Catastrophic Risk and Reinsurance

Modeling and Data Issues

Actuaries' Club of Hartford/Springfield
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Agenda

I. History of Cat Modeling

II. Use of P&C concepts to look at A&H risks

III. How reinsurers are modeling A&H risks

IV. Model outcomes and reinsurance rates

V. A&H data issues

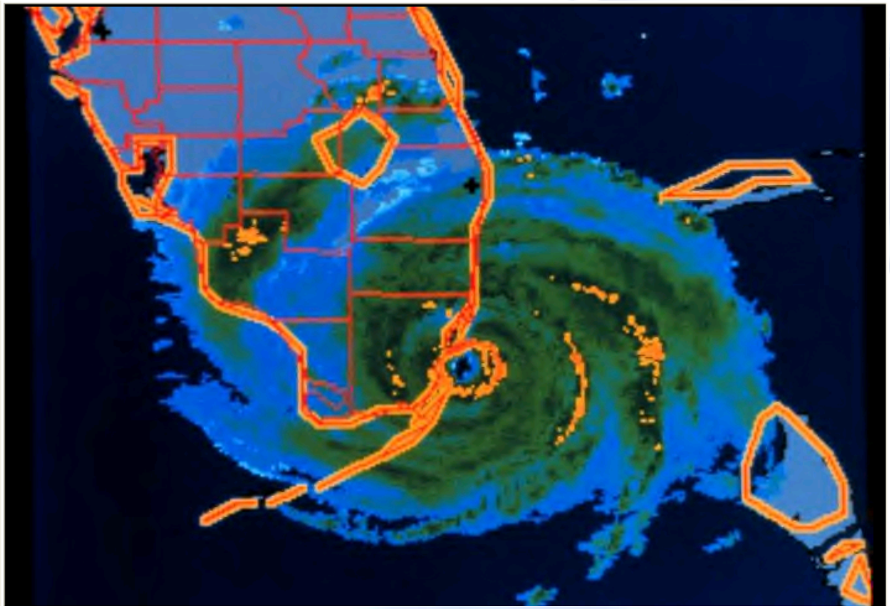
VI. Corporate risk limits

History of catastrophe modeling - Entrance of catastrophe modeling techniques

- First sophisticated, computer-based, catastrophe loss simulation technique developed in 1987 (AIR)
- Alternative to standard actuarial or "rule of thumb" approaches to project catastrophe losses
- Since 1987, catastrophe models have been embraced by insurance industry to project potential large losses as well as expected annual losses
  - ✓Estimated large loss potential – used in reinsurance purchase decision making
  - ✓Expected annual losses – used in insurance policy rating

History of catastrophe modeling – Hurricane Andrew

- The largest event loss was Hurricane Andrew of 1992
- Andrew caused $16 billion of insured losses
- Normalized for inflation and population growth to 2000 levels, the loss was over $24 billion



History of catastrophe modeling – Hurricane Andrew

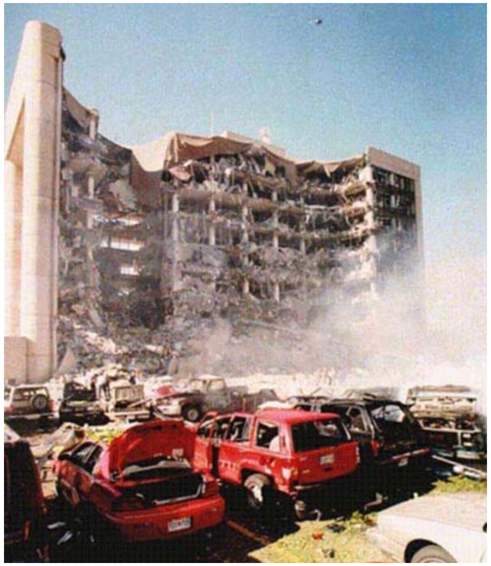
- 7 insurance companies went insolvent
- Many companies started non-renewing policies, attempting to withdraw from the state
  - Loss potential was too large
  - Rates not adequate to cover losses of this magnitude not previously contemplated

History of catastrophe modeling – Projecting future losses

- Historical loss data not reflective of current exposure:
  - ✓Increase in property values in Florida
  - ✓Increase in cost of repair and replacement
  - ✓Changes in building material and design
  - ✓New designs have different vulnerabilities
  - ✓More properties in highly vulnerable coastal locations
- Standard actuarial techniques to project hurricane catastrophe losses are inappropriate due to lack of significant historical loss data

History of catastrophe modeling – World Trade Center

New York City, NY
World Trade Center
Al Qaeda
September 11, 2001



Oklahoma City, OK
Alfred P. Murrah Federal Building
Timothy McVeigh
April 19, 1995

History of catastrophe modeling – WTC Insured Losses

- $32.5 billion total estimated insured loss
  - $9.6 billion Property
  - $1.8 billion Workers' Compensation
  - $1.0 billion Life
  - $11.0 billion Business Interruption
  - $4.0 billion Aviation Hull & Liability
  - $5.0 billion Other Liability & Event Cancellation
- Largest loss from a single "event" for each of these lines
- Does not include $7 billion in death and disability payments related to the attacks
- Loss could increase by $1.1 billion based on court ruling on insurance coverage

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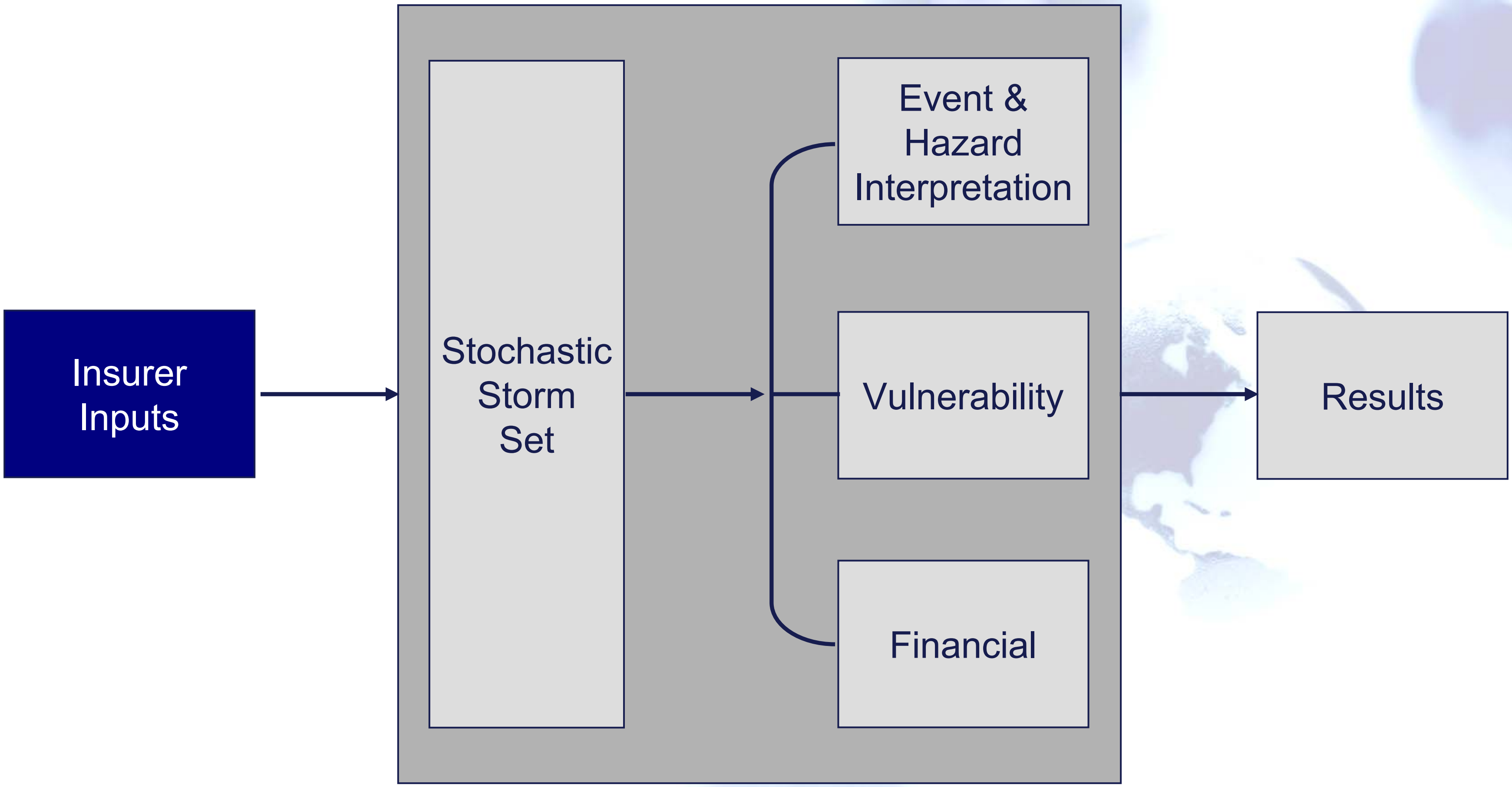
Catastrophe modeling process



Insurer inputs - general

Location

- State
- County
- ZIP Code (5 or 9 digit)
- Street Address

Policy

- Line of Insurance
- Coverage Limits
- Deductible(s)
- Written Premium
- Co-Insurance

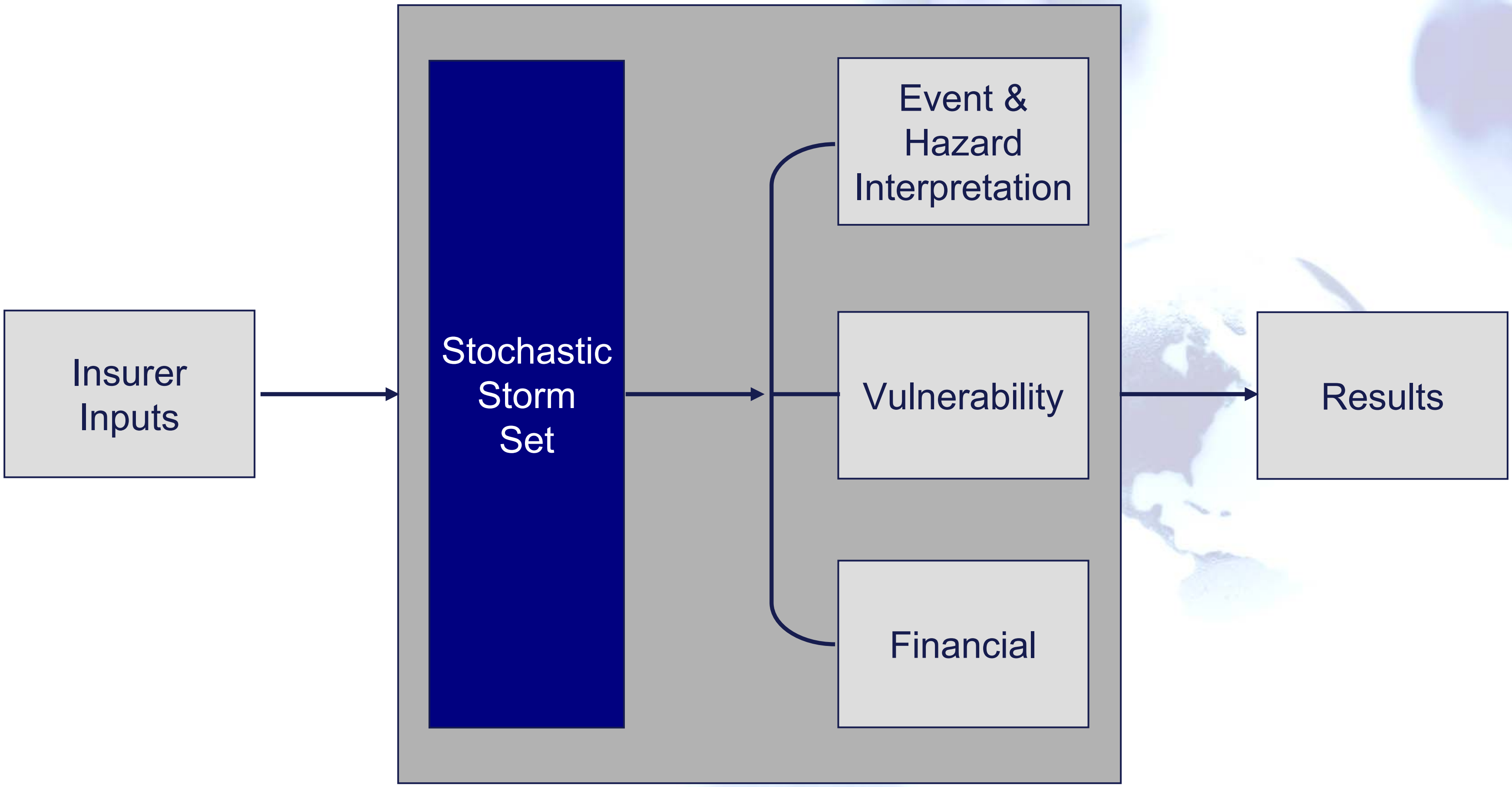
Structural

- Replacement Value
- Construction Type
- Year of Construction
- Height
- Occupancy

Reinsurance

- Type (FAC, XPR, XOL, Per Occ.)
- Retention
- Limits
- Pro-Rata Coverage

Catastrophe modeling process

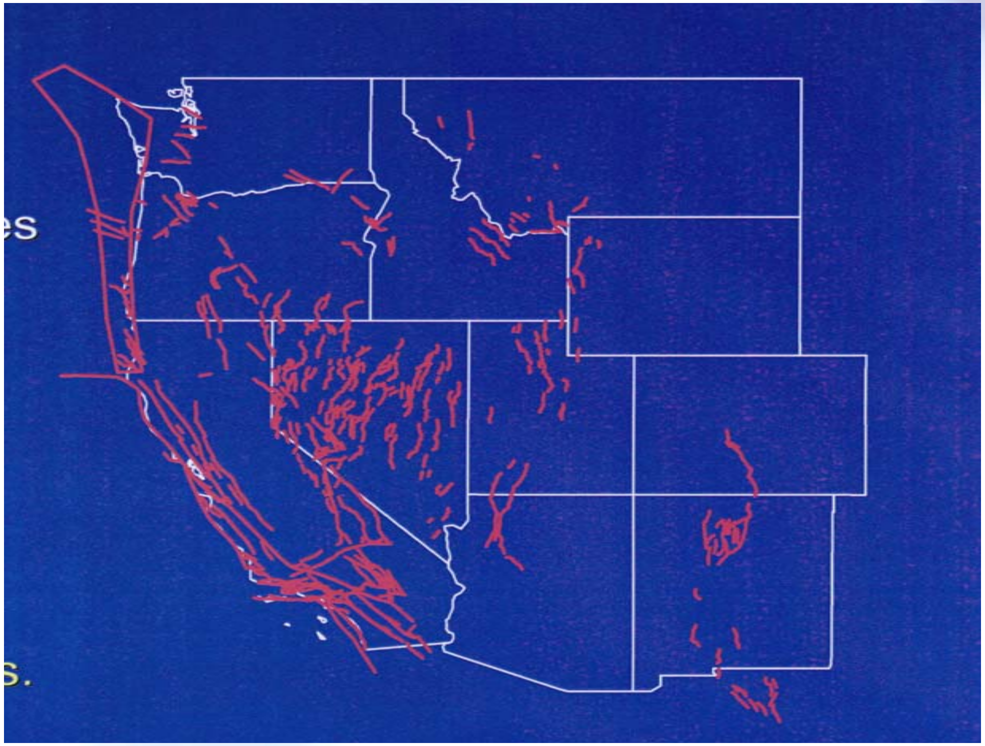


Stochastic event set - earthquake

Hypothetical events generated from known faults

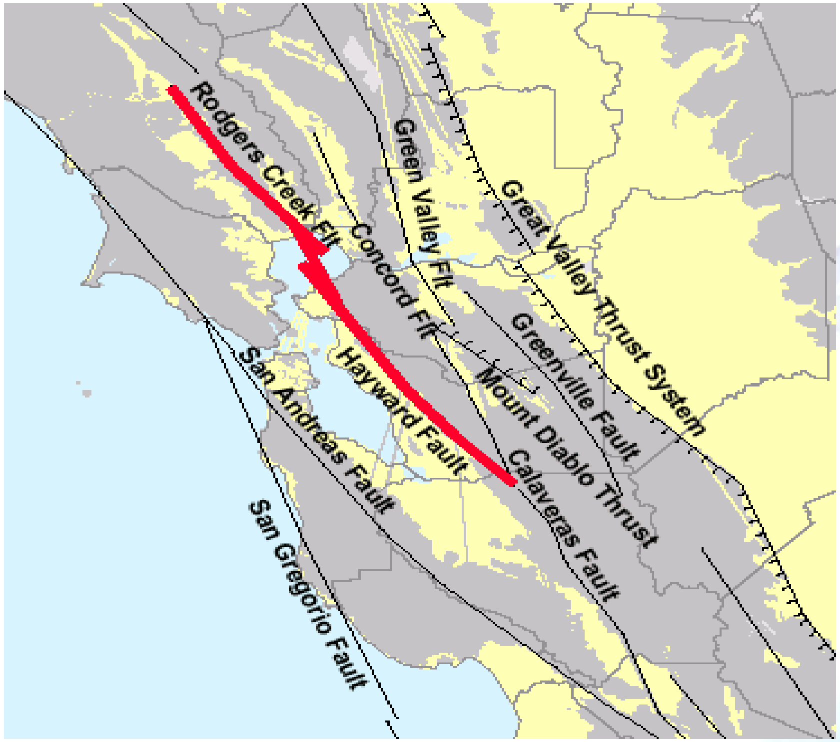
Regions

- California
- New Madrid
- Pacific Northwest
- Northeast
- Southeast
- Great Basin



Stochastic event set - earthquake

Line source



Area Source

Stochastic event set – Terrorism

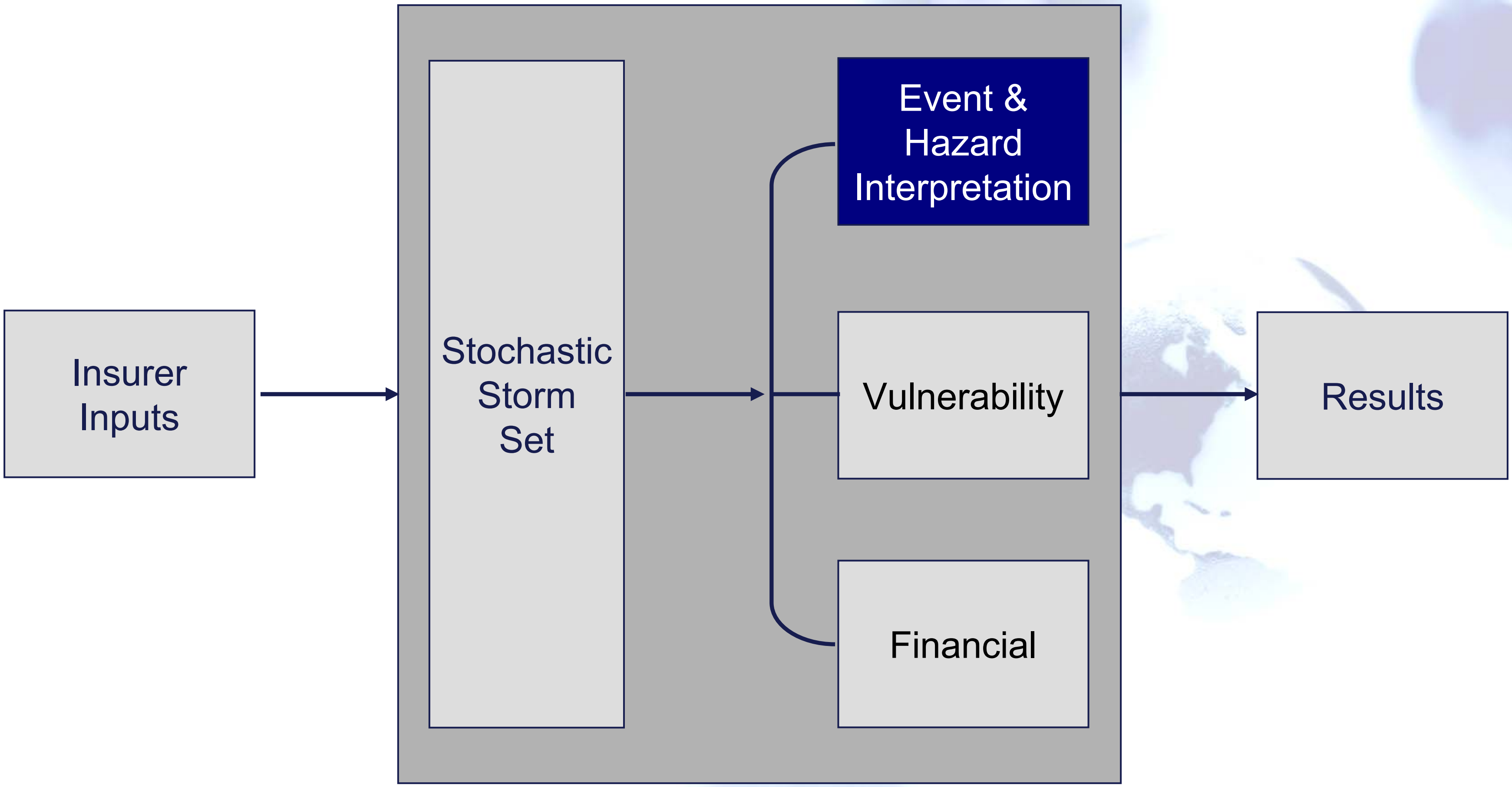
- **Conventional**
  - Bombs
    - Portable
    - Car
    - Van
    - Delivery Truck
  - Airplane Crash
    - General Aviation
    - Large Commercial Airliner
- **CBRN**
  - Chemical
    - Sarin
    - VX Nerve
  - Biological
    - Anthrax
    - Small Pox
  - Radiological
    - Cesium 137
    - Cobalt 60
  - Nuclear
    - Suitcase type
    - Medium
    - Large

Stochastic event set – Terrorism

Frequencies

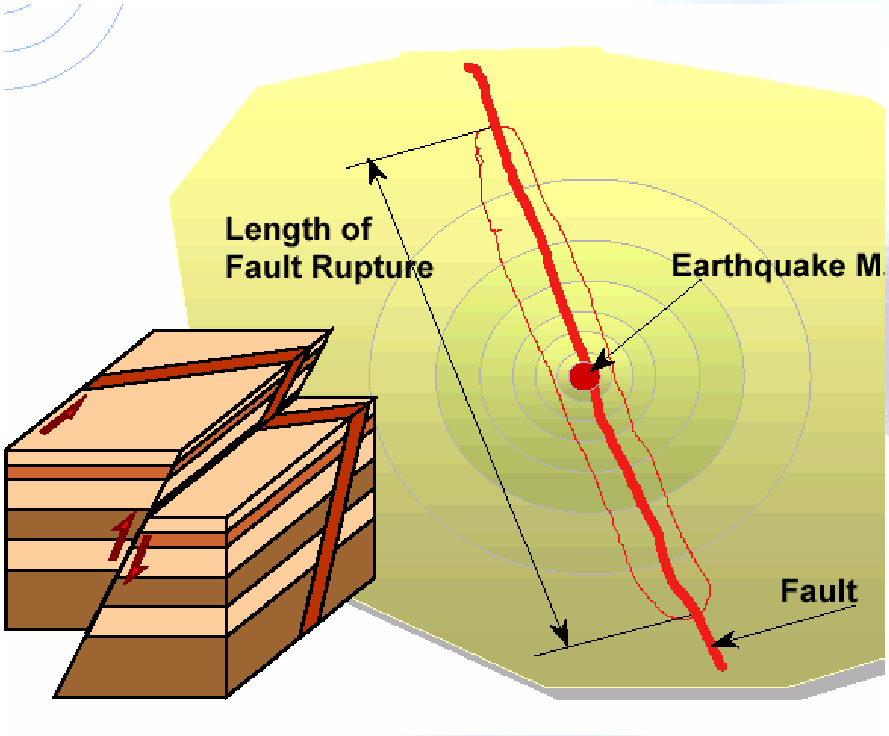
- Each attack type is assigned a frequency based on the terror group, city/location of event, and current threat level
- Terror groups have certain motives and capabilities that make it more or less likely to utilize a certain attack type at a location or city in the U.S.
- Probabilities are largely subjective based on expert opinion and rigorous statistical analysis such as Game Theory, Markov Chain, Delphi Method, etc.

Catastrophe modeling process



Earthquake - Ground motion

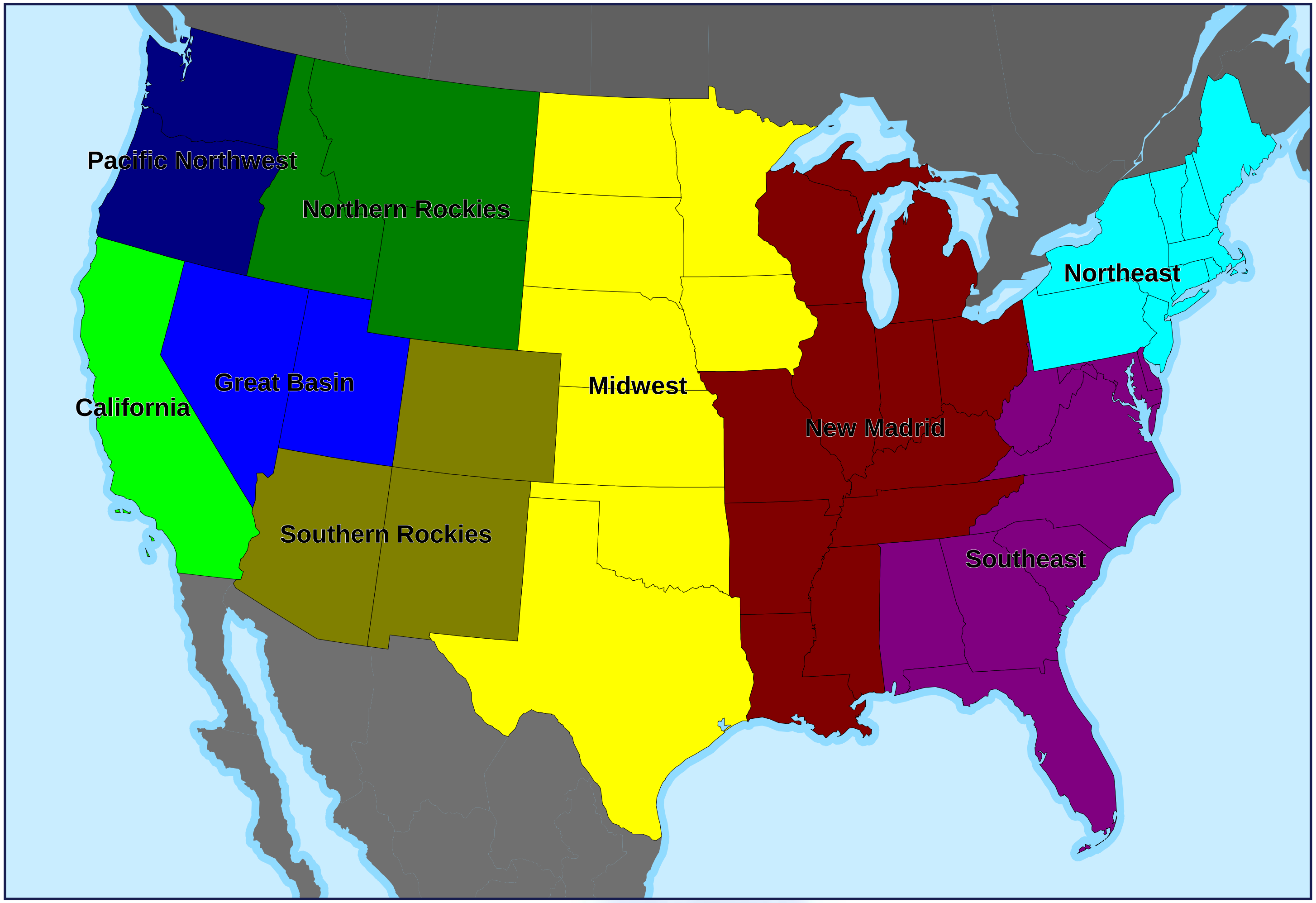
Ground Shaking “attenuates” from the source of event and dissipates as it moves away from the source



Earthquake - Landslide and liquefaction

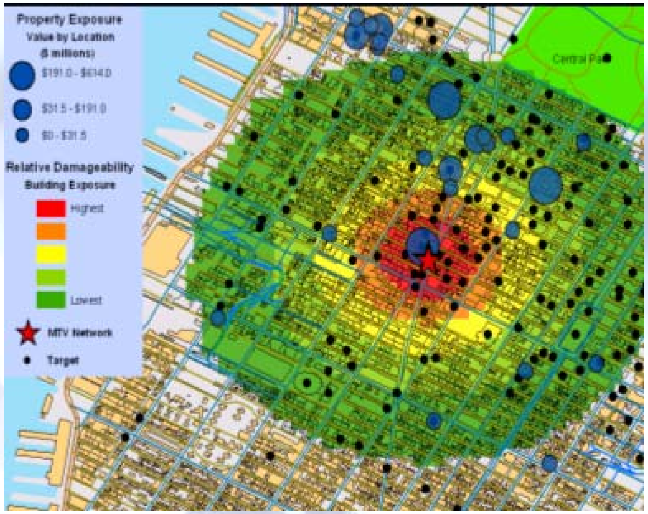
Simulated as collateral damage and based on the soil type at the location and the ground slope

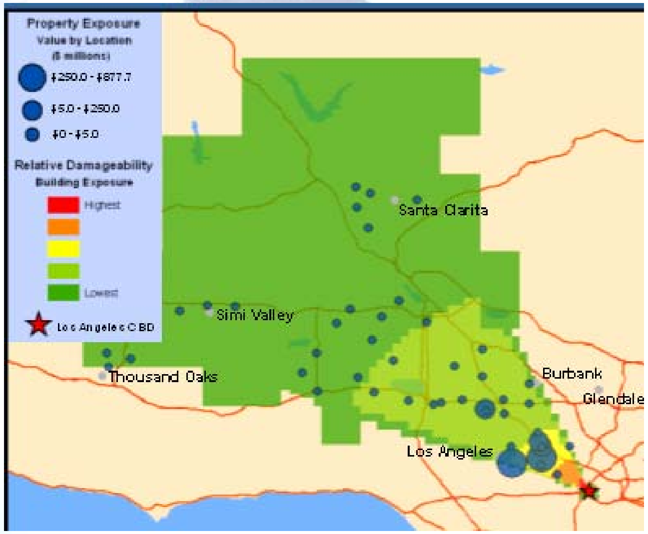
Earthquake regions



Terrorism – Area of impact by type of attack mode

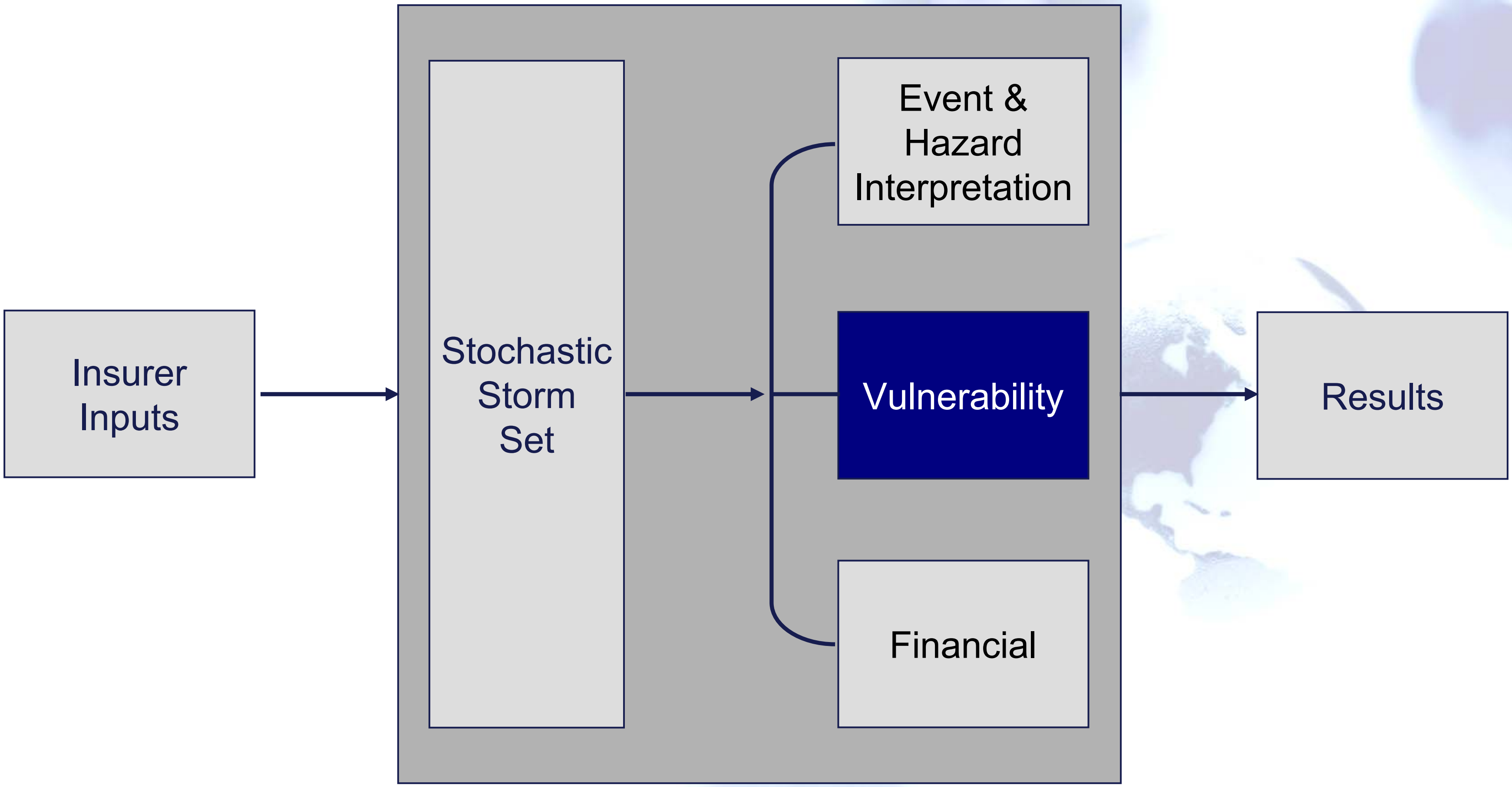
- Event hazard and interpretation for terrorism events are dependent on the type and size of attack mode
- Conventional events have more empirical data for interpretation of impact
- CBRN events are highly dependent on expert opinion for interpretation of impact





Graphics - RMS

Catastrophe modeling process



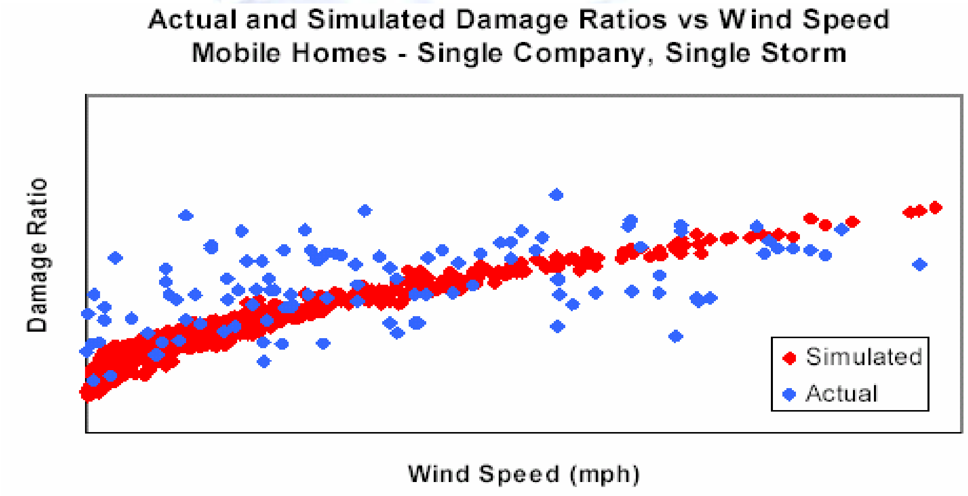
Damage/vulnerability functions

- Interaction of buildings (structural and non-structural components) to the shake intensity or bomb impact
- Expected damage expressed as a percent of the replacement cost value of the structure
- Varies by structural type – wood frame, masonry, etc.
- Uses insurer inputs of the building location, value and structural characteristics to determine damage level

Vulnerability

Based on four sources of information:

- Engineering research
- Structural tests (i.e., wind tunnels)
- Expert opinion
- Actual loss data



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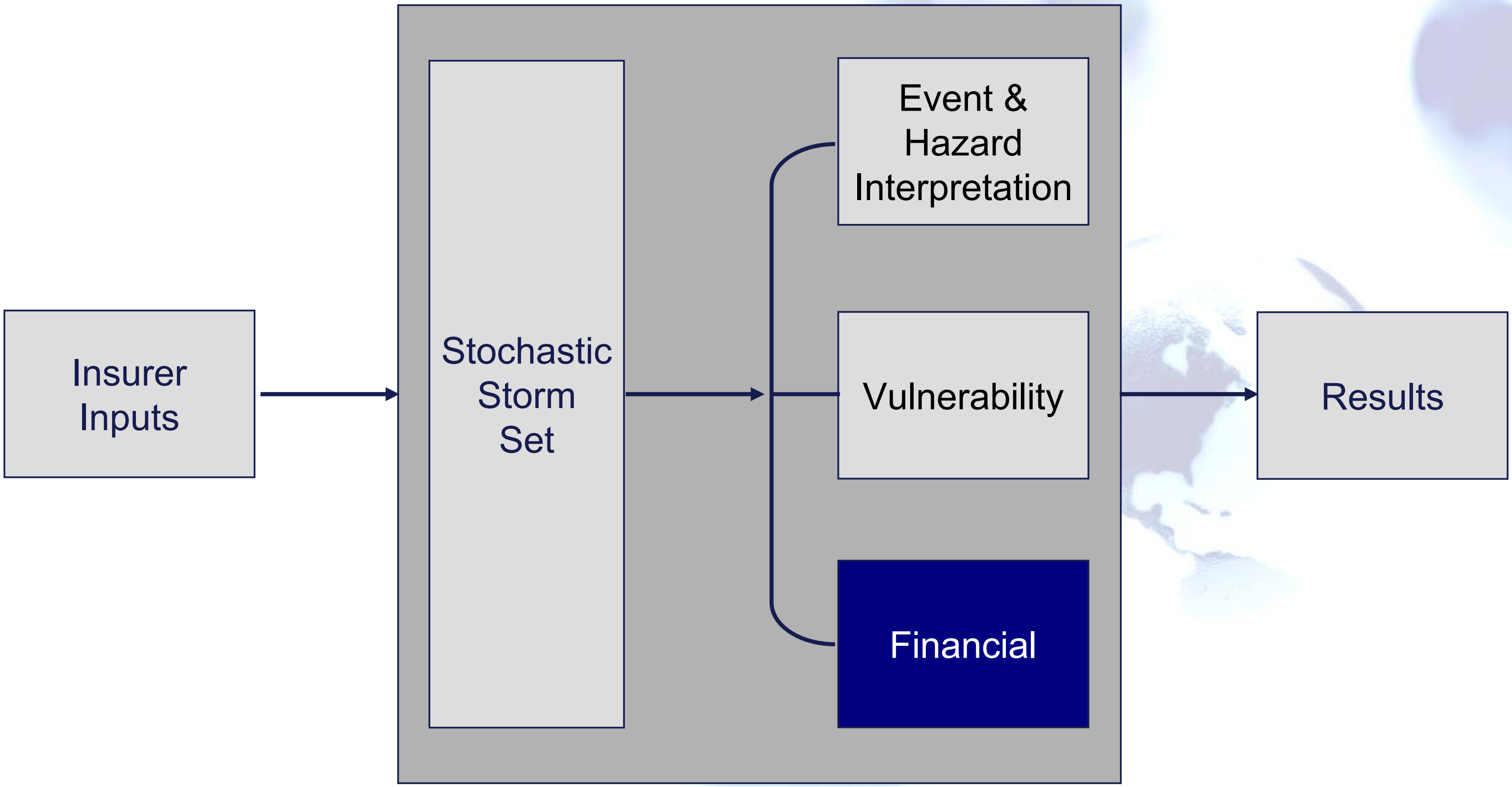


Uncertainty in modeling

Primary Uncertainty

- Uncertainty due to the number or type of events that may occur
- Whether or not an event will occur
- Which event it will be
- There could be none, or there could be more than one

Secondary Uncertainty

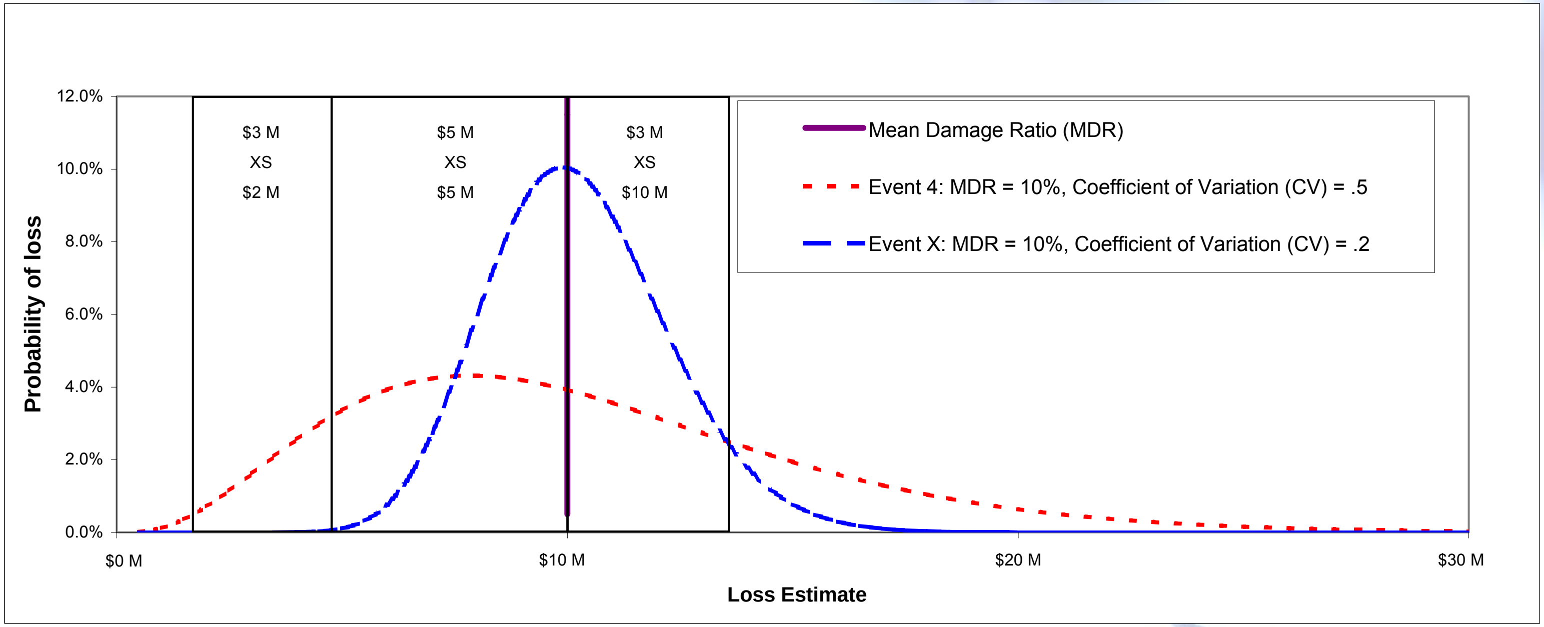
- Uncertainty in the amount of loss

Uncertainty in modeling

Very Similar Risk Characteristics - Significantly Different Damage

1964 Ni'igata earthquake in Japan

Distribution through financial perspectives



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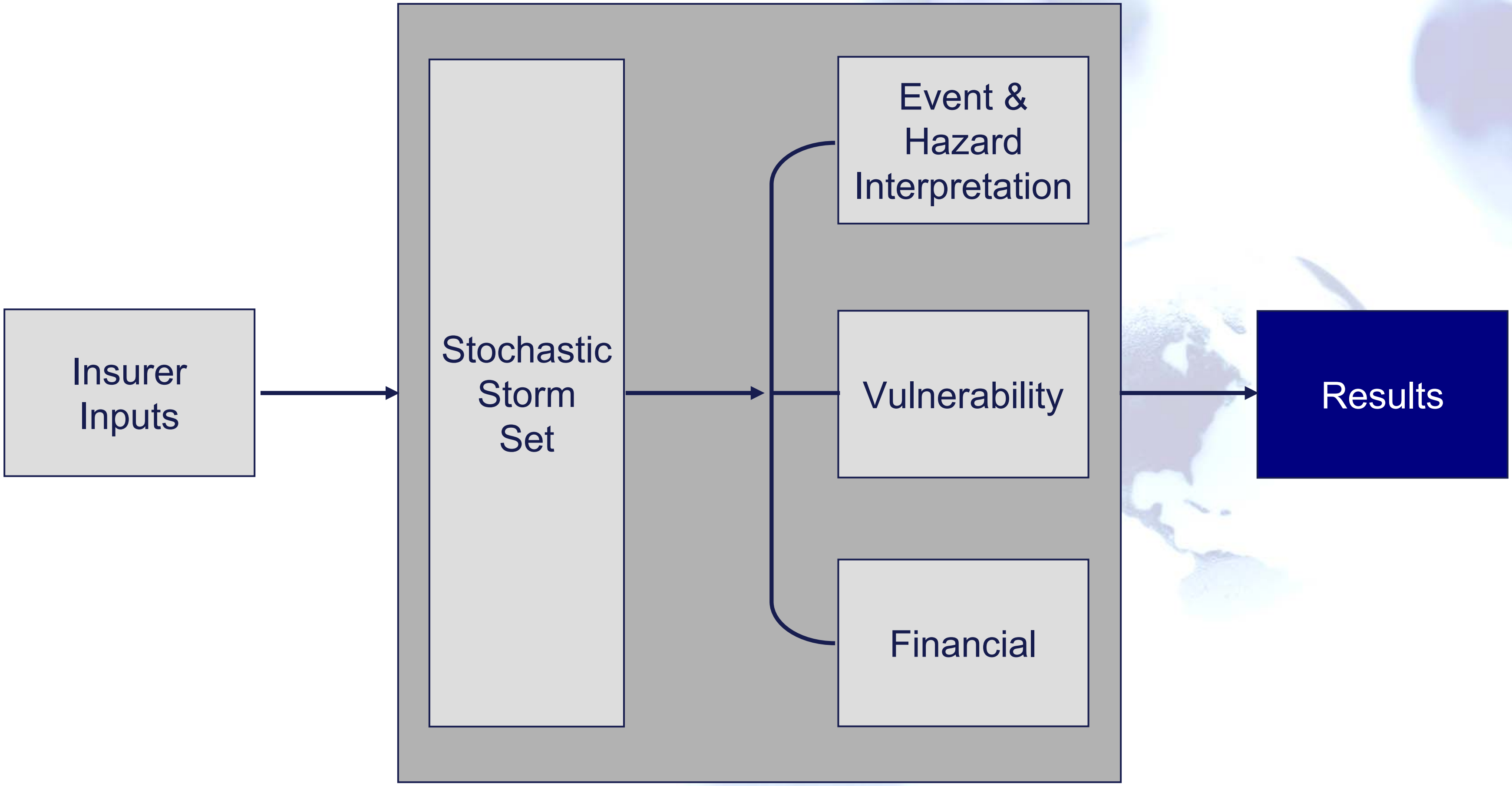


PML results

What are the largest losses?
What is the likelihood of occurrence?

Probable Maximum Loss

Confidence Level	Prob. Of Exceedence	Return Time	Estimated Loss	Percent of Total Value
99.99%	0.01%	10,000	$725,000	3.6%
99.98%	0.02%	5,000	$700,000	3.5%
99.95%	0.05%	2,000	$620,000	3.1%
99.90%	0.10%	1,000	$585,000	2.9%
99.80%	0.20%	500	$530,000	2.7%
99.60%	0.40%	250	$475,000	2.4%
99.50%	0.50%	200	$450,000	2.3%
99.00%	1.00%	100	$385,000	1.9%
98.00%	2.00%	50	$300,000	1.5%

AAL results

What is the expected loss from catastrophes each year?

Average Annual Loss

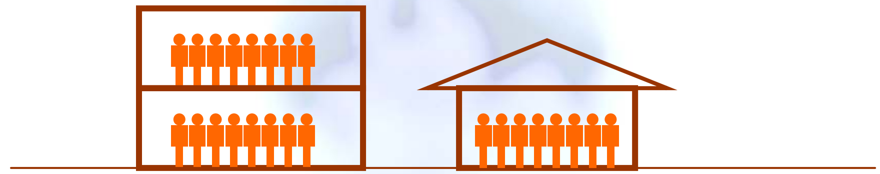
Represents the long run expected annual loss to the property or account

$$\sum \text{(Event Losses * Event Occurrence Rate)}$$

Terrorism and Earthquake Work Comp Modeling

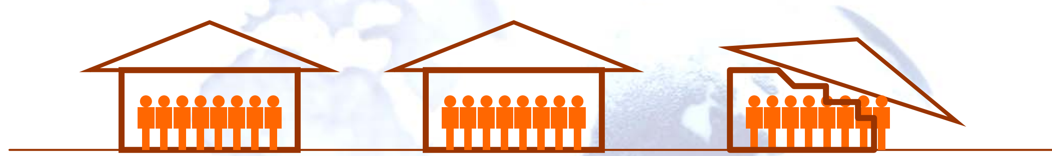
Modeling concept

Payroll Data by Occupancy



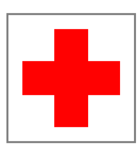
Employee distribution by ZIP Code, building type

Terror or Earthquake Event Set



Building damage and collapse distributions by building type, population injured, entrapped, rescued and injury distributions

Casualties & Losses by event



Treatment costs

Insurance claims settlements

Fatal | Permanent Total | Permanent Partial-Major | Permanent Partial-Minor | Temporary Total | Medical Only

Source: RMS

Terrorism and Earthquake Work Comp Modeling

Data requirements

- Required
  - Street address and/or ZIP Code
  - Number of people and/or payroll by SIC code
- Optional
  - Building construction class
  - Occupancy type
  - Payout per injury category
  - Variation of occupants by time of day or day of week

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Modeling A&H risks using a three-pronged approach

- Exposure management
  - Identify and manage multi-line concentrations
  - Monitor new submissions against existing exposure
- Terrorism scenario loss modeling
  - Manage losses of benchmark scenarios to “acceptable” loss levels
- Probabilistic loss modeling
  - Assists underwriters in risk selection
  - Evaluate reinsurance needs and options
  - Determine key drivers of risk

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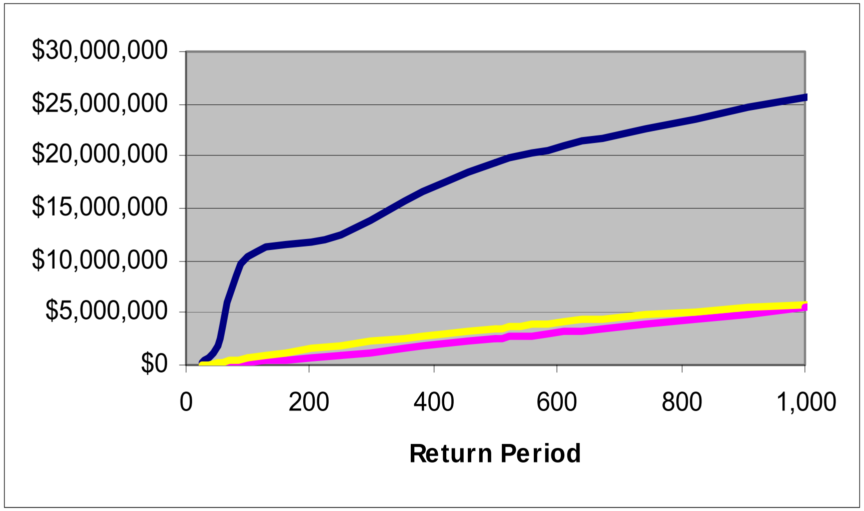
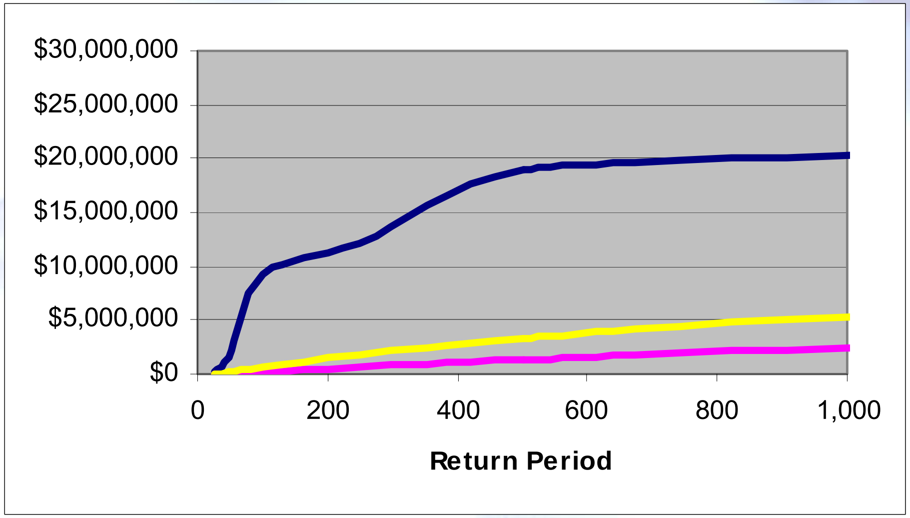
Model Outcomes - Probabilistic

New York A&H PML with NCBR



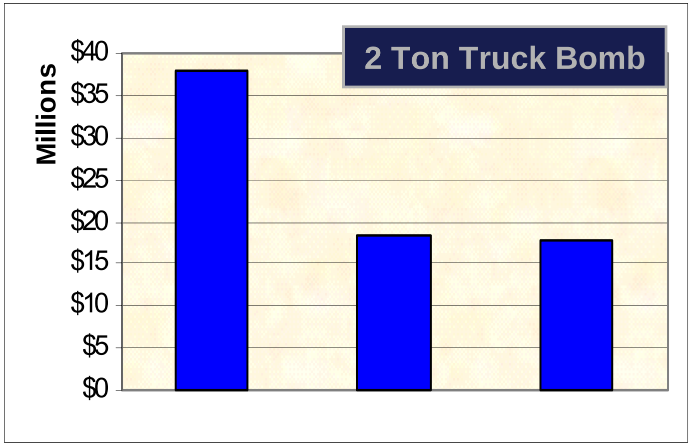
New York A&H PML without NCBR

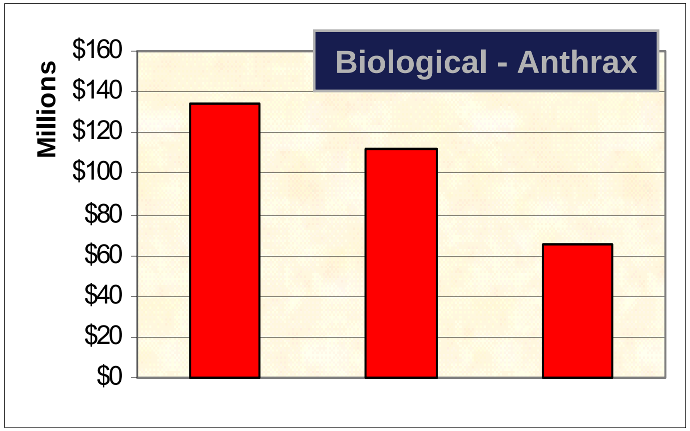


----- Model A ----- Model B ----- Model C

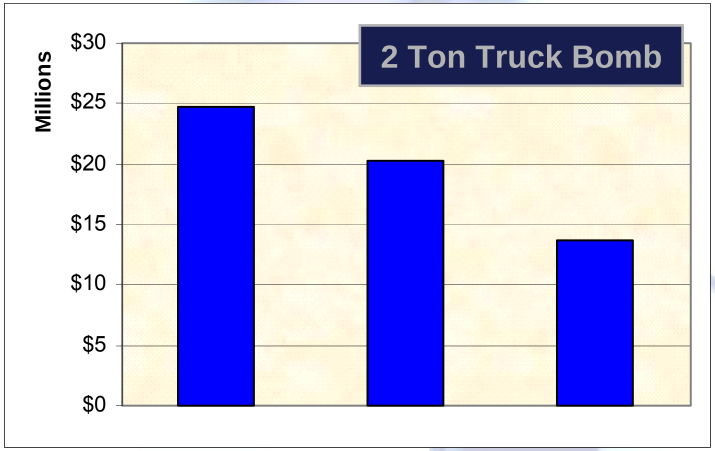
Model Outcomes - Deterministic

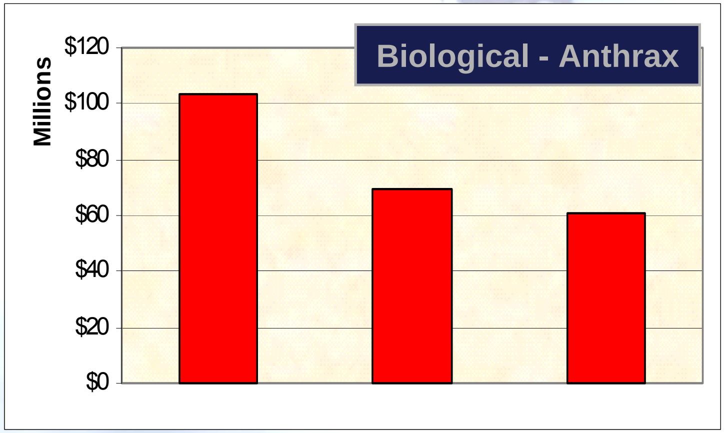
New York





San Francisco





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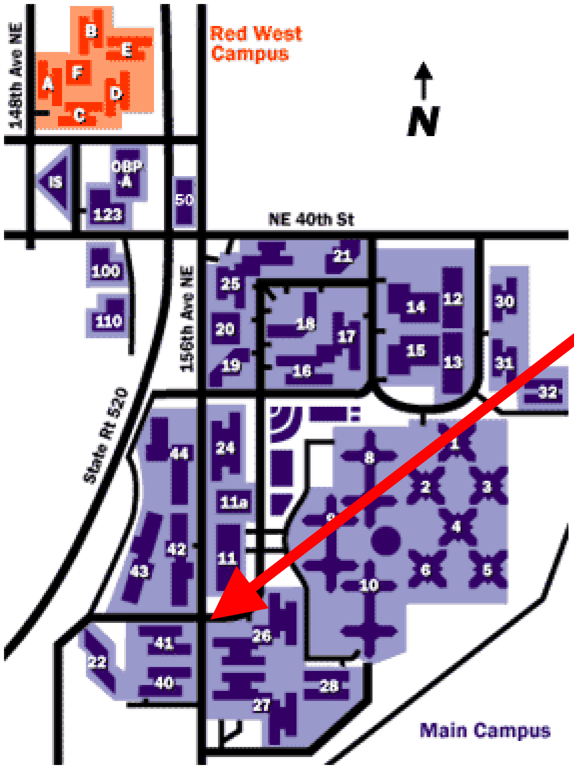
Data Issues—Lack of Address Information

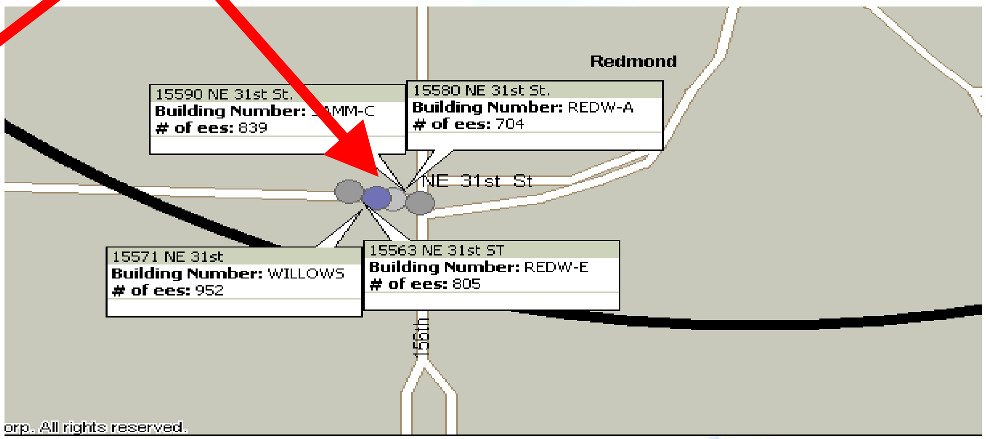
- Group insurers know where the employees work, but not where they live.
- Individual insurers know where policyholders live, but not where they work.
- And it gets worse:
  - Group insurers get billing address. Company may have multiple addresses.
    - We have built a database to address this, but getting information about EE location is not always easy.
    - External sources (e.g. D&B) have limited use.
      - May have different definition of EE.
      - May not have accuracy needed.
  - Individual insurers have the owner’s billing address.
    - We had a large “concentration” of individual insureds in the Citibank building in New York. - - where their trustee had its office

We don’t have all the address information that we need

Data Issues- - What does the Address Mean?



The four buildings at this intersection geocode to Locations so close together that the model assigns them all to the same cell



- No Geocoding engine can tell you exactly where a building is.
- Different Geocoding engines may differ by 100’s of feet in absolute position.
- No model is sophisticated enough to account for the size and shape of buildings

Truly accurate location information is not available even if you know the address

Aerial View of Murrah Building

Only 2 Fatalities in Water Resources Building, and None Further Away

- Oklahoma city bomb (1-2 tons) was approx 20 feet from Murrah building
- 46% fatality rate for those inside building, mostly from collapse
- Very low fatality rate outside 100 feet.
- Specific location is vital for the most likely attack modes. CBRN attacks tend to spread over wider areas, but are far less likely.

Location uncertainty can drive large differences in loss estimates

How do Models deal with incomplete information?

- Exclude
  - Need to find out if any large concentration is excluded
- Assign to Center of County or Zip Code
  - May create artificial concentration
- Use commuting models to assign probable work/home location when the other is known.
  - May create illusion of precision when only inexact assumptions underly model.

Know how the model is treating your data, and how it may drive results

How to deal with data issues

- Start with the concentrated coverages.
  - Group insurance, Worksite marketed, COLI, etc.
- Develop data on actual insured locations
  - Work on the biggest risks first.
  - Make sure all addresses of big risks geocode.
- Develop corporate risk reporting to highlight large concentrations.
  - This will accelerate data scrubbing in key locations.
- Accept the imperfections in the data and models.
  - Flaws will even out when smaller events are combined.
  - The largest events should be examined more closely so that you don't drive the wrong business decision.

The more information is used, the more incentive to make it better

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Corporate Risk Limits

- Understanding Concentrated Risks should not just be tied to reinsurance purposes.
  - No guarantee of reinsurer solvency in the event of an industry-wide event.
  - No federal backstop is guaranteed.
- What risks are correlated?
  - P&C, Life, Health, Equity Market, interest rates, etc.
- What is the corporate risk tolerance in the event of a catastrophe?
  - Corporate management should set risk limits for combined operations and develop combined reporting.
  - The Hartford has set a limit for risk we will allow for certain modeled events. We will make decisions to limit sales and renewals when we are close to or above that limit.
  - The largest events are very unlikely, but are you betting the company that they will not happen?
  - We are vulnerable to extreme events, but generally have not developed good tools for understanding and managing this vulnerability.

We need to know, if only imperfectly, our catastrophic exposure

Takeaways

- Catastrophic risk is here to stay.
- Start now. A little data is better than none.
- Understand the limits of the data and the models.
- Improve, Understand, don't over-react.