# Analysis of Event Risks

Clifford Angstman FSA / MAAA

May 2, 2005

GUARDIAN

http://www.ermsymposium.org/2005/erm2005/d3_bk.pdf (retrieved 1 May 2016)
(Lalonde further down)

## *SOA Extreme Events Task Group*

**GOALS:**

• Provide education and tools needed to quantify, manage, and price the risks associated with extreme-valued outcomes.

• Increase the actuarial profession's awareness of these extreme risks and of the pitfalls of using simplistic methods to assess these risks.

- **Extreme Event Models**
  - Links to math sites
  - Reviews of books on event risks
- **Extreme Event Analysis**
  - Never-happen list
  - Rare Events that have happened
  - Competition to analyze rare event scenario

Web Page :http//rmtf.soa.org/rmtf_evn.html

## *Event Risks*

### BENEFITS

- Look at secondary responses to event
- Impact of other driving forces after the event
  - Regulatory responses
  - Demographics
- Correlation analysis of related events
- Increased vulnerabilities as a result of the event
- Development of creative risk mitigation strategies

## *Scenario Analysis*

### DEVELOPMENT

- Developed by military and Royal Dutch/Shell
- Used to develop analyze the impact of political changes in the USSR on oil prices

- References:
  - **The Art of the Long View**, Peter Schwartz
  - *Disarming the Value Killers*, Deloitte & Touche, LLP

## *Systematic Event Risks*

- Event Driven Liquidity Risk
  - General American
  - Executive Life
- Correlations of Risks
  - Equity markets versus credit risks
- Impact of mortality/morbidity events
  - Can policy premiums be raised?
  - Are my reinsurance terms guaranteed?
  - Viatical impact on lapses
- Deflationary recession

## *Mitigation Plans*

- Develop & test liquidity plans
- Early-warning signals
- Develop and test response plans
- Prepare for operational changes after the event
  - Reductions in exposures
- Review function of reinsurance under stress

## *United Nations Threat Analysis* **December 2004**

High Level Panel on Threats, Challenges and Change

a) Examine today's global threats and provide an analysis of future challenges to international peace and security.
b) Identify clearly the contribution that collective action can make in addressing these challenges.
c) Recommend the changes necessary to ensure effective collective action, including but not limited to a review of the principal organs of the United Nations.

- Six Major Threat Groups
  - Social and Environmental
  - War
  - Internal conflict
  - Weapons of mass destruction
  - Terrorism
  - Organized Crime

Web Page ://www.un.org/secureworld/

## *United Nations Threat Analysis* Highlights

- **Threats**
  - Social collapse in Sub-Saharan Africa
  - Rapid Disease Transmission
  - Non-state violence against civilians
  - Supply of nuclear and biological materials
  - Organized crime to support terrorist activities
- **Suggested Response**
  - Improved Public Health system capacity
  - Closer ties to regional security groups
  - Development of early warning systems
  - Moratorium on nuclear facilities
  - Reduction and control of nuclear & biological materials
  - Improved training for mediators

# CS D3: Identification and Analysis of Event Risk

**David Lalonde, FCAS, FCIA, MAAA**

**2005 ERM Symposium**

**May 2-3, 2005**

**Chicago, Illinois**

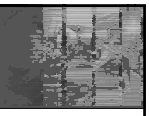
BETTER TECHNOLOGY
BETTER DATA
BETTER DECISIONS

AIR

**www.air-worldwide.com**

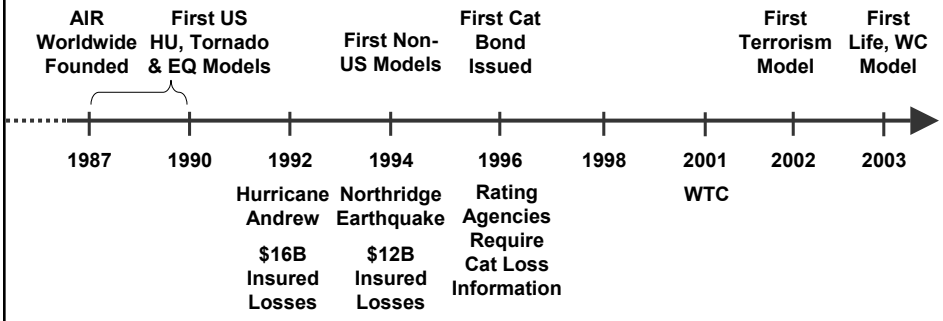
http://www.ermsymposium.org/2005/erm2005/d3_bk.pdf (retrieved 1 May 2016)

## Modeling Extreme Events



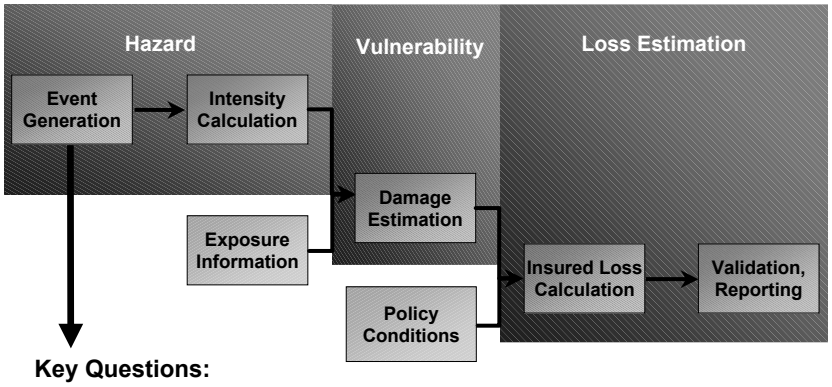
- Extreme event losses are highly variable and are a key driver of enterprise risk profile
- The high severity and low frequency of extreme events are not amenable to estimation via traditional actuarial methods
- Technology, science and engineering allow us to improve dramatically upon traditional approaches
  - Historical loss data is scarce
  - Property values change
  - Repair and replacement costs change
  - New properties continue to be built in areas of high hazard
- Modeling of detailed exposure allows incorporation of actual policy conditions
- Modeling of extreme event risk provides more complete picture of your company's current risk profile and the potential impact on financial results
- Modeling adds stability to the insurance markets

## History of Catastrophe Modeling





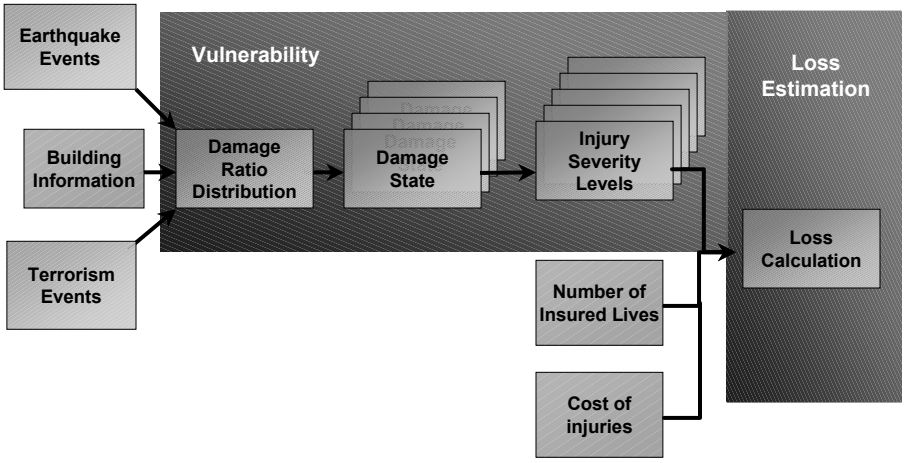

## Catastrophe Model Components




**Key Questions:**

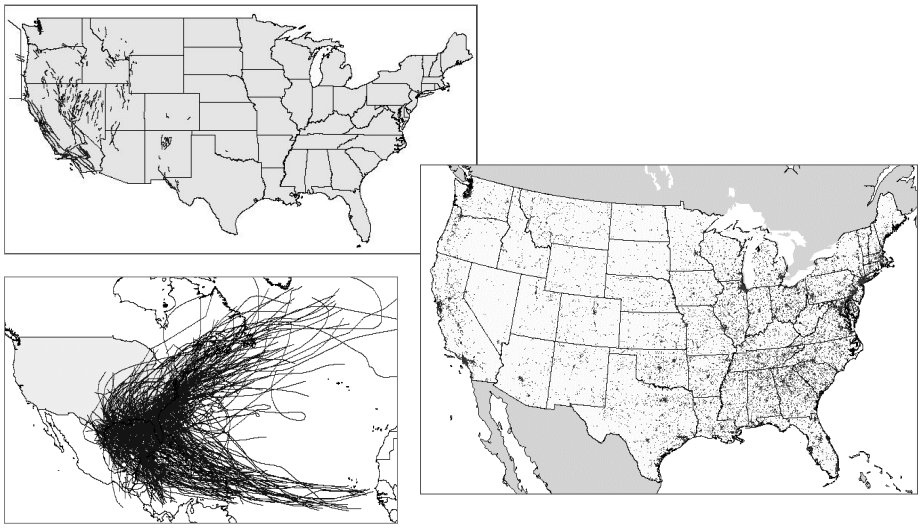
- What?
- Where?
- How big?
- How often?
- How much?

## Components of Injury Related Models






## Where are Future Events Likely to Occur?

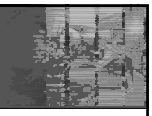


## Assessment of Data Elements for Modeling

- Location details
  - Address information sufficient for geocoding (street address preferable)
  - Number age and sex of insureds at each location
  - For life and accident, both work and home location of insureds
  - For workers' compensation, employee shift (day, evening, night)
- Property physical characteristics
  - Construction type
  - Occupancy type
  - Individual risk characteristics i.e. building height
- Insurance value and terms
  - Expected claim costs
    - Workers' compensation benefits by state and injury type
    - Life and Accident policy face value
    - Disability average payments and duration
  - Deductibles, waiting periods
  - Reinsurance terms



## Example of Augmenting Data



Determine the Location Details

- Utilize public industry databases
  - Identifies individual locations and total insureds per location
  - SIC code for each location

Determine the Structural Characteristics for Modeling

- Utilize detailed property industry database
  - Used for over 15 years by property insurance / reinsurance
  - SIC codes provide defaults for construction, age and height by ZIP Code

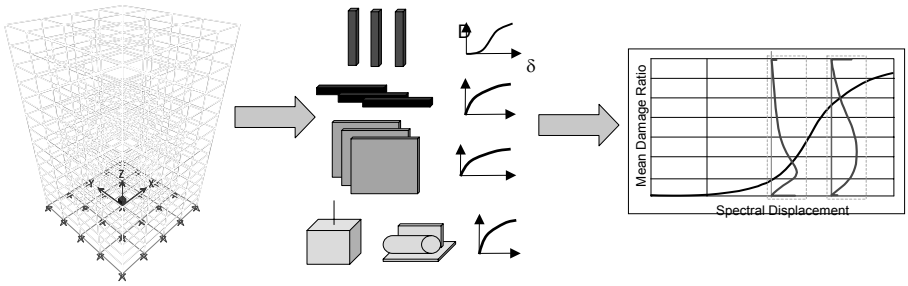
Determine Location by Time of Day

- Industrial occupancy rates vary by time of day
  - 2:00 p.m.: 80%
  - 5:00 p.m.: 50%
  - 2:00 a.m.: 10%

Determine Claims Benefit Structure

- Utilize client provided policy values
- Utilize medical cost data

## Estimating Earthquake Damage



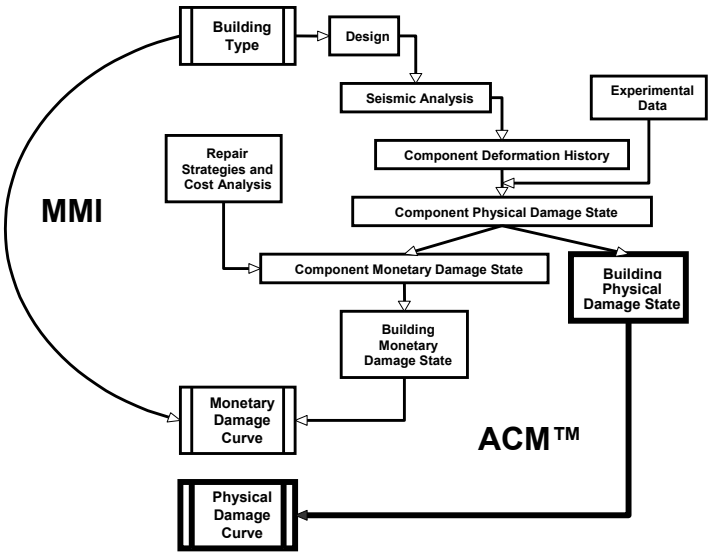

**Create engineering models.**

**Assess vulnerability at the component level.**

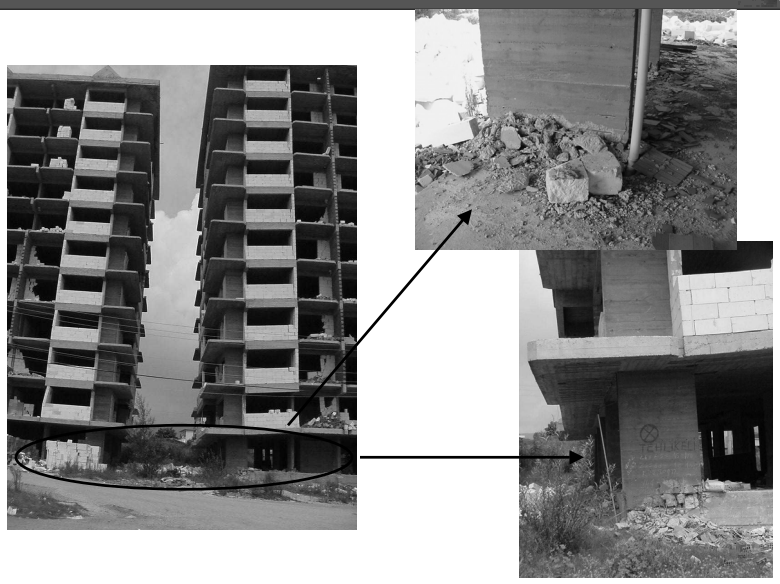
**Assemble composite damage function for the building.**



## Calculating Physical Damage from Earthquake Events



## Physical Damage versus Monetary Damage



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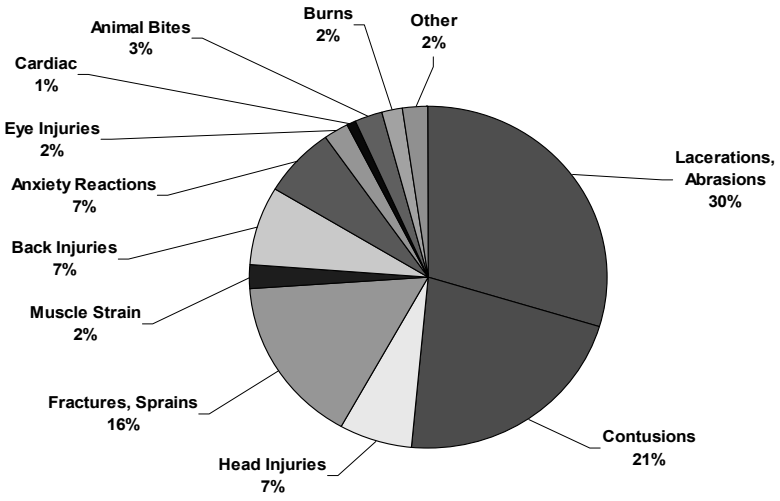
## Typical Injury Types from Earthquakes

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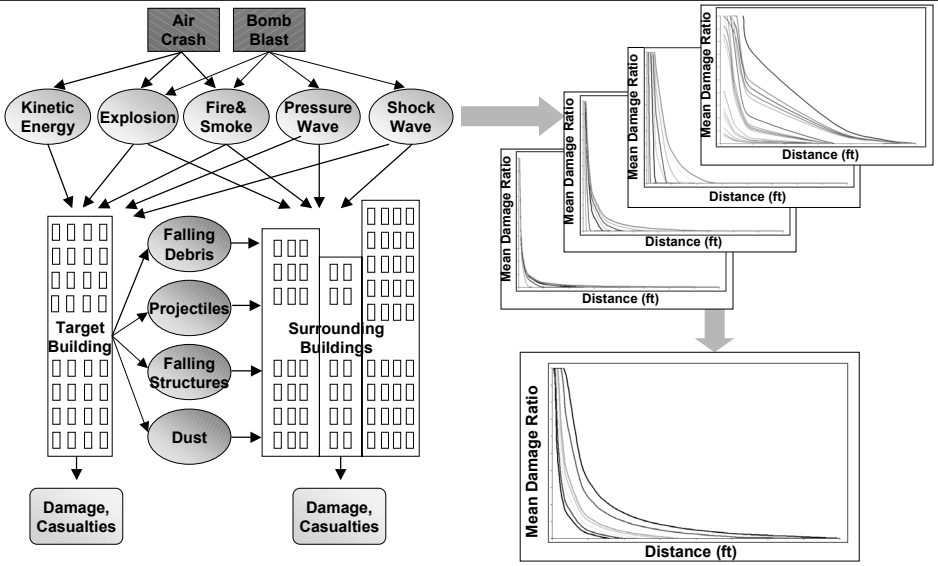
## Damage and Casualty Estimates Consider Multiple Effects on the Target and Surrounding Buildings

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## Damage States for Conventional Attacks: Oklahoma City Bombing


- Collapse
- Extensive Damage
- Moderate Damage
- Slight Damage

F: Fatality

I: Injury

**Murrah Building**

- 45% Fatality
- 46% Injury
- 9% Uninjured

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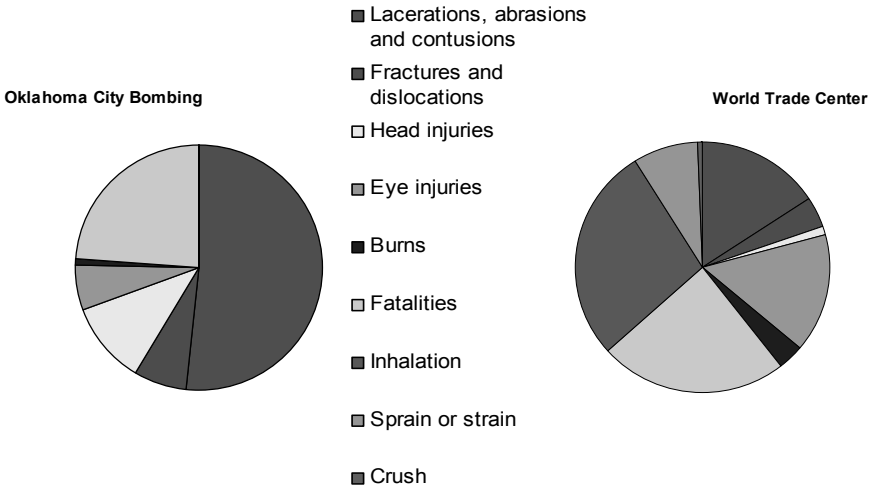
## Typical Injury and Fatalities from Conventional Attacks

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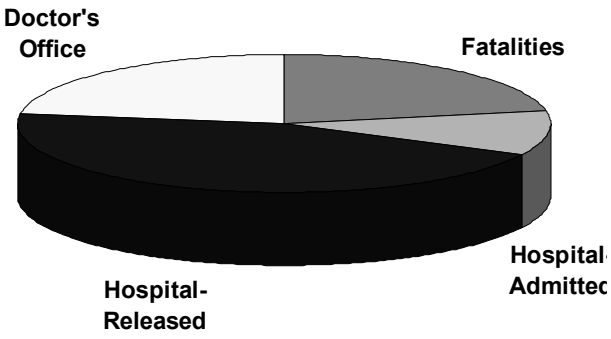
## Triage Figures from Oklahoma City Bombing

Oklahoma City Bombing, 1995




*Sources: Mallonee, S., et al, "Physical Injuries And Fatalities From The Oklahoma City Bombing"*
*Severance, Harry W, MD, FACEP. "Mass Casualty Victims 'Surge' Management"*

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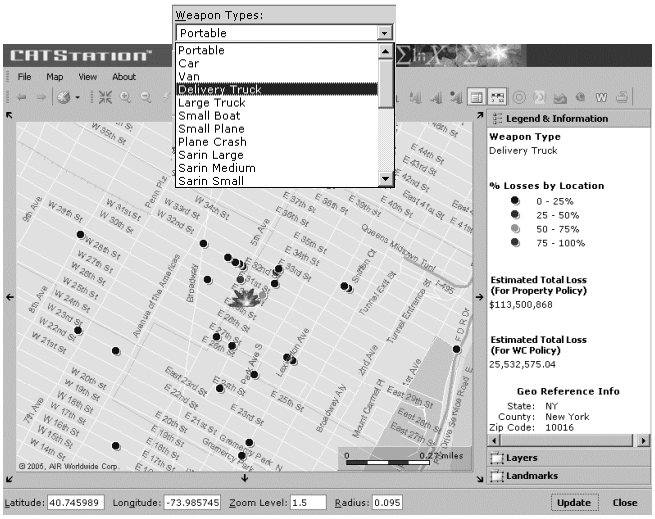
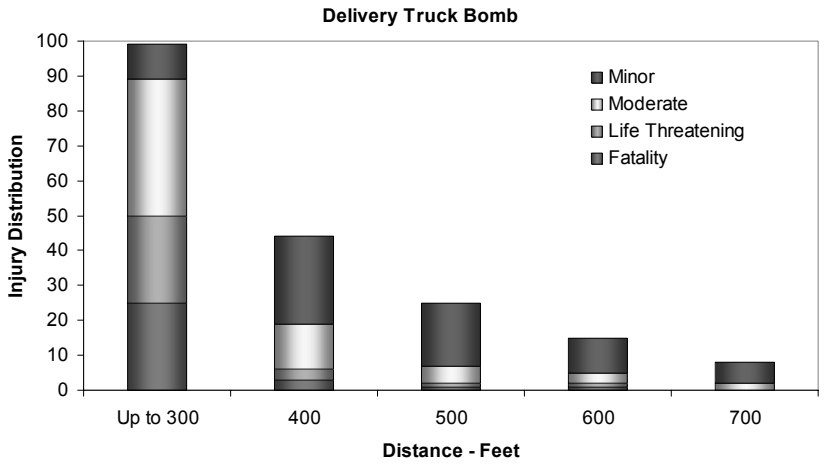
## Injury Severity Profile for Delivery Truck Bomb



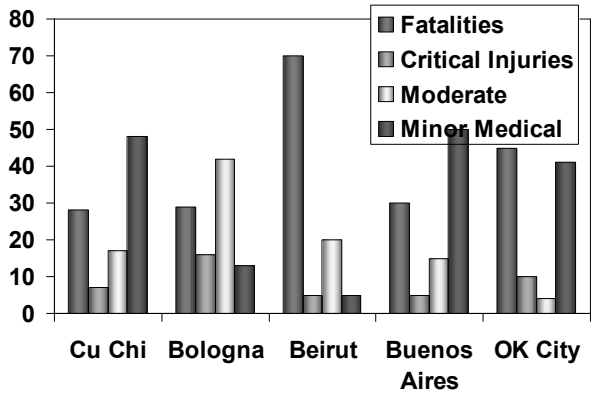



## Injury Severity Profiles for Delivery Truck Bomb



## Detailed Analysis of Building Collapses in Major Terrorist Bombings

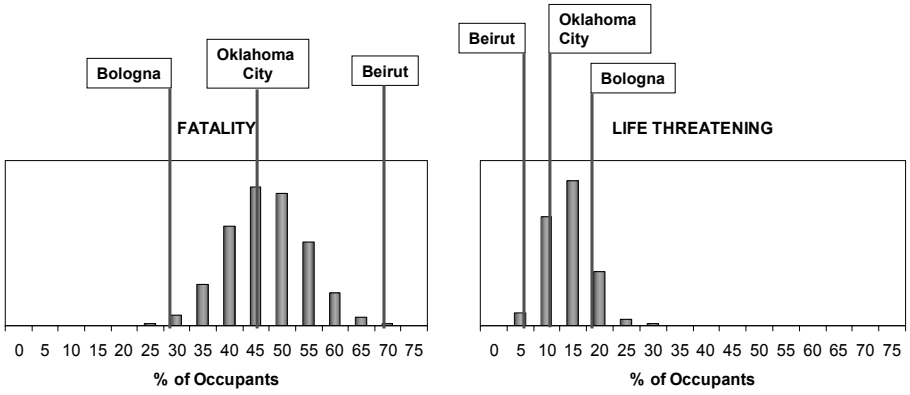
**Beirut Marine Barracks Bombing**
Photo from **Marines Magazine,** November, 1993



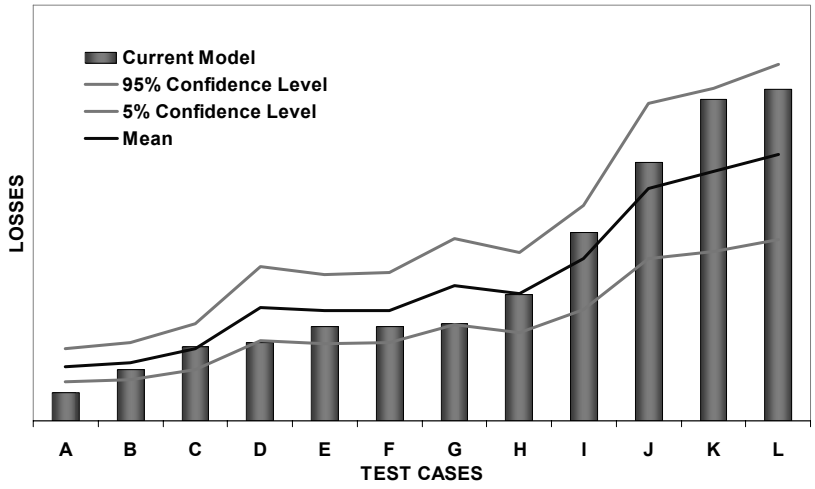

Source: Frykberg, Eric R, MD, FACS. "Medical Management Of Disasters And Mass Casualties From Terrorist Bombings: How Can We Cope?"



## Estimated Injury Severity Distributions for Collapsed Building



## Results of Sensitivity Analysis





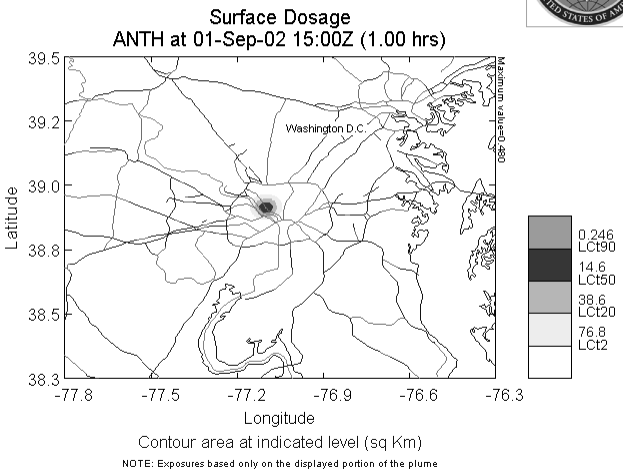

## Calculating Damage and Injuries from CBRN Attacks

- Physical damage state not relevant for CBRN attacks
- DOD's Hazard Prediction and Assessment Capability (HPAC) Model for CBRN Events
- Event simulation
  - Full spectrum of CBRN
  - Accurately predicts the effects of hazardous material releases
  - Embedded climatology and historical weather data
  - Terrain data and supporting wind-flow models calculate the local windfield
- Model output
  - Fatality rate contours
  - Contaminant concentration levels over time and distance

## Simulated Losses from a CBRN Attack

Anthrax Aerosol Dispersion

- 3,144 fatalities
- 250,811 injuries




## Typical Injury Types from CBRN Weapons
## *Sarin Attack - Tokyo Subway, March 20, 1995*

- 12 killed
- 5,122 injured
- 984 severe to moderate poisoning

- Types of injuries
  - Miosis
  - Headache
  - Dyspnea
  - Nausea
  - Ocular pain
  - Blurred vision
  - Vomiting
  - Coughing
  - Muscle weakness
  - Cardiac arrest
  - Respiratory arrest
  - Post-traumatic stress disorder

*Source: Intensive Care Medicine. 1995: 21:1032-1035.*

## Sample Severity Calculation

- The expected duration of injuries simulated by the model is used to determine if disability payments will result
- Disability payments begin after a number of days away from work
  - Short term disability provides benefits for 13 to 26 weeks
  - Long term disability picks up when short term benefits expire, and continues for an extended period of time
- Average ultimate disability claim cost = expected claim duration x average monthly payment
- Expected claim duration is developed from a claim continuance table

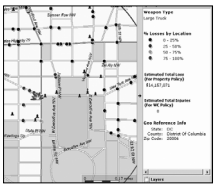
| Sample Reserve Factors per $1 Monthly Indemnity | | | |
|---|---|---|---|
| **Elimination Period** | | **14 days** | |
| **Sex** | | **M** | |
| **Age at disability** | | **35** | |
| | **Benefit Period** | | |
| **180 day** | **2 Year** | **5 Year** | **to Age 65** |
| 4.11 | 9.89 | 15.07 | 21.39 |



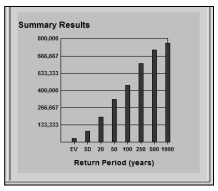
## Managing Life and Personal Accident Risk

- Where are our exposure concentrations the greatest?
- How close are we to any potential terrorist targets?

- What are our losses if a terrorist attack occurs in a certain location?
- What are our losses from a repeat of the 1906 San Francisco earthquake?



- How do we price or evaluate earthquake insurance?
- How do we quantify our total risk to terrorism?

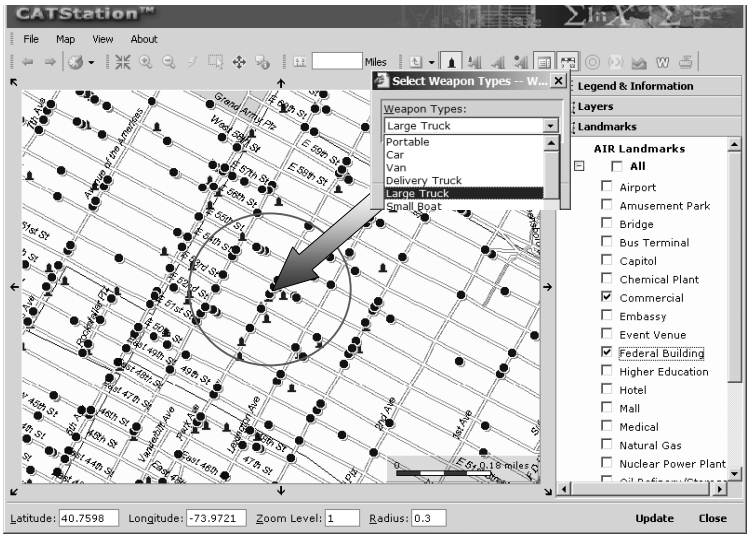


## Measuring Exposure Concentrations

- Defining exposure
  - Number of Locations
  - Number of Employees
  - Total Replacement Value
  - Total Insured Value
  - Number of Landmarks
  - Net Insured Value
- Select Boundary
  - State
  - County
  - Postal Code
  - Landmark Ring
  - Location Ring



## Identifying Exposure Concentrations and Proximity to Potential Targets



## Simulated Losses from Midtown Manhattan Delivery Truck Bomb

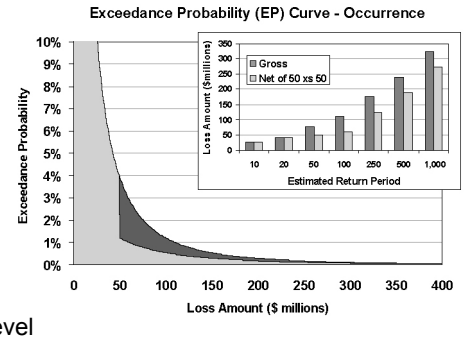
- Delivery truck bomb
- 80,000 workers in surrounding area
- Expected 25,000 casualties (workers)
  - 2,500 fatalities
- $4-5 billion workers' compensation loss
- $187M in group life losses
- $3-4 billion total property loss
  - 29 buildings affected



## Probabilistic Portfolio Analysis

## Results of the Catastrophe Models

- Event by event loss information
- Probability distribution of losses (EP curves)
- Annual aggregate losses
- Annual occurrence losses
- Industry and company specific
- Direct, ceded and net retained
- Loss costs
- Large losses, historic losses
- Number of injuries by severity level
- Structural flexibility
  - Location, policy, zone, territory, portfolio levels
  - Foreign vs. domestic sources, conventional vs. CBRN attacks






## Evolution of Catastrophe Modeling

- Originally, models were used to help insurers and reinsurers assess the price and structure of reinsurance contracts
- Today, models are integrated into companies operations and form the basis of sound risk management practices
  - Assess companies' risk profile
  - Ensure companies collect adequate premium
  - Manage exposures
  - Evaluate underwriting guidelines
  - Assess the feasibility and credits of mitigation strategies
  - Price various risk transfer strategies
  - Analyze the risk in securitizations of insurance risk
  - Assess aggregate exposure in mergers and acquisitions
  - Manage the correlation within portfolios of reinsurance contracts
  - Relied on by rating agencies and investors
  - Input to underwriting and enterprise risk management models

## Summary

- Catastrophe models have been successfully extended to life and personal accident insurance
- Ongoing improvement in the level of detailed data being collected to deal with accumulation exposures throughout the insurance industry
- Data augmentation methods are available to supplement incomplete data
- Companies are managing their catastrophe risk by monitoring concentrations of exposure and performing deterministic and fully probabilistic analyses

# Identification and Analysis of Event Risk

## Techniques for Assessing Terrorist Risks and Their Application

**Bryan S. Ware**
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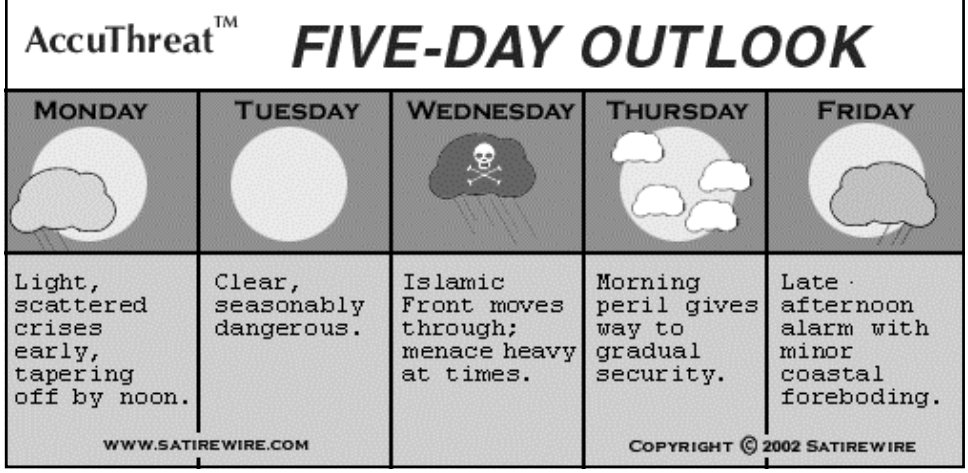
## What We Do (*and why are we here?*)

- Digital Sandbox Is an Enterprise Software Company Focused on Security Risk Management
- For National Security Organizations:
  - Prioritization of assets most likely to be targeted or most essential to national economy and security
  - Prioritization of potential terrorist threats and possible events
- For Governments:
  - Resource allocation among portfolios of potential terrorist risks
- For Asset Owners:
  - Management of day to day security operations
  - Cost-benefit analysis of security investments

## Wishful Thinking

- The absence of a major terrorist event is evidence of zero threat




## Probability Continuum

- Impossible
- Possible
- Plausible
- Likely
- Probable
- Certain

*Our work focuses in this region*

Our methodology seeks to provide a structure and metrics for prioritizing events for which there is high uncertainty and little history.

## A Framework for Modeling Terrorist Risk

- The Focus Is to Efficiently Allocate Resources Across Known, Historical Security Issues and Potentially High Consequence Future Events
- Prioritization of Assets: *Criticality, Desirability, Accessibility*
- Prediction of Future Events: *Time, Weapons, Tactics, Organizations*
- Assessment of the Consequences of Those Events
- Development and Stress Testing of Risk Mitigation Strategies

## Methodology (Rationale)

- Complex decisions are made by breaking problems down into smaller chunks that are more readily understood and bounded. Experts, anecdotal evidence, simulations, and even data are available when the chunks are small enough.
- Strategic and value decisions are made by considering cognitive or domain relationships (Aristotle's "Concept") which are unique to each individual and may have complex dependencies and structure.
- The physical world (Aristotle's "Substance") can be readily and unambiguously described through inheritance. Understanding of the physical world is necessary for detailed and tactical decision making and the assessment of physical phenomenology.

## The General Approach

- Bayesian Risk Metrics Represent the Degree of Belief That a Threat is Plausible, for example. (*vs. a frequentist approach that represents the ratio of events to non-events*)
- Analytic Foundation is Dynamic, Object-Oriented Bayesian Networks
  - Substance: World Object Model
  - Concept: Domain Object Model
  - Drivers: Composable Risk Influence Networks (RIN)
- The Domain Model and RIN Implicitly Represent Causality
- Expert Judgment Is Used Where Appropriate (And Essential)
- Risk = $f$ (Likelihood, Susceptibility, Consequences)

## Competitive Advantages of Security Event Risk Management

- Efficient Resource Allocation
  - Put the money behind the hazard
  - Avoid business risks
  - Receive federal assistance for key risks
- Manage Legal and Regulatory Exposure
  - Pro-action trumps the security mandate
  - “duty of care” vs. “force majeure”
  - “attractive nuisance” vs. “unwitting accomplice”

## What The National Security Community is Learning from the Financial Community

- Credit Ratings/expected Default Frequencies = Model for Rating and Ranking Commercial Critical Infrastructure
- Price/Volatility Indices = “Indications and Warnings (I&W)”
- VaR and Economic Capital = Other Threat Metrics
- Fusion of Unconventional, Commercially Available Data Into Intelligence Assessments

## What The Financial Community Might Learn from the National Security Community

- Benefits of Explicit Modeling of Causality
- Possible Solutions Where Historical Data is Sparse or Unrepresentative of the Future
- Systematic Approaches to Generation of Stress Test Scenarios
- Elicitation and Representation of Expert Judgment
- Bridging of Expert Judgment and Model / Objective Data
- Better Modeling of Integrated Enterprise Risk and Associated Optimization of Limited Resources/Capital

# Observations and Conclusions

- Certain Events Are Not Amenable to Traditional Methods
  - Methods that represent a combination of data and expert judgment are key to understanding
- Modeling of Causality Provides Insight into Risk Drivers and Correlation
  - Enables true *enterprise* risk management programs
- Traditional Scenario Modeling and Worst Case Modeling May Provide Misleading Results
  - Ensure that scenarios don't represent a pre-filter on possibilities and that second (and nth) order effects are considered in loss calculations

**Back-up**
**Overview of Simple Bayesian Network**

# Bayesian Network Basics

*Conditional Probability*

**P(A | B) = X => Given the event B, the Probability of A is X**

*Bayes Rule*

$$P(B \mid A) = \frac{P(A \mid B)\,P(B)}{P(A)}$$ **=> The Probability of B given A is equal to the Probability of A given B times the Probability of B, divided by the Probability of A**

*Parameters of Interest and States*

**A = The chance of rain**

**States = High ($a_1$), Medium ($a_2$), Low ($a_3$)**

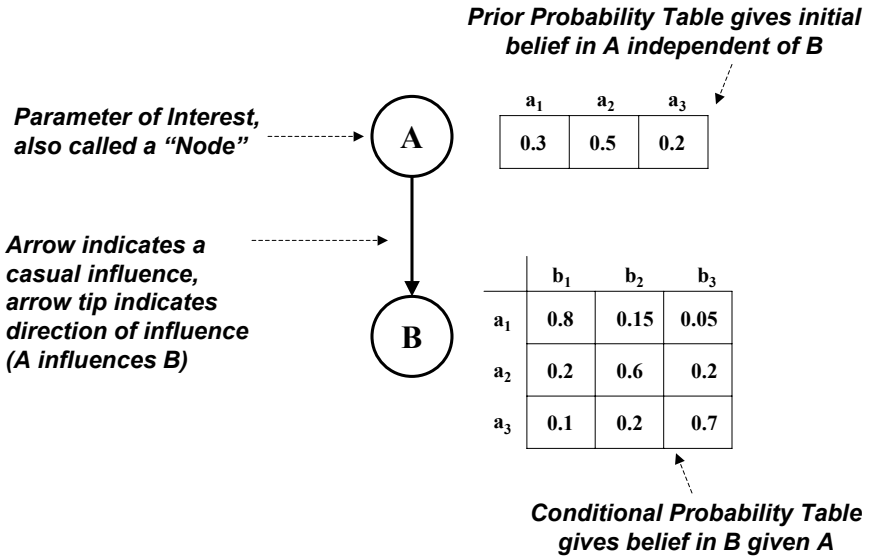
**B = The chance you'll carry an umbrella**

**States = High ($b_1$), Medium ($b_2$), Low ($b_3$)**

*Conditional Probability Table*

| | $b_1$ | $b_2$ | $b_3$ |
|---|---|---|---|
| $a_1$ | 0.8 | 0.15 | 0.05 |
| $a_2$ | 0.2 | 0.6 | 0.2 |
| $a_3$ | 0.1 | 0.2 | 0.7 |

# Simple Bayesian Network




| $a_1$ | $a_2$ | $a_3$ |
|---|---|---|
| 0.3 | 0.5 | 0.2 |

| | $b_1$ | $b_2$ | $b_3$ |
|---|---|---|---|
| $a_1$ | 0.8 | 0.15 | 0.05 |
| $a_2$ | 0.2 | 0.6 | 0.2 |
| $a_3$ | 0.1 | 0.2 | 0.7 |

# Example Bayesian Risk Influence Network