OVERVIEW

In this chapter, the calculation and interpretation of risk assessment ratings are discussed.

The potential risk, *R*, to a building subjected to terrorist attack is defined as a function of the product of three factors across all threat scenarios as follows:

$$R = \alpha \sqrt[n]{\sum_{i=1}^{9}\left(C_i \times T_i \times V_i\right)^n} = 7.227 \sqrt[10]{\sum_{i=1}^{9}\left(C_i \times T_i \times V_i\right)^{10}} \qquad (2)$$

where:

C_i = Consequences Rating for threat scenario i
T_i = Threat Rating for threat scenario i
V_i = Vulnerability Rating for threat scenario i

The multiplier of 7.227 (α, a scaling constant) and the 10th power summation formulation controls the limits of R such that $9 \le R \le 9000$. A power value of $n = 10$ produced realistic and practical risk scores, when validated during three formal pilot studies of this procedure in two cities within the United States.

Consequences rating refers to the relative importance of the building to an owner and the surrounding region, and the potential consequences of a terrorist attack. Threat rating refers to the attractiveness of the building to attack, analogous to a measure of the relative likelihood of the threat occurring. Vulnerability rating refers to the expected outcome, in terms of damage, casualties, and business interruption, given a threat is successfully carried out.

The value of each of the parameters *(C, T,* and *V)* varies from 1 to 10, where 1 represents the lowest risk and 10 represent the highest contribution to risk. The various attributes that contribute to the overall value of *C, T* and *V* are embedded in the scoring design of the Data Collection Form. A detailed description of the numerical derivation of the risk scoring procedure is provided in Appendix C.

DETERMINING THE RISK RATING

The values for each of the risk factors determined on the Data Collection Form are tabulated on the Risk Scoring Worksheet. The risk rating for each threat scenario is then computed as the

product of *consequences* rating (C), *threat* rating (T), and *vulnerability* rating (V), where *consequences* rating, *threat* rating and *vulnerability* rating are threat-specific and building-specific. The overall risk assessment rating for the building is then computed using Equation 2. An example of the use of the Risk Scoring Worksheet is shown in Figure 13.

FEMA 455 RISK SCORING WORKSHEET

THREAT SCENARIO		Consequences (C)	Threat Rating (T)	Vulnerability Rating (V)	Threat Scenario Risk Rating (C x T x V)
Internal	Intrusion	7.36	8.32	9.13	559
	Explosive	9.31	8.32	8.33	645
	CBR	8.77	8.32	7.68	560
Explosive	Zone I	9.31	9.17	8.96	765
	Zone II	9.31	10.00	8.56	797
	Zone III	9.31	10.00	8.68	808
CBR	Zone I	8.77	9.17	5.22	420
	Zone II	8.77	10.00	1.62	142
	Zone III	8.77	10.00	2.38	209
A. TOTAL RISK RATING FOR BUILDING (using Equation 2)					6427

Figure 13 Risk Rating Example.

Note that the total risk rating is NOT a simple addition for the component values, but the 10th root of the sum of the de-aggregated risk scores each raised to the power of 10, as represented in Equation 2. Assuming cutoff scores to distinguish low, moderate, and high total risk scores at the one third and two third values of the maximum achievable score of 9000, low-risk scores are less than 3006, and medium-risk scores are less than 6003 but more than or equal to 3006. Using these cutoffs, the total risk score for the example in Figure 13 is considered a high-risk score.

The de-aggregated values for each threat scenario and the individual risk factors can be used to obtain a more detailed understanding of the building's risk. For each threat scenario and risk factor, the higher the score, the greater the risk contribution. For example, using the risk factor and threat scenario risk rating results shown in Figure 13, the following observations can be made about the building's risk:

- The external and internal explosive threats, with consequence ratings of 9.31, have the highest consequences in terms of damages, business interruption and casualties;
- Explosive threats represent a greater risk than CBR threats; and
- The greatest overall risk for this building is an external explosive threat located more than 300 feet but less than 1000 feet from the building.

WEIGHTED BUILDING CHARACTERISTICS

The Data Collection Form contains a limited number of building characteristics that have more importance in the overall risk scoring than others. In part this "heavier" weighting is a function of the importance of the individual building characteristic. In addition, weighting is used to balance the scoring, so that the building systems with fewer building characteristics have scores that are comparable to those with many building characteristics. The building characteristics with heavily weighted scoring require more careful consideration than the others, because a slight difference in scoring of these may cause a significant change in the overall risk score. The heavily weighted building characteristics are identified in the tables that provide guidance for selecting attribute options in the individual chapters for each of the three risk factors: Consequences, Threat Rating and Vulnerability Rating.

A listing of the heavily weighted building characteristics is given below with the corresponding identification number (ID) on the Data Collection Form.

- Number of Occupants (1.2, 2.2)
- Replacement Value (1.3)
- Physical Loss Impact (1.6)
- Site Population Density (2.3)
- Visibility / Symbolic (2.4)
- Target Density (2.5)
- Target Potential (2.7)
- Unsecured Underground Access (3.4)
- Transfer Girder Conditions (6.6)
- Primary External Air Intake Conditions (7.1)

- Return Air Intake System (7.2)
- Internal Air Distribution System (7.3)
- Critical Utilities Located Close to High Risk Areas (7.4)
- Internal Threat - Security Systems (8.1)
- Zone 1 Threat - Security Systems (8.2)

EVALUATING THE RISK FOR MULTIPLE BUILDINGS IN A LOCALIZED AREA

This rapid visual screening procedure is well suited for obtaining the relative risk among buildings in a portfolio, community, or region, where each building is scored separately. In some cases it may be desirable to obtain a single risk rating for a group, or "cluster", of buildings that are located in close proximity to each other in a particular area. In this context, a cluster is defined as a group of buildings within a 1-mile radius for an area with a total target density of 10 or more for the three zones.

To evaluate a single risk rating for a cluster of buildings, it is recommended that up to six building types be identified that are representative of buildings that exist in the cluster. The risk rating for the cluster is taken as the weighted average rating of these representative buildings, based on the number of buildings of each type in the cluster.

EVALUATING THE RISK FOR INTERCONNECTED BUILDINGS

This screening procedure was developed for use on individual buildings. For a facility with multiple interconnected buildings some care needs to be given to proper application of the procedure.

Interconnected buildings may be joined by means of pedestrian passage ways that may or may not contain retail or other uses. Often, each of the buildings has a separate, distinct use, which has unique characteristics in terms of its risk. From an operational security viewpoint, the interconnected buildings may be reasonably considered one building. However, from a structural perspective often these types of interconnected buildings are structurally isolated and therefore an explosive attack on one may not mean the other building will be damaged. It Is also likely that there are separate ventilation systems with separate controls (which should be verified) for each building and

possibly the passageways. For this reason, it is recommended that each structure is considered separately. Consideration of the interconnectedness may be addressed through careful consideration of the building characteristics that focus on collateral effects associated with an attack on a structure under, next to, or connected to the building under consideration. The screener will need to pay careful attention to the attribute options provided for these building characteristics to capture the impact of their interrelationship on the terrorist risk. If a single score is desired, the average of the scores for the individual buildings may be computed when the assessments are complete.

INTERPRETATION OF THE RISK ASSESSMENT RATING

The risk scoring procedure results in an aggregated rating for the building, which is a power formulated summation of the ratings attributed to the nine defined threat scenarios. It also provides de-aggregated risk ratings for each threat scenario. Both the aggregated and de-aggregated scores are shown on the Risk Scoring Worksheet.

The aggregated and de-aggregated risk scores are identified as low, moderate or high risk in the electronic version of the tool by means of green, yellow and red color coding respectively. The cut-off scores are defined so that the low/moderate risk cut off is one third of the maximum range of scores (from 9 to 9,000), and the medium/high risk cut-off score is at two thirds of the maximum score range. These cut-offs were found to be accurate during the three pilot studies performed as part of the development of this procedure.

The specific cut-off values defining low-, moderate-, and high-risk may vary based on the priorities of the stakeholders. Risk management decisions and prioritization for further studies can be based on the overall risk assessment rating. Buildings identified as high risk should receive the highest priority for further evaluation while buildings identified as low risk should receive lower priority.

Decisions regarding moderate risk buildings would depend on the specifics of the risk management program and available resources. Regardless of the range in which the total ratings fall, the buildings can be ranked by overall risk assessment rating to determine the order in which further evaluation should be performed as resources become available.

De-aggregated ratings for each threat scenario, including the average risk rating of the nine threat scenarios and the maximum risk rating among the nine threat scenarios, provide useful information to help prioritize further action. The results identify the relative contribution of each to the overall risk rating for the building. Using this information, a specific aspect of the building may be identified for further evaluation or a specialist in a given type of threat (e.g., CBR) could be hired to further study the risk to the building caused by a specific threat.