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Airport Security Investment Model

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Abstract

In an increasingly mobile and diverse world, it is difficult to quantify the risk, or danger, associated with travelling. Airports have suffered greatly for being unable to define potential risks and protect against them. Intelligent adversary risk is a complicated high-level issue for many airports. Airports are targeted because of the large amount of people in a confined space and the social, economic, and psychological impact of terrorist attacks on the American people. In the months following September 11th, 2001, the airline industry in the United States lost $1.1 billion in revenue. The American people stayed grounded, for fear of another attack by plane. Recent airport attacks have had a similar effect. The nearly 350 airport attacks from 2000-2015 presents a massive opportunity for improvement. The presence of risk, in the form of terrorist attacks, is an influential deterrent for passengers. To combat the risk of attack, airports must provide a higher level of safety and security to people passing through their terminals. To decrease the risk of an attack, airports must increase the ability to defend itself. In the case of intelligent adversary attacks, a decrease in risk can be thought of as an increase in value. Multi-Objective Decision analysis (MODA), uses a Value-Focused Thinking model to quantify value. When dealing with human lives, models need to strive to add value not just increase cash flow. There are countless projects that could add value, so the selection will be complicated. A portfolio analysis will use a budget given by the decision maker and turn it into a set of the highest value projects for those dollars. The goal of this study is to canvas the type of solutions available, and give an optimal set of solutions to the decision maker.

Acknowledgements

Dr. Gregory Parnell has been a model of patience and understanding throughout my graduate career. He has afforded me the opportunity to complete a dream, and he has done it with smile. Dr. Parnell is one of the most decorated and storied members of the field of Decision Analysis, and I am proud to say he was my advisor. He deserves commendation for his work to progress the field, and for guidance of his graduate students.

Special thanks are extended to the staff of the University of Arkansas Graduate School for all their guidance, inspiration, and kind acceptance of panicked graduate students.

My wife, Jessica, has been instrumental to my success as a student, and none of this research would be possible without her support. The countless nights talking through issues, and being the person who coaches me on the best way to solve problems.

My parents gave me a foundation for learning, and taught me I could achieve my goals with patience, determination, grit, and faith. Thank you for all you have done to show me how to navigate through life. I would also like to thank my family for their support over the years, especially these past two years.

There are countless friends, colleagues, and mentors who have helped me, and given me guidance. It is not possible to name you all by name, but I hope this serves as a small appreciation for the support you have provided.

Dedication

I would like to dedicate this work to my wife, Jessica Bolton, and my parents, Curt Bolton III and Chandra Bolton. You three have put up with me for many years, and I hope, will continue to do so. Please consider this a show of my appreciation for the friendship you have given me throughout the years. Life is nothing but a series of friendships, and your friendship means the world to me.

Contents

List of Figures

1. Introduction

Perception of an impending attack on the United States has increased in the past three years. With crisis in the Middle East, North Korea stocking up on nuclear weapons, and continued uncertainty in Europe; many Americans are becoming even more fearful of the future. One continued source of fear caused an approximated $1.1 Billion in revenue loss in 2001, due to the World Trade Center attacks of September 11th (Blalock, Kadiyali, & Simon, 2007). The events of September 11th have caused the United States government to increase airport security funding and make it the top priority of the Department of Homeland Security. In addition, almost 350 terrorist attacks occurred at airports or on airplanes between 2000-2015, as listed by the Global Terrorism Database (University of Maryland Global Terrorism Database, n.d.). Funding levels for airport and airplane security increase have come, seemingly, without a question of the value of counter measures being implemented. Placing a value on a human life is difficult, but value can be placed on decreasing risk. This study focuses on the best methods to decrease the risk of an attack.

Before 2001, friends and families could walk passengers up to the gate to board a plane. Now, there are major security check points, and only passengers can pass through. There is no doubt security reform was needed, but reform without oversight to the value per dollar of funding does not provide holistic solutions. Questions like, ‘Do the measures being put in place actually prevent terrorist attacks from happening’, or ‘Do the added security features make the airport, as a whole, safer’ need to be addressed. Viewing airports as a system, instead of a series of independent obstacles, has been challenging in the wake of the tremendous losses experienced on September 11th. Defining a method for quantifying the ability of a specific technique or tool to reduce the risk of terrorist activity in a specific airport is important. The goal of this study is to design a portfolio analysis framework for airports to use in assessing: current value of security, possible projects to increase value of security, and given budgetary constraints, what projects they should implement. Since putting a dollar value on reduced risk is difficult, a Multiple Objective Decision Analysis (MODA) model will be used, along with expert opinion to determine value of actions to improve airport security. This methodology helps an airport to see the baseline value of current security, and what would be the most beneficial projects or counter measures to implement given budgetary requirements. Due to the diverse nature of airport security baselines, available alternatives, and Transportation Security Administration (TSA) guidelines, each airport will need to change the alternatives, weights, and current state of the model. The purpose of the model is to provide a tool to facilitate discussion among airport security leadership as to current threats, areas of vulnerability, and possible solutions.

Background

The growth of airport security has been significant over the past 15 years. In 2001, security was any person being able to walk up to the gate after passing through a metal detector. In 2017, only passengers can pass through security to access the terminals, and they must go through full body millimeter wave scanners. At large, often category X airports, passengers are randomly picked to provide a swab of their hands to be processed for residue of harmful chemicals. Bomb dogs, under-cover agents, and SWAT teams have also become common place in large airports around the busy times of year. Airports need a methodology to assess the added risk reduction of additional security measures.

Literature Review

Garrick Blalock, Vrinda Kaduyali, Daniel Simon consider the cost of employing the security agents at a check point (Blalock, Kadiyali, & Simon, 2007). The authors note, it takes roughly 15 seconds for the best, 25 seconds for average, and 60 seconds for worst case scenarios of a person passing through a security check point. They give the cost of processing 1 million average passengers as 1.361 million euros or $1.9 million. This does not include the cost of management, equipment, or situations where passengers cause longer than normal delays. If these are considered, costs would increase. However, the authors believe the impact of TSA security procedures on passengers should be assessed. These security procedures have the potential to cut down or increase time severely. The authors also argue a significant amount of infractions, 20-40%, go unreported because they are deemed benign (Blalock, Kadiyali, & Simon, 2007). If a passenger has negative comments or starts acting aggressive, additional time is required to handle the passenger.

Stewart and Mueller argue too much emphasis has been put on airport security and not enough on the security of the planes (Stewart & Mueller, 2013). They state in their paper on Cost-Benefit analysis of airport security that of all terrorist attacks, only .5% are on airports. They believe an analysis of prevention begins with the probability of attack. They go on to classify assessed security in terms of four threats: large car bomb, curbside car bomb, luggage or vest bomb, and public grounds shooting attack. Stewart and Mueller give several possible fixes for these threats and the probability of detecting the threat. They declare the possibility of an attack on each major US airport is .2% per year, and the consequences have been relatively small. However, there have been several attacks in airports have been very deadly in the past four years, including Brussels, Turkey, and Florida. Planes have previously been the main source of aviation attacks, but now it has changed to airports (Tuysuz & Almasy, 2016).

Stewart and Mueller based their analysis on a report created by the RAND Corporation. The RAND Corporation performed a vulnerability analysis of the Los Angeles airport (LAX) and came up with short term solutions to make the airport more secure. The RAND report utilizes 11 scenarios they believe canvas the most likely situations an attack could be carried out under. Some of these scenarios reflect actual events and some were created to represent possible attacks. The report states the desired results are to deter and limit possible damage. RAND developed a method for creating threat attack options by looking at the airport components, identifying defenses for each attack option, estimating the feasibility of an attack, examining historical data, and then compiling these data points. They developed creative and feasible alternatives with story lines. Then they binned the 11 scenarios into lists of major and minor threats. They identified three major areas to help reduce risk: improving airport processes, innovative technology purchases, and new construction projects. They included the costs of the projects but did not cross analyze the security value of the project (Figure 1). Cost benefit analysis, or portfolio analysis, was not done for these projects (Stevens, Hamilton, Mesic, & Brown, 2004).

Cost Estimates for Improving LAX Security (FY 2004 Dollars)

LAX Security Options	Capital Expenditure Cost ($M)	Recurring Operating Cost ($M)	Total Annual Cost ($M)
Add permanent vehicle checkpoints with bomb detection capability	$7	$11	$12
Direct all vehicles to remote parking lots	$259	$10	$50
Add curbside blast deflection and shatterproof glass	$17	$0.2	$3
Eliminate lane closest to terminals (1)	$0.5	$2	$2
Add additional pilings to support upper roadway	$30	$0.2	$5
Search all luggage entering terminals (2)	$0	$18	$18
Add 30 handheld bomb sniffers (2)	$8	$2	$3
Add 30 bomb sniffing dogs	$0	$4	$4
Add skycaps, check-in personnel, and TSA lines to hasten check -in (3)	$1	$4	$4
Inspect all cargo going into passenger planes (2)	$111	$76	$93
Add motion detection system near aircraft	$0.2	$0.3	$0.3
Enhance background checks on airport personnel	$2	$34	$34
Add double fence with motion detection around perimeter of airpo rt	$39	$0.5	$7
Enhance training of LAX rapid reaction team to SWAT standards	$0.2	$2	$2
Patrol MANPADS vulnerable areas (4)	$2	$8	$8
Add ground-based MANPADS countermeasures (2)	$65	$1	$11
Add sensors to locate mortars	$3	Part of enhanced training of LAX rapid reaction team	$0.5
Restrict roads near and under tower/utility plant	$1	$0.2	$0.4

Options will impact LAWA budget except where noted below:

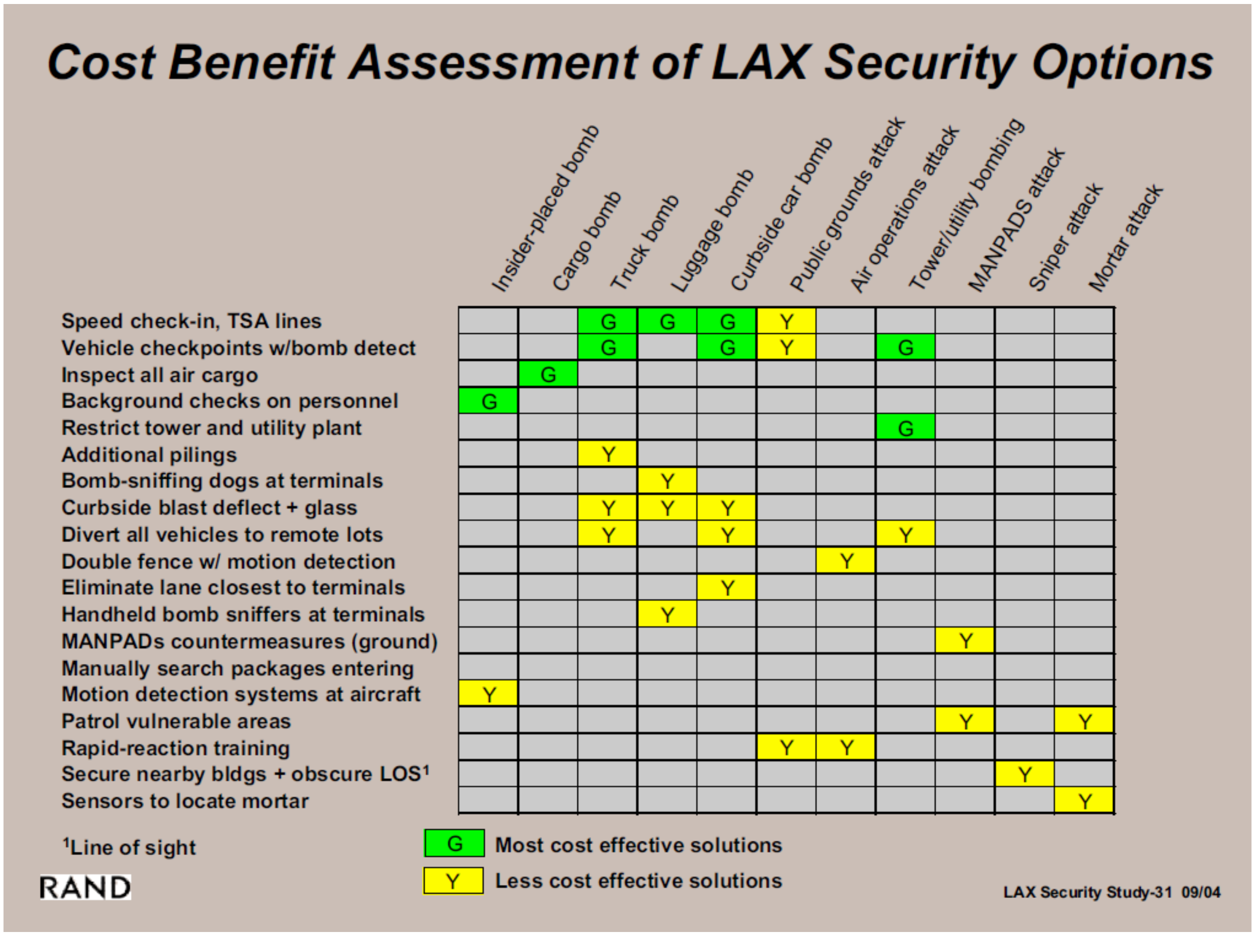
(1) Air carrier personnel budget impact (3) Combined air carrier personnel & TSA budget impacts

(2) TSA budget impact (4) LAPD budget impact

RAND LAX Security Study-24 09/04

Figure 1:Cost Estimation for LAX Security Improvements (Stevens, Hamilton, Mesic, & Brown, 2004)

The security options used to help solve major threats at LAX cover a number of possible avenues of attack. However, they did not show the benefit of the alternative or how much value is provided by each security option. The most beneficial security options for each of the 11 categories are shown, but no numerical value is assigned to the option. If the value had been assessed, the cost-benefit could be plotted on a graph instead of being put in a table like figure 2. This provides little insight into why the alternatives were chosen. (Stevens, Hamilton, Mesic, & Brown, 2004).



Cost Benefit Assessment of LAX Security Options

	Insider-placed bomb	Cargo bomb	Truck bomb	Luggage bomb	Curbside car bomb	Public grounds attack	Air operations attack	Tower/utility bombing	MANPADS attack	Sniper attack	Mortar attack
Speed check-in, TSA lines			G	G	G	Y					
Vehicle checkpoints w/bomb detect			G		G	Y		G			
Inspect all air cargo		G									
Background checks on personnel	G										
Restrict tower and utility plant								G			
Additional pilings			Y								
Bomb-sniffing dogs at terminals				Y							
Curbside blast deflect + glass			Y	Y	Y						
Divert all vehicles to remote lots			Y		Y			Y			
Double fence w/ motion detection							Y				
Eliminate lane closest to terminals					Y						
Handheld bomb sniffers at terminals				Y							
MANPADs countermeasures (ground)									Y		
Manually search packages entering											
Motion detection systems at aircraft	Y										
Patrol vulnerable areas									Y		Y
Rapid-reaction training						Y	Y				
Secure nearby bldgs + obscure LOS[1]										Y	
Sensors to locate mortar											Y

[1]Line of sight

G Most cost effective solutions

Y Less cost effective solutions

RAND

LAX Security Study-31 09/04

Figure 2: Cost-Benefit Assessment (Stevens, Hamilton, Mesic, & Brown, 2004)

Rountree and Demetsky used a portfolio model to examine the security measures of cargo facilities at airports. They used a survey filled out by major airports to provide a baseline analysis of the security systems. Then they determined the feasible alternatives and summarized them by cost, what they screen for, time to inspect the baggage, material discrimination, and installation type, as shown in figure 3. This knowledge was used, along with a case study of a major airport cargo facility, to create a computer simulation of outbound cargo flow through an airport facility. The results of the simulation were posted and discussed, but no cost-benefit analysis was used to determine the best alternative or an efficient frontier.

	Cost ($)	Screen for	Time to Inspect	Material Discr.	Material ID	Installation
Active systems						
X-ray	$1–10 million	Explosives, stolen materials, drugs	2–5 min	No	No	Mobile or fixed. Fixed sites need power, road access, personnel facilities, and attention to radiation safety. Vehicles needed for mobility.
Standard	$1–5 million		2–5 min	No	No	
Dual view	$10 million		2–5 min	No	No	
Backscatter	$2–5 million		2–5 min	No	No	
Gamma ray	$500,000–$3 million		2–5 min	No	No	
Pulsed fast Neutron Analysis	$10–25 million	Explosives, drugs	1 h +	Yes	Yes	
Thermal neutron activation	$500,000–$3 million	Explosives	1 h +	Yes	Yes	
Passive systems						
Vapor detection	$30,000–$50,000	Prohibited gases	30–60 s	Yes	Yes	Portable or desktop equipment operated by battery or wallplug
Trace detection	$30,000–$50,000	Explosives, drugs	30–60 s	Yes	Yes	
Radiation detection	$10,000–$50,000	Radiation	30–60 s	No	Yes, for radioactive material	
Canines	$7,000–$120,000 per unit per year	Explosives, drugs	10–60 s	Limited by amount of training	Yes	Require care, feeding, shelter

Figure 3: Alternative Analysis for Roundtree and Demetsky (Rountree & Demetsky)

All four of these papers contribute to the current body of knowledge, and help to lay the ground work for the next step. The use of three additional papers, on: X-ray machine effectiveness, the training of employees, and the security screen process provide back ground information, but do not directly contribute to the knowledge required for modeling.

The literature review identifies the need for portfolio analysis of airport security alternatives. Current papers look at cargo facilities, TSA screening, luggage screening, post-screening safety, and safety on the ramps. Attackers can often make it through one stage of security, but having a multi-layered security portfolio would provide a great increase in total security. Table 1. shows the topics covered by each of the four papers in the literature review.

Paper	Scope	Optimization Used	Value Model	Risk Analysis	Value Type
Blalock, Kadiyali, & Simon	Security Screening	-	NPV	-	AFT
Stewart & Mueller	Curb to Security	-	NPV	Monte Carlo	AFT
RAND Corp	Terminal, Cargo, and grounds	-	Non-Numeric MODA	Scenario Analysis	AFT
Rountree & Demetsky	Cargo Facilities	-	MODA	Simulation	AFT
Abidi, Et. Al	X-Ray Machine	-	-	-	AFT
Gramatica Et Al.	Training Employees	Linear	-	-	AFT
Kirschenbaum	Security Screening	-	NPV	-	AFT

Table 1: Airport Security Literature Review Summary

I argue the major flaw with many papers on risk reduction is they do not follow Value-Focused thinking (VFT) (Parnell, Bresnick, Tani, & Johnson, 2013). Their Alternative Focused Thinking (AFT) protects against most of the problems, but does not take care of the underlying issue of fear. The money lost in the fourth quarter of 2001 was due to fear of another attack. To decrease the public sense of fear in airport security, confidence in the whole system must be increased. The next step in airport security modeling is to answer the question of how to determine the most beneficial outcome for a given budget over a given period. A variable portfolio model adjusting for the size and passenger throughput is a practical way to determine the necessary level of funding to maintain safety for all passengers. This research focuses on Terminal E of the Dallas-Fort Worth International Airport, but can be adapted for other airports.

Methodology:

To combat the issue of fear among passengers, an atmosphere of safety must be cultivated. This paper uses a Value Focused Thinking (VFT) decision analysis methodology. VFT considers the ideal situation, and then considers how to best achieve a solution close to the ideal. VFT contrasts with Alternative Focused Thinking (ATF). ATF examines the options and choses the best option from among them. VFT allows the modeling team to come up with new creative solutions. Albert Einstein is famously quoted as stating, "*We can't solve problems by using the same kind of thinking we used when we created them*" (Mielach, 2012). By defining the desired value paramount in the model, the best solution set can be found. The first step is to identify the problem, then create a list of stakeholders, a value hierarchy, an influence diagram, a list of all possible alternatives, and an evaluation of how much value these alternatives will add. Value will be determined by a MODA model with expert insight. This will lead to a portfolio analysis of workable solutions to the types of security challenges faced by airports today. We know there is no money being directly created by implementing one, or several, of these projects; to justify these projects we will consider the potential losses prevented. It is easy to justify improvements by looking at the amount of revenue lost by the attacks of September 11th (Blalock, Kadiyali, & Simon, 2007). Without attempting to put a value on the nearly 3,000 priceless lives lost, the $1.1 billion dollars lost to the industry by these tragic events provides justification. The Department of Homeland Security received $3.8 billion in Aviation security funding in 2015 (Department of Homeland Security, 2015). However, Blalock, et al. have claimed a significant amount of aviation security infractions go unnoticed and unreported. It is important to minimize the unreported infractions in the most cost-effective way possible, but the focus is not on a particular aspect of the security process, but on providing a complete system to deter and defeat attackers.

MODA provides a frame work to best allocate aviation security resources to deter an attack and, if deterrence fails, to minimize the amount of potential injuries, damage, monetary loss among; passengers, personnel, and airports. The reduction of injuries and damage may come from the implementation of technology or personnel but cannot simply be assumed. Yearly evaluations must be done with the model to determine if the implemented solutions are still relevant. After the attacks of September 11th, there was a great increase in security, and a decline in injuries and fatalities caused by terrorist attacks. Figure 4 outlines the amount of injuries and fatalities over each six-year period, starting in 1968 and ending in 2009 (http://smapp.rand.org/rwtid/search_form.php). From 2010-2017, the number of injuries and fatalities due to attacks is 38 (Johnston, 2017).

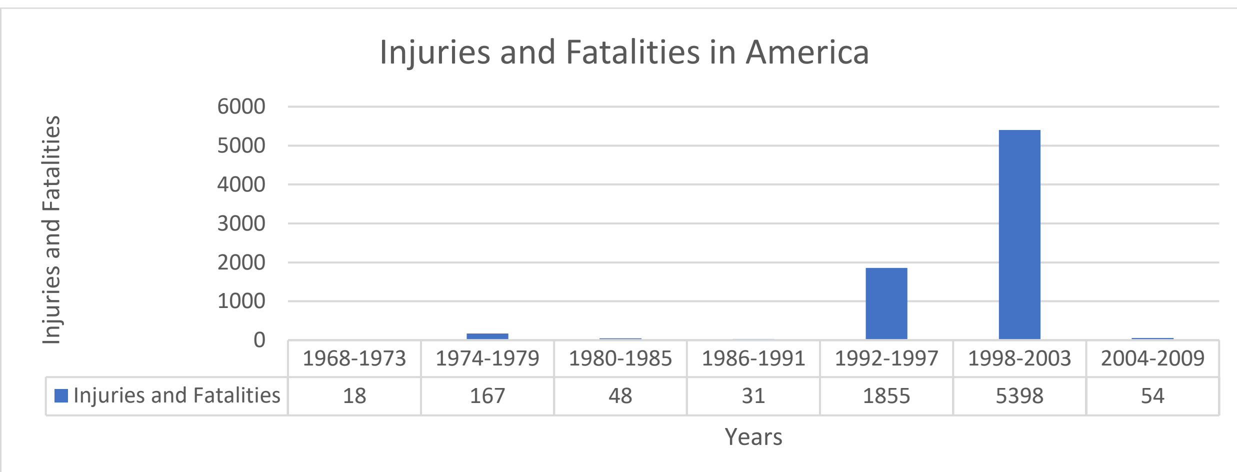


Figure 4: Terrorist Attacks in the US, 1968-2009 (http://smapp.rand.org/rwtid/search_form.php)

There is a spike from 1992-1997 when the airline industry started to grow rapidly. From 1998-2003, there were 5398 injuries and fatalities, mostly caused by the attack of the World Trade Center. The following six years saw relatively few injuries and deaths. In the past three years there has been an increase in attacks, a few of the most devastating include airports in Brussels and Fort Lauderdale. The attacks from 1998-2003 were by terrorists on airplanes. The attacks after 2009 are in the airport terminals and atriums. The next step in defense is to secure these areas and provide safety to passengers before going through TSA.

Decisions & Scope

Risk is difficult to quantify. It is based on knowledge of the motives, knowledge, and resources of the attackers. It is difficult to have insight into the objectives and the future methods of terrorist organizations can be very difficult to predict. It is hard to protect against unknown threats, especially with large, target rich environments such as airports. It is impossible to completely mitigate all risk. For this study, we will focus on four types of alternatives: Personnel, Procedures, Technology, and Awareness to mitigate risk and increase security. In the case of airport security, value can be thought of as the potential reduction of risk to passengers, airport personnel, and the infrastructure. This is described in the decision hierarchy (Parnell, Bresnick, Tani, & Johnson, 2013) found in figure 5. The Decision Hierarchy contains three categories of decisions: Done deals, In Scope, and Future Decisions. Done deals are decisions made prior to the start of the modeling process, and cannot be changed. Future decisions are things beyond the scope of the decision. Future decisions are part of the future research section. The In Scope section are decisions which are addressed in this paper.

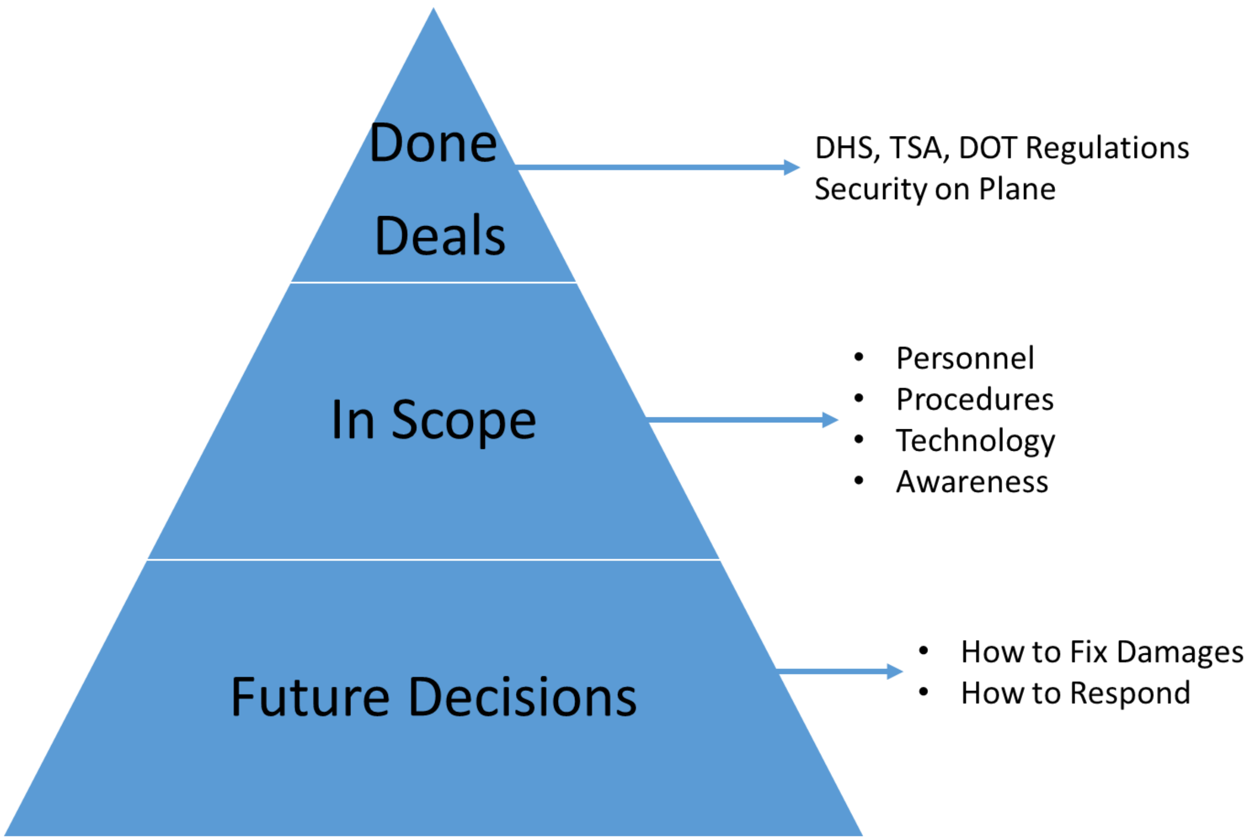


Figure 5: Decision Hierarchy for Airport Security Improvements

The Department of Homeland Security (DHS), Transportation Security Administration (TSA), and the Department of Transportation regulations are out of the scope of this paper. Safety and security of passengers and airport personnel, once they board a plane is also out of scope. Similarly, if a security event happens, the response and how to fix the problem should be considered for future work. It will focus solely on the items that can be implemented before a threat occurs. Methods for diagnosing the type of security event are included in the scope, but the initiation of a response to the event is not. The In Scope decisions are suggestions to the decision maker, and are to facilitate a discussion between the decision maker and their staff to help select the best portfolio of security options. It is the decision makers' ultimate responsibility to make sure the stakeholders are safe. To assist the decision makers, and to focus this project, a stakeholder identification matrix, can be found in table 1. A Stakeholder Issue Identification matrix helps the decision maker to understand the parties involved and their concerns (Parnell, Bresnick, Tani, & Johnson, 2013).

	Top Decision Maker	TSA Officials	Airport Employees	Passengers	Airlines
Economic	Tie up Capitol		Out of Work for	Could miss flights	Profit loss
Technology	New systems to learn	Did they let something through	Equipment could be damaged	Might loose personal tech	Destruction of Airplanes
Social	Bad press	Bad press			Bad press
Ethical	Further endangerment of people	Further endangerment of people	Forced to Choose between self and others		Endangering passenger
Regulators	Understand Drills		Understand Role in Evac		Federal Regulations
Psychological	Life vs Cost		Paralysis	nervous/endangered	
Legal	Liable if negligent	Legally responsible	Could be liable	cause no harm	Could be liable
Emotional	Past Events		Potential PTSD	distressed	
Environmental	Is the area high profile			too much sound	
Organizational	Culture for false alarms	System Integrity	Need to know role in emergency		
Security	Did security fail				Potentially dangerous

Table 2: Stakeholder Identification Matrix

The decision maker is the head of airport security. He has several diverse groups of stakeholders to take into account, and his main concerns are security, cost, and media attention. Airports are particularly sensitive to the news media because they are a business and rely on public trust to operate. Each of the stakeholders rely on the others, and they are influenced by each-other's actions. These interactions can prove to be significant. Passengers who become panicked during an attack will complicate the exfiltration process by the TSA officials.

To understand what the effect of a given implementation, we need to see what people, processes, and events influence each other. The use of an influence diagram, in figure 6, will help identify the interdependencies. In this case, we will use a System Risk-Actions-Management, SAM, model to show which factors, decisions, and risks influence each other or have some level of relevance. The SAM model shows what particular pieces are management focused and people focused.

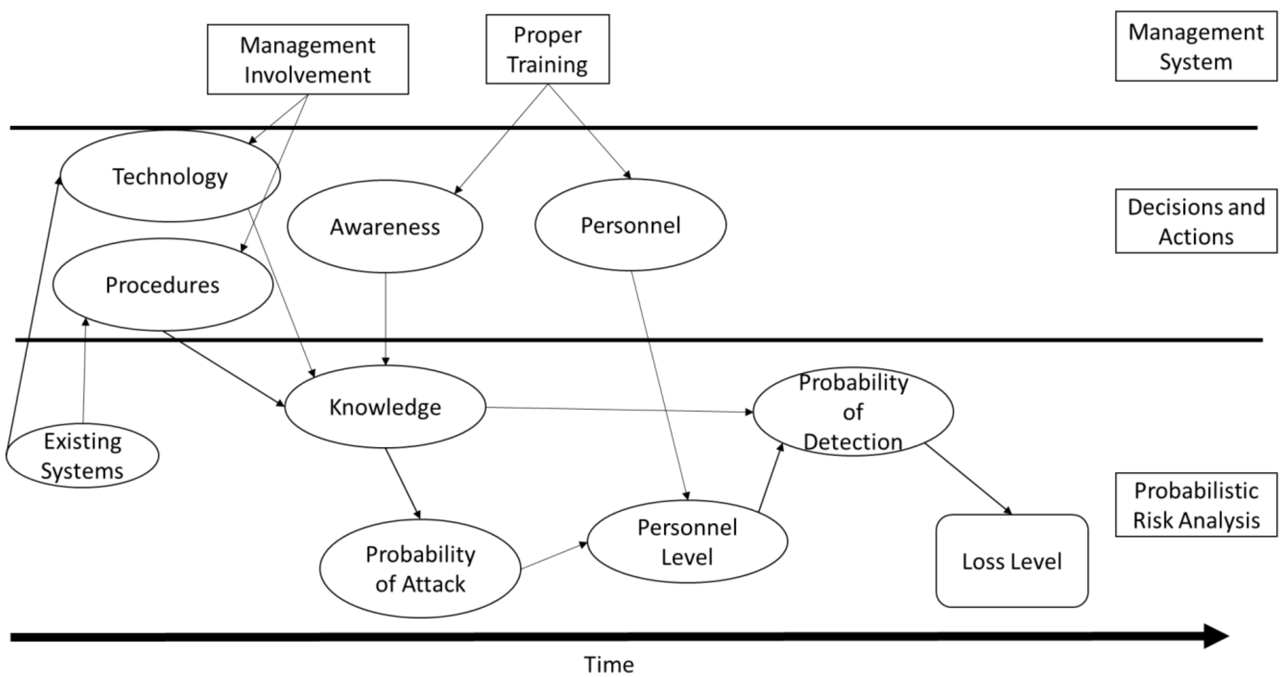


Figure 6: SAM Model for Airport Security

SAM models include management/system influences, decisions and actions to be taken, and risks/probabilistic analysis (Murphy & Pate-Cornell, The SAM Framework: Modeling the Effects of Management Factors on Human Behavior in Risk Analysis, 1996). The probabilistically determined events are listed apart from the decisions and actions to show top level management what is relavent to the situation. This is particularly important in this situation, (Blalock, Kadiyali, & Simon, 2007). The four decisions and actions come from the decision hierarchy. They are the four things management can do to have an impact on the security of the terminal: Technology, Awareness, Procedures, and Personnel.

In the case of Airport Security, the Management/System problems are management involvement in the security process and proper training. Does the management take an interest in what is happening in daily operations? For proper training, are the security agents given proper training, then updated training, and recertification? These factors set the tone for the organization. The Decisions and Actions level includes Technology, Awareness, Procedures, and Personnel.

Technology includes a variety of systems: computer based, physical, and sensors. This includes everything from a new biometric scanner for employees, to concrete barricades that prevent cars from driving into the airport. These are the type of improvements that have historically been implemented to increase security for airports. Body scanners and mass spectrometers are just two examples of personnel screening systems currently in use. Each airport in the world, and subsequently each of the terminals, will have unique needs. The systems will be highly dependent on the current state of the airport and their budget. This study attempts to cover the possibilities, not provide a comprehensive list of options.

Examples of Personnel are more TSA agents in the security screening lines, police officers with bomb dogs, or undercover agents patrolling the airport. Each of these types of personnel provides increased security and some even provide a feeling of safety for passengers. They contribute to the overall value of deterrent by providing visible, physical security.

The third and fourth decision are awareness and Procedures. These include, but is not limited to, the signage in security lines to inform passengers of the proper techniques to passing through security seamlessly. A second application of these decision would be posting signs related to the other types of security used by airports: Geiger counters, undercover agents, and video surveillance. The cost of processing passengers who are confused is high (Kirschenbaum, 2013). The larger problem is having a significant amount of people standing in one area. Large clusters of people make an obvious area of attack for potential terrorists. The RAND report focused on increasing value by taking measures to decrease the amount of people standing in long lines (Stevens, Hamilton, Mesic, & Brown, 2004). This will also include the procedures posted for airport employees, and signs noting the increase in systems security.

The probabilistic and risk components to this are many, but they also stem from the general idea that the probability of an attack is based on the system, new potential systems, and the adversary's knowledge of these systems. Do potential terrorists know how to penetrate them, or do they know that the airport's defense system is robust enough to prevent the major of attacks, and will thus be less likely to attack? Therefore, a system's effectiveness is uncertain, but can be improved by proper modeling and implementation. The final thing to note is the probability of detection of an attack. The probability of detecting a gun in a security is not as high as the 31% it used to be, but the techniques used by Abidi, et al. in 2006 were still only 56.5-69.5% effective in closing the gap (Abidi, Zheng, Gribok, & Abidi, 2006).

The density of people in the atrium and the attacks knowledge of it, bring relevant consequences to the discussion when looking at the loss level. These factors work towards increasing the value by increasing the feeling of security and the probability of early detection of potential threats.

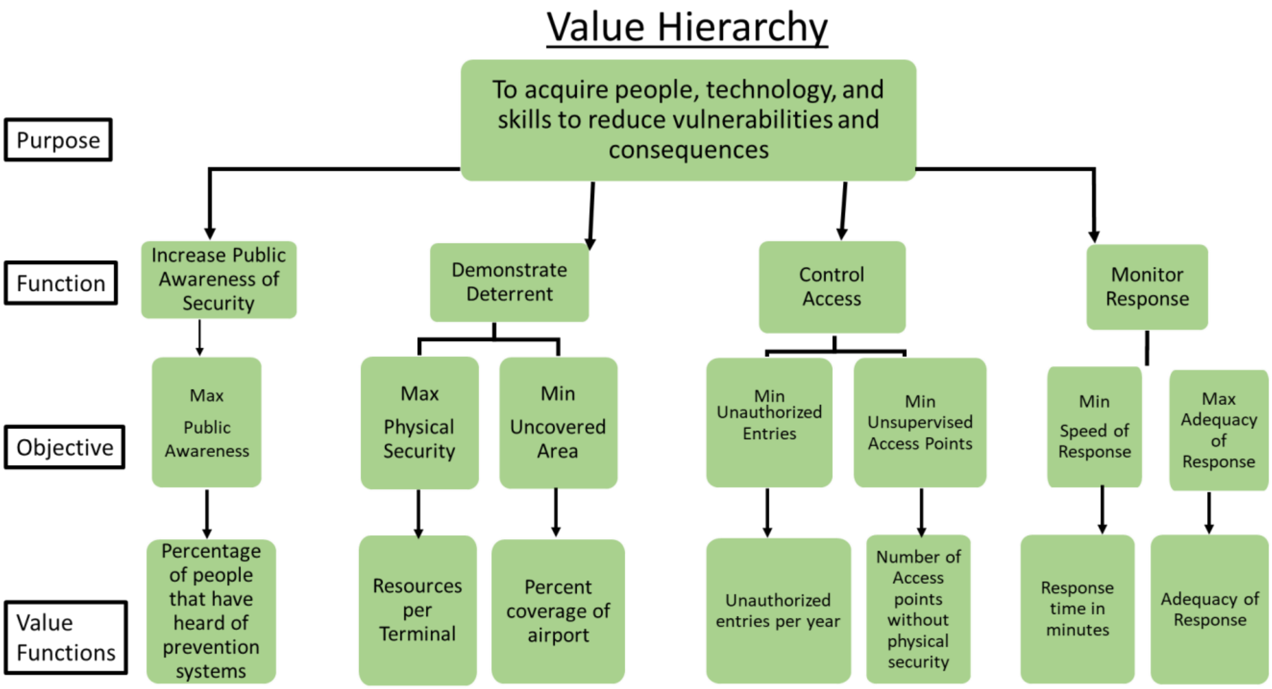


Figure 7: Value Hierarchy for Airport Security

The value hierarchy shows how airport security improvements can generate value by improving on one of these four functions: Increase Public Awareness of Security, Demonstrate Deterrent, Control Access, and Monitor Response. Functions are verb-noun phrases that describe categories the decision makers should consider when planning to increase value. They represent four distinct areas of value, but alternatives are not binned by function, rather alternatives can add value to each of these four functions if they have broad impact. These four functions map to objectives for improvement. Objectives are specific things which can be maximized or minimized to increase value. For example, to Control Access, we must minimize unsupervised access point. Value measures are the numerical way to determine how much value is provided by that objective. All the decisions/actions from our SAM model should help to maximize or minimize one or more of these objectives by increasing the numerical value. The benefit in our portfolio analysis will come from this increase in value.

Value Model

The scope of the value model can be found in the value hierarchy. The value hierarchy begins with the purpose of the research, and then gives four functions to optimize; each of the objectives under the four functions is a minimization or a maximization item. To increase value, we must maximize or minimize those objectives by decreasing or increasing the value measure for that specific objective.

Defining what adds value is a difficult problem. Value is not explicitly seen. If additional security systems are added to a small, low risk airport, has value been added? If a system is added to Jackson-Hartfield in Atlanta, the busiest airport in the world, but it does not prevent an attack, did it add value? In the field of decision analysis, value is defined differently by most experts. The general principle of value is that it is a measurable way of telling how close you are to achieving your goal. For airport security, our goal is to have 100% of the passengers passing through the airport, get from the front doors of the departing airport to the moment they get on the plane. That encompasses the atrium, security check-points, post security, and the ramp to get on the plane. In figure 5, in the past five years, we have seen many attacks at airports targeting passengers, employees, and non-passengers before the security check-points. The value model focuses on potential for decreasing the risk of attack before the security check-point.

The value model takes a set of alternatives, scores them using the value measures, and produces a numerical result of the improvement in value. A value measure has two components; the independent input, x, and a dependent value score for the input, v(x). Five data points are recorded, using subject matter experts to determine the independent and dependent values. The value score must have the first point at 0, and the last point at 100. These values give the model a minimum input to incur any value, and a maximum input to receive the most value. This can be seen in figure 8. The name of the value measure is Visible Security Resources per Terminal. If there are no visible resources in a terminal, then no value is incurred. If there are 20 visible security resources in the terminal, then 100 value points are incurred. If more than the maximum amounts of visible resources are present, then no additional value is incurred.

Visible Security Resources per Terminal	
x	v(x)
0	0
2	25
4	50
8	75
20	100

Figure 8: Value Measure Calculation

The value measure calculations are used to determine the amount of value achieved by the level of the input variable, x. For any level of resources, the amount of value can be interpolated between the points using a macro, ValuePL. The amount of value per visible resource can be graphed, and the shape of the curve provides additional insight into the measure. In figure 9, we see the shape of the curve is concave. We can interpret this as having a view visible resources per terminal significantly increases the value. Half of the value for this measure can be received if four visible security resources are present in the terminal. To achieve the other half of the value, an additional 16 resources must be implemented. This information is vital to a decision maker who must consider both value and budget. The shape of the curve was obtained from knowledge of subject matter experts, on how the input variable effects the value level.

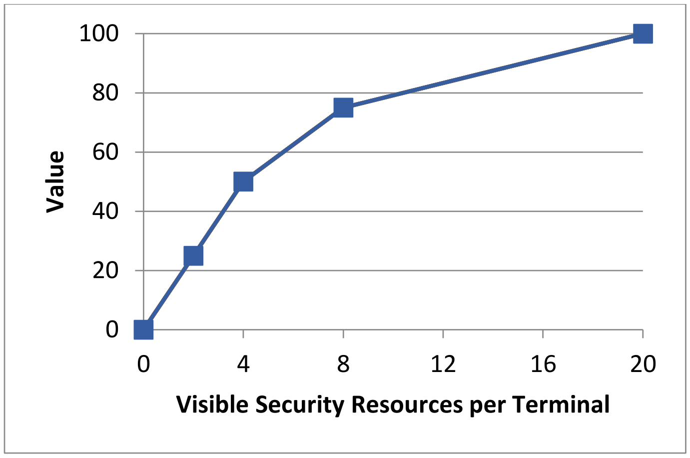


Figure 9: Visible Security Resources per Terminal Value Curve

The value measure, Visible Resources per Terminal is part of the Demonstrate Deterrent Function, and only displays the value for a specific measure. Each of the alternatives has a value score for this measure. This model has 12 alternatives. Each of the alternatives has a primary area of value, function. They can provide additional value to other functions, but it is secondary. The alternatives are the implementation options the decision maker can fund. This value functions assess the value for each value measure, but does not explain how important each value measure is to the overall value.

How important are each of those objectives to the overall goal of the research is a question which keeps decision analysts divided. There are two main philosophies on how to weigh the objectives. For both processes, the subject matter experts are asked for input. The Analytical Hierarchy Process, developed by Dr. Saaty, is a process by which the relative importance of an objective is the measure of how important it is compared to the other objectives (Saaty). The subject matter experts are asked to a series of pairwise comparison questions in which they are asked to determine which objective is more important. This process has the ability to induce motivational bias and Anchoring bias (Montibeller & von Winterfeldt, 2015). If the experts have a specific project or alternative they favor, they are likely to weigh all other alternatives or projects to be less important than that. This bias will discredit the importance of every other project, to save the subject matter expert's favorite. The aggregation of many subject matter expert's opinions will only dilute the model.

The second weighting technique is the swing weight matrix. This technique allows the subject matter experts to provide an unnormalized weight for each value measure, f_i, (Parnell, Bresnick, Tani, & Johnson, 2013) based on the importance and the variation of the value measure. Independent scoring allows for a reduction in motivation and cognitive bias by removing the competitive nature of ratings. Once they are each scored, the score of the value measure is divided by the sum of all scores, $\sum_{i=1}^{n} f_i$, to get the normalized weights. By providing normalized weights, it is easy to see how important to the overall value of the project, a specific objective is.

$$w_i = \frac{f_i}{\sum_{i=1}^{n} f_i}$$

Equation 1: Swing Weight Calculation

If the weights, w_i, are summed by objective, each function can be shown to represent a certain amount of the total normalized value. Using a swing weight matrix allows decision makers to see how important each function is to the overall value by summing the weights of each value measure for that function. Figure 10 shows the unnormalized weights in the yellow column, and the swing weights in the yellow column.

Swing Weight Matrix		Consequences of Improving Measures								
		Safety of all Airport Personnel			Improve Security and Effectiveness			Delay in Time		
			fi	wi		fi	wi		fi	wi
Need for Improvement	High Need for Improvement	Unmanned Access Points	100	0.24						
					Visible Security Resources per Terminal	80	0.19			
					Percent of People that have heard of system	70	0.17			
	Some Work							Percent of People that have heard of system	30	0.07
		Response Time in Minutes	60	0.14						
	Minor Work									
					Adequacy of Response	35	0.08			
		Access Control	40	0.10						

Figure 10: Airport Security Swing Weight Matrix

Swing weights are based on two distinct criteria: Importance and Need for improvement. An alternative could include room for improvement, but not be important to improve. For example, an airport could have no plan for a nuclear attack, but the probability a nuclear strike will happen to an airport is very low. Nuclear attacks would rank very high on need for improvement, but very low on the importance for improving. Being able to rank objectives in terms of both importance and need for improvement helps the decision maker identify the immediate needs, and the more long-term planning items.

The importance of a value measure is found using swing weights, and the value of an alternative, for each of the value measures, can be found using the value curve and interpolating from the 5 points in the value function. By combining these two pieces we can find the weighted value of each alternative for each value measure. Table 3 shows the transformation of the score for each alternative on Visible Resources per Terminal to value to weighted value.

Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	1	13	2
Publication of Security Features	1	13	2
Randomization of Security Features	3	38	7
Bomb Dogs	4	50	10
Police Officers	3	38	7
Under Cover Agents	0	0	0
Mass Spectrometer	1	13	2
Atrium Video Surveillance	1	13	2
CO2 Sensors	0	0	0
Back Up Power Generator	0	0	0
Mobile Geiger Counter	1	13	2
Surveillance Robot	3	38	7
Current Baseline	14	88	17
Entire Portfolio	18	96	18
Ideal	20	100	19

Table 3: Weighted Value Calculation for Visible Security Resources per Terminal

Equation 2 displays the mathematical reasoning for determining the weighted value of an alternative for each of the value measures. The weighted value, V(x), is equal to the sum of each swing weight, w_i, times the value, v_i, of score, x_i. A simplified explanation of V(x) is, the total amount of value for each alternative.

$$V(x) = \sum_{i=1}^{n} w_i v_i(x_i)$$

Equation 2: Additive Value Model

The current Baseline line in table 3 shows the score, value, and weighted value for the current state of security in the chosen terminal. The entire portfolio line shows the maximum amount of value possible to attain given the current set of alternatives. Finally, the ideal is the amount of value possible to attain for the given value measure. Visible Security Resources per Terminal is 19 points of value, out of 100. The clear definition and quantification of value gives the decision maker part of the picture, but the cost data is needed. The basis for the costs of each alternative can be found in the appendix.

Portfolio Model

When choosing to evaluate a set of projects, a decision maker has several quantitative methods available: Return on Investment (ROI), Cost-Benefit, Portfolio models, etc. Economic models such as ROI is a good method for problems where all the value can be turned into dollars. Places like manufacturing and sales can calculate the ROI on hiring more employees or using more expensive materials. The two major types of models to use cost and value are cost-benefit ratios and portfolio analysis with optimization.

Cost-benefit ratios pick projects by a simple ratio of benefits to cost. Cost-Benefit rations do not allow for addition constraints and assume independence among projects. In an optimization model the maximum value for a budget will be found. This research uses portfolio analysis with optimization. Figure 11 shows the model. Each of the alternatives from our value model are listed with the associated annual costs. The current state of airport terminal security is the input into the baseline column. A score of 1 designates that the airport uses the alternative in part of its daily operations, and a score of 0 designates that the alternative is not in daily use. The decision column utilizes the same scoring technique, and is used to add value to the baseline. The last four columns are the value added by deciding to, or not to, select an alternative.

The value accumulated for each function cannot surpass the total value of that function for the entire portfolio. The value for each of the functions using all alternatives in the portfolio is shown in red at the bottom of the table, and is taken from the value model. The total value for all functions is summed at the bottom middle of the table. The total cost is the sum of the costs for the decisions with a score of 1. The constraint for total cost is show directly below the sum of costs in the red cell.

Project	Alternatives	Cost	Decision	Baseline	Increase Public Awareness of Security Added Value	Demonstrate Deterrent Added Value	Monitor Response Added Value	Control Access Added Value
P1	Additional Signage in Airport	$750k	0	0	0.00	0.00	0.00	0.00
P2	Publication of Security Features	$500k	0	1	0.00	0.00	0.00	0.00
P3	Randomization of Security Features	$1,000k	0	0	0.00	0.00	0.00	0.00
P4	Bomb Dogs	$750k	0	1	0.00	0.00	0.00	0.00
P5	Police Officers	$500k	0	1	0.00	0.00	0.00	0.00
P6	Under Cover Agents	$1,000k	0	0	0.00	0.00	0.00	0.00
P7	Mass Spectrometer	$375k	0	0	0.00	0.00	0.00	0.00
P8	Atrium Video Surveillance	$750k	0	1	0.00	0.00	0.00	0.00
P9	CO2 Sensors	$500k	0	0	0.00	0.00	0.00	0.00
P10	Back Up Power Generator	$1,000k	0	1	0.00	0.00	0.00	0.00
P11	Mobile Geiger Counter	$750k	0	0	0.00	0.00	0.00	0.00
P12	Surveillance Robot	$500k	0	0	0.00	0.00	0.00	0.00
	Total Cost	**$3.50m**	**Total Value**	**76.86**	17	22	13	25
	Constraint	**$4.50m**			17	26	21	25

Figure 11: Portfolio Model for Airport Security

The portfolio model finds the set of optimal solutions. Depending on the funding level of the decision maker or the desired value a set of alternatives can be recommended. The efficient frontier technique will be used to create a set of solutions for varying funding levels. portfolio analysis gives the decision maker the most freedom to choose what they believe to be the optimal value for each funding level. The mathematical objective and constraints for the optimization model can be found in equations 3, 4, 5, and 6.

$$Maximize \sum_{j=1}^{m} y_j \sum_{i=1}^{n} w_i v_i(x_i)$$

Equation 3: Maximization of Total Value

$$\sum_{j=1}^{m} y_j c_j \leq B$$

Equation 4: Cost Constraint

$$y_j = \begin{cases} 0 & Not\ Funded \\ 1 & Funded \end{cases}$$

Equation 5: Decision Funding Set

Equation 3 states the goal of the optimization model to be the maximization of the total value of the portfolio. Maximizing the amount of value for a given dollar value allows us to find the upper limit of value, while constraining the cost. This method, replicated for range of budgets, will give the efficient frontier. Equation 4 states the sum of all costs, C_i, times the decision variable, y_j, cannot be greater than the Budget, B. Setting a budget allows the decision maker to put in his budget and create an optimal portfolio. Equations 5 lists the set of values Y_j can be. If the alternative is funded then a 1 is selected, and if it is not funded then a zero is selected

Insights

The value to the decision maker of having a tool to diagnose areas of improvement large is beneficial. Use of the same tool to assess the value of alternatives with the cost of providing the alternatives increases the viability of the tool. In this section we consider the current state of airport security of DFW terminal D, using an expert's opinions. Actual data provides a security risk to any airport being quantifiably analyzed.

Current State

The purpose of looking at the current state is to find areas of strength and areas of growth for the security team in Terminal D. We will evaluate each based on the four functions of security shown in the value hierarchy: Increase Public Awareness of Security, Demonstrate Deterrent, Control Access, and Monitor Response. Each area will receive an overall value, and also a value for each of its objectives. These scores come from value of the current security features. Figure 11 showed the alternatives which DFW utilizes on a regularly recurring basis: publication of security features, bomb dogs, police officers, atrium surveillance, backup power generators, and a mobile Geiger counter.

The Dallas/Fort Worth International (DFW) airport publishes some of security features in white papers and other public outlets. They also regularly use teams of bomb dogs to sweep the terminals, and police officers for additional security presence. DFW has atrium surveillance and a backup power generator to keep security features active in case of power outages. Each feature does not add the same amount of value to the model, so it is important to know which features are key components. Figure 12 is an Alternative value component chart. It shows the amount of value realized by for each of the alternatives. The color show the contribution by value measure.

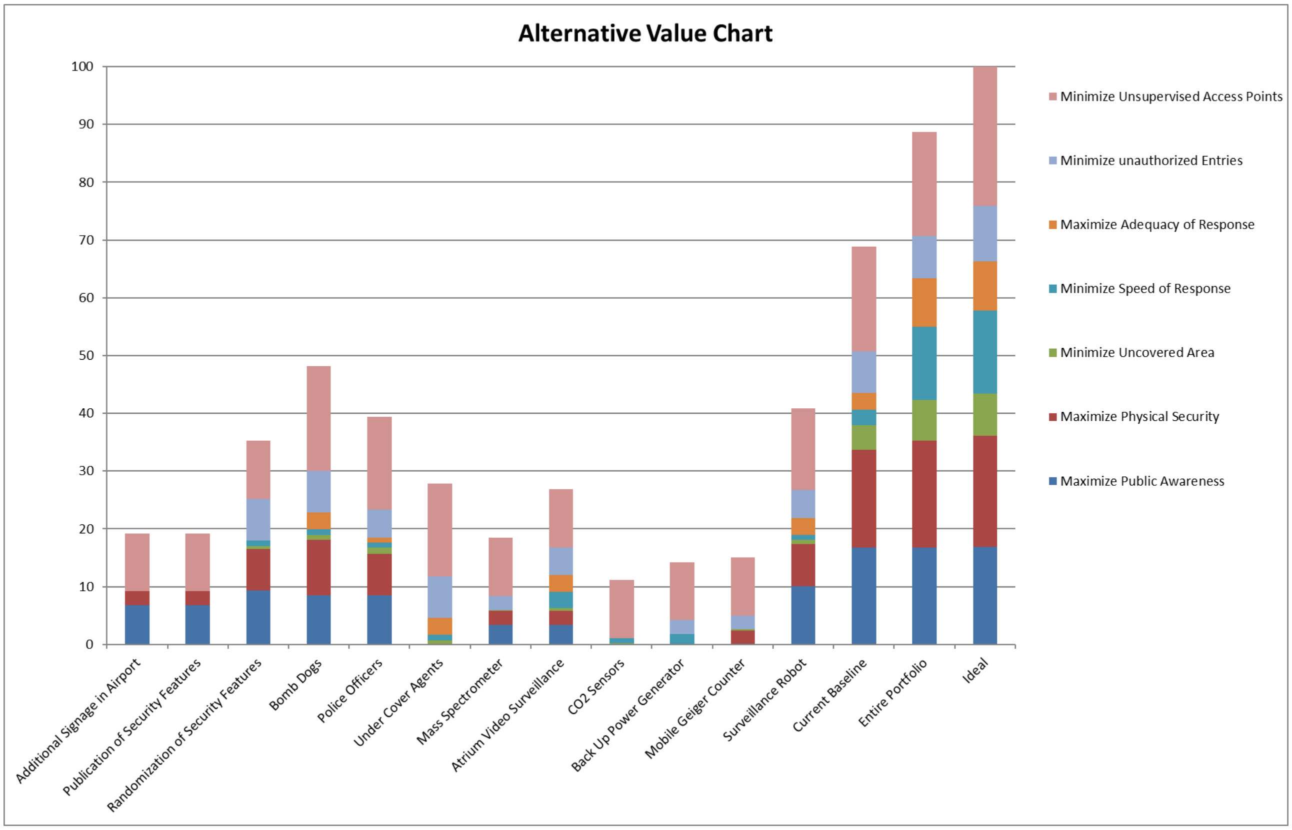


Figure 12: Alternative Value Component Chart

Along the bottom of the chart, all the alternatives are listed. The y-axis of the chart represents how much value, from the value model, is assessed for each measure. Visually, it is easy to tell that minimize Unsupervised Access Points and Maximize Public Awareness are both prevalent in the alternatives. Minimize Uncovered area and Maximize adequacy of response are both more scarce than the other alternatives. The decision maker will want to pay special attention to the value measures associated with those objectives because of the scarcity of solutions.

We can also see bomb dogs, randomizing security features, police officers, and surveillance robots provide the most value as alternatives. This follows logically with what we know about effect of security personnel on the potential for attacks. Terrorist's seek out easy targets, and do not attack robust defense systems. The more visible security forces, the more robust a system.

From the graph we can also see the value of the current baseline compared with the entire portfolio and the ideal. The baseline provides 77 points of value, and the idea value is 100. The amount of value that can be achieved is the value score for the entire portfolio, and has a score of 89. The difference between the ideal and the entire portfolio is called the value gap. This is the amount of value that cannot be achieved with the current technology, resources, and system knowledge. The gap can close, but it will require a more complex understanding of the threats posed to the terminal, and advanced knowledge of the methods the attackers will use to cause harm. Given the security features, we can estimate the cost of security to be $3.5 million dollars per year. To provide additional value, we must either optimize the current portfolio, or suggest addition value for additional funding.

Future State

The current spending cost is estimated at $3.5 million dollars. If the decision maker decides to keep these estimated costs and the 77 value points, we must provide additional levels of funding. To create the efficient frontier, we will vary the funding level by $.5 million increments and plot the cost vs. value. Figure 13 details the value of adding projects to the current baseline.

The greatest increase in value, over the baseline, comes from half million dollars in support. By adding $.5 million, in the form of a surveillance robot, almost 7 points of value are added. The second level of funding adds CO_2 sensors to the security protocol. The third level of funding adds undercover agents, but removes the CO_2 sensors. The addition of $2.5 million, includes; robotic surveillance, CO_2 sensors, and undercover agents. Any additional funding, after $2.5 million, does not increase value. The maximum system value has been achieved, for a total of $5.5 million.

The second option is a partial overhaul of the baseline to optimize dollars spent. To do this, we will vary the baseline funding from $1.5 million to $5.5 million to find the efficient frontier.

The new proposed baseline ramps up value more quickly than the current baseline. At $3.5 million in funding, the new baseline has 87 value points, while the current only has 77. The flaw of many airport security tests is the testing of attributes individually. Potential attackers must beat a series of systems, not just one step. By looking at the steps as a whole, and using our knowledge of swing weights to focus on measures that add value, not redundancy, we can increase the value of the system and decrease the cost.

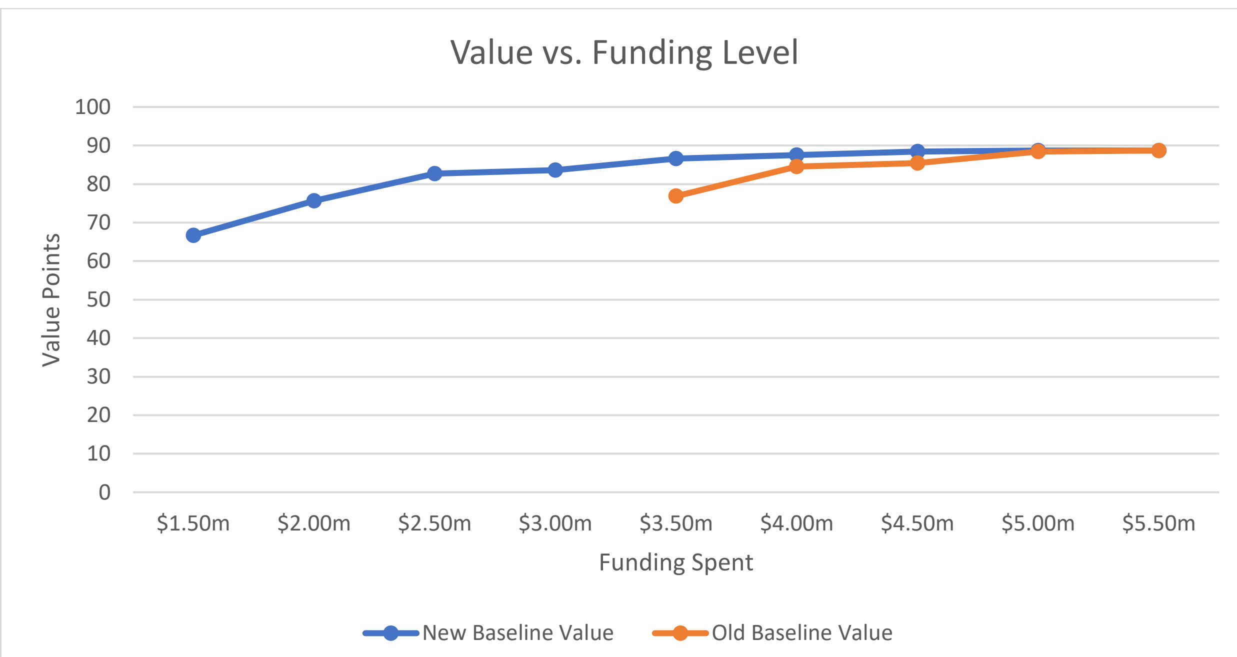


Figure 13 Cost Vs. Value for New Baseline and additional Funding of Current Baseline

By letting the simulation pick the alternatives to implement, we maximize the value for a set budget. The new baseline alternative is independent of the current regulatory scheme, but provides a case for a restructuring of regulations. For a budget of $2.5 million, terminal D would receive Bomb Dogs, Police Officers, and Atrium Video Surveillance. Table 4 shows the ramping of value for the new proposed and current baseline.

Dollars Available	New Baseline Value	Old Baseline Value
$1.50m	66.68	-
$2.00m	75.66	-
$2.50m	82.74	-
$3.00m	83.65	-
$3.50m	86.6	76.86
$4.00m	87.5	84.55
$4.50m	88.41	85.45
$5.00m	88.71	88.41
$5.50m	88.71	88.71

Table 4 New vs. Current Baseline

Restructuring the current set of security features could save money and provide more value. For $2.5 million, Terminal D could have more than 6 additional points in value, and would save $1 million dollars annually. The restructuring would take time and effort, on the part of senior management, but the airport would benefit in both dollars and value.

Monte Carlo Simulation

There are hundreds of commercial airports in the United States, and even more aboard. Each airport will bring its own unique challenges, security concerns, and current baseline. The weighting of the objectives, pricing of alternatives, and value of alternatives can change significantly, depending on the situation. Taking into account variable situations is one of the most difficult tasks of decision makers. Planning is done to diminish the amount of surprises and unexpected costs, but there will still be variation in any situation. To best consider variation, Monte Carlo simulation will be used. Monte Carlo simulation lets the modeler define the distribution, parameters, and number of randomized simulations. By quantifying the uncertain inputs and calculating the uncertain value and cost, a fuller picture is provided to the decision maker. The decision maker will understand the potential for failure, and the best way to protect against catastrophic failure.

For this simulation we will vary 3 things: cost of alternatives and swing weights. Varying the swing weights allows the decision maker to see how much variation could be caused if the subject matter experts perceived value is incorrect. Understanding the variation caused by the swing weights helps the decision maker to know how robust their decision is. Monte Carlo simulation uses random number generation to create an n'th number of trials. The distribution and parameters are set by the modeler, and the number generator creates trials to follow the distribution. In most cases, a triangular distribution can be used for inputs. The triangular distribution is useful because it requires only a min, most likely, and max, and roughly approximates several distributions.

Next, the swing weights are varied from 1 to 100, and the most likely value will be the value assigned by subject matter experts. Costs will be varied notionally, considering: ease of access, commonality of use, complexity of the system, propensity to break, and difficulty to replace. 1000 trials were used to add strength to simulation, and provide width of use. This simulation shows the distribution of cost and value for the current baseline.

Figure 15 shows the distribution of value brought by the variation of the swing weights and value measures. The graph is roughly, normally distributed with a mean of 72.18. The deterministic value, 76.86, found earlier, is larger than the probabilistic value of 72.18. The value of 76.86 was found by using expert assessment of the value curves and the weights of the value measures. The probabilistic value takes into account the worst possible situations, as well as the most likely, and the best. Human beings tend to ignore the worst-case scenario. The standard deviation for this distribution is 4.95 points. We can say with 95% confidence, from this distribution, the value of the baseline system is between 63.8 and 80.0.

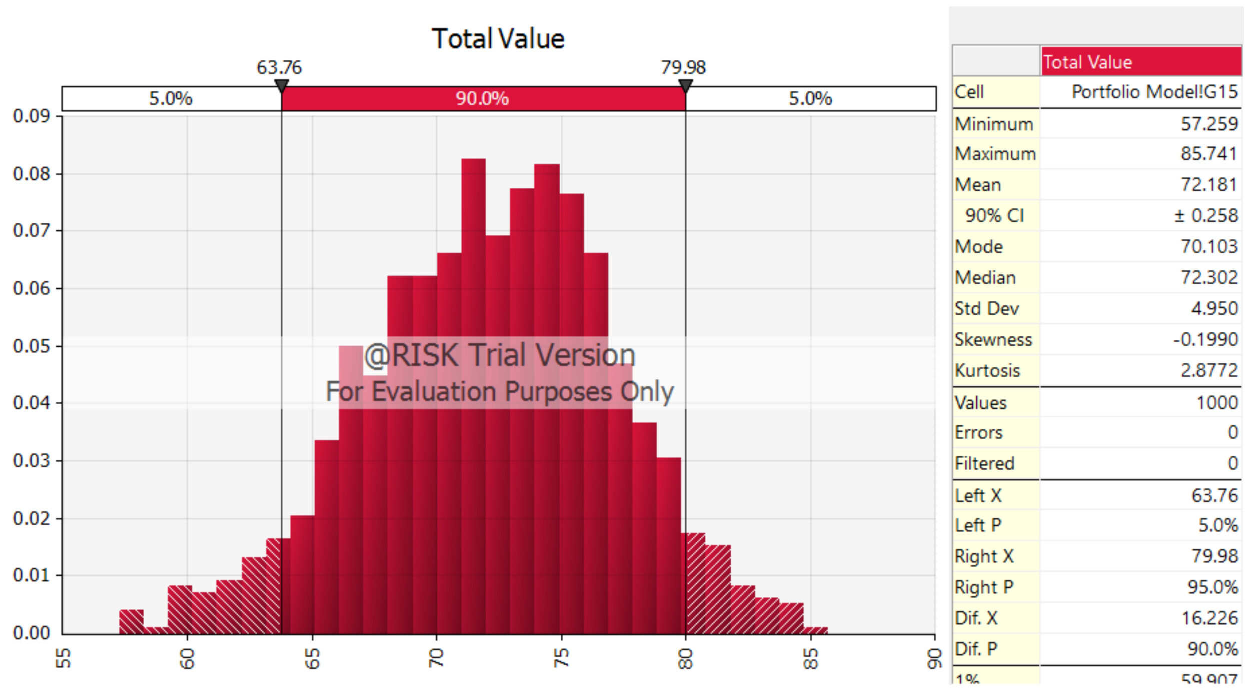


Figure 13: Value Histogram of Monte Carlo Simulation

Similarly, the cost of the current systems can be estimated using Monte Carlo simulation. The costs of each of the alternatives are estimated, using low, expected, and high-costs, and run through the simulation. Figure 16 contains the results of the cost simulation. The cost distribution shown, is the amount of funding required to achieve the baseline value of 77 points. These two figures come together to create a two-dimensional surface representing the cost and value of the baseline. This two-dimensional surface allows the decision maker to see the full realm of possibilities for the current baseline.

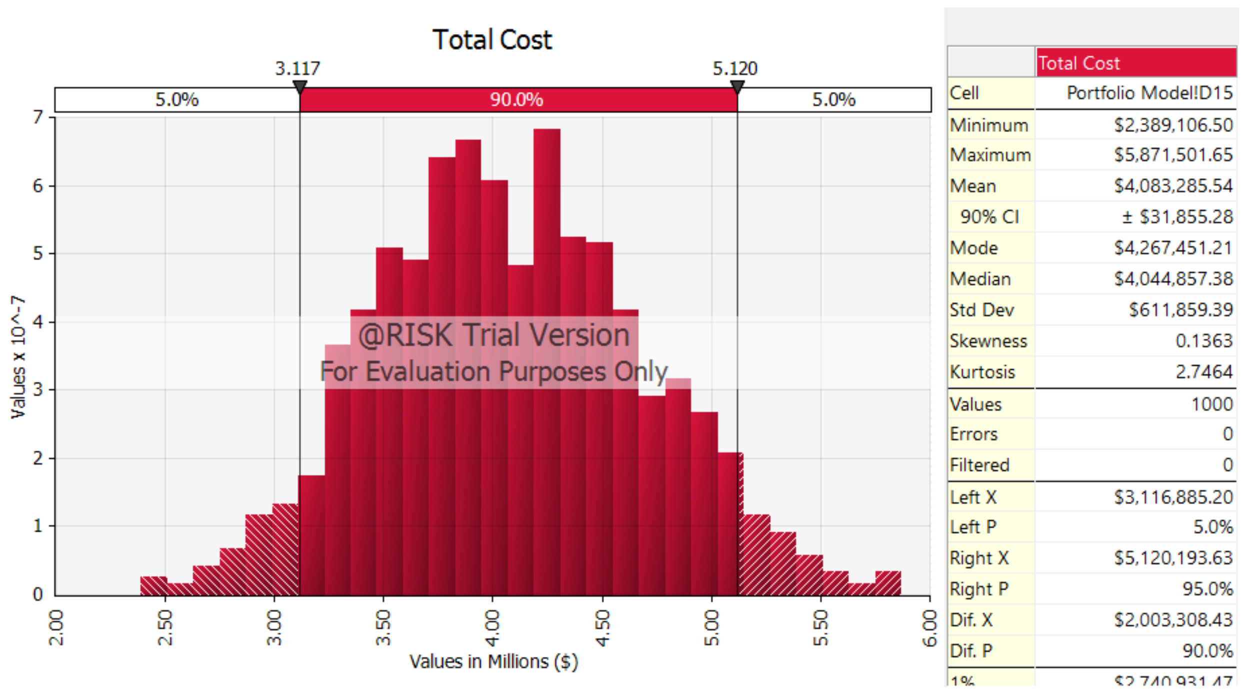


Figure 14:Cost Histograms of Monte Carlo Simulation

After seeing the 16 point variance between the upper and lower bounds of the confidence interval, the decision maker will want to see what caused the variation. A tornado diagram is a bar graph that visibly shows the amount of variation each variable contributes to the over all variation. Figure 17 shows the variation, in value, caused by the most significant independent variables.

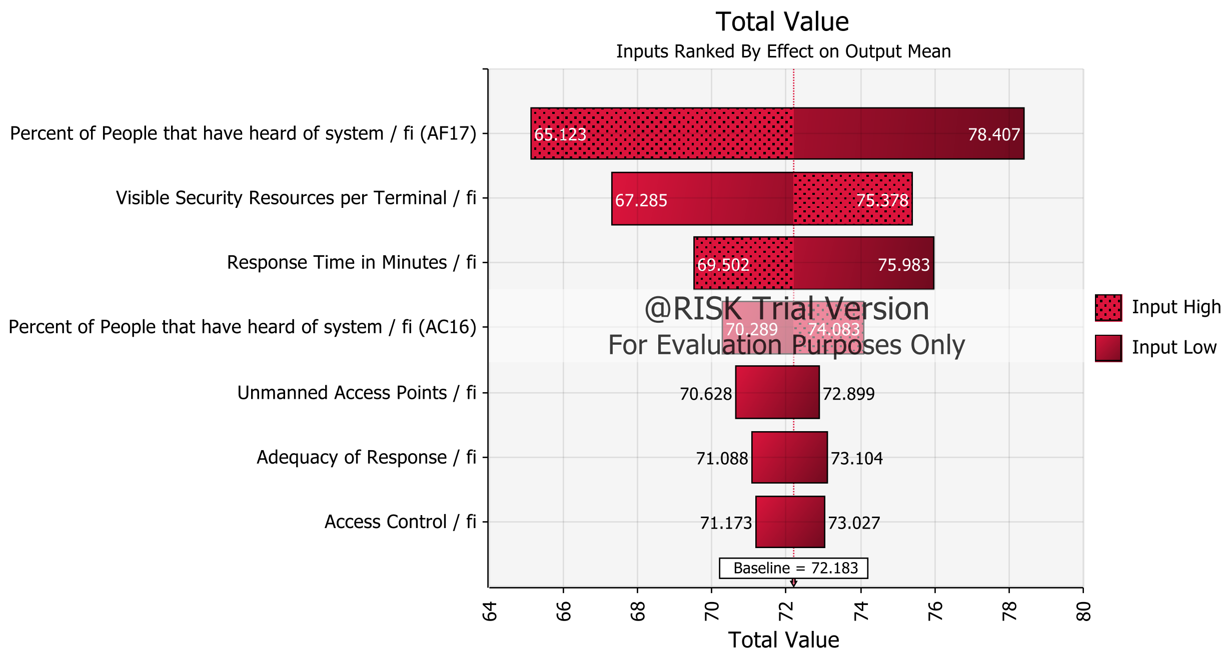


Figure 15: Tornado Diagram for Variation in Value

The top bar on the tornado diagram shows the minimum and maximum value of the total system when Percent of People that have heard of the System is changed from 1 to 100 in the swing weight matrix. By itself, Percent of People that have heard of system, can vary the value 13 points. Access control, however, can only vary the value 2 points. If a particular swing weight is scored higher by the subject matter expert, then the relative value of the other swings weights will decrease. The weighting of the system highly favors knowledge as a preventative measure. Knowledge is important asset for the TSA. They believe the most value can be incurred by terrorists knowing the great amount of preparation that goes into building defense systems.

Summary

The need for airport security is evident in our daily news. There are airport attacks several times a year, and the attacks have evolved. Our airports have tightened security for areas of previous attack, but to save lives a more holistic approach must be taken. Airport security can no longer be a series of groups operating independently of each other. The security team must be rigorous and unified. TSA, FBI, airport security, and police forces must operate in conjunction with one another to patrol the entire airport. Having red team testing of individual units helps that unit, but terminals will only become more secure if security measures are stacked together to form a chain of measures. It is much harder for a team of attackers to pass by a layered defense. This study provides a format for quantifying the value for each step in the process. The curb to ramp scope allows for law enforcement total control, where in the past attackers have thrived in atriums and on curbs.

The format of the model allows for decision makers to assign values to the swing weights to emphasize areas of growth for a terminal, while maintaining the rigor needed for a robust model. The benefit for a security team is to work through the model and understand the approach of defining goals, breaking the goals into objectives, providing a way to quantify those goals, and then rating the alternatives in terms of the value of towards those goals. The value of Monte Carlo simulation affords a decision maker the ability to understand the impact of uncertainties on value. The value can change if there are changes to the infrastructure, TSA procedures, and state of the nation. By reassessing the state of security once a year, the airport will be able to maintain value. Table 4 summarizes the results of model. If an additional $1 million dollars in funding is added to the current portfolio, 14 points of value can be added for a total of 89 value points. If, however, the terminal was to start over, assuming no initial resources, 89 value points could be achieved using the current estimated budget of $3.5 million.

There are a few concepts which are outside of the scope of this project. This project utilized an additive value methodology, and assumes the value added by each project is independent on the other projects chosen. Investigating the possibility of having dependent values and how to model them is a piece of future research. As previously mentioned, the regulations placed by TSA and DHS restrict the range of possible portfolios, and dictate the current baseline. If the baseline could be changed, due to a change one regulation, or a group of regulations, the shadow price of the regulation or regulations, could be found. Also, anything involving the security of parking garages, roads leading into the airport and the tarmac are outside of the scope, and would require further analysis.

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Appendix

Function	Demonstrate Deterrent
Value Measures	Visible Security Resources per Terminal

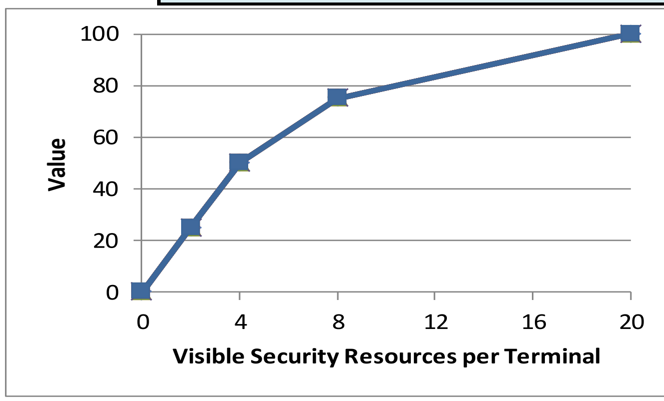
Natural or Constructed:`	Natural

Source for Scale:
Dr. Ham (Former DHS Official from DFW)

Value Curve Shape:
The value curve is concave. This is because the visible presence of a few resources is a discouragement to attackers.

Score	Value of Score
x	v(x)
0	0
2	25
4	50
8	75
20	100

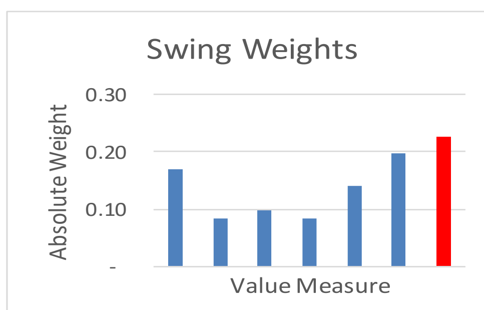
Value Curve



Swing Weight of Visible Security Resources per Terminal	
Absolute Score	Swing Weight (wi)
70	0.23

Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	1	13	3
Publication of Security Features	1	13	3
Randomization of Security Features	3	38	8
Bomb Dogs	4	50	11
Police Officers	3	38	8
Under Cover Agents	0	0	0
Mass Spectrometer	1	13	3
Atrium Video Surveillance	1	13	3
CO2 Sensors	0	0	0
Back Up Power Generator	0	0	0
Mobile Geiger Counter	1	13	3
Surveillance Robot	3	38	8
Current Baseline	14	88	20
Entire Portfolio	18	96	22
Ideal	20	100	23

Calculation of alternative score
The number of resources per terminal is defined as the number of units of police officers, bomb dogs, and security robots present in each terminal of the airport at all times.



Function	Increase Public Awareness of Security
Value Measures	Percent of People that have heard of system

Natural or Constructed:`	Natural

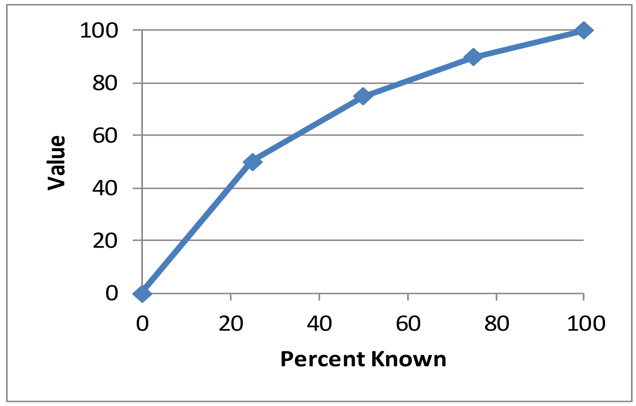
Source for Scale:
Notional and Expert Opinion

Value Curve Shape:
attackers will do research to have knowledge of defense systems, and will know of any defense systems.

Score	Value of Score
x	v(x)
0	0
25	50
50	75
75	90
100	100

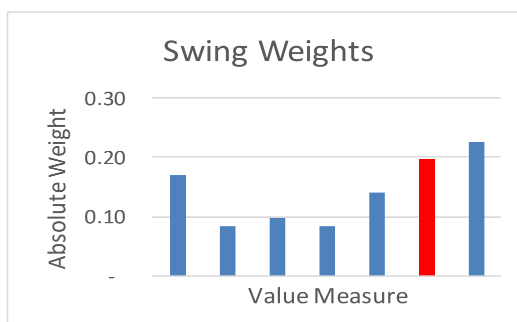
Swing Weight of Percent of People that have heard of system	
Absolute Score	Swing Weight (wi)
50	0.20

Value Curve



Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	20	40	8
Publication of Security Features	20	40	8
Randomization of Security Featu	30	55	11
Bomb Dogs	25	50	10
Police Officers	25	50	10
Under Cover Agents	0	0	0
Mass Spectrometer	10	20	4
Atrium Video Surveillance	10	20	4
CO2 Sensors	0	0	0
Back Up Power Generator	0	0	0
Mobile Geiger Counter	0	0	0
Surveillance Robot	35	60	12
Current Baseline	99	100	20
Entire Portfolio	99	100	20
Ideal	100	100	20

Calculation of alternative score
The percentage of passengers and non-employee occupents in the terminal who have heard of the security system being implemented at that airport.



Function	Demonstrate Deterrent
Value Measures	Percent of coverage of Airport

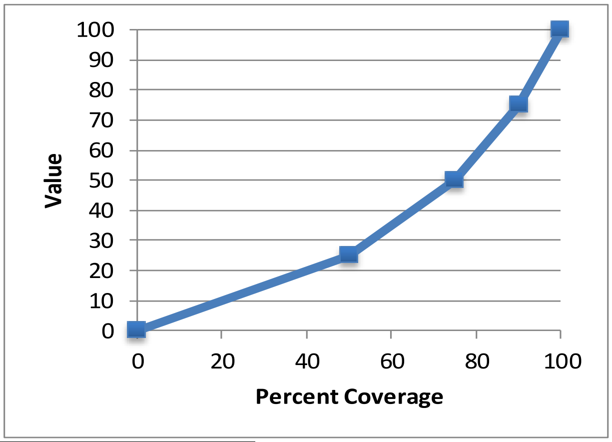
Natural or Constructed:	Natural

Source for Scale:
Notional and Expert Opinion

Value Curve Shape:
attackers will aim for the weakest spot, and less than total coverage affords them the opportunities

Score	Value of Score
x	v(x)
0	0
50	25
75	50
90	75
100	100

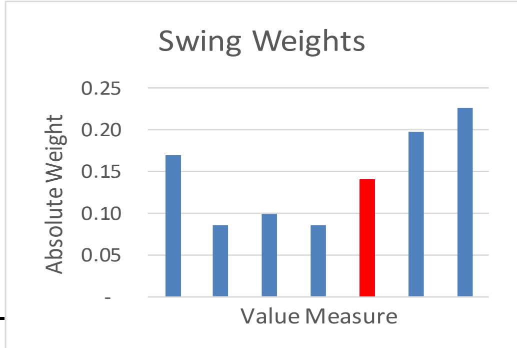
Value Curve



Swing Weight of Percent of coverage of Airport	
Absolute Score	Swing Weight (wi)
30	0.14

Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	0	0	0
Publication of Security Features	0	0	0
Randomization of Security Featu	15	8	1
Bomb Dogs	25	13	2
Police Officers	30	15	2
Under Cover Agents	20	10	1
Mass Spectrometer	5	3	0
Atrium Video Surveillance	15	8	1
CO2 Sensors	5	3	0
Back Up Power Generator	0	0	0
Mobile Geiger Counter	5	3	0
Surveillance Robot	20	10	1
Current Baseline	80	58	8
Entire Portfolio	99	98	14
Ideal	100	100	14

Calculation of alternative score
The percentage of square footage in a terminal that can be accessed by security assets within 15 seconds.



Function	Monitor Response
Value Measures	Response Time in Minutes

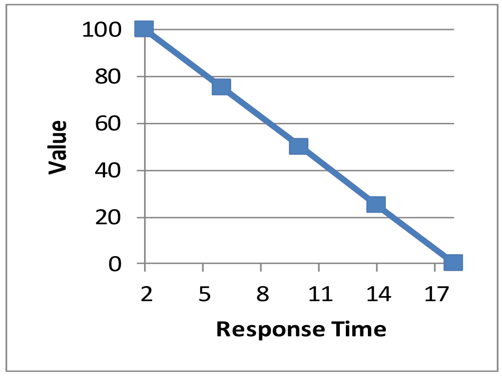
Natural or Constructed:`	Natural

Source for Scale:
Notional and Expert Opinion

Value Curve Shape:
The value curve is negative linear. This is because each minute of extra minute in response time is weighted equally

Score	Value of Score
x	v(x)
2	100
6	75
10	50
14	25
18	0

Value Curve

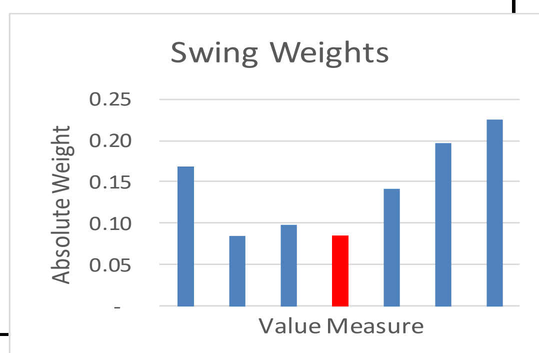


Swing Weight of Response Time in Minutes

Absolute Score	Swing Weight (wi)
30	0.085

Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	18	0	0
Publication of Security Features	18	0	0
Randomization of Security Featu	17	6	1
Bomb Dogs	17	6	1
Police Officers	17	6	1
Under Cover Agents	17	6	1
Mass Spectrometer	18	0	0
Atrium Video Surveillance	15	19	2
CO2 Sensors	17	6	1
Back Up Power Generator	16	13	1
Mobile Geiger Counter	18	0	0
Surveillance Robot	17	6	1
Current Baseline	15	19	2
Entire Portfolio	4	88	7
Ideal	2	100	8

Calculation of alternative score
The time, in minutes, elapsed between an incident occuring and the correct personnel responding.



Function	Monitor Response
Value Measures	Adequacy of Response

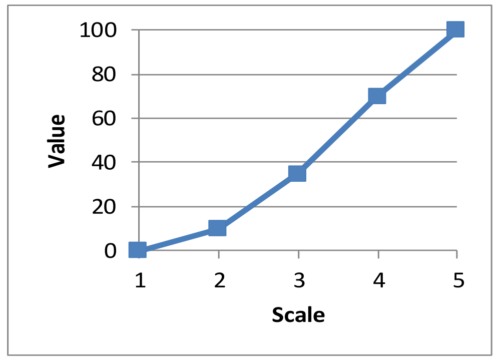
Natural or Constructed:`	Constructed

Source for Scale:
Notional and Expert Opinion

Value Curve Shape:
The value curve is convex. This is because a low accuracy of response can lead to significant damages.

Score	Value of Score
x	v(x)
1	0
2	10
3	35
4	70
5	100

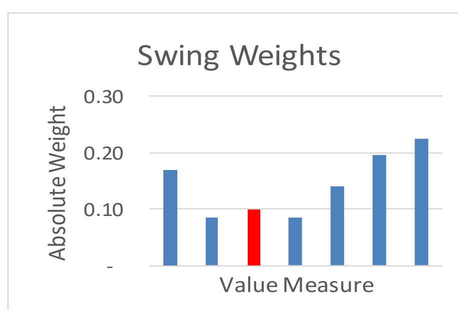
Value Curve



Swing Weight of Adequacy of Response	
Absolute Score	Swing Weight (wi)
20	0.10

Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	1	0	0
Publication of Security Features	1	0	0
Randomization of Security Features	1	0	0
Bomb Dogs	3	35	3
Police Officers	2	10	1
Under Cover Agents	3	35	3
Mass Spectrometer	1	0	0
Atrium Video Surveillance	3	35	3
CO2 Sensors	1	0	0
Back Up Power Generator	1	0	0
Mobile Geiger Counter	1	0	0
Surveillance Robot	3	35	3
Current Baseline	3	35	3
Entire Portfolio	5	100	10
Ideal	5	100	10

Calculation of alternative score	
1	It takes longer than 5 minutes for the resources to arrive
2	The right personnel and resources arrive within 5 minutes
3	The right personnel and resources arrive within 2 minutes
4	The right personnel and resources arrive within 1 minute
5	Within 15 seconds, right personnel and resources



Function	Control Access
Value Measures	Access Control

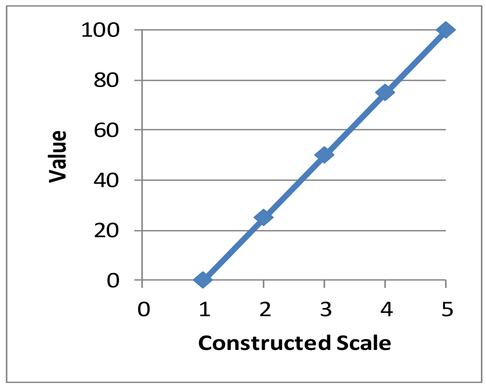
Natural or Constructed:`	Constructed

Source for Scale:
Notional and Expert Opinion

Value Curve Shape:
because the visible presence of a few resources is a discouragement to attackers.

Score	Value of Score
x	v(x)
1	0
2	25
3	50
4	75
5	100

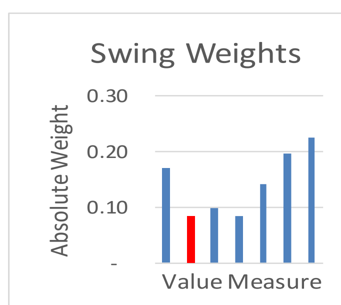
Value Curve



Swing Weight of Access Control	
Absolute Score	Swing Weight (wi)
30	0.08

Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	1	0	0
Publication of Security Features	1	0	0
Randomization of Security Featu	4	75	6
Bomb Dogs	4	75	6
Police Officers	3	50	4
Under Cover Agents	4	75	6
Mass Spectrometer	2	25	2
Atrium Video Surveillance	3	50	4
CO2 Sensors	1	0	0
Back Up Power Generator	2	25	2
Mobile Geiger Counter	2	25	2
Surveillance Robot	3	50	4
Current Baseline	4	75	6
Entire Portfolio	4	75	6
Ideal	5	100	8

Calculation of alternative score	
1	It detects breach attempts and denies access less than 95% of the time.
2	It detects breach attempts and denies access 95% of the time.
3	It detects breach attempts and denies access 100% of the time.
4	It detects breach attempts, denies access, and sends a notification.
5	It detects breach attempts, denies access, sends a notification, fail safe feature that prevents precedural violation from happening



Function	Control Access
Value Measures	Unmanned Access Points

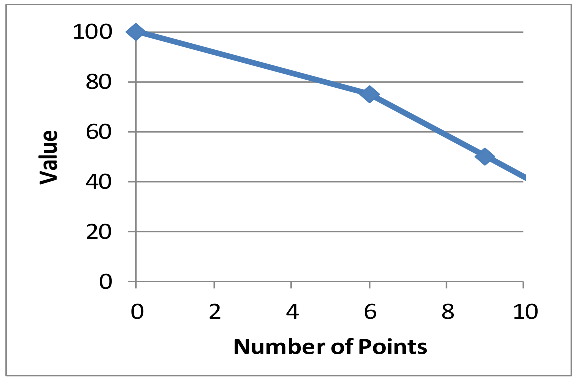
Natural or Constructed:`	Natural

Source for Scale:
Notional and Expert Opinion

Value Curve Shape:
The value curve is concave. This is because the visible presence of a few resources is a discouragement to attackers.

Score	Value of Score
x	v(x)
0	100
6	75
9	50
12	25
15	0

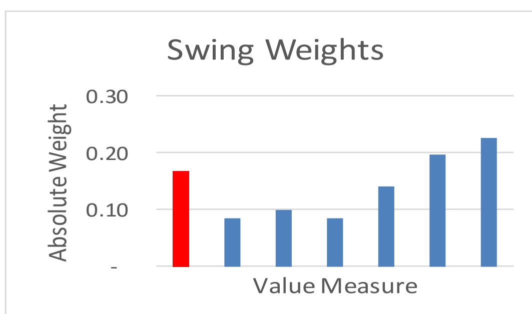
Value Curve



Swing Weight of Unmanned Access Points	
Absolute Score	Swing Weight (wi)
60	0.17

Alternative	Scores	Value	Weighted Value
Additional Signage in Airport	10	42	7
Publication of Security Features	10	42	7
Randomization of Security Featu	10	42	7
Bomb Dogs	6	75	13
Police Officers	7	67	11
Under Cover Agents	7	67	11
Mass Spectrometer	10	42	7
Atrium Video Surveillance	10	42	7
CO2 Sensors	10	42	7
Back Up Power Generator	10	42	7
Mobile Geiger Counter	10	42	7
Surveillance Robot	8	58	10
Current Baseline	6	75	13
Entire Portfolio	6	75	13
Ideal	0	100	17

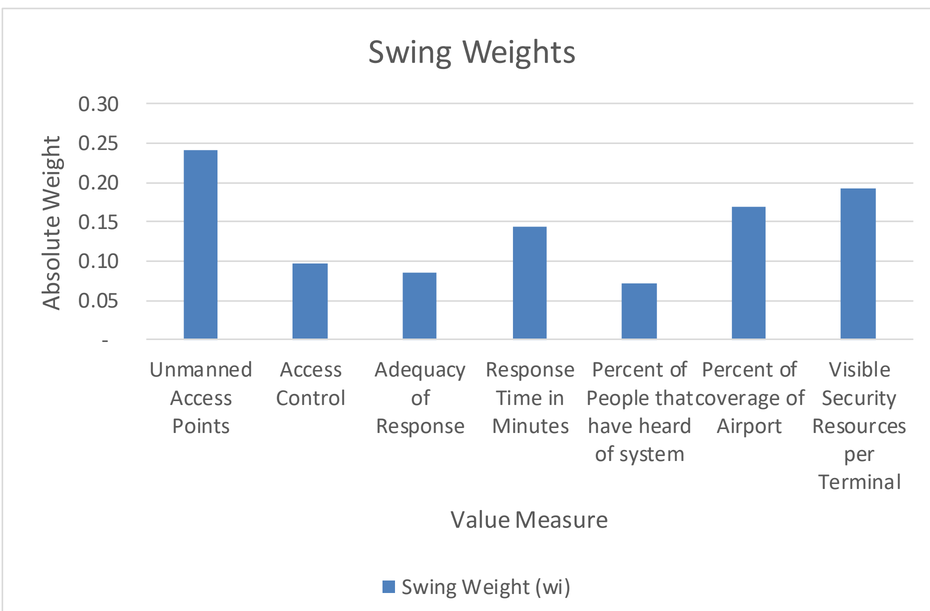
Calculation of alternative score
Count of the number of unmanned access points in a terminal. Excluding actively monitored points.



Swing Weight Matrix

Needs Improvement ----->	<-------More Critical--------		
		Visible Security Resources per Terminal	
	Unmanned Access Points	Percent of People that have heard of system	Percent of coverage of Airport
	Access Control	Adequacy of Response	Response Time in Minutes

Value Function	Unnormalized Weight	Swing Weight (wi)
Unmanned Access Points	100	0.24
Access Control	30	0.10
Adequacy of Response	20	0.08
Response Time in Minutes	60	0.14
Percent of People that have heard of system	30	0.07
Percent of coverage of Airport	50	0.17
Visible Security Resources per Terminal	70	0.19



Value Function	**Rationale for Value Measure Position**
Unmanned Access Points	Unmanned access points are likely targets for terrorists
Access Control	Controling access prevents terrorists from entering
Adequacy of Response	Sending the right personel to a problem sight is important
Response Time in Minutes	Quicker responses prevent catastrophic problems
Percent of People that have heard of system	Knowledge of defense systems is a deterent for terrorists
Percent of coverage of Airport	Full Over sight of the airport leads to quick reactions
Visible Security Resources per Terminal	The greatest deterent is a show of force