Casualty Actuarial Society

2010 Ratemaking and Product Management Seminar

Catastrophe Modeling Workshop: Terrorism

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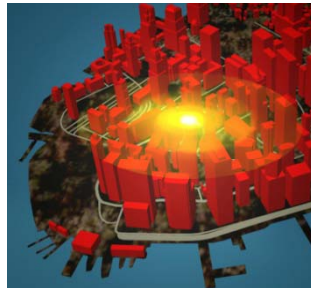
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Presentation Outline

- Framework for Terrorism Risk Modeling

- Probabilistic Model Framework

- Best Practices for Managing Terrorism Risk

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Framework for Terrorism Modeling

Exposure at Risk

- Property exposed
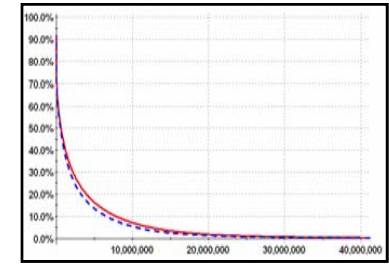- Population exposed
- Geocoding
- Building Attributes

Quantify Hazard

- Pressure waves
- Contaminant dispersal
- Debris
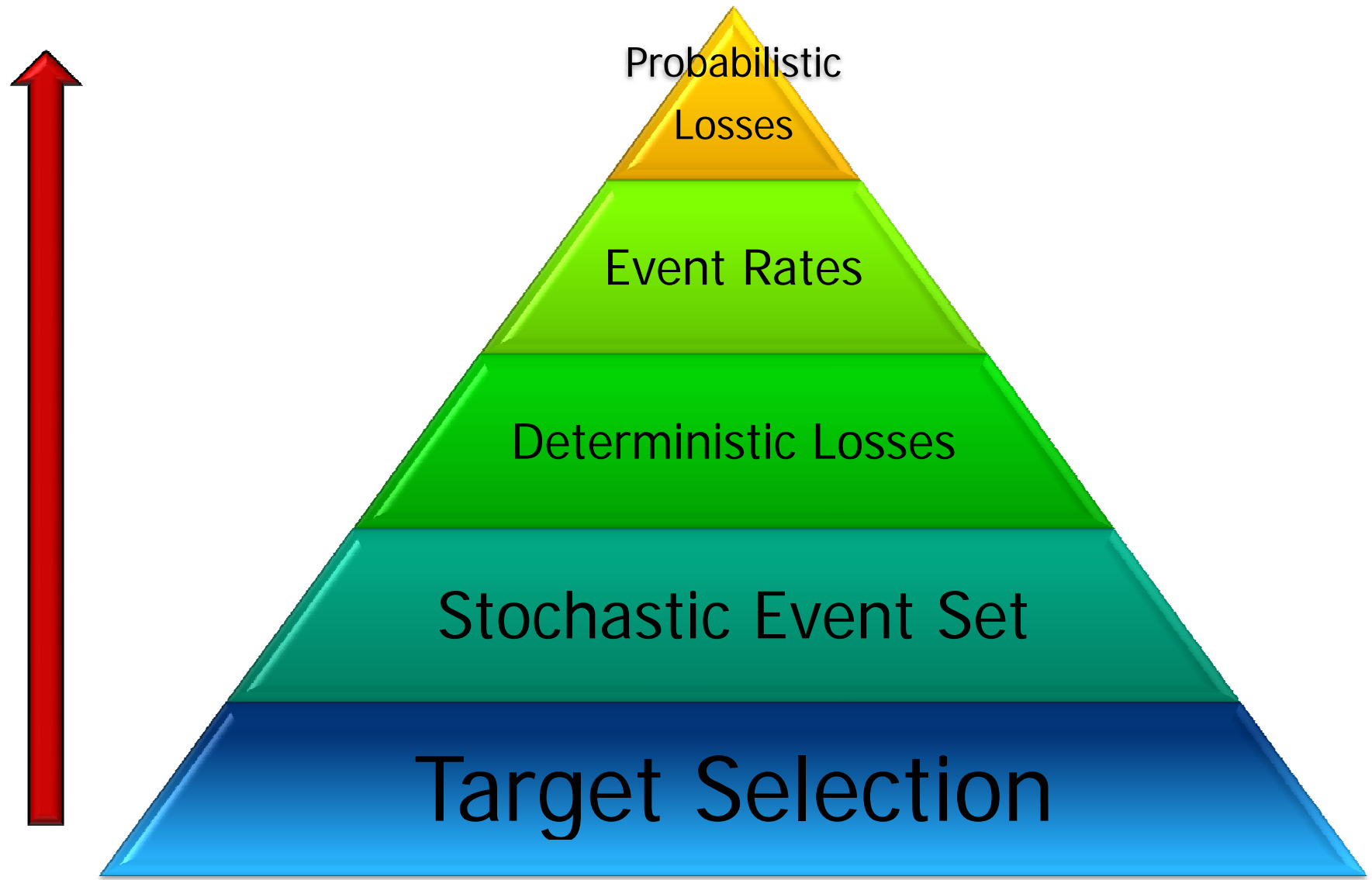- Fire

Assess Vulnerability

- Distance vs. Damage
- Impact of hazard on the building environment
  - Building Damage
  - Nature of injuries

Probabilistic Analysis

- Relative likelihood of scenarios
- Multiplicity of attacks
- Frequency of attacks

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Probabilistic Model Framework

Probabilistic Losses

Event Rates

Deterministic Losses

Stochastic Event Set

Target Selection

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What Questions Are We Trying to Answer?

We are not seeking to predict the time and place of a future attack.

- What is the probability that terrorists can acquire and deploy various weapons systems?

    - Ranging from conventional explosives to weapons of mass destruction

- What are the probable targets of a terrorist attack?

    - How ideological factors, weapons availability, logistical capacity, and security constraints determine targeting priorities

- What is the likelihood and frequency of possible attacks and how does this change over time?

Probabilistic Model Framework

Define Stochastic Attack Set

- Identification of targets and mapping relevant attack mode for each target
- Based on utility of attack, target & attack mode prioritization
- Expert elicitation and other supporting intelligence

Determine Attack Likelihood

- Targets: prioritizing by category and city tiers
- Attack modes: logistical burden and likelihoods
- Game theory engine

Determine Attack Multiplicity

- Likelihood of having multiple attacks per event (swarm)
- Determined by attack mode groups
- Historical precedent

Simulate Event Frequency

- Distribution of attempted events
- Distribution of successful events
- Suppression factor given an event occurs

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Determining Attack Modes, Targets, and Probabilities

Methodology based on application of game theory

➢ Utility of the Attack

➢ Logistical Cost of Attack

➢ Target Hardening and Security

Game Theory Engine

- **Weapons**
- **Targets**
- **Attack Modes**

Probabilities

Defining the Utility of Attack

- ■ Al-Qaeda strategy: maximize the expected *utility* of an attack

- ■ Utility is a function of the target's symbolic and publicity value to Al-Qaeda, as well as the consequential economic loss and number of casualties that result from an attack against a target

    - – Economic impact (direct and indirect)

    - – Casualties

    - – Symbolic value (e.g. name recognition and inspirational potency to their constituents)

    - – Fear and psychological terror

Attack Utility: Target Prioritization

> **" Al-Qaeda goes for symbolic, high prestige targets – *targets that matter.* Targets that inspire and influence other Muslims to go and take similar targets. The inspirational value is embedded in their targeting. "**
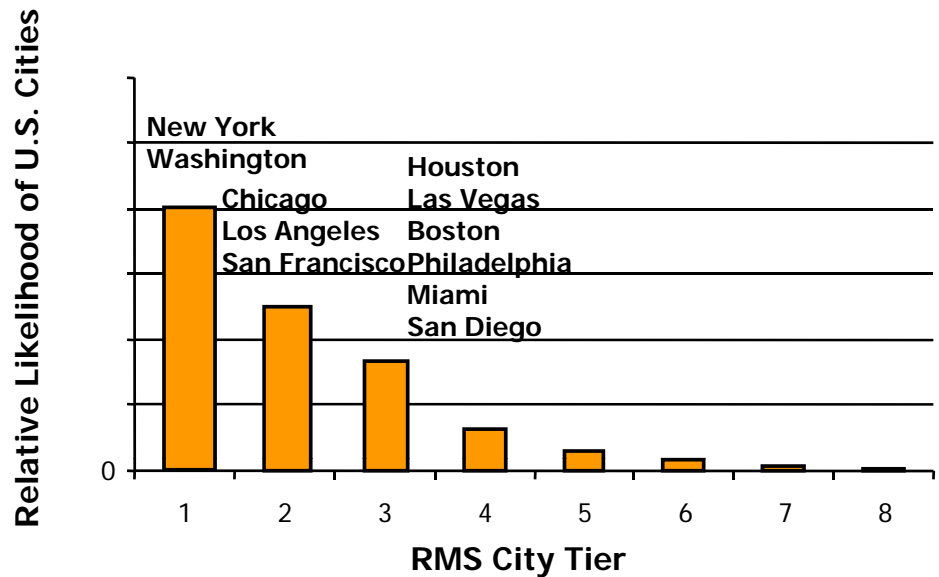

Dr. Rohan Gunaratna
Institute of Defence &
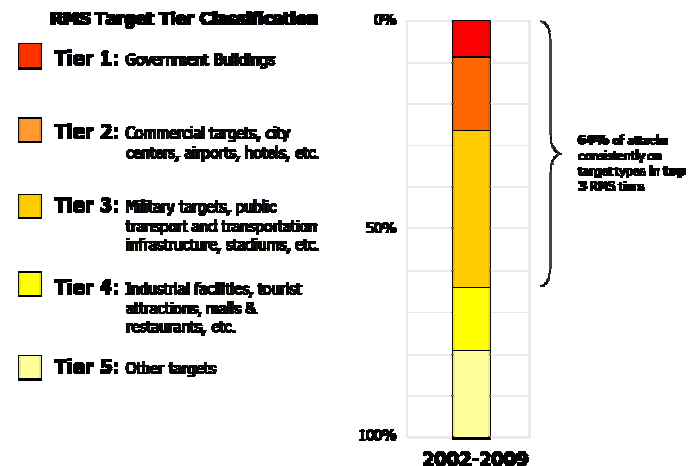Strategic Studies
Singapore
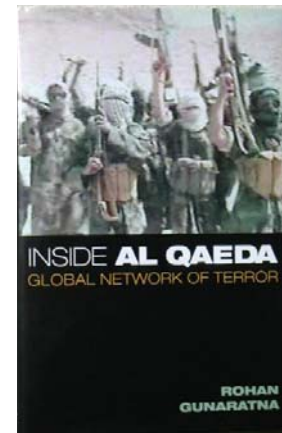
Likelihood of Targeting Specific Cities

Target city tiers based on:

- Name recognition in Middle East

- Historical attack patterns

- Economic value

- Population

- Intelligence reports

- Urban level of security

- Expert opinion

Bar chart: Relative Likelihood of U.S. Cities vs RMS City Tier (1–8)

Tier 1: New York, Washington, Chicago, Los Angeles, San Francisco
Tier 2: Houston, Las Vegas, Boston, Philadelphia, Miami, San Diego

Targets selected in jihadist Macro Attacks, Worldwide 2002-2009

RMS Target Tier Classification

- Tier 1: Government Buildings
- Tier 2: Commercial targets, city centers, airports, hotels, etc.
- Tier 3: Military targets, public transport and transportation infrastructure, stadiums, etc.
- Tier 4: Industrial facilities, tourist attractions, malls & restaurants, etc.
- Tier 5: Other targets

64% of attacks consistently on target types in top 3 RMS tiers

2002-2009

Factors Determining Target Likelihood

- Target utility

- Debriefings of operatives

- Historical attack patterns

- Known planned attacks

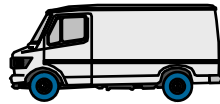- Intelligence

- Local level of security

- Expert opinion

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Attack Modes Modeled

Conventional Weapons:

- **Bombs**
  - 600 lb, 1 Ton, 2 Ton, 5 Ton, 10 Ton
- **Aircraft Impact**
- **Conflagration**
- **SAM/Stand-Off Weapons**
- **Industrial Sabotage (small, med., large)**
  - Explosion
  - Toxic Release
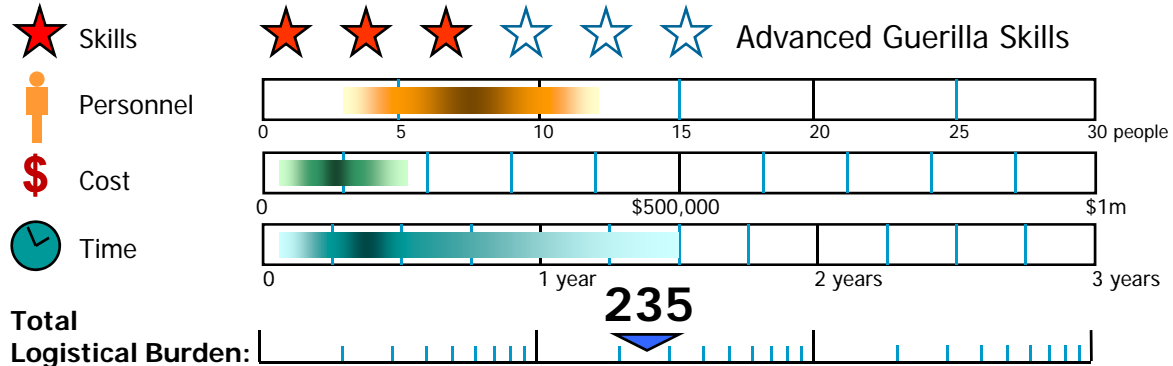 - Explosion & Toxic Release

CBRN Weapons:

- **Nuclear Plant Sabotage**
- **Chemical – Sarin Gas**
  - Outdoor: 10/300/1000 kg
  - Indoor
- **Biological – Anthrax Slurry**
  - Outdoor: 1/10/75 kg
  - Indoor
- **Biological – Smallpox**
  - Small, Medium, Large
  - GE Medium, GE Large
- **Dirty Bomb**
  - 1,500 Curies Cesium 137
  - 15,000 curies Cesium 137
- **Nuclear Bomb**
  - 1 kiloton, 5 kiloton
- **Hazardous Transportation Sabotage**
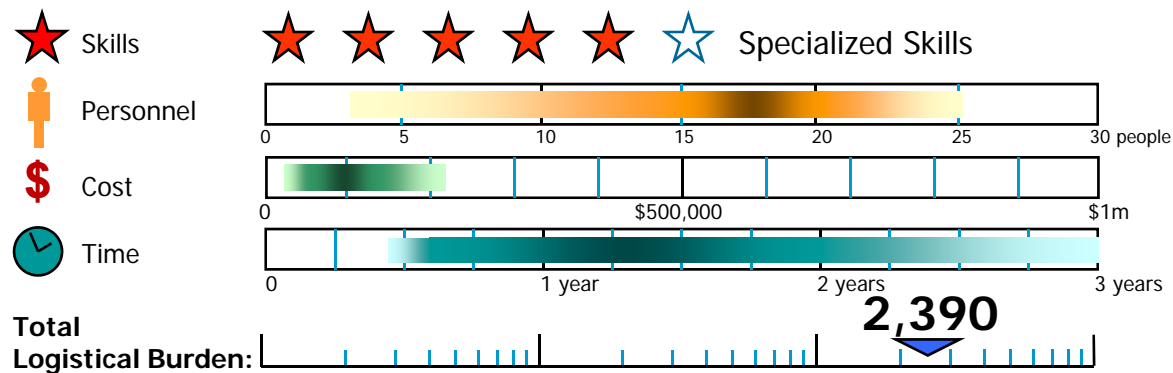 - 90 ton spill

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Cost of Attack: Logistical Burden Assessments

Bomb – 1 Ton

| ★ Skills | ★ ★ ★ ☆ ☆ ☆ Advanced Guerilla Skills |

Personnel

0   5   10   15   20   25   30 people

Cost

0                    $500,000 $1m

Time

0   1 year   2 years   3 years

Total Logistical Burden: **235**

Biological – Anthrax – Medium, Outdoor

| ★ Skills | ★ ★ ★ ★ ★ ☆ Specialized Skills |

Personnel

0   5   10   15   20   25   30 people

Cost

0                    $500,000 $1m

Time

0   1 year   2 years   3 years

Total Logistical Burden: **2,390**

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Calculation Of Interdiction Rates

■ Relative likelihood of one type of attack mode (e.g. vehicle bomb) over another (e.g. sabotage) is assumed to depend on terrorist preference and the comparative logistical burden.

■ However, the relative likelihood of different attack scales associated with a given mode depends not just on the logistical burden, but also on the increasing interdiction likelihood as the number of operatives grows

■ Account by factoring the non-interdiction probability into the relative likelihoods, and normalizing so that the probability associated with each type of attack

■ Relative likelihood of attack modes succeeding in the western alliance homelands differs from active terrorist zones like the Middle East or Asia in respect of interdiction
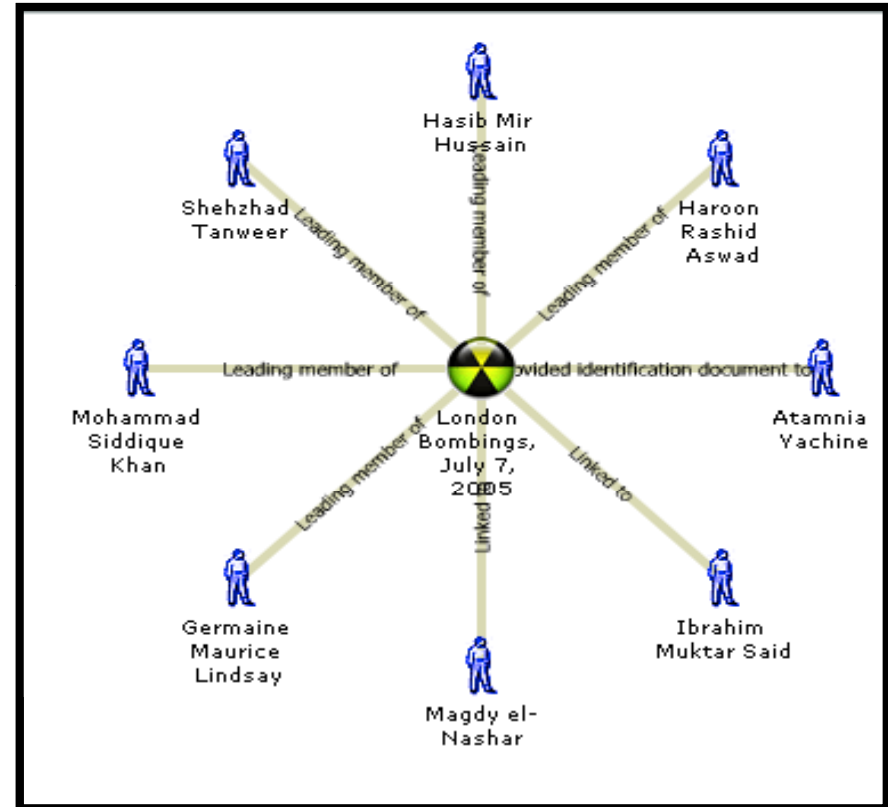
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Calculation Of Interdiction Rates

Madrid Bombing – March 2004
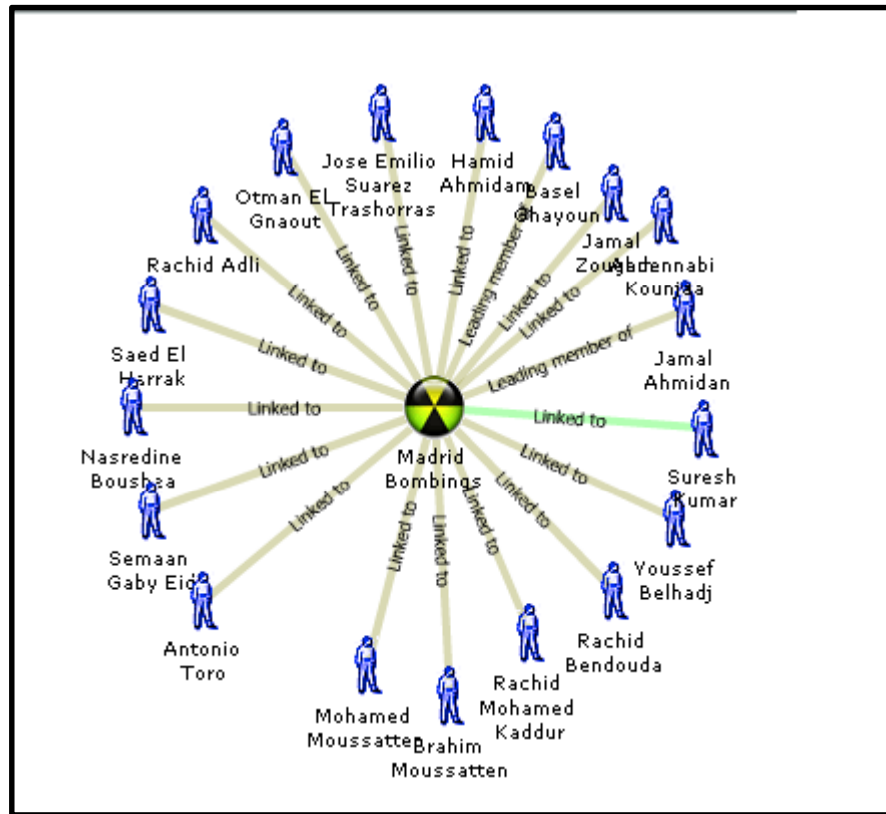
19 People Involved in Attack

London Bombing – July 2007

7 People Involved in Attack

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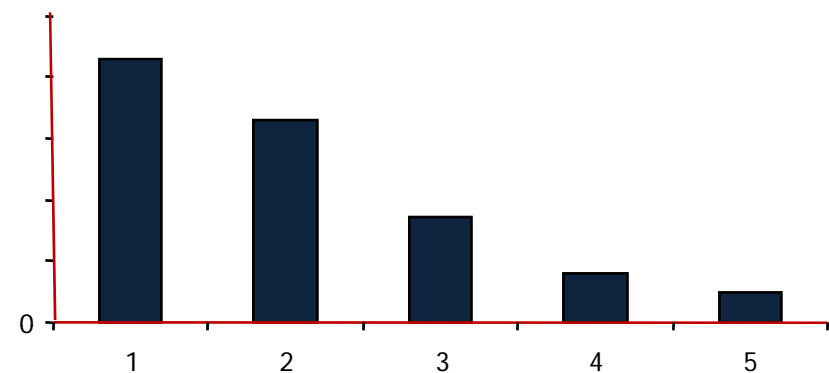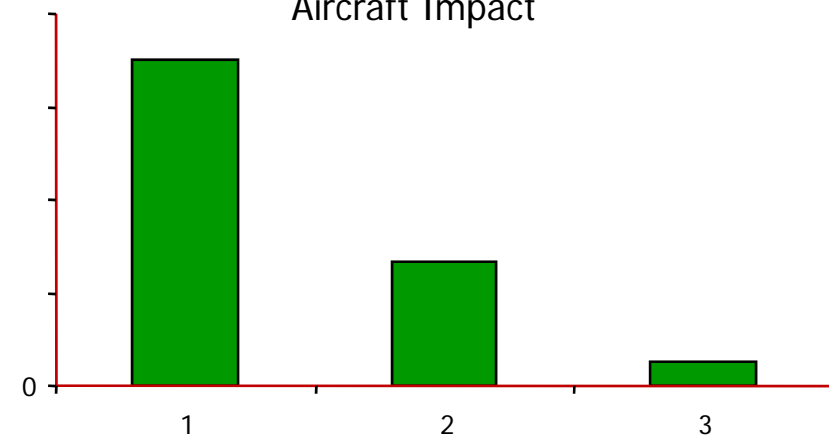
Determining Attack Multiplicity

Potential for swarm based on:

- Al-Qaeda historical attacks

- Target type defense

- Weapon availability

- Al-Qaeda capabilities and resources

- Chance of detection

- Expert opinion

Large Truck Bombs

Aircraft Impact

Determining Event Frequency

- Factors considered in developing annual frequency
  - List of foreign groups likely to attack applicable cities
  - Historical activity of terrorist groups
  - Interdiction rate
  - Counter-terrorism measures
  - Intelligence reports
  - Terrorist debriefings
  - Expert opinion

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Terrorism Is A Control Process

In order to model terrorism frequency as a control process rather than a series of random events, the following are considered:

- Number of attempted events in a year

  - Represented as a truncated Poisson distribution

- Distribution of successful events (success rate)

  - Based on observed statistics of success rates in developed countries (range is from 10% to 25%)

- Limiting factor based on government response to an event

  - This control process is analyzed through a **suppression factor** which is also represented by a probability distribution

Alternative Risk Outlooks

- To quantify uncertainty around the rate of terrorism event occurrences, RMS has introduced the concept of alternative risk outlooks:

    - Standard Risk Outlook: RMS' best assessment of risk

    - Increased Risk Outlook: Event frequency at upper 90% confidence interval

    - Reduced Risk Outlook: Event frequency at lower 90% confidence interval
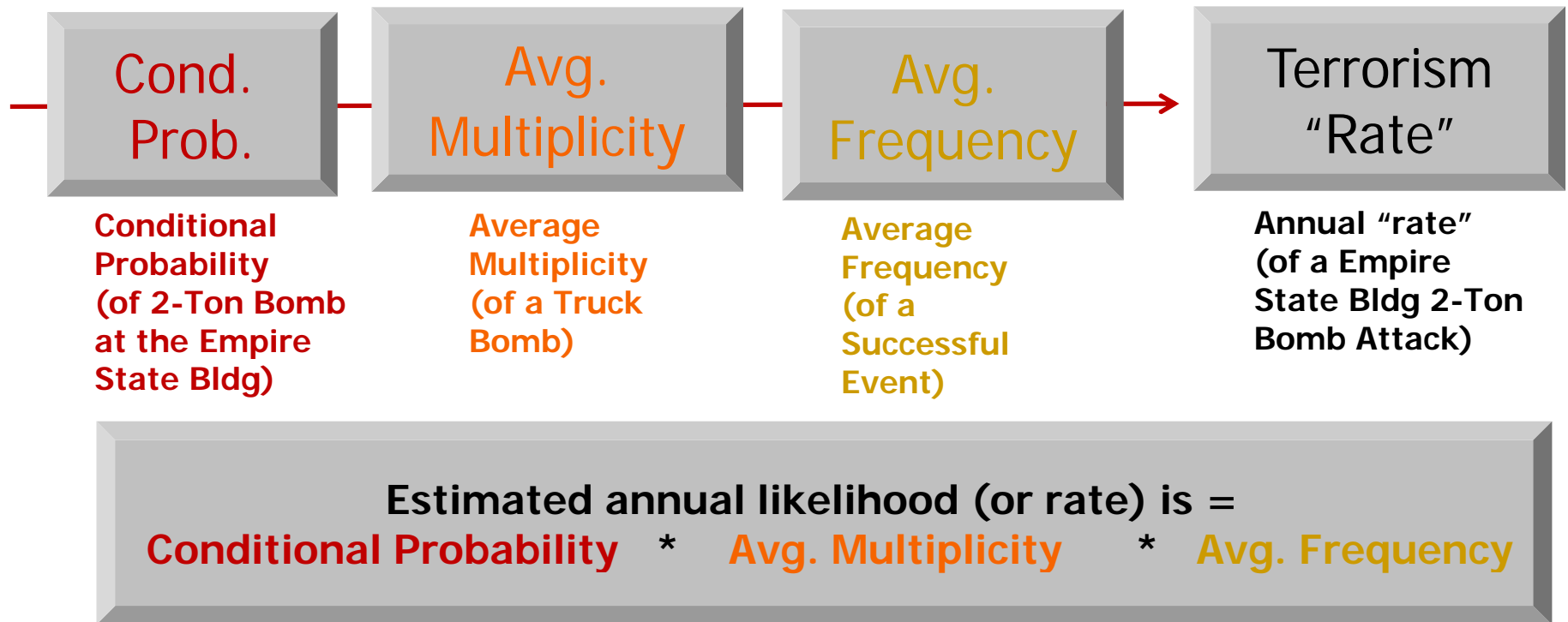
- Each risk outlook consists of the three probabilistic rate components:

    - Conditional probability, event frequency, attack multiplicity

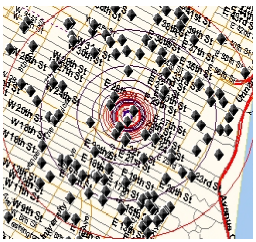- AAL and EP curves can be assessed using any of the available outlooks.

Risk Outlook	Description
RMS Standard Risk Outlook (2010) CA	Best assessment of 2010 Canada risk from all known terrorist groups. Medium scale conventional attacks predominate; synchronous attacks likely; chance of CBRN low.
RMS Reduced Risk Outlook (2010) CA	Fewer planned attacks implies lower 2010 Canada risk. Med-scale conventional attacks predominate; synchronous attacks likely; reduced chance of CBRN.
RMS Increased Risk Outlook (2010) CA	More planned attacks implies higher 2010 Canada risk. Destructive attack modes and multiple synchronous attacks likely. Chance of Islamic Militant CBRN attack significant.

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Single Attack Example for Terrorism

- Attack: 2-ton bomb at the Empire State Building

- Unlike a single rate output for each natural peril event, "rate" for terrorism expected loss calculations must account for the three terrorism components:

Cond. Prob.	Avg. Multiplicity	Avg. Frequency	Terrorism "Rate"

Conditional Probability (of 2-Ton Bomb at the Empire State Bldg)

Average Multiplicity (of a Truck Bomb)

Average Frequency (of a Successful Event)

Annual "rate" (of a Empire State Bldg 2-Ton Bomb Attack)

**Estimated annual likelihood (or rate) is =
Conditional Probability   *   Avg. Multiplicity   *   Avg. Frequency**

Industry Best Practices for Managing Terrorism Risk
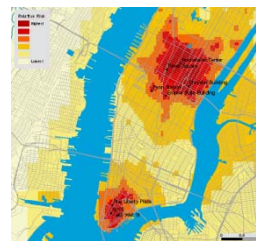

- **Exposure Management**
  - Identify & manage multi-line exposure concentrations
  - Evaluate new submissions in real-time
  - Visualize accumulation areas, exposures, and terrorism-specific data layers such as terrorist targets

- **Terrorism scenario loss modeling**
  - Manage losses of benchmark scenarios to "acceptable" loss levels
  - Create "what-if" scenarios

- **Probabilistic loss modeling**
  - Assist underwriters in risk selection
  - Evaluate reinsurance needs and options
  - Determine key drivers of risk

Multiple methods of risk quantification help users triangulate on the magnitude and sources of risk

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Thank You