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DEVELOPMENT OF A DECISION SUPPORT SYSTEM FRAMEWORK FOR THE IMPROVEMENT OF A SURFACE TRANSPORTATION SECURITY TRAINING PROGRAM

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DEVELOPMENT OF A DECISION SUPPORT SYSTEM FRAMEWORK

FOR THE IMPROVEMENT OF A SURFACE TRANSPORTATION

SECURITY TRAINING PROGRAM

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The purpose of this thesis is to develop a decision support system framework that could be used for improving a surface transportation security training program involving the roadway sector. The program provides domain awareness, reporting, and information sharing capabilities to aid in protecting the nation's critical infrastructure and key resources. Literature reviews were conducted on training performance, service quality, and decision support systems to understand the elements that will be incorporated in the decision support system framework. A discussion of freight flow analysis of the nation's commercial trucking industry is then given. The analysis could be used for estimating the coverage of the trainees from the training program. The basic elements and requirements of the framework for such a decision support system are described including database, model management, and user interface subsystems, data inputs, possible actions, performance measures, and recommended actions along with the calculation of a security confidence level.

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CHAPTER I

INTRODUCTION

1.1 Surface Transportation Security Training Program

Surface transportation applies to the roadway, rail, and waterway sectors of the nation's transportation infrastructure. Those whose employment requires them to travel throughout these sectors could provide the nation with an extra line of defense against terrorist activities or enhancement of safety if properly trained on how to be aware of their surroundings and given the ability to report any suspicious events or unsafe conditions. Federally funded programs such as this are already in existence and can simply be described as domain awareness, reporting, and information sharing programs. Because of the potentially great benefit to the nation, the participants in such programs should be recruited in a manner to maximize their coverage area, receive sufficient training on what to look for and what to do, and their reports should be handled in an organized fashion so as to reap the most possible benefits.

Such programs would need to be evaluated on a regular basis to facilitate continuous improvement in the operational effectiveness of the program and therefore their contribution to the nation's security and safety. Evaluation of such a training program may involve many factors and require a sophisticated approach to deal with the factors and possible action in a systematic way. The evaluation system requires a quantitative means of measuring performance in order to highlight the most advantageous avenues for improvement. It is proposed that a decision support system could fulfill this role. This thesis presents a framework of the decision support system that can be used to evaluate a surface transportation security training program and come up with improvement recommendations. The nation's highways in comparison to its rail systems and waterway systems cover much more areas and therefore could offer higher and broader level of awareness. Therefore the proposed decision support framework will mainly deal with the roadway sector. However, the overall framework is adaptable for other transportation modes.

The operations of the highway driver training program under the study are briefly described as follows. Program participants, who would include mainly truck drivers but also law enforcement officers, school bus drivers, and other highway professionals, would undergo initial training in which they are instructed on what to look out for and why and also how to report any incident and the importance of complete information. Once trained, they would be given access to a phone number to call for reporting events. These reports would be taken and initially evaluated on their importance and would be sent to proper recipients who could belong to local law enforcement or a security analysis center for further evaluation.

Critical infrastructure and key resources (CI/KR) are the two possible terrorist targets that the surface transportation security program would be concerned with. Critical infrastructure are things both real and virtual, whose loss would debilitate America's security, economy, and public health and safety, and key resources are public or private resources that are essential for the economy and government to operate (TSP, 2008). The nation's CI/KR are vital to the economic health and daily operations of the nation and in part could be protected by such a surface transportation security program's domain awareness, reporting, and information sharing capabilities. Different CI/KR may be assigned to different importance levels based on the impact of their disruption on the national economy and security. A major reason for improving the surface transportation security training program would be the presumption of a significant gap between the security coverage objective and the number and distribution of the program participants. In order to improve the effectiveness of the security program, the recruiting effort should be tailored based on the areas in greatest need of coverage and the industry sectors that could help provide the needed coverage.

1.2 National Preparedness Guidelines

Being funded by the federal government, the goals and objectives of such a surface transportation security training programs would be mainly influenced by the government documents that express the nation's goals pertaining to preparedness not only in the case of terrorism but for all hazards. The National Preparedness Guidelines, set forth in September 2007, provide the basic principles for preparing for all hazards. The guidelines were a result of the Homeland Security Presidential Directive 8 (HSPD-8), which was issued in December, 2003, and aimed to develop a better prepared America by setting up a preparedness architecture to serve as an outline for all involved entities to follow. The vision of the national preparedness guidelines is "a nation prepared with coordinated capabilities to prevent, protect against, and recover from all hazards in a way that balances risk with resources and need."

The guidelines were established with an all hazards approach in which the United States would be as prepared as possible for any large-scale national incident. Specifically the nation's all hazards preparedness goal is a continuously evolving objective to build, maintain, and enhance the United States' ability to prevent, protect against, respond to, and recover from terrorist incidents, natural and manmade disasters, and any other major emergency or catastrophic events within the United States. Furthermore, it is important for all agencies to become familiar with the threats, vulnerabilities, and resources needed to accomplish the goal. Vital to this national preparedness is the cooperation and coordination of all levels of government, the private sector, nongovernmental agencies, and individual citizens to ensure swift and coordinated efforts. Under the guidelines, it is the responsibility of every level of the involved organizations and individuals to sustain the nation's preparedness and to develop the best possible ways to implement the guidelines.

In preparing for all hazards, capabilities-based preparedness is utilized, which is defined as "preparing, under uncertainty, to provide capabilities suitable for a wide range of challenges while working within an economic framework that necessitates prioritization and choice (NPG, 2007)." Any means of completing an objective that attains a predicted result is a capability and is composed of a mixture of six elements: planning, organization and leadership, personnel, equipment and systems, training, and exercises, evaluations, and corrective measures. Capabilities-based preparedness allows for flexibility, but requires cooperation and the building, maintenance, measurement, and improvement of the capabilities in order to sustain a desired state of preparedness. The proposed framework would take in to account these capabilities-based aspects by using them as inputs for its improvement evaluation.

The guidelines also take a risk-based approach to preparedness. The level of relative risk in different areas concerning terrorist attacks or disasters is used to determine where resources should be allocated. To determine risk, three variables are taken into account: threat, vulnerability, and consequence. Allocating appropriate risk levels reduces the wasting of resources and results in the best possible level of preparedness. The proposed framework would help improve the security program and therefore raise the awareness of threats and lower vulnerability. The effectiveness of the surface transportation security program can be calculated as the probability that an event would be seen and reported in a complete and quality manner.

The guidelines set up measurable national priorities to form a framework for domestic preparedness which include: expand regional collaboration, implement the national incident management system and national response plan, implement the National Infrastructure Protection Plan, strengthen information sharing and collaboration capabilities, strengthen interoperable and operable communications capabilities, strengthen chemical, biological, radiological, nuclear, and explosive (CBRNE) detection, response, and decontamination capabilities, strengthen medical surge and mass prophylaxis capabilities, and strengthen planning and citizen preparedness capabilities.

Of particular interest is the National Infrastructure Protection Plan whose goal is to "build a safer, more secure, and more resilient America by enhancing the protection of the Nation's critical infrastructure and key resources to prevent, deter, neutralize, or mitigate the effects of deliberate efforts by terrorists to destroy, incapacitate, or exploit them; and to strengthen national preparedness, timely response, and rapid recovery in the event of an attack, natural disaster, or other emergency (NIPP, 2006). This federal mandate directly applies to and provides guidance for surface transportation security programs and therefore would be a major consideration for the decision support system framework.

There are no detailed instructions for implementing the priorities. Instead, the guidelines provide tools such as national planning scenarios, a target capabilities list, and a universal task list to assist and guide preparedness efforts. The Department of Homeland Security is charged with establishing, supporting, and participating in a structure to manage and maintain a supportive architecture for the national preparedness guidelines and the tools presented in them. By evaluating, maintaining, and improving lower level security programs such as surface transportation security programs using feedback, assessments, and measurable goals while working with its partners, the Department of Homeland Security can stay consistent with the guidelines and maintain a high degree of preparedness. Because the Department of Homeland Security accomplishes its goals and those of the nation through the programs it funds such as surface transportation security programs, such programs should be evaluated and improved on a regular basis to keep them up to date with the nature of the threats and in line with the nation's security objectives.

1.3 Trucking Security Program

Another federal mandate that should be considered is the Trucking Security Program grant because the decision support system framework could be applied to the roadway sector. The Fiscal Year 2008 Trucking Security Program is one of five grants authorized by U.S. Congress and funded by the Department of Homeland Security for securing the nation's infrastructure from terrorist incidents (TSP, 2008). The Trucking

Security Program also supports and abides by the National Preparedness Guidelines, and its area of concern is the entire highway sector. The program deals with highway safety, but the main emphasis is placed on terrorism and specifies five priority areas on which the funds should be spent: participant identification and recruitment, planning, training, communications, and information analysis and distribution (TSP, 2008).

The requirements for the Trucking Security Program grant could provide further insight into what is required of the surface transportation security program and therefore what should be considered when developing the possible actions to take within the decision support system framework. For a surface transportation security program that is established, participant identification and recruitment to would be the most important priority in order to gain complete coverage of the nation's roadways. This priority requires finding ways to gain new recruits and share knowledge and program developments with participants (TSP, 2008). The second priority involves planning for high risk scenarios and performing a risk assessment and hazard analysis in order to be prepared for and to hopefully prevent any catastrophic events and the third priority is training, which involves training methods and content (TSP, 2008). The last two priorities are communication and information analysis and distribution which deal with how events are reported, received, evaluated, and passed on to the appropriate authorities (TSP, 2008).

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

In the crisis management literature, experts recommend proactive terrorism prevention, which could be provided by a surface transportation security training program, to mitigate disastrous consequences following a terrorist attack. In recent literature, frameworks have been proposed to develop effective crisis management strategies for prevention of terrorist attacks, which are classified as “man-made crises with low-probability high-impact property” (Mitroff, 2005). Crisis management models developed by most researchers focus on post-crisis response based on lessons learned from terrorist attacks in history. Systematic design of response to a crisis was originally introduced by Pauchant and Mitroff (1992). There are frameworks considering risk assessment and disaster contingency plans especially for the tourism industry (Faulkner and Vikulov, 2001; Ritchie, 2004). Destination management organizations play important roles in conducting specific crisis management strategies at each stage of the crisis lifecycle, including proactive prevention strategies. Ritchie (2004) extended crisis management beyond terrorist attacks to employee strikes and economic recessions, etc. Later, Mitroff (2005) proposed a ‘holistic’ crisis management framework including six distinct components: signal detection; prevention/preparation; containment (damage limitation); recovery, ‘no-fault’ learning; and redesign. This remarkable work prompted actions throughout the whole crisis lifecycle rather than exclusively during the post-crisis period. In the signal detection stage, crisis management activities focus on seeking signals that might warn of a crisis, which would be very similar to the major purpose of a surface transportation security program in detecting unusual signals in transportation systems. The decision support system framework will be developed to improve the target confidence level that the security program participants will be able to identify the efforts of suspicious terrorists and report them completely. In the following sections, we study the background of training performance, service quality, and decision support systems, which are three major instruments in the decision support system framework development.

2.2 Background of Training Performance

The purpose of training is to increase job performance, which is the effectiveness of using skills learned in training in the workplace (Rowold, 2007). According to Olsen (1998) this training can represent large financial investments, and therefore training programs and their performance should be evaluated using theoretical models or by performing real-life studies. One comprehensive theoretical model for evaluating training effectiveness based on different stages of training and variables at each stage is the Canon-Bower model (Rowold, 2007). For testing training variables, the within-subject and within-group method designs have been proven very useful (Oliver and Fleming, 1997). No matter what model or method is used several principles and ideas are common to both.

Most training evaluations are done based on trainee reactions (Tannenbaum 1992) which are likely to be measured based on trainee satisfaction, and are not always the best indicators of future job performance (Kirkpatrick 1976). At the end of training, anonymous questionnaires and tests can be given immediately to evaluate trainees' knowledge of the training material and their reactions after training (Rowold, 2007) providing a subjective self-evaluation of training. Oliver and Fleming (1997) state that because how a trainee reacts after training and how their actual behavior changes do not always agree, further evaluation is needed to understand the training's effectiveness. For more meaningful evaluations of training, measurements of reactions must take place alongside measurements of how the training affects job performance (Rowold, 2007). Before evaluating trainees, the workplace and training variables must be specified and measured to provide integrity to the independent variables (Oliver and Fleming, 1997). Once the variables are prepared, direct observation of behavior, which provides the best accuracy, should be done over time to allow for the best picture of behavior changes and skill decay (Oliver and Fleming, 1997). Also if a relatively long-term evaluation of training is conducted, observations can be done at longer intervals to decrease cost. In addition to direct observations, peer ratings can be obtained to improve accuracy and better understand the workplace (Eubanks, 1993).

Optimal training methods are different for certain training subjects, and care should be taken to determine the correct method for a given subject (Clarke, 2002). The appropriate training method will also depend on personality and other individual trainee characteristics (Colquitt, 2000). However, the method should also take into account work and training atmosphere, which both affect knowledge transfer: i.e. the climate where training takes place should be supportive to learning (Rouiller and Goldstein, 1993). To be effective, the training program should be designed to focus on tasks of high significance instead of low significance tasks (McKillip and Cox, 1998). There are several characteristics of trainees that may positively influence training programs and aid in evaluating the effectiveness of training programs. The program should also be tailored around the attitudes and motivation levels of the trainees (Colquitt, 2000). The fact that a trainee will be more likely to change his/her behavior if the training makes his/her job easier is an important consideration according to Oliver and Fleming (1997). Ruona (2002) points out that another important aspect to consider is the trainee's motivation to learn which is proportional to transfer of training which according to Cannon-Bowers (1995) is proportional to general mental ability, which implies a willingness to learn and can be related to the trainee's amount of education (Colquitt, 2000). Other characteristics such as trainee personality may also affect knowledge transfer and should be taken into account (Lievens, 2003).

2.3 Literature Review of Service Quality

For the last two decades, U.S. economy has been becoming more and more service-based. Actually, about 70 percent of OECD (2005) (Organization for Economic Co-operation and Development) countries' GDP is contributed from service activities (Carrillat *et al.*, 2007). The trend of increased service marketing prompts marketing researchers to address more service-related issues, including how to measure service quality with quantitative scales. Service quality is defined as how well the service meets or exceeds customers' expectations on a consistent basis (Parasuraman *et al.*, 1985). Both academics and practitioners agree that service quality is a critical determinant of business performance as well as corporations' long-term viability (Bolton and Drew, 1991; Gale, 1994). Service quality becomes so important in the current service-dominated marketing environment that some organizations must have a high level of service quality for survival not just success (Chen *et al.*, 1994).

In the 1980s questions of measuring quality in both products and services arose in academics research. While quality models and scales in goods have been well studied and developed, quality in service is mostly undefined and unresearched. The first generic instrument for measuring service quality is provided by Parasuraman *et al.* (1985) by investigating four service categories: retail banking, credit card, securities brokerage, and product repair and maintenance. Relying on information from three focus group interviews of each category, it is reported that service quality is evaluated based on the comparison of expectations of service level with perceptions of service received. In this original work, the author identified ten dimensions of scales to measure service quality, which were reduced to five in his later work (Parasuraman *et al.*, 1988): tangibles, reliability, responsiveness, empathy, and assurance. This generic instrument for measuring service quality is named the 'SERVQUAL' scale, which has been widely used in various service industries including the healthcare sector, banking, fast food, telecommunications, retail chain, information systems, and library services (Ladhari 2008). While the SERVQUAL scale has enjoyed and continues to enjoy the extensive usage in assessing service quality (Chebat *et al.*, 1995; Furrer *et al.*, 2000; Zeithaml and Bitner, 2003), it has been subject to several theoretical and empirical criticisms in literature over years.

The concept of "different scores" has been criticized because little evidence shows that customers evaluate service quality in terms of perception-minus-expectations scores based on a psychological construct (Buttle, 1996; Van Dyke *et al.*, 1999). Cronin and Taylor (1992) developed the SERVPERF scale, which measures service quality directly by capturing customers' perceptions. Numerous researchers have attempted to compare SERVQUAL and SERVPERF to assess their predictive validity in different types of industries. However, since the study context of the scale items are subject to one or two types of industries at most, these individual studies introduce more ambiguity to the measurement debate. For example, SERVPERF is reported to be a better alternative than SERVQUAL in some literature (Babakus and Boller, 1992; Brown *et al.,* 1993; McAlexander *et al,* 1994; Brady *et al.,* 2002) whereas Quester and Romaniuk (1997) reported that SERVQUAL was more strongly correlated to overall service quality. By conducting meta-analysis on 17 empirical studies containing 42 effect sizes of comparisons between SERVQUAL and SERVPERF, Carrillat *et al.* (2007) reported that these two scales were equally valid predictors of overall service quality while SERVQUAL required more efforts to be adapted to the study context than SERVPERF.

Questioning the generic scale SERVQUAL for measuring service quality, Carman (1990) proposed that it was insufficient to simply adapt SERVQUAL items to measure service quality across various service industries. Other researchers suggest different dimensionality other than the five dimensions of SERVQUAL to better describe expectations, perceptions, and different scores. For example, unidimensionality was introduced by Cronin and Taylor (1992); two dimensions were first addressed by Babakus and Boller (1992) and further discussed by Gounaris (2005); three, four, six, eight and nine dimensions were further reported (Chi Cui *et al.,* 2003; Arasli *et al.,* 2005; Kibourne *et al.,* 2004; Carman 1990). Some services require complex multi-dimensional constructs (Babakus and Boller, 1992) while a simple unidimensional construct is adequate enough for others. Therefore, it is suggested that industry-specific measures of service quality are more appropriate than a single generic instrument (Babakus and Boller, 1992; Van Dyke *et al.*, 1997; Caro and Garcia, 2007). Chowdhary and Prakash (2007) concluded that there were no simple generalizations of importance ranking of service quality dimensions, which strongly depends on service types. Ladhari (2008) reviewed numerous industry-specific measurement scales proposed in literature since the 1990s after the SERVQUAL instrument was published in 1988. To measure service quality more adequately for specific industries, these scales have different characteristics in dimensional structure, score methodology, number of survey items, sample sizes, reliability and validity, and analysis methods. In general, future research needs to be done investigating dimensionality of service quality measurement in general and/or of SERVQUAL in particular (Parasuraman *et al.*, 1994).

In addition, SERVQUAL is criticized for focusing solely on the process of service delivery ("how" the service is provided) rather than the outcome of service encounter ("what" service is provided) (Gronroos, 1990; Richard and Allaway, 1993). These are identified as two dimensions – a technical aspect ("what") and a functional aspect ("how") by Gronroos (1982). In some service industries such as healthcare, technical quality might be even more important to evaluate because a patient evaluates a health care provider's service quality by the result of treatment.

After reviewing and comparing existing industry-specific measurement scales of service quality, some researchers believe several aspects of such scales are under debate and require future research efforts and suggest hierarchical construct consisting of various sub-dimensions of measurement scales (Dabholkar *et al.*, 1996; Brady and

Cronin, 2001; Gounaris, 2005; Caro and Garcia, 2007; Wilkins *et al.*, 2007). However, little empirical evidence exists to support such structure. There are insufficient empirical studies to show that SERVQUAL underperforms alternative industry-specific measurements besides a single scale in present literature ("INDSERV"). The small sample sizes used in industry-specific studies are less rigorous than those used in developing and refining SERVQUAL (Parasuraman *et al.*, 1985, 1988, 1991).

The measuring of service quality for a surface transportation security training program requires the appropriate selection of measurement scales from a generic instrument SERVQUAL/SERVPERF or customized industry-specific measurement. For either choice, dimensions of quality in training services are to be identified for qualitative and/or quantitative purposes. To construct the SERVQUAL instrument, 11 steps are pre-defined and ready to implement step by step in developing a particular measurement scale for the improvement of the training program's service level, which is more customer-oriented and may outperform SERVQUAL as long as scaling dimensions, such as the number of drivers in an area of interest, level of driver training, driver attrition, and etc., are appropriately identified. With penetratingly investigating these pertinent dimensions, the metric scale for each dimension can be defined to evaluate and assess the current and target level of service quality of the training program. The decision support system framework will be developed to address feasible tactical adjustments of key decision variables (scaling dimensions of service quality) to improve the service quality of the training program.

2.4 Literature Review of Decision Support Systems

Decision-making in an organization is always an important aspect of management activity because it has large impacts on the organizational performance (Mintzberg, 1973; Taylor, 1975). However, it is not an easy task to make decisions for complex problems since decision makers may not be able to process complicated masses, information are subject to some degrees of biases, or it is hard to acquire agreement across differing interests (Kahnemann *et al.*, 1982; Zigurs *et al.*, 1988). Numerous operations researchers, management scientists, psychologists, and information technology (IT) researchers have been investing great efforts on supporting and improving managerial decision-making processes in the last two decades. Recent research shows that development and implementation of model-driven Decision Support Systems (DSS) are still big challenges.

Model-driven DSS contain one or more quantitative models accessible to non-technical decision makers through an easy-to-use interface. Advanced quantitative models such as decision matrix and decision tree, network and optimization models, and Monte Carlo and discrete-event simulation models are the dominant components in the model-driven DSS architecture to provide functionality for the DSS (Bonczek, 1981). Though model-driven DSS conduct situation analysis based on data and parameters from decision-makers, they are different from data-driven DSS in which the functionality usually results from manipulation of a large database of structured data. Despite the huge amount of existing articles in data-driven DSS, there is a vast amount of research related to model-driven DSS. It is reported that 474 DSS applications are presented in literature from 1970 to 1992 (Eom, 2002, 2003). In addition, Eom (2003) identified more than

1,800 DSS related articles among which many focused on model-driven DSS. In the early years, algebraic models developed with personal computer-based spreadsheets were very popular in building model-driven DSS applications. Recently, three more complex techniques, decision analysis, mathematical programming, and simulation, have been widely applied for model-driven DSS development.

Decision analysis methodologies evaluate pre-defined utility functions measuring performance of the particular application under investigation. The evaluations refer to assessments of probabilities and preference elicitation using decision tree, influence diagrams, and other methodologies. Various applications in manufacturing, finance, military, public policy decisions, and other areas have been reported in academic literature (Keefer *et al.*, 2003) while specific applications using commercial decision analysis software are also widely used by practitioners. For example, model-driven DSS was developed to make decisions on reducing congestion in the Bosphorus Sea (Ulengin *et al.*, 2001). In this work, 19 experts from different background proposed decision-making objectives, which were analyzed in a decision matrix. Dunning *et al.* (2001) investigated decisions to develop a multi-year schedule for refueling a nuclear power plant by applying influence diagrams and decisions trees. Commercial software packages, such as Precision Tree, Expert Choice, Catalyze, and Logical Decisions are widely used to generate model-driven DSS in business applications. Surveys of such software generators are conducted regularly and published in *OR/MS Today* (Maxwell, 2002).

Mathematical programming in developing model-driven DSS optimizes desired decision criteria to some degree. *OR/MS Today* publishes review optimization software such as AIMMS, ILOG, and MPL periodically (Fourer, 2003). Revenue management aiming optimal price levels of services is one of the most important applications in optimization-based model-driven DSS. Optimization models with parameters of current sales levels and forecasts are developed to maximize overall revenue. American Airlines is one of the pioneers to conduct such modeling DSS (Smith *et al.,* 1992). Boyd and Bilegan (2003) reviewed recent revenue management research and practices in many industries to illustrate that DSS for revenue management was necessarily required for some business to stay competitive. In addition to revenue management, model-driven DSS are available for logistics planning, production planning, demand management, pricing decisions, and many other applications in literature. For example, a model-driven DSS for sourcing allocation in private retailers is developed to maximize their expected gross profits (Smith *et al.,* 2003). An emerging application of model-driven DSS is to employ optimization models to decide products' prices with considering uncertainty in demands and stock levels etc. It has been reported that software generators of model-driven DSS including stochastic programming, integer programming, and modeling language interfaces are beginning to be applied in Radio Shack, Cargill, and Duane Reade (McCain, 2004). Kim and Eom (2004) reviewed numerous additional applications of optimization-based DSS that have been discussed in recent literature. Such applications are likely to expand to large databases.

Simulation is another important technique in building DSS models, especially quantitative and behavioral models to capture more in-depth details for specific systems. Among various simulation techniques being used for DSS development, several of the most popular ones are going to be reviewed along with applications addressed in literature. *Monte Carlo* methodology simulates uncertainty of independent variables by introducing probability distribution of values. Evans and Olson (2002) explored several *Monte Carlo* simulation-based decision-making examples: a call center staff capacity analysis, a study evaluating government policy options, and a design of facilities. Agent-based or multi-agent based simulations supplement traditional simulation techniques such as *Monte Carlo* simulation. Gimblett *et al.* (1996) developed a decision support system by integrating a multi-agent simulation system and a GIS system to assess and manage dynamic recreation behavior and social interactions. A DSS combining GIS and simulation into a DSS was also developed to make evacuation decisions in emergency situation (Silva and Eglese, 2000).

The three quantitative techniques reviewed can be used individually or in combination. Selection of the techniques depends on the characteristics of applications but also the delivery mechanism suiting the implementation environment. Spreadsheets are still one of the most popular technologies for developing model-driven DSS, especially with one or more small models because of computational time restriction (Gimblett, 2002). Web-based DSS takes advantage of the web services concept to deliver the decision support functionality to users through the Internet Web browser. Specific research is needed to select appropriate techniques and delivery mechanisms for developing customized model-driven DSS of particular application such as the performance improvement of a surface transportation security training program.

CHAPTER III

FREIGHT FLOW ANALYSIS

3.1 Global Insight® Transearch Database and TransCAD®

Because the decision support system framework will deal with the roadway sector, a previously performed freight flow analysis was used to determine the flow of security program trainees as a percentage of the total aggregated flow.

Global Insight® Transearch database is a nationwide database of freight traffic in the U.S., which was used to perform the freight data analysis. The database was chosen because it has the most complete freight-demand data that are drawn from a wide variety of data sources covering commodity volume and modal flow, including commercial motor carriers' traffic samples. The Transearch data were defined by origin-to-destination Business Economic Areas (BEA) because county data would be too expensive and state level data would be insufficient also and a 2-digit Standard Transportation Commodity Code (STCC). A sample of the data is displayed in Table 1.

Table 1 Part of Transearch 2006 Database

Origin BEA	Destination BEA	STCC	Mode	Net Tons 2006	Net Tons 2015
1	1	22	PVT	244.89	94.67
1	1	22	TL	552.96	235.20
1	1	23	LTL	7.76	11.86
1	1	23	PVT	1,904.24	3,898.39
1	1	23	TL	428.31	746.74

The STCC code refers to the category of commodity being shipped such as 01 for farm products. There are totally 41 categories in the dataset. The Mode describes how it is transported such as TL for truckload and LTL for less-truckload.

The Transearch database is in the form of an Access 2000 database that is importable to TransCAD®, a geographical information system (GIS) software package that could be used to conduct the traffic assignment. The database contained the historical data for the year 2006 and forecasts for years 2015, 2025, and 2035. The freight flow analysis is conducted with 2006 freight flow data. However, the same procedure can be used to analyze scenarios based in future years.

3.2 Traffic Assignment Procedure

A widely used frequency measure for traffic flow over roadway segments is the average number of vehicles passing across each segment each day. Since the focus is on the passage of commercial trucks carrying freight to represent a large portion of the surface transportation security program trainees, the expected number of trucks passing daily across each roadway segment is obtained by performing traffic assignment in TransCAD® based on the traffic demand data contained in the Transearch database.

TransCAD® provides a variety of traffic assignment methods, including equilibrium methods (User Equilibrium, Stochastic User Equilibrium, etc) and non-equilibrium methods (All-or-Nothing, STOCH assignment, etc). In the analysis, it is assumed that drivers select the shortest path to deliver their goods because they want to minimize their own travel time rather than consider the nation-wide traffic balance or the least total travel time for all drivers all over the nation. In practice, drivers may consider other factors, such as available amenities, ease of driving, etc, when deciding their routes, but the analysis focuses on the overall traffic flow rather than the routing process for specific drivers. The non-equilibrium method of All-or-Nothing (AON) is used to perform the traffic assignment since all equilibrium methods are not applicable because only freight flow is involved and no passenger traffic is considered. The AON traffic assignment assumes only one path between every O-D pair. The assignment doesn't consider the impact of congestion on travel times. Since we only want to know the average number passing per day, this was not a concern. Under the AON assignment, all traffic flows between O-D pairs were assigned the shortest paths connecting the origins and destinations.

Required data for traffic assignment include an O-D matrix, a network with appropriate attribute fields, and the line layer from which the network was derived. The Transearch database provide the necessary commodity flow information to build the O-D matrices. To have an overview of traffic conditions on each highway segment, a summarized O-D matrix, containing total number of trucks from origins to destinations, is developed by aggregating the data records in the Transearch database. The AON traffic assignment analysis is conducted with O-D matrices for each commodity type to obtain the information, which denotes the annual tons of certain commodity types from a certain origin passing each highway segment. TransCAD® has a tremendous network, including all U.S. roadways, which is too huge for the analysis performed. In practice, almost all trucks follow Interstate and U.S. highways for long distance trips to avoid local traffic. Therefore, only Interstate and U.S. highways are used to form the network for the traffic assignment.

For the traffic assignment in TransCAD®, a special set of link nodes in the network are defined as Centroids, which represented the center of a transportation analysis zone. In the analysis, the 172 origins and destinations from the Transearch database are defined as centroids. In other words, the whole continental U.S. is divided into 172 zones, with one node (origin and destination) located at the center of each zone. The data in Transearch actually represent the aggregated freight flows from one zone to another.

3.3 Traffic Assignment Results

Standard outputs of a traffic assignment in TransCAD® include link flows, volume-to-capacity ratios, congested travel times, and congested speeds. In the analysis, only the link flows on highway segments are considered. The resulting table, a portion of which is shown in Table 2, contains the estimated link volumes (in trucks per day) and shows the traffic assignment results for the total expected daily number of trucks passing each roadway segment indicated by link IDs in both directions.

Table 2 Part of Traffic Link Flow on Highway Segments

Highway Segment ID	AB_Flow	BA_Flow	Total_Flow
625055	2389.52	378.15	2767.67
625722	3085.79	2764.76	5850.55
626233	3085.79	2764.76	5850.55
626405	9.76	36.05	45.80
626786	3095.55	2800.81	5896.36
627197	0	0	0
630846	2666.9313	3274.4831	5941.4144
4100367	4079.863	4719.0892	8798.9522
4102111	1076.5901	2570.823	3647.4131
3269835	1018.6418	1407.5986	2426.2405

The national flow is displayed in Figure 1. The stars are the origin/destination nodes of the freight flow. The thickness of a highway segment shows the total flow volume for all commodity types over the segment.

Figure 1 National Freight Flow Map

To obtain the information for evaluating the security confidence level of the surface transportation security program, the numbers in each cell in Table 2 needed to be extended in two dimensions, origins and commodity types. The following information in Table 3 indicates the two-way extension of flow volume (in trucks per day) for one highway segment (i.e., link).

Table 3 Link ID: 624678, Link AB_Flow: 2389.52 trucks/day

Origin	1	2	3	4	5	…
1	33.60	0.00	0.00	0.00	12.20	…
9	57.72	0.00	0.00	23.35	60.36	…
14	11.23	12.25	35.65	56.32	0.00	…
20	37.00	15.20	28.36	56.50	8.76	…
22	23.28	0.00	0.00	16.33	37.21	…
…	…	…	…	…	…	

In total, there were 68,209 highway links in the national highway network. This number is doubled to be the number of tables that contain disaggregated flow information on both directions of all segments. In each of the 136,418 tables, 41 commodity types and 172 origins result in a 41 by 172 matrix to store the flow of trucks for each segment and direction.

CHAPTER IV

THE DSS FRAMEWORK

4.1 DSS Framework Overview

The purpose of the DSS is to help improve a surface transportation security training program with regard to making strategic and tactical decisions to use the program's allotted funding to operate as efficiently and as effectively as possible in protecting the nation's critical infrastructure and key resources (CI/KR). Therefore, the program can give the highest degree of service quality possible to its funding organization. The nation's CI/KR are vital to the economic health and daily operations of the United States and in part could be protected by a surface transportation security program through domain awareness, reporting, and information sharing. The measure to evaluate such a surface transportation security program would be an overall security confidence level which is elaborated on in Chapter V and describes the effectiveness of CI/KR protection and should be weighed against cost efficiency and scarcity of resources. The DSS should help to make decisions to maximize the effectiveness of CI/KR protection and minimize the total cost.

The flow chart in Figure 2 shows the proposed framework of the DSS, which would contain three subsystems: a database subsystem, a model management subsystem, and a user interface subsystem. The model would use the data inputs and the performance measures to determine what possible actions should be taken and how much funding should be allotted to each determined action. All of these subsystems have broad definitions and would have more detailed systems within them based on the specifics concerning the actual program.

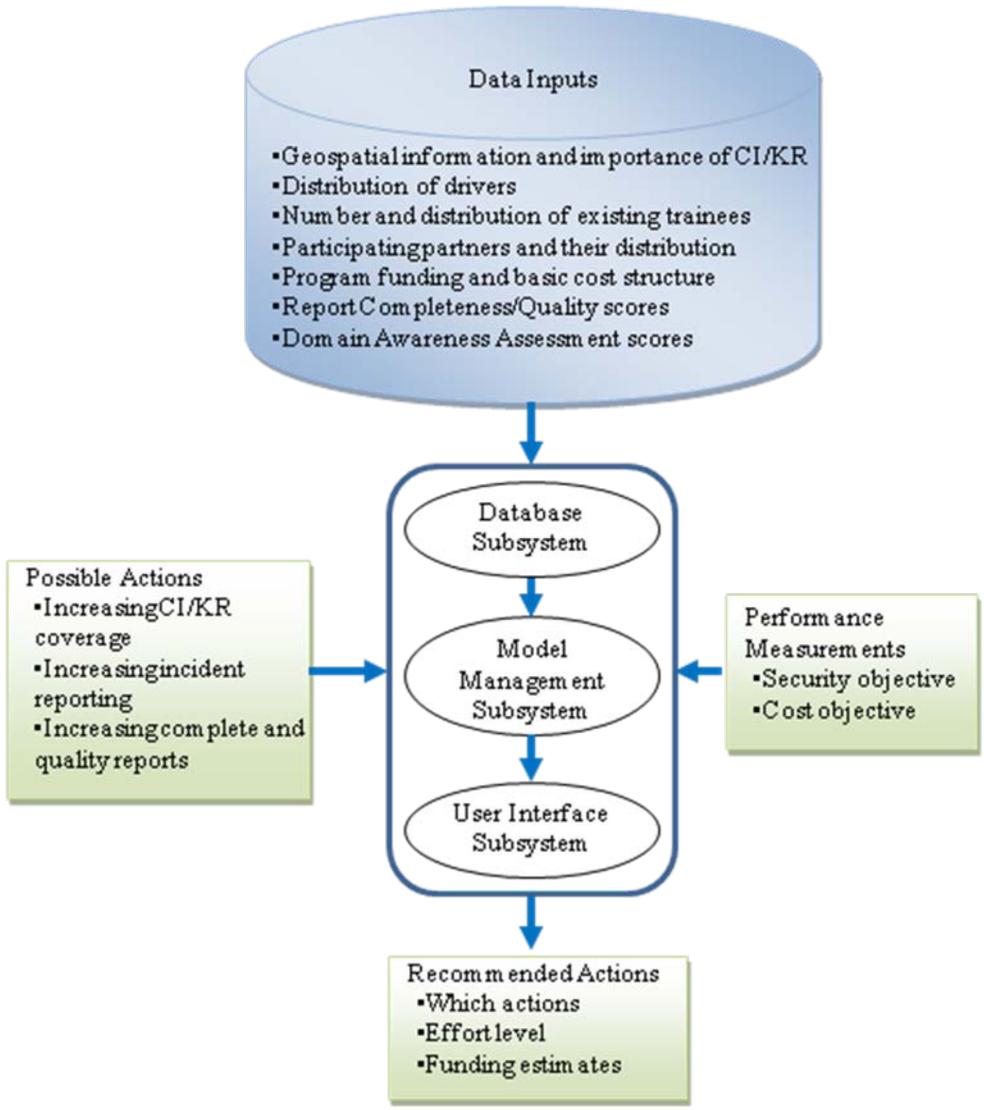

Figure 2 DSS Framework Flowchart

4.2 Database Subsystem

The database subsystem will store, organize, and move all of the information put into the model, as well as any information created by the model (Turban, 2004). All input data would be stored and managed in the database subsystem of the DSS. This type of database subsystem is commercially available from software companies such as the Oracle Corporation or Microsoft's Access. Products such as these allow for customized organization, storage, and updating of data on which queries can be run to retrieve pertinent information to be used in any calculations or for display. An example of the database subsystem's contents would be the freight flow data and trainee location data used to predict the movement of trained drivers for comparison to the locations of CI/KR.

4.3 Model Management Subsystem

The model management subsystem is the mathematical heart of the DSS and would contain the actual analytical tools that the model would use to determine the best possible actions to improve the surface transportation security training program (Turban, 2004). The relationships between the inputted data and the possible actions would be used to determine the recommended actions to based on their potential improvement of the security program in terms of increasing the performance measures along with their required resources. The performance measures' value structure would be partly based on the importance weightings given by the HSIP Gold database. The calculation of coverage gaps should result in a scale from the worst to best coverage of CI/KR so as to indicate an areas relative need for improvement and to assign a certain set and level of actions to it. The analytical models contained here would more than likely involve simple calculations and would include the resource constraints faced by the training program.

4.4 User Interface Subsystem

The user interface subsystem would provide a link between the technical parts of the decision support system, the database and model management subsystems, and the operator who would run the model (Turban, 2004). The operator would likely be the team or individual responsible for the program's management or planning appointed by the company administering the security program. The user interface subsystem would include areas for inputting information such as funding constraints, controls for operating the decision support system, a graphical display of the program's coverage and existing coverage gaps, display of the security confidence level and its component parts, and a display for the recommended actions along with how much funding should be allotted to each action.

4.5 Data Inputs

There are multiple data inputs that are needed to calculate values for the performance measures of the surface transportation security training program. The information concerning CI/KR coverage would come from an existing demographic/geo-spatial model which shows the locations, based on day and night time situations, of what are considered to be the important CI/KR (NPG, 2007). This would include the freight flow analysis, the number and distribution of existing trainees from the member database, and the HSIP Gold database of CI/KR. Different CI/KR are assigned different importance levels based on the impact of their disruption on the national economy and the nation's security.

The DSS would need the program's funding and existing cost structure to take into account financial constrains, as well as the estimated costs that improvements to the program will bring. Both are important inputs because of the scarcity of resources, and actual values could be obtained from the program itself and its funding source. Also, information concerning the enthusiasm and participation of the program's partners, various government agencies, private companies, and state associations, would be included because of their likely relationships with and support of the surface transportation security training program; it is expected that these organizations would play a large role in administering and encouraging training. This partner data could include such things as frequency of training and a number trained to funding ratio. Finally, the information concerning the scores for completeness and quality of incident reports would be included as well as the domain awareness assessment scores. The calculation of the various scores will be discussed later.

4.6 Possible Actions

The possible actions that could be taken to increase the effectiveness of the surface transportation security training program would fall into three categories: increasing the coverage of CI/KR, increasing the likelihood that incidents will be reported, and increasing the percentage of complete and quality reports. These actions deal with recruitment and training and are discussed in detail in Chapter VI. The TSP outlines three other areas for improvement besides recruitment and training: planning, communication, and information sharing.

4.7 Performance Measures

The measure that should be used to evaluate a surface transportation security program's overall security confidence level is the effectiveness of CI/KR protection and should be weighed against the program's cost efficiency and scarcity of resources. The DSS should help to make decisions to maximize the effectiveness of CI/KR protection and minimize the total cost. The topic of performance measures will be elaborated on in Chapter V.

4.8 Recommended Actions

The recommended actions would determine how to allot the available recruitment and training funds so as to maximize the performance measures and thus the security confidence level while certain constraints would be added to the model to ensure that basic funding requirements are met for all areas. The model's output would then suggest what proportion, to which area, and for what purpose the remaining funds for recruitment and training should be allocated. These results would be weighed against the funding and actions for improving planning, communication, and information sharing and might be altered based on management's judgment.

CHAPTER V

THE SECURITY CONFIDENCE LEVEL

5.1 Estimation of Overall Security Confidence

The security confidence level is a quantitative measure of how effectively the surface transportation security program protects the nation's critical infrastructure and key resources (CI/KR) through domain awareness, reporting, and information sharing. The security confidence level is defined by the weighted average probability that there is one quality trained program participant passing over all critical infrastructure defined by

$$\bar{p} = \frac{\sum_{i=1}^{n} w_i p_i}{\sum_{i=1}^{n} w_i}, \qquad (1)$$

where p_i is the probability that there is one or more vehicles with quality trained program participants passing by CI/KR i in x miles distance in the time interval of T minutes, and w_i is used to represent the importance of CI/KR i. Let us consider a system with two CI/KRs as an example. Assume $w_1 = 1$ and $w_2 = 2$, which means the second CI/KR is more important than the first one. Assume p_1=0.2 as the probability that there are one or more trainees passing the first CI/KR in 1 mile distance (x=1) in the time interval of 10 minutes (T=10) and p_2=0.1. Then, the overall security confidence level for this example is $\bar{p} = \frac{(1)(0.2)+(2)(0.1)}{1+2} = 0.133$.

The high quality of trained program participants means the trainee could detect potential threats and report them by making a phone call, and the report is complete and of high quality.

The security confidence level for one specific CI/KR i (p_i) is determined by the product of three factors: the expected number of program trainees passing the CI/KR when a threat is posed to the CI/KR, the probability that a trainee (f_1) will detect the threat and report it when he or she passes the threat, and the probability (f_2) that the threat report is complete and of high quality. The value of p_i can be estimated by the following formula:

$$p_i = \frac{N_i T f_1 f_2}{1440}, \tag{2}$$

where N_i is the average number of vehicles with program trainees passing by CI/KR i in x miles distance every day. The formula of $\frac{N_i T}{1440}$ converts the daily traffic amount into the counts over the valid interval of T minutes. How to define the interval of T requires more understanding on the nature of threats. Please note formula (2) is valid only when $\frac{N_i T}{1440}$ is significantly smaller than 1, which is usually the case. If f_1=0.1 (i.e., 10% of chance that a trainee will detect the threat and report it if he/she passes a threat), f_2=0.6 (i.e., 60% of chance that the report is complete and of high quality), and N_i=100 (i.e., 100 vehicles with HWW trainees passing the CI/KR in 1 mile every day), the security confidence level for CI/KR i is $p_i = \frac{N_i T f_1 f_2}{1440} = \frac{(100)(10)(0.1)(0.6)}{1440} = 0.00694$, which is the chance of

receiving a report upon a threat at the CI/KR under the assumption of x=1 mile and t=10 minutes. In the following, we will discuss how to derive the three factors influencing the security confidence level $\bar{p}$: N_i, f_1, and f_2.

5.2 Estimation of the Flow of the Program Trainees over a CI/KR

Because of the probable large number of program trainees, it would not likely be possible to obtain the routes of each trainee directly by conducting a survey or applying other technologies. It is realized the long-haul truck drivers, who would likely comprise the majority of the program trainees, move along with the freight that they carry. In order to estimate the expected daily number of program trainees over a CI/KR, these three steps can be followed: traffic assignment for general freight flow, calculation of program trainee flow based on the distribution of trainees, and calculation of the coverage of each CI/KR.

The first step in estimating the flow of program trainees over the CI/KR is to estimate the expected daily passage of trucks from each origin by commodities types through the traffic assignment performed in the freight flow analysis. This step has been discussed in Chapter III and uses TransCAD® and the BEA level Global Insight commodity flow data which include the annual tonnage for each OD pair and each commodity type.

The traffic assignment results show the tonnage of various commodities, from various origins, which pass each specific highway segment. Let $v_i^{o,t}$ denote the annual tonnage of commodity type *t* from origin *o* passing highway segments related to CI/KR *i*, which is the results from traffic assignment. Please note that $v_i^{o,t}$ is for all freight flow and not just for the freight carried by program trainees. Furthermore, based on the average truckload (tons per truck), we can obtain the annual number of trucks that pass CI/KR *i* with commodity type *t* from origin *o*. A small portion of extremely detailed truck position data, provided by the American Transportation Research Institute Inc (ATRI), from their Freight Performance Measures database, could be used to validate the procedure described in this step.

The second step in estimating the flow of program trainees over the CI/KR is to obtain the program trainee flow over the national highway network based on the geospatial and industry-sector distribution of program trainees. The surface transportation security program member database would have a record of trainees' industry sectors and trainees' addresses. Hopefully this database would be near complete, but even if there are information gaps within it, an incomplete database could still provide valuable information. The state and area trainers could also provide insight into the industry segments trained and drivers present at various training locations. Let $u_i^{o,t}$ be the annual number of trips, conducted by program trainees carrying commodity type *t*, from origin *o*, passing highway segment *i;* and $u_i^{o,t}$ can be obtained by

$$u_i^{o,t} = \frac{w^{o,t} v_i^{o,t}}{l^t}, \tag{3}$$

where l^t is the average truck load for commodity type *t*, and $w^{o,t}$ is the percentage of truck drivers, for commodity type *t*, that are trained in area *o*. For example, if we assume the annual tonnage of freight type *t* from one origin A passing CI/KR *i* is 4,000 tons (i.e., $v_i^{o,t} = 4000$), 20 percent of freight type *t* from area A is carried by program trainees (i.e., $w_i^{o,t} = 0.2$), and the average truck load for freight type *t* is 20 tons (i.e., $l^t = 20$), then the number of program members from origin A carrying freight type t and passing CI/KR *i* is $u_i^{o,t} = \frac{w^{o,t} v_i^{o,t}}{l^t} = \frac{(4000)(0.2)}{20} = 40$ members per year.

The third step in estimating the flow of program trainees over the CI/KR is to obtain the average number of vehicles with program trainees passing by CI/KR *i* within *x* miles distance every day based on the location of CI/KR *i* which can be obtained by

$$N_i = \frac{\sum_{o,t} u_i^{o,t}}{365}. \tag{4}$$

Formula (4) adds the drivers from all origins carrying all freight types to obtain the number of program trainees passing one specific CI/KR. Regarding the locations of CI/KR throughout the nation, the HSIP Gold database, made up of some 300 layers and 10 million records, would be used to relate the locations of CI/KR to the estimation of where trainees pass. The HSIP is made up of vector data, which is graphical information representing points, lines, or shapes that are compatible with GIS packages, such as TransCAD®. With the HSIP database input into TransCAD®, the traffic flow along the roadway network, surrounding the locations of CI/KR, would be used to determine the extent of coverage provided by the program.

The coverage of program trainees (N_i) would be visually represented with the GIS map. Different line widths and colors indicate the various flows of trainees across the model's networks, and icons represent the locations of CI/KR on the same map. More important, for a quantitative measurement of coverage, will be the data behind the visual display. By accessing the data, concerning how many trainees pass individual points or line segments within *x* miles distance of CI/KR each day, a probability can be determined for each CI/KR that a trainee will pass within x distance of that CI/KR each day.

5.3 Estimation of the Percentage of Incidents Being Reported

It would important to know if incidents could be recognized by passing program trainees and whether they would be reported, if observed. Unfortunately, obtaining this information, by a direct way, requires knowledge of incidents or attempts that have occurred, which could likely be classified information. Furthermore, the historical data are insufficient to conduct any statistical analysis because terrorist attacks are, by their natures, events with very low probability. However, it would possible to conduct domain awareness assessment exercises to evaluate the probability (f_1) that program trainees will detect and report security threats when they pass a threat.

5.4 Estimation of the Percentage of Quality/Complete Calls

The probability (f_2) that a threat report is complete and of high quality could be evaluated based on the historical data. With current and future reports, there should be a two-tiered system for assessing calls. When a call is placed the call center's system could automatically assign the report a score based on the report's completeness. Completeness would be evaluated based on the percentage of the possible data entry fields, available in the reporting software, that are filled in. Each blank could carry a weight describing how important it is relative to others such as the location of an incident might be more important than the exact time it was observed.

Then, if the report is passed on to the security analysis center, an analyst can perform an individual analysis of the report to determine an initial numerical quality score that will be compatible with those assigned by the call center's automatic system. This score will describe how actionable the report so that a report that directly links to a terrorist incident will receive a higher score than a false alarm. With these two initial assessments, each report will be scored based on its quality and completeness. Those scores will be used to estimate f_2. Reports that are not sent to the analysis center would receive a low quality score unless the report was considered trivial and later found to be pertinent after querying the report database for reports concerning an incident. This of course wouldn't aid in the prevention of that particular incident, but it would give a clearer view of reporting.

Assuming the surface transportation security program has been in existence for some time, another measure of quality would be to know the quality of past reports from the viewpoint of the government agencies who receive the reports. This information would have to be provided by the agency because of its classified nature. As before, a simple percentage of calls that are actionable and the percentage of reports that are sent to each level of authority would provide a quantitative measure of quality and program effectiveness.

5.5 Framework for the Security Confidence Level Calculation

Figure 2 illustrates the hierarchy of the factors that decide the security confidence level and the procedure to calculate the security confidence level. The green boxes are the information that is likely available or possible to be obtained. The purple box indicates that the collection of the responding data is necessary. This step would require more development and further analysis.

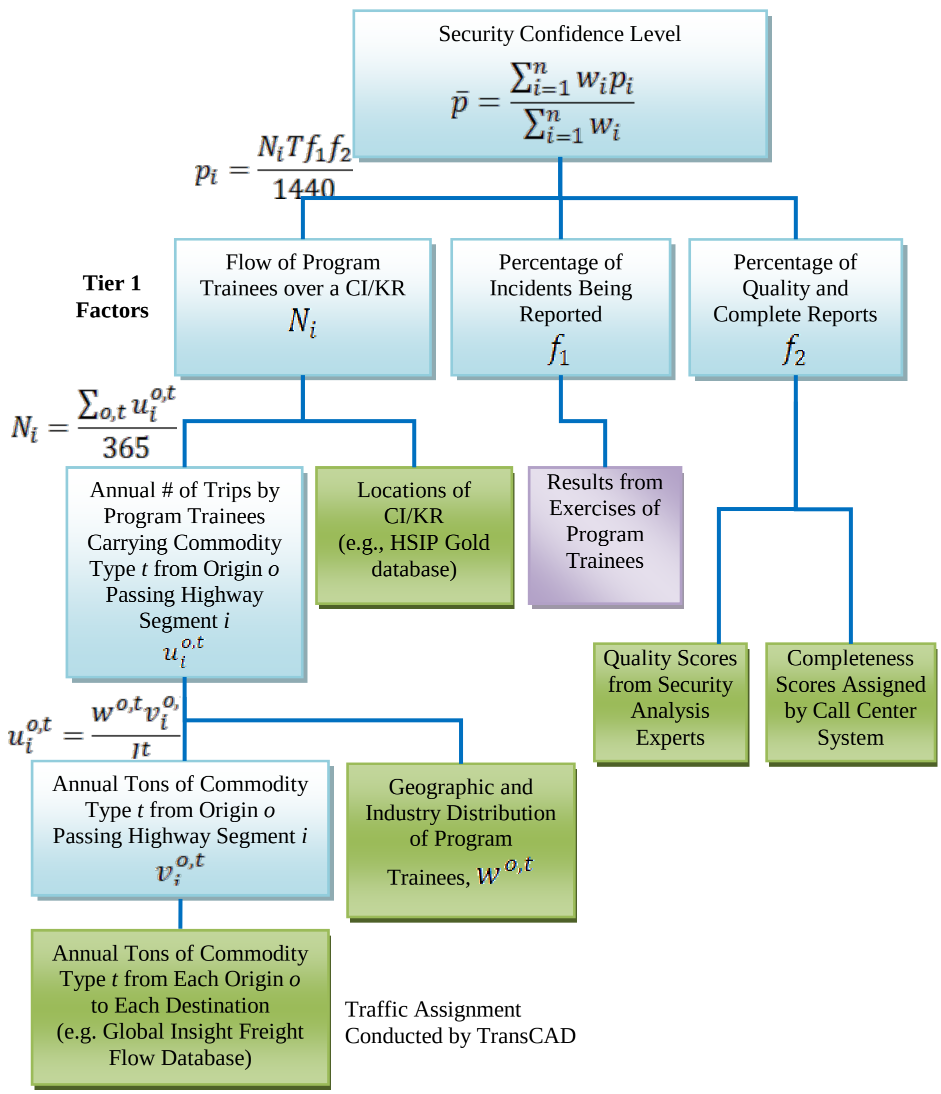

Figure 3 Calculation Procedure for the Security Confidence Level

CHAPTER VI

ACTIONS AFFECTING THE SECURITY CONFIDENCE LEVEL

The actions to influence each of the tier-one factors from the hierarchy are identified below. Please note that which actions should be chosen and their effort level be decided based on their impact on the overall objective of the security confidence level and costs rather than on a single tier-one or tier-two factor. The actions concerning CI/KR coverage would be targeted to specific areas where coverage gaps exist while the actions concerning incident reporting and completeness and quality of reports would be applied to the security training program as a whole.

6.1 Actions for Increasing CI/KR Coverage

The first tier-one factor is the extent of CI/KR coverage offered by the program, which is based on the flow of trainees in and around each CI/KR, as demonstrated with the freight flow model. The model would indicate the varying amounts of CI/KR coverage across the nation. Figure 2 indicates that the coverage is mainly decided by three lower-level factors: the locations of the CI/KR, the freight flow (annual tons of commodity type *t* from each origin *o* to each destination), and the Geographic and Industry Distribution of Program Trainees.

The first two lower-level factors would be out of the control of a surface transportation security program. However, the geographic and industry distribution of the program trainees ($w^{o,t}$) can be partially controlled by the surface transportation security program. Which combinations of origin (*o*) and freight type (*t*) should receive more attention to enhance the overall security confidence level during participant identification and recruitment is an aim of the DSS and depends on the importance of each CI/KR, the locations of CI/KR, and the freight flow demand. Please note that freight flow data are based on freight types.

The distribution of the participants, $w^{o,t}$, is directly influenced by three measures: total number of participants enrolled (*TP*), number of participants enrolled in each area (SP_j), and number of participants enrolled in each industry segment (IP_s). Truck drivers in different industry segments may carry different types of freight and therefore have different routes. Though some specific actions could be used to directly change $w^{o,t}$ for specific area *o* and specific commodity type *t*, many efforts to promote participation may be aimed at all areas and industry segments, to one specific area and all industry segments in the area, or to one specific industry segment and all areas. Some recruiting actions and their relationships to the measures are listed in Table 3. The costs associated with each of these actions could be obtained easily based on the level of undertaking for each, and the expected impacts used for improvement calculations for each would be estimates. Which actions should be taken depends on their costs and impact on the overall coverage of the CI/KR based on these three measures.

The program should consider all three measures when evaluating various actions because all of the measures influence the overall CI/KR coverage. Of particular importance will be the gaps or areas of weak coverage. It would be a priority to recruit in a manner that fills these gaps in coverage and would be accomplished by examining the freight flow data in and around the weak coverage areas to determine the areas and industry segments to recruit from that would yield the best results in terms of increased coverage. Please see Figure 2 to review the procedure to calculate the overall CI/KR coverage.

Regular evaluations of CI/KR coverage should be done on a yearly basis to reflect updated CI/KR and threat information. The HSIP Gold database, a unified homeland infrastructure foundational geospatial data inventory assembled by National Geospatial-Intelligence Agency (NGA) in partnership with DOD, DHS and U.S. Geological Survey (USGS), are usually updated once every two years. The freight flow data are currently updated yearly by Global Insights®. Without continuously re-examining the coverage model, the program will be flawed and out of date.

Table 4 Possible recruiting actions and relationships to the measures and factors

Possible Actions	Geographic and Industry Distribution of Program Trainees ($w^{o,t}$)		
	Total number of participants enrolled (*TP*)	Number of participants enrolled in an area (SP_j)	Number of participants enrolled in an industry segment (IP_s).
Enhance the collaboration with state associations	√	√	
Attend and display at trade shows	√		√
Provide different incentives to state associations for training members		√	
Increase public exposure through radio/TV	√		
Build relationships with partner corporations or industry organizations	√		√
Conduct a telephone-based recruitment	√	√	√
Conduct a web-based recruiting campaign	√		
Targeted recruiting mailings	√	√	√
Other actions			

6.2 Actions for Increasing the Percentage of Incidents Reported

The second tier-one factor in calculating the security confidence level is whether or not incidents that occur are being reported (f_1). To fully understand this would require government cooperation concerning the accuracy of program reports. However, this information would likely be classified. It would be possible to conduct assessment exercises to evaluate the probability that program trainees will detect and report security threats when they encounter one. Also a survey distributed among trainees not only would serve to update trainee records, but would provide feedback from trainees on the likelihood of reporting incidents. There are three types of actions that can influence the factor of whether or not incidents that occur are being reported: training content, the training format, and memory refreshment training. Approximations of the likely impact of these actions could be used for the model's calculations of f_1 based off of past program experience and the relevant literature.

Training content should be updated on a regular basis to keep up with changes in the nature of threats, and should also include a detailed description of what CI/KRs are and their differences from each other to increase the probability of reporting threats. The training content should provide clear guidance about how to detect a threat and how to report one. The purpose of the surface transportation security training program with regard to government objectives, such as the National Preparedness Guidelines, the National Infrastructure Protection Plan, and Transportation Security Program requirements, should also be emphasized during training. The content must teach trainees to become more aware of their surroundings and might also include a pamphlet covering the training program's salient points for drivers to keep in their vehicles to use as a reference.

There are different formats to deliver the training content, such as on-site instructor-led training web-based training, CD-based training, etc. The choice of the delivery methods, or their mix, would influence both the percentage of incidents reported and program costs. The training format should be tailored to fit the learning profile of the majority of targeted participants in order to increase knowledge retention taking into consideration the length of training sessions and delivery or presentation methods. The quality of trainers is another factor affecting training effectiveness. Also the training process should include interactive activities and possibly quizzes or post-training questionnaires to increase retention of information concerning what to be aware of while on the nation's roadways.

Steps can be taken to reinforce retention of training content after the initial training workshop. Memory refreshment training is an option where trainees could retake the training as it is updated to expose them to new developments or after they have been in the program a certain length of time to reinforce the previous training, and useful information should be displayed on the program's website and regularly updated for trainees with a deeper interest in the program. Other ideas to retain trainees' awareness would be to send out mailings or e-mails with updates and general program information in addition to the reference pamphlet to keep in the vehicle.

6.3 Actions for Increasing the Quality/Completeness of Reports

The third tier-one factor contributing to the security confidence level is the quality and completeness of reports (f_1). An initial evaluation of the completeness of reports will require a computer program that is compatible with the call center database. This program would assign a score to each report based on how many of the available data fields are filled and could be applied to the report database to determine a historical value. Each field would be weighed according to its relative importance. For instance, the location of an incident would be more important than the time of day when it occurred. This is only a measure of completeness and not quality. If the report is sent to the security analysis center, a security analyst would perform a quality analysis on the report and assign it a score based on its possible intelligence value. Both of these scores would be percentages used to calculate f_2.

The three major actions listed for the second tier-one factor of the percentage of incidents reports also apply to the third tier-one factor of the percentage of quality and complete reports: training content, the method of training, and memory refreshment training. The feedback from the completeness evaluation would highlight which aspects of reporting should have greater emphasis during training, and because of the incompleteness of past calls, the general importance of completeness should be stressed during training. The quality evaluations might possibly provide feedback on what is missing from low quality reports and, based on the quality evaluation and cooperation with the security analysts, training materials regarding what to look for and what details are important to remember when reporting incidents can be updated to improve future report quality. Memory refreshment training could also be used to reinforce the importance of completeness and quality in reporting incidents. As with reporting, approximations of the likely impact of these actions could be used for the model's calculations based off of past program experience and the relevant literature.

6.4 Overall Action-Factor Relationship

Figure 3 presents the relationships between actions and the factors. Though we have identified the major actions and the required data to calculate tier 1 factors, , the actual relationship between actions and required data and costs associated with each action require additional studies.

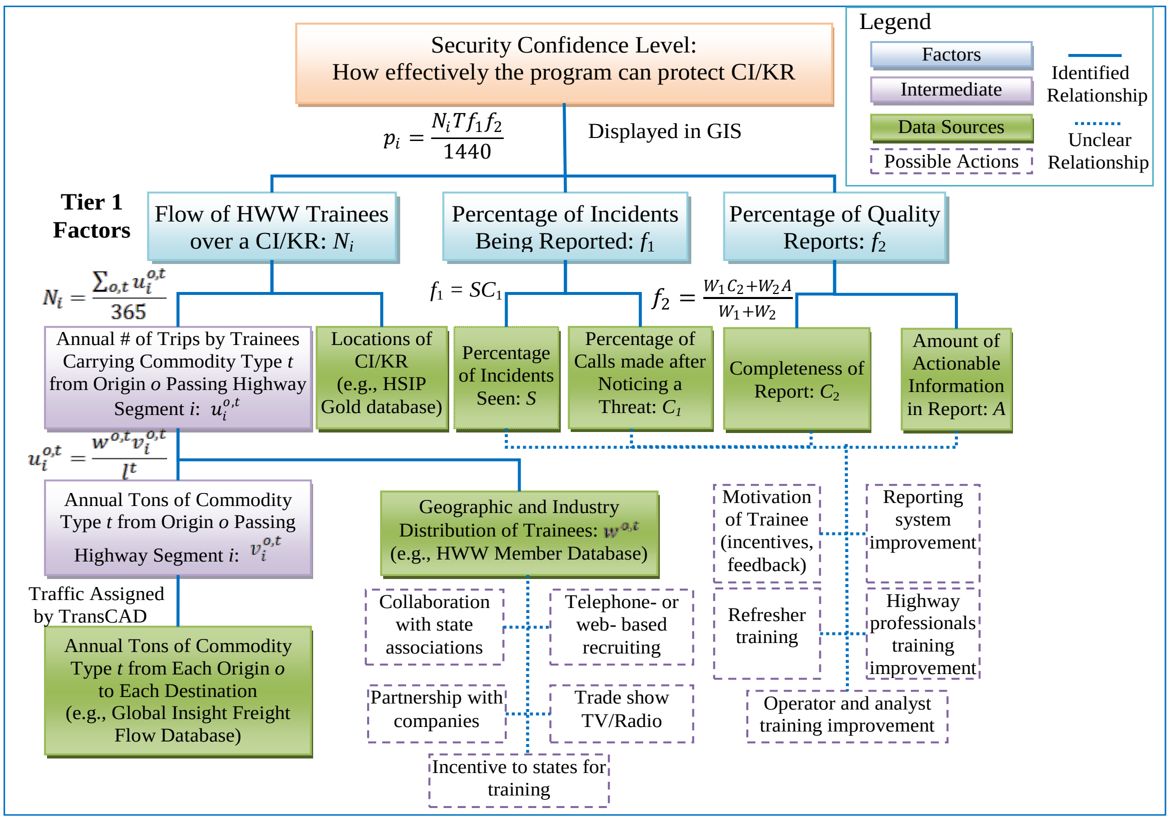

Figure 4 Factors and actions for Concerning the Security Confidence Level and Calculation Procedure

CHAPTER VII

CONCLUSIONS AND FURTHER RESEARCH

The decision support system framework presented in this thesis is expected to aid a surface transportation security training program in improving its effectiveness. The proposed decision support system would not only improve the program operations but also help the management of the program become more familiar with the training program and understand those things that affect the program effectiveness. In order for it to be functional, the decision support system would need to have an actual model management subsystem to perform the necessary calculations to determine what actions, such as recruitment and training actions, should be taken. Another important aspect of the model is the cost related to the actions. Without the cost information, the actions cannot be compared. In the future, the DSS may also include the aspects of planning, communication, and information sharing to get a broader picture of improving the training program.

REFERENCES

Arasli, H., Mehtap-Smadi, S. and Katircioglu, S.T. (2005), “Customer service quality in the Greek Cypriot banking industry”, Managing Service Quality, Vol. 15 No. 1, pp. 41-56.

Babakus, E. and Boller, G.W. (1992), “An empirical assessment of the SERVQUAL scale”, Journal of Business Research, Vol. 24, pp. 253-268.

Bolton, R.N. and Drew, J.H. (1991), “A multistage model of customers’ assessments of service quality and value”, Journal of Consumer Research, Vol. 17 No. 4, pp. 375-384.

Bonczek, R.H., Holsapple, C.W. and Whinston, A.B. (1981) “Foundations of Decision Support Systems”, Academic Press, New York, NY.

Boyd, E.A. and Bilegan, J.C. (2003), “Revenue management and e-commerce”, Management Science, Vol. 49 No. 10 pp. 1363–1386.

Brady, M. and Cronin, J. (2001), “Some new thoughts on conceptualizing perceived service quality: a hierarchical approach”, Journal of Marketing, Vol. 65 No. 3, pp. 34-49.

Brown, T.J., Churchill, G.A. Jr and Peter, P.J. (1993), “Improving the measurement of service quality”, Journal of Retailing, Vol. 68 No. 1, pp. 127-139.

Buttle, F. (1996), “SERVQUAL: review, critique, research agenda”, European Journal of Marketing, Vol. 30 No. 1, pp. 8-32.

Cannon-Bowers, J. A., Salas, E., Tannenbaum, S. I., and Mathieu J. E. (1995), “Toward theoretically based principles of training effectiveness: a model and initial empirical investigation”, Military Psychology, Vol. 7, pp. 141-164.

Carman, J.M. (1990), “Consumer perceptions of service quality: an assessment of the SERVQUAL dimensions”, Journal of Retailing, Vol. 66 No. 1, pp. 33-55.

Caro, L.M. and Garcia, J.A.M. (2007), “Measuring perceived service quality in urgent transport service”, Journal of Retailing and Consumer Services, Vol. 14 No. 1, pp. 60-72.

Carrillat, F.A., Jaramillo, F., Mulki, J.P. (2007) “The validity of the SERVQUAL and SERVPERF scales: A meta-analytic view of 17 years of research across five continents”, International Journal of Service Industry Management, Vol. 18 No. 5, pp. 472–490.

Chebat, J-C., Filiatrault, P., Gelinas-Chebat, C. and Vaninsky, A. (1995), “Impact of waiting attribution and consumer’s mood on perceived quality”, Journal of Business Research, Vol. 34 No. 3, pp. 191-196.

Chen, I., Gupta, A. and Rom, W. (1994), “A study of Price and Quality in Service Operation”, International Journal of Service Industry Management, Vol. 5 No. 2, pp. 23-33.

Chi Cui, C., Lewis, B.R. and Park, W. (2003), “Service quality measurement in the banking sector in South Korea”, International Journal of Bank Marketing, Vol. 21 Nos 4/5, pp. 191-201.

Chowdhary, N. and Prakash, M. (2007), “Prioritizing service quality dimensions”, Managing Service quality, Vol. 17 No. 5, pp. 493–509.

Clarke, N. (2002), “Job/Work environment factors influencing training transfer within a human service agency: some indicative support for Baldwin and Ford’s transfer climate construct”, International Journal of Training and Development, Vol. 6, pp. 146-162.

Cronin, J.J. Jr and Taylor, S.A. (1992), “Measuring service quality: a reexamination and extension”, Journal of Marketing, Vol. 56, pp. 55-68.

Colquitt, J. A., Lepine, J. A. and Noe R. A. (2000), “Toward an integrative theory of training motivation: a meta-analytic path analysis of 20 years of research”, Journal of Applied Psychology, Vol. 85, pp. 678-707.

Dabholkar, P., Thorpe, D.I. and Rentz, J.O. (1996), “A measure of service quality for retail stores: scale development and validation”, Journal of the Academy of Marketing Science, Vol. 24 No. 1, pp. 3-16.

DeSanctis, G. and Gallupe, R.B. (1987), “A Foundation for the Study of Group Decision Support Systems”, Management Science, Vol. 33 No. 5, pp. 589-609.

Dunning, D.J., Lockfort, S., Ross, Q.E., Beccue, P.C. and Stonebraker, J.S. (2001), “New York power authority uses decision analysis to schedule refueling of its Indian point 3 nuclear power plant”, Interfaces, Vol. 31 No. 5, pp. 121–135.

Eierman, M.A., Niederman, F. and Adams, C. (1995), “DSS theory: A model of constructs and relationships”, Decision Support Systems, Vol. 14, pp. 1–26.
Eom, S.B. (2002), “Decision Support Systems Research (1970–1999) as Cumulative Tradition and Reference Disciplines”, Edwin Mellen Press, Lewiston, NY.

Eom, S.B. (2003), “Decision Support Systems Research and Reference Disciplines (1970–2001): A Research Guide to the Literature and an Unobtrusive Bibliography with Citation Frequency”, Edwin Mellen Press, Lewiston, NY.

Eubanks, J., Kowalski, A., and Taylor, P. (1993), “Training Evaluation: The Role of Verbal Self-Report in Experimental Analyses”, Paper presented at the twentieth annual convention for the Association for Behavioral Analysis: International, Atlanta.

Evans, J.R. and Olson, D.L. (2002), “Introduction to Simulation and Risk Analysis”, 2nd edition, Prentice Hall, Upper Saddle River, NJ.

Faulkner, B., and Vikulov, S. (2001). “Katherine, washed out one day, back on track the next: A post mortem of a tourism disaster”, Tourism Management, Vol. 22 No. 4, pp. 331–344.

Fourer, R. (2003), “Software Survey: Linear Programming”, OR/MS Today, Vol. 30 No. 6, pp. 34–35, 42–43.

Furrer, O., Liu, B.S-C. and Sudharshan, D. (2000), “The relationships between culture and service quality perceptions: basis for cross-cultural market segmentation and resource allocation”, Journal of Service Research, Vol. 2 No. 4, pp. 355-371.

Gale, B.T. (1994), Managing Customer Value: Creating Quality and Service that Customers can See, The Free Press, New York, NY.

Gimblett, R., Durnota, B. and Itami, R. (1996), “Spatially-explicit Autonomous Agents for Modeling Recreation Use in Complex Wilderness Landscapes”, Complexity International Vol. 3.

Gounaris, S. (2005), “Measuring service quality in b2b services: an evaluation of the SERVQUAL scale vis-a-vis the INDSERV scale”, Journal of Services Marketing, Vol. 19 Nos 6/7, pp. 421-435.

Graham, C. (2005), “Business Intelligence Software Market Grows by 12% (Gartner Research Report ID. G00130216)”, Gartner Inc, Stamford, CT.

Gronroos, C. (1982), Strategic Management and Marketing in Service Sector, Marketing Science Institute, Cambridge, MA.

Gronroos, C. (1990), Service Management and Marketing, Lexington Books, Lexington, MA.

Kahnemann, D., Slovic, P. and Tversky, A. (1982), “Judgment under Uncertainly: Heuristics and Biases”, Cambridge University Press, Cambridge, England.

Keefer, D., Kirkwood, C. and Corner, J. (2003), “Perspective on decision analysis applications, 1990–2001”, Decision Analysis, Preview Issue, October, pp. 5–24.

Kilbourne, W.E., Duffy, J.A., Duffy, M. and Giarchi, G. (2004), “The applicability of SERVQUAL in cross-national measurements of health-care quality”, Journal of Services Marketing, Vol. 18 Nos 6/7, pp. 524-533.

Kim, E. and Eom, S.B. (2004), “Decision Support Systems Applications Research: A Bibliography (1995–2001)”, Working Paper, Southern Missouri State University.

Kirkpatrick, D. L. and Craig, R. L. (1976), “Evaluation of Training’. In Training and Development Handbook: A Guide Resource Development”, McGraw Hill, New York.

Ladhari, R. (2008), “Alternative measures of service quality: a review”, Managing Service Quality, Vol. 18 No. 1, pp. 65-86.

Liang, T.P. (1986), “Critical Success Factors of Decision Support Systems: An Experimental Study”, DATABASE, pp. 3-16.

Lievens, F., Harris, M. M., Van Keer, E. and Bisqueret, C. (2003), “Predicting cross-cultural training performance: the validity of personality, cognitive ability, and dimensions measured by and assessment center and behavior description interview”, Journal of Applied Psychology, Vol. 88, 476-489.

Maxwell, D.T. (2002), “Decision analysis: aiding insight VI—it’s not your grandfather’s decision analysis software”, OR/MS Today, Vol. 29 No. 3, pp. 44–51.

McAlexander, J.H., Kaldenberg, D.O. and Koenig, H.F. (1994), “Service quality measurement: examination of dental practices sheds more light on the relationships between service quality, satisfaction, and purchase intentions in a health care setting”, Journal of Health Care Marketing, Vol. 14 No. 3, pp. 34-40.

McClain, A. (2004), “Managing Consumer Demands: Art Becoming Science”, Retailwire.

McKillip, J. and Cox, C. (1998), “Strengthening the Criterion-Related Validity of Professional Certifications”, Evaluation and Program Planning, Vol. 21, pp. 191-197.

Mintzberg, H. (1973), "The Nature of Managerial Work", Harper and Row, New York, NY.

Mitroff, I. I. (2005), "Why some companies emerge stronger and better from a crisis: 7 essential lessons for surviving disaster", New York: AMACOM.

Oliver, J.R. and Fleming, R.K. (1997), "Applying within-subject methodology to transfer of training research", International Journal of Training and Development, Vol. 1 No. 3, pp. 173–180.

Olsen, J.H. (1998), "The evaluation and enhancement of training transfer", International Journal of Training and Development, Vol. 2 No. 1, pp. 61-75.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1985), "A conceptual model of service quality and its implications for future research", Journal of Marketing, Vol. 49 No. 4, pp. 41-50.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1988), "SERVQUAL: a multiple-item scale for measuring consumer perception of service quality", Journal of Retailing, Vol. 64 No. 1, pp. 12-40.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1994), "Alternative scales for measuring service quality: a comparative assessment based on psychometric and diagnostic criteria", Journal of Retailing, Vol. 70 No. 3, pp. 201-230.

Pauchant, T. C., & Mitroff, I. I. (1992). "Transforming the crisis prone organization: Preventing individual, organizational and environmental tragedies", Jossey-Bass, San Francisco.

Quester, P.G. and Romaniuk, S. (1997), "Service quality in the Australian advertising industry: a methodological study", Journal of Services Marketing, Vol. 11 No. 3, pp. 180-192.

Ragsdale, C., Power, D.J. and Bergey, P.K. (2002), "Spreadsheet-based DSS curriculum issues", Communications of the Association for Information Systems, Vol. 9 No. 21, pp. 356–365.

Richard, M.D. and Allaway, A.W. (1993), "Service quality: insights and managerial implications from the frontier", in Rust, R.T. and Oliver, R.L. (Eds), Service Quality: New Directions in Theory and Practice, Sage Publications, Thousand Oaks, CA, pp. 1-19.

Ritchie, B. W. (2004). "Chaos, crises and disasters: A strategic approach to crisis management in the tourism industry", Tourism Management, Vol. 25 No. 6, pp. 669–683.

Rouiller, J. Z. and Goldstein, I. L. (1993), “The relationship between organizational transfer climate and positive transfer of training”, Human Resource Development Quarterly, Vol. 4, pp. 377-390.

Rowold, J. (2007), “Individual influences on knowledge acquisition in a call center training context in Germany”, International Journal of Training and Development, Vol. 11 No. 1, pp. 21–34.

Ruona, W. E., Leimbach, M., Holton, E. F. and Bates, R. (2002), “The relationship between learner utility reactions and predicted learning transfer among trainee”, International Journal of Training and Development, Vol. 6, pp. 218-228.

Silva, F.N. de, Eglese, R.W. (2000), “Integrating simulation modeling and GIS: spatial decision support systems for evacuation planning”, Journal of the Operational Research Society Vol. 51 No. 4, pp. 423–430.

Smith, B.C., Leimkuhler, J.F. and Darrow, R.M. (1992), “Yield management at American airlines”, Interfaces, Vol. 22 No. 1, pp. 8–31.

Smith, S., Agrawal, N., and Tsay, A. (2003), “A decision support system for retail supply chain planning for private-label merchandise with multiple vendors”, in: J. Geunes, P. Pardalos, H. Romeijn (Eds.), Supply Chain Management Model, Applications, and Research Directions, Kluwer, pp. 163–198.

Tannenbaum, S. and Yukl, G. (1992), “Training and development in work organizations”, Annual Review of Psychology, Vol. 43, pp. 399-441.

Taylor, R.N. (1975), “Psychological Determinants of Bounded Rationality: Implications for Decision-Making Strategies”, Decision Sciences, Vol. 6, pp. 409-429.

Turban, E. and Aronson, J.E. (2004), Decision Support Systems and Intelligent Systems, Prentice Hall, Inc, New Jersey.

Ulengin, F., Topcu, Y.I. and Sahin, S.O. (2001), “An integrated decision aid system for Bosphorus water-crossing problem”, European Journal of Operational Research, Vol. 134 No. 1, pp. 179–192.

United States of America, Department of Homeland Security, National Infrastructure Protection Plan (2006)

United States of America, Department of Homeland Security, National Preparedness Guidelines September (2007)

United States of America, Federal Emergency Management Agency, Fiscal Year 2008 Trucking Security Program Guidance and Application Kit (2008)

Van Dyke, T.P., Prybutok, V.R. and Kappelman, L.A. (1999), "Cautions on the use of the SERVQUAL measure to assess the quality of information systems services", Decision Sciences, Vol. 30 No. 3, pp. 877-891.

Wilkins, H., Merrilees, B. and Herington, C. (2007), "Toward an understanding of total service quality in hotels", International Journal of Hospitality Management, Vol. 26 No. 4, pp. 840-853.

Zeithaml, V.A. and Bitner, M.J. (2003), Services Marketing: Integrating Customer Focus across the Firm, 3rd ed., Irwin McGraw-Hill, Boston, MA.

Zigurs, I., Poole, M.S. and DeSanctis, G.L. (1988) "A Study of Influence in Computer-Mediated Group Decision Making", MIS Quarterly, Vol. 13, pp. 625-644