ASME Critical Assets Protection Initiative

ASME Homeland Security

ASME Risk Analysis and Management for Critical Assets Protection (RAMCAP) Methodology Document

PS&S Interagency Working Group

September 17, 2004

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RAMCAP Phase I Project Objectives

Produce technical basis document that describes overall methodology and provides a common framework for homeland security risk analysis decision-making

- **Common terminology**
- **Common metrics for comparing risks across sectors**
- **Common basis for reporting results**
- **Basis for informing resource allocation decisions**
  - **Countermeasures**
  - **Consequence mitigation actions**

RAMCAP Concept Development

The Executive Office of the President's Office of Science and Technology Policy (OSTP) sponsored a workshop on Critical Infrastructure Protection Priorities (CIPP) on September 23-24, 2002

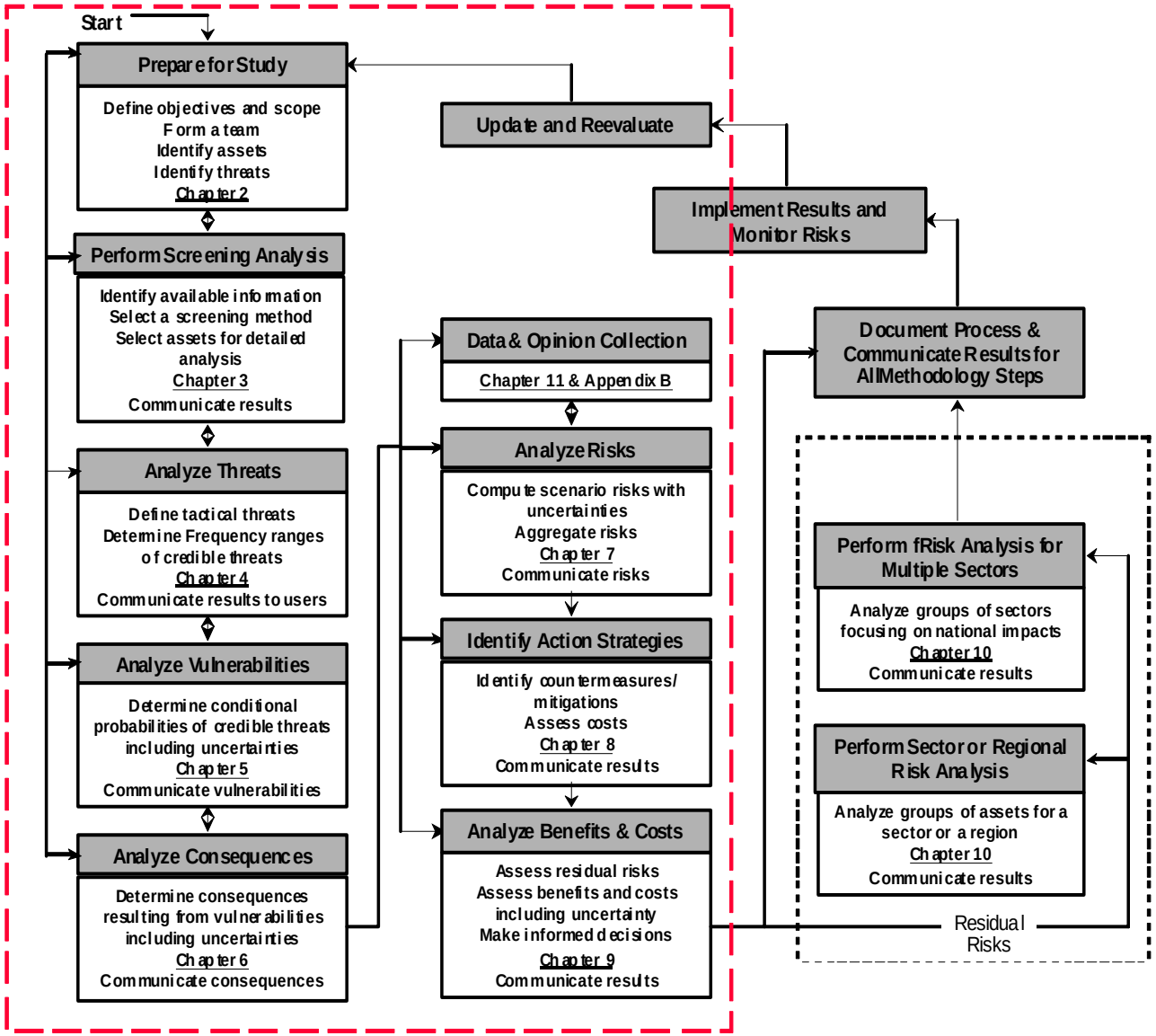
- **Over 90 industry leaders and government officials participated**
- **Topic: Role of Science and Technology in Countering Terrorism**
- **Key priorities were identified**
- **Guidance on the use of risk-based evaluation methods was identified as the top priority**
- **Risk-based methods are needed by both the private and the public sector for informing resource allocation decisions**
- **ASME awarded grant by the Department of Homeland Security to develop uniform risk-based guidance in September 2003**

RAMCAP Guidance Document Status

The RAMCAP methodology document is in the final stages of preparation for the Department of Homeland Security

- **Initial draft prepared in April 2004**
- **Workshop with some 125 interested parties held on April 14-16**
- **Numerous comments received, with a heavy response from organizations and industries that object to quantitative risk assessment**
- **Briefing with security professionals held on June 1-2, 2004**
- **Simplified version (Asset Application Handbook) prepared**
- **Both RAMCAP and Handbook under peer review**
- **Revision 0 to be delivered to DHS by early 2005**

Overall RAMCAP Methodology



Basic Risk Equation 1

$$R_{ai} = F_{ai} \times (Vulnerability)_{ij} \times (Consequences)_{ij}$$

Where:

R_{ai} = the annual economic risk for a given threat *i*

F_{ai} = the annual frequency of an adversary attacking a critical asset using a specific type of threat, *i*

Vulnerability = the conditional probability that a specific failure mode, *j*, will occur, assuming that the assumed threat, *i*, has occurred

Consequences = total measure of consequences of failure for threat *i* failing in mode *j*

Basic Risk Equation 2

$$R_{ijk} = F_{ai} P_{fij} P_{cijk} C_{cijk}$$

Where:

R_{ijk} = the economic risk

F_{ai} = the annual frequency of an adversary attacking a critical asset using a specific type of threat,

P_{cijk} = the combination of the probability ranges at each node of the event tree starting at the node, after the node where P_{fij} is defined,

P_{fij} = conditional probability of failure mode ***j*** due to threat **i**

Frequency of Occurrence

F_{ai} = the annual frequency of an adversary attacking a critical asset using a specific type of threat, *i*

If F_{ai} is set to 1.0, then the calculated risk is termed ***"Conditional-threat risk"***

Conditional-threat risk can be used to evaluate alternatives and to calculate the probability of occurrence that will justify the cost of countermeasures or mitigation strategies. Conditional risk cannot be used to calculate for comparison across diverse assets or sectors.

Vulnerability

- The vulnerability of an asset can be changed by employing countermeasures that will reduce the probability that a particular attack scenario will be successful.

- An example of a countermeasure is hardening the asset to explosives.

Consequences

- The consequences of failure for a particular attack scenario can be reduced by employing mitigation strategies.

- An example of a mitigation strategy is to insure early detection of a chemical or biological release.

Risk Managment

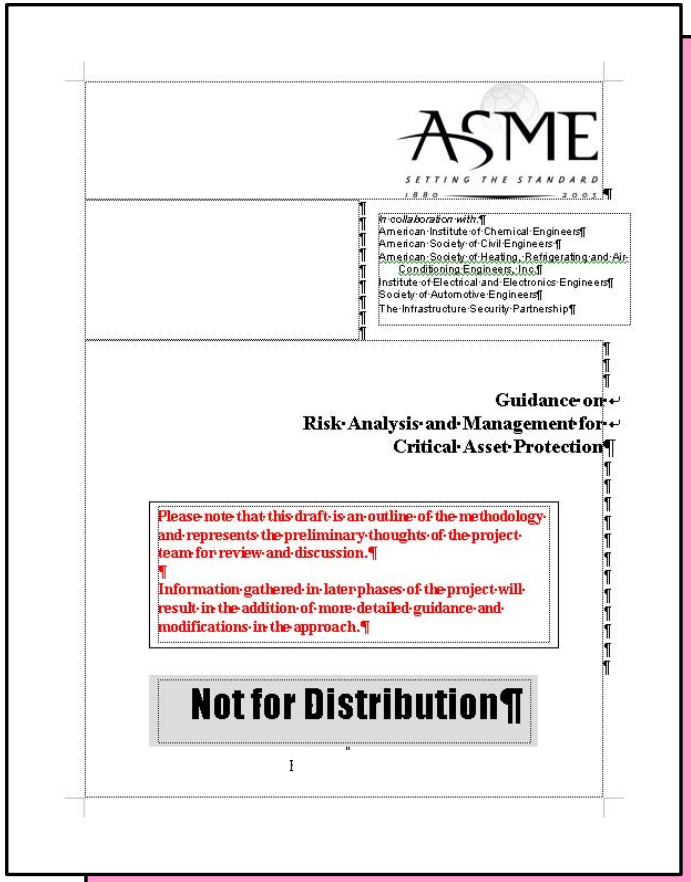
- Risk management is the process of determining the most beneficial combination of countermeasures and mitigation strategies that can be employed within the constraints the available resources.

- The risk equation can be used to evaluate alternatives and to select the best available practices. Conditional risk methods can be used to compare like assets. A complete risk analysis is necessary to compare risk across diverse assets and sectors.

RAMCAP Document Description

- Current document is a reference document rather than a guidance document
- Provides technical basis for Asset Application Handbook (individual asset screening)
- Provides technical basis for Phase II sector-specific vulnerability assessment guidance
- Administrative guidance (e.g. roles and responsibilities) is not in scope
- Background and explanatory information included

RAMCAP Document Outline


ASME
SETTING THE STANDARD
1880 2005

In collaboration with:
American Institute of Chemical Engineers
American Society of Civil Engineers
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
Institute of Electrical and Electronics Engineers
Society of Automotive Engineers
The Infrastructure Security Partnership

Guidance on
Risk Analysis and Management for
Critical Asset Protection

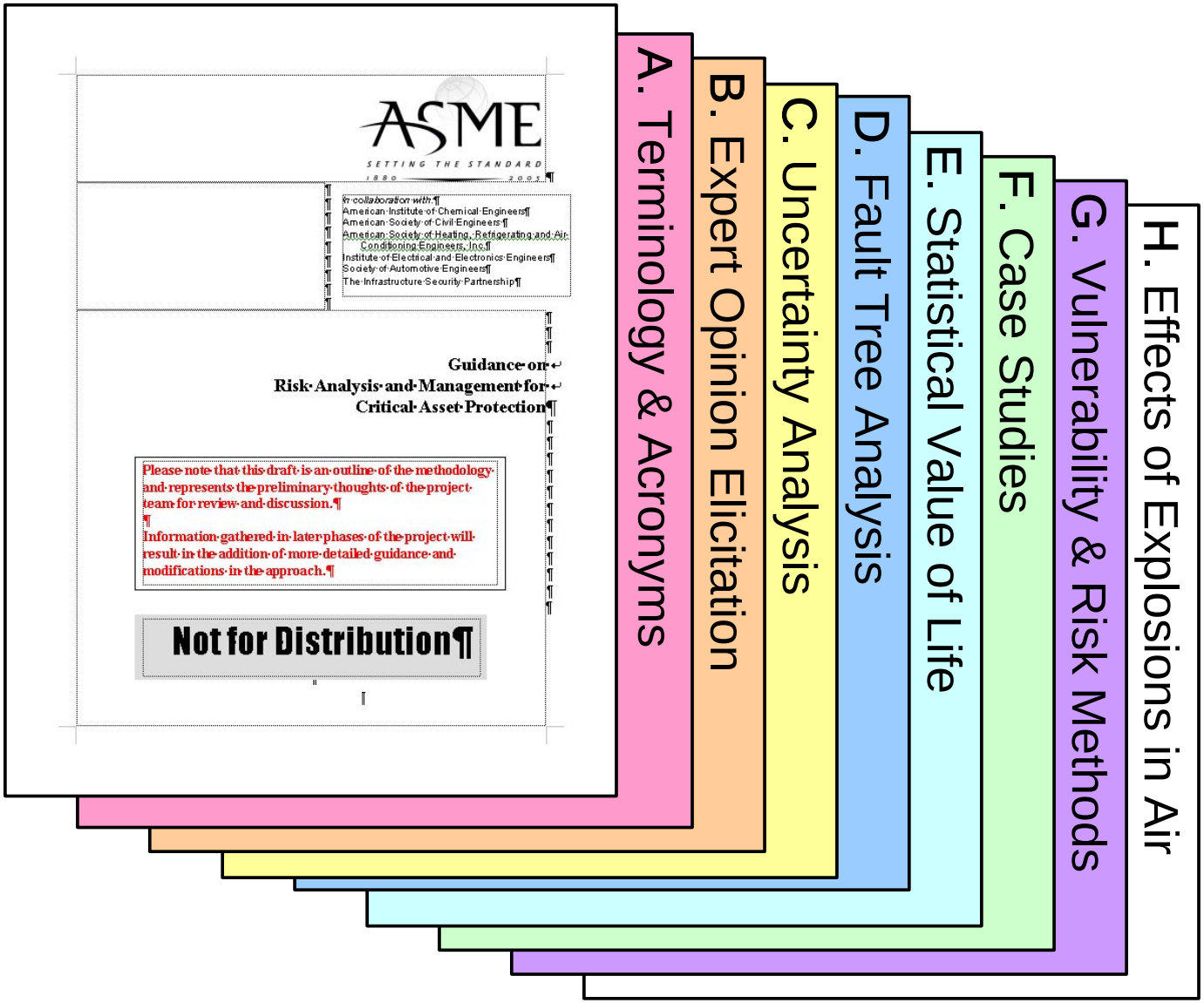
Please note that this draft is an outline of the methodology and represents the preliminary thoughts of the project team for review and discussion.

Information gathered in later phases of the project will result in the addition of more detailed guidance and modifications in the approach.

Not for Distribution

1. Introduction
2. Fundamentals & Methodology
3. Asset Screening
4. Threat Analysis
5. Vulnerability Analysis
6. Consequence Analysis
7. Risk Analysis
8. Countermeasure and Mitigation
9. Decision Analysis
10. Multiple Assets and Sectors
11. Data Collection Methods

RAMCAP Document Outline



RAMCAP Document Outline

Chapters 1 - 4 provide:

- Introduction
- Terminology (also see Appendix A) and overview of the methodology
- Screening methods – can be used as stand alone guidance or supplemented by the Asset Application Handbook
- Threat analysis – a threat frequency approach is recommended for higher levels of decision-making (national or regional), but is not needed at the asset level

RAMCAP Document Outline

Chapters 5 - 10 cover the sequential steps in the application of the methodology:

- Vulnerability analysis
- Consequence analysis
- Risk analysis
- Countermeasures and mitigation
- Decision analysis
- Multiple assets and sectors

Chapter 11 covers data collection methods

RAMCAP Document Description

- Qualitative screening (see Asset Application Handbook) to screen out assets or identify critical assets for further analysis
  - Primary screening at the asset owner level
  - Risk rating categories “calibrated” for consistency
- The absence of threat information leads to semi-quantified risk calculations (conditional-threat risk) and conditional-threat risk thresholds to support decision-making
- Risk ratings from 0 to 5 or from 0 to 10, based on existing methods and completed qualitative assessments, can be quantified and used to evaluate countermeasures and mitigation measures
- If threat information can be quantified, full Quantitative Risk Assessment (QRA) is possible

RAMCAP Document Examples

Two example applications of the RAMCAP document methodology prepared:

- Petroleum refinery example
  - Threat frequency assumed, in order to exercise full risk quantification and cost-benefit analysis
- Suspension bridge example
  - Analysis based on conditional-threat risk

Petroleum Refinery Example

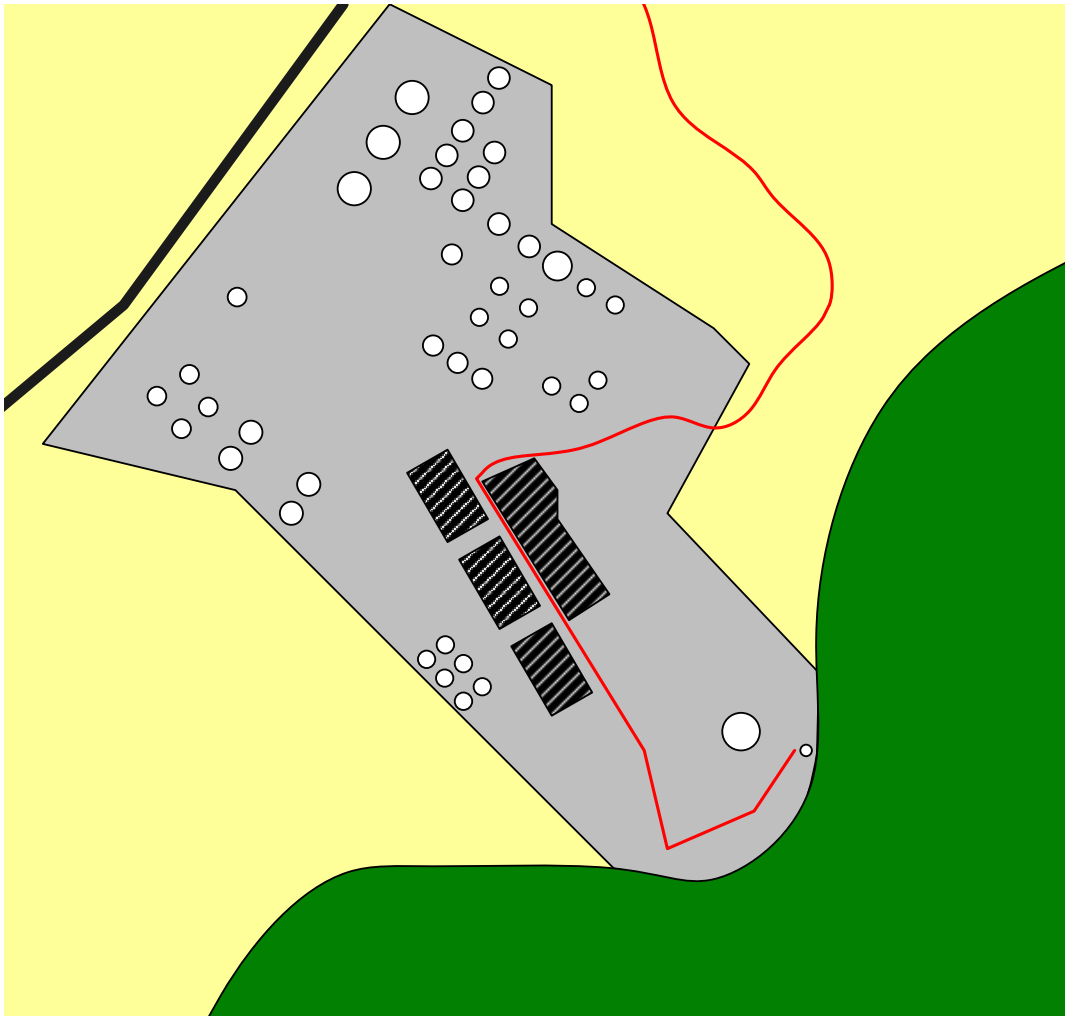
Objectives
- Analyze Risks for Individual Critical Asset

Form Team
- Section 2.4

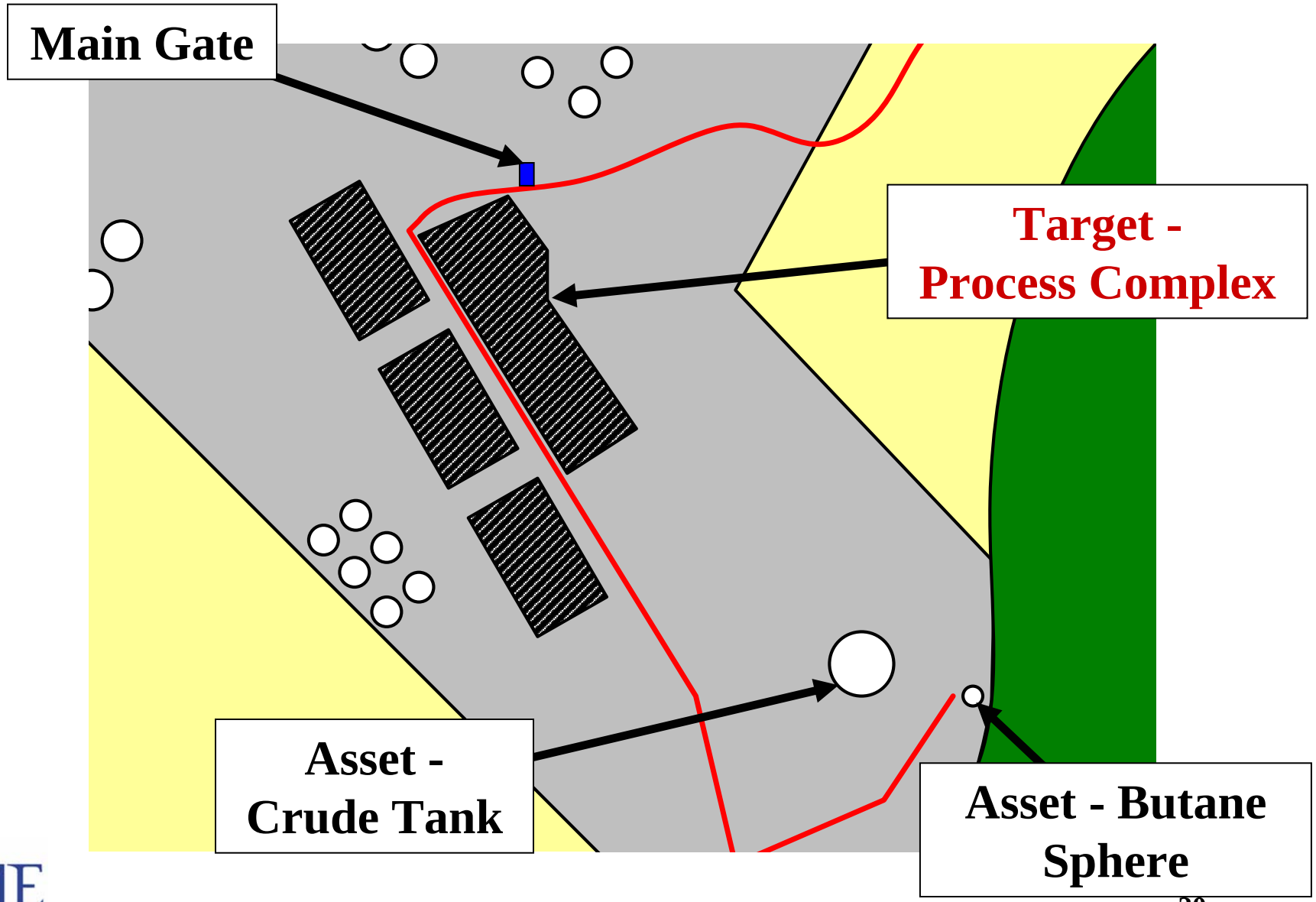
Identify Assets
- Energy
  - Oil & Natural Gas
    - Refinery

Identify Threats
- Truck Bomb Attack

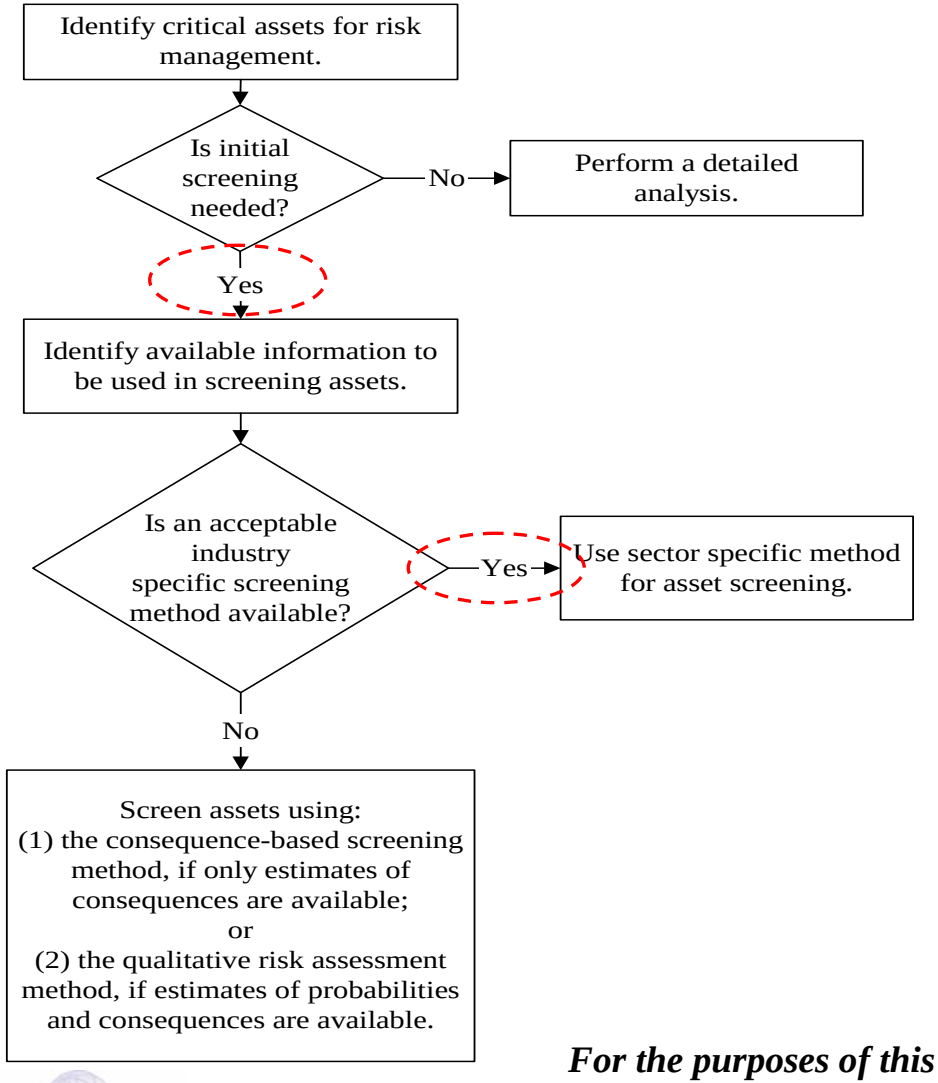
Calculation Method
- Monte-Carlo Simulation



Identify Potential Targets



Perform Screening Analysis



Screening Method
- API/NPRA SVA

Technique
- Qualitative

Key Concepts
- Asset Based
- Threat/Adversary Review

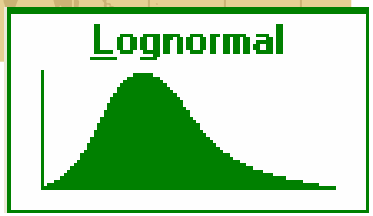
Attractiveness/Target Rank

Vulnerability Analysis

Results
- Process Complex Vulnerable to Truck Bomb Attack
- Countermeasure 1 – Move Gate
- Countermeasure 2 – Active Vehicle Barricade
- Countermeasure 3 - Combined

For the purposes of this analysis it has been assumed that the API/NPRA methodology is an "Acceptable" screening method.

Threat Frequency



Tactical Threat

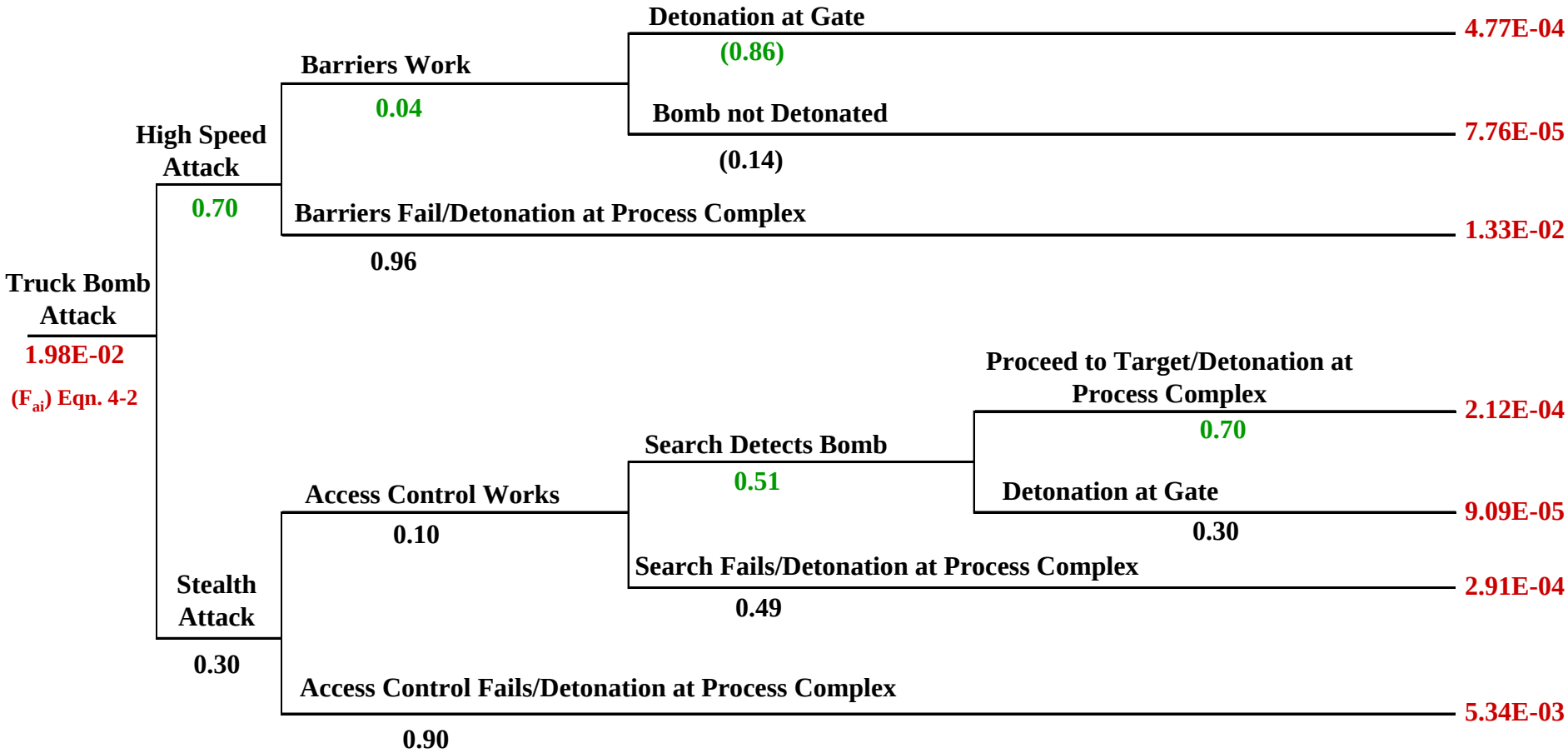
- Scenario 5
  - (Section 2.6.4)
- Truck Bomb Case
  - 4,000 pounds TNT

Frequency Range of Credible Threats

- $F_{ai} = F_{ti} P_{csi} P_{asi} P_{ti}$ (4-1)

Parameter	Description	Base Case Distribution	Base Case Comments
Case Description			
F_{ti}	Frequency of attacks of the type under consideration for the country as a whole (events per year) - **TRUCK BOMB**	4.0	**Log-normal distribution from 1 to 10 events per year with a 90% interval (minimum of 0 maximum of 365)**
P_{csi}	Conditional probability that attack will target an asset class - **US Refineries Given Truck Bomb**	0.35	**Log-normal distribution from 0.1 to 1 with a 90% interval (minimum of 0 maximum of 1)**
P_{asi}	Conditional probability that attack will target a specific asset given class selection - **Refinery ABC Given Refineries are Target and Truck Bomb will be used**	0.04	**Log-normal distribution from 0.01 to 0.1 with a 90% interval (minimum of 0 maximum of 1)**
P_{ti}	Conditional probability that attack will occur given asset selection given all of the above are true	0.35	**Log-normal distribution from 0.1 to 1 with a 90% interval (minimum of 0 maximum of 1)**
F_{ai}	**Frequency of attacks of the type under consideration for the specific asset class (events/year)**	1.98E-02	

Analyze Vulnerabilities

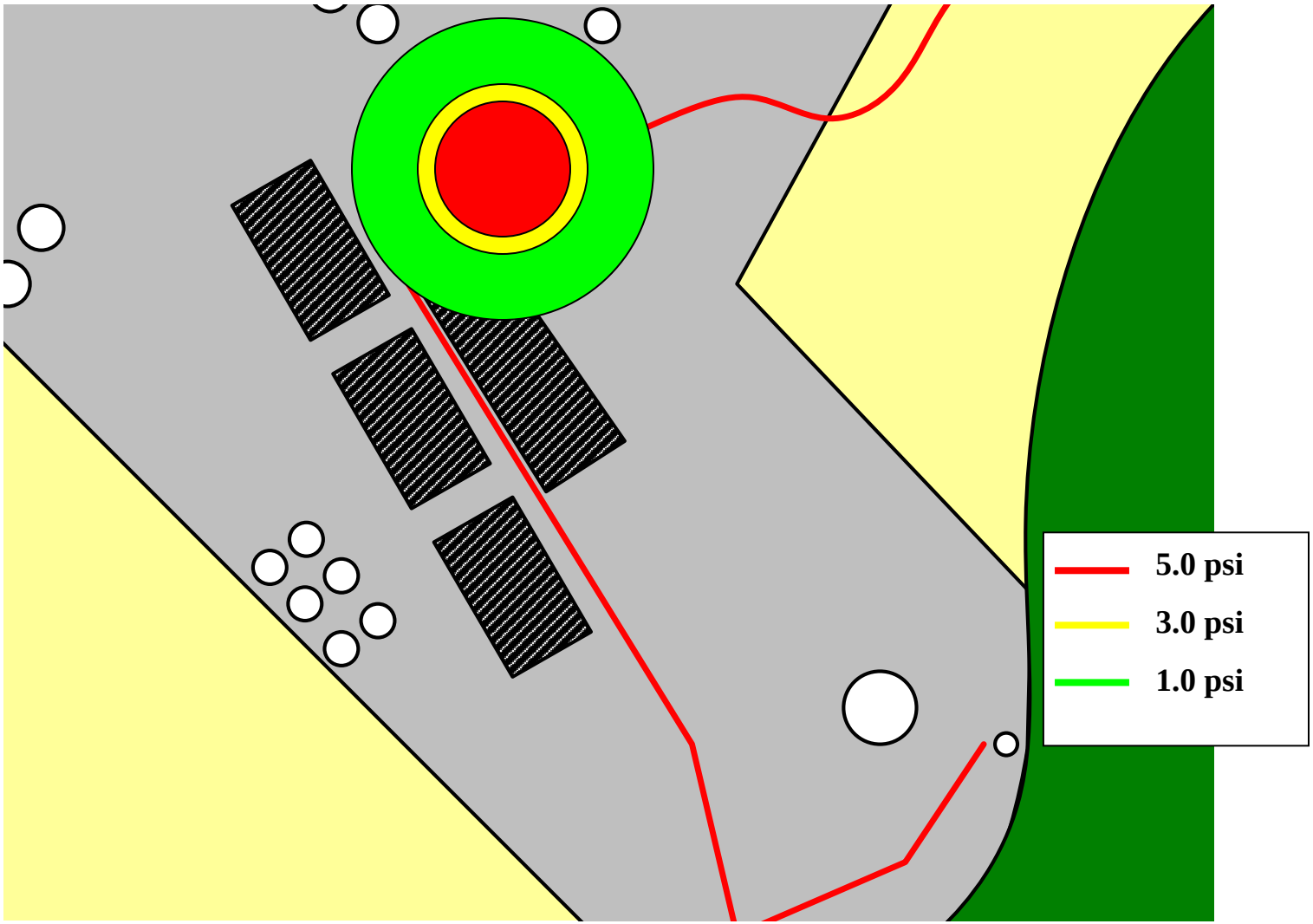


Analyze Consequences

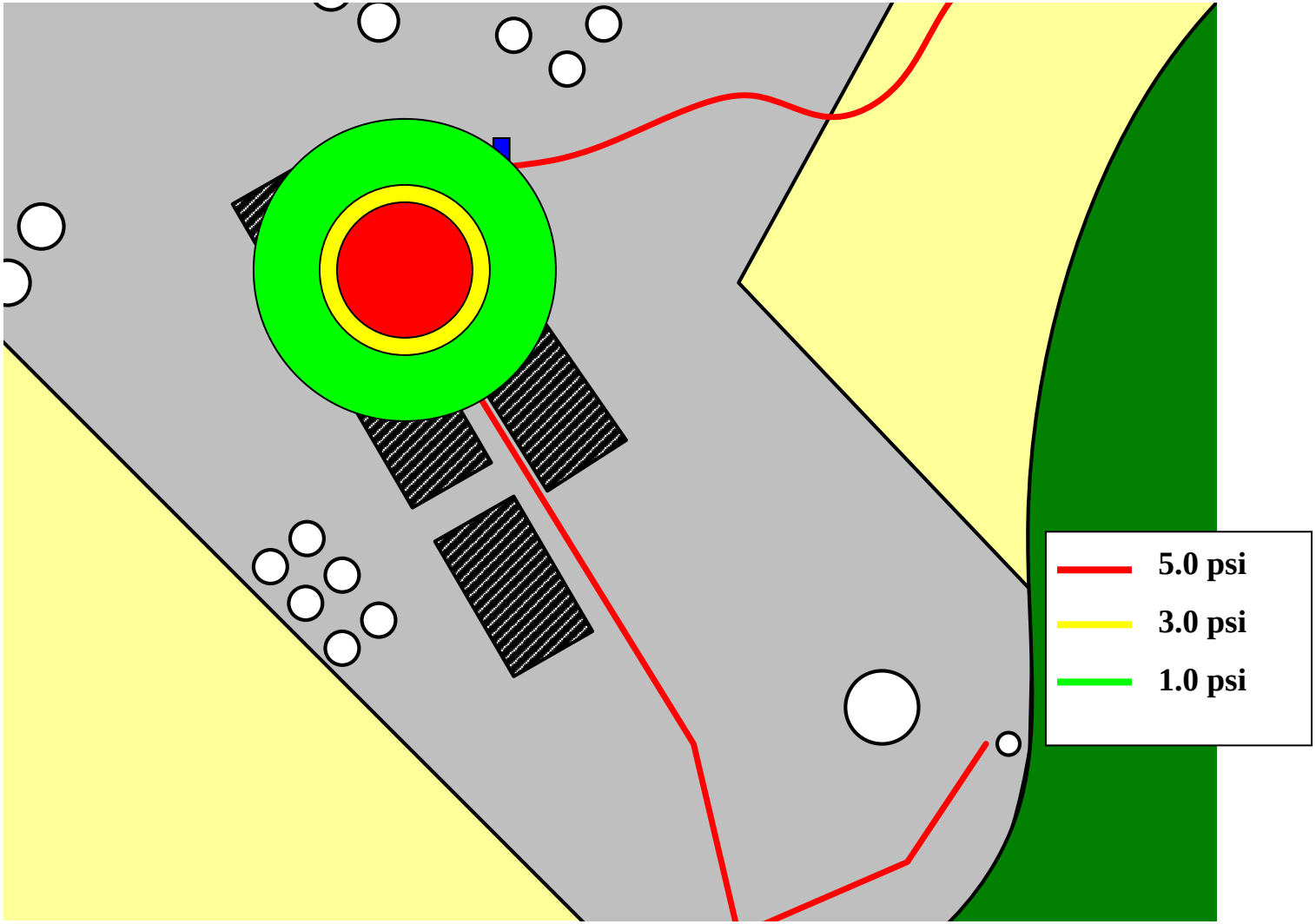
TNT Truck Bomb Detonation
4,000 lbs TNT
Overpressure Levels and Distances

Overpressure Level	Distance from Source
5.0 psi	60
3.0 psi	85
1.0 psi	190

Detonation at Main Gate



Detonation at Process Complex



Identify Action Strategies

Countermeasure 1 (CM-1)

- Relocate Main Gate
- Cost = $100,000

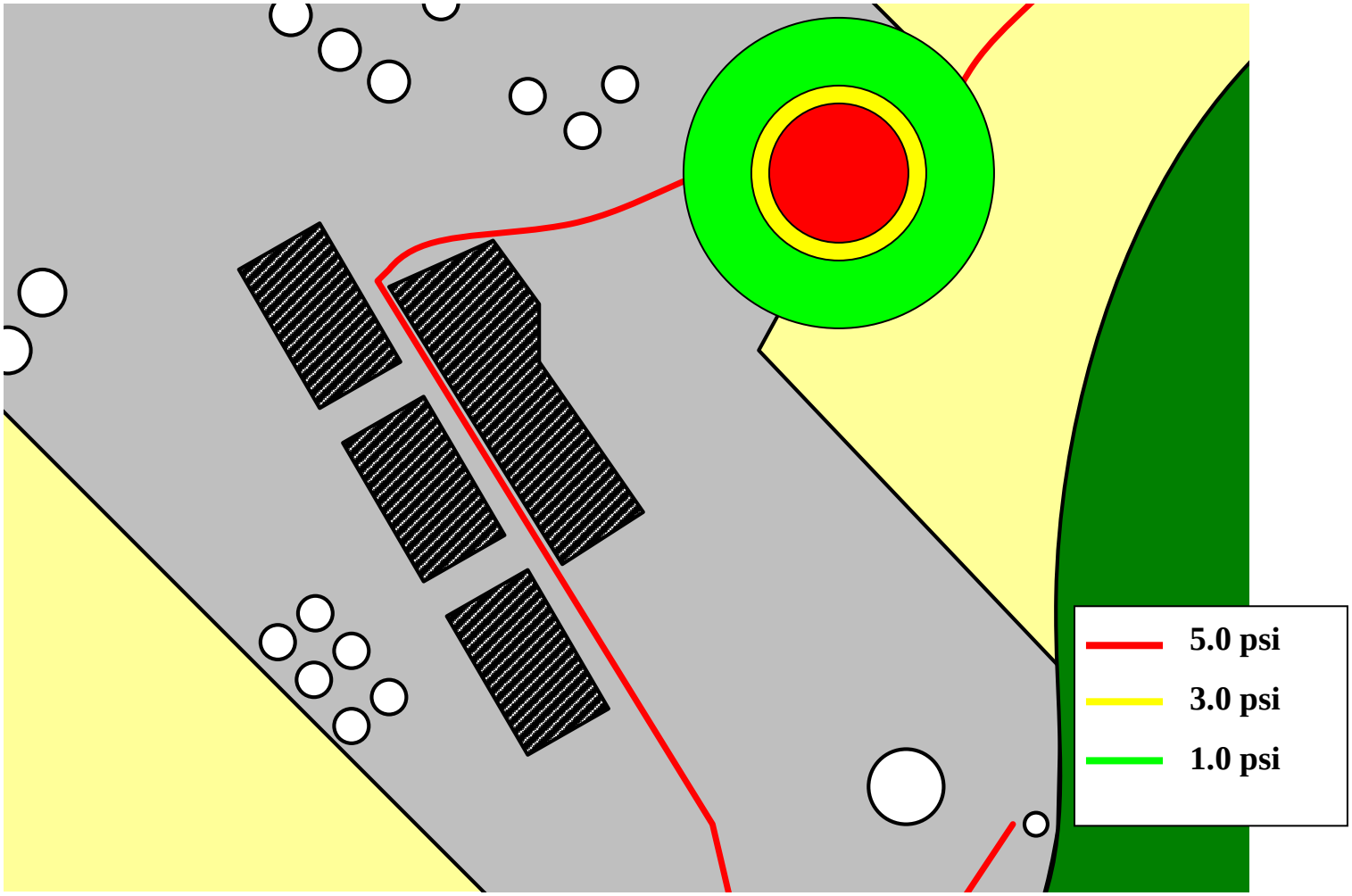
Countermeasure 2 (CM-2)

- Install Active Vehicle Barrier at BASE CASE gate location
- Cost = $50,000

Countermeasure 3 (CM-3)

- Relocate Main Gate and Install Active Vehicle Barrier at new gate location
- Cost = $150,000

Action Strategy Consequences at New Gate Location

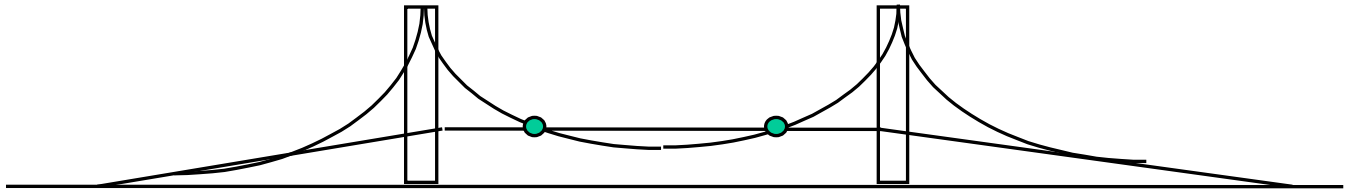


Conclusions

- RAMCAP methodology provided a framework for analyzing alternative proposals to reduce vulnerabilities
- Quantifying both the threat probability and the consequences allowed the analysis to be more complete and gave insights into the value of the investments and an understanding of the degree of consequences
- The RAMCAP analysis indicated that the value of the investments exceeded costs

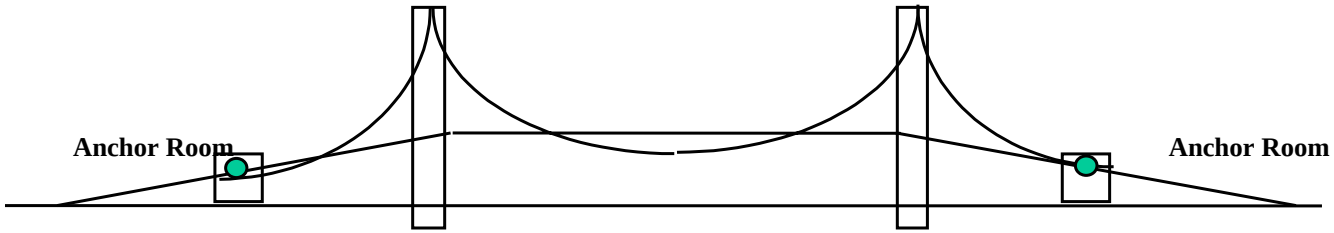
Suspension Bridge Example

Threat Scenario
Truck Bomb, 4000 Pounds of TNT

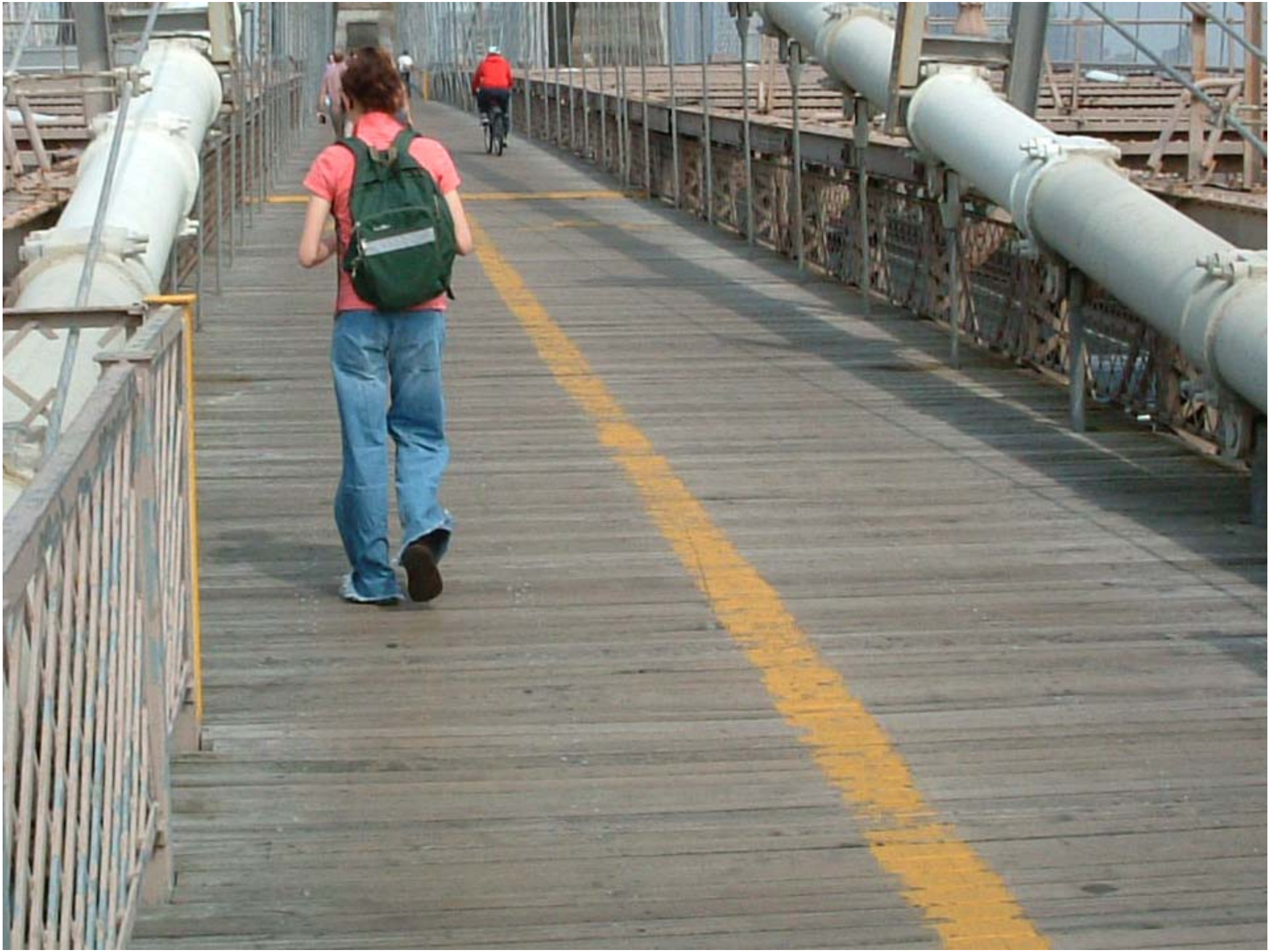


Threat Scenario – Center Span Locations of Denotation

Threat Scenario
Sector-Dependent



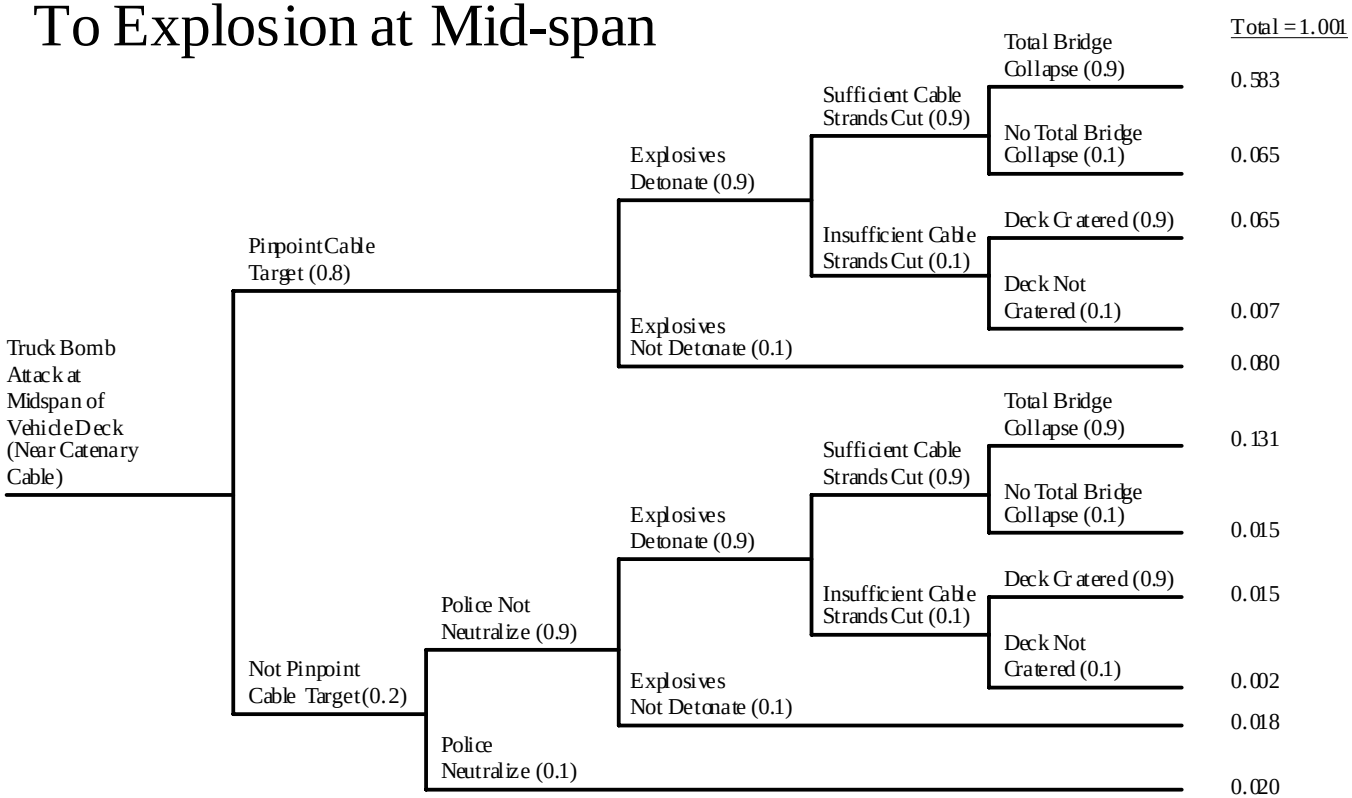
Threat Scenario – Anchor Room Locations



Suspension Bridge Example

Analyze Baseline Vulnerabilities -

To Explosion at Mid-span



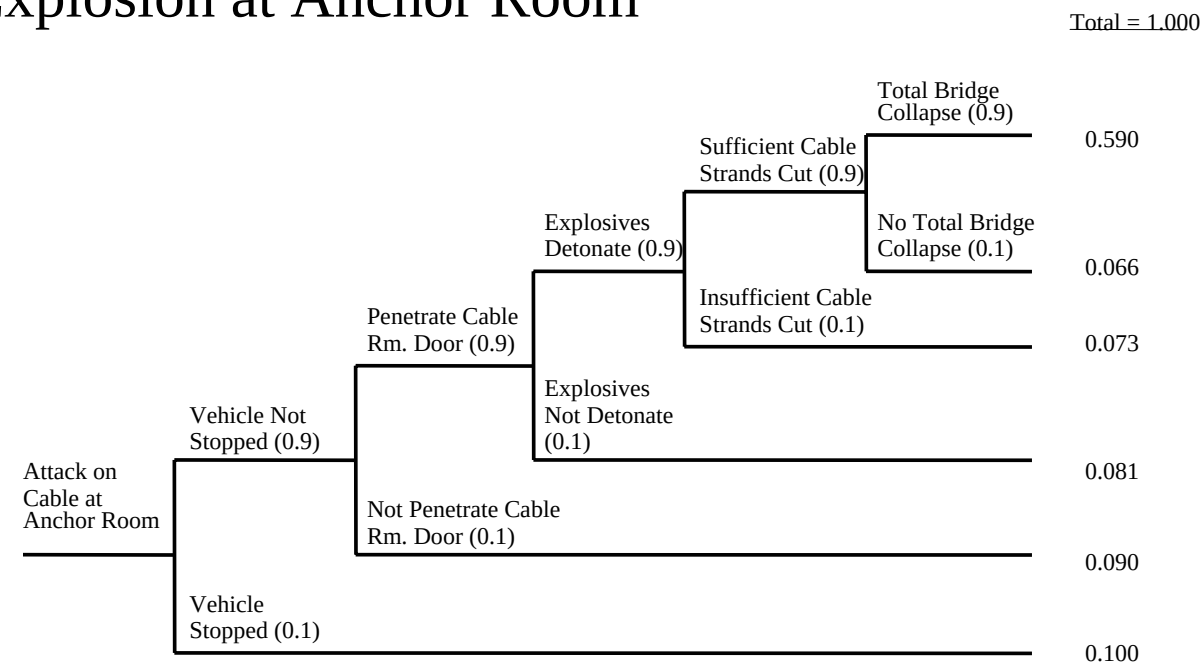
No Countermeasures

Event Tree Showing Baseline Vulnerabilities to an Explosion at Mid-span

Suspension Bridge Example

Analyze Baseline Vulnerabilities -

To Explosion at Anchor Room



No Countermeasures

Event Tree Showing Baseline Vulnerabilities to an Explosion at the Anchorage

Suspension Bridge Example

Conditional Risks for the Baseline Bridge Collapse

Total Bridge Collapse						
Anchor Room - Baseline				Mid-span – Baseline		
Consequence	**Outcome**	**Condit. Risk**		**Consequence**	**Outcome**	**Condit. Risk**
$2,700,000,000	**0.59**	$1,593,000,000		$2,500,000,000	**0.71**	$1,775,000,000
Loss of 350 lives	**0.59**	207 lives		Loss of 600 lives	**0.71**	426 lives
Risk is conditional on occurrence of attack.						

Suspension Bridge Example

- Countermeasure 1 (CM-1) at Cable Anchor
  - Cage in Front of Anchor Room Door ……. $175k
    - Expanded Metal
  - Cage Door & Lock …….... $100k
    - Hardened
  - Anchor Room ……. $ 50k
    - Door & Lock Hardening
  - Sensors at Cable Anchor ……. $ 75k

Total $400k

- Countermeasure 2 (CM-2) - Cable at Mid-span
  - Cable Shield at Center Span …….. $250k
  - Video Camera ……. $ 50k

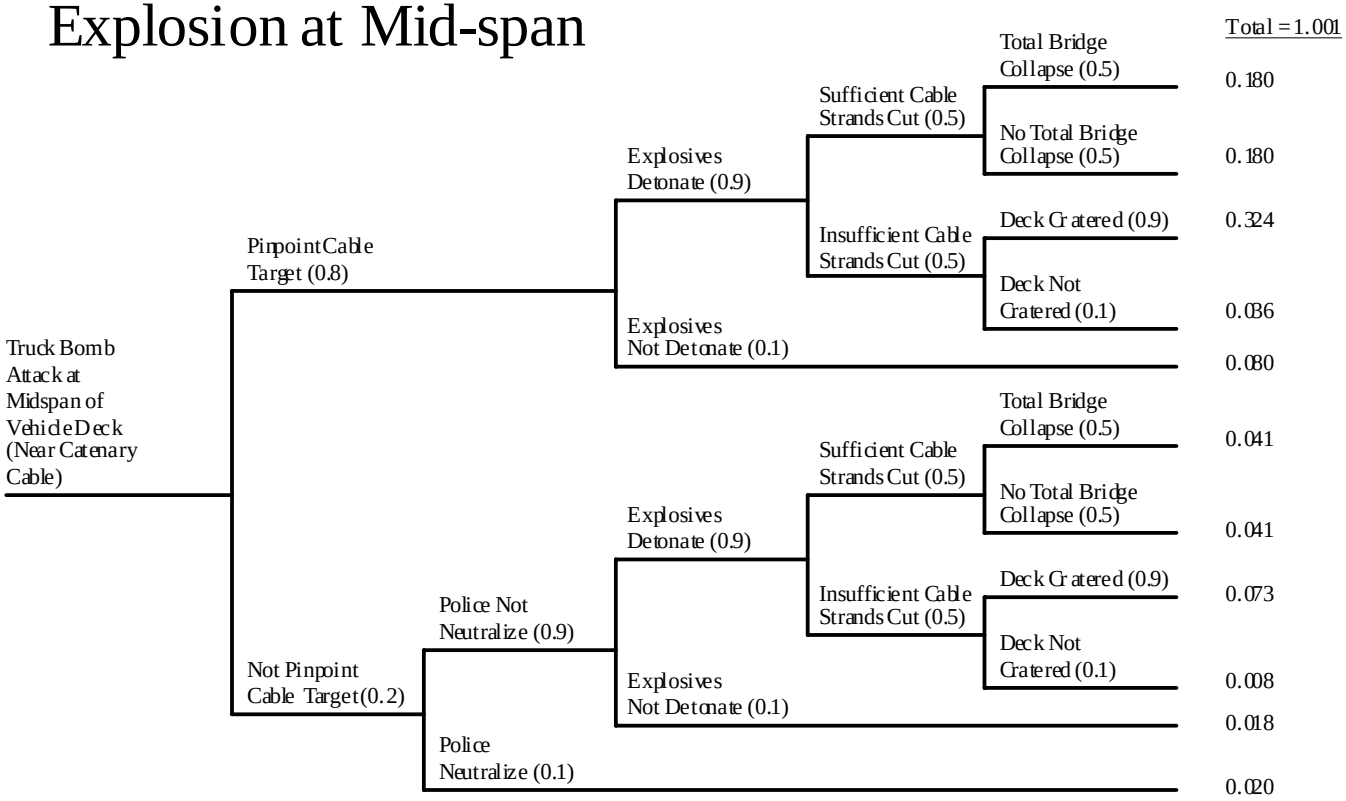
Total $300k

Costs of Countermeasures 1 and 2 to Reduce Risk at Example Bridge

Suspension Bridge Example

Analyze Vulnerabilities of Upgrade -

Explosion at Mid-span



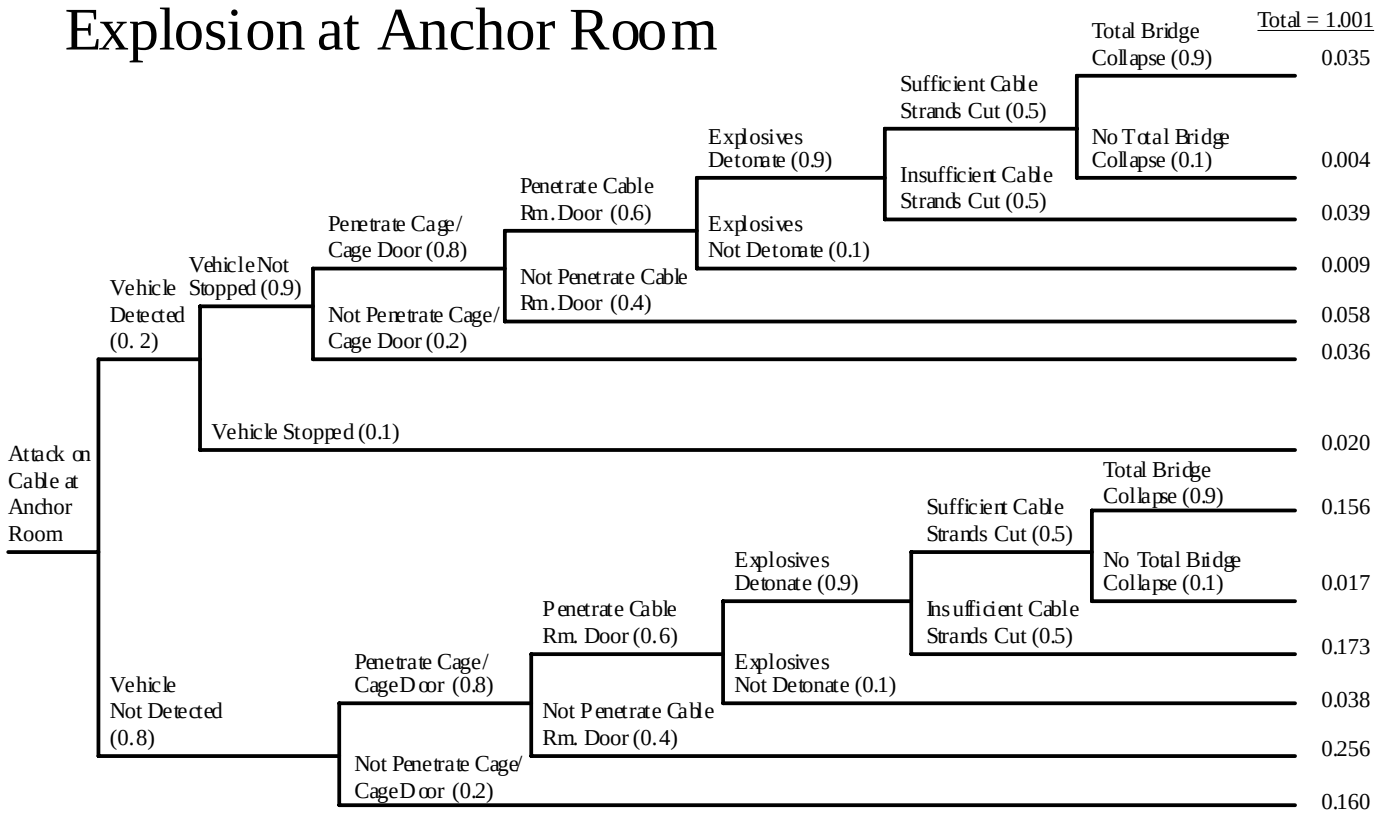
Countermeasure #2

Event Tree Showing Upgrade Vulnerabilities to Attack at Mid-span (CM-2)

Suspension Bridge Example

Analyze Vulnerabilities of Upgrade -

Explosion at Anchor Room



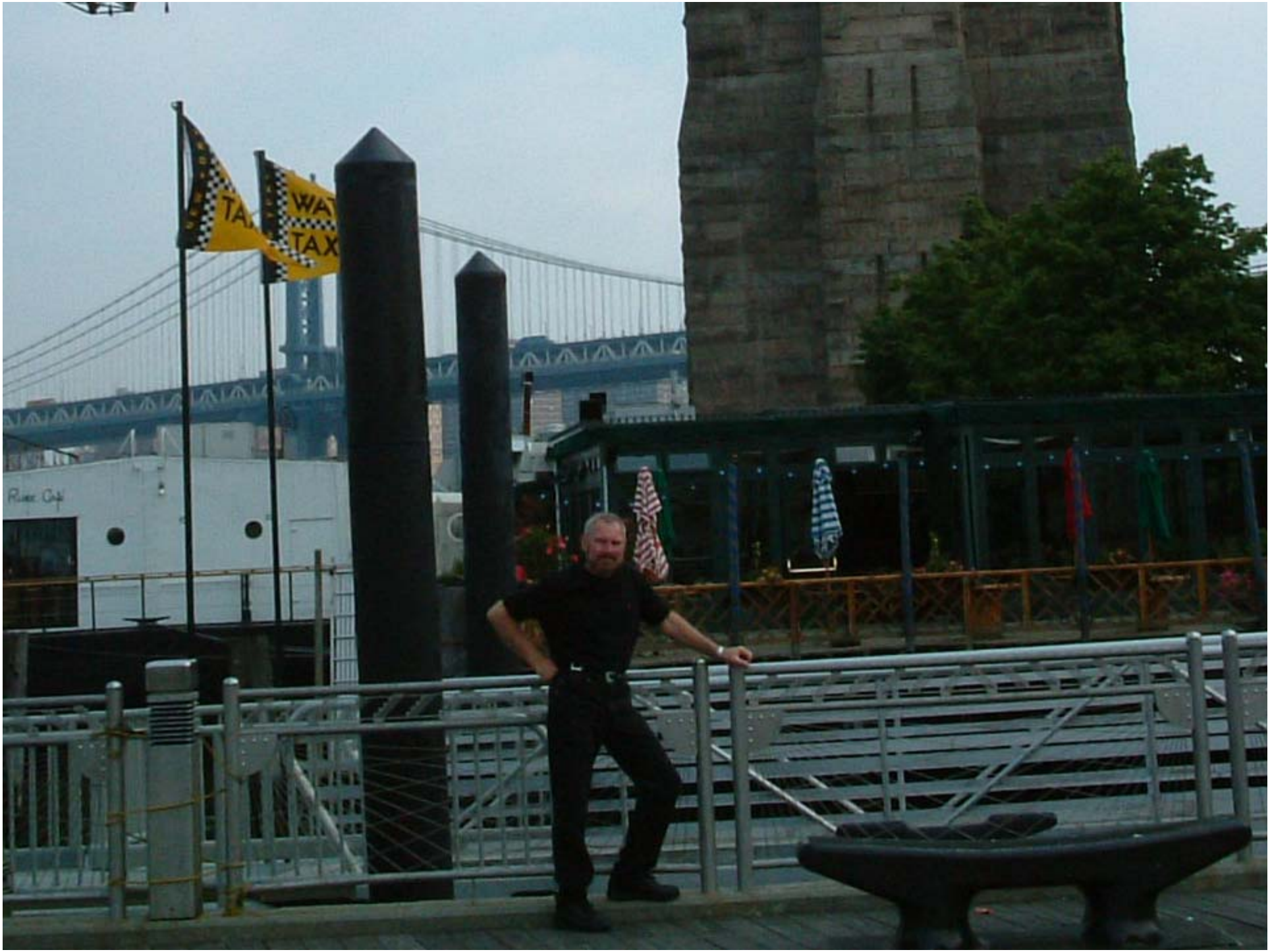
Countermeasure #1

Event Tree Showing Upgrade Vulnerabilities to Explosion at Anchor Room (CM-1)

Suspension Bridge Example

Conditional Risk of Total Bridge Collapse for the Baseline and Upgraded Conditions at Each of the Two Attack Targets

Total Bridge Collapse					
Anchor Room - Baseline			**Mid-span - Baseline**		
Consequence	**Outcome**	**Condit. Risk**	**Consequence**	**Outcome**	**Condit. Risk**
$2,700,000,000	**0.59**	$1,593,000,000	$2,500,000,000	**0.71**	$1,775,000,000
Loss of 350 lives	**0.59**	207 lives	Loss of 600 lives	**0.71**	426 lives
Anchor Room - CM-1			**Mid-span - CM-2**		
Consequence	**Outcome**	**Condit. Risk**	**Consequence**	**Outcome**	**Condit. Risk**
$2,700,000,000	**0.19**	$513,000,000	$2,500,000,000	**0.22**	$550,000,000
Loss of 350 lives	**0.19**	67 lives	Loss of 600 lives	**0.22**	132 lives
Risk is conditional on occurrence of attack.					


TAX
WAT
TAX

Phase II Project Scope

- Use RAMCAP document as overall reference
- Integrate key features of RAMCAP document that cover Security Vulnerability Assessment (i.e., threat and consequence analyses) into existing sector-specific methods, metrics, and documentation
- Assist sector organizations in developing new Security Vulnerability Assessment methods, metrics, and documentation, as appropriate

Phase II Project Scope

Applicable to 9 critical asset sectors:

- Commercial nuclear power plants
- Commercial nuclear spent fuel storage facilities
- Chemical plants
- Petroleum refineries
- Liquefied Natural Gas (LNG) storage facilities
- Subway Systems (including bridges and tunnels)
- Railroad Systems (including bridges and tunnels)
- Highway Systems (including bridges and tunnels)
- Power generation and transmission facilities

Phase II Project Scope

Two of the nine sectors are "pilot" sectors:

- The sector-specific guidance must be completed by December 31, 2004
- The guidance for commercial nuclear power plants will build on the RAMCAP document and on existing vulnerability assessment guidance prepared by EPRI for the U. S. commercial nuclear power industry and vetted by the Nuclear Energy Institute (NEI)
- The sector-specific guidance for chemical plants will build on the RAMCAP document and existing guidance prepared by the American Chemistry Council and the American Institute of Chemical Engineers (AIChE)

Closing Commentary

- Risk-informed decision making has been used successfully by industry and government for many years.
- Cost-benefit analysis is an important tool to prioritize the allocation of national resources in the war on terrorism.
- Quantified measures are needed for benefit-cost analysis.
- Even if risk can be quantified only within very broad ranges, the results provide a much better basis for informing decisions than the use of judgment alone.