annual expected loss from damage caused by terrorist attacks and that the expected loss accounts for the probability of that the attack will occur and the consequence of

the attacks. Furthermore, Willis and LaTourette (2008) state that "since terrorism risk reflects both probability and consequence, using risk reduction as a measure of benefit in a benefit-cost analysis captures both effects." The authors state that the benefit of a security regulation can be expressed in terms of the reduction in the expected loss of damage. This principle is echoed in the calculation of residual security risk by Talas and Menachof (2009) and is also applied in this research. Willis and LaTourette (2008) also describe how benefit-cost analysis is the normative framework for determining whether a regulation is efficient. They qualify their argument by stating that a regulation is justified if the incremental cost of implementing the regulation is exceeded by the incremental benefit generated by the regulation.

Pinto and Talley (2006) propose a framework for calculating the risk-based return on investment (RROI) for a port's security systems. The authors state that their approach may be used to determine whether the expenditure on security resources is sufficient given the corresponding reduction in risk. Pinto and Talley (2006, p281) refer to the framework developed by Arora et al (2004, p35) which "uses a risk management approach that integrates risk profile with actual damages and implementation costs to determine the costs and benefits of information security solutions." The Arora et al (2004, p37) framework describes RROI as the ratio between the net benefit in implementing an IT solution and the implementation cost. In particular, RROI measures "how effectively you use resources to avoid or reduce risk. Specifically, a positive RROI means that the dollar value of the avoided risk is greater than the implementation cost." Furthermore, the RROI helps to guide the company in its IT security investment by indicating the point where further investment in IT security has such a diminished return that "you're better off investing the money elsewhere." Pinto and Talley (2006) also describe how investments should be made in port security until the RROI falls to the minimum acceptable rate but do not elaborate on what the minimum acceptable rate might be or how it can be assessed. Also, the framework proposed by Pinto and Talley (2006) is unable to assess how port security systems can be deployed efficiently. Finally, the authors make no provision for the interpretation of RROI when certain security measures are mandated by initiatives such as the ISPS Code.

2.10 Portfolio Selection Theory and Efficient Frontiers

Chopra and Sodhi (2004) describe the challenges that companies face to mitigate supply chain risks without eroding profits. The manager's role is similar to that of a stock portfolio manager: achieve the highest possible profits for varying levels of risk, and do so efficiently.

Markowitz (1952) states that a portfolio is efficient when it is impossible to obtain a greater average return (of the stocks in the portfolio) without incurring greater standard deviation; that it is impossible to obtain a smaller standard deviation without giving up return on the average. Furthermore, the investor must choose one combination of average return and standard deviation which, more than any other, satisfies his needs and preferences with respect to risk and return. Markowitz (1952) also states that portfolio selection can not only rely on past averages and standard deviations (of stocks) as reasonable measures of the likely return and the uncertainty of return in the future but that it is also possible to use the 'probability beliefs' of experts as inputs to a portfolio analysis. He describes a scenario in which a meteorologist is asked to advise on the probability belief that it will 'rain tomorrow' and describes how the 'security analyst is the meteorologist of stocks and bonds'. The security analyst in Markowitz' (1952) example becomes the port security analyst in this model. He also shows how an investor can compute the set of efficient portfolios and efficient expected returns – variance (E-V) combinations by combining statistical techniques and the judgements of experts to form reasonable probability beliefs. In the application of Markowitz (1952) theory of portfolio selection to port security, the theory shows that it is possible to arrange the security systems in such a way as to obtain a certain level of expected performance of the portfolio of security systems for a given level of risk, in this case represented by the standard deviation of the portfolio. Markowitz (1952) theory of portfolio selection calculates how the efficient portfolio should be structured by allocating a security investment coefficient for each security system.

Byrne and Lee (1994) describe how the Markowitz portfolios can be connected to generate the efficient frontier and how Markowitz Efficient Frontiers can be calculated using Microsoft Excel Solver. The Markowitz efficient frontier "represents the boundary of the risk/return set of asset combinations (portfolios)." The Byrne and

Lee (1994) process involves matrix methods for the portfolio calculations and follows these five steps:

1) Find the maximum return portfolio and compute the risk for this
2) Find the minimum risk portfolio and compute the return for this
3) Compute the difference between the maximum and minimum risk portfolios and divide into a sufficient number of points to produce a reasonable graph
4) Solve the maximum return combinations for each of the subdivided risk levels
5) Graph these returns against the risks.

2.11 Some Parallels between Portfolio Theory and Port Security Investment

Some interesting parallels exist between the balancing of a portfolio of stocks and shares and the implementation of port security measures to protect a port facility and its operations. These parallels are set out below.

- An investor buys shares in a stock in the belief that he will gain a positive return from his investment. This is equivalent to a port security manager investing in a security solution in the belief that it will protect his port facility and the port's operations against a security incident and thus lower his risk towards a particular security incident.
- An investor could invest solely in the one stock with the maximum predicted return but instead invests in such a way as to balance his portfolio against risk and return. Similarly, the port security manager does not invest solely in one security solution, such as fencing, at the expense of any other security solution because he realises that he faces more than one type of security risk. He must balance his investments in security solutions in such a way as to counteract the threats that his port faces until he has lowered his overall risk level to his satisfaction.
- The value of a share portfolio is equivalent to the performance of a portfolio of security solutions in a port. Certain security solutions may perform well but the overall performance can be negatively affected by the failure of or lack of a security solution designed to tackle a particular security incident which interrupts port operations.

- Stock prices react to unforeseen events. The performance of a security solution can be tested by a security incident in the port. The security incident is equivalent to the unforeseen event.
- Stocks are correlated or uncorrelated to movements in an index: certain security solutions have no bearing on a particular type of security incident and as such their individual performance will be unaffected by it.
- Stocks are correlated or uncorrelated to each other. Certain security solutions are related in terms of their performance in the face of a security incident e.g. access control and intruder detection measures. Others, such as container radiation detectors and office smoke alarms are unrelated and their performance uncorrelated.

The existence of these parallels lends weight to the justification for employing the Markowitz (1952) theory of portfolio selection in determining the efficient relationship between residual security risk and security investment for maritime port facilities. However, the cross-disciplinary adaptation of theory from finance to port security requires a statement of assumptions which will need to stand up to scrutiny before the efficient relationship between residual security risk and security investment can be calculated.

Chapter 3 - Research Methodology

The chapter is structured as follows. First, the research design and methodology are discussed in detail. This includes the research questions; data sources and collection methods; and units of analysis. Secondly, the issues of research reliability and validity are addressed. The chapter concludes with a discussion of the research protocol.

3.1 Research Design

The research in this study has both qualitative and quantitative elements and follows an adaptive cross-disciplinary approach of recasting Markowitz (1952) theory of portfolio selection into maritime port security in an industry example. . The research does not follow a case study methodology because case studies necessarily generate new theory (Yin, 1994) and furthermore, it was felt that a case study approach would not be suitable given the extensive literature on the different forms of theory generation from case study research (Yin, 1994; Eisenhardt, 1989; Eisenhardt, 1991, Eisenhardt & Graebner, 2007; Bryman, 2004; Mangan et al, 2004; Hilmola et al, 2005; Siggelkow, 2007). The objective behind the research is not the generation of new theory about port security efficiency but is aimed at addressing some of the problems faced by port security managers today through the cross-disciplinary application of financial portfolio theory in the field of port security. The research uncovers some of the parallels which exist in managing a portfolio of stocks and shares and a portfolio of port security systems while at the same seeking to identify the limitations and potential problems with the application of portfolio theory in a security setting. Furthermore, the choice of the mixed methods approach of survey questionnaires and structured interviews fits with the epistemological and ontological considerations mentioned below. Nevertheless, one key principle of case study research is evident in the methodology, which is the adoption of a research protocol, as championed by Yin (1994).

3.1.1 Epistemological and Ontological Considerations

Research where the emphasis is on quantification in the collection and analysis of data and entails a deductive approach to the relationship between theory and research typically points to a positivist epistemology with an objectivist ontology (Bryman, 2004). While this research contains some quantitative elements, the lionshare of the research is of a qualitative nature. The clue to the epistemology can be found in the definition of port security at the end of section 2.1: "….perception of the absence of threat." The researcher's role is to see the World View of the company security officers and to interpret it from their point of view. Furthermore, according to Bryman (2004) a phenomenologist views human behaviour as a product of how people interpret the world in order to grasp the meaning of a person's behaviour: the phenomenologist attempts to see things from that person's point of view. Given these considerations, the epistemology can be described as interpretivist-phenomenological. Positivism can be ruled out because much of the data on the performance of port security systems is subjective in nature and cannot be measured with any physical gauge. In the same vein, it is possible to eliminate realism as an epistemological position because the perception of security cannot be discerned by the 'effect' of the security measures alone.

The definition of port security also guides the ontological considerations. The 'perception of the absence of threat' is an interpretation of social phenomena and thus necessarily dependent on social actors, in this case the company security officers.

The ontology is therefore constructionist. Furthermore, the interpretations cannot be independent of social actors and thus cannot follow an objectivist ontology.

3.2 Main Research Question

Recalling the statement of the research problem from the introduction, the problem the research aims to solve is the determination by ISPS Code compliant port facilities of whether they have been able to discover the efficient relationship between security and investment. Considering the earlier definition of security, in order to arrive at a quantitative measure of the threat to a port facility following the application of security measures, it is necessary to consider the residual security risk, which can be estimated in financial terms. From this it follows that the main research question is: how can ISPS Code compliant port facilities discover the efficient relationship

between residual security risk and security investment? In order to address this main research question it is necessary to split it into two further questions. The first is: what does it mean for a port facility to be ISPS Code compliant? The second is: how can the efficient relationship between residual security risk and security investment be calculated? However, in order to address the second question, it is necessary to pose a further five questions, as set out below.

1) What does it mean for a port facility to be ISPS Code compliant?

In the section on the ISPS Code above, a port facility is deemed to be ISPS Code compliant once it has been granted a Statement of Compliance for Port Facility (SoCPF) certificate by its Contracting Government which is valid for a maximum of five years. However, in order to obtain a SoCPF certificate, the port facility will have had to have drawn up the Port Facility Security Plan (PFSP) and in so doing, have introduced ISPS Code compliant security working practices which will likely include new security procedures, personnel and technology. The security working practices that will have been introduced must comply with the requirements of Part A of the ISPS Code and these will be detailed in the PFSP. Furthermore, while the ISPS Code is silent on minimum security personnel manning levels for port facilities, these details would also be included in the PFSP. However, the minimum requirements for the security equipment which must be deployed in an ISPS Code compliant port facility can be obtained by conducting a line-by-line analysis of Parts A and B of the ISPS Code. This will apply only to those port facilities which have either voluntarily or through local legislation been required to adhere to the guidance under part B of ISPS Code. A copy of this analysis can be found in appendix A. Therefore, in terms of the port security procedures, personnel and technology, it is possible to comprehend what is meant by an ISPS Code compliant port facility.

2) How can the efficient relationship between residual security risk and security investment be calculated?

The calculation of a port facility's residual security risk follows the model developed by Talas and Menachof (2009) and given that the level of security investment for ISPS Code compliance can be known and the residual security risk can be estimated, two of the three key components in this question can be answered. The third component, the mapping of the efficient frontier between residual security risk and security investment, is tackled using a dual approach: first, by applying Markowitz

(1952) theory of portfolio selection to each port facility individually and secondly, by examining the 216 possible portfolios of security systems which can be constructed from the six port facilities. This twin pronged approach is addressed in greater detail in chapter IV. However, in order to follow the model described in Talas and Menachof (2009), it is necessary to address the following five questions:

1. What are the security threats to the port facility and what are their probabilities?
2. What are the estimated gross losses to the port facility following each prescribed security threat?
3. What do the security systems consist of in each port facility?
4. How well do the port security systems perform in the face of the prescribed security threats?
5. What are the port security systems' costs?

1. What are the security threats to the port facility and what are their probabilities

Pinto and Talley (2006) describe a number of major US port security fears, which include chemical or nuclear weapons smuggled inside containers; mines used on ships to block shipping channels; and pirated vessels crashed into bridges or famous landmarks. Other examples of the types of potential security incidents that a port facility faces can be found in the Congressional Research Service Report for the United States Congress (Parfomak and Fritelli, 2007). Furthermore, the security threats that a given port facility faces and their probabilities are regularly considered in the normal course of business by the specialist marine war and terrorism underwriters in the Lloyd's Insurance Market in London. Terrorism underwriters regularly review the probabilities and subsequently their pricing levels of security risks and according to Kunreuther, et.al. (1995, p338) "underwriters make pricing decisions regularly as part of their jobs; they are expert, experienced risk evaluators." Furthermore, a comprehensive risk assessment is a requirement for port facilities that are compliant with the International Organisation of Standards' (ISO) Supply Chain Security Standard ISO 28000. Section 4.3.1 of ISO 28000 states that: "the risk assessment shall consider the likelihood of an event and all of its consequences."

The research concentrates on seven different types of security incident. These have been selected from examples in Pinto and Talley (2006), Parfomak and Fritelli (2007) and from discussions with Dubai Ports World. The types of security incident are: bomb introduced by person on foot; car bomb; truck bomb; biological agent attack on the port facility – on foot; biological agent attack on the port facility – by vehicle; mining of port infrastructure; and vessel attacked by suicide boat. The methodology used to select the scenarios is based on a breach of the port facility's security systems from both the land and seaward entrances with varying degrees of severity with attacks aimed at different parts of the port facility using both conventional explosives and a biological agent.

The security scenarios for each port facility were presented to a Lloyd's terrorism underwriter for his pure premium rating in an interview at his desk in the underwriting room in Lloyd's of London. The terrorism underwriter, Russell Kennedy of BRIT Insurance, employs a similar approach to that described in Willis and LaTourette (2008), except that he employs the services of Exclusive Analysis, a competitor of Risk Management Solutions in the London Insurance Market, to guide him in his pricing of terrorism risk. The methodology which Kennedy applies for pricing a terrorism risk in a given country is as follows. He refers to his "notional base rate" for a terrorism risk which is 0.02% per annum. He then examines the Exclusive Analysis risk score for terrorism for the country in question which is represented as a number between 1 and 10 to one decimal place. This scale he has interpreted as a logarithmic scale of base 2. In order to arrive at his country rate for a particular terrorism risk he multiplies his base rate of 0.02% by 2 to the power of the Exclusive Analysis risk score minus 1. He then makes a further subjective adjustment depending on the nature of the business ('occupancy' in Kennedy's parlance) of the proposed assured. He has subdivided 'the occupancies' into 20 business sectors and examples include: professional services such as banking and finance; oil and gas; power generation; and ports and harbours. Kennedy's methodology subsequently yields a single country rate for a terrorism risk in a specific business sector. However, his methodology is unable to distinguish between two different locations in the same country and nor will it distinguish between different types of terrorism attack modus operandi.

While Kennedy's underwriting methodology appears to follow some logical path to arriving at a suitable pure premium pricing level for terrorism risks, there are a

number of issues which need to be highlighted. First, his selection of 0.02% as a notional base rate for an annual terrorism premium may in time be revised upwards in the event of sustained losses on his underwriting book. Any such decision might be driven by the higher cost of reinsurance in future years but it should also be borne in mind that any increase in the notional base rate may also reflect a global increase in terrorist activity. Secondly, there are limitations with seeking data from a single underwriter but the justification for following this method is as follows. Kennedy bases much of his terrorism premium setting on the expert opinion of Exclusive Analysis, a respected provider of terrorism and political risk intelligence to the Lloyd's Insurance Market. Exclusive Analysis gather their data from in-country specialists who feed intelligence back to the London headquarters. The London headquarters of Exclusive Analysis in turn interpret the intelligence provided to them by their network of contacts and subsequently feed this information to underwriters such as Kennedy in a quantitative form. Thus the expert opinion of a number of specialists outside of the insurance market has a direct bearing on the subjectivity which Kennedy exhibits in his underwriting process.

Nevertheless, it is accepted that seeking the opinions of either a panel of terrorism underwriters or more underwriters individually would have been preferable but difficulties with access unfortunately prevented this from happening. The transcript of the interview with Russell Kennedy is in appendix E.

2. What are the estimated gross losses to the port facility following each prescribed security threat?

The OECD (2003) report and Farrow and Shapiro's (2009) review of the potential economic losses following security incidents show two of the levels at which losses can be calculated: at the port facility level and the national level. This research aims to capture the data at the port facility level, as per the OECD (2003) report. The reason for this is that trying to estimate the damage to the host economy or to entire supply chains is beyond the scope of this study.

The data source for the estimates of potential economic damage to the port facilities following the prescribed security incidents listed above is chiefly a copy of the schedule of one of the insured port facilities owned by Dubai Ports World. Given that insurance limits generally reflect the values of property at risk, this can be judged to be a valid data source. However, the data which was provided by the Director of

Security is limited to port facility A as this was the only data available. The seven security scenarios were presented to the Director of Security on 24 March 2009 and based on the port facility A insurance data and through his own professional experience, he estimated the size of financial loss of physical damage and business interruption for the different terrorism attacks for the terminal in port facility A only. The full results are presented at the beginning of chapter IV.

3. What do the security systems consist of in each port facility?

The units of analysis in the research are the port security systems in each port facility. The security systems have been classified as access control, biometrics and detection, which in turn consist of individual security components. The access control systems include all the physical gates, fencing and security personnel engaged in access control procedures. The biometric systems, also described as 'enhanced access control systems' range from pass cards to fingerprint scanning. The detection systems include CCTV systems, automatic intruder alerts, radar, sonar and also the security personnel involved in security patrols.

The security components in the port facility can be identified through the use of a survey questionnaire completed by each of the port facilities' Port Facility Security Officer (PFSO). The questionnaire, a copy of which can be found in appendix B, was compiled following a line-by-line analysis of the port security equipment and components mandated by the ISPS Code (see appendix A).

Questions 1-4 are concerned with the details of the port, the specific port facility owned by Dubai Ports World, the role of the respondent and the principal activity of the port facility. Questions 5-8 are concerned with the specification and cost of the perimeter fencing in the port facility. Questions 9-10 are concerned with the type and cost of access control measures (excluding fencing) in the port facility. Questions 11-14 are concerned with the types, specifications and costs of detection systems, including lighting coverage in the port facility. Questions 15-17 are concerned with the types and cost of biometric security systems deployed in the port facility. Question 18 is concerned with a description of the types and coverage of security patrols in the port facility. Question 19-21 are concerned with security communications in the port facility. Questions 22-23 are concerned with the number,

location and cost of security personnel in the port facility. Questions 24-26 are concerned with the type, location and cost of cargo security detection equipment in the port facility. Questions 27-28 are concerned with security systems integration, monitoring and cost in the port facility's main control room. Questions 29-30 are concerned with the extent and cost of crisis management systems in the port facility. The survey questions were formulated in line with De Vaus' (2002) principles of question design and his key benchmarks for setting questions.

The data sources for the completed survey questionnaires are the Port Facility Security Officers in the six port facilities.

4. How well do the port security systems perform in the face of the prescribed security threats?

While it may appear impossible to assign a quantitative measure to the performance of access control measures or intruder detection measures, the ISPS Code Part B 18.5 requires that "drills should be conducted every three months unless the specific circumstances dictate otherwise. These drills should test individual elements of the port facility security plan such as those security threats listed in paragraph 15.11." The performance of the individual security systems can be assessed based on a series of key performance indicators (KPIs) that the port facility security officers (PFSOs) report monthly to the company security officers (CSOs). They report, among other measures, the number of security non-conformities for each security system. This means that the CSOs are able to build a picture over time of how effectively the security systems are operating in the port facilities for which they have responsibility. By conducting semi-structured interviews with the company security officers (CSOs), the intention is to collect quantitative data by asking the CSOs to interpret and translate the KPI data into percentage performance measures for each of the three main security systems: access control, biometrics and detection for each of the port facilities. The quantitative responses to the interview questions are an evaluation of how effectively each security system works to prevent the occurrence of each of the prescribed security incidents, working completely in isolation of the other two security systems.

5. What are the port security systems' costs

The survey questionnaire described in 3 above also captures details of the investment of each port facility's security systems and their components. The data captured includes both the cost of the security infrastructure from 2004 to 2007 and the running costs of the port facility's security systems for the 2007 year. The term 'security investment' in this research combines both the cost of the security infrastructure from 2004 to 2007 and the running costs for the 2007 year. The figure for the cost of the security infrastructure is aggregated across the years 2004 – 2007 to capture all of the improvements made to the port facilities' security systems in that time. This is because the CSOs were not confident that the PFSOs would be able to provide accurate figures for the security investments for 2004 alone, the year of the introduction of the ISPS Code.

3.3 Units of Analysis: Representativeness

The units of analysis in this research are the port facilities and the security systems in the six port facilities owned by Dubai Ports World which have been labelled A to F. All of the port facilities are container terminals. One of the port facilities is located in the Americas, one in Europe and the remaining four are located in Asia. The six port facilities presented in this research are a representative sample of the types and locations of port facilities in the Dubai Ports World portfolio in terms of their container throughput, geographic location and background terrorist threat, as determined by the two company security officers The company security officers selected the six port facilities based on the following criteria:

1) The port facilities were equally spread between developed and developing countries;
2) The port facilities ranged from low to high in terms of their terrorism threat, in the opinion of the company security officers;
3) The port facilities were equally spread across the various time zones in which the parent company's portfolio of ports are located.

While the selection of port facilities in this research is deemed to be representative, it is acknowledged that the reader will be unable to satisfy him or herself as to the validity of these statements given that the locations of the port facilities are not disclosed, arising from the company's security concerns.

3.4 Research Reliability and Construct Validity

The research reliability test focuses on one key aspect of the research: the methods employed in the data gathering process. Yin (1994) describes reliability as the ability of a later researcher to conduct the research all over again and to arrive at the same findings and conclusions. Yin (1994, p36) states that the reliability issue can be addressed through the documentation of the procedures followed in the research to minimize the occurrence of errors or bias. Bryman (2004, p71) describes reliability in terms of stability. Bryman's description of stability involves the test-retest method, with the results presented by way of Cronbach's Alpha, a computed coefficient which calculates the average of all possible split-half reliability coefficients (Cronbach, 1951). Forza (2002, p177) describes Cronbach's Alpha as the "most commonly used reliability indicator in Operations Management research" and states that it is expressed in terms of the average inter-item correlation $\bar{\rho}$ among the n measurement items in the instrument under consideration thus:

$$\propto = \frac{n\bar{\rho}}{1 + (n-1)\bar{\rho}}$$

Forza (2002, p177) describes an alpha value of equal to or greater than 0.8 to represent a high level of reliability in the data being measured.

Bryman's (2004, p72) description of construct validity refers to "whether an indicator that is devised to gauge a concept really measures that concept." In this research, the performance of each security system is defined as a separate construct. The research protocol contains details on how the research addresses the validity of each construct in the interviews.

3.5 Research Protocol

While the research is not adopting a case study strategy per se, nevertheless, there are many tools employed by case study researchers which can increase the reliability of research. One such tool is the case study protocol (Yin, 1994, p63).

For the purposes of this research, a research protocol was prepared which specifically addresses two key issues: the interviews and construct validity. A copy of the research protocol is reproduced below.

Research Protocol (Interviews & Construct Validity)

1. Procedures
    a. Scheduling of field visits. Field visits were arranged to both the offices of Dubai Ports World in Jebel Ali, United Arab Emirates and to Lloyd's of London. The visit to the main office in Jebel Ali was scheduled for March 2009. A two day visit to the offices of Dubai Ports World was required in order to complete the interviews. The visit to Lloyd's of London was arranged for April 2009.
    b. Access procedures. Access to the two Company Security Officers (CSOs) of Dubai Ports World has been secured through the Director of Security. Access to the Lloyd's Terrorism Underwriter, Russell Kennedy of BRIT Insurance, has been arranged through Nigel Miller of Miller Insurance Services.
    c. Interview documents. The interview documents required for the interviews with the CSOs at DP World are the prepared (blank) spreadsheets for the performance of the security systems in the face of the prescribed security threats. One form was filled in for each port facility. An example of this form can be found in table 3.1.

Name of Terminal	**Security system performance**		
Type of Security Incident	**Access Control**	**Biometrics**	**Detection**
Bomb introduced by person on foot			
Car Bomb			
Truck bomb			
Biological agent attack on terminal - on foot			
Biological agent attack on terminal - by vehicle			
Mining of port infrastructure			
Vessel attacked by a suicide boat			

Table 3.1 - Interview document for CSO interviews (one per port facility)

These were filled out by the interviewer during the interview process in the full view of the interviewee. It was arranged that DP World will provide the documents regarding the size of the port facilities' insured assets. The

interview with the terrorism underwriter was unstructured and required no prior documents.

2. Persons to be interviewed. The four persons interviewed were: the two company security officers of DP World; the Director of Security for DP World and the Lloyd's Underwriter, Russell Kennedy.

3. Interview questions
    a. Topics. The interviews with the CSOs concentrated on their subjective assessments of the performances of the individual port facilities' security systems in the face of the prescribed security threats.

    The interview with the Global Head of Security concentrated on his own subjective assessments of the expected losses due to the prescribed terrorist attacks in the port facilities. This sought to capture his knowledge and experience of munitions explosions in the maritime environment and translate it into quantifiable loss estimates in US$ terms.

    The interview with the Lloyd's Underwriter sought to understand his underwriting methodology and his subjective assessments of the probabilities of the occurrences of the prescribed security incidents.

    b. Research constructs.

    The research constructs are defined as the performance of the security systems of access control, biometrics and detection.

    c. Procedure to ensure construct validity during interviews.

    The procedure to ensure construct validity during the interviews is specifically relevant to the interviews with the CSOs. In order to ensure construct validity, it was necessary to draw to the interviewees' attention that the interviewees' subjective assessments of the performance of each security system should be considered to be independent of the other two. This was done on three occasions in each interview: first when the interviewee was asked to give their subjective assessments of the performance of the access control measures; secondly when the interviewee was asked to give their subjective assessments of the performance of the biometrics systems; and thirdly when the interviewee

was asked to give their subjective assessments of the performance of the detection systems.

3.6 Ethics

The nature of the research in the security field necessarily requires a high level of trust between researcher and researched. The researched does not want security sensitive information about any potential weaknesses in a port facility's security system to leak out and to be used by criminal or terrorist interests for their own ends. They also do not wish to share with their competitors the data on what security systems are located in each port facility and their costs. Therefore, the identities of the port facilities cannot be disclosed. Furthermore, it may be interesting to note that the level of trust between researcher and researched was such that no confidentiality agreement was ever signed or deemed necessary to be signed.

Chapter 4- Port Security Risk: A Model and its Application in Portfolio Analysis

The chapter is divided into three sections. The first section concerns the construction of the model for port security risk, though limited in this research to acts of terrorism. The second section shows how the model can be applied in a portfolio optimization analysis of port facilities' security systems. The third section shows how Markowitz theory of portfolio selection can be applied to a port facility's portfolio of security systems in order to construct the risk-return efficient frontier.

4.1 Constructing the Port Security Risk Model

First, the port security risk model is described, which is based on the Willis et al (2005) definition of terrorism risk. Secondly, we examine Gleason's (1980) method of modelling terrorism risk using the Poisson distribution. Thirdly, we repeat Gleason's (1980) Kolmogorov-Smirnov test on the data from the RAND database of worldwide maritime terrorist attacks[19] from 1968 to 2007 and from Jenkins et al (1983) in order to test whether the port-focussed data describes a Poisson distribution. Fourthly, we show how empirical data of the terrorist incidents in ports and on vessels in ports can be used to predict the probability of future terrorist attacks of this nature and provide the model for port security risk with a coefficient of threat, though limited to terrorist incidents.

Willis et al (2005) describe terrorist risk as "the expected consequence of an existent threat, which, for a given target, attack mode and damage type can be expressed as:

Risk = P (attack occurs) * P (attack results in damage | attack occurs) * E (damage | attack occurs and results in damage)

= Threat * Vulnerability * Consequence"

This definition is not inconsistent with the new definition for port security risk as described in II.2 above. In order to be able to estimate the terrorist risk, it is necessary

[19] RAND Terrorism Incidents Database URL:http://www.rand.org/nsrd/projects/terrorism-incidents/ [Accessed 23 April 2010]

to be able to estimate the probability of the threat manifesting itself in an attack, the probability that the attack results in damage and an estimate of the expected damage that might follow. Willis et al (2005) also state that if terrorist risks are independent, expected damages of a specific type can be aggregated by summing across threat types and target types.

4.1.1. Modelling Terrorism Risk Using the Poisson Distribution

Gleason (1980) modelled terrorism risk using the Poisson distribution and focused exclusively on acts of international terrorism in the United States which occurred between 1968 and 1974. Gleason (1980) describes the Poisson distribution as a good model for occurrences such as terrorist events for three reasons: first, "the probability than an event of terrorism occurs during a time interval increases with the length of the time interval"; secondly, "the probability is almost negligible that two events of terrorism occurs will occur in a very small time interval" and thirdly, "events of terrorism which occur during one time interval are independent of those which occur in any other time interval".

The poisson distribution is described by equation 1: $$p(N = n) = \frac{\lambda^n e^{-\lambda}}{n!} \quad (1)$$

where n = number of occurrences of an event and λ = expected number of occurrences during a given time interval.

The data in the RAND terrorism databases found in Jenkins et al (1983); Gardela and Hoffman (1990); Gardela and Hoffman (1991); Gardela and Hoffman (1992) and the online RAND database of terrorism incidents were analysed and only terrorist attacks in the maritime domain were recorded. See appendix F for the complete list of maritime terrorist attacks. These include attacks on port facilities as well as attacks on vessels while alongside at or at anchor in any port but excludes attacks on vessels that were not in a port or harbour. A summary of the number of terrorist attacks in each year can be found in table 4.1. The mean, λ=1.85, represents 74 attacks over 40 years from 1968 to 2007. Performing the calculation in equation 1, the probabilities of the number of attacks in any given year are shown in table 4.2.

Year	# Attacks	Year	# Attacks	Year	# Attacks	Year	# Attacks	Year	# Attacks
1968	2	1970	1	1980	3	1990	0	2000	1
1969	0	1971	1	1981	2	1991	0	2001	1
		1972	2	1982	4	1992	0	2002	1
		1973	2	1983	2	1993	1	2003	2
		1974	6	1984	5	1994	1	2004	3
		1975	5	1985	2	1995	1	2005	1
		1976	3	1986	2	1996	2	2006	1
		1977	1	1987	3	1997	4	2007	2
		1978	2	1988	3	1998	0		
		1979	2	1989	0	1999	0		

Table 4.1 – Number of worldwide maritime terrorist attacks in ports: years 1968-2007

No of attacks	Probability	Expected years in 40 years	Actual years in 40 years
0	0.157237166	6.289487	7
1	0.290888758	11.635550	11
2	0.269072101	10.762884	12
3	0.165927796	6.637112	5
4	0.076741605	3.069664	2
5	0.028394394	1.135776	2
6	0.008754938	0.350198	1
7	0.002313805	0.092552	0
8	0.000535067	0.021403	0
9	0.000109986	0.004399	0
10	2.03474E-05	0.000814	0

Table 4.2 – Probabilities of a given number of attacks in a year in the maritime domain calculated using the Poisson distribution, the actual number of attacks and the expected number of attacks.

Gleason (1980) hypothesised that the Poisson distribution was a good model for incidents of international terrorism in the United States and performed two goodness of fit tests, namely Chi-square and the Kolmogorov-Smirnov (K-S) tests to test the hypothesis. Owing to the nature of his data, Gleason (1980) combined the 'Number of Incidents' classes in order to ensure a valid Chi-square test, to ensure that the expected frequency in each class was at least five. Owing to this combination of classes, he decided to follow up with the K-S test as this "test treats individual observations separately; consequently, information is not lost through the combining

of categories". The Kolmogorov-Smirnov test, specifically the one-sample K-S test, is a non-parametric test used to compare a sample distribution with a reference probability distribution, in this case, the Poisson distribution. Gleason (1980) showed that the results of both the Chi-square and the K-S tests suggested that the Poisson distribution was a good model.

Following Gleason's (1980) example, it was decided to test the hypothesis that the Poisson distribution is a good model for the maritime terrorism attack data contained in column 4 of table 4.2. However, in order to apply the Chi-square test, the data would have to be aggregated into three combinations and as this was the same problem that Gleason (1980) had encountered with the data on terror attacks on the United States, it was decided to apply the K-S goodness of fit test in isolation. The K-S test rejects the null hypothesis that the sample distribution is drawn from the (in this case) Poisson distribution if the Z-value is greater than the critical values in the one-sample K-S test table in appendix G. The results of the K-S test performed using SPSS are shown in table 4.3.

One-Sample Kolmogorov-Smirnov Test

		VAR00001
N		40
Poisson Parameter[a,b]	Mean	1.8500
Most Extreme Differences	Absolute	.035
	Positive	.033
	Negative	-.035
Kolmogorov-Smirnov Z		.221
Asymp. Sig. (2-tailed)		1.000

a. Test distribution is Poisson.

b. Calculated from data.

Table 4.3 – Results of the one-sample Kolmogorov-Smirnov test from SPSS

The Kolmogorov-Smirnov Z-value of 0.221 means that the data in column 4 of table 4.2 describes a Poisson distribution as the K-S Z-value is critical at the alpha=0.01 level. This means that the probability of future terrorist incidents in ports or on vessels in ports can be modelled using the Poisson distribution and the data in table 4.2.

The model for port security risk is based on Willis et al (2005), Gleason (1980) and the RAND terrorism database data in table 4.2.

If l_j is the loss (consequence) from an attack type j and the probability of the occurrence of l_j is $p(l_j)$ and the vulnerability of the port facility from l_j is defined as $1-p(s_{ij})$ where s_{ij} is the ability of security system i to prevent l_j, then it follows that the aggregate port security risk is $\sum_{i=1}^{n}\sum_{j=1}^{m} p(l_j)\times(1-p(s_{ij}))\times l_j$ (2)

for n security systems against m different types of security incident. Furthermore, we can use Poisson to calculate $p(l_j)$ for any given terminal. However, this requires two assumptions: first, that each terrorist attack is independent and secondly, that each port facility is equally likely to be attacked.

The probability for n attacks in a given year $(0 \le n \le 10)$ is shown in table 4.2 and what is required for our model is the probability of 1 or more attacks in any year. This is calculated by summing the probabilities of n attacks where $1 \le n \le 10$. The probabilities of n>10 were disregarded as they are very small and unlikely to affect the overall result.

Given that there are 4339 ports in the world[20], if we were to model the probability of one or more attacks in any year on one of those port facilities with λ=1.85, the probability would be 0.000426355 (see equation 3).

$$p(l)=\sum_{n=1}^{10}\frac{p(n)\times n}{4339}=0.000426355 \qquad (3)$$

The resulting model for port security terrorism risk is shown in equation 4.

$$PortSecurityRisk = 0.000426355\times\sum_{i=1}^{n}\sum_{j=1}^{m}(1-p(s_{ij}))\times l_j \qquad (4)$$

[20] <URL:http://www.ports.com> [Accessed 23 April 2010]

While this model holds for the assumption that each port is equally likely to be attacked, it can be improved by obtaining the subjective assessment (expert opinion) of a terrorism underwriter regarding the terrorism risks in ports in different countries around the world.

4.2 Portfolio Optimization Analysis of Port Facilities' Security Systems

The port facility is considered to consist of a portfolio of security systems and a portfolio optimization exercise is performed to construct the theoretical portfolio of security systems which performs best to reduce, in turn, security risk and cost.

4.2.1. Portfolio Optimization

The parallels that exist between investing in a port facility's security systems and a stock portfolio as described in section 2.2 above mean that it is possible to perform portfolio optimization to discover, for any k port facilities which consist of i security systems, the optimum combination of the security systems drawn from any of the port facilities which either minimise the residual risk or the security investment. In our industry example, there are 216 possible different combinations of the six port facilities' three security systems which can be examined and compared to the original portfolios of security systems in each of the six port facilities on the basis of how the alternative portfolios reduce the residual risk for the given security investment.

The 216 possible different combinations of the six port facilities' three security systems are each labelled as a portfolio as follows:

- Port facility A becomes port facility 1
- Port facility B becomes port facility 2
- Port facility C becomes port facility 3
- Port facility D becomes port facility 4
- Port facility E becomes port facility 5
- Port facility F becomes port facility 6

The three security systems are defined as follows:

- Access Control - A
- Biometrics - B
- Detection - D

The change in the labelling is necessary to avoid a clash and potential confusion between, say, port facility A and access control system A. Therefore, the port facilities adopt a numerical format for the purposes of the portfolio optimization exercise.

The portfolio of 216 possible combinations of the 6 port facilities and 3 security systems is listed in appendix E. The main portfolios are the actual portfolios of the port facilities themselves:

- Port facility A = A1-B1-D1 (portfolio #1)
- Port facility B = A2-B2-D2 (portfolio #44)
- Port facility C = A3-B3-D3 (portfolio #87)
- Port facility D = A4-B4-D4 (portfolio #130)
- Port facility E = A5-B5-D5 (portfolio #173)
- Port facility F = A6-B6-D6 (portfolio #216)

The performance of the security systems of each port facility's actual portfolio of security systems is compared with the 215 alternative portfolios and their residual security risk is calculated using equation 2, where for each port facility, the probability of an attack remains the same, as do the consequences of a loss, but the vulnerability of the port facility to security risk will vary as the portfolio of security systems vary. Furthermore, as each of the 215 alternative portfolios are modelled for each port facility, there will be differences in cost of the 215 alternatives to the status quo. Therefore, the analysis looks for alternative portfolios where *both* the residual risk and the security investment can be reduced. The best alternative portfolios which result in both the greatest reduction in residual security risk and the smallest security investment are presented in the findings chapter.

4.2.2. The Application of Markowitz Portfolio Selection Theory

In this section the adoption of Markowitz theory of portfolio selection to port security is described, beginning with the mechanics of the cross-disciplinary adoption of the theory and concluding with a discussion of the relevant assumptions and limitations of the adoption in practice. Markowitz theory of portfolio selection is adopted to

discover the portfolio of a port facility's security systems which describe the Markowitz risk-return efficient frontier. The risk-return equivalents in this research are the standard deviation and expected performance of the port facility's portfolio of security systems. The application of Markowitz theory is subsequently applied to the port security risk model in a simulation to identify how efficient portfolios can reduce a port facility's residual security risk.

The application of Markowitz theory of portfolio selection is achieved by considering a port facility's security systems as securities in an investment portfolio and ex-post the application of Markowitz theory, altering the security investment strategy among the security systems in order to maximise the portfolio's performance (return) while minimising the risk (in this case, standard deviation). The data that is generated reflects the arrangement of security systems which results in a reduction in the port facility's residual security risk for the same investment as ex-ante the application of Markowitz theory. However, it is necessary to point out the difference between trading in financial assets and assets such as security systems. While Markowitz theory was developed for the efficient investment in stocks and shares for a given level of risk, it is necessary to recognise that there is no market for the trading in a port facility's security systems. In these circumstances, tradeability is not applicable as ownership of port security systems lies with the port facility's owners, is not publically traded and knowledge of the subjective assessments of the performance of security systems is not publically available. Furthermore, such a market would be constrained by liquidity issues. Nevertheless, this does not mean that the mechanics of portfolio selection cannot be applied in the field of port security.However, there are some assumptions which must be made for this approach to work. The first is that the assets in a portfolio must be sufficiently diversified, that is to say that they should not be perfectly or too closely correlated in their performance. The second assumption is than an increase in investment in a security system will result in an improvement in its performance as part of a portfolio of security systems in a port facility. That is to say that investment diverted from an underperforming security system to one which performs favourably in comparison will result in a better performance of the portfolio as a whole.

Another assumption is that while the probability distribution of terrorist attacks on ports (from 1968-2007, as demonstrated earlier in this study) follows a Poisson

distribution, the performance of the security systems themselves in the face of terrorist threats is not Poisson, but is normally distributed. However, it is important to highlight that there is no evidence in this research which suggests that terrorist attacks against non-port targets follow a Poisson distribution and that there may well be patterns in terrorism events which cannot be explained by a Poisson distribution. Further research needs to be done in order to shed light on potential probability distributions of non-port terrorism.

This is not an unrealistic assumption yet it is essential for a valid application of Markowitz theory. Furthermore, the risk-return efficient frontier in this research is not directly concerned with the risk of a terrorist attack but with the risk (in the form of the standard deviation) of the performance of the port facility's security systems in the face of the prescribed security threats. These two concepts of risk are separate and it is important to make the distinction because we have shown that maritime terrorist attacks on ports and on vessels in ports follow a Poisson distribution but that the performance of security systems themselves are more likely to follow a normal distribution.

The mechanics behind the calculation of a port facility's residual security risk is set out below, followed by the methodology for applying Markowitz portfolio selection theory to the performance of the security systems:

In order to apply Markowitz (1952) theory of portfolio selection to each portfolio or security systems, it is necessary to calculate the following for each port facility:

- the expected performance of the i^{th} security system as shown in equation 5.

$$e_i = E(s_i) \tag{5}$$

- the standard deviation of the performance of the i^{th} security system σ_i

- the correlations between the performances of the i^{th} and j^{th} security systems in each port facility ρ_{ij}, yielding the covariances between the i^{th} and j^{th} security systems in each port facililty as shown in equation 6: $c_{ij} = \sigma_i \sigma_j \rho_{ij}$ (6)

The correlations between the performances of the security systems can be calculated using standard statistical software such as in Excel or SPSS but the key is that expert

opinion is required to make subjecting quantitative assessments of the performance of a particular security system in the face of various prescribed security incidents. Another security system's performance will vary in the face of the same prescribed set of security incidents and these two sets of subjective quantitative performance assessments can be compared and their correlations subsequently calculated.

The expected return E(R) of the security portfolio for each port facility is the weighted sum of the expected return from each of the security systems and is shown in equation 7, where x_i is the proportion invested in the i[th] security system

$$E(R) = \sum_{i=1}^{n} x_i e_i \tag{7}$$

The variance V(R) of the security portfolio is shown in equation 8 with the variance of the i[th] security system v_i calculated as follows: $v_i = \sigma_i^2$

$$V(R) = \sum_{i=1}^{n} x_i^2 v_i + \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j c_{ij}, i \neq j \tag{8}$$

The next step is to calculate the standard deviation $\sigma(R)$ as in equation 9 thus:

$$\sigma(R) = \sqrt{\sum_{i=1}^{n} x_i^2 v_i + \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \rho_{ij} \sigma_i \sigma_j} \tag{9}$$

and then to minimise it subject to the following constraints.

$$\sum_{i=1}^{n} x_i = 1 \quad x_i \geq 0 \quad \sum_{i=1}^{n} e_i x_i \geq k$$

However, it is not necessary to follow the mechanical methodology as set out in Byrne and Lee (1994) as it is now possible to purchase software which calculates the Markowitz risk-return efficient frontier. The software used to calculate the Markowitz risk-return efficient frontier is VisualMvo version 1.6 by Efficient Solutions Inc.

There are two stages to the execution of the software: the data input stage and the calculation stage. In the data input stage, the first operation is to set up a record for

each of the three security systems: access control, biometrics and detection. For each record there are five fields which require populating. They are:

1. the mean of the performance of the security system
2. the standard deviation of the performance of the security system
3. the correlation of the performance of the security system with the performances of the other two security systems
4. A minimum constraint
5. A maximum constraint

The minimum and maximum constraints represent the constraints that are imposed on the proportion of the overall port facility's security investment on any one security system. For example, if no minimum constraint is applied to any of the security systems, the application of Markowitz theory of portfolio selection may result in the algorithm selecting a single security system solution to secure the port facility efficiently. Furthermore, there are two problems with a 'no minimum' constraint approach. First, it is contrary to the principle of a portfolio of security systems to counteract the prescribed security incidents by employing only one security solution. Secondly, it would be in breach of the principles of the ISPS Code which prescribes the application of different types of security equipment in order to comply with the Code. In view of this, it was decided that a minimum security investment constraint of 5% of the overall security budget for each port facility would be applied to each security system in the application of Markowitz theory of portfolio selection.

A simulation of the port security model and the application of Markowitz theory is set out below. Recalling equation 4, in order to calculate the security risk, it is necessary to arrive at estimates for the performance of the security systems in the face of prescribed security incidents. In the simulation it is assumed that there are three security systems: access control, biometrics and detection in a given port facility. The simulation includes one type of terrorist attack: a bomb planted in the engine room of a container vessel moored alongside the port facility. The occurrence of the security incident would cause the engine room and subsequently the vessel and half the containers to catch fire and sink at the mooring. Vessel and cargo damage, wreck removal and business interruption to the port facility is estimated to total $100,000,000. The probability of the attack is taken to be the threat coefficient in equation 4. Therefore, in the absence of any security systems, i.e. with the port

facility's vulnerability set equal to 1, the port security risk is $100,000,000 * 0.0426355% = $42,635.50.

In order to calculate the residual security risk, estimated for the performances of the three security systems are made. They are set out in table 4.4. Furthermore, estimates of how the performances of the security systems are correlated are set out in table 4.5. This is necessary in order to be able to plot the Markowitz risk-return efficient frontier.

Security System	Performance	Standard deviation
Access Control	80%	20%
Biometrics	60%	10%
Detection	40%	8%

Table 4.4 – Port security simulation: estimates of the performance of the security systems

The figures for the performances in table 4.4 represent the probability that each security solution will, independently, prevent the occurrence of the security incident. Taken together, these performance figures represent the port facility's vulnerability to attack and the higher the performance figures, the lower the vulnerability.

Correlations	Access Control	Biometrics	Detection
Access Control	1	0.75	0.25
Biometrics	0.75	1	0.5
Detection	0.25	0.5	1

Table 4.5 – Port security simulation: estimates of the correlations of the performance of the security systems

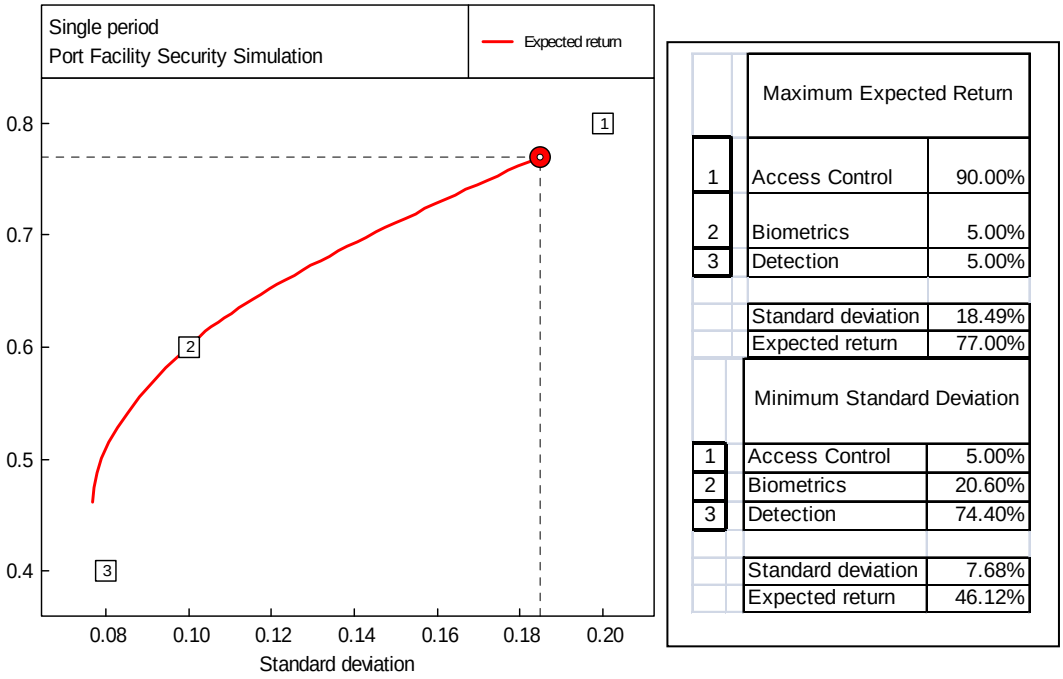
The data in tables 4.4 and 4.5 are used to plot the expected return-standard deviation efficient frontier for the port facility's security systems, as shown in chart 4.1. The result tells us that in order to achieve the maximum return for the performance of the security systems of 77.00%, it is necessary to tolerate a level of risk reflected in the standard deviation of 18.49%. This is achieved by investing 90% of the port security budget in the access control system and 5% in both the biometrics and detection systems.

However, it is also possible to achieve a much more modest level of performance in the security systems but at lower level of risk that the systems fail to perform as they should. The corresponding figures for performance and standard deviation are 46.12% and 7.68% respectively. This is achieved by investing 5% of the port security budget in access control, 20.6% in biometrics and 74.4% in detection systems.

What this means in practice is that the company security officer may decide to rearrange the security investments in order to suit his or her appetite for risk. A higher risk security investment strategy would be allocate the majority of the security budget to access control measures in order to benefit from a higher mean performance while accepting the accompanying risk that the performance level has a higher standard deviation. A lower risk security investment strategy would be one where the majority of the security investment is directed towards detection systems and the biometrics: while the overall performance may be less, the security officer has the knowledge that the performance of the security systems has a lower standard deviation. One way in which the company security officer might settle on a particular strategy would be to evaluate the performance / cost-benefit ratios of the two security strategies and decide accordingly at which point along the efficient frontier should the company's security strategy be based.

From equation 4, the port security risk when the performances of the security systems are maximised is $9,806.17 and when the standard deviation is minimised, the corresponding figure for the port security risk is $22,972.01.

It is important to note that these two solutions represent the extremes of the efficient solutions which can be obtained and that all the points along the line in chart 4.1 are efficient, each point representing a different portfolio of the three security systems with corresponding results for expected performance and risk that the security solutions do not perform as they should to mitigate the security threatIn the next chapter, both the Markowitz theory of portfolio selection and the portfolio optimization method as described above will be applied to the data gathered in the research.



	Maximum Expected Return	
1	Access Control	90.00%
2	Biometrics	5.00%
3	Detection	5.00%
	Standard deviation	18.49%
	Expected return	77.00%

	Minimum Standard Deviation	
1	Access Control	5.00%
2	Biometrics	20.60%
3	Detection	74.40%
	Standard deviation	7.68%
	Expected return	46.12%

Chart 4.1 – Port security simulation: the expected return – standard deviation efficient frontier for the performance of the security systems

Chapter 5 – Findings

The chapter begins with the estimates for physical damage and business interruption to Port facility A resulting from the prescribed security incidents from the interview with the Director of Security on 24 March 2009. As has already been mentioned, the data for the insured values of port facility Equipment and infrastructure was provided by the Director of Security only for port facility A. Therefore, estimates of the equivalent figures for the other terminals were extrapolated based on the quay length and number of quay cranes in the other terminals. The data for the insured values is not subject to any excess which may be applicable for each and every loss or in the aggregate. This is because the use of insurance data is intended as a guide for potential loss in US Dollar terms for each of the prescribed security incidents.

Subsequently, each port facility is presented in turn. The findings for each port facility consist of four data tables and a chart showing the expected performance-standard deviation efficient frontier. The first table contains the estimates of physical damage, business interruption and the expected gross loss to the port facility following the seven prescribed security incidents. The table includes the underwriter's assessment of the probability of the occurrence of the security incident. In the first table, the expected loss of each security incident is calculated as the product of the combined physical damage and business interruption amounts and the probability of occurrence.

The second table shows the company security officer's subjective assessment of the performance of the port facility's security systems (access control, biometrics and detection) in the face of the prescribed security scenarios. The table includes the means and standard deviations of the performances of each security system.

The third table shows the calculation of the port facility's residual risk after the application of security measures. The fourth table contains the correlations of the performances of the port facility's security systems. Correlations that are significant at the 0.01 or 0.05 level are marked accordingly.

It is appropriate to mention at this juncture one key assumption, namely that security investment diverted from an underperforming security system to one which performs better will result in an overall improvement in the performance of the portfolio of security systems as a whole. This is, after all, one of the key tenets of portfolio theory.

Next, the portfolio optimization is performed which examines the performances of the 216 possible portfolios consisting of the three security systems across the six port facilities. The chapter concludes with an explanation for the clustering effect encountered in the portfolio optimization; and then presents the data gathered from a follow-up telephone interview with the second CSO which is used to calculate Cronbach's measure for data reliability (Cronbach, 1951; Forza, 2002).

5.1 Estimates for Physical Loss and Business Interruption from the Prescribed Security Incidents

In this section the estimates for physical loss and business interruption from the seven different prescribed security threats are presented. For each prescribed security incident the potential losses of physical damage and business interruption are estimated in US$ terms and consideration is given to the likely location and severity of each prescribed security incident within the port facility.

For the bomb introduced by person on foot, The Director of Security estimated that the physical loss would be $5,375,000, with a breakdown by area of loss in table 5.1. This consists chiefly of destruction of the security hut and main security gate with replacement costs of biometric equipment and a certain amount of damage to the CCTV systems. It also contains a figure for other unspecified infrastructure damage. The total business interruption figure he estimated to be $10,000,000: representing $5,000,000 from business interruption and $5,000,000 from increased direct and indirect insurance costs.

security hut	250,000
main security gate	50,000
Biometrics	50,000
CCTV systems	25,000
Infrastructure	5,000,000
	5,375,000

Table 5.1 – Estimated physical loss arising from a bomb introduced by foot

For the car bomb, he estimated that the physical loss would be $36,769,695, with a breakdown by area of loss in table 5.2. This consists chiefly of destruction of the security hut and main security gate with replacement costs of biometric equipment and a certain amount of damage to the CCTV systems. It also contains a figure for the destruction of the operations building and a figure for other unspecified

infrastructure damage. The total business interruption figure he estimated to be $45,000,000, representing $30,000,000 business interruption and $15,000,000 in increased direct and indirect insurance costs.

security hut	250,000
main security gate	50,000
Biometrics	50,000
CCTV systems	25,000
Operations building	11,394,695
Infrastructure	25,000,000
	36,769,695

Table 5.2 – Estimated physical loss arising from a car bomb

For the truck bomb, he estimated that the physical loss would be $125,012,575, with a breakdown by area of loss in table 5.3. This consists chiefly of destruction of the security hut and main security gate with replacement costs of biometric equipment and a certain amount of damage to the CCTV systems. It also contains a figure for the destruction of the operations building and extensive damage to the wharf and cargo handling equipment. The total business interruption figure he estimated to be $92,112,118 representing $62,122,118 business interruption and $30,000,000 in increased direct and indirect insurance costs.

security hut	250,000
main security gate	50,000
Biometrics	50,000
CCTV systems	25,000
Operations building	11,394,695
Wharf	32,318,501
Cargo handling equip	80,924,379
	125,012,575

Table 5.3 – Estimated physical loss arising from a truck bomb

For a biological agent attack on the terminal on foot, he estimated that the loss would be $16,902,973 which chiefly consists of total loss of the main security gate, security hut, operations building and its contents and a figure for the replacement of biometric equipment. While the loss is not physical in terms of blast damage, it is deemed that the loss is of such a nature that replacement or demolition and reconstruction may be required. The total business interruption figure he estimated to be $102,112,118 representing $62,122,118 business interruption; $30,000,000 in increased direct and indirect insurance costs; and an additional $10,000,000 cost for decontamination.

Security hut	250,000
Main security gate	50,000
Biometrics	50,000
Building contents	5,158,278
Operations building	11,394,695
	16,902,973

Table 5.4 – Estimated loss arising from a biological agent attack on the terminal on foot

For a biological agent attack on the terminal by car, he estimated that the physical damage loss would be $87,432,657 which chiefly consists of total loss of the main security gate, security hut, operations building and its contents and a figure for the replacement of biometric equipment. While the loss is not physical in terms of blast damage, it is deemed that the loss is of such a nature that replacement or demolition and reconstruction may be required. The total business interruption figure he estimated to be $122,112,118 representing $62,122,118 business interruption; $30,000,000 in increased direct and indirect insurance costs; and an additional $30,000,000 cost for decontamination.

security hut	50,000
main security gate	50,000
biometrics	50,000
Building contents	5,158,278
Wharf	1,000,000
Cargo handling equip	80,924,379
	87,432,657

Table 5.5 – Estimated loss arising from a biological agent attack on the terminal by car

For the mining of port infrastructure, he estimated a physical damage loss of $56,000,000 being $16,000,000 damage to the wharf and $40,000,000 damage to cargo handling equipment, based on a blast radius of 300 metres. The total figure for business interruption is $92,122,118 consisting of a business interruption loss of $62,122,118 and increased direct and indirect insurance costs of $30,000,000.

For the vessel attacked by a suicide boat, he estimated a physical damage loss of damage of $113,242,880 being $32,318,501 damage to the wharf and $80,924,379 damage to cargo handling equipment, effectively a total loss. The total figure for business interruption is $122,122,118 consisting of a business interruption loss of

$62,122,118; increased direct and indirect insurance costs of $30,000,000; and a wreck removal expense of $30,000,000.

While the data for the insured values of the wharfs and cargo handling equipment of the other port facilities can be estimated through extrapolation, the figures for business interruption are difficult to quantify. In theory it could be feasible to extrapolate the business interruption figures based on the TEU throughput of the port facility but as port facility charges, profit margins and other unknowns are at play, it was felt that pure extrapolation could potentially introduce further errors into the data. Therefore, it was decided that the figures for business interruption across all the port facilities would remain the same as for the data for port facility A. While this is not ideal, it is the gap in the empirical data which has necessitated this approach.

5.2 Port Facility A

The estimates for the physical damage, business interruption and expected gross loss for port facility A are in table 5.6. The port facility is rated by the underwriters to have the highest terrorist risk of all of the port facilities in this study. The probability assigned to a possible terrorist attack on the container terminal at 0.522% is 34 times greater than the equivalent figure for port facility B. This high figure for the probability of a terrorist attack results in a large figure for the expected loss, in the absence of any security measures, being $5,525,216 on an annualised basis.

Port Facility A	Infrastructure Damage and Business Interruption			Expected Loss	
Type of Security Incident	Physical damage	Business interruption	Total $	Probability	Expected Loss
Bomb introduced by person on foot	5,375,000	10,000,000	15,375,000	0.522%	80,258
Car Bomb	36,769,695	45,000,000	81,769,695	0.522%	426,838
Truck bomb	125,012,575	92,122,118	217,134,693	0.522%	1,133,443
Biological agent attack on terminal - on foot	16,902,973	102,122,118	119,025,091	0.522%	621,311
Biological agent attack on terminal - by vehicle	87,432,657	122,122,118	209,554,775	0.522%	1,093,876
Mining of port infrastructure	56,000,000	92,122,118	148,122,118	0.522%	773,197
Vessel attacked by a suicide boat	113,242,880	122,122,118	235,364,998	0.522%	1,228,605
			1,026,346,370	Total	5,357,528

Table 5.6 –Port facility A estimates of physical damage, business interruption and gross expected loss

Security Systems' Performance

The access control measures (see table 5.7) have a mean performance of 72.86% which is the second highest among the six terminals and a standard deviation of 15.77% which is the second lowest among the terminals. The access control measures are also the cheapest of the six terminals, being $187,826. The biometric systems have a mean performance of 63.57% which is the fourth highest and a standard deviation of 43.47% which is also the fourth highest among the terminals. The biometric systems are also the third cheapest at $33,637, compared with the other systems. Of the detection systems, the mean performance is 68.57% which is the second highest and the standard deviation of 12.82% is the second lowest compared with the five other terminals. The cost of the detection systems at $261,999 are also the second cheapest of the detection systems across the six terminals. Overall, the access control and detection systems compare very favourably on both performance and cost when compared with the other terminals.

Port Facility A	Security system performance		
Type of Security Incident	Access Control	Biometrics	Detection
Bomb introduced by person on foot	80%	90%	75%
Car Bomb	80%	90%	75%
Truck bomb	85%	85%	80%
Biological agent attack on terminal - on foot	80%	90%	75%
Biological agent attack on terminal - by vehicle	85%	90%	75%
Mining of port infrastructure	50%	0%	50%
Vessel attacked by a suicide boat	50%	0%	50%
Mean	72.86%	63.57%	68.57%
Standard deviation	15.77%	43.47%	12.82%

Table 5.7 – Port facility A security system performances, including means and standard deviations

Security Performance Ratios

Two ratios are now introduced for port security: a benefit-cost ratio and a residual risk : expected loss ratio.

The application of the security measures results in a reduction in the expected loss of $3,444,899 to $1,912,629. Given that the overall expenditure on security is $483,462, the residual risk reduction : security expenditure (benefit-cost) ratio is 7.13. This means that for every $1 spent on security, the residual security risk is reduced by $7.13.

The residual risk : expected loss ratios for the different types of security incident are lowest for the truck bomb and the biological agent attack by vehicle at 16.7% (see table 5.8). This means that the terminal is best placed to thwart attacks of that type compared to the other types of security incident.

Port Facility A	Residual Risk Calculations				
Type of Security Incident	Access Control	Biometrics	Detection	Total	Residual Risk/Expected Loss
Bomb introduced by person on foot	5,351	2,675	6,688	14,714	18.3%
Car Bomb	28,456	14,228	35,570	78,254	18.3%
Truck bomb	56,672	56,672	75,563	188,907	16.7%
Biological agent attack on terminal - on foot	41,421	20,710	51,776	113,907	18.3%
Biological agent attack on terminal - by vehicle	54,694	36,463	91,156	182,313	16.7%
Mining of port infrastructure	128,866	257,732	128,866	515,465	66.7%
Vessel attacked by a suicide boat	204,768	409,535	204,768	819,070	66.7%
Residual Risk	**520,227**	**798,016**	**594,387**	**1,912,629**	
Security Cost	**187,826**	**33,637**	**261,999**	**483,462**	

Table 5.8 –Port facility A residual security risk calculations

Markowitz Portfolio Analysis

Recalling the Markowitz methodology as set out in section 4.2.1, the application of Markowitz theory of portfolio selection requires the calculation of the expected performance of the i^{th} security system; the standard deviation of the performance of the i^{th} security system; and the correlations between the performances of the i^{th} and j^{th} security systems in each port facility, which yields the covariances between them.

The correlations between the security systems are set out in table 5.9. All of them are positive and significant at the 0.01 level.

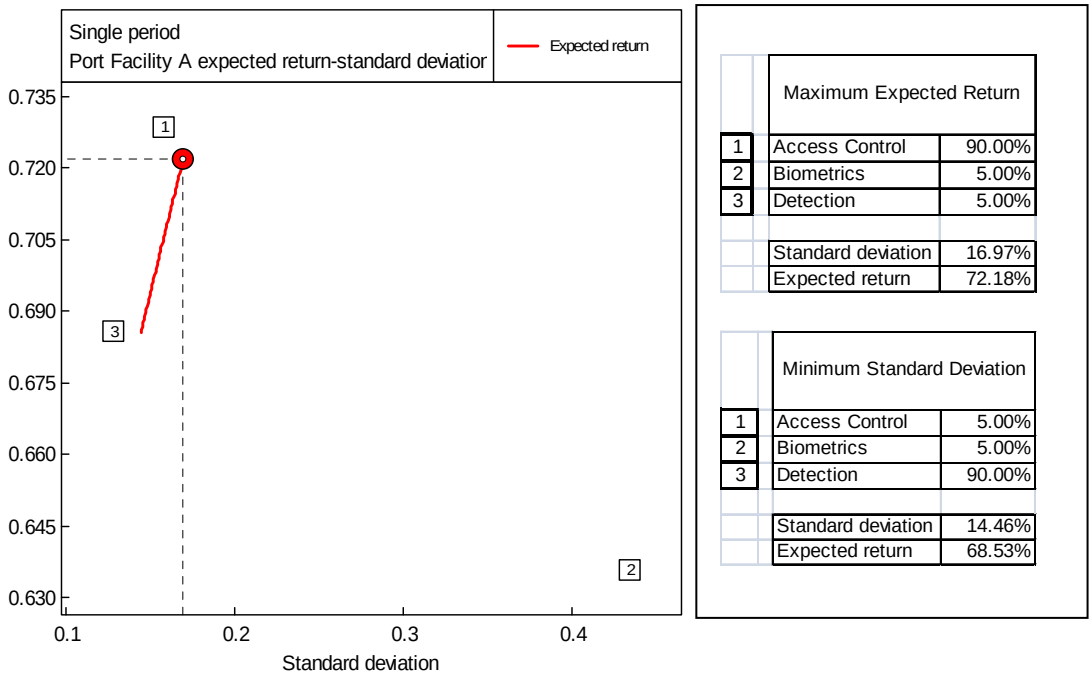
Correlations

Access Control	Biometrics	Detection	
1.000	0.985**	0.992**	**Access Control**
0.985**	1.000	0.983**	**Biometrics**
0.992**	0.983**	1.000	**Detection**

**Correlation significant at the 0.01 level (2-tailed)

Table 5.9 – Port facility A security system performance correlations

The Markowitz efficient frontier is calculated from the data in tables 5.7 and 5.9 and the efficient expected return-standard deviation frontier is plotted in chart 5.1. The application of Markowitz theory yields a maximum expected return of 72.18% with a standard deviation of 16.97%. This is based on 90% of the security spend being invested in access control measures with 5% respectively invested in biometrics and detection. This results in a revised figure for the residual risk of $1,490,464, which is a reduction of $422,165.



	Maximum Expected Return	
1	Access Control	90.00%
2	Biometrics	5.00%
3	Detection	5.00%
	Standard deviation	16.97%
	Expected return	72.18%

	Minimum Standard Deviation	
1	Access Control	5.00%
2	Biometrics	5.00%
3	Detection	90.00%
	Standard deviation	14.46%
	Expected return	68.53%

Chart 5.1 – Markowitz expected return-standard deviation efficient frontier for Port Facility A

The results of the minimum standard deviation with accompanying expected return are 68.53% for the performance and the figure for the standard deviation is 14.46%. This is derived by diverting 90% of the security spend on detection with only 5% investment in both access control measures and biometrics. This results in a revised figure for the residual risk of $1,686,014 which is a reduction of $226,615.

5.3 Port Facility B

The port facility is rated by the underwriters to have the lowest terrorist risk of all of the port facilities in this study. The probability assigned to a possible terrorist attack on the container terminal is just 0.0152%. This low figure for the probability of a terrorist attack results in a low figure for the expected loss, in the absence of any security measures, being $160,888 an annualised basis. The estimates for the physical damage, business interruption and expected gross loss for port facility B are in table 5.10.

Port Facility B	Infrastructure Damage and Business Interruption			Expected Loss	
Type of Security Incident	Physical damage	Business interruption	Total $	Probability	Expected Loss
Bomb introduced by person on foot	5,375,000	10,000,000	15,375,000	0.0152%	2,337
Car Bomb	36,769,695	45,000,000	81,769,695	0.0152%	12,429
Truck bomb	125,012,575	92,122,118	217,134,693	0.0152%	33,004
Biological agent attack on terminal - on foot	11,744,695	97,122,118	108,866,813	0.0152%	16,548
Biological agent attack on terminal - by vehicle	92,472,157	132,122,118	224,594,275	0.0152%	34,138
Mining of port infrastructure	113,242,880	92,122,118	205,364,998	0.0152%	31,215
Vessel attacked by a suicide boat	113,242,880	92,122,118	205,364,998	0.0152%	31,215
			1,058,470,472	Total	160,888

Table 5.10 – Port facility B estimates of physical damage, business interruption and gross expected loss

The detection systems for waterborne attack scenarios are more sophisticated than in other terminals. The company has recently installed cameras along the quay walls which are linked to the local port authority and are used by the terminal as a security detection measure and by the port authority to supplement their traffic management systems. The terminal's main concern had been the prevention of canoeists who frequent the channel from landing at the port facility. Furthermore, the high level of detection rates results from a reciprocal use of port authority cameras by the port facility and also the fact that the port facility Authority will warn the terminal before an attempt has been made to gain access to the terminal.

From the point of view of the access control measures concerning the seaward attacks scenarios, the access control measure results of 50% reflect the presence of the waterborne patrols by local coast guard.

Security Systems' Performance

The access control measures (see table 5.11) have a mean performance of 76.43% which is the highest among the six terminals and a standard deviation of 18.42% which is the third lowest among the terminals. The cost of the access control

measures are also the third highest of the six terminals, being $715,000. The biometric systems have a mean performance of 65.71% which is the third highest and a standard deviation of 45.04% which is also the third highest among the terminals. The biometric systems are the second cheapest at $8,000, compared with the other systems. Of the detection systems, the mean performance is 87.86% which is the highest and the standard deviation of 7.56% is the lowest compared with the five other terminals. The cost of the detection systems at $2,756,325 is by far the greatest amount spent on detection systems across the six terminals. Overall, the access control and detection systems compare very favourably on performance but not necessarily on cost when compared with the other terminals.

Port Facility B	**Security system performance**		
Type of Security Incident	**Access Control**	**Biometrics**	**Detection**
Bomb introduced by person on foot	90%	95%	95%
Car Bomb	90%	95%	95%
Truck bomb	80%	85%	80%
Biological agent attack on terminal - on foot	90%	95%	95%
Biological agent attack on terminal - by vehicle	85%	90%	90%
Mining of port infrastructure	50%	0%	80%
Vessel attacked by a suicide boat	50%	0%	80%
Mean	76.43%	65.71%	87.86%
Standard deviation	18.42%	45.04%	7.56%

Table 5.11 – Port facility B security system performances, including means and standard deviations

Security Performance Ratios

The application of the security measures results in a reduction in the expected loss of $113,389 to $47,499. Given that the overall expenditure on security is $3,479,325, the residual risk reduction : security expenditure ratio is 0.0325. This means that for every $1 spent on security, the residual security risk is reduced by $0.0325.

The residual risk : expected loss ratios for the different types of security incident are lowest for the bomb introduced by person on foot, the car bomb and the biological agent attack on foot at 6.7% (see table 5.12). This means that the terminal is best placed to thwart attacks of this type compared to the other types of security incident.

Port Facility B	Residual Risk Calculations				
Type of Security Incident	Access Control	Biometrics	Detection	Total	Residual Risk/Expected Loss
Bomb introduced by person on foot	78	39	39	156	6.7%
Car Bomb	414	207	207	829	6.7%
Truck bomb	2,200	1,650	2,200	6,051	18.3%
Biological agent attack on terminal - on foot	552	276	276	1,103	6.7%
Biological agent attack on terminal - by vehicle	1,707	1,138	1,138	3,983	11.7%
Mining of port infrastructure	5,203	10,405	2,081	17,689	56.7%
Vessel attacked by a suicide boat	5,203	10,405	2,081	17,689	56.7%
Residual Risk	**15,356**	**24,120**	**8,022**	**47,499**	
Security Cost	**715,000**	**8,000**	**2,756,325**	**3,479,325**	

Table 5.12 –Port facility B residual security risk calculations

Markowitz Portfolio Analysis

The correlations between the security systems are set out in table 5.13. The correlations of the performances of access control and biometrics are positive and significant at the 0.01 level while the correlations of the performances of access control and detection and biometrics and detection are positive and significant at the 0.05 level.

Correlations

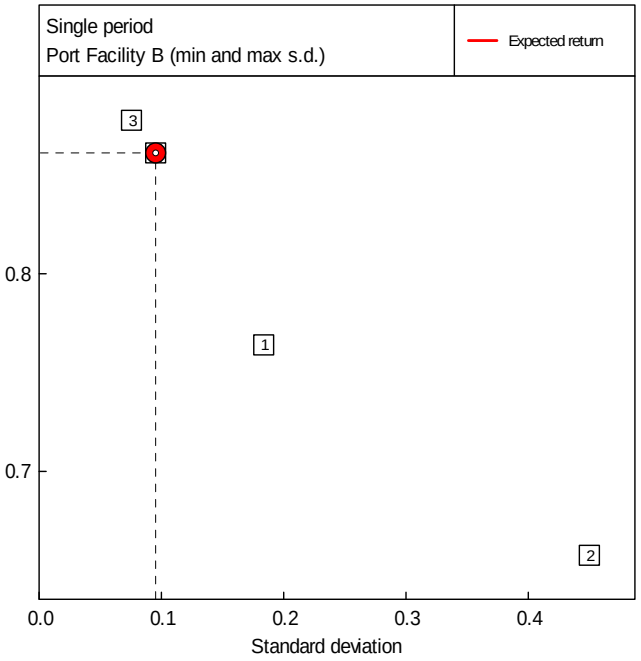
Access Control	Biometrics	Detection	
1.000	0.993**	0.834*	**Access Control**
0.993**	1.000	0.764*	**Biometrics**
0.834*	0.764*	1.000	**Detection**

**Correlation significant at the 0.01 level (2-tailed)

*Correlation significant at the 0.05 level (2-tailed)

Table 5.13 – Port facility B security system performance correlations

The Markowitz efficient frontier is calculated from the data in tables 5.11 and 5.13 and the efficient expected return-standard deviation frontier is plotted in chart 5.2. The application of Markowitz theory yields only one solution: an expected return of 86.18% with a standard deviation of 9.5%. This is based on 90% of the security spend being invested in detection measures with 5% respectively invested in access control and biometrics. This results in a revised figure for the residual risk of $22,235, which is a reduction of $25,264.



	Maximum Expected Return and Minimum Standard Deviation	
1	Access Control	5.00%
2	Biometrics	5.00%
3	Detection	90.00%
	Standard deviation	9.50%
	Expected return	86.18%

Chart 5.2 – Markowitz expected return-standard deviation efficient frontier for Port Facility B

5.4 Port facility C

The port facility is rated by the underwriter to have a probably of 0.018% for the occurrence of any of the prescribed security incidents. The resulting figure for the gross expected loss to the port facility without any security measures being in place is $223,878.

The estimates for the physical damage, business interruption and expected gross loss for port facility C are shown in table 5.14.

Port Facility C	Infrastructure Damage and Business Interruption			Expected Loss	
Type of Security Incident	Physical damage	Business interruption	Total $	Probability	Expected Loss
Bomb introduced by person on foot	5,375,000	10,000,000	15,375,000	0.018%	2,768
Car Bomb	36,769,695	45,000,000	81,769,695	0.018%	14,719
Truck bomb	176,226,244	92,122,118	268,348,362	0.018%	48,303
Biological agent attack on terminal - on foot	11,744,695	97,122,118	108,866,813	0.018%	19,596
Biological agent attack on terminal - by vehicle	124,126,575	132,122,118	256,248,693	0.018%	46,125
Mining of port infrastructure	164,456,549	92,122,118	256,578,667	0.018%	46,184
Vessel attacked by a suicide boat	164,456,549	92,122,118	256,578,667	0.018%	46,184
				Total	223,878

Table 5.14 – Port facility C estimates of physical damage, business interruption and gross expected loss

Security Systems' Performance

The access control measures (see table 5.15) have a mean performance of 59.29% which is the third highest among the six terminals and a standard deviation of 40.56% which is the second highest among the terminals. The cost of the access control measures are also the third lowest of the six terminals, being $412,734. The biometric systems have a mean performance of 66.43% which is the second highest and a standard deviation of 45.43% which is also the second highest among the terminals. The biometric systems are the cheapest by far at $2,680, compared with the other systems. Of the detection systems, the mean performance is 51.43% which is the third highest and the standard deviation of 35.20% is the second lowest compared with the five other terminals. The cost of the detection systems at $51,538 is also the cheapest across the six terminals. Overall, the biometric systems compare very favourably on both performance and cost when compared with the other terminals and the detection systems compare fairly well on both performance and cost.

Port Facility C	Security system performance		
Type of Security Incident	Access Control	Biometrics	Detection
Bomb introduced by person on foot	80%	90%	70%
Car Bomb	85%	95%	75%
Truck bomb	85%	95%	70%
Biological agent attack on terminal - on foot	80%	90%	70%
Biological agent attack on terminal - by vehicle	85%	95%	75%
Mining of port infrastructure	0%	0%	0%
Vessel attacked by a suicide boat	0%	0%	0%
Mean	59.29%	66.43%	51.43%
Standard deviation	40.56%	45.43%	35.20%

Table 5.15 – Port facility C security system performances, including means and standard deviations

Security Performance Ratios

The application of the security measures results in a reduction in the expected loss of $109,860 to $114,018. Given that the overall expenditure on security is $466,952, the residual risk reduction : security expenditure ratio is 0.235. This means that for every $1 spent on security, the residual security risk is reduced by $0.235.

The residual risk : expected loss ratios for the different types of security incident are lowest for the car and the biological agent attack by vehicle at 15.0% (see table 5.16). This means that the terminal is best placed to thwart attacks of this type compared to the other types of security incident.

Port Facility C	Residual Risk Calculations				
Type of Security Incident	Access Control	Biometrics	Detection	Total	Residual Risk/Expected Loss
Bomb introduced by person on foot	185	92	277	554	20.0%
Car Bomb	736	245	1,227	2,208	15.0%
Truck bomb	2,415	805	4,830	8,050	16.7%
Biological agent attack on terminal - on foot	1,306	653	1,960	3,919	20.0%
Biological agent attack on terminal - by vehicle	2,306	769	3,844	6,919	15.0%
Mining of port infrastructure	15,395	15,395	15,395	46,184	100.0%
Vessel attacked by a suicide boat	15,395	15,395	15,395	46,184	100.0%
Residual Risk	**37,738**	**33,354**	**42,926**	**114,018**	
Security Cost	**412,734**	**2,680**	**51,538**	**466,952**	

Table 5.16 – Port facility C residual security risk calculations

Markowitz Portfolio Analysis

The correlations between the security systems are set out in table 5.17. All of them are positive and significant at the 0.01 level.

Correlations

Access Control	Biometrics	Detection	
1.000	1.000**	0.999**	**Access Control**
1.000**	1.000	.0999**	**Biometrics**
0.999**	0.999**	1.000	**Detection**

**Correlation significant at the 0.01 level (2-tailed)

Table 5.17 – Port facility C security system performance correlations

The Markowitz efficient frontier is calculated from the data in tables 5.15 and 5.17 and the efficient expected return-standard deviation frontier is plotted in chart 5.3. The application of Markowitz theory yields a maximum expected return of 65.32% with a standard deviation of 44.67%. This is based on 90% of the security spend being invested in biometrics with 5% respectively invested in access control and detection. This results in a revised figure for the residual risk of $77,641 which is a reduction of $36,377.

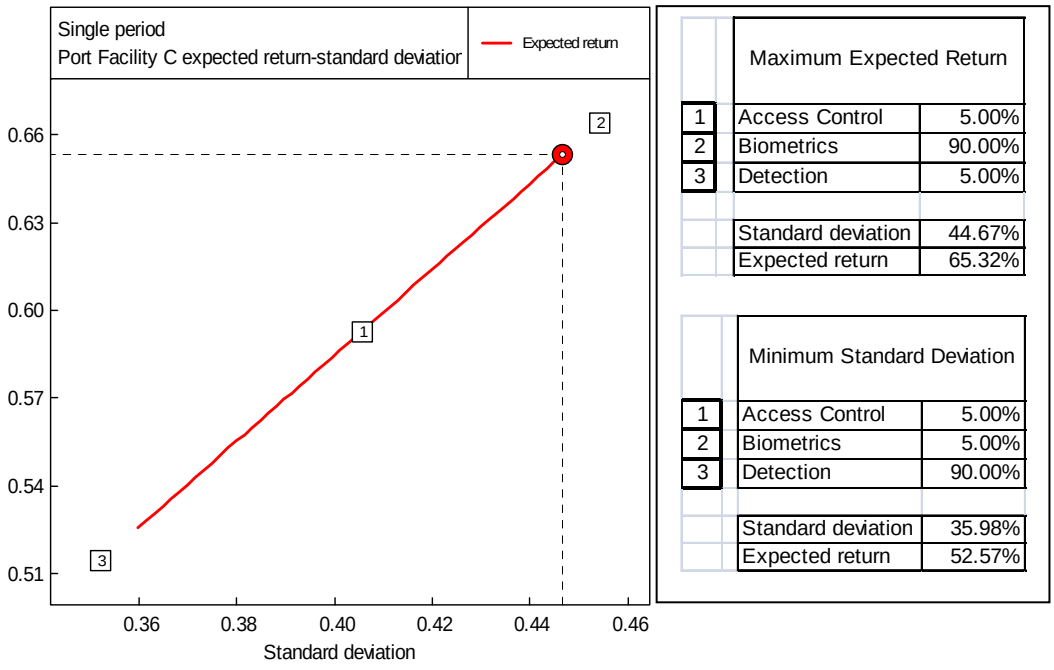


Chart 5.3 - Markowitz expected return-standard deviation efficient frontier for Port Facility C

For the Markowitz minimum standard deviation with accompanying expected return, the figure for the expected return is 52.57% and the figure for the standard deviation is 35.98%. This is derived by diverting 90% of the security spend on detection with only 5% investment in both access control measures and biometrics. This results in a revised figure for the residual risk of $106,185 which is a reduction of $7,833.

5.5 Port facility D

The port facility is rated by the underwriter to have a probably of 0.07% for the occurrence of any of the prescribed security incidents. The resulting figure for the gross expected loss to the port facility without any security measures being in place is $758,988. The estimates for the physical damage, business interruption and expected gross loss for port facility D are shown in table 5.18.

Port Facility D	Infrastructure Damage and Business Interruption			Expected Loss	
Type of Security Incident	Physical damage	Business interruption	Total $	Probability	Expected Loss
Bomb introduced by person on foot	5,375,000	10,000,000	15,375,000	0.070%	10,763
Car Bomb	36,769,695	45,000,000	81,769,695	0.070%	57,239
Truck bomb	133,092,200	92,122,118	225,214,318	0.070%	157,650
Biological agent attack on terminal - on foot	11,744,695	97,122,118	108,866,813	0.070%	76,207
Biological agent attack on terminal - by vehicle	94,032,032	132,122,118	226,154,150	0.070%	158,308
Mining of port infrastructure	121,322,505	92,122,118	213,444,623	0.070%	149,411
Vessel attacked by a suicide boat	121,322,505	92,122,118	213,444,623	0.070%	149,411
				Total	758,988

Table 5.18 – Port facility D estimates of physical damage, business interruption and gross expected loss

Security Systems' Performance

The access control measures (see table 5.19) have a mean performance of 22.86% which is the lowest among the six terminals and a standard deviation of 7.56% which is also the lowest among the terminals. However, the cost of the access control measures are the second highest of the six terminals, being $829,730. The biometric systems have a mean performance of 34.29% which is the lowest and a standard deviation of 15.12% which is also the lowest among the terminals. The biometric systems are only the third lowest at $12,200, compared with the other systems. Of the detection systems, the mean performance is 20.00% which is the second lowest and the standard deviation of 20.00% is the third highest compared with the five other terminals. The cost of the detection systems at $787,670 are the second highest across the six terminals. Overall, all three security systems perform poorly compared to the other terminals and yet are among the most expensive.

Port Facility D	Security system performance		
Type of Security Incident	Access Control	Biometrics	Detection
Bomb introduced by person on foot	20%	40%	40%
Car Bomb	20%	40%	0%
Truck bomb	20%	40%	0%
Biological agent attack on terminal - on foot	20%	40%	40%
Biological agent attack on terminal - by vehicle	20%	40%	0%
Mining of port infrastructure	20%	40%	40%
Vessel attacked by a suicide boat	40%	0%	20%
Mean	22.86%	34.29%	20.00%
Standard deviation	7.56%	15.12%	20.00%

Table 5.19 – Port facility D security system performances, including means and standard deviations

Security Performance Ratios

The application of the security measures results in a reduction in the expected loss of $183,315 to $575,673. Given that the overall expenditure on security is $1,629,600 the residual risk reduction : security expenditure ratio is 0.112. This means that for every $1 spent on security, the residual security risk is reduced by $0.112.

The residual risk : expected loss ratios for the different types of security incident are lowest for the bomb introduced by person on foot, the biological agent attack on foot and the mining of the port infrastructure at 66.7% (see table 5.20). However, these figures are much higher than for any other terminal.

Port Facility D	Residual Risk Calculations				
Type of Security Incident	Access Control	Biometrics	Detection	Total	Residual Risk/Expected Loss
Bomb introduced by person on foot	2,870	2,153	2,153	7,175	66.7%
Car Bomb	15,264	11,448	19,080	45,791	80.0%
Truck bomb	42,040	31,530	52,550	126,120	80.0%
Biological agent attack on terminal - on foot	20,322	15,241	15,241	50,805	66.7%
Biological agent attack on terminal - by vehicle	42,215	31,662	52,769	126,646	80.0%
Mining of port infrastructure	39,843	29,882	29,882	99,607	66.7%
Vessel attacked by a suicide boat	29,882	49,804	39,843	119,529	80.0%
Residual Risk	**192,436**	**171,719**	**211,518**	**575,673**	
Security Cost	**829,730**	**12,200**	**787,670**	**1,629,600**	

Table 5.20 – Port facility D residual security risk calculations

Markowitz Portfolio Analysis

The correlations between the security systems are set out in table 5.21. The correlation between the performances of access control and biometrics are perfectly

negative, while the correlation between access control and detection and biometrics and detection are zero.

Correlations

Access Control	Biometrics	Detection	
1.000	-1.000**	0.000	**Access Control**
-1.000**	1.000	0.000	**Biometrics**
0.000	0.000	1.000	**Detection**

**Correlation significant at the 0.01 level (2-tailed)

Table 5.21 – Port facility D security system performance correlations

The Markowitz efficient frontier is calculated from the data in tables 5.19 and 5.21 and the efficient expected return-standard deviation frontier is plotted in chart 5.4. The application of Markowitz theory yields a maximum expected return of 33.00% with a standard deviation of 13.27%. This is based on 90% of the security spend being invested in biometrics with 5% respectively invested in access control and detection. This results in a revised figure for the residual risk of $508,522 which is a reduction of $67,151.

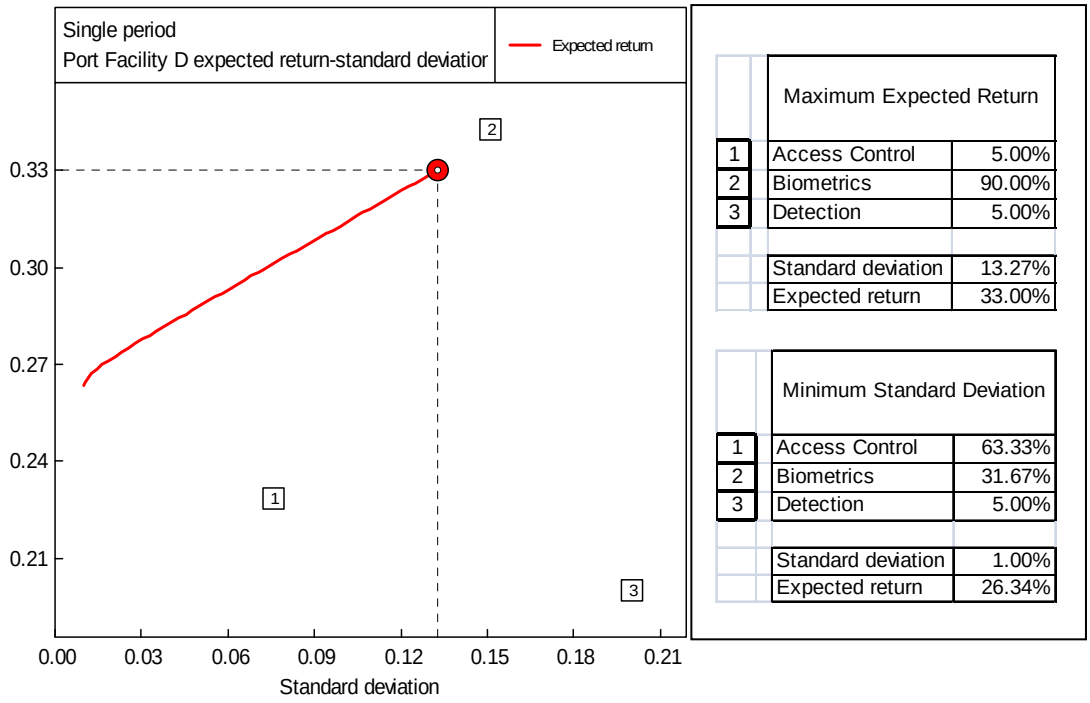


Chart 5.4 - Markowitz expected return-standard deviation efficient frontier for Port Facility D

For the Markowitz minimum standard deviation with accompanying expected return, the figure for the expected return is 26.34% and the figure for the standard deviation is 1.00%. This is derived by diverting 63.33% of the security spend on access control; 31.67% of the security spend on biometrics and 5% invested in detection. This results in a revised figure for the residual risk of $559,071 which is a reduction of $16,602.

5.6 Port facility E

The port facility is rated by the underwriter to have a probably of 0.03% for the occurrence of any of the prescribed security incidents. The resulting figure for the gross expected loss to the port facility without any security measures being in place is $416,525. The estimates for the physical damage, business interruption and expected gross loss for port facility E are in table 5.22.

Port Facility E	Infrastructure Damage and Business Interruption			Expected Loss	
Type of Security Incident	Physical damage	Business interruption	Total $	Probability	Expected Loss
Bomb introduced by person on foot	5,375,000	10,000,000	15,375,000	0.030%	4,613
Car Bomb	36,769,695	45,000,000	81,769,695	0.030%	24,531
Truck bomb	211,302,016	92,122,118	303,424,134	0.030%	91,027
Biological agent attack on terminal - on foot	11,744,695	97,122,118	108,866,813	0.030%	32,660
Biological agent attack on terminal - by vehicle	163,548,848	132,122,118	295,670,966	0.030%	88,701
Mining of port infrastructure	199,532,321	92,122,118	291,654,439	0.030%	87,496
Vessel attacked by a suicide boat	199,532,321	92,122,118	291,654,439	0.030%	87,496
				Total	416,525

Table 5.22 – Port facility E estimates of physical damage, business interruption and gross expected loss

Security Systems' Performance

The access control measures (see table 5.23) have a mean performance of 58.57% which is the third lowest among the six terminals and a standard deviation of 35.79% which is the third highest among the six terminals. The cost of the access control measures are the second lowest of the six terminals, being $207,000. The biometric systems have a mean performance of 57.14% which is the second lowest and a standard deviation of 39.04% which is also the second lowest among the terminals. However, the biometric systems are the second most expensive at $84.000, compared with the other systems. Of the detection systems, the mean performance is 10.00% which is the lowest of all and the standard deviation of 19.15% is the third lowest compared with the five other terminals. The cost of the detection systems at $453,000 are the third highest across the six terminals. Overall, none of the three security systems performs particularly well when compared with the peers, especially not detection given its cost in comparison with others.

Port Facility E	Security system performance		
Type of Security Incident	Access Control	Biometrics	Detection
Bomb introduced by person on foot	60%	80%	0%
Car Bomb	90%	80%	0%
Truck bomb	90%	80%	0%
Biological agent attack on terminal - on foot	60%	80%	0%
Biological agent attack on terminal - by vehicle	90%	80%	0%
Mining of port infrastructure	10%	0%	50%
Vessel attacked by a suicide boat	10%	0%	20%
Mean	58.57%	57.14%	10.00%
Standard deviation	35.79%	39.04%	19.15%

Table 5.23 – Port facility E security system performances, including means and standard deviations

Security Performance Ratios

The application of the security measures results in a reduction in the expected loss of $159,390 to $257,135. Given that the overall expenditure on security is $744,000 the residual risk reduction : security expenditure ratio is 0.214. This means that for every $1 spent on security, the residual security risk is reduced by $0.214.

The residual risk : expected loss ratios for the different types of security incident are lowest for the car bomb, the truck bomb and the biological agent attack by vehicle at 43.3% (see table 5.24). However, these figures do not compare favourably with the other terminals.

Port Facility E	Residual Risk Calculations				
Type of Security Incident	Access Control	Biometrics	Detection	Total	Residual Risk/Expected Loss
Bomb introduced by person on foot	615	308	1,538	2,460	53.3%
Car Bomb	818	1,635	8,177	10,630	43.3%
Truck bomb	3,034	6,068	30,342	39,445	43.3%
Biological agent attack on terminal - on foot	4,355	2,177	10,887	17,419	53.3%
Biological agent attack on terminal - by vehicle	2,957	5,913	29,567	38,437	43.3%
Mining of port infrastructure	26,249	29,165	14,583	69,997	80.0%
Vessel attacked by a suicide boat	26,249	29,165	23,332	78,747	90.0%
Residual Risk	**64,276**	**74,433**	**118,426**	**257,135**	
Security Cost	**207,000**	**84,000**	**453,000**	**744,000**	

Table 5.24 –Port facility E residual security risk calculations

Markowitz Portfolio Analysis

The correlations between the security systems are set out in table 5.25. The correlation between the performance of access control and biometrics are positive and significant at the 0.01 level. The correlation of the performances of access control

and detection is negative and significant at the 0.05 level; while the correlation of the performance of biometrics and detection is negative and significant at the 0.01 level.

Correlations

Access Control	Biometrics	Detection	
1.000	0.927**	-0.827*	**Access Control**
0.927**	1.000	-0.892**	**Biometrics**
-0.827*	-0.892**	1.000	**Detection**

**Correlation significant at the 0.01 level (2-tailed)

*Correlation significant at the 0.05 level (2-tailed)

Table 5.25 – Port facility E security system performance correlations

The Markowitz efficient frontier is calculated from the data in tables 5.23 and 5.25 and the efficient expected return-standard deviation frontier is plotted in chart 5.5. The application of Markowitz theory yields a maximum expected return of 56.07% with a standard deviation of 33.23%. This is based on 90% of the security spend being invested in access control measures with 5% respectively invested in biometrics and detection. This results in a revised figure for the residual risk of $182,979 which is a reduction of $74,156.

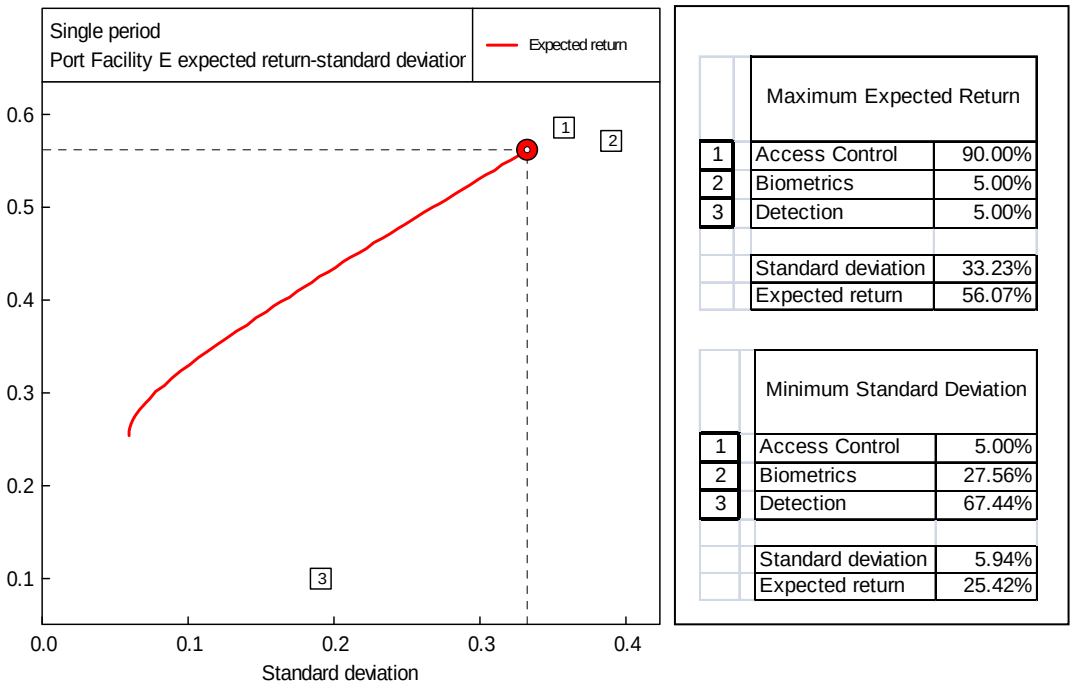


Chart 5.5 - Markowitz expected return-standard deviation efficient frontier for Port Facility E

For the Markowitz minimum standard deviation with accompanying expected return, the figure for the expected return is 25.42% and the figure for the standard deviation is 5.94%. This is derived by diverting 67.44% of the security spend on detection with 27.56% investment in biometrics and 5% invested in access control. This results in a revised figure for the residual risk of $310,644 which is an *increase* of $53,509. On this occasion the application of portfolio theory has resulted in a portfolio with a higher level of residual risk than the status quo.

5.7 Port Facility F

The underwriter has assigned a probably of 0.023% for the occurrence of any of the prescribed security incidents. The resulting figure for the gross expected loss to the port facility without any security measures being in place is $269,702. The estimates for the physical damage, business interruption and expected gross loss for port facility F are in table 5.26.

Port Facility F	Infrastructure Damage and Business Interruption			Expected Loss	
Type of Security Incident	Physical damage	Business interruption	Total $	Probability	Expected Loss
Bomb introduced by person on foot	5,375,000	10,000,000	15,375,000	0.023%	3,536
Car Bomb	36,769,695	45,000,000	81,769,695	0.023%	18,807
Truck bomb	157,352,430	92,122,118	249,474,548	0.023%	57,379
Biological agent attack on terminal - on foot	11,744,695	97,122,118	108,866,813	0.023%	25,039
Biological agent attack on terminal - by vehicle	109,599,262	132,122,118	241,721,380	0.023%	55,596
Mining of port infrastructure	145,582,735	92,122,118	237,704,853	0.023%	54,672
Vessel attacked by a suicide boat	145,582,735	92,122,118	237,704,853	0.023%	54,672
				Total	269,702

Table 5.26 – Port facility F estimates of physical damage, business interruption and gross expected loss

Security Systems' Performance

The access control measures (see table 5.27) have a mean performance of 45.71% which is the second lowest among the six port facilities and a standard deviation of 42.37% which is among the highest. The cost of the access control measures are the highest of the six port facilities, being $1,324,312. The biometric systems have a mean performance of 67.86% which is the highest and a standard deviation of 46.36% which is also the highest among the terminals. The cost of the biometric systems are also the highest at $275,600, compared with the other terminals. Of the detection systems, the mean performance is 41.43% which is the third lowest and the standard deviation of 40.18% is the highest compared with the five other terminals. The cost of the detection systems at $349,777 are the third lowest across the six terminals. Overall, the biometrics system is the best performer but also the most expensive; access control systems do not perform particularly well and are also the most expensive and the detection systems are average when compared to the other terminals.

Port Facility F	Security system performance		
Type of Security Incident	Access Control	Biometrics	Detection
Bomb introduced by person on foot	90%	95%	80%
Car Bomb	90%	95%	0%
Truck bomb	90%	95%	0%
Biological agent attack on terminal - on foot	10%	95%	80%
Biological agent attack on terminal - by vehicle	10%	95%	0%
Mining of port infrastructure	0%	0%	80%
Vessel attacked by a suicide boat	30%	0%	50%
Mean	45.71%	67.86%	41.43%
Standard deviation	42.37%	46.36%	40.18%

Table 5.27 – Port facility F security system performances, including means and standard deviations

Security Performance Ratios

The application of the security measures results in a reduction in the expected loss of $114,163 to $155,539. Given that the overall expenditure on security is $1,949,689 the residual risk reduction : security expenditure ratio is 0.059. This means that for every $1 spent on security, the residual security risk is reduced by $0.059.

The residual risk : expected loss ratio for the different types of security incident are lowest for the bomb introduced by person on foot at 11.7%.

Port Facility F	Residual Risk Calculations				
Type of Security Incident	Access Control	Biometrics	Detection	Total	Residual Risk/Expected Loss
Bomb introduced by person on foot	118	59	236	413	11.7%
Car Bomb	627	313	6,269	7,209	38.3%
Truck bomb	1,913	956	19,126	21,995	38.3%
Biological agent attack on terminal - on foot	7,512	417	1,669	9,598	38.3%
Biological agent attack on terminal - by vehicle	16,679	927	18,532	36,137	65.0%
Mining of port infrastructure	18,224	18,224	3,645	40,093	73.3%
Vessel attacked by a suicide boat	12,757	18,224	9,112	40,093	73.3%
Residual Risk	**57,829**	**39,121**	**58,589**	**155,539**	
Security Cost	**1,324,312**	**275,600**	**349,777**	**1,949,689**	

Table 5.28 –Port F residual security risk calculations

Markowitz Portfolio Analysis

The correlations between the security systems are set out in table 5.29. The correlations of the performances of the security systems differ greatly from the other port facilities with no significant positive or negative correlations.

Correlations

Access Control	Biometrics	Detection	
1.000	0.495	-0.368	**Access Control**
0.495	1.000	-0.401	**Biometrics**
-0.368	-0.401	1.000	**Detection**

Table 5.29 – Port F security system performance correlations

The Markowitz efficient frontier is calculated from the data in tables 5.27 and 5.29 and the efficient expected return-standard deviation frontier is plotted in chart 5.6. The application of Markowitz theory yields a maximum expected return of 65.43% with a standard deviation of 42.03%. This is based on 90% of the security spend being invested in biometrics with 5% respectively invested in access control and detection. This results in a revised figure for the residual risk of $93,236 which is a reduction of $62,303.

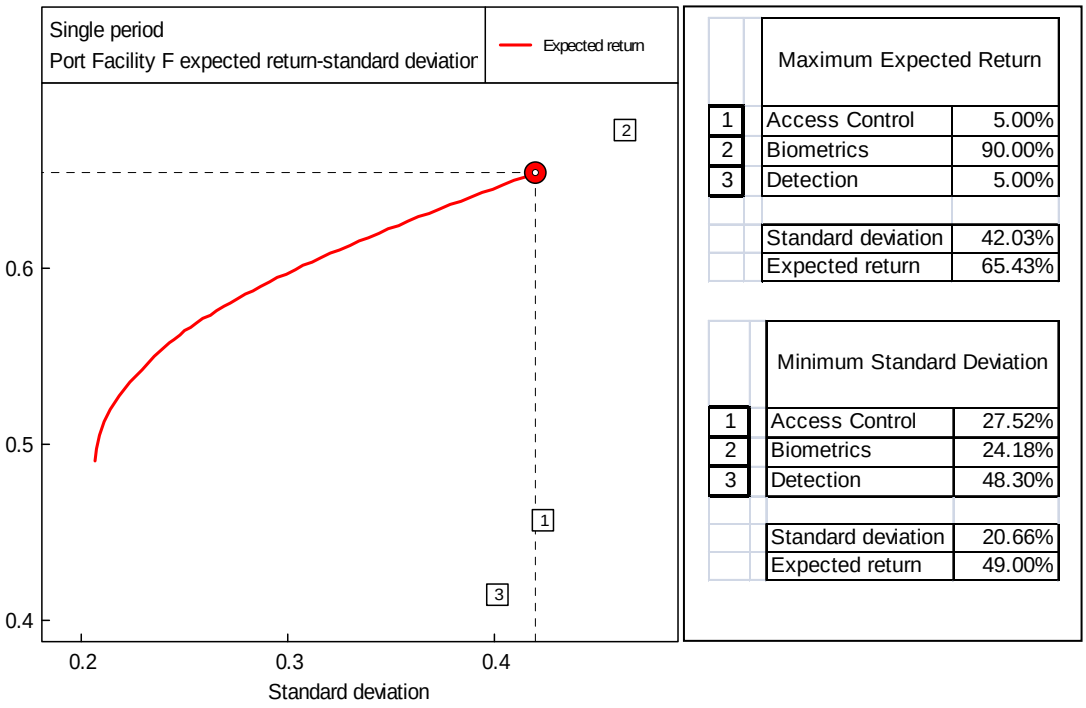


Chart 5.6 - Markowitz expected return-standard deviation efficient frontier for Port Facility F

For the Markowitz minimum standard deviation with accompanying expected return, the figure for the expected return is 49.00% and the figure for the standard deviation is 20.66%. This is derived by diverting 48.30% of the security spend on detection with 27.52% invested in access control and 24.18% invested in biometrics. This results in a revised figure for the residual risk of $137,548 which is a reduction of $17,991.

5.8 Findings Summary

A summary of the findings is presented below.

5.8.1 Mean and Standard Deviation of the Security Systems

Table 5.30 contains a summary of the port facilities' security systems' performances. The best performing port facility for access control is port facility B with a mean of 76.43% and with a standard deviation (s.d.) of 18.42% followed closely by port facility A with mean of 72.86% and s.d. of 15.77% respectively. However, port facility B's access control system cost $715,000 whereas port facility A's is only $187,826. The worst performing access control system belongs to port facility D with a mean of 22.86% and a s.d. of 7.56%.

In terms of biometrics, port facility F was the best performing with a mean of 67.86% and a s.d. of 46.36% followed closely by both port facility C (mean 66.43% & s.d. of 45.43%) and port facility B (mean 65.71% and s.d. of 45.04%). However, the cost of the biometrics systems varies considerably. The worst performing port facility for biometrics was port facility D with a mean of 34.29% and a s.d. of 15.12%.

In terms of detection, port facility B was the best performing with a mean of 87.86% and a s.d. of 7.56%. The detection systems in port facility E were worst with a mean of only 10.00% and a s.d. of 19.15%. What is of interest is the size of the difference in the performance of the detection systems in port facility F where the mean is 41.43% and the s.d. is 40.18% compared to port facility B given that the size of the investment in both port facilities' detection systems are quite similar.

Port Facility	Access Control			Biometrics			Detection		
	mean	s.d.	Cost $	mean	s.d.	Cost $	mean	s.d.	Cost $
A	72.86%	15.77%	187,826	63.57%	43.47%	33,637	68.57%	12.82%	261,999
B	76.43%	18.42%	715,000	65.71%	45.04%	8,000	87.86%	7.56%	2,756,325
C	59.29%	40.56%	412,734	66.43%	45.43%	2,680	51.43%	35.20%	51,538
D	22.86%	7.56%	829,730	34.29%	15.12%	12,200	20.00%	20.00%	787,670
E	58.57%	35.79%	207,000	57.14%	39.04%	84,000	10.00%	19.15%	453,000
F	45.71%	42.37%	1,324,312	67.86%	46.36%	275,600	41.43%	40.18%	1,949,689

Table 5.30 – Summary of the Port Facilities'Security Systems' Performances

5.8.2 Security Benefit-Cost Ratios

The findings also showed some interesting results concerning the port facilities' security benefit-cost ratios which show by how much each port facility's residual

security risk is reduced for every $1 spent on security. The figures for the security benefit-cost ratios are shown in table 5.31.

Port Facility	Security Performance Ratio
A	7.13
B	0.0325
C	0.235
D	0.112
E	0.214
F	0.059

Table 5.31 – Port Facilities' Security Benefit-cost Ratios

While most of the ratios range from 0.0325 for port facility B to 0.235 for port facility C, the corresponding figure for port facility A is 7.13. It is possible that the size of this figure may reflect the higher level of terrorist threat that exists in that country. However, the figure for Port facility D is lower than for Port facility C where the terrorist threat is lower so it would be premature to try to draw such a conclusion.

5.8.3 Residual Risk / Expected Loss Ratios

An analysis of the ratios for residual risk : expected loss per type of prescribed security incident show which of the port facilities are best placed to prevent such an attack. These are shown in table 5.32.

Port Facility	Bomb introduced by person on foot	Car Bomb	Truck bomb	Biological agent attack on terminal - on foot	Biological agent attack on terminal - by vehicle	Mining of port infrastructure	Vessel attacked by a suicide boat
A	18.30%	18.30%	16.70%	18.30%	16.70%	66.70%	66.70%
B	6.70%	6.70%	18.30%	6.70%	11.70%	56.70%	56.70%
C	20.00%	15.00%	16.70%	20.00%	15.00%	100.00%	100.00%
D	66.70%	80.00%	80.00%	66.70%	80.00%	66.70%	80.00%
E	53.30%	43.30%	43.30%	53.30%	43.30%	80.00%	90.00%
F	11.70%	38.30%	38.30%	38.30%	65.00%	73.30%	73.30%

Table 5.32 – Port Facilities' Residual Risk : Expected Loss Ratios by per type of Security Incident

For the bomb introduced by person on foot, the best performing port facility is port facility B at 6.7% while the worst performing is port facility D at 66.7%. This means that for a given attempt on port facility B, only 6.7% are expected to be successful whereas in port facility D, two thirds of attempted attacks are expected to be successful.

For the car bomb, port facility B again scores the highest with 6.7% and port facility D is again the worst performing with only a fifth of attempted attacks being thwarted.
For the truck bomb scenario, it is port facility A and port facility C that perform equal best at 16.7% and port facility D is again the worst performer at 80%.
In the case of the biological agent attack on the port facilities either by on foot or by vehicle, port facility B is again the best performing with port facility D the worst performing.
However, for both the mining of the port infrastructure and the vessel attacked by a suicide boat, while port facility B is again the best performing, the worst performing being port facility C, which was judged to be unable to prevent any kind of attack from the water. This highlights that while port facility C is relatively good at preventing attacks that have their origins on the land, the port facility is very vulnerable to any waterborne threats.

5.8.4 Residual Security Risk Ex-ante and Ex-post Markowitz Portfolio Analysis

One of the key findings of the research is how the application of Markowitz theory of portfolio selection has reduced each port facility's residual security risk. A summary of ex-ante and ex-post application of portfolio theory can be found in table 5.33. The figures reproduced are the ones which maximise the expected return, rather than minimise the standard deviation of the ex-post portfolio.
The ex-post application of portfolio theory has the largest impact on port facility A in terms of a US$ reduction in residual security risk of $422,165. However, the range of reduction in residual security risk for the other port facilities is between $25,000 and $75,000. The largest ex-post percentage reduction is port facility B with 53.2%.

Port Facility	Residual Risk US$			
	Ex-ante Markowitz	Ex-post Markowitz	Difference	% Change
A	1,912,629	1,490,464	422,165	-22.1%
B	47,499	22,235	25,264	-53.2%
C	114,018	77,641	36,377	-31.9%
D	575,673	508,522	67,151	-11.7%
E	257,135	182,979	74,156	-28.8%
F	155,539	93,236	62,303	-40.1%

Table 5.33 – Summary of Ex-ante and Ex-post Markowitz Portfolio Analysis

5.9 Portfolio Optimization

The portfolio optimization resulted in an examination of all 216 (6^3) possible portfolios constructed from the 3 security systems in each of the 6 port facilities, as listed in appendix D. The portfolios were analysed in terms of their security investment and their residual security risk, based on the same methodology as described in section 2.1. An optimum portfolio is defined as one which yields either the lowest residual security risk or the lowest security investment compared to the status quo. An alternative portfolio is defined as one which has either a lower residual security risk or lower security investment than the status quo.

The 216 possible portfolios were then plotted on a chart and the charts are reproduced within the context of each port facility. In the analysis, the possible portfolio combinations of the port facilities' security systems which result in both a reduction in residual security risk and security investment were selected. In some instances, there are only a handful of alternative portfolios which have a reduction in both residual security risk and security investment and their details are reproduced in full. In other instances, there are many alternative portfolios of security systems which meet the criteria. In these cases, only the top ten performing portfolios are reproduced. The optimum and alternative portfolio combinations of security systems are presented first on minimising residual security risk and secondly on minimising security investment.

5.9.1 Port Facility A

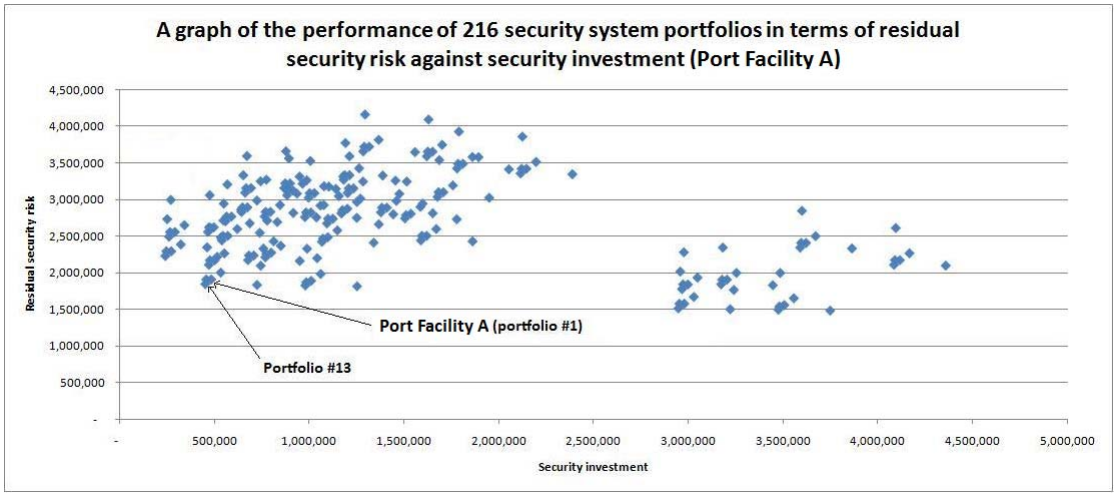


Chart 5.7: Optimum Portfolio Analysis: Port Facility A

Port facility A has a security investment of $483,462 and a residual risk of $1,912,629. Following the portfolio analysis there exists only one alternative portfolio which results in both a reduced residual risk and a reduction in security investment and the details can be found in table 5.34 and as shown in chart 5.7.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B3-D1	13	452,505	30,957	1,849,503	63,136

Table 5.34 - Optimal Security System Portfolio for Port Facility A

This can be achieved by maintaining the existing access control and detection systems in port facility A but substituting the existing biometrics system for the system used in port facility C.

5.9.2 Port Facility B

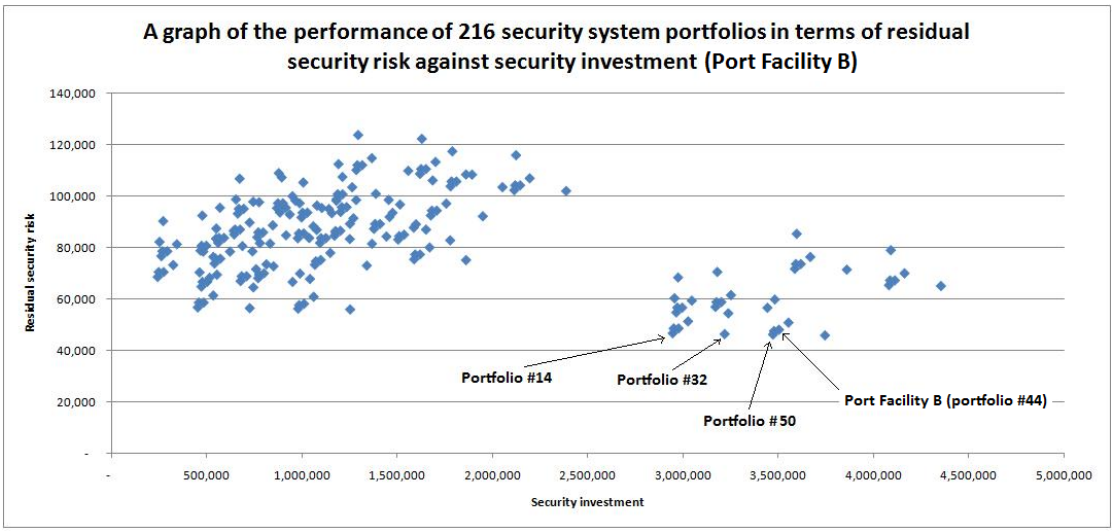


Chart 5.8: Optimum Portfolio Analysis: Port facility B

Port facility B has a security investment of $3,479,325 and a residual risk of $47,499. Following the portfolio analysis, there are three alternative portfolios where both the residual risk and the security investment are less than the status quo. Their details can be found in table 5.35 and in chart 5.8.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B3-D2	14	2,946,831	532,494	46,638	861
A1-B6-D2	32	3,219,751	259,574	46,323	1,176
A2-B3-D2	50	3,474,005	5,320	46,144	1,355

Table 5.35 –Optimal and Alternative Security System Portfolios for Port Facility B

The portfolio which minimises the residual risk is number 50, which consists of the access control and detection systems from port facility B and the biometrics system from port facility C. The portfolio which minimises the security investment is number 14 which consists of the access control system from port facility A, the biometrics system from port facility C and the detection system from port facility B. However, it is interesting to note that all three portfolios include port facility B's detection system which is selected above any of the other detection systems from the other port facilities.

5.9.3 Port Facility C

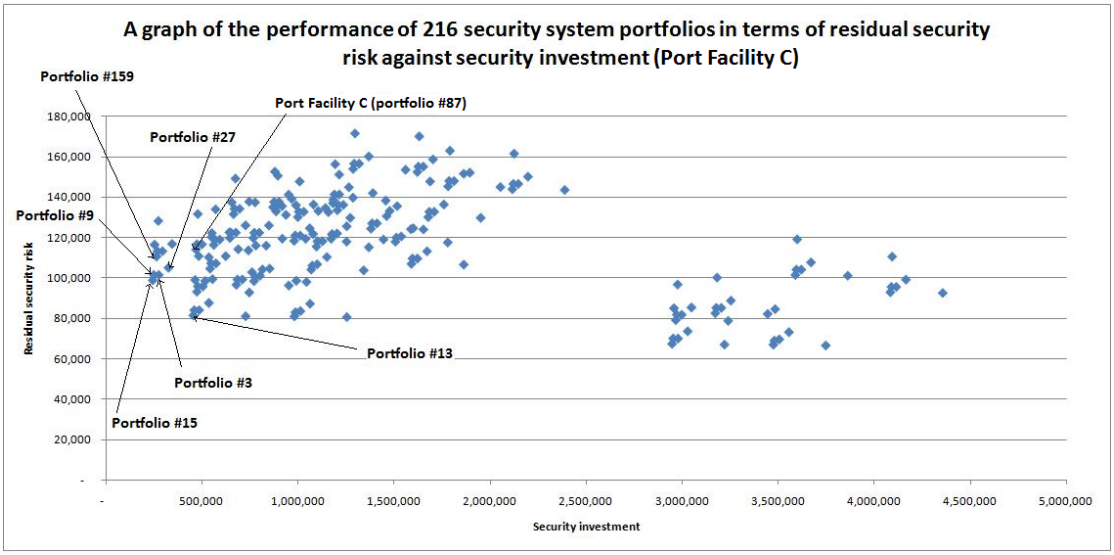


Chart 5.9: Optimum Portfolio Analysis: Port Facility C

Port facility C has a security investment of $466,952 and a residual risk of $114,018. There are 10 alternative portfolios which yield reductions in residual risk and their details can be found in table 5.36. A selection of these portfolios are also shown in chart 5.9.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B3-D1	13	452,505	14,447	81,491	32,527
A1-B2-D1	7	457,825	9,127	84,115	29,903
A1-B3-D3	15	242,044	224,908	98,869	15,149
A1-B4-D1	19	462,025	4,927	99,070	14,948
A1-B2-D3	9	247,364	219,588	101,493	12,525
A1-B1-D3	3	273,001	193,951	101,493	12,525
A1-B5-D3	27	323,364	143,588	105,071	8,947
A5-B3-D3	159	261,218	205,734	110,611	3,407
A5-B2-D3	153	266,538	200,414	113,235	783
A5-1B-D3	147	292,175	174,777	113,235	783

Table 5.36 - Optimum and Alternative Security System Portfolios for Port Facility C (Residual Risk Reduction)

The optimum portfolio for residual risk reduction is portfolio number 13, which represents the access control system from port facility A, the biometrics system from port facility C and the detection system from port facility A. The top two portfolios

include both the access control and detection systems from port facility A and the top 7 portfolios include the access control system from port facility A. The 10 alternative portfolios which yield reduced security investment can be found in table 5.37.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B3-D3	15	242,044	224,908	98,869	15,149
A1-B2-D3	9	247,364	219,588	101,493	12,525
A5-B3-D3	159	261,218	205,734	110,611	3,407
A5-B2-D3	153	266,538	200,414	113,235	783
A1-B1-D3	3	273,001	193,951	101,493	12,525
A5-1B-D3	147	292,175	174,777	113,235	783
A1-B5-D3	27	323,364	143,588	105,071	8,947
A1-B3-D1	13	452,505	14,447	81,491	32,527
A1-B2-D1	7	457,825	9,127	84,115	29,903
A1-B4-D1	19	462,025	4,927	99,070	14,948

Table 5.37 – Optimum and Alternative Security System Portfolios (Security Investment Reduction) for Port Facility C

The optimum portfolio for reduction in security investment is portfolio number 15, which represents the access control system from port facility A and both the biometrics and the detection system from port facility C. It is interesting to note that the top 7 portfolios include the detection system from port facility C.

5.9.4 Port Facility D

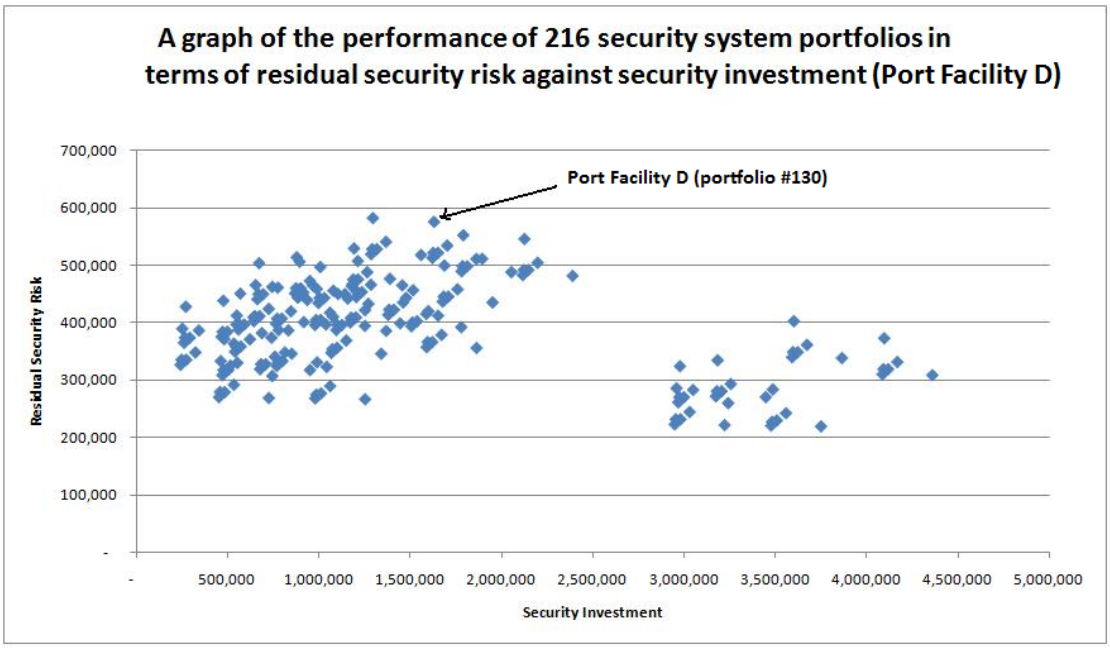


Chart 5.10: Optimum Portfolio Analysis: Port Facility D

Port facility D has a security investment of $1,629,600 and a residual risk of $575,673. There are 154 alternative portfolios which yield reductions in both security investment and residual risk. The top ten alternative portfolios for residual risk reduction can be found in table 5.38.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A2-B6-D1	67	1,252,599	377,001	265,836	309,837
A2-B3-D1	49	979,679	649,921	267,286	308,387
A1-B6-D1	31	725,425	904,175	268,016	307,658
A1-B3-D1	13	452,505	1,177,095	269,465	306,208
A2-B2-D1	43	984,999	644,601	273,730	301,943
A2-B1-D1	37	1,010,636	618,964	276,133	299,540
A1-B2-D1	7	457,825	1,171,775	278,313	297,361
A1-B1-D1	1	483,462	1,146,138	278,313	297,361
A2-B5-D1	61	1,060,999	568,601	288,845	286,829
A1-B5-D1	25	533,825	1,095,775	291,024	284,649

Table 5.38 - Optimum and Alternative Security System Portfolios (Residual Risk Reduction) for Port Facility D

The portfolio which provides the greatest reduction in residual security risk is portfolio number 67, which combines the access control system from port facility B,

the biometrics system from port facility F and the detection system from port facility A. It is interesting to note that the top 10 alternative portfolios for residual risk reduction consist of the detection system from port facility A.

The top ten alternative portfolios for reduction in security investment are in table 5.39.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B3-D3	15	242,044	1,387,556	325,974	249,700
A1-B2-D3	9	247,364	1,382,236	334,821	240,852
A1-B4-D3	21	251,564	1,378,036	388,966	186,707
A5-B3-D3	159	261,218	1,368,382	364,441	211,233
A5-B2-D3	153	266,538	1,363,062	373,288	202,385
A5-B4-D3	165	270,738	1,358,862	427,433	148,240
A1-B1-D3	3	273,001	1,356,599	334,821	240,852
A5-B1-D3	147	292,175	1,337,425	373,288	202,385
A1-B5-D3	27	323,364	1,306,236	347,532	228,141
A5-B5-D3	171	342,538	1,287,062	385,999	189,674

Table 5.39 - Optimum and Alternative Security System Portfolios for (Security Investment Reduction) Port Facility D

The portfolio which yields the greatest saving in security investment is portfolio number 15, which consists of the access control system from port facility A and the biometrics and detection systems from port facility C. Furthermore, all of the top 10 alternative portfolios for security investment reduction consist of the detection system from port facility C.

5.9.5 Port Facility E

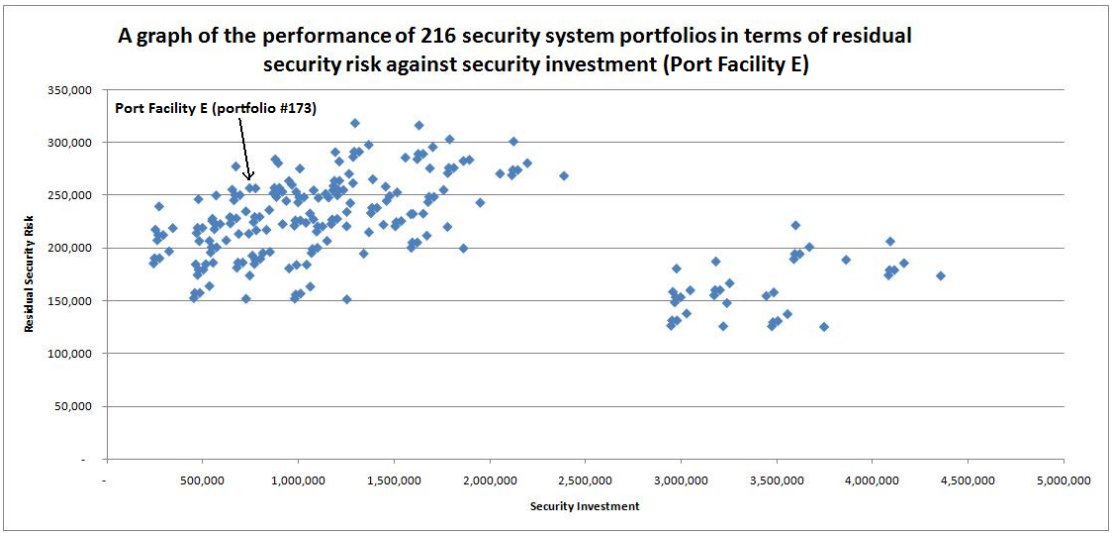


Chart 5.11: Optimum Portfolio Analysis: Port facility E

Port facility E has a security investment of $744,000 and a residual risk of $257,135. There are 50 alternative portfolios which yield reductions in both security cost and residual risk. The top ten alternative portfolios for residual risk reduction can be found in table 5.40.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B6-D1	31	725,425	18,575	152,405	104,730
A1-B3-D1	13	452,505	291,495	153,026	104,109
A1-B2-D1	7	457,825	286,175	157,947	99,188
A1-B1-D1	1	483,462	260,538	157,947	99,188
A1-B5-D1	25	533,825	210,175	164,481	92,654
A5-B3-D1	157	471,679	272,321	175,030	82,105
A5-B2-D1	151	476,999	267,001	179,951	77,184
A5-B1-D1	145	502,636	241,364	179,951	77,184
A3-B3-D1	85	677,413	66,587	181,782	75,353
A1-B4-D1	19	462,025	281,975	185,019	72,116

Table 5.40 - Optimum and Alternative Security System Portfolios (Residual Risk Reduction) for Port Facility E

The optimum portfolio for reduction of residual risk is portfolio number 31 which consists of the access control system from port facility A, the biometrics system from port facility F and the detection system from port facility A. However, it is interesting to note that the top 5 alternative portfolios consist of both the access control and the

detection systems from port facility A. The top ten alternative portfolios for reduction in security investment are in table 5.41.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B3-D3	15	242,044	501,956	185,847	71,288
A1-B2-D3	9	247,364	496,636	190,768	66,367
A1-B4-D3	21	251,564	492,436	217,840	39,295
A5-B3-D3	159	261,218	482,782	207,851	49,284
A5-B2-D3	153	266,538	477,462	212,772	44,363
A5-B4-D3	165	270,738	473,262	239,844	17,291
A1-B1-D3	3	273,001	470,999	190,768	66,367
A5-B1-D3	147	292,175	451,825	212,772	44,363
A1-B5-D3	27	323,364	420,636	197,302	59,833
A5-B5-D3	171	342,538	401,462	219,306	37,829

Table 5.41 - Optimum and Alternative Security System Portfolios (Security Investment Reduction) for Port Facility E

The optimum portfolio is number 15 which consists of the access control system from port facility A and both the biometrics and detection systems from port facility C. As in previous instances , all of the top 10 alternative portfolios for security investment reduction contain the detection system from port facility C.

5.9.6 Port Facility F

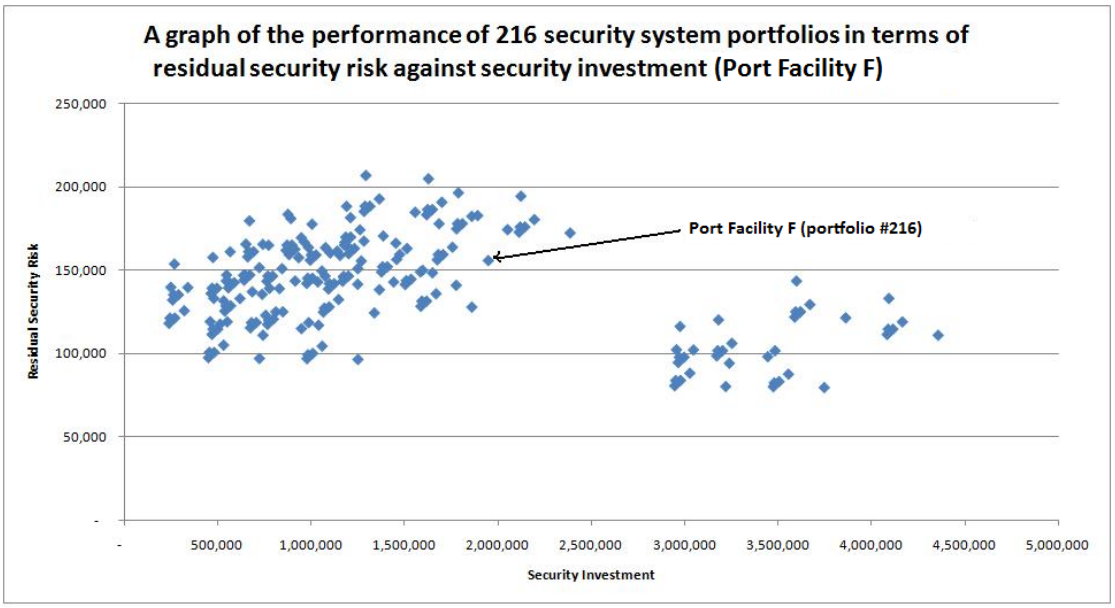


Chart 5.12: Optimum Portfolio Analysis: Port Facility F

Port facility F has a security investment of $1,949,689 and a residual risk of $155,539. There are 105 alternative portfolios which yield reductions in both security cost and residual risk. The top ten alternative portfolios for residual risk reduction can be found in table 5.42.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A2-B6-D1	67	1,252,599	697,090	96,160	59,379
A2-B3-D1	49	979,679	970,010	96,636	58,902
A1-B6-D1	31	725,425	1,224,264	96,783	58,756
A1-B3-D1	13	452,505	1,497,184	97,259	58,279
A2-B2-D1	43	984,999	964,690	98,999	56,539
A2-B1-D1	37	1,010,636	939,053	99,789	55,750
A1-B2-D1	7	457,825	1,491,864	100,412	55,127
A1-B1-D1	1	483,462	1,466,227	100,412	55,127
A2-B5-D1	61	1,060,999	888,690	104,178	51,361
A1-B5-D1	25	533,825	1,415,864	104,801	50,738

Table 5.42 - Optimum and Alternative Security System Portfolios (Residual Risk Reduction) for Port Facility F

The optimum portfolio for reduction of residual risk is portfolio number 67 which consists of the access control system from port facility B, the biometrics system from

port facility F and the detection system from port facility A. However, it is interesting to note that the top 10 alternative portfolios contain the detection systems from port facility A. The top ten optimum portfolios for reduction in security investment are in table 5.43.

Portfolio	Portfolio No.	Security Cost	Security Cost Reduction	Residual Risk	Residual Risk Reduction
A1-B3-D3	15	242,044	1,707,645	117,872	37,666
A1-B2-D3	9	247,364	1,702,325	121,025	34,514
A1-B4-D3	21	251,564	1,698,125	139,505	16,033
A5-B3-D3	159	261,218	1,688,471	131,847	23,692
A5-B2-D3	153	266,538	1,683,151	135,000	20,539
A5-B4-D3	165	270,738	1,678,951	153,480	2,059
A1-B1-D3	3	273,001	1,676,688	121,025	34,514
A5-B1-D3	147	292,175	1,657,514	135,000	20,539
A1-B5-D3	27	323,364	1,626,325	125,414	30,125
A5-B5-D3	171	342,538	1,607,151	139,388	16,150

Table 5.43 - Optimum and Alternative Security System Portfolios (Security Investment Reduction) for Port Facility F

As for port facility E above, the top performing portfolio is number 15 which consists of the access control system from port facility A and both the biometrics and detection systems from port facility C. As in previous instances , all of the top 10 alternative portfolios for security investment reduction contain the detection system from port facility C.

5.10 Sensitivity Analysis

It is necessary to conduct a sensitivity analysis to account for the bias which is introduced when working with a small sample. The sensitivity analysis concerns the two dimensions of the security investment – residual security risk relationship. In order to compensate for this bias, two simulations are conducted. The first simulation models a 10% reduction in the cost of the individual security systems (access control, biometrics and detection) and the second simulation models a 10% improvement in the performance of the individual security systems, aimed at reducing residual security risk.

Consideration was given to a third simulation to vary the underwriter's pure premium probability assessment of the risks of the prescribed security incidents. It is acknowledged that the small sample of terrorism probabilities used in the research may result in the introduction of anchoring effects into the data and that a simulation of a 10% increase or decrease in the terrorism probabilities may serve to address this bias. However, given that the underwriter allocated only one probability to cover all of the prescribed security incidents in the six port facilities, rather than individual probabilities for each threat scenario, the process of modelling different terrorism threat probabilities for each prescribed security incident may unintentionally introduce further errors or bias into the model. Therefore, it is decided to conduct only the aforementioned simulations but nevertheless it is important to highlight the limitations of working with limited terrorism probabilities from only one source.

5.10.1 Sensitivity Analysis Methodology

The objective of running the two simulations is to assess the extent to which the portfolio optimization exercise is affected, specifically in relation to how the optimum and alternative portfolios differ for each port facility ex-post the simulations. The methodology behind the simulations is presented in the following steps.

The first step is to revisit the breakdown in costs of the three security system components (access control, biometrics and detection) for each of the 216 possible portfolios. In each of the possible portfolios a simulation of a 10% reduction is conducted in turn for each of the three security systems and a calculation is made of the reduction of the cost of the 216 individual portfolios. For example, for portfolio

#1, the cost of the access control systems is $187,826; the cost of biometrics is $33,637; and the cost of the detection systems is $261,999. The total cost of portfolio #1 is therefore $483,462. By reducing the cost of the access control systems by 10% to $169,043, the overall cost of the portfolio is now $464,679 which represents a reduction of 3.89% compared to the original. This process is then repeated for biometrics which results in a reduction of 0.7% of the overall cost of the portfolio and the corresponding figure for the reduction in the cost of the portfolio following a 10% reduction in the cost of detection systems is 5.42%. When the cost of the access control system was simulated to decrease by 10%, the mean reduction in the overall portfolio was 4.92%. When the cost of the biometrics system was simulated to decrease by 10%, the mean reduction in the overall portfolio was 0.62%. When the cost of the detection system was simulated to decrease by 10%, the mean reduction in the overall portfolio was 4.46%. The inbalance between the three figures is explained by the fact that in this portfolio the cost of biometric systems is less than that of either access control or detection. This process is then repeated a further 215 times for all of the other possible portfolios.

The second step is to conduct a simulation along similar lines but for a 10% increase in the performance of each of the three security systems and to make calculations of the corresponding figures for the overall portfolios' reduction in the residual security risk. Considering all of the 216 possible portfolios, the mean increase in the performance of access control systems is 3.15%; the mean increase in the performance of biometrics systems is 3.28% and the corresponding figure for detection systems is 3.57%. The results of simulating the 10% reduction in cost and 10% improvement in performance of the security systems are listed in appendix H.

The third step is to apply the sensitivity analysis to each of the six port facilities in turn, including the data on the simulations of the 10% reduction in cost and the 10% improvement in performance. For each port facility, the aim is to identify any alternative portfolios (additional to the ex-ante portfolio optimization) ex-post the simulation where both the security cost and residual security risk are lower than the port facility's actual portfolio of security systems. The results for the six port facilities are set out in the tables 5.44 - 5.49.

5.10.2 Sensitivity Analysis Results

The results of the sensitivity analysis are presented below by port facility. In each table, the portfolio shown first in bold is the actual portfolio of port security systems for that port facility. The portfolio(s) listed below it is(are) the ex-post additional alternative portfolios which exhibit a reduction in both security cost and residual risk compared to the port facility's actual portfolio.

5.10.2.1 Port Facility A

Additional alternative portfolios ex-post the simulations:									
Portfolio No	Portfolio	Ex-ante simulation: security costs	Ex-ante simulation: residual risk	Ex-post simulation security costs: access control cost - 10%	Ex-post simulation security costs: biometrics cost - 10%	Ex-post simulation security costs: detection cost - 10%	Ex-post simulation residual risk: access control performance +10%	Ex-post simulation residual risk: biometrics performance +10%	Ex-post simulation residual risk: detection performance +10%
1	**A1-B1-D1**	**483,462**	**1,912,629**	**464,679**	**480,098**	**457,262**	**1,860,607**	**1,832,828**	**1,853,191**
7	A1-B2-D1	457,825	1,912,629	439,042	457,025	431,625	*1,860,607*	1,832,828	1,853,191

Table 5.44: Port Facility A – additional alternative portfolios ex-post the simulations

In the ex-ante portfolio optimization in section 5.9.1, only portfolio number 13 resulted in both a reduction in residual risk and a reduction in security investment compared to portfolio 1 (port facility A). Following the sensitivity analysis, portfolio number 7 is added as an alternative portfolio where ex-post the simulation, combinations of security investment and residual security risk are less than those for portfolio 1. For example, the figure for the security cost for portfolio number 7 when access control costs are reduced by 10% is $439,042. This is less than all three of the ex-post simulations for security costs for portfolio 1.

Furthermore, the ex-post simulation of the biometrics and detection systems of portfolio 7 result in figures of residual security risk which are less than or equal to the corresponding figures for portfolio 1. However, the ex-post simulation of a 10% improvement in the performance of the access control systems in portfolio 7 results in an overall figure for the residual security risk which is equal to the equivalent figure for portfolio 1 but greater than portfolio 1's ex-post simulation of a 10% improvement in the performance of the biometrics or detection systems. This results in an ex-post simulation overlap between portfolios 1 and 7. Where this occurs, the overlapping portfolio figures are shown in italics.

5.10.2.2 Port Facility B

Additional alternative portfolios ex-post the simulations:									
Portfolio No	Portfolio	Ex-ante simulation: security costs	Ex-ante simulation: residual risk	Ex-post simulation security costs: access control cost - 10%	Ex-post simulation security costs: biometrics cost - 10%	Ex-post simulation security costs: detection cost - 10%	Ex-post simulation residual risk: access control performance +10%	Ex-post simulation residual risk: biometrics performance +10%	Ex-post simulation residual risk: detection performance +10%
44	**A2-B2-D2**	**3,479,325**	**47,499**	**3,407,825**	**3,478,525**	**3,203,693**	**45,957**	**45,103**	**46,686**
8	A1-B2-D2	2,952,151	48,514	2,933,368	2,951,351	2,676,519	*46,920*	46,068	*47,704*
2	A1-B1-D2	2,977,788	48,514	2,959,005	2,974,424	2,702,156	*46,920*	46,068	*47,704*
38	A2-B1-D2	3,504,962	48,021	3,433,462	*3,501,598*	3,229,330	46,481	45,570	*47,209*

Table 5.45: Port Facility B – additional alternative portfolios ex-post the simulations

In the ex-ante portfolio optimization in section 5.9.2, portfolios 14, 32 and 50 are judged to be alternative portfolios where both the residual security risk and security investment are less than the status quo. Following the sensitivity analysis, a further three portfolios can be included: portfolios 8, 2 and 38. All three portfolios had higher security costs and residual security risk ex-ante the simulations than portfolio 44 but ex-post the simulations, combinations of security cost and residual security risk for the three portfolios can be found which are both less than the ex-post simulation for portfolio 44. As in table 5.44, there is overlap between the four portfolios

5.10.2.3 Port Facility C

Additional alternative portfolios ex-post the simulations:									
Portfolio No	Portfolio	Ex-ante simulation: security costs	Ex-ante simulation: residual risk	Ex-post simulation security costs: access control cost - 10%	Ex-post simulation security costs: biometrics cost - 10%	Ex-post simulation security costs: detection cost - 10%	Ex-post simulation residual risk: access control performance +10%	Ex-post simulation residual risk: biometrics performance +10%	Ex-post simulation residual risk: detection performance +10%
87	**A3-B3-D3**	**466,952**	**114,018**	**425,679**	**466,684**	**461,798**	**110,245**	**110,744**	**109,663**
157	A5-B3-D1	471,679	93,233	450,979	*471,411*	445,479	89,778	89,989	90,609
151	A5-B2-D1	476,999	95,857	456,299	*476,199*	450,799	92,408	92,340	93,238
163	A5-B4-D1	481,199	110,813	460,499	*479,979*	454,999	107,493	105,573	108,291
1	A1-B1-D1	483,462	84,115	464,679	*480,098*	457,262	81,827	80,606	81,501

Table 5.46: Port Facility C – additional alternative portfolios ex-post the simulations

In the ex-ante portfolio optimization in section 5.9.3, there were 10 portfolios judged to be alternative portfolios where both the residual security risk and security investment are less than the status quo. Following the sensitivity analysis, a further four portfolios can be included: portfolios 157, 151, 163 and 1. All four portfolios had higher security costs and residual security risk ex-ante the simulations than portfolio 87 but ex-post the simulations, combinations of security cost and residual security risk for the four portfolios can be found which are both less than the ex-post

simulation for portfolio 44. As in table 5.44, there is overlap between the five portfolios.

5.10.2.4 Port Facility D

Additional alternative portfolios ex-post the simulations:									
Portfolio No	Portfolio	Ex-ante simulation: security costs	Ex-ante simulation: residual risk	Ex-post simulation security costs: access control cost - 10%	Ex-post simulation security costs: biometrics cost - 10%	Ex-post simulation security costs: detection cost - 10%	Ex-post simulation residual risk: access control performance +10%	Ex-post simulation residual risk: biometrics performance +10%	Ex-post simulation residual risk: detection performance +10%
130	**A4-B4-D4**	**1,629,600**	**575,673**	**1,546,627**	**1,628,380**	**1,550,833**	**556,715**	**558,283**	**554,455**
112	A4-B1-D4	1,651,037	521,528	1,568,064	*1,647,673*	1,572,270	502,296	510,132	500,003
213	A6-B6-D3	1,651,450	411,851	1,519,019	1,623,890	*1,646,296*	395,554	401,268	397,546
205	A6-B5-D1	1,670,311	378,351	1,537,880	*1,661,911*	*1,644,111*	362,139	365,381	369,698
198	A6-B3-D6	1,676,769	436,328	1,544,338	*1,676,501*	*1,641,791*	420,325	425,768	419,259
192	A6-B2-D6	1,682,089	445,176	1,549,658	*1,681,289*	*1,647,111*	429,181	433,714	428,115
204	A6-B4-D6	1,686,289	499,321	1,553,858	*1,685,069*	*1,651,311*	483,599	481,881	482,552
136	A4-B5-D4	1,701,400	534,239	1,618,427	*1,693,000*	1,622,633	515,027	521,529	512,737
186	A6-B1-D6	1,707,726	445,176	1,575,295	*1,704,362*	*1,672,748*	429,181	433,714	428,115
210	A6-B5-D6	1,758,089	457,887	1,625,658	*1,749,689*	*1,723,111*	441,914	445,108	440,851

Table 5.47: Port Facility D – additional alternative portfolios ex-post the simulations

In the ex-ante portfolio optimization in section 5.9.4, there were 154 portfolios judged to be alternative portfolios where both the residual security risk and security investment are less than the status quo. Following the sensitivity analysis, a further nine portfolios can be included, as listed in table 5.47. All nine portfolios had higher security costs and residual security risk ex-ante the simulations than portfolio 130 but ex-post the simulations, combinations of security cost and residual security risk for the four portfolios can be found which are both less than the ex-post simulation for portfolio 130. As in table 5.44, there is overlap between the 10 portfolios.

5.10.2.5 Port Facility E

Additional alternative portfolios ex-post the simulations:									
Portfolio No	Portfolio	Ex-ante simulation: security costs	Ex-ante simulation: residual risk	Ex-post simulation security costs: access control cost - 10%	Ex-post simulation security costs: biometrics cost - 10%	Ex-post simulation security costs: detection cost - 10%	Ex-post simulation residual risk: access control performance +10%	Ex-post simulation residual risk: biometrics performance +10%	Ex-post simulation residual risk: detection performance +10%
173	**A5-B5-D5**	**744,000**	**257,135**	**723,300**	**735,600**	**698,700**	**250,941**	**250,083**	**244,668**
175	A5-B6-D1	744,599	174,409	723,899	717,039	718,399	167,910	168,403	169,472
97	A3-B5-D1	758,733	193,238	717,460	*750,333*	732,533	186,222	185,855	188,313
51	A2-B3-D3	769,218	185,304	697,718	*768,950*	*764,064*	181,106	179,153	177,122
45	A2-B2-D3	774,538	189,195	703,038	*773,738*	*769,384*	184,993	182,667	181,005
57	A2-B4-D3	778,738	217,297	707,238	*777,518*	*773,584*	213,282	207,408	209,472

Table 5.48: Port Facility E – additional alternative portfolios ex-post the simulations

In the ex-ante portfolio optimization in section 5.9.5, there were 50 portfolios judged to be alternative portfolios where both the residual security risk and security investment are less than the status quo. Following the sensitivity analysis, a further five portfolios can be included, as listed in table 5.48. All five portfolios had higher security costs and residual security risk ex-ante the simulations than portfolio 173 but ex-post the simulations, combinations of security cost and residual security risk for the four portfolios can be found which are both less than the ex-post simulation for portfolio 173. As in table 5.44, there is overlap between the six portfolios.

5.10.2.6 Port Facility F

Additional alternative portfolios ex-post the simulations:									
Portfolio No	Portfolio	Ex-ante simulation: security costs	Ex-ante simulation: residual risk	Ex-post simulation security costs: access control cost - 10%	Ex-post simulation security costs: biometrics cost - 10%	Ex-post simulation security costs: detection cost - 10%	Ex-post simulation residual risk: access control performance +10%	Ex-post simulation residual risk: biometrics performance +10%	Ex-post simulation residual risk: detection performance +10%
216	**A6-B6-D6**	**1,949,689**	**155,539**	**1,817,258**	**1,922,129**	**1,914,711**	**149,812**	**151,820**	**149,431**
215	A6-B6-D5	2,052,912	174,093	1,920,481	*2,025,352*	*2,007,612*	*168,411*	*170,403*	*166,057*

Table 5.49: Port Facility F – additional alternative portfolios ex-post the simulations

In the ex-ante portfolio optimization in section 5.9.6, there were 105 portfolios judged to be alternative portfolios where both the residual security risk and security investment are less than the status quo. Following the sensitivity analysis, not one portfolio can be included. Portfolio number 215 is listed in the table 5.49 to illustrate only that it nearly qualified as an alternative portfolio in that the ex-post simulation of 10% reduction in access control costs is less than the ex-post simulation for portfolio 216 in respect of a 10% reduction in the cost of the biometrics systems.

5.10.3 Sensitivity Analysis Discussion

The sensitivity analysis consisted of two simulations: a 10% reduction in security cost of each security system and a 10% improvement in performance. The sensitivity analysis has shown that in five out of six of the port facilities, the number of alternative portfolios which (ex-post the simulation) resulted in both a reduction in residual risk and a reduction in security investment compared to the status quo was

five or less. In the case of port facility F, there were no alternative portfolios found ex-post the simulation; in port facility A there was only one alternative portfolio found ex-post the simulation; in port facility C there were four alternative portfolios found ex-post the simulation; and in port facility E there were five alternative portfolios found ex-post the simulation.

From this it can be inferred that the results of the original (ex-ante) portfolio optimization exercise appear to be robust. Only in the case of port facility D were there nine alternative portfolios identified by the simulations, but it should be borne in mind that the nine portfolios are in addition to 154 portfolios ex-ante the simulations where both the residual security risk and security investment .

However, the appearance of robustness of the original portfolio optimization exercise can be affirmed by plotting the results of the portfolio optimization ex-post the sensitivity analysis. The ex-post simulation results for port facility A are shown in chart 5.13. When compared with chart 5.7, which represents the portfolio optimization exercise for port facility A ex-ante the sensitivity analysis, the overall pattern remains similar. As the clustering of the mapped points of the portfolios ex-post the sensitivity analysis is similar for all of the port facilities, it is not necessary to re-draw charts 5.8 to 5.12 to illustrate this.

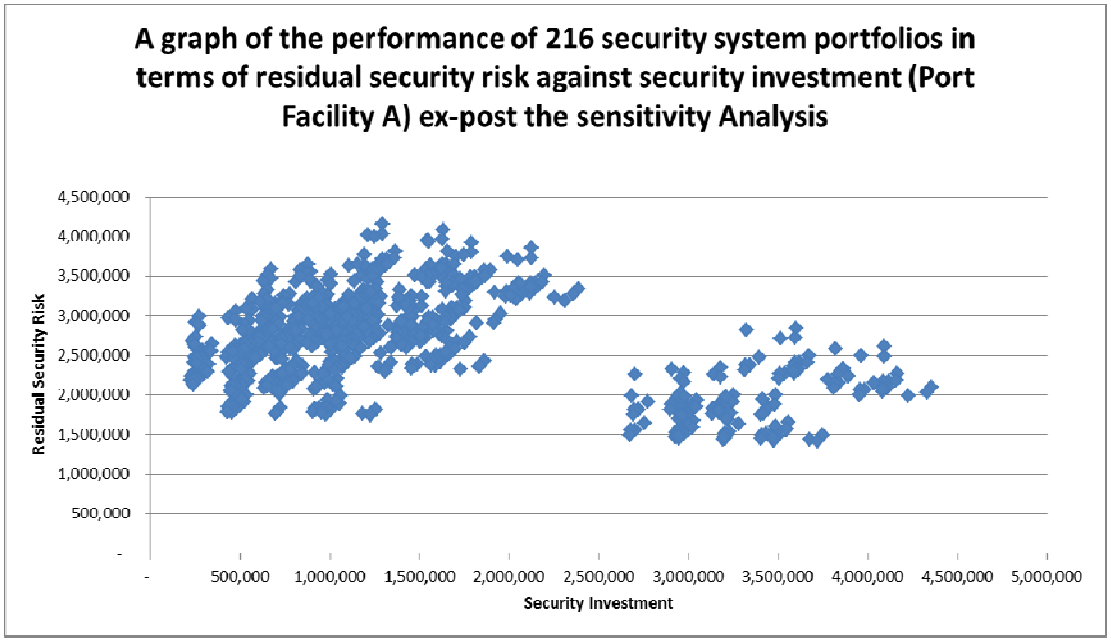


Chart 5.13 – Optimum Portfolio Analysis (Port Facility A) ex-post the sensitivity analysis

5.11 Results of the Portfolio Optimization

The portfolio optimization has produced some interesting results. The results are presented in two parts: first, the optimum and alternative portfolios which are most successful in reducing residual security risk; and secondly, the optimum and alternative portfolios which are most successful in reducing the security investment. Thirdly, a Venn Diagram shows the combination of the two. Finally, an explanation for the clustering effect found in the portfolio optimization will be made.

5.11.1 Reducing Residual Security Risk

The optimum portfolio for minimising the residual risk for both port facility A and port facility C is portfolio number 13, which consists of access control from port facility A, biometrics from port facility C and detection system from port facility A. The optimum portfolio for minimising the residual risk in both port facility D and port facility F is portfolio number 67, which consists of access control from port facility B, biometrics from port facility F and detection from port facility A. The optimum portfolios for minimising the residual risk in port facility B and port facility E are portfolio numbers 50 (A2-B3-D2) and 31 (A1-B6-D1) respectively. Overall, the security systems which make up the optimum portfolios for the reduction of residual risk across all of the port facilities consist of the following (in various combinations):

- Access control from either port facility A (A1) or port facility B (A2)
- Biometrics from either port facility C (B3) or port facility F (B6)
- Detection from either port facility A (D1) or port facility B (D2)

5.11.2 Reducing Security Investment

The optimum portfolio for minimising the security investment for port facility C, port facility D, port facility E and port facility F is portfolio number 15, which consists of access control from port facility A and biometrics and detection from port facility C. It is particularly interesting that one optimum portfolio of security systems is so dominant in minimising security investment. The portfolio for minimising the security investment in port facility A is portfolio number 13 (see above); and the corresponding portfolio for port facility B is number 14, which consists of access control from port facility A, biometrics from port facility C and detection from port

facility B. Overall, the security systems which make up the best performing portfolios for the reduction of security investment across all of the port facilities consist of the following (in various combinations):

- Access control from port facility A (A1)
- Biometrics from port facility C (B3)
- Detection from port facility A (D1), port facility B (D2) or port facility C (D3)

5.11.3 Reducing both Residual Security Risk and Security Investment

The security systems which are common to both the optimum portfolios for reduction in residual security risk and security investment are A1, B3, D1 and D2 as depicted in the intersection in the Venn Diagram in figure 5.1. They represent the access control and detection systems from port facility A, the biometrics system from port facility C and the detection system from port facility B.

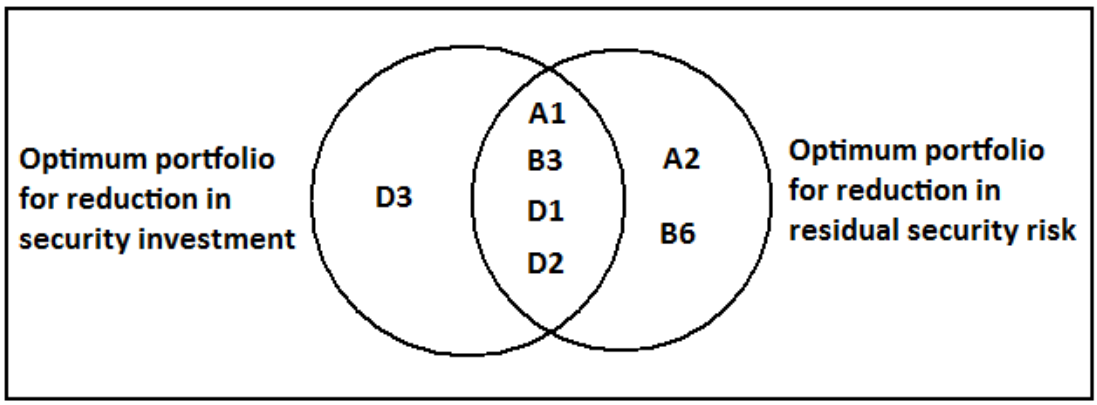


Figure 5.1: Venn Diagram of Optimum Portfolios for Reduction of both Security Investment and Residual Security Risk

5.12 Explanation for Clustering Effect

An explanation is offered for the clustering effect highlighted by the portfolio optimization. The clear division in the figures for the security investment between the two clusters makes the process relatively straightforward. The left hand cluster in charts 1 to 6 ends where the security investment is $2,387,582 (in portfolio #14) and the right hand cluster begins where the security investment is $2,946,811 (in portfolio #214). An examination of the portfolios where the security investment is $2,946,811 or greater yielded one common denominator: the inclusion in every alternative

portfolio in the right hand cluster of the security system D2, namely the detection system from port facility B. The evidence for this is shown in table 5.50. However, in order to be able to prove conclusively that security system D2 is responsible for the clustering, an analysis was conducted of the other 180 alternative portfolios and none were found to contain the security system D2. It is therefore shown that the clustering effect is entirely down to the inclusion in the alternative portfolios of the security system D2.

Portfolio number	Security system			Cost
212	A6	B6	D2	4,356,237
206	A6	B5	D2	4,164,637
182	A6	B1	D2	4,114,274
200	A6	B4	D2	4,092,837
188	A6	B2	D2	4,088,637
194	A6	B3	D2	4,083,317
140	A4	B6	D2	3,861,655
68	A2	B6	D2	3,746,925
134	A4	B5	D2	3,670,055
110	A4	B1	D2	3,619,692
128	A4	B4	D2	3,598,255
116	A4	B2	D2	3,594,055
122	A4	B3	D2	3,588,735
62	A2	B5	D2	3,555,325
38	A2	B1	D2	3,504,962
56	A2	B4	D2	3,483,525
44	A2	B2	D2	3,479,325
50	A2	B3	D2	3,474,005
104	A3	B6	D2	3,444,659
98	A3	B5	D2	3,253,059
176	A5	B6	D2	3,238,925
32	A1	B6	D2	3,219,751
74	A3	B1	D2	3,202,696
92	A3	B4	D2	3,181,259
80	A3	B2	D2	3,177,059
86	A3	B3	D2	3,171,739
170	A5	B5	D2	3,047,325
26	A1	B5	D2	3,028,151
146	A5	B1	D2	2,996,962
2	A1	B1	D2	2,977,788
164	A5	B4	D2	2,975,525
152	A5	B2	D2	2,971,325
158	A5	B3	D2	2,966,005
20	A1	B4	D2	2,956,351
8	A1	B2	D2	2,952,151
14	A1	B3	D2	2,946,831

Table 5.50 – Cluster Analysis of Alternative Portfolios where the Security Investment is $2,946,831 or greater.

5.13 Results of the Reliability Test using Cronbach's Alpha

The final result to be presented in this chapter is the measure of Cronbach's Alpha as described in section 3.4 above. In a 40 minute telephone call follow-up interview held on 21 October 2009, the second CSO was asked to repeat the exercise of providing his subjective assessments of the performances of the security systems for port facilities E and F. While the CSO was aware that the telephone call would take place, he was not made aware beforehand of the content of the call.

The results are shown in table 5.51.

Port Facility E	**Security system performance**		
Type of Security Incident	**Access Control**	**Biometrics**	**Detection**
Bomb introduced by person on foot	70%	80%	0%
Car Bomb	100%	80%	0%
Truck bomb	75%	80%	0%
Biological agent attack on terminal - on foot	90%	80%	0%
Biological agent attack on terminal - by vehicle	0%	0%	0%
Mining of port infrastructure	0%	0%	50%
Port Facility F	**Security system performance**		
Type of Security Incident	**Access Control**	**Biometrics**	**Detection**
Bomb introduced by person on foot	90%	90%	90%
Car Bomb	90%	90%	0%
Truck bomb	90%	90%	0%
Biological agent attack on terminal - on foot	20%	90%	80%
Biological agent attack on terminal - by vehicle	20%	90%	80%
Mining of port infrastructure	0%	0%	80%

Table 5.51 – Subjective assessments of Security system performance provided by the second CSO when re-interviewed on 21 October 2009 for Port Facility E and Port Facility F

The subjective assessments of the performances of the security systems from the telephone interview were compared with the data obtained in the interviews in March 2009 and the correlations are shown in table 5.52.

Cronbach's Alpha Calculation: Correlations						
	A5 first	B5 first	D5 first	A6 first	B6 first	D6 first
A5 second	0.974					
B5 second		1				
D5 second			1			
A6 second				0.996		
B6 second					1	
D6 second						0.726

Table 5.52 – Correlations of security system performances for Port facility E and Port F used for calculating Cronbach's Alpha

In the follow-up telephone interview, the second CSO stated that he did not have a copy of the data which he had given in the first interview in March 2009 but nevertheless the results are astonishing in how closely correlated they are: they yield a figure for Cronbach's Alpha of 0.9912. Given that the figure for Alpha is over 0.8, this means that the data can be considered to be very reliable (Forza, 2002, p177.) This means that there is no need to revise the subjective assessments of the performance of the port facilities' security systems given by the CSOs and that the data supplied by them in the earlier interviews is still valid for the purposes of this research.

Chapter 6 – Discussion

The chapter begins with an overview of the research findings, including linking the results to the literature. Next, the discussion compares the two approaches, the Markowitz method and the portfolio optimization approach. Finally, the discussion addresses the contribution which this thesis makes to academic research and makes suggestions for areas of future research.

6.1 Overview of the Research Findings

The research has focussed on the modelling of efficiency in port security systems and has addressed the research questions introduced in section 1.4. The efficient relationship between port security residual security risk and security investment has been discovered through the application of Markowitz theory of portfolio selection.

Furthermore, the structured nature of the research enables direct comparisons to be made between the security systems in the port facilities. Recalling the security performance results in tables 5.30, 5.31 and 5.32, some interesting conclusions can be drawn about the findings. Table 5.30 allows a direct comparison between the port facilities as to how the security systems perform and their costs. This is useful for a CSO to understand better where the strengths and weaknesses in the port facilities' security systems lie.

The benefit-cost ratios in table 5.31 enable a CSO to compare how much the residual risk is reduced in the port facilities given the security investment. This ratio can be used to identify by how much the residual risk would reduce given the introduction of new technology.

The residual risk : expected loss ratios in table 5.32 allow a comparison of how well the port facilities overall security systems perform in the face of the prescribed security threats. It is from this table that a CSO can draw some conclusions regarding how secure the port facilities are: the lower the ratio, the higher the level of security.

6.2 Research Findings – Links to the Literature

The purpose of this section is to discuss the research findings in the light of the literature. The four main areas linked to the existing literature are: security investment; security incident costs; port security risk sources; and port security benefit-cost analysis.

6.2.1 Security Investment

The figures for security investment for Port facility A (table 5.8), Port facility C (table 5.16) and Port facility E (table 5.24) compare favourably with the average security investments in both Dekker and Stevens (2007) and Benamara and Asariotis (2007) in section 2.7. However, the literature only provides the average security investments and running costs for different types of port facilities and does not include all of the results. Therefore, it is difficult to know how the three remaining port facilities compare.

6.2.2 Security Incident Costs

The figures for the security incident costs provided by the Director of Security and reproduced in section 5.1 appear to be on a comparable scale to the figures provided in the OECD (2003) report in section 2.7 and focus explicitly on the port facility rather than try to estimate the economic impact on the economy as a whole. This addition to the literature is useful in that it provides a subjective assessment by a port security expert on the potential losses arising from certain prescribed terrorist attacks.

6.2.3 Port Security Risk Sources

The one weakness with this research has been the inability to address, in their entirety, the port security risk sources adapted from Juttner et al (2003) as described in section 2.3.2: the research was limited to sources of terrorism risk by the limitations of the data available. Consideration must be given to wider environmental, network-related and organisational risk sources for future research of this nature to be of greater value.

6.2.4 Port Security Benefit-Cost Analysis

The benefit-cost analysis described by Willis and LaTourette (2008) in section 2.9 refers to a regulation being justified if the incremental cost of implementing the regulation is exceeded by the incremental benefit generated by the regulation. The security benefit-cost ratios in table 5.31 tell us that this principle is upheld only in the

example of Port facility A where $1 of investment in security results in a $7.13 reduction in residual security risk. In the other five examples , the security performance ratios are well below 1 and in the case of Port facility B it is particularly low at 0.0325. This suggests that the ISPS Code would not qualify as a justified regulation in the sense that Willis and LaTourette (2008) intended.

6.3 Markowitz Portfolio Selection Approach

As has been shown in Talas & Menachof (2009), a conceptual model of the application of portfolio selection theory can be applied to port security. However, the conceptual model in the paper and the application of Markowitz theory of portfolio selection in this research differs in one key aspect: the conceptual model assumes that the portfolio of security systems is sufficiently diversified for the application of portfolio theory to work.

In this research, the very close correlations between the performances of the security systems in three of the port facilities: A, B and C means that the application of the Markowitz theory may lose some of its value for these port facilities, though the application of the methodology is still valid.

However, this still begs the question: why are the performances of the security systems so closely correlated for port facilities A, B and C?

There does not appear to be any clear answer to the question. However, the interviews conducted with the two CSOs divide the six port facilities into two groups: the port facilities for which the first CSO was interviewed are, coincidentally port facilities A, B and C; while the second CSO was interviewed about port facilities D, E and F. No firm conclusions can be drawn at this stage regarding the differences between the subjective assessments given by the two CSOs but scope exists for further research into this phenomenon, perhaps beginning with Tversky and Kahneman's (1974) work on cognitive bias and the phenomenon of anchoring.

6.4 Portfolio Optimization Approach

The portfolio optimization approach follows a robust methodology. Its application has shown the optimum and alternative portfolios which result in both a reduction in residual security risk and security investment. This is significant because it tells us a

great deal about the performance of the security systems and how to combine them in the most efficient manner. The Venn Diagram in figure 5.1 shows the security systems which form the optimum portfolios for reducing both residual security risk and security investment. It is interesting to note that two of the security systems belong to port facility A, the port facility with the highest benefit-cost ratio.

Furthermore, the distribution of optimum and alternative portfolios in charts 5.7 to 5.12 in themselves give rise to a solution of the efficient relationship between a port facility's residual security risk and the security investment, an illustration of which is shown in chart 6.1. Given the existing levels of security threats to the port facilities and the existing security systems with their associated levels of performance in view of the security threats, the efficient frontier marks the boundary of what is achievable in terms of the efficient relationship between residual risk and security investment and the 216 possible portfolios lie either on the curve or to the right of the curve. This addresses the problem the research set out to address in section 1.2.

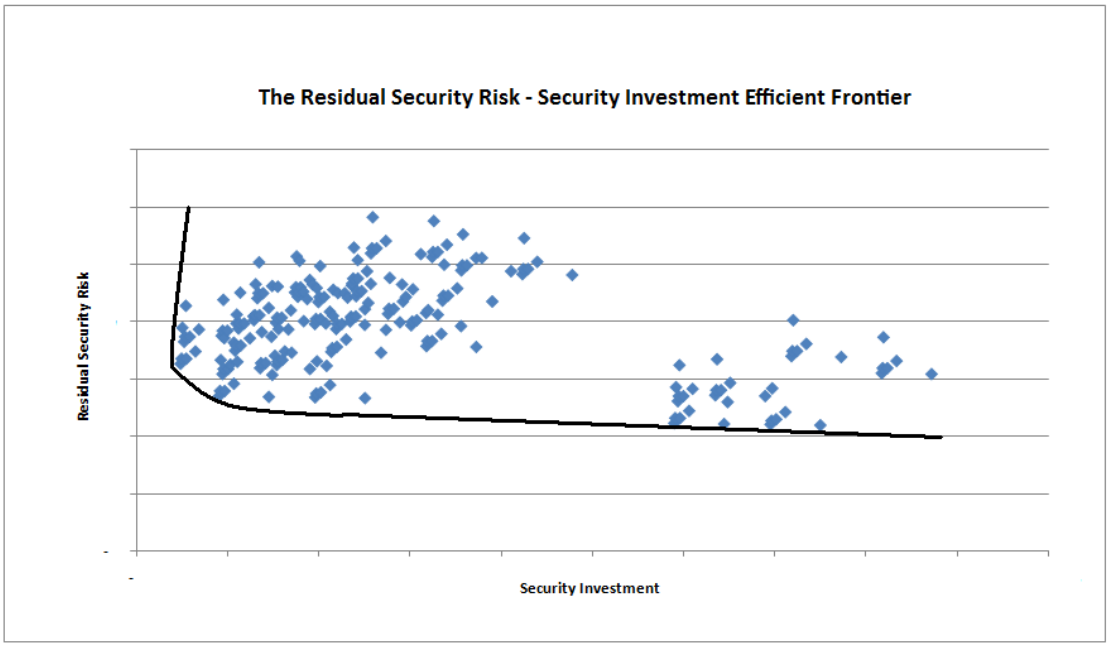


Chart 6.1: An illustration of the residual security risk – security investment efficient frontier

As in Chopra and Sodhi (2004), it is possible to move along the curve and for the port facility still to have an efficient relationship between residual security risk and security investment. However, what is interesting is what causes the efficient frontier curve to shift up and down and by how much. The curve might shift downwards if a

new technology were to be introduced which causes a security system to perform better than the status quo. However, the curve might shift upwards if the background threat level deteriorates. The key outcome of the research is that movements in and along the efficient frontier curve are quantifiable and their significance can be understood in financial terms. This can be particularly useful for decision makers without a background in security who can, nonetheless appreciate the change in such terms.

6.5 A Comparison of the Markowitz Method and Portfolio Optimization

One of the outcomes of the research has been the ability to compare the ability of the two approaches in the reduction of residual security risk in a port facility. The Markowitz approach works by efficiently rearranging the existing security systems as a portfolio and the portfolio optimization approach works by theoretically importing better performing security systems from other port facilities and modelling how the new portfolio of security systems works compared with the status quo. A comparison of the results shows that there is no clear winner between the two approaches. For port facility A, the Markowitz approach reduces risk by $422,165 while the portfolio optimization approach produces a reduction in risk of only $63,136. Similarly, for port facility B, the Markowitz approach reduces risk by $25,264 while the portfolio optimization approach manages only a $1,355 reduction in risk. For port facility C, the results are much closer as the Markowitz approach reduces risk by $67,151 and the portfolio optimization approach reduces risk by $32,527.

However, for port facility D, the positions are reversed. The Markowitz approach reduces risk by $67,151 but the portfolio optimization approach reduces risk by $309,837 which is a considerable difference. Similarly, for port facility E, the Markowitz approach reduces risk by $74,156 while the portfolio optimization approach reduces risk by $104,730. Finally, the comparison of the two methods for port facility F is similar to port facility C in that the Markowitz approach reduces risk by $62,303 and the portfolio optimization approach reduces risk by $59,379.

In attempting an explanation for these differences, it is perhaps useful to examine the positions of the six port facilities' portfolios in relation to the frontier in chart 6.1.

The positions of port facilities A and B are very close to the frontier, ie their security systems are already quite efficient and in both instances , the Markowitz approach

was clearly more successful in risk reduction. Considering port facilities C and F, they can be described as being near to the frontier and in both instances , the two approaches are comparable in their ability to reduce risk. However, what is clear is that for port facilities D and E, which lie much further away from the efficient frontier, the portfolio optimization approach produces the much larger reduction in risk, compared to the Markowitz approach. Further research could be carried into producing a definitive explanation for this phenomenon.

6.6 Contribution

The use of Markowitz theory of portfolio selection and portfolio optimization to arrive at the efficient relationship between residual security risk and security investment for port facilities is significant on three accounts. First, the methods can be employed in the development of Greenfield sites to guide a Company Security Officer to implement a security system which best suits his/her requirements in terms of both residual security risk and security investment and to do so efficiently. Secondly, the proposed introduction of new port security technology with an enhanced performance in an existing port facility can be modelled to learn the extent to which the residual security risk might be reduced, for a new given level of security investment. Thirdly, a change in the background security threat to a port facility can be quantified in terms of a change to the residual security risk. CSOs can use this information to help them decide on a possible course of action to address the change in threat. Furthermore, the quantifiable nature of the measure of residual security risk will enable executives from outside of the security department to understand the impact of security investment generally and to enable CSOs to justify their security spend. Fourthly, a theoretical contribution is derived through the adaptation of the Markowitz model from the field of finance, including stock markets, to the field of port security, in both cases with different sets of assumptions.

Finally, the research has yielded new definitions of port security and port security risk as well as providing the tools to measure two port security ratios: the security benefit-cost ratio which can be used when conducting a benefit-cost analysis; and the residual risk : expected loss ratio which enables a CSO or PFSO to compare the effectiveness of port security systems against prescribed security incidents.

6.7 Areas for Further Research

There are a three main areas for further research. The first concerns the implications of the cross-disciplinary application of Markowitz theory of portfolio selection and portfolio optimization. The second area continues the work of Gleason (1980) and examines probability distributions for terrorism which are not explained by Poisson. The third area for further research is concerned with the use of new data sources. Each of the three areas will be examined briefly below.

The first area for further research would be to collect empirical data on the change in performance of a port facility's security systems through the introduction of new technology or working practices. Further research could also include the application of the theory in the selection of a new security system for a Greenfield site. A further suggestion could be an attempt to discover whether the application of the ISPS Code, or some of the other security initiatives outlined in chapter II, can be made to be more efficient, in line with Willis and LaTourette's (2008) test for justified security legislation.

The second area of further research is to continue the work in this research which builds on Gleason's (1980) research on the probability distributions which may describe terrorism events. While this research has demonstrated that between 1968 and 2007, terrorist attacks against ports or against shipping in ports follows a Poission distribution, there is no evidence to suggest that terrorist attacks against non-port targets or other non-port maritime targets follow a Poisson distribution. Therefore, there is scope to research terrorist attacks of both marine and non-marine locations in order to discover the nature of the probability distributions which best describe them.

The third area of further research is the use of new sources of data. Such sources include ISPS Code compliant port facilities which are not container terminals, or other nodes in the supply chain such as warehouses or logistics parks which have adopted security systems and practices which are aligned with the ISPS Code. Furthermore, new sources of data can also include different forms of risk, not limited to terrorism alone, such as in this research. This would serve to address the gap in the literature described by Juttner et al (2003).

Chapter 7 - Conclusion

The research has focussed on the field of port security, an area of increasing interest to academics and was based on an industry example, namely six container port facilities owned by Dubai Ports (DP) World. The existing literature has been examined and new definitions of security, port security, port security risk and port security risk management have been proposed. Furthermore, a model of port security risk has been developed, based on Willis et al's (2005) definition of terrorist risk.

The main research question considered how ISPS Code compliant port facilities can discover the efficient relationship between residual security risk and security investment. In order to address the main research question, it was broken down into two further research questions which addressed what it means for a port facility to be ISPS Code compliant and how the efficient relationship between residual security risk and security investment can be calculated. The latter was tackled by means of asking a further five questions concerning security threats to port facilities; estimated gross losses to the port facilities following prescribed security threats; the security systems present in the port facilities; the performance of the security systems in the face of the prescribed security threats; and the security systems' costs. In order to tackle the main research question, an adaptive research strategy was employed, which combined contemporary empirical data in an industry example with a theory from the field of finance to produce a solution to the current problem. The research methodology employed mixed methods, which included survey questionnaires to assess the six DP World port facilities' security systems and costs; structured interviews with two of DP World's company security officers for their subjective evaluations of the performance of the security systems; and an interview with a Lloyd's Underwriter of terrorism risks.

The research has intentionally not produced any new theory about port security but has shown how company security officers can assess whether a port facility's security systems are efficient. This has been achieved in two ways: first, the Markowitz approach has treated a port facility's security systems as a portfolio in order to arrive at an efficient solution based on the risk-return (expected performance – standard

deviation) efficient frontier of the performance of the port facilities' security systems in the face of prescribed security threats.

The second approach was a portfolio optimization approach which theoretically constructed an optimum portfolio drawn from the security systems in the different port facilities in order to arrive at the best solution for risk reduction for that port facility, in much the same way as one might construct a 'fantasy cricket team' drawn from the best players in a cricket league. The portfolio optimization approach produced the efficient solution for the relationship between risk and security investment drawn from all 216 possible combinations of security system portfolios from among the three security systems (access control, biometrics and detection) across the six port facilities. The issue of the use of a relatively small dataset was addressed by conducting a sensitivity analysis using a simulation whereby the costs of the security systems were individually reduced by 10% while at the same time the performance of the individual security systems were individually improved by 10%. The results of the sensitivity analysis showed that following the simulation, the initial results of the portfolio optimization were still valid.

The main difference between the two approaches is that Markowitz method can be applied to a port facility in isolation, whereas the portfolio optimization approach relies on data from more than one port facility.

These two approaches were then compared and the results were mixed as to which method was more effective in reducing port security risk, though it appears that for those portfolios of security systems which lie closest to the efficient frontier solution, the Markowitz approach would be best suited to reduce risk and vice versa for the portfolios that lie furthest away from the efficient frontier.

Furthermore, the results of the research are generalizable to any ISPS Code compliant port facility or to any other type of node in the supply chain, such as a warehouse or logistics park, which consists of similar security systems and follows a similar security regime as that described in the ISPS Code.

The work by Gleason (1980) was extended to include more contemporary data on terrorist attacks on ports and on shipping in ports and these attacks were also shown to follow a Poisson distribution. This means that it is possible to arrive at a probability for a terrorist attack on a port or on shipping in a port in any given year, though with two key assumptions, namely that all attacks are independent and all port facilities are equally likely to be attacked. However, these two assumptions may be too great to

bear and thus it is still necessary to rely on the expert opinion of maritime terrorism underwriters from Lloyd's of London or other reputable underwriting establishments.

Furthermore, the research has produced two new port security ratios: the residual risk reduction : security expenditure ratio; and the residual risk : expected loss ratio. These ratios can be of use to port security personnel and company security officers when evaluating their security systems. The research contribution also includes a roadmap for developing security systems for Greenfield sites based on knowledge of existing security systems and the modelling of changes in background security risk and the introduction of new technology.

Finally, there is scope to extend the research in the future to include many more types of security threat, not only including the threat from terrorists, in order to build a more comprehensive model which will be of interest to academics and practitioners alike.

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Appendix A – ISPS Code Port Facility Security Equipment Checklist

	ISPS Port Facility Security Equipment Checklist			
ISPS Part/ Section Reference	**PORT FACILITY SECURITY PLAN TOPIC**	**ISPS CATEGORY**	**EQUIPMENT CATEGORY**	**EQUIPMENT REQUIRED**
A.16.3.2	The plan shall address measures designed to prevent unauthorised access to the port facility, ships at the facility & restricted areas	ACCESS TO PORT FACILITY	ACCESS CONTROL	FENCING / GATES
B.16.17.1	At security level 1, the plan should establish control points for the following:restricted areas, which should be bounded by fencing or other barriers to a standard which should be approved by the Contracting Government	ACCESS TO PORT FACILITY	ACCESS CONTROL	FENCING / GATES
B.16.19.2	At security level 2, the plan should establish the additional measures: limiting the number of access points to the port facility, and identifying those to be closed and the means of adequately securing them	ACCESS TO PORT FACILITY	ACCESS CONTROL	FENCING / GATES
B.16.28.7	At security level 2, the plan should address: establishing and restricting access to areas adjacent to the restricted areas	ACCESS TO PORT FACILITY	ACCESS CONTROL	FENCING / GATES
B.16.27.2	At security level 1, the plan should address: provision of access points controlled by security	ACCESS TO PORT FACILITY	ACCESS CONTROL	GATES

	guards when not locked.			
B16.25.4	Restricted areas may include: locations where security-sensitive information, including cargo documentation, is held.	ACCESS TO PORT FACILITY	ACCESS CONTROL	LOCKED PREMISES
B.16.29.1	At security level 3, the plan should address: setting up additional restricted areas within the port facility in proximity to the security incident, to which access is denied;	ACCESS TO PORT FACILITY	ACCESS CONTROL	MOBILE BARRIERS
B.16.27.1	At security level 1, the plan should address: provision of permanent or temporary barriers to surround the restricted area of a Government approved standard	ACCESS TO PORT FACILITY	ACCESS CONTROL	RESTRICTED AREA BARRIERS: FENCING / GATES
B.16.28.1	At security level 2, the plan should address: enhancing the effectivenes of the barriers or fencing surrounding restricted areas, including the use of patrols or automatic intrusion-detection devices;	ACCESS TO PORT FACILITY	ACCESS CONTROL	RESTRICTED AREA BARRIERS: FENCING / GATES
B.16.38.3	The security measures in the plan relating to the delivery of ships stores should prevent tampering	ACCESS TO PORT FACILITY	ACCESS CONTROL	RESTRICTED AREA BARRIERS: FENCING / GATES
B.16.19.3	At security level 2, the plan should establish the additional measures: providing for means of impeding movement through the remaining access points eg security barriers	ACCESS TO PORT FACILITY	ACCESS CONTROL	SECURITY BARRIERS
A.16.3.12	The plan shall address measures designed to ensure effective security of cargo and the cargo handling equipment at the port facility	ACCESS TO PORT FACILITY	ACCESS CONTROL	
B.16.20.1	At security level 3, the plan should detail the security measures which address the suspension of access to all or part of the port facility	ACCESS TO PORT FACILITY	ACCESS CONTROL / COMMS	AUTOMATIC ALERTS / ALARM SYSTEMS / PA / VHF UHF
B.16.20.2	At security level 3, the plan should detail the security measures which address the granting of access only to those responding to security	ACCESS TO PORT FACILITY	ACCESS CONTROL / COMMS / BIOMETRICS	ID PASSES

	incident or threat thereof			
B16.8.13	At all security levels, the procedures for assisting ship security officers in confirming the identity of those seeking to board the ship when requested	ACCESS TO PORT FACILITY	BIOMETRICS	ID PASSES
B.16.8.14	At all security levels, procedures for facilitating shore leave for ships' crews, or crew changes, or legitimate social & welfare visitors?	ACCESS TO PORT FACILITY	BIOMETRICS	ID PASSES
A.16.3.15	The plan shall address procedures for facilitating shore leave for ship's crews or crew changes, or legitimate welfare and social ship visitors	ACCESS TO PORT FACILITY	BIOMETRICS	ID PASSES
B.16.17.2	At security level 1, the plan should establish control points for the following: checking identity of all persons seeking entry to the port facility in connection with a ship including passengers, ship's personnel and visitors, and confirming their reasons for doing so by checking, for example, joining instructions, passenger tickets, boarding party, work orders etc.	ACCESS TO PORT FACILITY	BIOMETRICS	ID PASSES
A.16.3.5	The plan shall address procedures for evacuation in case of security threat or breaches	ACCESS TO PORT FACILITY	COMMS	ALARM SYSTEMS
B.16.20.5	At security level 3, the plan should detail the security measures which address the suspension of port operation within all or part of the port facility	ACCESS TO PORT FACILITY	COMMS	AUTOMATIC ALERTS / ALARM SYSTEMS / GATES / PA / VHF UHF
B.16.20.7	At security level 3, the plan should detail the security measures which address evacuation of all or part of the port facility	ACCESS TO PORT FACILITY	COMMS	AUTOMATIC ALERTS / ALARM SYSTEMS / PA / VHF UHF
B.16.20.3	At security level 3, the plan should detail the security measures which address the suspension of pedestrian or vehicular	ACCESS TO PORT FACILITY	COMMS / ACCESS CONTROL	AUTOMATIC ALERTS / ALARM SYSTEMS / GATES / PA / VHF UHF

	movement within all or part of the facility;			
B.16.17.4	At security level 1, the plan should identify control points for the verification of the identity of port facility personnel and those within the port facility and their vehicles	ACCESS TO PORT FACILITY	DATA RECORDING / BIOMETRICS	ID PASSES / VEHICLE PASSES
B.16.27.6	At security level 1, the plan should address: providing automatic intrusion detection devices, surveillance equipment, or systems designed to prevent unauthorised access into or movement within restricted areas	ACCESS TO PORT FACILITY	INTRUSION DETECTION DEVICE / CCTV / ACCESS CONTROL	
B.16.50	When used, automatic intrusion-detection devices should activate an audible and/or visual alarm at a location that is continuously attended or monitored	ACCESS TO PORT FACILITY	INTRUSION DETECTION DEVICES / AUDIO & VISUAL ALARMS	INTRUSION DETECTION DEVICES / AUDIO & VISUAL ALARMS
B.16.28.8	At security level 2, the plan should address: enforcing restrictions on access by unauthorised craft to the waters adjacent to ships using the port facility	ACCESS TO PORT FACILITY	PATROL VESSELS	PATROL VESSELS
B.16.17.3	At security level 1, the plan should identify control points for the following: checking vehicles used by those seeking entry to the port facility in connection with a ship	ACCESS TO PORT FACILITY	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT
B.16.17.6	At security level 1, the plan should identify control points for the undertaking of searches of persons, personal effects, verhicles & their contents	ACCESS TO PORT FACILITY	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT
B.16.19.4	At security level 2, the plan should establish the additional measures: increasing the frequency of searches of persons, personal effects, and vehicles;	ACCESS TO PORT FACILITY	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT

B.16.45	The plan should establish routines for screening unaccompanied baggage and personnel effects, whether of passengers or crew, before it enters the port facility, and if the storage arrangements dictate, before it is transferred between port facility and ship. At Security Level 1, the PFSP should allow for some Xray screening: at Security level 2, 100% Xray screening should be invoked	ACCESS TO PORT FACILITY	SCREENING EQUIPMENT	X-RAY
A.16.3.1	The plan shall address measures designed to prevent weapons or any other dangerous substances & devices whose carriage is not authorised from entering the port facility or ship	ACCESS TO PORT FACILITY	SCREENING EQUIPMENT	X-RAY SCANNERS
B.16.44	The plan should detail the security measures which could be taken by the port facility, which may include preparation for restriction or suspension, of the delivery of ship's stores within all, or part, of the port facility	DELIVERY OF SHIP'S STORES	COMMS	VHF / UHF
B.16.8.10	At all security levels procedures covering the delivery of ships' stores	DELIVERY OF SHIP'S STORES	SCREENING EQUIPMENT	HAND HELD SCANNER
B.16.40.3	At security level 1, the security measures in the plan relating to the delivery of ships stores should ensure the searching the delivery vehicle	DELIVERY OF SHIP'S STORES	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT
B.16.41	At security level 1, the use of scanners/detection equipment, mechanical devices and dogs, may be used for checking of ship's stores?	DELIVERY OF SHIP'S STORES	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT
B.16.42.1	At security level 2, the plan should establish the additional security measures to be applied to enhance the control of the delivery of ship's stores, which may include detailed checking of ship's stores	DELIVERY OF SHIP'S STORES	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT

B.16.42.2	At security level 2, the plan should establish the additional security measures to be applied to enhance the control of the delivery of ship's stores, which may include detailed searches of the delivery vehicles	DELIVERY OF SHIP'S STORES	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT
B.16.37.1	At security level 3, the plan should detail the security measures which could be taken by the port facility in cooperation with those responding and the ships, which may include: restriction or suspension of cargo movements or operations within all or part of the facility or specific ships	HANDLING OF CARGO	COMMS	AUTOMATIC ALERTS / ALARMS / VHF UHF
B.16.35.4	At security level 2, the plan should establish the additional security measures to be applied during cargo handling to enhance control, which may include: increased frequency and detail in checking of seals and other methods used to prevent tampering	HANDLING OF CARGO	E-SEAL INTEGRITY CHECKING EQUIPMENT	E-SEAL INTEGRITY CHECKING EQUIPMENT
B.16.32.4	At security level 1, the plan should address security measures to be applied during cargo handling which may include: checking of seals and other methods used to prevent tampering upon entering the port facility and upon storage within the port facility	HANDLING OF CARGO	E-SEAL INTEGRITY CHECKING EQUIPMENT	
B.16.32.3	At security level 1, the plan should address security measures to be applied during cargo handling which may include: searches of vehicles	HANDLING OF CARGO	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT
B.16.35.3	At security level 2, the plan should establish the additional security measures to be applied during cargo handling to enhance control, which may include: intensified searches of vehicles	HANDLING OF CARGO	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT

B.16.32.1	At security level 1, the plan should address security measures to be applied during cargo handling which may include: routine checking of cargo, cargo transporters and cargo storage areas within the port facility prior to and during cargo handling	HANDLING OF CARGO	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT / X-RAY
B.16.35.1	At security level 2, the plan should establish additional security measures to be applied during cargo handling to enhance control, which may include: detailed checking of cargo, cargo transporters, and cargo storage areas within the port facility	HANDLING OF CARGO	SCREENING EQUIPMENT	MOBILE SCANNING EQUIPMENT / X-RAY
B.16.48.1	The plan should stipulate that at Security Level 3, unaccompanied baggage should be subject to more extensive screening, for example x-raying it from at least two different angles	HANDLING OF UNACCOMPANIED BAGGAE	SCREENING EQUIPMENT	X-RAY
B.16.8.7	At all security levels, procedures to assess the continuing effectiveness of security measures, procedures & equipment, including identification of & response to equipment failure or malfunction;	MONITORING SECURITY OF PORT FACILITY	BACKUP SYSTEMS	
B.16.51	The plan should establish procedures and equipment needed at each Security Level and the means of ensuring that monitoring equipment will be able to perform continually, including consideration of the possible effects of weather conditions or of power disruptions?	MONITORING SECURITY OF PORT FACILITY	BACKUP SYSTEMS	
B.16.28.5	At security level 2, the plan should address: use of continuously monitored & recording surveillance equipment	MONITORING SECURITY OF PORT FACILITY	CCTV	CCTV
B.16.54.2	For security level 3, the plan should detail the security measures which could be taken by the port facility which may include: switching on of all surveillance equipment capable of recording activities within, or adjacent to, the port facility	MONITORING SECURITY OF PORT FACILITY	CCTV	CCTV

B.16.54.3	For security level 3, the plan should detail the security measures which could be taken by the port facility which may include: maximising the length of time such surveillance equipment can continue to record	MONITORING SECURITY OF PORT FACILITY	CCTV / DATA RECORDING	CCTV / DATA RECORDING
A.16.3.14	The plan shall address procedures for responding in case the ship security alert system of a ship at the port facility has been activated	MONITORING SECURITY OF PORT FACILITY	COMMS	AUTOMATIC ALERTS / ALARM SYSTEMS / UHF VHF
A.16.3.3	The plan shall address procedures for responding to security threats or breaches of security, including provisions for maintaining critical operations of ship or ship/port interface	MONITORING SECURITY OF PORT FACILITY	COMMS	AUTOMATIC ALERTS / ALARM SYSTEMS / VHF UHF
A.16.3.4	The plan shall address procedures for responding to any security instructions the contracting government may give at Security Level 3	MONITORING SECURITY OF PORT FACILITY	COMMS	AUTOMATIC ALERTS / ALARM SYSTEMS / VHF UHF / PA
B.16.57	The plan should establish the procedures to be followed when, on the instructions of the Contracting Government, the PFSO requests a DoS or when a DoS is requested by a ship	MONITORING SECURITY OF PORT FACILITY	COMMS	EMAIL ALERT
B.16.3.2	Links and communications arrangements with ships in port facility And other relevant authorities	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF
B.16.8.4	At all security levels a communications system which allows effective & continuous communication between port facility security personnel & ships & national or local security authorities	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF
A.16.3.7	The plan shall address procedures for interfacing with ship security activities	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF
B.16.20.6	At security level 3, the plan should detail the security measures which address the direction of vessel movements relating to all or part of the port facility	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF

B.16.27.7	At security level 1, the plan should address: control of the movement of vessels in the vicinity of ships using the port facility.	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF
B.16.56.1	The plan should establish procedures and security measures the port facility should apply when it is interfacing with a ship which has been at a port of a State which is not a Contracting Government	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF
B.16.56.2	The plan should establish procedures and security measures the port facility should apply when it is interfacing with a ship to which the Code does not apply	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF
B.16.56.3	The plan should establish procedures and security measures the port facility should apply when it is interfacing with fixed or floating platforms or mobile offshore drilling unit on location?	MONITORING SECURITY OF PORT FACILITY	COMMS	VHF / UHF
B16.8.12	At all security levels, the means of alerting & obtaining waterside patrols & specialist search teams including bomb & underwater;	MONITORING SECURITY OF PORT FACILITY	COMMS / PATROL VESSELS / IED DETECTION EQUIPMENT	VHF UHF / PATROL VESSELS / IED DETECTION EQUIPMENT
A.16.7	If the plan is kept in an electronic format, it shall be protected by procedures aimed at preventing its unauthorised deletion, destruction, or amendment	MONITORING SECURITY OF PORT FACILITY	DATA RECORDING	DATA PROTECTION SYSTEM
B.16.8.6	At all security levels protection of security information held in paper or electronic format	MONITORING SECURITY OF PORT FACILITY	DATA SECURITY	FIRE PROOF CABINET / ENCRYPTED SOFTWARE
A.16.8	The plan shall be protected from unauthorized access or disclosure	MONITORING SECURITY OF PORT FACILITY	DATA SECURITY	FIRE PROOF CABINET / ENCRYPTED SOFTWARE
A.16.3.11	The plan shall address measures to ensure the security of the information in the plan	MONITORING SECURITY OF PORT FACILITY	DATA SECURITY	FIREPROOF SAFE / ENCRYPTION SOFTWARE
B.16.7	Guidance on the bearing and use of firearms (if appropriate)	MONITORING SECURITY OF PORT FACILITY	FIREARMS CABINETS	FIREARMS CABINETS

B.16.49.3	The plan should include as means of monitoring the port facility day and night, and the ships and areas surrounding them, the following measures: automatic intrusion-detection devices and surveillance equipment	MONITORING SECURITY OF PORT FACILITY	INTRUSION DETECTION DEVICES / CCTV	INTRUSION DETECTION DEVICES / CCTV
B.16.49.1	The plan should include as means of monitoring the port facility day and night, and the ships and areas surrounding them, the following measures: lighting	MONITORING SECURITY OF PORT FACILITY	LIGHTING	LIGHTING
B.16.54.1	For security level 3, the plan should detail the security measures which could be taken by the port facility which may include: switching on of all lighting within, or illuminating the vicinity of, the port facility	MONITORING SECURITY OF PORT FACILITY	LIGHTING	LIGHTING
B.16.52.2	For Security Level 1, the plan should establish the security measures to be applied, which may be a combination of lighting, security guards or use of security and surveillance equipment to allow port facility security personnel to observe access points, barriers and restricted areas	MONITORING SECURITY OF PORT FACILITY	LIGHTING / CCTV	LIGHTING / CCTV
B.16.53.1	For security level 2, the plan should establish the security levels to be applied for increasing the coverage and intensity of lighting and surveillance equipment, including the provision of additional lighting and surveillance coverage	MONITORING SECURITY OF PORT FACILITY	LIGHTING / CCTV	LIGHTING / CCTV
B.16.52.1	For Security Level 1, the plan should establish the security measures to be applied, which may be a combination of lighting, security guards or use of security and surveillance equipment to allow port facility security personnel to observe the general port facility area, including shore and waterside accesses to it	MONITORING SECURITY OF PORT FACILITY	LIGHTING / CCTV / RADAR	LIGHTING / CCTV / RADAR
B.16.19.6	At security level 2, the plan should establish the additional measures: using patrol vessels to enhance water-side security	MONITORING SECURITY OF PORT FACILITY	PATROL VESSELS	PATROL VESSELS

B.16.28.6	At security level 2, the plan should address: enhancing the number and frequency of patrols, including water-side patrols, undertaken on the boundaries of the restricted areas & within the areas	MONITORING SECURITY OF PORT FACILITY	PATROL VESSELS	PATROL VESSELS
B.16.49.2	The plan should include as means of monitoring the port facility day and night, and the ships and areas surrounding them, the following measures: security guards including foot, vehicle and waterborne patrols	MONITORING SECURITY OF PORT FACILITY	PATROL VESSELS	PATROL VESSELS
B.16.53.2	For security level 2, the plan should establish the security levels to be applied for increasing the frequency of foot, vehicle and waterborne patrols	MONITORING SECURITY OF PORT FACILITY	PATROL VESSELS	PATROL VESSELS
B.16.52.3	For Security Level 1, the plan should establish the security measures to be applied, which may be a combination of lighting, security guards or use of security and surveillance equipment to allow port facility security personnel to monitor areas and movements adjacent to ships using the port facility, including augmentation of lighting provided by ships themselves	MONITORING SECURITY OF PORT FACILITY	RADAR	RADAR
B.16.27.3	At security level 1, the plan should address: providing compulsorily displayed restricted area passes.	RESTRICTED AREAS	BIOMETRICS	ID PASSES
B.16.27.4	At security level 1, the plan should address: clearly marking vehicles allowed access to restricted areas.	RESTRICTED AREAS	BIOMETRICS	VEHICLE MARKINGS
B.16.25.7	Restricted areas may include: areas where security & surveillance equipment are located.	RESTRICTED AREAS	SIGNAGE	LOCKED PREMISES
B.16.25.1	Restricted areas may include: shore and waterside areas immediately adjacent to the ship	RESTRICTED AREAS	SIGNAGE	SIGNS

B.16.25.2	Restricted areas may include: embarkation and disembarkation areas, passenger and ship's personnel holding & processing areas, including search points.	RESTRICTED AREAS	SIGNAGE	SIGNS
B.16.25.3	Restricted areas may include: areas where loading, unloading or storage of cargo and stores is undertaken.	RESTRICTED AREAS	SIGNAGE	SIGNS
B.16.25.5	Restricted areas may include: areas where dangerous goods and hazardous substances are held.	RESTRICTED AREAS	SIGNAGE	SIGNS
B.16.25.8	Restricted areas may include: essential electrical, radio & terlecommunication, water & other utility installations.	RESTRICTED AREAS	SIGNAGE	SIGNS
B.16.25.9	Restricted areas may include: other locations in the port facility where access by vessels, vehicles and individuals shbould be restricted.	RESTRICTED AREAS	SIGNAGE	SIGNS
B16.25.6	Restricted areas may include: VTM system control rooms, aids to navigation & port facility Control buildings, including security & surveillance control rooms.	RESTRICTED AREAS	SIGNAGE / SECURITY CONTROL ROOM	CONTROL SYSTEMS

Appendix B - Copy of Confidential Questionnaire on Port Security

Confidential Questionnaire on Port Security

1) Please enter the name of your Port

_____

2) Please enter the name of the Port Facility

_____

3) Please select your job position from the list below

- ❍ Port Security Officer
- ❍ Port Facility Security Officer
- ❍ Other (please specify)

If you selected other please specify:

_____

4) Please select the principal activity of the port facility

- ❍ Container Terminal
- ❍ Passenger Terminal
- ❍ Oil / Oil Products Terminal
- ❍ Ro-Ro Terminal
- ❍ LNG / LPG Terminal
- ❍ Bulk Terminal
- ❍ General Cargo Terminal
- ❍ Car Terminal
- ❍ Other (please specify)

If you selected other please specify:

_____

5) Please select the type of perimeter fencing in the port facility

- ❑ Chain link
- ❑ Expanded metal
- ❑ Steel pallisades
- ❑ Weldmesh
- ❑ Opaque
- ❑ Other (please specify)

If you selected other please specify:

_____

6) Please indicate the costs of the perimeter fencing in question 5

Cost of installation _____
Annual cost of maintenance _____

7) What is the height of the perimeter fence at its lowest point in metres?

_____

8) What is the approximate overall length of the perimeter fence?

_____

9) Please select from the list the access control measures in the port facility

- ❑ Main security gate
- ❑ Main security gate guardhouse
- ❑ Second security gate
- ❑ Second security gate guardhouse
- ❑ Additional security gates / guardhouses
- ❑ Mobile security gates
- ❑ Mobile security barriers
- ❑ Other (please specify)

If you selected other please specify:

_____

10) Please indicate the costs of the access control measures in question 9

Installation cost _____
Annual cost of maintenance _____

11) Please select the types of security detection systems which are present in the port facility

- ❑ Perimeter intruder detection system
- ❑ Perimeter lighting
- ❑ Lighting of restricted areas
- ❑ Cargo handling lighting
- ❑ Passenger handling lighting
- ❑ Access routes lighting
- ❑ CCTV - main gate
- ❑ CCTV - other gates
- ❑ CCTV - restricted areas
- ❑ CCTV - perimeter
- ❑ CCTV - cargo handling areas
- ❑ CCTV - passenger handling areas
- ❑ CCTV - office buildings
- ❑ Surface radar
- ❑ Underwater sonar
- ❑ Other (please specify)

If you selected other please specify:

_____

12) Please indicate the installation costs of the types of security detection systems in question 11

Perimeter intruder detection system _____
Perimeter lighting _____
Lighting of restricted areas _____
Cargo handling lighting _____
Passenger handling lighting _____
Access routes lighting _____
CCTV - main gate _____
CCTV - other gates _____
CCTV - restricted areas _____
CCTV - perimeter _____
CCTV - cargo handling areas _____
CCTV - passenger handling areas _____
CCTV - office buildings _____
Surface radar _____
Underwater sonar _____
Other (as specified above) _____

13) Please indicate the maintenance / running costs of the types of security detection systems in question 11

Perimeter intruder detection system _____
Perimeter lighting _____
Lighting of restricted areas _____
Cargo handling lighting _____
Passenger handling lighting _____
Access routes lighting _____
CCTV - main gate _____
CCTV - other gates _____
CCTV - restricted areas _____
CCTV - perimeter _____
CCTV - cargo handling areas _____
CCTV - passenger handling areas _____
CCTV - office buildings _____
Surface radar _____
Underwater sonar _____
Other (as specified above) _____

14) Please select the options which best describe the security lighting in the port facility

	Excellent - no black spots	Good - only a few black spots	Marginal - patchy coverage	Poor - hardly any coverage
Perimeter lighting	❍	❍	❍	❍
Restricted access lighting	❍	❍	❍	❍
Cargo handling lighting	❍	❍	❍	❍
Passenger handling lighting	❍	❍	❍	❍
Access routes lighting	❍	❍	❍	❍

15) Please select the biometric security systems which operate in the port facility

- ❑ Retinal scans
- ❑ Fingerprint scans
- ❑ Photo ID cards for employees
- ❑ Photo ID cards for regular port facility Contractors / vendors
- ❑ Instant photo ID cards for visitors
- ❑ Visitor passes (numbered)
- ❑ Vessel crew passes (numbered)
- ❑ Vehicle passes (numbered)
- ❑ Other (please specify)

If you selected other please specify:

_____

16) Please indicate the installation costs of the biometric security systems in question 15

Retinal scans _____
Fingerprint scans _____
Photo ID cards for employees _____
Photo ID cards for regular port facility _____
Contractors / vendors
Instant photo ID cards for visitors _____
Visitor passes (numbered) _____
Vessel crew passes (numbered) _____
Vehicle passes (numbered) _____
Other (as specified above) _____

17) Please indicate the maintenance / running costs of the biometric security systems in question 15

Retinal scans _____
Fingerprint scans _____
Photo ID cards for employees _____
Photo ID cards for regular port facility _____
Contractors / vendors
Instant photo ID cards for visitors _____
Visitor passes (numbered) _____
Vessel crew passes (numbered) _____
Vehicle passes (numbered) _____
Other (as specified above) _____

18) Please select the options which best describe the security patrols in the port facility

	All areas	Restricted areas only	Other specific areas (please state below)
Land side patrols – scheduled regular	❍	❍	❍
Land side patrols – scheduled random	❍	❍	❍
Land side patrols – unscheduled	❍	❍	❍
Water side patrols – scheduled regular	❍	❍	❍
Water side patrols – scheduled random	❍	❍	❍
Water side patrols – Unscheduled	❍	❍	❍

19) Please select the security communications systems used in the port facility

❑ VHF radio
❑ UHF radio
❑ Push-to-Talk radio
❑ General audio alarm
❑ Visual alarm
❑ Public address system
❑ Other (please specify)

If you selected other please specify:

_____

20) Please indicate the costs of the security communications systems used in the port facility

Installation cost _____
Annual cost of maintenance / running costs _____

21) Please select the forms of security data communication in the port facility

- ❑ Trunk cabling (copper wire)
- ❑ Microwave
- ❑ Fibre optics
- ❑ Other (please specify)

If you selected other please specify:

_____

22) Please list the number of security personnel employed in the port facility

Number of security guards on the access gates / gatehouses _____
Number of security guards on patrols _____
Number of security personnel in the control room _____
Number of security personnel that can respond quickly to an incident _____
Other specialised security personnel _____

23) Please indicate the average annual cost of security guards / personnel

On the access gates / guardhouses _____
Patrolling _____
In the control room _____
Other specialised security personnel as specified above _____

24) Please identify the location and type of cargo security detection equipment in the port facility

	Fixed chemical / biological / radiological detectors	Mobile chemical / biological / radiological detectors	Fixed X-ray scanners	Mobile X-ray scanners	Other fixed scanning equipment	Other mobile scanning equipment
Access points	❑	❑	❑	❑	❑	❑
Cargo handling terminal	❑	❑	❑	❑	❑	❑
Passenger handling terminal	❑	❑	❑	❑	❑	❑
Segregated areas	❑	❑	❑	❑	❑	❑
Restricted areas	❑	❑	❑	❑	❑	❑

25) Please indicate the installation costs of the cargo security detection equipment in question 24

Fixed chemical / biological / radiological detectors _____
Mobile chemical / biological / radiological detectors _____
Fixed X-ray scanners _____
Mobile X-ray scanners _____
Other fixed scanning equipment _____
Other mobile scanning equipment _____

26) Please indicate the maintenance / running costs of the cargo security detection equipment in question 24

Fixed chemical / biological / radiological detectors _____
Mobile chemical / biological / radiological detectors _____
Fixed X-ray scanners _____
Mobile X-ray scanners _____
Other fixed scanning equipment _____
Other mobile scanning equipment _____

27) Please indicate how the individual security systems are integrated and monitored from the central control room

	Are the systems integrated?		Are they monitored from the security control room?	
	Yes	No	Yes	No
Gatehouse alarms	❍	❍	❍	❍
AIDD alarms	❍	❍	❍	❍
CCTV motion detector alarms	❍	❍	❍	❍
Restricted area alarms	❍	❍	❍	❍
Cargo handling area alarms	❍	❍	❍	❍
Passenger handling area alarms	❍	❍	❍	❍
General alarms	❍	❍	❍	❍
CBR detector alarms	❍	❍	❍	❍
Container scanner alarms	❍	❍	❍	❍
Communication systems	❍	❍	❍	❍
Security patrols	❍	❍	❍	❍

28) Please indicate an estimate for the overall cost of security systems integration

_____

29) Please list the crisis management systems which exist in the port facility

- ❑ Specialist crisis management software
- ❑ Duplicate (remote) IT system
- ❑ Emergency power supply
- ❑ Other (please specify)

If you selected other please specify:

_____

30) Please indicate the costs of the crisis management systems in question 29

Installation cost _____
Annual cost of maintenance / running costs _____

Appendix C – Port Facilities' Security Costs

Terminals' Security System Costs – Port facility A

Region	
Business Unit/Site	Port facility A

Perimeter Fencing	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Chain link	$73,170	$1,000
Expanded metal		
Steel pallisades		
Weldmesh		
Masonry/brick	$34,156	$5,000
Opaque		
Other (Please specify)		
Total	$107,326	$6,000
Height of fence at lowest point (meters)		
Length of fence (meters)		
Comments on perimeter fencing	Perimeter on PQA channel water side is fenced (510 m) and landside is masonary (600 + 457 = 1057 m).	

Access Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Main security gate	$7,361	$200
Main security gate guardhouse	$7,361	$200
Second security gate	$7,361	$200
Second security gate guardhouse	$15,950	$1,329
Additional security gates/guardhouses	$4,878	$300
Mobile security gates		
Mobile security barriers	$3,453	
Other (please specify)	$19,000	$4,000
Comments on access control		
Total	$65,364	$6,229

Identity Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Retinal scans		
Fingerprint scans	$20,320	

Photo ID cards for employees	$3,867	
Photo ID cards for regular Business Unit contractors / vendors	$3,867	
Instant photo ID cards for visitors	$1,933	
Visitor passes (numbered)	$100	$50
Vessel crew passes (numbered)		
Vehicle passes (numbered)		$3,500
Other (please specify)		
Comments on identity control		
Total	$30,087	$3,550

Security Detection	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Perimeter intruder detection system	$5,000	$1
Perimeter lighting	$16,250	$4,000
Lighting of restricted areas		$2,500
Cargo handling lighting	$106,250	$12,500
Passenger handling lighting		
Access routes lighting		$3,500
CCTV - main gate	$18,650	$2,700
CCTV - other gates	$18,552	$2,700
CCTV - restricted areas	$37,300	$4,050
CCTV - perimeter	$9,325	$1,350
CCTV - cargo handling areas	$9,325	$1,350
CCTV - passenger handling areas		
CCTV - office buildings	$3,370	
Surface radar		
Underwater sonar		
Other (please specify)		
Comments on security detection		
Total	$224,022	$34,651

Security Communications	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
VHF radio	$160	$1
UHF radio		
Push-to-Talk radio		

General audio alarm		
Visual alarm		
Public address system	$9,500	
Other (please specify)	$400	$100
Comments on security communications		
Total	$10,060	$101

Please describe the shift pattern at your site		**2007 Annual cost in US$**
Number of security guards on the access gates / gatehouses (included in figure for access control)		$2,907
Number of security guards on patrols (included in figure for detection)		$1,663
Number of security personnel in the control room (included in figure for detection)		$1,663
Other specialised security personnel		$2,078
Number of security personnel that can respond quickly to an incident		$6,858
Are your security personnel licenced?		$100
Type of license		
Does your site hold their training records?		$150

Crisis Management	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Specialist crisis management software		
Duplicate (remote) IT system	$90,000	$6,000
Emergency power supply	$46,700	$5,000
Crisis management - Service Providers		
Other (please specify)		

	Fixed	**Variable**
Access Control	$172,690	$15,136
Biometrics	$30,087	$3,550

Detection	$224,022	$37,977

Terminals' Security System Costs – Port facility B

Region	
Business Unit/Site	Port facility B

Perimeter Fencing	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Chain link	$270,000	$5,000
Expanded metal		
Steel pallisades		
Weldmesh		
Masonry/brick		
Opaque		
Other (Please specify)		
Total	$270,000	$5,000
Height of fence at lowest point (meters)	3m	
Length of fence (meters)	1300m	
Comments on perimeter fencing		

Access Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Main security gate	$125,000	$5,000
Main security gate guardhouse		
Second security gate		
Second security gate guardhouse		
Additional security gates/guardhouses		
Mobile security gates		
Mobile security barriers		
Other (please specify)		
Comments on access control		
Total	$125,000	$5,000

Identity Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Retinal scans		
Fingerprint scans		
Photo ID cards for employees	$7,000	$1,000

Photo ID cards for regular Business Unit contractors / vendors		
Instant photo ID cards for visitors		
Visitor passes (numbered)		
Vessel crew passes (numbered)		
Vehicle passes (numbered)		
Other (please specify)		
Comments on identity control		
Total	$7,000	$1,000

Security Detection	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Perimeter intruder detection system		
Perimeter lighting		
Lighting of restricted areas		
Cargo handling lighting		
Passenger handling lighting		
Access routes lighting		
CCTV - main gate CCTV - other gates CCTV - restricted areas	$2,223,000	$100,000
CCTV - perimeter	$125,000	
CCTV - cargo handling areas		
CCTV - passenger handling areas		
CCTV - office buildings	$46,325	
Surface radar		
Underwater sonar		
Other (please specify)		
Comments on security detection		
Total	$2,394,325	$100,000

Security Communications	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
VHF radio	$1,200	$200
UHF radio		
Push-to-Talk radio		
General audio alarm		
Visual alarm		

Public address system		
Other (please specify)		
Comments on security communications		
Total	$1,200	$200

Please describe the shift pattern at your site		**2007 Annual cost in US$**
Number of security guards on the access gates / gatehouses (included in figure for access control)		$310,000
Number of security guards on patrols (included in figure for detection)		$186,000
Number of security personnel in the control room (included in figure for detection)		$76,000
Other specialised security personnel		
Number of security personnel that can respond quickly to an incident		
Are your security personnel licenced?		
Type of license		
Does your site hold their training records?		

Crisis Management	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Specialist crisis management software		
Duplicate (remote) IT system	$125,000	$15,000
Emergency power supply		
Crisis management - Service Providers		
Other (please specify)		

	Fixed	**Variable**
Access Control	$395,000	$320,000
Biometrics	$7,000	$1,000
Detection	$2,394,325	$362,000

Terminals' Security System Costs – Port facility C

Region	
Business Unit/Site	Port facility C

Perimeter Fencing	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Chain link		
Expanded metal		
Steel pallisades		
Weldmesh	$223,222	
Masonry/brick		
Opaque		
Other (Please specify)		
Total	$223,222	$0
Height of fence at lowest point (meters)	2.30m	
Length of fence (meters)	250 metres	
Comments on perimeter fencing		

Access Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Main security gate		
Main security gate guardhouse		
Second security gate		
Second security gate guardhouse		
Additional security gates/guardhouses		
Mobile security gates		
Mobile security barriers		
Other (please specify)	$12,000	$2,750
Comments on access control	security car	security car
Total	$12,000	$2,750

Identity Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Retinal scans		
Fingerprint scans		
Photo ID cards for employees	$2,480	

Photo ID cards for regular Business Unit contractors / vendors		
Instant photo ID cards for visitors		
Visitor passes (numbered)	$100	
Vessel crew passes (numbered)		
Vehicle passes (numbered)	$100	
Other (please specify)		
Comments on identity control		
Total	$2,680	$0

Security Detection	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Perimeter intruder detection system		
Perimeter lighting		
Lighting of restricted areas		
Cargo handling lighting		
Passenger handling lighting		
Access routes lighting		
CCTV - main gate	$13,000	
CCTV - other gates		
CCTV - restricted areas		
CCTV - perimeter		
CCTV - cargo handling areas		
CCTV - passenger handling areas		
CCTV - office buildings	$5,250	
Surface radar		
Underwater sonar		
Other (please specify)		
Comments on security detection		
Total	$18,250	$0

Security Communications	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
VHF radio	$150	$60
UHF radio		
Push-to-Talk radio		
General audio alarm		
Visual alarm		

Public address system		
Other (please specify)		
Comments on security communications		
Total	$150	$60

Please describe the shift pattern at your site		**2007 Annual cost in US$**
Number of security guards on the access gates / gatehouses (included in figure for access control)		$174,762
Number of security guards on patrols (included in figure for detection)		$16,644
Number of security personnel in the control room (included in figure for detection)		$16,644
Other specialised security personnel		$17,116
Number of security personnel that can respond quickly to an incident		
Are your security personnel licenced?		
Type of license		
Does your site hold their training records?		

Crisis Management	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Specialist crisis management software		
Duplicate (remote) IT system	$115,000	$14,000
Emergency power supply	$20,710	
Crisis management - Service Providers		
Other (please specify)		

	Fixed	**Variable**
Access Control	$235,222	$177,512
Biometrics	$2,680	$0
Detection	$18,250	$33,288

Terminals' Security System Costs – Port facility D

Region	
Business Unit/Site	Port facility D

Perimeter Fencing	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Chain link	$209,840	
Expanded metal		
Steel pallisades		
Weldmesh		
Masonry/brick		
Opaque		
Other (Please specify)		
Total	$209,840	$0
Height of fence at lowest point (meters)		
Length of fence (meters)		
Comments on perimeter fencing		

Access Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Main security gate Main security gate guardhouse	$369,890	$10,000
Second security gate		
Second security gate guardhouse		
Additional security gates/guardhouses		
Mobile security gates		
Mobile security barriers		
Other (please specify)		
Comments on access control		
Total	$369,890	$10,000

Identity Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Retinal scans		
Fingerprint scans	$10,000	$1,000
Photo ID cards for employees	$1,200	

Photo ID cards for regular Business Unit contractors / vendors		
Instant photo ID cards for visitors		
Visitor passes (numbered)		
Vessel crew passes (numbered)		
Vehicle passes (numbered)		
Other (please specify)		
Comments on identity control		
Total	$11,200	$1,000

Security Detection	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Perimeter intruder detection system		
Perimeter lighting	$625,920	$33,750
Lighting of restricted areas		
Cargo handling lighting		
Passenger handling lighting		
Access routes lighting		
CCTV - main gate		
CCTV - other gates		
CCTV - restricted areas		
CCTV - perimeter		
CCTV - cargo handling areas		
CCTV - passenger handling areas		
CCTV - office buildings	$5,000	
Surface radar		
Underwater sonar		
Other (please specify)		
Comments on security detection		
Total	$630,920	$33,750

Security Communications	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
VHF radio	$400	$50
UHF radio		
Push-to-Talk radio		
General audio alarm	$125	$20
Visual alarm		

Public address system	$2,200	$100
Other (please specify)		
Comments on security communications		
Total	$2,725	$170

Please describe the shift pattern at your site		**2007 Annual cost in US$**
Number of security guards on the access gates / gatehouses (included in figure for access control)		$240,000
Number of security guards on patrols (included in figure for detection)		$123,000
Number of security personnel in the control room (included in figure for detection)		
Other specialised security personnel		
Number of security personnel that can respond quickly to an incident		
Are your security personnel licenced?		
Type of license		
Does your site hold their training records?		

Crisis Management	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Specialist crisis management software		
Duplicate (remote) IT system	$97,715	
Emergency power supply	$670,000	$36,000
Crisis management - Service Providers		
Other (please specify)		

	Fixed	**Variable**
Access Control	$579,730	$250,000
Biometrics	$11,200	$1,000
Detection	$630,920	$156,750

Terminals' Security System Costs – Port facility E

Region	
Business Unit/Site	Port facility E

Perimeter Fencing	Installation cost in US$ (2004 - present)	2007 Annual maintenance cost in US$
Chain link		$8,000
Expanded metal		
Steel pallisades		
Weldmesh		
Masonry/brick		
Opaque		
Other (Please specify)	$18,000	
Total	$18,000	$8,000
Height of fence at lowest point (meters)		
Length of fence (meters)		
Comments on perimeter fencing		

Access Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Main security gate	$11,000	$10,000
Main security gate guardhouse		
Second security gate		
Second security gate guardhouse		
Additional security gates/guardhouses	$79,000	
Mobile security gates		
Mobile security barriers	$6,000	
Other (please specify)		
Comments on access control		
Total	$96,000	$10,000

Identity Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Retinal scans		
Fingerprint scans	$73,000	$5,000
Photo ID cards for employees	$5,000	$1,000

Photo ID cards for regular Business Unit contractors / vendors		
Instant photo ID cards for visitors		
Visitor passes (numbered)		
Vessel crew passes (numbered)		
Vehicle passes (numbered)		
Other (please specify)		
Comments on identity control		
Total	$78,000	$6,000

Security Detection	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Perimeter intruder detection system		
Perimeter lighting		$10,000
Lighting of restricted areas		$5,000
Cargo handling lighting	$160,000	$20,000
Passenger handling lighting		
Access routes lighting		
CCTV - main gate	$28,000	$9,000
CCTV - other gates	$14,000	$5,000
CCTV - restricted areas	$77,000	$15,000
CCTV - perimeter	$14,000	$5,000
CCTV - cargo handling areas	$21,000	$8,000
CCTV - passenger handling areas	$28,000	$9,000
CCTV - office buildings		
Surface radar		
Underwater sonar		
Other (please specify)		
Comments on security detection		
Total	$342,000	$86,000

Security Communications	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
VHF radio		
UHF radio	$141,000	$10,000
Push-to-Talk radio	$11,000	$1,000
General audio alarm		
Visual alarm		

Public address system		
Other (please specify)		
Comments on security communications		
Total	$152,000	$11,000

Please describe the shift pattern at your site		**2007 Annual cost in US$**
Number of security guards on the access gates / gatehouses (included in figure for access control)		$75,000
Number of security guards on patrols (included in figure for detection)		$15,000
Number of security personnel in the control room (included in figure for detection)		$10,000
Other specialised security personnel		
Number of security personnel that can respond quickly to an incident		
Are your security personnel licenced?		
Type of license		
Does your site hold their training records?		

Crisis Management	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Specialist crisis management software		
Duplicate (remote) IT system		
Emergency power supply	$73,000	$5,000
Crisis management - Service Providers		
Other (please specify)		

	Fixed	**Variable**
Access Control	$114,000	$93,000
Biometrics	$78,000	$6,000
Detection	$342,000	$111,000

Terminals' Security System Costs – Port Facility F

Region	
Business Unit/Site	Port Facility F

Perimeter Fencing	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Chain link	$120,000	$12,000
Expanded metal		
Steel pallisades		
Weldmesh		
Masonry/brick		
Opaque		
Other (Please specify)		
Total	$120,000	$12,000
Height of fence at lowest point (meters)		
Length of fence (meters)		
Comments on perimeter fencing		

Access Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance cost in US$**
Main security gate	$430,000	$43,000
Main security gate guardhouse		
Second security gate		
Second security gate guardhouse		
Additional security gates/guardhouses		
Mobile security gates		
Mobile security barriers		
Other (please specify)		
Comments on access control		
Total	$430,000	$43,000

Identity Control	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Retinal scans		
Fingerprint scans		
Photo ID cards for employees	$197,600	$78,000

Photo ID cards for regular Business Unit contractors / vendors		
Instant photo ID cards for visitors		
Visitor passes (numbered)		
Vessel crew passes (numbered)		
Vehicle passes (numbered)		
Other (please specify)		
Comments on identity control		
Total	$197,600	$78,000

Security Detection	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Perimeter intruder detection system		
Perimeter lighting		
Lighting of restricted areas		
Cargo handling lighting		
Passenger handling lighting		
Access routes lighting		
CCTV - main gate		
CCTV - other gates	$317,777	$32,000
CCTV - restricted areas		
CCTV - perimeter		
CCTV - cargo handling areas		
CCTV - passenger handling areas		
CCTV - office buildings		
Surface radar		
Underwater sonar		
Other (please specify)		
Comments on security detection		
Total	$317,777	$32,000

Security Communications	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
VHF radio		
UHF radio		
Push-to-Talk radio		
General audio alarm		
Visual alarm		

Public address system		
Other (please specify)		
Comments on security communications		
Total	$0	$0

Please describe the shift pattern at your site		**2007 Annual cost in US$**
Number of security guards on the access gates / gatehouses (included in figure for access control)		$719,312
Number of security guards on patrols (included in figure for detection)		
Number of security personnel in the control room (included in figure for detection)		
Other specialised security personnel		
Number of security personnel that can respond quickly to an incident		
Are your security personnel licenced?		
Type of license		
Does your site hold their training records?		

Crisis Management	**Installation cost in US$ (2004 - present)**	**2007 Annual maintenance costs in US$**
Specialist crisis management software		
Duplicate (remote) IT system		
Emergency power supply	$60,000	
Crisis management - Service Providers		
Other (please specify)		

	Fixed	**Variable**
Access Control	$550,000	$774,312
Biometrics	$197,600	$78,000
Detection	$317,777	$32,000

Appendix D – List of Possible Portfolio Combinations

Portfolio No.	Type of Security Incident		Security System Performance		Cost
1		A1	B1	D1	483,462
	Bomb introduced by person on foot	80%	90%	75%	
	Car Bomb	80%	90%	75%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
2		A1	B1	D2	2,977,788
	Bomb introduced by person on foot	80%	90%	95%	
	Car Bomb	80%	90%	95%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	90%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
3		A1	B1	D3	273,001
	Bomb introduced by person on foot	80%	90%	70%	
	Car Bomb	80%	90%	75%	
	Truck bomb	85%	85%	70%	
	Biological agent attack on terminal - on foot	80%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
4		A1	B1	D4	1,009,133
	Bomb introduced by person on foot	80%	90%	40%	
	Car Bomb	80%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	40%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
5		A1	B1	D5	674,463
	Bomb introduced by person on foot	80%	90%	0%	
	Car Bomb	80%	90%	0%	
	Truck bomb	85%	85%	0%	

	Biological agent attack on terminal - on foot	80%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
6		A1	B1	D6	571,240
	Bomb introduced by person on foot	80%	90%	80%	
	Car Bomb	80%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
7		A1	B2	D1	457,825
	Bomb introduced by person on foot	80%	90%	75%	
	Car Bomb	80%	90%	75%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
8		A1	B2	D2	2,952,151
	Bomb introduced by person on foot	80%	90%	95%	
	Car Bomb	80%	90%	95%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	90%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
9		A1	B2	D3	247,364
	Bomb introduced by person on foot	80%	90%	70%	
	Car Bomb	80%	90%	75%	
	Truck bomb	85%	85%	70%	
	Biological agent attack on terminal - on foot	80%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
10		A1	B2	D4	983,496
	Bomb introduced by person on foot	80%	90%	40%	

	Car Bomb	80%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	40%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
11		A1	B2	D5	648,826
	Bomb introduced by person on foot	80%	90%	0%	
	Car Bomb	80%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
12		A1	B2	D6	545,603
	Bomb introduced by person on foot	80%	90%	80%	
	Car Bomb	80%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
13		A1	B3	D1	452,505
	Bomb introduced by person on foot	80%	90%	75%	
	Car Bomb	80%	95%	75%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
14		A1	B3	D2	2,946,831
	Bomb introduced by person on foot	80%	90%	95%	
	Car Bomb	80%	95%	95%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	95%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	

15		A1	B3	D3	242,044
	Bomb introduced by person on foot	80%	90%	70%	
	Car Bomb	80%	95%	75%	
	Truck bomb	85%	95%	70%	
	Biological agent attack on terminal - on foot	80%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
16		A1	B3	D4	978,176
	Bomb introduced by person on foot	80%	90%	40%	
	Car Bomb	80%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	90%	40%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
17		A1	B3	D5	643,506
	Bomb introduced by person on foot	80%	90%	0%	
	Car Bomb	80%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
18		A1	B3	D6	540,283
	Bomb introduced by person on foot	80%	90%	80%	
	Car Bomb	80%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
19		A1	B4	D1	462,025
	Bomb introduced by person on foot	80%	40%	75%	
	Car Bomb	80%	40%	75%	
	Truck bomb	85%	40%	80%	
	Biological agent attack on terminal - on foot	80%	40%	75%	
	Biological agent attack on terminal - by vehicle	85%	40%	75%	
	Mining of port infrastructure	50%	40%	50%	

	Vessel attacked by a suicide boat	50%	0%	50%	
20		A1	B4	D2	2,956,351
	Bomb introduced by person on foot	80%	40%	95%	
	Car Bomb	80%	40%	95%	
	Truck bomb	85%	40%	80%	
	Biological agent attack on terminal - on foot	80%	40%	95%	
	Biological agent attack on terminal - by vehicle	85%	40%	90%	
	Mining of port infrastructure	50%	40%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
21		A1	B4	D3	251,564
	Bomb introduced by person on foot	80%	40%	70%	
	Car Bomb	80%	40%	75%	
	Truck bomb	85%	40%	70%	
	Biological agent attack on terminal - on foot	80%	40%	70%	
	Biological agent attack on terminal - by vehicle	85%	40%	75%	
	Mining of port infrastructure	50%	40%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
22		A1	B4	D4	987,696
	Bomb introduced by person on foot	80%	40%	40%	
	Car Bomb	80%	40%	0%	
	Truck bomb	85%	40%	0%	
	Biological agent attack on terminal - on foot	80%	40%	40%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	50%	40%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
23		A1	B4	D5	653,026
	Bomb introduced by person on foot	80%	40%	0%	
	Car Bomb	80%	40%	0%	
	Truck bomb	85%	40%	0%	
	Biological agent attack on terminal - on foot	80%	40%	0%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	50%	40%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
24		A1	B4	D6	549,803
	Bomb introduced by person on foot	80%	40%	80%	
	Car Bomb	80%	40%	0%	
	Truck bomb	85%	40%	0%	
	Biological agent attack on terminal - on foot	80%	40%	80%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	50%	40%	80%	

	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
25		A1	B5	D1	533,825
	Bomb introduced by person on foot	80%	80%	75%	
	Car Bomb	80%	80%	75%	
	Truck bomb	85%	80%	80%	
	Biological agent attack on terminal - on foot	80%	80%	75%	
	Biological agent attack on terminal - by vehicle	85%	80%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
26		A1	B5	D2	3,028,151
	Bomb introduced by person on foot	80%	80%	95%	
	Car Bomb	80%	80%	95%	
	Truck bomb	85%	80%	80%	
	Biological agent attack on terminal - on foot	80%	80%	95%	
	Biological agent attack on terminal - by vehicle	85%	80%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
27		A1	B5	D3	323,364
	Bomb introduced by person on foot	80%	80%	70%	
	Car Bomb	80%	80%	75%	
	Truck bomb	85%	80%	70%	
	Biological agent attack on terminal - on foot	80%	80%	70%	
	Biological agent attack on terminal - by vehicle	85%	80%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
28		A1	B5	D4	1,059,496
	Bomb introduced by person on foot	80%	80%	40%	
	Car Bomb	80%	80%	0%	
	Truck bomb	85%	80%	0%	
	Biological agent attack on terminal - on foot	80%	80%	40%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
29		A1	B5	D5	724,826
	Bomb introduced by person on foot	80%	80%	0%	
	Car Bomb	80%	80%	0%	
	Truck bomb	85%	80%	0%	
	Biological agent attack on terminal - on foot	80%	80%	0%	

	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
30		A1	B5	D6	621,603
	Bomb introduced by person on foot	80%	80%	80%	
	Car Bomb	80%	80%	0%	
	Truck bomb	85%	80%	0%	
	Biological agent attack on terminal - on foot	80%	80%	80%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
31		A1	B6	D1	725,425
	Bomb introduced by person on foot	80%	95%	75%	
	Car Bomb	80%	95%	75%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	95%	75%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
32		A1	B6	D2	3,219,751
	Bomb introduced by person on foot	80%	95%	95%	
	Car Bomb	80%	95%	95%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	95%	95%	
	Biological agent attack on terminal - by vehicle	85%	95%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
33		A1	B6	D3	514,964
	Bomb introduced by person on foot	80%	95%	70%	
	Car Bomb	80%	95%	75%	
	Truck bomb	85%	95%	70%	
	Biological agent attack on terminal - on foot	80%	95%	70%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
34		A1	B6	D4	1,251,096
	Bomb introduced by person on foot	80%	95%	40%	
	Car Bomb	80%	95%	0%	

	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	95%	40%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
35		A1	B6	D5	916,426
	Bomb introduced by person on foot	80%	95%	0%	
	Car Bomb	80%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	95%	0%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
36		A1	B6	D6	813,203
	Bomb introduced by person on foot	80%	95%	80%	
	Car Bomb	80%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	95%	80%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
37		A2	B1	D1	1,010,636
	Bomb introduced by person on foot	90%	90%	75%	
	Car Bomb	90%	90%	75%	
	Truck bomb	80%	85%	80%	
	Biological agent attack on terminal - on foot	90%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
38		A2	B1	D2	3,504,962
	Bomb introduced by person on foot	90%	90%	95%	
	Car Bomb	90%	90%	95%	
	Truck bomb	80%	85%	80%	
	Biological agent attack on terminal - on foot	90%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	90%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
39		A2	B1	D3	800,175

	Bomb introduced by person on foot	90%	90%	70%	
	Car Bomb	90%	90%	75%	
	Truck bomb	80%	85%	70%	
	Biological agent attack on terminal - on foot	90%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
40		A2	B1	D4	1,536,307
	Bomb introduced by person on foot	90%	90%	40%	
	Car Bomb	90%	90%	0%	
	Truck bomb	80%	85%	0%	
	Biological agent attack on terminal - on foot	90%	90%	40%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
41		A2	B1	D5	1,201,637
	Bomb introduced by person on foot	90%	90%	0%	
	Car Bomb	90%	90%	0%	
	Truck bomb	80%	85%	0%	
	Biological agent attack on terminal - on foot	90%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
42		A2	B1	D6	1,098,414
	Bomb introduced by person on foot	90%	90%	80%	
	Car Bomb	90%	90%	0%	
	Truck bomb	80%	85%	0%	
	Biological agent attack on terminal - on foot	90%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
43		A2	B2	D1	984,999
	Bomb introduced by person on foot	90%	95%	75%	
	Car Bomb	90%	95%	75%	
	Truck bomb	80%	85%	80%	
	Biological agent attack on terminal - on foot	90%	95%	75%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	

44		A2	B2	D2	3,479,325
	Bomb introduced by person on foot	90%	95%	95%	
	Car Bomb	90%	95%	95%	
	Truck bomb	80%	85%	80%	
	Biological agent attack on terminal - on foot	90%	95%	95%	
	Biological agent attack on terminal - by vehicle	85%	90%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
45		A2	B2	D3	774,538
	Bomb introduced by person on foot	90%	95%	70%	
	Car Bomb	90%	95%	75%	
	Truck bomb	80%	85%	70%	
	Biological agent attack on terminal - on foot	90%	95%	70%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
46		A2	B2	D4	1,510,670
	Bomb introduced by person on foot	90%	95%	40%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	85%	0%	
	Biological agent attack on terminal - on foot	90%	95%	40%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
47		A2	B2	D5	1,176,000
	Bomb introduced by person on foot	90%	95%	0%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	85%	0%	
	Biological agent attack on terminal - on foot	90%	95%	0%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
48		A2	B2	D6	1,072,777
	Bomb introduced by person on foot	90%	95%	80%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	85%	0%	
	Biological agent attack on terminal - on foot	90%	95%	80%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
49		A2	B3	D1	979,679
	Bomb introduced by person on foot	90%	90%	75%	
	Car Bomb	90%	95%	75%	
	Truck bomb	80%	95%	80%	
	Biological agent attack on terminal - on foot	90%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
50		A2	B3	D2	3,474,005
	Bomb introduced by person on foot	90%	90%	95%	
	Car Bomb	90%	95%	95%	
	Truck bomb	80%	95%	80%	
	Biological agent attack on terminal - on foot	90%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	95%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
51		A2	B3	D3	769,218
	Bomb introduced by person on foot	90%	90%	70%	
	Car Bomb	90%	95%	75%	
	Truck bomb	80%	95%	70%	
	Biological agent attack on terminal - on foot	90%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
52		A2	B3	D4	1,505,350
	Bomb introduced by person on foot	90%	90%	40%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	95%	0%	
	Biological agent attack on terminal - on foot	90%	90%	40%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
53		A2	B3	D5	1,170,680
	Bomb introduced by person on foot	90%	90%	0%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	95%	0%	
	Biological agent attack on terminal - on foot	90%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	

	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
54		A2	B3	D6	1,067,457
	Bomb introduced by person on foot	90%	90%	80%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	95%	0%	
	Biological agent attack on terminal - on foot	90%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
55		A2	B4	D1	989,199
	Bomb introduced by person on foot	90%	40%	75%	
	Car Bomb	90%	40%	75%	
	Truck bomb	80%	40%	80%	
	Biological agent attack on terminal - on foot	90%	40%	75%	
	Biological agent attack on terminal - by vehicle	85%	40%	75%	
	Mining of port infrastructure	50%	40%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
56		A2	B4	D2	3,483,525
	Bomb introduced by person on foot	90%	40%	95%	
	Car Bomb	90%	40%	95%	
	Truck bomb	80%	40%	80%	
	Biological agent attack on terminal - on foot	90%	40%	95%	
	Biological agent attack on terminal - by vehicle	85%	40%	90%	
	Mining of port infrastructure	50%	40%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
57		A2	B4	D3	778,738
	Bomb introduced by person on foot	90%	40%	70%	
	Car Bomb	90%	40%	75%	
	Truck bomb	80%	40%	70%	
	Biological agent attack on terminal - on foot	90%	40%	70%	
	Biological agent attack on terminal - by vehicle	85%	40%	75%	
	Mining of port infrastructure	50%	40%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
58		A2	B4	D4	1,514,870
	Bomb introduced by person on foot	90%	40%	40%	
	Car Bomb	90%	40%	0%	
	Truck bomb	80%	40%	0%	

	Biological agent attack on terminal - on foot	90%	40%	40%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	50%	40%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
59		A2	B4	D5	1,180,200
	Bomb introduced by person on foot	90%	40%	0%	
	Car Bomb	90%	40%	0%	
	Truck bomb	80%	40%	0%	
	Biological agent attack on terminal - on foot	90%	40%	0%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	50%	40%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
60		A2	B4	D6	1,076,977
	Bomb introduced by person on foot	90%	40%	80%	
	Car Bomb	90%	40%	0%	
	Truck bomb	80%	40%	0%	
	Biological agent attack on terminal - on foot	90%	40%	80%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	50%	40%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
61		A2	B5	D1	1,060,999
	Bomb introduced by person on foot	90%	80%	75%	
	Car Bomb	90%	80%	75%	
	Truck bomb	80%	80%	80%	
	Biological agent attack on terminal - on foot	90%	80%	75%	
	Biological agent attack on terminal - by vehicle	85%	80%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	
62		A2	B5	D2	3,555,325
	Bomb introduced by person on foot	90%	80%	95%	
	Car Bomb	90%	80%	95%	
	Truck bomb	80%	80%	80%	
	Biological agent attack on terminal - on foot	90%	80%	95%	
	Biological agent attack on terminal - by vehicle	85%	80%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
63		A2	B5	D3	850,538
	Bomb introduced by person on foot	90%	80%	70%	

	Car Bomb	90%	80%	75%	
	Truck bomb	80%	80%	70%	
	Biological agent attack on terminal - on foot	90%	80%	70%	
	Biological agent attack on terminal - by vehicle	85%	80%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
64		A2	B5	D4	1,586,670
	Bomb introduced by person on foot	90%	80%	40%	
	Car Bomb	90%	80%	0%	
	Truck bomb	80%	80%	0%	
	Biological agent attack on terminal - on foot	90%	80%	40%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
65		A2	B5	D5	1,252,000
	Bomb introduced by person on foot	90%	80%	0%	
	Car Bomb	90%	80%	0%	
	Truck bomb	80%	80%	0%	
	Biological agent attack on terminal - on foot	90%	80%	0%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
66		A2	B5	D6	1,148,777
	Bomb introduced by person on foot	90%	80%	80%	
	Car Bomb	90%	80%	0%	
	Truck bomb	80%	80%	0%	
	Biological agent attack on terminal - on foot	90%	80%	80%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
67		A2	B6	D1	1,252,599
	Bomb introduced by person on foot	90%	95%	75%	
	Car Bomb	90%	95%	75%	
	Truck bomb	80%	95%	80%	
	Biological agent attack on terminal - on foot	90%	95%	75%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	50%	

68		A2	B6	D2	3,746,925
	Bomb introduced by person on foot	90%	95%	95%	
	Car Bomb	90%	95%	95%	
	Truck bomb	80%	95%	80%	
	Biological agent attack on terminal - on foot	90%	95%	95%	
	Biological agent attack on terminal - by vehicle	85%	95%	90%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	80%	
69		A2	B6	D3	1,042,138
	Bomb introduced by person on foot	90%	95%	70%	
	Car Bomb	90%	95%	75%	
	Truck bomb	80%	95%	70%	
	Biological agent attack on terminal - on foot	90%	95%	70%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	50%	0%	0%	
	Vessel attacked by a suicide boat	50%	0%	0%	
70		A2	B6	D4	1,778,270
	Bomb introduced by person on foot	90%	95%	40%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	95%	0%	
	Biological agent attack on terminal - on foot	90%	95%	40%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	40%	
	Vessel attacked by a suicide boat	50%	0%	20%	
71		A2	B6	D5	1,443,600
	Bomb introduced by person on foot	90%	95%	0%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	95%	0%	
	Biological agent attack on terminal - on foot	90%	95%	0%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	50%	
	Vessel attacked by a suicide boat	50%	0%	20%	
72		A2	B6	D6	1,340,377
	Bomb introduced by person on foot	90%	95%	80%	
	Car Bomb	90%	95%	0%	
	Truck bomb	80%	95%	0%	
	Biological agent attack on terminal - on foot	90%	95%	80%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	50%	0%	80%	
	Vessel attacked by a suicide boat	50%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
73		A3	B1	D1	708,370
	Bomb introduced by person on foot	80%	90%	75%	
	Car Bomb	85%	90%	75%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	50%	
74		A3	B1	D2	3,202,696
	Bomb introduced by person on foot	80%	90%	95%	
	Car Bomb	85%	90%	95%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	90%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	80%	
75		A3	B1	D3	497,909
	Bomb introduced by person on foot	80%	90%	70%	
	Car Bomb	85%	90%	75%	
	Truck bomb	85%	85%	70%	
	Biological agent attack on terminal - on foot	80%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	0%	0%	0%	
76		A3	B1	D4	1,234,041
	Bomb introduced by person on foot	80%	90%	40%	
	Car Bomb	85%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	40%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	0%	0%	20%	
77		A3	B1	D5	899,371
	Bomb introduced by person on foot	80%	90%	0%	
	Car Bomb	85%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	0%	0%	50%	

	Vessel attacked by a suicide boat	0%	0%	20%	
78		A3	B1	D6	796,148
	Bomb introduced by person on foot	80%	90%	80%	
	Car Bomb	85%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
79		A3	B2	D1	682,733
	Bomb introduced by person on foot	80%	90%	75%	
	Car Bomb	85%	90%	75%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	50%	
80		A3	B2	D2	3,177,059
	Bomb introduced by person on foot	80%	90%	95%	
	Car Bomb	85%	90%	95%	
	Truck bomb	85%	85%	80%	
	Biological agent attack on terminal - on foot	80%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	90%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	80%	
81		A3	B2	D3	472,272
	Bomb introduced by person on foot	80%	90%	70%	
	Car Bomb	85%	90%	75%	
	Truck bomb	85%	85%	70%	
	Biological agent attack on terminal - on foot	80%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	90%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	0%	0%	0%	
82		A3	B2	D4	1,208,404
	Bomb introduced by person on foot	80%	90%	40%	
	Car Bomb	85%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	40%	

	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	0%	0%	20%	
83		A3	B2	D5	873,734
	Bomb introduced by person on foot	80%	90%	0%	
	Car Bomb	85%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	20%	
84		A3	B2	D6	770,511
	Bomb introduced by person on foot	80%	90%	80%	
	Car Bomb	85%	90%	0%	
	Truck bomb	85%	85%	0%	
	Biological agent attack on terminal - on foot	80%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	90%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
85		A3	B3	D1	677,413
	Bomb introduced by person on foot	80%	90%	75%	
	Car Bomb	85%	95%	75%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	90%	75%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	50%	
86		A3	B3	D2	3,171,739
	Bomb introduced by person on foot	80%	90%	95%	
	Car Bomb	85%	95%	95%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	90%	95%	
	Biological agent attack on terminal - by vehicle	85%	95%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	80%	
87		A3	B3	D3	466,952
	Bomb introduced by person on foot	80%	90%	70%	
	Car Bomb	85%	95%	75%	

	Truck bomb	85%	95%	70%	
	Biological agent attack on terminal - on foot	80%	90%	70%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	0%	0%	0%	
88		A3	B3	D4	1,203,084
	Bomb introduced by person on foot	80%	90%	40%	
	Car Bomb	85%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	90%	40%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	0%	0%	20%	
89		A3	B3	D5	868,414
	Bomb introduced by person on foot	80%	90%	0%	
	Car Bomb	85%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	90%	0%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	20%	
90		A3	B3	D6	765,191
	Bomb introduced by person on foot	80%	90%	80%	
	Car Bomb	85%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	90%	80%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
91		A3	B4	D1	686,933
	Bomb introduced by person on foot	80%	40%	75%	
	Car Bomb	85%	40%	75%	
	Truck bomb	85%	40%	80%	
	Biological agent attack on terminal - on foot	80%	40%	75%	
	Biological agent attack on terminal - by vehicle	85%	40%	75%	
	Mining of port infrastructure	0%	40%	50%	
	Vessel attacked by a suicide boat	0%	0%	50%	
92		A3	B4	D2	3,181,259

	Bomb introduced by person on foot	80%	40%	95%	
	Car Bomb	85%	40%	95%	
	Truck bomb	85%	40%	80%	
	Biological agent attack on terminal - on foot	80%	40%	95%	
	Biological agent attack on terminal - by vehicle	85%	40%	90%	
	Mining of port infrastructure	0%	40%	80%	
	Vessel attacked by a suicide boat	0%	0%	80%	
93		A3	B4	D3	476,472
	Bomb introduced by person on foot	80%	40%	70%	
	Car Bomb	85%	40%	75%	
	Truck bomb	85%	40%	70%	
	Biological agent attack on terminal - on foot	80%	40%	70%	
	Biological agent attack on terminal - by vehicle	85%	40%	75%	
	Mining of port infrastructure	0%	40%	0%	
	Vessel attacked by a suicide boat	0%	0%	0%	
94		A3	B4	D4	1,212,604
	Bomb introduced by person on foot	80%	40%	40%	
	Car Bomb	85%	40%	0%	
	Truck bomb	85%	40%	0%	
	Biological agent attack on terminal - on foot	80%	40%	40%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	0%	40%	40%	
	Vessel attacked by a suicide boat	0%	0%	20%	
95		A3	B4	D5	877,934
	Bomb introduced by person on foot	80%	40%	0%	
	Car Bomb	85%	40%	0%	
	Truck bomb	85%	40%	0%	
	Biological agent attack on terminal - on foot	80%	40%	0%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	0%	40%	50%	
	Vessel attacked by a suicide boat	0%	0%	20%	
96		A3	B4	D6	774,711
	Bomb introduced by person on foot	80%	40%	80%	
	Car Bomb	85%	40%	0%	
	Truck bomb	85%	40%	0%	
	Biological agent attack on terminal - on foot	80%	40%	80%	
	Biological agent attack on terminal - by vehicle	85%	40%	0%	
	Mining of port infrastructure	0%	40%	80%	
	Vessel attacked by a suicide boat	0%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
97		A3	B5	D1	758,733
	Bomb introduced by person on foot	80%	80%	75%	
	Car Bomb	85%	80%	75%	
	Truck bomb	85%	80%	80%	
	Biological agent attack on terminal - on foot	80%	80%	75%	
	Biological agent attack on terminal - by vehicle	85%	80%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	50%	
98		A3	B5	D2	3,253,059
	Bomb introduced by person on foot	80%	80%	95%	
	Car Bomb	85%	80%	95%	
	Truck bomb	85%	80%	80%	
	Biological agent attack on terminal - on foot	80%	80%	95%	
	Biological agent attack on terminal - by vehicle	85%	80%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	80%	
99		A3	B5	D3	548,272
	Bomb introduced by person on foot	80%	80%	70%	
	Car Bomb	85%	80%	75%	
	Truck bomb	85%	80%	70%	
	Biological agent attack on terminal - on foot	80%	80%	70%	
	Biological agent attack on terminal - by vehicle	85%	80%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	0%	0%	0%	
100		A3	B5	D4	1,284,404
	Bomb introduced by person on foot	80%	80%	40%	
	Car Bomb	85%	80%	0%	
	Truck bomb	85%	80%	0%	
	Biological agent attack on terminal - on foot	80%	80%	40%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	0%	0%	20%	
101		A3	B5	D5	949,734
	Bomb introduced by person on foot	80%	80%	0%	
	Car Bomb	85%	80%	0%	
	Truck bomb	85%	80%	0%	
	Biological agent attack on terminal - on foot	80%	80%	0%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	0%	0%	50%	

	Vessel attacked by a suicide boat	0%	0%	20%	
102		A3	B5	D6	846,511
	Bomb introduced by person on foot	80%	80%	80%	
	Car Bomb	85%	80%	0%	
	Truck bomb	85%	80%	0%	
	Biological agent attack on terminal - on foot	80%	80%	80%	
	Biological agent attack on terminal - by vehicle	85%	80%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
103		A3	B6	D1	950,333
	Bomb introduced by person on foot	80%	95%	75%	
	Car Bomb	85%	95%	75%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	95%	75%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	50%	
104		A3	B6	D2	3,444,659
	Bomb introduced by person on foot	80%	95%	95%	
	Car Bomb	85%	95%	95%	
	Truck bomb	85%	95%	80%	
	Biological agent attack on terminal - on foot	80%	95%	95%	
	Biological agent attack on terminal - by vehicle	85%	95%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	80%	
105		A3	B6	D3	739,872
	Bomb introduced by person on foot	80%	95%	70%	
	Car Bomb	85%	95%	75%	
	Truck bomb	85%	95%	70%	
	Biological agent attack on terminal - on foot	80%	95%	70%	
	Biological agent attack on terminal - by vehicle	85%	95%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	0%	0%	0%	
106		A3	B6	D4	1,476,004
	Bomb introduced by person on foot	80%	95%	40%	
	Car Bomb	85%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	95%	40%	

	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	0%	0%	20%	
107		A3	B6	D5	1,141,334
	Bomb introduced by person on foot	80%	95%	0%	
	Car Bomb	85%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	95%	0%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	0%	0%	20%	
108		A3	B6	D6	1,038,111
	Bomb introduced by person on foot	80%	95%	80%	
	Car Bomb	85%	95%	0%	
	Truck bomb	85%	95%	0%	
	Biological agent attack on terminal - on foot	80%	95%	80%	
	Biological agent attack on terminal - by vehicle	85%	95%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	0%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
109		A4	B1	D1	1,125,366
	Bomb introduced by person on foot	20%	90%	75%	
	Car Bomb	20%	90%	75%	
	Truck bomb	20%	85%	80%	
	Biological agent attack on terminal - on foot	20%	90%	75%	
	Biological agent attack on terminal - by vehicle	20%	90%	75%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	50%	
110		A4	B1	D2	3,619,692
	Bomb introduced by person on foot	20%	90%	95%	
	Car Bomb	20%	90%	95%	
	Truck bomb	20%	85%	80%	
	Biological agent attack on terminal - on foot	20%	90%	95%	
	Biological agent attack on terminal - by vehicle	20%	90%	90%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	80%	
111		A4	B1	D3	914,905
	Bomb introduced by person on foot	20%	90%	70%	
	Car Bomb	20%	90%	75%	

	Truck bomb	20%	85%	70%	
	Biological agent attack on terminal - on foot	20%	90%	70%	
	Biological agent attack on terminal - by vehicle	20%	90%	75%	
	Mining of port infrastructure	20%	0%	0%	
	Vessel attacked by a suicide boat	40%	0%	0%	
112		A4	B1	D4	1,651,037
	Bomb introduced by person on foot	20%	90%	40%	
	Car Bomb	20%	90%	0%	
	Truck bomb	20%	85%	0%	
	Biological agent attack on terminal - on foot	20%	90%	40%	
	Biological agent attack on terminal - by vehicle	20%	90%	0%	
	Mining of port infrastructure	20%	0%	40%	
	Vessel attacked by a suicide boat	40%	0%	20%	
113		A4	B1	D5	1,316,367
	Bomb introduced by person on foot	20%	90%	0%	
	Car Bomb	20%	90%	0%	
	Truck bomb	20%	85%	0%	
	Biological agent attack on terminal - on foot	20%	90%	0%	
	Biological agent attack on terminal - by vehicle	20%	90%	0%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	20%	
114		A4	B1	D6	1,213,144
	Bomb introduced by person on foot	20%	90%	80%	
	Car Bomb	20%	90%	0%	
	Truck bomb	20%	85%	0%	
	Biological agent attack on terminal - on foot	20%	90%	80%	
	Biological agent attack on terminal - by vehicle	20%	90%	0%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
115		A4	B2	D1	1,099,729
	Bomb introduced by person on foot	20%	90%	75%	
	Car Bomb	20%	90%	75%	
	Truck bomb	20%	85%	80%	
	Biological agent attack on terminal - on foot	20%	90%	75%	
	Biological agent attack on terminal - by vehicle	20%	90%	75%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	50%	
116		A4	B2	D2	3,594,055

	Bomb introduced by person on foot	20%	90%	95%	
	Car Bomb	20%	90%	95%	
	Truck bomb	20%	85%	80%	
	Biological agent attack on terminal - on foot	20%	90%	95%	
	Biological agent attack on terminal - by vehicle	20%	90%	90%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	80%	
117		A4	B2	D3	889,268
	Bomb introduced by person on foot	20%	90%	70%	
	Car Bomb	20%	90%	75%	
	Truck bomb	20%	85%	70%	
	Biological agent attack on terminal - on foot	20%	90%	70%	
	Biological agent attack on terminal - by vehicle	20%	90%	75%	
	Mining of port infrastructure	20%	0%	0%	
	Vessel attacked by a suicide boat	40%	0%	0%	
118		A4	B2	D4	1,625,400
	Bomb introduced by person on foot	20%	90%	40%	
	Car Bomb	20%	90%	0%	
	Truck bomb	20%	85%	0%	
	Biological agent attack on terminal - on foot	20%	90%	40%	
	Biological agent attack on terminal - by vehicle	20%	90%	0%	
	Mining of port infrastructure	20%	0%	40%	
	Vessel attacked by a suicide boat	40%	0%	20%	
119		A4	B2	D5	1,290,730
	Bomb introduced by person on foot	20%	90%	0%	
	Car Bomb	20%	90%	0%	
	Truck bomb	20%	85%	0%	
	Biological agent attack on terminal - on foot	20%	90%	0%	
	Biological agent attack on terminal - by vehicle	20%	90%	0%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	20%	
120		A4	B2	D6	1,187,507
	Bomb introduced by person on foot	20%	90%	80%	
	Car Bomb	20%	90%	0%	
	Truck bomb	20%	85%	0%	
	Biological agent attack on terminal - on foot	20%	90%	80%	
	Biological agent attack on terminal - by vehicle	20%	90%	0%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
121		A4	B3	D1	1,094,409
	Bomb introduced by person on foot	20%	90%	75%	
	Car Bomb	20%	95%	75%	
	Truck bomb	20%	95%	80%	
	Biological agent attack on terminal - on foot	20%	90%	75%	
	Biological agent attack on terminal - by vehicle	20%	95%	75%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	50%	
122		A4	B3	D2	3,588,735
	Bomb introduced by person on foot	20%	90%	95%	
	Car Bomb	20%	95%	95%	
	Truck bomb	20%	95%	80%	
	Biological agent attack on terminal - on foot	20%	90%	95%	
	Biological agent attack on terminal - by vehicle	20%	95%	90%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	80%	
123		A4	B3	D3	883,948
	Bomb introduced by person on foot	20%	90%	70%	
	Car Bomb	20%	95%	75%	
	Truck bomb	20%	95%	70%	
	Biological agent attack on terminal - on foot	20%	90%	70%	
	Biological agent attack on terminal - by vehicle	20%	95%	75%	
	Mining of port infrastructure	20%	0%	0%	
	Vessel attacked by a suicide boat	40%	0%	0%	
124		A4	B3	D4	1,620,080
	Bomb introduced by person on foot	20%	90%	40%	
	Car Bomb	20%	95%	0%	
	Truck bomb	20%	95%	0%	
	Biological agent attack on terminal - on foot	20%	90%	40%	
	Biological agent attack on terminal - by vehicle	20%	95%	0%	
	Mining of port infrastructure	20%	0%	40%	
	Vessel attacked by a suicide boat	40%	0%	20%	
125		A4	B3	D5	1,285,410
	Bomb introduced by person on foot	20%	90%	0%	
	Car Bomb	20%	95%	0%	
	Truck bomb	20%	95%	0%	
	Biological agent attack on terminal - on foot	20%	90%	0%	
	Biological agent attack on terminal - by vehicle	20%	95%	0%	
	Mining of port infrastructure	20%	0%	50%	

	Vessel attacked by a suicide boat	40%	0%	20%	
126		A4	B3	D6	1,182,187
	Bomb introduced by person on foot	20%	90%	80%	
	Car Bomb	20%	95%	0%	
	Truck bomb	20%	95%	0%	
	Biological agent attack on terminal - on foot	20%	90%	80%	
	Biological agent attack on terminal - by vehicle	20%	95%	0%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
127		A4	B4	D1	1,103,929
	Bomb introduced by person on foot	20%	40%	75%	
	Car Bomb	20%	40%	75%	
	Truck bomb	20%	40%	80%	
	Biological agent attack on terminal - on foot	20%	40%	75%	
	Biological agent attack on terminal - by vehicle	20%	40%	75%	
	Mining of port infrastructure	20%	40%	50%	
	Vessel attacked by a suicide boat	40%	0%	50%	
128		A4	B4	D2	3,598,255
	Bomb introduced by person on foot	20%	40%	95%	
	Car Bomb	20%	40%	95%	
	Truck bomb	20%	40%	80%	
	Biological agent attack on terminal - on foot	20%	40%	95%	
	Biological agent attack on terminal - by vehicle	20%	40%	90%	
	Mining of port infrastructure	20%	40%	80%	
	Vessel attacked by a suicide boat	40%	0%	80%	
129		A4	B4	D3	893,468
	Bomb introduced by person on foot	20%	40%	70%	
	Car Bomb	20%	40%	75%	
	Truck bomb	20%	40%	70%	
	Biological agent attack on terminal - on foot	20%	40%	70%	
	Biological agent attack on terminal - by vehicle	20%	40%	75%	
	Mining of port infrastructure	20%	40%	0%	
	Vessel attacked by a suicide boat	40%	0%	0%	
130		A4	B4	D4	1,629,600
	Bomb introduced by person on foot	20%	40%	40%	
	Car Bomb	20%	40%	0%	
	Truck bomb	20%	40%	0%	
	Biological agent attack on terminal - on foot	20%	40%	40%	

	Biological agent attack on terminal - by vehicle	20%	40%	0%	
	Mining of port infrastructure	20%	40%	40%	
	Vessel attacked by a suicide boat	40%	0%	20%	
131		A4	B4	D5	1,294,930
	Bomb introduced by person on foot	20%	40%	0%	
	Car Bomb	20%	40%	0%	
	Truck bomb	20%	40%	0%	
	Biological agent attack on terminal - on foot	20%	40%	0%	
	Biological agent attack on terminal - by vehicle	20%	40%	0%	
	Mining of port infrastructure	20%	40%	50%	
	Vessel attacked by a suicide boat	40%	0%	20%	
132		A4	B4	D6	1,191,707
	Bomb introduced by person on foot	20%	40%	80%	
	Car Bomb	20%	40%	0%	
	Truck bomb	20%	40%	0%	
	Biological agent attack on terminal - on foot	20%	40%	80%	
	Biological agent attack on terminal - by vehicle	20%	40%	0%	
	Mining of port infrastructure	20%	40%	80%	
	Vessel attacked by a suicide boat	40%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
133		A4	B5	D1	1,175,729
	Bomb introduced by person on foot	20%	80%	75%	
	Car Bomb	20%	80%	75%	
	Truck bomb	20%	80%	80%	
	Biological agent attack on terminal - on foot	20%	80%	75%	
	Biological agent attack on terminal - by vehicle	20%	80%	75%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	50%	
134		A4	B5	D2	3,670,055
	Bomb introduced by person on foot	20%	80%	95%	
	Car Bomb	20%	80%	95%	
	Truck bomb	20%	80%	80%	
	Biological agent attack on terminal - on foot	20%	80%	95%	
	Biological agent attack on terminal - by vehicle	20%	80%	90%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	80%	
135		A4	B5	D3	965,268
	Bomb introduced by person on foot	20%	80%	70%	
	Car Bomb	20%	80%	75%	

	Truck bomb	20%	80%	70%	
	Biological agent attack on terminal - on foot	20%	80%	70%	
	Biological agent attack on terminal - by vehicle	20%	80%	75%	
	Mining of port infrastructure	20%	0%	0%	
	Vessel attacked by a suicide boat	40%	0%	0%	
136		A4	B5	D4	1,701,400
	Bomb introduced by person on foot	20%	80%	40%	
	Car Bomb	20%	80%	0%	
	Truck bomb	20%	80%	0%	
	Biological agent attack on terminal - on foot	20%	80%	40%	
	Biological agent attack on terminal - by vehicle	20%	80%	0%	
	Mining of port infrastructure	20%	0%	40%	
	Vessel attacked by a suicide boat	40%	0%	20%	
137		A4	B5	D5	1,366,730
	Bomb introduced by person on foot	20%	80%	0%	
	Car Bomb	20%	80%	0%	
	Truck bomb	20%	80%	0%	
	Biological agent attack on terminal - on foot	20%	80%	0%	
	Biological agent attack on terminal - by vehicle	20%	80%	0%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	20%	
138		A4	B5	D6	1,263,507
	Bomb introduced by person on foot	20%	80%	80%	
	Car Bomb	20%	80%	0%	
	Truck bomb	20%	80%	0%	
	Biological agent attack on terminal - on foot	20%	80%	80%	
	Biological agent attack on terminal - by vehicle	20%	80%	0%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
139		A4	B6	D1	1,367,329
	Bomb introduced by person on foot	20%	95%	75%	
	Car Bomb	20%	95%	75%	
	Truck bomb	20%	95%	80%	
	Biological agent attack on terminal - on foot	20%	95%	75%	
	Biological agent attack on terminal - by vehicle	20%	95%	75%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	50%	
140		A4	B6	D2	3,861,655

	Bomb introduced by person on foot	20%	95%	95%	
	Car Bomb	20%	95%	95%	
	Truck bomb	20%	95%	80%	
	Biological agent attack on terminal - on foot	20%	95%	95%	
	Biological agent attack on terminal - by vehicle	20%	95%	90%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	80%	
141		A4	B6	D3	1,156,868
	Bomb introduced by person on foot	20%	95%	70%	
	Car Bomb	20%	95%	75%	
	Truck bomb	20%	95%	70%	
	Biological agent attack on terminal - on foot	20%	95%	70%	
	Biological agent attack on terminal - by vehicle	20%	95%	75%	
	Mining of port infrastructure	20%	0%	0%	
	Vessel attacked by a suicide boat	40%	0%	0%	
142		A4	B6	D4	1,893,000
	Bomb introduced by person on foot	20%	95%	40%	
	Car Bomb	20%	95%	0%	
	Truck bomb	20%	95%	0%	
	Biological agent attack on terminal - on foot	20%	95%	40%	
	Biological agent attack on terminal - by vehicle	20%	95%	0%	
	Mining of port infrastructure	20%	0%	40%	
	Vessel attacked by a suicide boat	40%	0%	20%	
143		A4	B6	D5	1,558,330
	Bomb introduced by person on foot	20%	95%	0%	
	Car Bomb	20%	95%	0%	
	Truck bomb	20%	95%	0%	
	Biological agent attack on terminal - on foot	20%	95%	0%	
	Biological agent attack on terminal - by vehicle	20%	95%	0%	
	Mining of port infrastructure	20%	0%	50%	
	Vessel attacked by a suicide boat	40%	0%	20%	
144		A4	B6	D6	1,455,107
	Bomb introduced by person on foot	20%	95%	80%	
	Car Bomb	20%	95%	0%	
	Truck bomb	20%	95%	0%	
	Biological agent attack on terminal - on foot	20%	95%	80%	
	Biological agent attack on terminal - by vehicle	20%	95%	0%	
	Mining of port infrastructure	20%	0%	80%	
	Vessel attacked by a suicide boat	40%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
145		A5	B1	D1	502,636
	Bomb introduced by person on foot	60%	90%	75%	
	Car Bomb	90%	90%	75%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	60%	90%	75%	
	Biological agent attack on terminal - by vehicle	90%	90%	75%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	50%	
146		A5	B1	D2	2,996,962
	Bomb introduced by person on foot	60%	90%	95%	
	Car Bomb	90%	90%	95%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	60%	90%	95%	
	Biological agent attack on terminal - by vehicle	90%	90%	90%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	80%	
147		A5	B1	D3	292,175
	Bomb introduced by person on foot	60%	90%	70%	
	Car Bomb	90%	90%	75%	
	Truck bomb	90%	85%	70%	
	Biological agent attack on terminal - on foot	60%	90%	70%	
	Biological agent attack on terminal - by vehicle	90%	90%	75%	
	Mining of port infrastructure	10%	0%	0%	
	Vessel attacked by a suicide boat	10%	0%	0%	
148		A5	B1	D4	1,028,307
	Bomb introduced by person on foot	60%	90%	40%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	60%	90%	40%	
	Biological agent attack on terminal - by vehicle	90%	90%	0%	
	Mining of port infrastructure	10%	0%	40%	
	Vessel attacked by a suicide boat	10%	0%	20%	
149		A5	B1	D5	693,637
	Bomb introduced by person on foot	60%	90%	0%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	60%	90%	0%	
	Biological agent attack on terminal - by vehicle	90%	90%	0%	
	Mining of port infrastructure	10%	0%	50%	

	Vessel attacked by a suicide boat	10%	0%	20%	
150		A5	B1	D6	590,414
	Bomb introduced by person on foot	60%	90%	80%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	60%	90%	80%	
	Biological agent attack on terminal - by vehicle	90%	90%	0%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
151		A5	B2	D1	476,999
	Bomb introduced by person on foot	60%	90%	75%	
	Car Bomb	90%	90%	75%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	60%	90%	75%	
	Biological agent attack on terminal - by vehicle	90%	90%	75%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	50%	
152		A5	B2	D2	2,971,325
	Bomb introduced by person on foot	60%	90%	95%	
	Car Bomb	90%	90%	95%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	60%	90%	95%	
	Biological agent attack on terminal - by vehicle	90%	90%	90%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	80%	
153		A5	B2	D3	266,538
	Bomb introduced by person on foot	60%	90%	70%	
	Car Bomb	90%	90%	75%	
	Truck bomb	90%	85%	70%	
	Biological agent attack on terminal - on foot	60%	90%	70%	
	Biological agent attack on terminal - by vehicle	90%	90%	75%	
	Mining of port infrastructure	10%	0%	0%	
	Vessel attacked by a suicide boat	10%	0%	0%	
154		A5	B2	D4	1,002,670
	Bomb introduced by person on foot	60%	90%	40%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	60%	90%	40%	

	Biological agent attack on terminal - by vehicle	90%	90%	0%	
	Mining of port infrastructure	10%	0%	40%	
	Vessel attacked by a suicide boat	10%	0%	20%	
155		A5	B2	D5	668,000
	Bomb introduced by person on foot	60%	90%	0%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	60%	90%	0%	
	Biological agent attack on terminal - by vehicle	90%	90%	0%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	20%	
156		A5	B2	D6	564,777
	Bomb introduced by person on foot	60%	90%	80%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	60%	90%	80%	
	Biological agent attack on terminal - by vehicle	90%	90%	0%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
157		A5	B3	D1	471,679
	Bomb introduced by person on foot	60%	90%	75%	
	Car Bomb	90%	95%	75%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	60%	90%	75%	
	Biological agent attack on terminal - by vehicle	90%	95%	75%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	50%	
158		A5	B3	D2	2,966,005
	Bomb introduced by person on foot	60%	90%	95%	
	Car Bomb	90%	95%	95%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	60%	90%	95%	
	Biological agent attack on terminal - by vehicle	90%	95%	90%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	80%	
159		A5	B3	D3	261,218
	Bomb introduced by person on foot	60%	90%	70%	
	Car Bomb	90%	95%	75%	

	Truck bomb	90%	95%	70%	
	Biological agent attack on terminal - on foot	60%	90%	70%	
	Biological agent attack on terminal - by vehicle	90%	95%	75%	
	Mining of port infrastructure	10%	0%	0%	
	Vessel attacked by a suicide boat	10%	0%	0%	
160		A5	B3	D4	997,350
	Bomb introduced by person on foot	60%	90%	40%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	60%	90%	40%	
	Biological agent attack on terminal - by vehicle	90%	95%	0%	
	Mining of port infrastructure	10%	0%	40%	
	Vessel attacked by a suicide boat	10%	0%	20%	
161		A5	B3	D5	662,680
	Bomb introduced by person on foot	60%	90%	0%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	60%	90%	0%	
	Biological agent attack on terminal - by vehicle	90%	95%	0%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	20%	
162		A5	B3	D6	559,457
	Bomb introduced by person on foot	60%	90%	80%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	60%	90%	80%	
	Biological agent attack on terminal - by vehicle	90%	95%	0%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
163		A5	B4	D1	481,199
	Bomb introduced by person on foot	60%	40%	75%	
	Car Bomb	90%	40%	75%	
	Truck bomb	90%	40%	80%	
	Biological agent attack on terminal - on foot	60%	40%	75%	
	Biological agent attack on terminal - by vehicle	90%	40%	75%	
	Mining of port infrastructure	10%	40%	50%	
	Vessel attacked by a suicide boat	10%	0%	50%	
164		A5	B4	D2	2,975,525

	Bomb introduced by person on foot	60%	40%	95%	
	Car Bomb	90%	40%	95%	
	Truck bomb	90%	40%	80%	
	Biological agent attack on terminal - on foot	60%	40%	95%	
	Biological agent attack on terminal - by vehicle	90%	40%	90%	
	Mining of port infrastructure	10%	40%	80%	
	Vessel attacked by a suicide boat	10%	0%	80%	
165		A5	B4	D3	270,738
	Bomb introduced by person on foot	60%	40%	70%	
	Car Bomb	90%	40%	75%	
	Truck bomb	90%	40%	70%	
	Biological agent attack on terminal - on foot	60%	40%	70%	
	Biological agent attack on terminal - by vehicle	90%	40%	75%	
	Mining of port infrastructure	10%	40%	0%	
	Vessel attacked by a suicide boat	10%	0%	0%	
166		A5	B4	D4	1,006,870
	Bomb introduced by person on foot	60%	40%	40%	
	Car Bomb	90%	40%	0%	
	Truck bomb	90%	40%	0%	
	Biological agent attack on terminal - on foot	60%	40%	40%	
	Biological agent attack on terminal - by vehicle	90%	40%	0%	
	Mining of port infrastructure	10%	40%	40%	
	Vessel attacked by a suicide boat	10%	0%	20%	
167		A5	B4	D5	672,200
	Bomb introduced by person on foot	60%	40%	0%	
	Car Bomb	90%	40%	0%	
	Truck bomb	90%	40%	0%	
	Biological agent attack on terminal - on foot	60%	40%	0%	
	Biological agent attack on terminal - by vehicle	90%	40%	0%	
	Mining of port infrastructure	10%	40%	50%	
	Vessel attacked by a suicide boat	10%	0%	20%	
168		A5	B4	D6	568,977
	Bomb introduced by person on foot	60%	40%	80%	
	Car Bomb	90%	40%	0%	
	Truck bomb	90%	40%	0%	
	Biological agent attack on terminal - on foot	60%	40%	80%	
	Biological agent attack on terminal - by vehicle	90%	40%	0%	
	Mining of port infrastructure	10%	40%	80%	
	Vessel attacked by a suicide boat	10%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
169		A5	B5	D1	552,999
	Bomb introduced by person on foot	60%	80%	75%	
	Car Bomb	90%	80%	75%	
	Truck bomb	90%	80%	80%	
	Biological agent attack on terminal - on foot	60%	80%	75%	
	Biological agent attack on terminal - by vehicle	90%	80%	75%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	50%	
170		A5	B5	D2	3,047,325
	Bomb introduced by person on foot	60%	80%	95%	
	Car Bomb	90%	80%	95%	
	Truck bomb	90%	80%	80%	
	Biological agent attack on terminal - on foot	60%	80%	95%	
	Biological agent attack on terminal - by vehicle	90%	80%	90%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	80%	
171		A5	B5	D3	342,538
	Bomb introduced by person on foot	60%	80%	70%	
	Car Bomb	90%	80%	75%	
	Truck bomb	90%	80%	70%	
	Biological agent attack on terminal - on foot	60%	80%	70%	
	Biological agent attack on terminal - by vehicle	90%	80%	75%	
	Mining of port infrastructure	10%	0%	0%	
	Vessel attacked by a suicide boat	10%	0%	0%	
172		A5	B5	D4	1,078,670
	Bomb introduced by person on foot	60%	80%	40%	
	Car Bomb	90%	80%	0%	
	Truck bomb	90%	80%	0%	
	Biological agent attack on terminal - on foot	60%	80%	40%	
	Biological agent attack on terminal - by vehicle	90%	80%	0%	
	Mining of port infrastructure	10%	0%	40%	
	Vessel attacked by a suicide boat	10%	0%	20%	
173		A5	B5	D5	744,000
	Bomb introduced by person on foot	60%	80%	0%	
	Car Bomb	90%	80%	0%	
	Truck bomb	90%	80%	0%	
	Biological agent attack on terminal - on foot	60%	80%	0%	
	Biological agent attack on terminal - by vehicle	90%	80%	0%	
	Mining of port infrastructure	10%	0%	50%	

	Vessel attacked by a suicide boat	10%	0%	20%	
174		A5	B5	D6	640,777
	Bomb introduced by person on foot	60%	80%	80%	
	Car Bomb	90%	80%	0%	
	Truck bomb	90%	80%	0%	
	Biological agent attack on terminal - on foot	60%	80%	80%	
	Biological agent attack on terminal - by vehicle	90%	80%	0%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
175		A5	B6	D1	744,599
	Bomb introduced by person on foot	60%	95%	75%	
	Car Bomb	90%	95%	75%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	60%	95%	75%	
	Biological agent attack on terminal - by vehicle	90%	95%	75%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	50%	
176		A5	B6	D2	3,238,925
	Bomb introduced by person on foot	60%	95%	95%	
	Car Bomb	90%	95%	95%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	60%	95%	95%	
	Biological agent attack on terminal - by vehicle	90%	95%	90%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	80%	
177		A5	B6	D3	534,138
	Bomb introduced by person on foot	60%	95%	70%	
	Car Bomb	90%	95%	75%	
	Truck bomb	90%	95%	70%	
	Biological agent attack on terminal - on foot	60%	95%	70%	
	Biological agent attack on terminal - by vehicle	90%	95%	75%	
	Mining of port infrastructure	10%	0%	0%	
	Vessel attacked by a suicide boat	10%	0%	0%	
178		A5	B6	D4	1,270,270
	Bomb introduced by person on foot	60%	95%	40%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	60%	95%	40%	

	Biological agent attack on terminal - by vehicle	90%	95%	0%	
	Mining of port infrastructure	10%	0%	40%	
	Vessel attacked by a suicide boat	10%	0%	20%	
179		A5	B6	D5	935,600
	Bomb introduced by person on foot	60%	95%	0%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	60%	95%	0%	
	Biological agent attack on terminal - by vehicle	90%	95%	0%	
	Mining of port infrastructure	10%	0%	50%	
	Vessel attacked by a suicide boat	10%	0%	20%	
180		A5	B6	D6	832,377
	Bomb introduced by person on foot	60%	95%	80%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	60%	95%	80%	
	Biological agent attack on terminal - by vehicle	90%	95%	0%	
	Mining of port infrastructure	10%	0%	80%	
	Vessel attacked by a suicide boat	10%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
181		A6	B1	D1	1,619,948
	Bomb introduced by person on foot	90%	90%	75%	
	Car Bomb	90%	90%	75%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	10%	90%	75%	
	Biological agent attack on terminal - by vehicle	10%	90%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	50%	
182		A6	B1	D2	4,114,274
	Bomb introduced by person on foot	90%	90%	95%	
	Car Bomb	90%	90%	95%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	10%	90%	95%	
	Biological agent attack on terminal - by vehicle	10%	90%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	80%	
183		A6	B1	D3	1,409,487
	Bomb introduced by person on foot	90%	90%	70%	
	Car Bomb	90%	90%	75%	

	Truck bomb	90%	85%	70%	
	Biological agent attack on terminal - on foot	10%	90%	70%	
	Biological agent attack on terminal - by vehicle	10%	90%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	30%	0%	0%	
184		A6	B1	D4	2,145,619
	Bomb introduced by person on foot	90%	90%	40%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	10%	90%	40%	
	Biological agent attack on terminal - by vehicle	10%	90%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	30%	0%	20%	
185		A6	B1	D5	1,810,949
	Bomb introduced by person on foot	90%	90%	0%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	10%	90%	0%	
	Biological agent attack on terminal - by vehicle	10%	90%	0%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	20%	
186		A6	B1	D6	1,707,726
	Bomb introduced by person on foot	90%	90%	80%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	10%	90%	80%	
	Biological agent attack on terminal - by vehicle	10%	90%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
187		A6	B2	D1	1,594,311
	Bomb introduced by person on foot	90%	90%	75%	
	Car Bomb	90%	90%	75%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	10%	90%	75%	
	Biological agent attack on terminal - by vehicle	10%	90%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	50%	
188		A6	B2	D2	4,088,637

	Bomb introduced by person on foot	90%	90%	95%	
	Car Bomb	90%	90%	95%	
	Truck bomb	90%	85%	80%	
	Biological agent attack on terminal - on foot	10%	90%	95%	
	Biological agent attack on terminal - by vehicle	10%	90%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	80%	
189		A6	B2	D3	1,383,850
	Bomb introduced by person on foot	90%	90%	70%	
	Car Bomb	90%	90%	75%	
	Truck bomb	90%	85%	70%	
	Biological agent attack on terminal - on foot	10%	90%	70%	
	Biological agent attack on terminal - by vehicle	10%	90%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	30%	0%	0%	
190		A6	B2	D4	2,119,982
	Bomb introduced by person on foot	90%	90%	40%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	10%	90%	40%	
	Biological agent attack on terminal - by vehicle	10%	90%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	30%	0%	20%	
191		A6	B2	D5	1,785,312
	Bomb introduced by person on foot	90%	90%	0%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	10%	90%	0%	
	Biological agent attack on terminal - by vehicle	10%	90%	0%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	20%	
192		A6	B2	D6	1,682,089
	Bomb introduced by person on foot	90%	90%	80%	
	Car Bomb	90%	90%	0%	
	Truck bomb	90%	85%	0%	
	Biological agent attack on terminal - on foot	10%	90%	80%	
	Biological agent attack on terminal - by vehicle	10%	90%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
193		A6	B3	D1	1,588,991
	Bomb introduced by person on foot	90%	90%	75%	
	Car Bomb	90%	95%	75%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	10%	90%	75%	
	Biological agent attack on terminal - by vehicle	10%	95%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	50%	
194		A6	B3	D2	4,083,317
	Bomb introduced by person on foot	90%	90%	95%	
	Car Bomb	90%	95%	95%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	10%	90%	95%	
	Biological agent attack on terminal - by vehicle	10%	95%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	80%	
195		A6	B3	D3	1,378,530
	Bomb introduced by person on foot	90%	90%	70%	
	Car Bomb	90%	95%	75%	
	Truck bomb	90%	95%	70%	
	Biological agent attack on terminal - on foot	10%	90%	70%	
	Biological agent attack on terminal - by vehicle	10%	95%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	30%	0%	0%	
196		A6	B3	D4	2,114,662
	Bomb introduced by person on foot	90%	90%	40%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	10%	90%	40%	
	Biological agent attack on terminal - by vehicle	10%	95%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	30%	0%	20%	
197		A6	B3	D5	1,779,992
	Bomb introduced by person on foot	90%	90%	0%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	10%	90%	0%	
	Biological agent attack on terminal - by vehicle	10%	95%	0%	
	Mining of port infrastructure	0%	0%	50%	

	Vessel attacked by a suicide boat	30%	0%	20%	
198		A6	B3	D6	1,676,769
	Bomb introduced by person on foot	90%	90%	80%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	10%	90%	80%	
	Biological agent attack on terminal - by vehicle	10%	95%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
199		A6	B4	D1	1,598,511
	Bomb introduced by person on foot	90%	40%	75%	
	Car Bomb	90%	40%	75%	
	Truck bomb	90%	40%	80%	
	Biological agent attack on terminal - on foot	10%	40%	75%	
	Biological agent attack on terminal - by vehicle	10%	40%	75%	
	Mining of port infrastructure	0%	40%	50%	
	Vessel attacked by a suicide boat	30%	0%	50%	
200		A6	B4	D2	4,092,837
	Bomb introduced by person on foot	90%	40%	95%	
	Car Bomb	90%	40%	95%	
	Truck bomb	90%	40%	80%	
	Biological agent attack on terminal - on foot	10%	40%	95%	
	Biological agent attack on terminal - by vehicle	10%	40%	90%	
	Mining of port infrastructure	0%	40%	80%	
	Vessel attacked by a suicide boat	30%	0%	80%	
201		A6	B4	D3	1,388,050
	Bomb introduced by person on foot	90%	40%	70%	
	Car Bomb	90%	40%	75%	
	Truck bomb	90%	40%	70%	
	Biological agent attack on terminal - on foot	10%	40%	70%	
	Biological agent attack on terminal - by vehicle	10%	40%	75%	
	Mining of port infrastructure	0%	40%	0%	
	Vessel attacked by a suicide boat	30%	0%	0%	
202		A6	B4	D4	2,124,182
	Bomb introduced by person on foot	90%	40%	40%	
	Car Bomb	90%	40%	0%	
	Truck bomb	90%	40%	0%	
	Biological agent attack on terminal - on foot	10%	40%	40%	

	Biological agent attack on terminal - by vehicle	10%	40%	0%	
	Mining of port infrastructure	0%	40%	40%	
	Vessel attacked by a suicide boat	30%	0%	20%	
203		A6	B4	D5	1,789,512
	Bomb introduced by person on foot	90%	40%	0%	
	Car Bomb	90%	40%	0%	
	Truck bomb	90%	40%	0%	
	Biological agent attack on terminal - on foot	10%	40%	0%	
	Biological agent attack on terminal - by vehicle	10%	40%	0%	
	Mining of port infrastructure	0%	40%	50%	
	Vessel attacked by a suicide boat	30%	0%	20%	
204		A6	B4	D6	1,686,289
	Bomb introduced by person on foot	90%	40%	80%	
	Car Bomb	90%	40%	0%	
	Truck bomb	90%	40%	0%	
	Biological agent attack on terminal - on foot	10%	40%	80%	
	Biological agent attack on terminal - by vehicle	10%	40%	0%	
	Mining of port infrastructure	0%	40%	80%	
	Vessel attacked by a suicide boat	30%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
205		A6	B5	D1	1,670,311
	Bomb introduced by person on foot	90%	80%	75%	
	Car Bomb	90%	80%	75%	
	Truck bomb	90%	80%	80%	
	Biological agent attack on terminal - on foot	10%	80%	75%	
	Biological agent attack on terminal - by vehicle	10%	80%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	50%	
206		A6	B5	D2	4,164,637
	Bomb introduced by person on foot	90%	80%	95%	
	Car Bomb	90%	80%	95%	
	Truck bomb	90%	80%	80%	
	Biological agent attack on terminal - on foot	10%	80%	95%	
	Biological agent attack on terminal - by vehicle	10%	80%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	80%	
207		A6	B5	D3	1,459,850
	Bomb introduced by person on foot	90%	80%	70%	
	Car Bomb	90%	80%	75%	

	Truck bomb	90%	80%	70%	
	Biological agent attack on terminal - on foot	10%	80%	70%	
	Biological agent attack on terminal - by vehicle	10%	80%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	30%	0%	0%	
208		A6	B5	D4	2,195,982
	Bomb introduced by person on foot	90%	80%	40%	
	Car Bomb	90%	80%	0%	
	Truck bomb	90%	80%	0%	
	Biological agent attack on terminal - on foot	10%	80%	40%	
	Biological agent attack on terminal - by vehicle	10%	80%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	30%	0%	20%	
209		A6	B5	D5	1,861,312
	Bomb introduced by person on foot	90%	80%	0%	
	Car Bomb	90%	80%	0%	
	Truck bomb	90%	80%	0%	
	Biological agent attack on terminal - on foot	10%	80%	0%	
	Biological agent attack on terminal - by vehicle	10%	80%	0%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	20%	
210		A6	B5	D6	1,758,089
	Bomb introduced by person on foot	90%	80%	80%	
	Car Bomb	90%	80%	0%	
	Truck bomb	90%	80%	0%	
	Biological agent attack on terminal - on foot	10%	80%	80%	
	Biological agent attack on terminal - by vehicle	10%	80%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	50%	

Portfolio No.	Type of Security Incident		Security System Performance		Cost
211		A6	B6	D1	1,861,911
	Bomb introduced by person on foot	90%	95%	75%	
	Car Bomb	90%	95%	75%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	10%	95%	75%	
	Biological agent attack on terminal - by vehicle	10%	95%	75%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	50%	
212		A6	B6	D2	4,356,237

	Bomb introduced by person on foot	90%	95%	95%	
	Car Bomb	90%	95%	95%	
	Truck bomb	90%	95%	80%	
	Biological agent attack on terminal - on foot	10%	95%	95%	
	Biological agent attack on terminal - by vehicle	10%	95%	90%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	80%	
213		A6	B6	D3	1,651,450
	Bomb introduced by person on foot	90%	95%	70%	
	Car Bomb	90%	95%	75%	
	Truck bomb	90%	95%	70%	
	Biological agent attack on terminal - on foot	10%	95%	70%	
	Biological agent attack on terminal - by vehicle	10%	95%	75%	
	Mining of port infrastructure	0%	0%	0%	
	Vessel attacked by a suicide boat	30%	0%	0%	
214		A6	B6	D4	2,387,582
	Bomb introduced by person on foot	90%	95%	40%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	10%	95%	40%	
	Biological agent attack on terminal - by vehicle	10%	95%	0%	
	Mining of port infrastructure	0%	0%	40%	
	Vessel attacked by a suicide boat	30%	0%	20%	
215		A6	B6	D5	2,052,912
	Bomb introduced by person on foot	90%	95%	0%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	10%	95%	0%	
	Biological agent attack on terminal - by vehicle	10%	95%	0%	
	Mining of port infrastructure	0%	0%	50%	
	Vessel attacked by a suicide boat	30%	0%	20%	
216		A6	B6	D6	1,949,689
	Bomb introduced by person on foot	90%	95%	80%	
	Car Bomb	90%	95%	0%	
	Truck bomb	90%	95%	0%	
	Biological agent attack on terminal - on foot	10%	95%	80%	
	Biological agent attack on terminal - by vehicle	10%	95%	0%	
	Mining of port infrastructure	0%	0%	80%	
	Vessel attacked by a suicide boat	30%	0%	50%	

Appendix E - Transcript of interview with Russell Kennedy at Lloyd's of London, 23 April 2009.

RK: So I'm going to talk you through this and it will all make sense. The idea is that you rate each individual location on its own technical rate. So for instance let's say you were doing….where this comes from really is from the all risks, from the property….so let's say you've got a portfolio that is exposed to all risks in the States.

RT: Yes

RT: So that means you've got exposure for fire, you've got exposure for flood, quake and wind. So you would need to effectively price those separately. So you would need to get a price for the fire and each of those. They would come up in a model for flood, quake and wind. The fire you would rate separately on occupancy so a saw mill has a different rate to a hotel or an office building. So each one of those is rated separately, you would then add on all of your expenses on top of those rates per risk so you have a percentage of expenses to be included that you would need to charge for profit and added with profit to give you a market price.

RT: So when you work back from the market price and you strip out all of those additional expenses you are looking to arrive at the technical rate so effectively the closest to a pure premium rate you can actually achieve.

RK: And that is effectively based on your expected losses which is your expected probability. So that's different to….the difficulty is when you're rating something that is, for instance this here….I mean it may be if you were doing a port then it's OK as you've got an actual set of locations. Let's say you're doing ABC and they have ten thousand locations. Well how do you actually rate each one of those individual locations? How do you come up with a technical rate for that? I mean it's a difficult thing to get your head round. So what we've done is started off with a rate per country so I'll just talk you through it. So let's assume we're writing a risk, let's take this one. I'll just call this up (on the computer screen) so this is….excuse my handwriting it's terrible….This is XXX Energy Group. This is a….they're basically underground oil storage. So they will be in and around terminals. So, we assume twenty percent brokerage, then we have all these other various expenses, then the different ULR's that we're writing. We would want to target Y% return on capital, which is quite ambitious. This really is about Z% over the risk-free rate of what we're trying to target. So we then divide it by a loss ratio that we need to make over the long term. So this might be a bit confusing. There are 34 locations over 4 countries. South Africa….

RT: Yes

RK: ….there's two locations in the Congo which all around they have locations of eleven million each. Then there's seventy five million (US Dollars) in Ashkelon, and then there's a hundred and fifty million which is worldwide. The schedule which we have for worldwide is Belgium, Netherlands, Luxembourg, Norway, and they've got this a hundred and fifty million facility which fluctuates depending on how much they've got in different terminals.

RT: Sure

RK: So what I did was, you put in the limits for each of those, and each one of those will have a different limit

RT: So where it is on other people's property, it's just stocks of oil

RK: Yeah

RT: Alright

RK: It can fluctuate over the year but that's the maximum amount, in fact, it's slightly misleading but because I saw the amounts they had last year, it was never anything like that but they buy that just in case.

RT: Sure

RK: Each one of those is then in excess of a hundred thousand (US Dollars). A straight hundred thousand, no additional deductible. So we rate per country. So, South Africa, Belgium, Israel, Congo, then we have a sector is....now that sector is divided….comprised of a set of indices that I came up with twenty occupancies from our book, divided everything we've written into twenty occupancies and then came up with an average rate, divided them all up with an average rate…market price for each one of those. Now that was kind of difficult.

RT: So they are professional services, light industry….

RK: Energy, oil and gas, power, banking, finance….and there is....there is ports and harbours.

RT: Ports and harbours.

RK: Now what I did was, the reason I did that, even they are all market prices is you're going to have so many differences in terms of security, clients, territory. What it gave me was basically a proportional spread so I could see which ones were paying more or less in comparison to each other. That's the occupancy. So then I thought how am I going to rate per country? So I took the Exclusive Analysis rating....

RT: Would that be a minimum country rate?

RK: Yes. So they give you, on their website, risk maps. So they give you a risk score for each one of these perils, effectively. So, terrorism, war, civil unrest. That's to one decimal place between one and ten. So in my thinking, how was I going to translate that into a risk score? So, what I did was, I took the US to be the midpoint: forty percent of my risks are in the US. I had to take a midpoint somewhere, I think the US in terms of risk....I assumed a base rate for each occupancy of x%....that didn't come out of the book for market price....I took x% to be my notional base rate...that's....and that's not come out of nowhere.

RT: Right. OK. How would you describe that base rate of x% per annum rate?

RK: So. This is the key. This is where everything I've thought about stacks up. It's a combination of finding...in essence what I'm doing here is trying to find a price that I can price that risk at. And the reason I took x% the average fire rate is about y%....notionally it's a peril where you write all risks including terrorism....it makes up a part of that.

RT: And your x% background rate would be unaffected by any movement in terms of how the market is moving or the dollar rate.

RK: Yes, that's right. It's just my opinion of what I think, so for instance, energy terminals or oil and gas storage....I spoke at length with our energy underwriter, sat down with him for about three hours....he described to me, he's got about forty years of experience, and they write terrorism within their programme....he talked me through facilities and actually how impenetrable they are, how difficult it is to have a large loss. And from that, my energy oil and gas rate for terrorism went from....was slightly above average and I took it down to being the lowest one. So it moves over time as different information....

RT: Do you include in that rate the likelihood of a particular industry being targeted?

RK: I'll come on to that. So then I have to get a country rate. I take the country rate from Exclusive Analysis rating and information. So that is effectively....on an index from one to ten at one decimal place. Most of the rates tend to hang around the one or two mark. Afghanistan is seven....obviously it's not seven times more likely to get hit than UK, it's multiples of that, so how do I get....

RT: It's almost like a logarithmic scale.

RK: It's exactly what it is. So, what I did was I basically took two to the power of the index to elongate the scale, so that now gives me....with US as the midpoint....actually Afghanistan is two thousand five hundred times more likely to get hit than the US as a notional, you know, for there to be an event, whether it's a pipe bomb or a suicide attack or a....just to give you some indication of risk. So then when you combine, times one by the other....that gives you a technical rate for the country. So it gives you a rate for the occupancy in the territory and a price.

RT: So would you be able to give me country rates for these port locations? [RT hands RK list of locations]

RK: Yes, of course.

Appendix F – Attacks on Port Facilities 1968-2007

1 June 1968
UNITED STATES, GALVESTON, TEXAS
The Japanese vessel "Mikagasan Maru" was extensively damaged by a bomb allegedly placed by El Poder Cubano, a Cuban exile group.

16 September 1968
UNITED STATES, MIAMI HARBOUR
El Poder Cubano terrorists fired at the Polish general cargo vessel "Polancia".

24 January 1970
ISRAEL
Al Fatah and the Popular Front for the Liberation of Palestine jointly claim credit for an explosion in an ammunition truck unloading in the docks.

19 February 1971
TURKEY, ISTANBUL
A U.S. army passenger vessel was damaged by a bomb.

29 March 1972
UNITED STATES, BISCAYNE, FLORIDA
A Soviet research vessel was bombed by the JCN, an anti-Castro Cuban group.

1 December 1972
CYPRUS
An attempt by the Black September Organisation to hijack an Italian passenger vessel was thwarted by Coast Guard police.

4 March 1973
LEBANON
The Greek charter vessel "Sanya" sank in Beirut harbor following an explosion on board. The official investigation revealed that the explosion was caused by a limpet mine. Black September Organisation claimed credit for the attack.

30 December 1973
UNITED STATES, MIAMI, FLORIDA
Two bombs damaged the 573 ton "Mereghan II" while moored alongside waiting to lift cargo in Miami River docks.

2 February 1974
PAKISTAN, KARACHI
Three gunmen, members of the Muslim International Guerrillas seized a Greek general cargo vessel and threatened to blow up the ship unless the Greek government free two Arab prisoners.

2 March 1974

FRANCE
The Pierre Overnay brigade attacked the barge “Ouest France” while moored alongside the quay and firebombed 180 Renault cars.

May 1974
UNITED STATES, LOS ANGELES
The “Caribe Star” was sunk in the harbor by a bomb placed on board. The 120 ft former ferry had been fitted out for Arab interests. The Jewish Defense League claimed responsibility.

9 April 1974
PORTUGAL
The Revolutionary Brigades attacked the Portuguese troop ship “Niassa”. The vessel’s hull was holed in two places on the waterline.

20 July 1974
IRELAND, BELFAST
A bomb exploded on board the ferry “Ulster Queen”. Provisional IRA suspected after coded telephone warning to a newspaper.

16 December 1974
UNITED STATES, MIAMI
A bomb exploded in the port offices of the Eastern Steamship Lines. Frente de Liberacion Nacional Cubana suspected.

9 March 1975
IRELAND, GREENCASTLE HARBOUR
Over 30 incendiary devices were planted on trawlers in the harbour. Only two exploded, destroying the vessels. Ulster Defence Association suspected.

23 July 1975
JAPAN, OKINAWA
A Chilean training vessel and a Kobe University vessel docked at the International Ocean Expo were attacked by terrorists using Molotov cocktails. Radical leftists suspected.

1 August 1975
ARGENTINA, SANTA FE
The Montoneros and the People’s Revolutionary Army made lighting bomb strikes on the river port.

2 November 1975
PUERTO RICO, SAN JUAN
Russian vessel “Maxim Gorkiy” damaged by two bomb blasts below the waterline while at anchor in the port.

28 November 1975
PUERTO RICO

Russian vessel “Maxim Gorkiy” hit by a second attack when a bomb was thrown onboard injuring one crew member and causing minor damage.

August 1976
LEBANON
The Greek vessel “Tina” was sunk by three limpet mines believed to be by members of a right wing Lebanese Christian group while the vessel was part loaded with a cargo of arms for Fatah.

16 September 1976
UNITED STATES, PORT ELIZABETH, JERSEY
A Soviet cargo vessel was damaged by a limpet mine planted by an anti-Castro refugee.

23 October 1976
LEBANON
Three Greek vessels “Eko”, “Riri” and “Spiro” were attacked in port with limpet mines. All vessels sank at their moorings.

22 July 1977
PERU
A Cuban trawler, docked at a port near Lima was bombed and vessel sank. The International Commandos of Zone 6 of CORU claimed responsibility.

30 April 1978
PHILIPPINES
The “Don Carlos” was boarded by armed members of a Muslim Separatist rebel group of the South Philippines. Cargo offloaded and passengers taken hostage.

3 October 1978
ISRAEL
Israeli Navy sank a bomb laden vessel belonging to Fatah heading for Eilat with the intention of destroying the Eilat-Ashkelon pipeline and oil tank farms in the port.

March-June 1979
UNITED STATES, MASSACHUSETTS
Multiple bomb threats against vessels and petroleum storage site disrupt port operations.

1979 (month unknown)
PORTUGAL
Whaler “Sierra” rammed by “Sea Shepherd”. Perpetrators arrested by escaped – suspected to be members of Greenpeace or Fund for Animals.

9 January 1980
UNITED STATES, SACRAMENTO, CALIFORNIA
Port closed for three days following threats to bomb the Soviet vessel “Nicolay Karamzin” and that the harbour had been mined.

16 June 1980
BELGIUM
Demonstrators smashed navigational and radio equipment onboard "Andrea Smits" while loading nuclear waste for disposal in the Atlantic.

29 October 1980
ITALY, GENOA
A Libyan vessel under repair almost sank following a limpet mine explosion on the waterline. Maltese National Front suspected.

2 October 1981
SPAIN, SANTANDER
A powerful bomb caused a six foot hole in the hull of a destroyer moored in the port. ETA military wing suspected.

2 November 1981
FRANCE, NANTES
British hydrographic survey vessel "Hecate" suffered minor explosion on the hull while docked. Divers subsequently found another bomb with 2.2 lbs of plastic explosive which had failed to explode. Irish National Liberation Army terrorists suspected.

2 January 1982
LEBANON, TRIPOLI
The Lebanese-registered tanker "Babanaft" is shelled while lifting Iraqi crude in the port. Fire on deck extinguished and vessel sailed immediately.

9 March 1982
LEBANON, TYRE
Lebanese general cargo vessel bombed in the port despite strict security.

16 March 1982
BRAZIL, RIO DE JANEIRO
Liberian-flagged tanker "Hercules" ordered to leave after a bomb was found onboard. Outcome unknown.

16 December 1982
PHILIPPINES
The ferry "Santa Lucia" was damaged while in Pagadian by an explosive device planted by the Moro National Liberation Front.

23 February 1983
IRELAND, LOUGH FOYLE
A British cargo vessel was seized in an inlet by IRA and the ship was blown up.

5 August 1983
FALKLAND ISLANDS, PORT STANLEY

An ultra-nationalist Argentine group claimed responsibility for an explosion onboard the Danish vessel "Kraka" moored in the harbour. The vessel was unloading granite blocks to be used to build a memorial to fallen British soldiers during the Falklands War.

20 March 1984
NICARAGUA, PUERTO SANDINO
Explosive device planted at port entrance which damaged a Soviet tanker.

Jan-March 1984
NICARAGUA, CORINTO, BLUEFIELDS & EL BLUFF
Mine laying operations in three ports caused a total of 11 ships to sink, including Soviet, Panamanian Dutch, Liberian and Nicaraguan Registered.

28 June 1984
ARGENTINA, BUENOS AIRES
Two tankers, the "Perito Morena" and "Belgrano" set ablaze by the Sargento Cisneros Commandos.

25 September 1985
CYPRUS
Three members of the PLO's elite Force-17 seized an Israeli yacht on Yom Kippur and killed the three inhabitants.

7 October 1985
EGYPT
The Italian cruise vessel "Achille Lauro" was seized with 511 passengers onboard by four members of the Popular Front for the Liberation of Palestine. An American passenger, Leon Klinghoffer was shot in the head and thrown overboard in his wheelchair.

30 January 1986
ITALY, MESSINA
Two 135-ton Cypriot-flagged hydrofoils were bombed and sunk while docked for repairs.

14 September 1986
MOROCCO
A Spanish vessel was attacked by Polisario guerrillas.

23 January 1987
MAURITANIA
Panamanian bulker "Maritime King" attacked with rocket fire by Polisario guerrillas.

1 February 1987
LEBANON
Egyptian vessel "Fast Carrier" damaged by two limpet mines placed on the port side.

25 March 1987
GERMANY, HAMBURG

Molotov cocktails thrown at British truck and trailer parked in the port.

14 February 1988
CYPRUS, LIMASSOL
A ferry boat damaged by an explosion in the port.

11 July 1988
GREECE
Two men preparing an explosive device to attack the vessel "City of Poros" died when the bomb went off prematurely in the port. Middle Eastern gunmen then attacked the "City of Poros" firing automatic weapons at the crowd of passengers and throwing grenades.

1 August 1988
NICARAGUA
A ferryboat with a 10-person US delegation was ambushed by guerrillas in the south east of the country.

25 December 1993
ISRAEL, EILAT
An Israeli vessel "Jrush Shalom" was bombed while docked in the port.

8 July 1994
ALGERIA, JIJEL
GIA attackers boarded a cargo vessel moored in the port and murdered seven Italian sailors.

16 January 1995
TURKEY, TRABZON
A ferry "Avraysa" hijacked in the port by Turkish-Abkhaz terrorists.

April 1996
SRI LANKA, COLOMBO
Van Ommeren vessel docked in the port came under mortar attack by two LTTE gunboats. Damage to accommodation block and two sailors injured.

9 August 1996
SRI LANKA, TRINCOMALEE
A Philippine registered vessel was bombed under the waterline by LTTE while loading sand.

1 July 1997
SRI LANKA, JAFFNA
The LTTE abducted the Indonesia crew of a ferry and blew up the ship.

7 July 1997
SRI LANKA, JAFFNA
LTTE hijack "Morang Bong" and abduct 37 North Korean sailors.

1 September 1997

SRI LANKA, TRINCOMALEE
A Chinese owned vessel is attacked by the LTTE. Crew members killed, wounded or missing.

9 September 1997
SRI LANKA, TRINCOMALEE
LTTE attack vessel "Athena" with a limpet mine while at anchor in the roads. Main engine room fire and vessel was in danger of sinking.

12 October 2000
YEMEN, ADEN
USS Cole attacked by suicide boat causing 20ft by 40 ft hole in the port side. 17 sailors killed.

11 September 2001
UNITED STATES, NEW YORK
Ports of New York and New Jersey severely disrupted following the terrorist attacks on the World Trade Centre.

October 2002
YEMEN, ADEN
The French tanker "Limburg" was attacked by a suicide boat while waiting to take on pilot for docking in Aden causing explosion and fire. 1 sailor drowned.

15 March 2003
RUSSIA
Explosion in Khasan district killed a naval lieutenant and a former military officer.

30 November 2003
IRAQ
A Turkish tanker was attacked.

25 May 2004
PAKISTAN, KARACHI
A bomb exploded in the port, killing two and injuring two others.

23 June 2004
PAKISTAN, GWADAR
Chinese engineers developing deep-sea port came under rocket attack.

31 July 2004
PAKISTAN, GWADAR
A series of explosions in the port city with the first occurring by the port.

28 August 2005
PHILIPPINES, LAMITAN
A bomb exploded among the LPG tanks on the ferry Dona Ramona" injuring at least 30, including nine children.

13 May 2006
CORSICA, BASTIA
A bomb exploded in the Bastia Maritime Authority complex.

3 March 2007
INDONESIA, AMBON
A bomb exploded at the port gates in the Yos Sudarso port in Ambon.

8 September 2007
ALGERIA, DELLYS
Coast Guard troops targeted by suicide truck bomber during a flag-raising ceremony.

Appendix G – Kolmogorov-Smirnov One Sided Test Critical Values Table

Kolmogorov-Smirnov One-Sided Test

n	0.1	0.05	0.025	0.01	0.005
1	0.9000	0.9500	0.9750	0.9900	0.9950
2	0.6838	0.7764	0.8419	0.9000	0.9293
3	0.5648	0.6360	0.7076	0.7846	0.8290
4	0.4927	0.5652	0.6239	0.6889	0.7342
5	0.4470	0.5094	0.5633	0.6272	0.6685
6	0.4104	0.4680	0.5193	0.5774	0.6166
7	0.3815	0.4361	0.4834	0.5384	0.5758
8	0.3583	0.4096	0.4543	0.5065	0.5418
9	0.3391	0.3875	0.4300	0.4796	0.5133
10	0.3226	0.3687	0.4092	0.4566	0.4889
11	0.3083	0.3524	0.3912	0.4367	0.4677
12	0.2958	0.3382	0.3754	0.4192	0.4490
13	0.2847	0.3255	0.3614	0.4036	0.4325
14	0.2748	0.3142	0.3489	0.3897	0.4176
15	0.2659	0.3040	0.3376	0.3771	0.4042
16	0.2578	0.2947	0.3273	0.3657	0.3920
17	0.2504	0.2863	0.3180	0.3553	0.3809
18	0.2436	0.2785	0.3094	0.3457	0.3706
19	0.2373	0.2714	0.3014	0.3369	0.3612
20	0.2316	0.2647	0.2941	0.3287	0.3524
21	0.2262	0.2586	0.2872	0.3210	0.3443
22	0.2212	0.2528	0.2809	0.3139	0.3367
23	0.2165	0.2475	0.2749	0.3073	0.3295
24	0.2120	0.2424	0.2693	0.3010	0.3229
25	0.2079	0.2377	0.2640	0.2952	0.3166
26	0.2040	0.2332	0.2591	0.2896	0.3106
27	0.2003	0.2290	0.2544	0.2844	0.3050
28	0.1968	0.2250	0.2499	0.2794	0.2997
29	0.1935	0.2212	0.2457	0.2747	0.2947
30	0.1903	0.2176	0.2417	0.2702	0.2899
31	0.1873	0.2141	0.2379	0.2660	0.2853
32	0.1844	0.2108	0.2342	0.2619	0.2809
33	0.1817	0.2077	0.2308	0.2580	0.2768
34	0.1791	0.2047	0.2274	0.2543	0.2728
35	0.1766	0.2018	0.2242	0.2507	0.2690
36	0.1742	0.1991	0.2212	0.2473	0.2653
37	0.1719	0.1965	0.2183	0.2440	0.2618
38	0.1697	0.1939	0.2154	0.2409	0.2584
39	0.1675	0.1915	0.2127	0.2379	0.2552
40	0.1655	0.1891	0.2101	0.2349	0.2521
> 40	$1.07/\sqrt{n}$	$1.22/\sqrt{n}$	$1.36/\sqrt{n}$	$1.52/\sqrt{n}$	$1.63/\sqrt{n}$

Appendix H – Sensitivity Analysis Simulations: Cost Reduction and Performance Enhancement of Port Security Systems

	Sensitivity Analysis: Costs			Sensitivity Analysis: Performance		
Portfolio No.	Access Control	Biometrics	Detection	Access Control	Biometrics	Detection
1	-3.89%	-0.70%	-5.42%	102.72%	104.17%	103.11%
2	-0.63%	-0.11%	-9.26%	103.29%	105.04%	101.67%
3	-6.88%	-1.23%	-1.89%	102.27%	103.48%	104.26%
4	-1.86%	-0.33%	-7.81%	101.84%	102.82%	105.33%
5	-2.78%	-0.50%	-6.72%	101.80%	102.76%	105.44%
6	-3.29%	-0.59%	-6.12%	102.08%	103.18%	104.74%
7	-4.10%	-0.17%	-5.72%	102.72%	104.17%	103.11%
8	-0.64%	-0.03%	-9.34%	103.29%	105.04%	101.67%
9	-7.59%	-0.32%	-2.08%	102.27%	103.48%	104.26%
10	-1.91%	-0.08%	-8.01%	101.84%	102.82%	105.33%
11	-2.89%	-0.12%	-6.98%	101.80%	102.76%	105.44%
12	-3.44%	-0.15%	-6.41%	102.08%	103.18%	104.74%
13	-4.15%	-0.06%	-5.79%	102.81%	103.97%	103.21%
14	-0.64%	-0.01%	-9.35%	103.42%	104.84%	101.74%
15	-7.76%	-0.11%	-2.13%	102.33%	103.29%	104.38%
16	-1.92%	-0.03%	-8.05%	101.88%	102.66%	105.46%
17	-2.92%	-0.04%	-7.04%	101.84%	102.60%	105.57%
18	-3.48%	-0.05%	-6.47%	102.13%	103.01%	104.86%
19	-4.07%	-0.26%	-5.67%	102.21%	105.26%	102.53%
20	-0.64%	-0.04%	-9.32%	102.58%	106.12%	101.31%
21	-7.47%	-0.48%	-2.05%	101.90%	104.52%	103.58%
22	-1.90%	-0.12%	-7.97%	101.59%	103.79%	104.62%
23	-2.88%	-0.19%	-6.94%	101.56%	103.71%	104.73%
24	-3.42%	-0.22%	-6.36%	101.77%	104.20%	104.04%
25	-3.52%	-1.57%	-4.91%	102.59%	104.44%	102.96%
26	-0.62%	-0.28%	-9.10%	103.10%	105.32%	101.58%
27	-5.81%	-2.60%	-1.59%	102.18%	103.73%	104.09%
28	-1.77%	-0.79%	-7.43%	101.78%	103.05%	105.16%
29	-2.59%	-1.16%	-6.25%	101.74%	102.98%	105.27%
30	-3.02%	-1.35%	-5.63%	102.00%	103.43%	104.57%
31	-2.59%	-3.80%	-3.61%	102.83%	103.94%	103.23%
32	-0.58%	-0.86%	-8.56%	103.45%	104.80%	101.75%
33	-3.65%	-5.35%	-1.00%	102.34%	103.26%	104.40%
34	-1.50%	-2.20%	-6.30%	101.89%	102.63%	105.48%
35	-2.05%	-3.01%	-4.94%	101.85%	102.57%	105.59%
36	-2.31%	-3.39%	-4.30%	102.14%	102.97%	104.89%
37	-7.07%	-0.33%	-2.59%	102.65%	104.21%	103.14%
38	-2.04%	-0.10%	-7.86%	103.21%	105.10%	101.69%
39	-8.94%	-0.42%	-0.64%	102.20%	103.50%	104.29%
40	-4.65%	-0.22%	-5.13%	101.79%	102.84%	105.37%
41	-5.95%	-0.28%	-3.77%	101.74%	102.78%	105.48%

42	-6.51%	-0.31%	-3.18%	102.02%	103.21%	104.78%
43	-7.26%	-0.08%	-2.66%	102.67%	104.16%	103.17%
44	-2.05%	-0.02%	-7.92%	103.25%	105.04%	101.71%
45	-9.23%	-0.10%	-0.67%	102.22%	103.45%	104.33%
46	-4.73%	-0.05%	-5.21%	101.80%	102.79%	105.41%
47	-6.08%	-0.07%	-3.85%	101.76%	102.73%	105.52%
48	-6.66%	-0.07%	-3.26%	102.03%	103.16%	104.81%
49	-7.30%	-0.03%	-2.67%	102.74%	104.01%	103.25%
50	-2.06%	-0.01%	-7.93%	103.34%	104.90%	101.76%
51	-9.30%	-0.03%	-0.67%	102.27%	103.32%	104.42%
52	-4.75%	-0.02%	-5.23%	101.83%	102.68%	105.49%
53	-6.11%	-0.02%	-3.87%	101.78%	102.61%	105.60%
54	-6.70%	-0.03%	-3.28%	102.07%	103.03%	104.90%
55	-7.23%	-0.12%	-2.65%	102.15%	105.30%	102.55%
56	-2.05%	-0.04%	-7.91%	102.51%	106.17%	101.32%
57	-9.18%	-0.16%	-0.66%	101.85%	104.55%	103.60%
58	-4.72%	-0.08%	-5.20%	101.55%	103.81%	104.65%
59	-6.06%	-0.10%	-3.84%	101.51%	103.73%	104.76%
60	-6.64%	-0.11%	-3.25%	101.71%	104.22%	104.06%
61	-6.74%	-0.79%	-2.47%	102.52%	104.48%	102.99%
62	-2.01%	-0.24%	-7.75%	103.03%	105.38%	101.60%
63	-8.41%	-0.99%	-0.61%	102.12%	103.76%	104.12%
64	-4.51%	-0.53%	-4.96%	101.73%	103.07%	105.20%
65	-5.71%	-0.67%	-3.62%	101.69%	103.00%	105.31%
66	-6.22%	-0.73%	-3.04%	101.94%	103.45%	104.60%
67	-5.71%	-2.20%	-2.09%	102.76%	103.98%	103.27%
68	-1.91%	-0.74%	-7.36%	103.37%	104.86%	101.77%
69	-6.86%	-2.64%	-0.49%	102.28%	103.28%	104.44%
70	-4.02%	-1.55%	-4.43%	101.84%	102.65%	105.52%
71	-4.95%	-1.91%	-3.14%	101.79%	102.58%	105.63%
72	-5.33%	-2.06%	-2.61%	102.08%	103.00%	104.92%
73	-5.83%	-0.47%	-3.70%	103.78%	103.56%	102.65%
74	-1.29%	-0.11%	-8.61%	104.44%	104.18%	101.38%
75	-8.29%	-0.68%	-1.04%	103.23%	103.04%	103.73%
76	-3.34%	-0.27%	-6.38%	102.69%	102.53%	104.78%
77	-4.59%	-0.37%	-5.04%	102.63%	102.48%	104.89%
78	-5.18%	-0.42%	-4.39%	102.99%	102.82%	104.19%
79	-6.05%	-0.12%	-3.84%	103.78%	103.56%	102.65%
80	-1.30%	-0.03%	-8.68%	104.44%	104.18%	101.38%
81	-8.74%	-0.17%	-1.09%	103.23%	103.04%	103.73%
82	-3.42%	-0.07%	-6.52%	102.69%	102.53%	104.78%
83	-4.72%	-0.09%	-5.18%	102.63%	102.48%	104.89%
84	-5.36%	-0.10%	-4.54%	102.99%	102.82%	104.19%
85	-6.09%	-0.04%	-3.87%	103.89%	103.38%	102.73%
86	-1.30%	-0.01%	-8.69%	104.59%	103.98%	101.43%
87	-8.84%	-0.06%	-1.10%	103.31%	102.87%	103.82%
88	-3.43%	-0.02%	-6.55%	102.74%	102.38%	104.88%
89	-4.75%	-0.03%	-5.22%	102.68%	102.33%	104.99%

90	-5.39%	-0.04%	-4.57%	103.06%	102.65%	104.29%
91	-6.01%	-0.18%	-3.81%	103.16%	104.62%	102.22%
92	-1.30%	-0.04%	-8.66%	103.61%	105.26%	101.13%
93	-8.66%	-0.26%	-1.08%	102.77%	104.04%	103.19%
94	-3.40%	-0.10%	-6.50%	102.36%	103.44%	104.20%
95	-4.70%	-0.14%	-5.16%	102.32%	103.38%	104.31%
96	-5.33%	-0.16%	-4.51%	102.59%	103.78%	103.63%
97	-5.44%	-1.11%	-3.45%	103.63%	103.82%	102.55%
98	-1.27%	-0.26%	-8.47%	104.23%	104.45%	101.32%
99	-7.53%	-1.53%	-0.94%	103.12%	103.28%	103.60%
100	-3.21%	-0.65%	-6.13%	102.61%	102.75%	104.64%
101	-4.35%	-0.88%	-4.77%	102.56%	102.69%	104.75%
102	-4.88%	-0.99%	-4.13%	102.89%	103.05%	104.06%
103	-4.34%	-2.90%	-2.76%	103.91%	103.34%	102.75%
104	-1.20%	-0.80%	-8.00%	104.62%	103.94%	101.44%
105	-5.58%	-3.72%	-0.70%	103.32%	102.84%	103.84%
106	-2.80%	-1.87%	-5.34%	102.75%	102.35%	104.90%
107	-3.62%	-2.41%	-3.97%	102.69%	102.30%	105.01%
108	-3.98%	-2.65%	-3.37%	103.07%	102.62%	104.31%
109	-7.37%	-0.30%	-2.33%	104.92%	102.91%	102.17%
110	-2.29%	-0.09%	-7.61%	105.59%	103.31%	101.10%
111	-9.07%	-0.37%	-0.56%	104.31%	102.56%	103.13%
112	-5.03%	-0.20%	-4.77%	103.69%	102.19%	104.13%
113	-6.30%	-0.26%	-3.44%	103.62%	102.15%	104.23%
114	-6.84%	-0.28%	-2.88%	104.04%	102.39%	103.56%
115	-7.54%	-0.07%	-2.38%	104.92%	102.91%	102.17%
116	-2.31%	-0.02%	-7.67%	105.59%	103.31%	101.10%
117	-9.33%	-0.09%	-0.58%	104.31%	102.56%	103.13%
118	-5.10%	-0.05%	-4.85%	103.69%	102.19%	104.13%
119	-6.43%	-0.06%	-3.51%	103.62%	102.15%	104.23%
120	-6.99%	-0.07%	-2.95%	104.04%	102.39%	103.56%
121	-7.58%	-0.02%	-2.39%	105.03%	102.75%	102.22%
122	-2.31%	-0.01%	-7.68%	105.74%	103.13%	101.13%
123	-9.39%	-0.03%	-0.58%	104.40%	102.40%	103.20%
124	-5.12%	-0.02%	-4.86%	103.75%	102.05%	104.20%
125	-6.45%	-0.02%	-3.52%	103.68%	102.01%	104.31%
126	-7.02%	-0.02%	-2.96%	104.12%	102.25%	103.63%
127	-7.52%	-0.11%	-2.37%	104.24%	103.89%	101.87%
128	-2.31%	-0.03%	-7.66%	104.73%	104.34%	100.93%
129	-9.29%	-0.14%	-0.58%	103.78%	103.47%	102.75%
130	-5.09%	-0.07%	-4.83%	103.29%	103.02%	103.69%
131	-6.41%	-0.09%	-3.50%	103.24%	102.97%	103.79%
132	-6.96%	-0.10%	-2.94%	103.57%	103.28%	103.15%
133	-7.06%	-0.71%	-2.23%	104.76%	103.15%	102.10%
134	-2.26%	-0.23%	-7.51%	105.38%	103.56%	101.06%
135	-8.60%	-0.87%	-0.53%	104.19%	102.77%	103.04%
136	-4.88%	-0.49%	-4.63%	103.60%	102.38%	104.02%
137	-6.07%	-0.61%	-3.31%	103.53%	102.34%	104.13%

138	-6.57%	-0.66%	-2.77%	103.93%	102.60%	103.47%
139	-6.07%	-2.02%	-1.92%	105.05%	102.71%	102.23%
140	-2.15%	-0.71%	-7.14%	105.77%	103.10%	101.13%
141	-7.17%	-2.38%	-0.45%	104.42%	102.37%	103.21%
142	-4.38%	-1.46%	-4.16%	103.76%	102.02%	104.21%
143	-5.32%	-1.77%	-2.91%	103.69%	101.98%	104.32%
144	-5.70%	-1.89%	-2.40%	104.13%	102.22%	103.65%
145	-4.12%	-0.67%	-5.21%	103.60%	103.67%	102.73%
146	-0.69%	-0.11%	-9.20%	104.24%	104.33%	101.43%
147	-7.08%	-1.15%	-1.76%	103.06%	103.12%	103.82%
148	-2.01%	-0.33%	-7.66%	102.53%	102.58%	104.88%
149	-2.98%	-0.48%	-6.53%	102.48%	102.53%	104.99%
150	-3.51%	-0.57%	-5.92%	102.83%	102.88%	104.29%
151	-4.34%	-0.17%	-5.49%	103.60%	103.67%	102.73%
152	-0.70%	-0.03%	-9.28%	104.24%	104.33%	101.43%
153	-7.77%	-0.30%	-1.93%	103.06%	103.12%	103.82%
154	-2.06%	-0.08%	-7.86%	102.53%	102.58%	104.88%
155	-3.10%	-0.12%	-6.78%	102.48%	102.53%	104.99%
156	-3.67%	-0.14%	-6.19%	102.83%	102.88%	104.29%
157	-4.39%	-0.06%	-5.55%	103.71%	103.48%	102.81%
158	-0.70%	-0.01%	-9.29%	104.39%	104.12%	101.48%
159	-7.92%	-0.10%	-1.97%	103.14%	102.95%	103.92%
160	-2.08%	-0.03%	-7.90%	102.59%	102.43%	104.98%
161	-3.12%	-0.04%	-6.84%	102.53%	102.38%	105.09%
162	-3.70%	-0.05%	-6.25%	102.89%	102.72%	104.39%
163	-4.30%	-0.25%	-5.44%	103.00%	104.73%	102.28%
164	-0.70%	-0.04%	-9.26%	103.43%	105.41%	101.16%
165	-7.65%	-0.45%	-1.90%	102.61%	104.12%	103.26%
166	-2.06%	-0.12%	-7.82%	102.22%	103.50%	104.28%
167	-3.08%	-0.18%	-6.74%	102.18%	103.44%	104.38%
168	-3.64%	-0.21%	-6.15%	102.44%	103.85%	103.71%
169	-3.74%	-1.52%	-4.74%	103.45%	103.93%	102.62%
170	-0.68%	-0.28%	-9.05%	104.04%	104.60%	101.36%
171	-6.04%	-2.45%	-1.50%	102.95%	103.36%	103.69%
172	-1.92%	-0.78%	-7.30%	102.46%	102.80%	104.74%
173	-2.78%	-1.13%	-6.09%	102.41%	102.74%	104.85%
174	-3.23%	-1.31%	-5.46%	102.73%	103.11%	104.15%
175	-2.78%	-3.70%	-3.52%	103.73%	103.44%	102.83%
176	-0.64%	-0.85%	-8.51%	104.42%	104.09%	101.49%
177	-3.88%	-5.16%	-0.96%	103.15%	102.91%	103.94%
178	-1.63%	-2.17%	-6.20%	102.60%	102.40%	105.00%
179	-2.21%	-2.95%	-4.84%	102.54%	102.35%	105.11%
180	-2.49%	-3.31%	-4.20%	102.91%	102.68%	104.41%
181	-8.18%	-0.21%	-1.62%	104.44%	103.18%	102.37%
182	-3.22%	-0.08%	-6.70%	105.12%	103.67%	101.21%
183	-9.40%	-0.24%	-0.37%	103.85%	102.76%	103.38%
184	-6.17%	-0.16%	-3.67%	103.26%	102.33%	104.41%
185	-7.31%	-0.19%	-2.50%	103.19%	102.29%	104.52%

186	-7.75%	-0.20%	-2.05%	103.59%	102.57%	103.83%
187	-8.31%	-0.05%	-1.64%	104.44%	103.18%	102.37%
188	-3.24%	-0.02%	-6.74%	105.12%	103.67%	101.21%
189	-9.57%	-0.06%	-0.37%	103.85%	102.76%	103.38%
190	-6.25%	-0.04%	-3.72%	103.26%	102.33%	104.41%
191	-7.42%	-0.04%	-2.54%	103.19%	102.29%	104.52%
192	-7.87%	-0.05%	-2.08%	103.59%	102.57%	103.83%
193	-8.33%	-0.02%	-1.65%	104.56%	103.01%	102.43%
194	-3.24%	-0.01%	-6.75%	105.27%	103.48%	101.25%
195	-9.61%	-0.02%	-0.37%	103.94%	102.60%	103.46%
196	-6.26%	-0.01%	-3.72%	103.32%	102.19%	104.49%
197	-7.44%	-0.02%	-2.54%	103.25%	102.15%	104.60%
198	-7.90%	-0.02%	-2.09%	103.67%	102.42%	103.91%
199	-8.28%	-0.08%	-1.64%	103.78%	104.20%	102.02%
200	-3.24%	-0.03%	-6.73%	104.26%	104.73%	101.01%
201	-9.54%	-0.09%	-0.37%	103.35%	103.71%	102.94%
202	-6.23%	-0.06%	-3.71%	102.89%	103.20%	103.91%
203	-7.40%	-0.07%	-2.53%	102.84%	103.15%	104.01%
204	-7.85%	-0.07%	-2.07%	103.15%	103.49%	103.36%
205	-7.93%	-0.50%	-1.57%	104.28%	103.43%	102.29%
206	-3.18%	-0.20%	-6.62%	104.91%	103.93%	101.16%
207	-9.07%	-0.58%	-0.35%	103.73%	102.99%	103.28%
208	-6.03%	-0.38%	-3.59%	103.17%	102.54%	104.29%
209	-7.11%	-0.45%	-2.43%	103.11%	102.49%	104.40%
210	-7.53%	-0.48%	-1.99%	103.49%	102.79%	103.72%
211	-7.11%	-1.48%	-1.41%	104.58%	102.97%	102.44%
212	-3.04%	-0.63%	-6.33%	105.30%	103.44%	101.26%
213	-8.02%	-1.67%	-0.31%	103.96%	102.57%	103.47%
214	-5.55%	-1.15%	-3.30%	103.33%	102.16%	104.51%
215	-6.45%	-1.34%	-2.21%	103.26%	102.12%	104.62%
216	-6.79%	-1.41%	-1.79%	103.68%	102.39%	103.93%
mean	-4.92%	-0.62%	-4.46%	103.15%	103.28%	103.57%
SD	2.48%	0.94%	2.56%	0.98%	0.86%	1.31%