THREAT AND VULNERABILITY RISK ASSESSMENT FOR THE INSURANCE INDUSTRY

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Abstract
The terrorist attacks of September 11th, 2001 significantly changed the American view of security. AIG Consultants, Inc. (AIGC), a member company of American International Group, Inc. asked the Engineering Management program at the United States Military Academy (USMA) to develop a method to quantify the risks from potential terrorist events to clients. The methodology uses multi-objective decision analysis techniques to weight and assess risk in eight defined areas. These areas are assessed with user responses to questionnaires tailored to specific industries and risk assessment scores are calculated as a weighted average of the question responses in a web application.

Introduction
After September 11th, the entire nation became concerned with the threat of terrorist attacks. Economically the insurance industry was hit particularly hard and needed methods to better define their risk exposure considering terrorism as a real threat to business worldwide. They recognized the need for a comprehensive risk assessment process that quantified the threat and vulnerability of corporations to terrorist attacks. A group of Engineering Management majors developed a web-based prototype model to implement this risk assessment system that AIGC modified, reprogrammed and is now actively using in client assessment.

The Senior Vice President for the Safety Division of AIGC, Mr. Mike Castelli, brought this problem along with ideas for a proposed solution methodology to the Engineering Management program at USMA. AIGC wanted a web-based threat and vulnerability assessment tool that they could use to quantitatively assess the risk from potential terrorist activity to their clients and prospective clients. Cadets majoring in Engineering Management at USMA in the Department of Systems Engineering engage in a multidisciplinary program of study that culminates with a senior Capstone group project. This project allows cadets to apply skills learned in the classroom to a problem for a real-world client. This paper will report the results from a senior cadet group Capstone project that led to a standardized methodology for AIGC to use in quantifying the vulnerabilities of various businesses to threats from terrorism.

Methodology
Overview. The key outcome of this project was a quantitative measure of the level of risk AIGC clients are subject to due to potential terrorist threats. The project goal was to develop a tool that could assess that risk and convert it into a numerical value. This value can be used in numerous ways. Risk level is assessed by asking the client a series of questions in eight defined areas and then scoring their answers. Each question within an area has a predetermined weight to reflect the relative importance of that question in determining the overall score in the given area. Similarly, each area is weighted to reflect the relative importance of the area in determining an overall risk assessment score for the client. Based on the client's answers to each question and performance in each area, an overall threat and vulnerability risk assessment score is generated.

Standardizing the assessment process required creating a hierarchy of risk assessment categories. Mr. Castelli provided an initial list of these categories: vulnerability, corporate security planning, physical security, personnel security, training, and services. However, businesses are also subject to varying degrees of risk to terrorist activity based on their location and type of industry. For example, as seen in the events of 9/11, New York and other metropolitan locales are higher targets for terrorists than more rural areas. Also, the type of industry should be considered in determining an overall risk assessment. For example, as again demonstrated on 9/11, the airline industry and financial services companies are targets for terrorists. Therefore, industry location and type assessment areas were added to this risk assessment process.

AIGC recognized that 'one size cannot fit all' in performing a credible risk and vulnerability assessment of clients. AIGC provided an initial list of questions to use in assessing clients in the original six areas. However, AIGC wanted assessments tailored to specific types of industries. The focus was for the

industry categories AIGC normally services. These industries include airline transportation, rail transportation and petrochemical to name a few.

The overall goal of this project was to develop a threat and vulnerability assessment tool to evaluate the level of risk and vulnerability of AIGC's current clients. The tool had to be web-based and tailored to specific industry types. The tool also needed to be scalable and flexible for incorporation into AIGC's other programs for risk assessment.

Assessment question development. AIGC wanted this risk and vulnerability assessment to be relatively easy to complete and not overly time consuming. This translated into a goal to have the total number of assessment questions limited to approximately 60 to 80 questions. The overall approach was to design a set of general questions within each of the six areas (vulnerability, corporate security planning, physical security, personnel security, training, and services) that would apply to all clients regardless of industry-type. Then a set of questions specific to each industry-type would be added to these general questions to complete the assessment questionnaire. Industry location and type are assessed using a different methodology specified later in this paper.

Mr. Castelli provided an extensive list of possible general assessment questions to use as the basis for the project. The project team refined these questions and added a few more based on research of existing US Army risk assessment methods. The team then developed more, specific questions unique to each of the industry types discussed above for each area of assessment. These questions address the aspects that are unique to each industry and are significant in evaluating the threat to and vulnerability of a company.

The team consulted a number of public sources in order to gain more information about each industry and to help generate the industry-specific assessment questions. The most up-to-date information was taken from world-wide-web sources (TRBC, 2002), (FAA, 2002), (Cyber, 2002), (USAA, 2002), (State, 2002), (SOCMA, 2002), (McGraw, 2002). The most critical part of the assessment question development process was interaction with industry experts in AIGC. These experts critiqued and refined the questions as the project team developed them.

Scoring of assessment questions. Equally important to developing a comprehensive set of assessment questions was determining a method for assigning a score to the answers. Most questions were answered on a scale of one to five with one as the worst and five as the best answer. Other questions were answered with yes/no responses. To facilitate the weighted-average scoring methodology the answer schema was normalized using a discrete distribution from 0 (worst answer) to 1 (best answer). Exhibit 1 provides the answer scales along with their corresponding normalized scores.

Exhibit 1. Question Answer Scores.

Answer Scale for Questions	Normalized Score
yes	1
no	0
1	0
2	0.25
3	0.50
4	0.75
5	1

Assessing risk due to industry location. The location and industry areas of assessment are not evaluated with a series of questions. Instead, the client identifies the industry location and type from lists of pre-determined choices provided upon initial entry into the assessment tool. These selections are used to assign a quantitative level of risk to the client's corporation based on its physical location and type of business performed.

The industry location assessment was based off a survey completed and presented by the Cable News Network (CNN). They performed surveys of the largest thirty cities in the United States in terms of population and evaluated their preparedness in several areas (CNN, 2002). The cities were given ratings of well prepared, prepared, and less prepared based on a set of assessment criterion. In the interest of space, Exhibit 2 provides a sample of the list of city assessments.

Exhibit 2. Sample of CNN City Preparedness Assessment.

City	State	Rating	Score
Atlanta	GA	Well Prepared	5
Austin	TX	Well Prepared	5
Baltimore	MD	Well Prepared	5
Boston	MA	Less Prepared	1
Charlotte	NC	Well Prepared	5
Chicago	IL	Prepared	3
Cleveland	OH	Prepared	3
Columbus	OH	Well Prepared	5
Dallas/ Fort Worth	TX	Prepared	3

Because these cities are the largest cities in the nation, they are considered the most vulnerable to attack. On the project location rating scale of one to ten, a well-prepared city receives a score of 5 out of 10. A prepared city gets a 3, and a less- prepared city gets a 1 out of 10. Locations that are not on this list of the thirty largest cities are classified by the user into urban, suburban, or rural. An urban location gets a score of 6 out of 10 on the location scale; a suburban location receives an 8, while a rural location scores the maximum of 10. The rationale is that any location not on the CNN list is somewhat less at risk to terrorism since they are smaller. Hence, locations not on the list receive a higher score for location than those on the list. These industry location scores also have to be normalized on a scale of 0 to 1. These scores are shown in Exhibit 3.

Exhibit 3. Industry Location Scores.

Answer	Score	Normalized Score
CNN Less Prepared	1	0.10
CNN Prepared	3	0.30
CNN Well Prepared	5	0.50
Urban	6	0.60
Suburban	8	0.80
Rural	10	1.00

Assessing risk due to industry type. A user starts the industry type area assessment by selecting from a current list of eight industries and an "other" category for clients who do not fall into one of the given choices. When the client selects their industry, it automatically populates the rest of the areas of assessment with the correct industry-specific questions. The tool also assigns an industry type score based on a scale of one to ten, similar to the location area score.

Unlike the location area, the project team found no quantitative assessment tool like the CNN survey for industries. Instead, the industry scores are based on historical data of terrorist attacks (IPICT, 2002). The team sorted data on all terrorist attacks worldwide since 1980 by the intended target of the attack. This information provided a general idea of the industries that are most likely to be the target of terrorist attacks. Not surprisingly, the airline industry had been attacked 27 times since 1980, followed by the railway and financial industries, with 17 and 13 attacks, respectively.

The team supplemented this worldwide data with select information from the Federal Bureau of Investigation (FBI, 2002). This source gave unique American statistics about terrorist targets and intended targets since 1990. The data revealed that 7 of these 27 targets were financial institutions, which raised the likelihood of a financial institution being a risky client in terms of the assessment. The final assignment of scores for industry type is considered proprietary information by AIGC and cannot be published in this article. Similar to the industry location scores, the eight industry types are assigned scores between one and ten, which are then normalized.

When a user selects the 'other' industry category, the industry type area score is zero. The project team did this because there was little information upon which to base a valid assumption for assigning a score to 'other' industry types. When a user selects the 'other' industry category, the risk assessment is performed in the six question-based assessment areas using the general questions that apply to all industry types. The industry location assessment is performed as discussed previously. An 'other' type industry user is not penalized in the calculation of their overall risk assessment score by this score of zero. The other seven area weights (discussed next) are proportionally scaled to sum to one to account for a score of zero in the industry type area for an 'other' type industry.

Weighting of assessment areas and questions. The next step in developing the threat and vulnerability quantitative assessment was to establish the relative weights for each element of the program. The intent of weighting is to emphasize the aspects of the overall assessment that the client feels are most important. Given that assessments are industry-specific, questions within each of the six main assessment areas are weighted relative to each other for each industry type.

Further, each of the six main assessment areas plus the industry type and location assessment areas are weighted relative to each other.

The team considered two different approaches to elicit the proper weights from the customer, AIGC, to capture their relative preferences. One was similar to the risk analysis system used by the US Army, where the customer would be given a question and the set of answers to that question, either yes/no or the scale of 1 to 5. The customer would then assign a level of risk to each answer, for example, extremely high for an answer of no or 1, and low risk for a 5 or yes. Although this method would be an effective weighting system, the team decided to use a more robust method to develop the weighting scheme.

Due to time constraints for developing weights, the swing weighting methodology was chosen in order to help AIGC weigh the questions and assessment areas (Clemen, 2001) and (Kirkwood, 1997). The swing weighting method basically entails creating a series of alternatives that are compared against the theoretical worst possible alternative as a baseline. The swing weighting method applied to this project is illustrated through a discussion of the information provided in Exhibit 4.

The first step in swing weighting is to create a list of all the alternatives that you wish to weigh. The example in Exhibit 4 shows the assessment questions for the vulnerability area from the "other" industry. The "other" industry type provides an assessment using the general questions that apply to all industry types for the vulnerability area.

The next step in swing weighting is to rank the alternatives from highest to lowest, with the best or most desirable alternative being ranked number one. The worst possible alternative, serving as the benchmark, is that a client scores the worst possible score on all questions. Each subsequent alternative is interpreted as the client receives the best possible score on this particular question while all of the other questions receive the worst possible score. These "alternatives" are then ranked from best to worst based on their value added to the overall vulnerability area assessment. For example, in the case of Exhibit 4, the client has ranked the sixth alternative, "Does your company do business internationally?," as the top alternative. That means that this question represents the most important factor in the vulnerability area assessment score for the prototype model.

Exhibit 4. Example of the Swing Weighting Method.

Alter-native	Question	Rank	Rate (r_i)	Weight (W_i)
1	Benchmark (worst on all questions)	--	0	0/320 =0
2	Is your corporation located near a major highway?	3	70	0.219
3	How many employees work at your location?	4	40	0.125
4	The corporation receives a lot of media attention. (1-5)	2	80	0.25
5	How many other companies do you share your building with?	5	30	.094
6	Does your company do business internationally?	1	100	0.312
			$\Sigma r_i = R = 320$	$\Sigma W_i = 1$

The third step in swing weighting is to rate on a scale of 0 to 100 those alternatives that have just been ranked. This is done because the difference in value between the first and second ranked choices may not be the same as the difference in value between the second and third ranked alternatives. This is illustrated in Exhibit 4 where there is a relatively greater difference in value from the first to second ranked alternative than there is from the second to third ranked alternative.

The fourth step in swing weighting is to calculate the weight for each alternative, that is, each question (or area, depending on what you are weighting). To calculate the question's weight you first sum the ratings of all the questions in that area. This variable is 'R' in the equation $R= \Sigma r_i$. The weight (W_i) of that question is then calculated as $W_i= r_i/R$. The sum of all the weights in an area is one, $\Sigma W_i= 1$. This was used as a check to ensure calculations were correct.

The example in Exhibit 4 demonstrates the weighting process for assessment questions, however the eight assessment areas were also weighted using the same methodology. Experts at AIGC used this swing weighting process to determine the weights for all questions and areas using a special tool developed in Microsoft EXCEL© by the project team.

Implementation

Overview. AIGC wanted this threat and vulnerability assessment tool to be a web-based program they could make available to both their insurance consultants and their current clients to use for self-assessment. This required some extensive systems work by the project team to implement the methodology described earlier. The team developed a web-based prototype of the tool that AIGC programmers then modified to fit their own system requirements. The overall implementation approach included these components of the system: a tool built in Excel© for AIGC to use in applying the swing weighting method to determine assessment area and question weights; a database to store and manipulate assessment questions, scores and weights; and a web-based interface to implement the tool. The project team performed this in close coordination with the information technology group at AIGC to insure the prototype adhered as closely as possible to AIGC system requirements.

Excel© Tool. The team developed a Microsoft Excel© tool to aid in eliciting the proper question and area weights from AIGC using the swing weighting methodology. The Excel© tool is expandable, flexible and user friendly because the type and number of questions change for every area assessment and every type of industry that is being assessed. The user or client can add, delete or change any question they wish and they can go back and change the previous ranking and rating scheme to get a different resulting weight. The weights that are determined from this tool are stored in a Microsoft Access© database so that they can be used in the interface between the Access© database and the web-based questionnaire.

Exhibit 5 provides an example of the results from using this Excel© tool to determine the weights for a small subset of assessment questions in a particular area used for an industry type undefined due to AIGC proprietary concerns. There are both general and industry-specific questions in this example area. Note that the answer scales provide a frame of reference for how to assess the client on a given question. The general format of each worksheet is a column with the alternatives (questions), a column with a rating scale from 0-100, and a column for the weight. To make this user-friendly, the team used a scroll bar button in each cell of the rating column to allow the user to visualize their rating. The worksheet also contained formulas to automatically update the question / area weights based on any changes in a rating. The formulas insured that the sum of weights equaled one.

Exhibit 5. Example of the Excel© Tool.

General Questions	Rating (0-100)	Weight
Is your corporation located near major highway access? (adjacent =1, >5 miles =5)	91	0.163964
How many employees work at your location? (<50 = 5, <100=4, <150=3, <200=2, >200=1)	100	0.18018
The corporation receives a lot of media attention. (international =1, national =2, regional =3, local =4, none = 5)	46	0.082883
How many other companies do you share your building with? (>3 =1, none =5)	86	0.154955
Does your company do business internationally (1)? Nationally (2)? Regionally (3)? Locally(4)?	78	0.140541
Specific Questions		
The government is the sole corporate customer. (No-5, Yes-1)	77	0.138739
The corporation deals only with national businesses. (Yes -5, No-1)	77	0.138739
Totals	555	1

Database. To implement this project as a web-based program to reside on AIGC's Intranet required designing a database to store and manipulate information. The project team built a Microsoft Access© database, which contains all of the questions for the program as well as their assigned weights, the area assigned weights, and the information regarding the separate industry and location queries for use with the web program code.

The main tables in the database are for storing question text, answer scales and weights. The tables are designed so that all potential questions, regardless of selected industry, are organized into tables by area. Another table in the database identifies the eight assessment areas (vulnerability, corporate security

planning, physical security, personnel security, training, services, industry location, and industry type) and their respective weights developed for the prototype model. Exhibit 6 provides this although the weights are not the final weights used by AIGC.

Exhibit 6. Table of Assessment Areas and Weights for the Prototype Model.

ID	Area	Weight
1	Vulnerability	0.132695
2	Corporate Security Planning	0.120383
3	Physical Security	0.131327
4	Personnel	0.129959
5	Training	0.109439
6	Services	0.116279
7	Location	0.136799
8	Industry	0.123119

A third type of Access© database table was created to identify the types of industries and their respective scores. Similar to the Industry table, another table was created for identifying the industry locations with their respective scores. This table contains the data to support the scoring process discussed for Exhibits 2 and 3.

A final table was created for the purpose of storing the information and scores of clients that take the assessment. This table captures data such as the company name, evaluator name, email address, industry type and location, the calculated score for each assessment area and the overall threat and vulnerability score.

The database structure is very flexible making it easy to add or change any questions, weights, locations, or industries to the above-mentioned tables. This enabled AIGC to make revisions to the prototype tool prior to their launching the inaugural version of the Threat and Vulnerability Risk Assessment Tool. This database structure met the requirement for the tool to be flexible and expandable.

Web interface application. The Access© database was connected to the program's web page through the use of Active Server Page (ASP) code in the prototype tool. The program uses input data from the user to populate the prototype web pages with the proper assessment questions from the Access© database. For each subsequent screen of the web interface application, the user answers questions from each area of the assessment. On the final screen of the prototype interface, the user sees the calculated score for each assessment area and the overall threat and vulnerability assessment score.

The score for each of the six main assessment areas (vulnerability, corporate security planning, physical security, personnel security, training, and services) is based on the user's answer to each question and the weight for each question. The area score is calculated as the sum product of the normalized question scores and question weights. The industry location and industry type area scores are generated based on the user input and the information discussed previously for Exhibits 3 and industry type scores. The user is also provided an overall threat and vulnerability assessment score, which is calculated as the sum product of the eight assessment area scores and their weights (Exhibit 6). This final score, as well as each area score, is displayed on the final screen of the prototype as a percentage.

After the prototype web application was developed, the project team worked through a verification and validation process. This involved verifying scores by hand area by area, over several iterations, to insure scores generated by the program were correct. This process was repeated for several different industries until the team was confident that the program was generating output as designed in the project methodology.

The web-interface application was an interdisciplinary effort for this project. The team sought and received assistance from the Department of Electrical Engineering and Computer Science at USMA to complete the application. This was also worked in close coordination with the Information Technology group at AIGC. Due to proprietary considerations and client confidentiality, please contact AIGC for information about, and a demonstration of, the web application.

AIGC Application

The project team completed the prototype in May 2002. AIGC modified the database, weights and web application code to meet the system and security requirements of their intranet. AIGC wanted the program to be used by the AIG member companies for evaluating new clients, and also by current clients for self-assessment. AIGC launched the Threat and Vulnerability Risk Assessment (TVRA)sm tool in October 2002.

The launch and usefulness of the TVRA tool has been cited in several business and insurance periodicals (CNN Money, 2002), (Business Insurance, 2002), (Insurance News Net, 2003), (Hennessy, 2003). A quote from John Carey, former President, AIG Consultants, Inc., sums up the applicability of the TVRA to their operations: "At a time when safety and security have new relevance, businesses are expected

to identify and manage the potential risks that can impact their organization and be prepared to immediately and effectively respond to crisis situations. Together the state-of-the-art TVRA and PATROL programs can provide the cornerstone for every company's risk management program, offering not only an organized response to such incidents, but evidence of a responsible and prepared company" (CNN Money, 2002, 2).

As AIGC uses the TVRA to evaluate potential clients and for clients to evaluate themselves, they are using the data to validate the scoring and weighting process, along with the assessment questions. The flexibility of the TVRA allows AIGC to modify assessment questions and weights with relative ease. AIGC is also expanding the TVRA to incorporate more industry types and locations.

Potential Additional Applications for the Military

The Army Corps of Engineers builds and manages a number of public works projects across the country such as dams, waterways, and buildings. The threat and vulnerability assessment tool methodology could be expanded to evaluate the risk and security at these establishments. By adding another industry-type that specifically addresses the work of the Corps of Engineers, this program can be tailored to fit the related projects. By adding this new industry, each area will then have questions designed specifically to assess the preparedness of the Corps of Engineers projects, giving them a detailed threat and vulnerability assessment.

Another potential application is to evaluate the threat and security issues of military installations. The program would need to be expanded to capture the unique military aspects of vulnerability and safety. However, the current program provides a framework for a useful tool that can not only evaluate post security but also show the areas of security in which an installation is weak and therefore provide focus to improve force protection. It can also help installations across the Army standardize their safety and security measures and share ideas and procedures. The Department of Systems Engineering at USMA has developed a prototype application to perform this based on the methodology employed by the TVRA.

Conclusion

This Capstone project for Engineering Management majors at USMA led to a standardized methodology for AIGC to use in quantifying the vulnerabilities of various businesses to threats from terrorism. This real-world project enabled cadets to use the multidisciplinary aspect of their education to provide a useful product to the project client. The methodology developed is being expanded to other business and military applications.

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