Beyond NatCat
Developing Scenarios for Use in Insurance Risk Management

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Director of Advisory Board, Cambridge Centre for Risk Studies
GLOBAL EXPOSURE ACCUMULATION AND CLASH (GEAC) INITIATIVE

- Insurers are increasingly consolidating and standardizing exposure management across all their lines of business
- The GEAC initiative is to develop a standardized exposure data schema for classes of insurance that account for at least 80% of global insurance premium
- This is seen as an enabler of transfer of exposure data between market players
  - Reinsurance; intermediation; co-share; bordereau;
- It is also an enabler of scenario development
  - Encourages third party development: an eco-system of
  - Most insurers develop internal and proprietary scenarios
  - A standardized data schema means that scenarios can be shared and results replicated
USE CASES OF MULTI-LINE EXPOSURE MANAGEMENT

- **Single policyholder aggregation risk**
  - How many lines of cover do you provide to the same policyholder?
  - What are your worst aggregations for a single policyholder?
  - Tracing the chain of connected risks for a major corporation

- **Enabling exposure analytics in more lines of business**
  - Ability to explore scenarios for PMLs in additional insurance lines
  - e.g. casualty liability, aviation, marine
  - Enable accumulation management beyond NatCat

- **High value single location aggregation risk**
  - e.g. Deep Water Horizons, World Trade Centre losses
  - Where are my concentrations of multiple insureds on same risk?
  - Are “non-modeled” lines at risk?

- **Multi-line clash in complex loss events**
  - Consequences impact many different lines of insurance
  - Commercial interconnectivity and liability relationships between counterparties causes non-intuitive losses
TOTAL EXPOSURE VALUE: COMMERCIAL LINES

Aggregate limits, Asset value under management

Property

- Commercial Property
- Marine
  - Energy
  - Aviation
- Specialty
  - Cyber
  - Agriculture
  - Financial Credit & Surety
  - Terrorism, War & Political Risk
  - Other

Casualty Liability

- Liability
  - GL
  - Professional (E&O)
  - Medical Malpractice
  - D&O
  - Environmental

Personal Accident

- Group Personal Accident
  - Group Auto
- Auto
- Workers Comp

Distribution of $105 Quadrillion ($105,000 Trillion) Insured Exposure Worldwide

- Physical Damage
- Duty of care 3rd party
- Injury, illness or death
- Financial Asset Devaluation
- Revenue Loss. Business Interruption
- Digital asset loss (cyber)

No specific limit for compulsory auto 3rd party liability; average upper limits assumed

Estimated total insured exposure values, aggregate limits. Pension asset value under management
# CURRENT STATUS OF DATA SCHEMA DEVELOPMENT PHASE 1

<table>
<thead>
<tr>
<th></th>
<th>Casualty Liability</th>
<th>Marine</th>
<th>Energy</th>
<th>Aviation</th>
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<tbody>
<tr>
<td>1</td>
<td>Insured Policyholder</td>
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<tr>
<td>2</td>
<td>Financial Structure</td>
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<td>Asset Types</td>
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<td>Asset Attributes</td>
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<td>6</td>
<td>Geographical Locations</td>
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<td>□</td>
<td>□</td>
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<td>7</td>
<td>Coverage Wordings</td>
<td>□</td>
<td>□</td>
<td>□</td>
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<tr>
<td>8</td>
<td>Exclusions</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

- Well defined (90%)
- Still being developed (70%)
- In development (50%)
SCENARIOS DEVELOPED BY CAMBRIDGE CENTRE FOR RISK STUDIES

Freeze Event: US-Europe
Marine Piracy: Horn of Africa
Interstate Conflict: China-Japan War
Systemic Cyber: Sybil Logic Bomb
Pandemic: São Paulo Virus
Social Unrest: Millennium Uprising
Financial: Global Property Crash
Financial: Eurozone Meltdown
Financial: High Inflation World
Financial: Dollar Deposed
Power Outage Cyber: US Business Blackout
Power Outage Cyber: UK Regional Blackout
Systemic Cyber: Data Exfiltration
Systemic Cyber: Denial of Service
Systemic Cyber: Extortion
Systemic Cyber: Cloud Outage
Systemic Cyber: Financial Theft
Power Outage: Solar Storm
Cyber-Physical: Commercial Property Laptop Fires
Cyber-Physical: Industrial Facilities Explosion
Cyber-Physical: Oil Rig Fire and Explosion
Cyber-Physical: Marine Cargo Theft
Cyber-Physical: Aviation Spoofing Attack
Cyber-Physical: Terrorism Cyber Attacks
Investment Risk: Climate Change
Marine Realistic Disaster Scenarios
Project Pandora Scenario Suite
Trillion Dollar NatCats
CAMBRIDGE SCENARIO DEVELOPMENT METHODOLOGY

Context
A justification and context e.g. for a 1% annual probability of occurrence worldwide

Timeline & Footprint
Sequencing of events in time and space in hypothetical scenario

Narrative & Variants
Detailed description of events
Multiple Variants of events
S1; S2; X1

Loss Assessment
Metrics of underwriting loss across standardized lines of insurance business

Macroeconomic Consequences
GDP@Risk: Quantification of effects on many variables in the global economy

Investment Portfolio Impact
Returns and performance over time of a range of investment assets
CAMBRIDGE SCENARIO DEVELOPMENT PROCESS

Research and Context Preparation

State-of-the-Art Literature Review  
Research and Analysis  
Subject Matter Specialists

Scenario Specification

Workshops

Primary Impacts and Insurance Loss

Damage Inventory  
Insurance Payouts

Secondary Impacts and Insurance Loss

Consequential Losses

Secondary Consequences  
Insurance Payouts

Macroeconomic Consequences and Investment Portfolio Impact

Market Impact Modelling

Imagineering & Scenario Design

Schedule of Losses

连接模型

Imagine Software

重尾分布

Imagineering & Scenario Design

财务

BlackRock  Aladdin

Imagine Software

重尾分布

Imagineering & Scenario Design
START WITH UNDERSTANDING THE EXPOSURE

- Identify the main exposure types
  - Geographical markets and locations of main exposure
  - Business sectors, company size, and characteristics
  - Insurance coverage inclusions, exclusions, T&Cs

- Identify the levels of loss that would be material
  - What are average annual loss rates?
  - What is an exceptional loss?
  - What would be catastrophic?
THREAT IDENTIFICATION

- Identify the threats to that exposure type
  - Historical precedents; Technical principles; Expert Opinion
- ‘Reverse engineer’ how the main classes of and geographies of exposure could be highly impacted
- Develop a list of loss causes (‘Threat Taxonomy’)
- ‘Imagineer’ potential causes of those levels of loss
  - ‘Red Team’ – how could you maximize loss?
  - What are the upper bounds of loss?
  - What prevents a loss from being even larger?
  - How does loss scale up? What are the step functions?
- Cascades: How might an event trigger other events?
SCENARIO DEVELOPMENT WORKSHOPS

- Stakeholder engagement
- Interaction between subject matter specialists and the business users
- Plausibility testing
  - Can you ‘sell’ this scenario to senior management?
  - Answering the “well that would never happen” response
- Severity level sanity check
SETTING THE SEVERITY LEVEL

- A specified scenarios has no inherent return period
  - Only the loss has a probability of exceedance
- Physical, behavioural or technical processes are usually being reflected in the extreme scenario
  - Is there an objective para-metric that can be assessed as a frequency-severity distribution of the causal trigger? e.g.:
    - Virulence and infectiousness metrics for a pandemic
    - dB/dt for a solar storm
    - Gbps/hours for denial of service cyber attacks on businesses
- CCRS has typically attempted to identify the para-metric severity of the causal trigger with a global return period of 1-in-100 for the S1 variant
BENCHMARKING TO EP CURVES OF OTHER PERILS

US Homeowner Fire Insurance
Probability of Exceedance
Distribution of Industry Annual Loss Ratios
1950-2015

Annual Average Loss Ratio 67%

In one year in 10, loss ratio has exceeded 1.3X of average

Worst year in 65 years, loss ratio exceeded 2X of average

Annual Loss Ratio
(Claims as % of Premium)

US Modeled NatCat Industry Loss
Probability of Exceedance
RMS EQ and HU Models, US Res+Comm

US EQ 100 yr loss is 8X of 10 yr loss

US HU 100 yr loss is 5X of 10 yr loss

$ Billion
IMAGINEERING THE EVENT TREE

- From the ideation we develop a narrative
  - Identify a timeline and event sequence
- Plausibility is a major issue
  - Identify the near-precedents or counter-factual
- Various nodes where large variables can occur
  - Stress the key variables
- CCRS has typically developed three variants:
  - S1: 1-in-100 parametric trigger occurrence with ‘best estimate’ assumptions of consequences
  - S2: Significantly worse assumption set for the same event
  - X1: Worst case assumptions for same event
A Bayesian variant event tree enables a much clearer assessment of potential permutations of outcomes.

It generates thousands of scenario variants, which improves assessments of uncertainty and extremes.

An insurance PML, stress test, or accumulation scenario needs to explore uncertain extremes.

Project to reassess Lloyd’s RDS scenarios for marine vessel loss.
LOSS CALCULATION

- Loss estimation is the most complex, resource intensive, and important part of the scenario development
- It might be possible to make top-down high level loss estimates, but the only way to try to make an assessment with any confidence is to build a ground-up loss estimate from component parts
- There are two stages
  - Primary impact (Direct loss)
  - Secondary, consequential losses as a result of direct losses
- Secondary losses in systemic events can exceed primary losses (by a multiple)
- Go through a checklist of each of the categories of exposure and test whether they would have a loss
- Estimating losses has to be carried out transparently
  - What is the evidence-base for the loss ratio being applied?
  - It is OK to make experienced guesses as long as these are flagged and can be adjusted by others
LOSS MODELLING: EXHAUSTIVE ANALYSIS OF ALL EXPOSURES

- Work through a check-list of exposed assets
- Direct loss estimates require a collation of global exposure
- Insurance industry loss estimation requires both an estimation of uninsured assets and their insured penetration
- Ground-up uninsured direct loss is often (confusingly) called an ‘economic loss’ estimate

<table>
<thead>
<tr>
<th>GICS Sector</th>
<th>GICS Industry Group</th>
<th>Bores Day Scenario Facilities Affected</th>
<th>High/Low</th>
<th>$ per day</th>
<th>No. Days outage</th>
<th>Total Days</th>
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<tbody>
<tr>
<td>10 Energy</td>
<td>1010 Energy</td>
<td>Large administrative operations buildings (non-generating)</td>
<td>1 - Low</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>15 Materials</td>
<td>1510 Materials</td>
<td>Large mining and mineral processing facilities</td>
<td>1 - Low</td>
<td>??</td>
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<td>21</td>
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<tr>
<td>20 Industrials</td>
<td>2010 Capital Goods</td>
<td>Large manufacturing factories &amp; despatch warehouses</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>2020 Commercial &amp; Professional Services</td>
<td>Large commercial buildings</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>2030 Transportation</td>
<td>Airports, Railways, Port facilities</td>
<td>3 - High</td>
<td>??</td>
<td>3</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>25 Consumer Discretionary</td>
<td>2510 Automobiles &amp; Components</td>
<td>Auto manufacturing plants &amp; warehousing</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>2520 Consumer Durables &amp; Apparel</td>
<td>Manufacturing facilities and large commercial operations</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>2530 Consumer Services</td>
<td>Manufacturing facilities and large commercial operations</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>2540 Media</td>
<td>Broadcasting and headquarters operations</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
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<tr>
<td>2550 Retailing</td>
<td>Large shopping malls and major retail outlets</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>30 Consumer Staples</td>
<td>Large supermarket, cold storage facilities, warehousing &amp; despatch</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>3010 Food &amp; Staples Retailing</td>
<td>Large factories and food processing plants, storage &amp; despatch</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>3020 Food, Beverage &amp; Tobacco</td>
<td>Large factories, warehouses &amp; despatch</td>
<td>1 - Low</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>3030 Household &amp; Personal Products</td>
<td>Large hospitals and healthcare facilities</td>
<td>3 - High</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
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<tr>
<td>35 Health Care</td>
<td>3510 Health Care Equipment &amp; Services</td>
<td>Large hospitals and healthcare facilities, R&amp;D Labs, headquarters campuses</td>
<td>3 - High</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>3520 Pharmaceuticals, Biotechnology &amp; Life Sciences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 Financials</td>
<td>4010 Banks</td>
<td>Headquarters and financial operation hubs</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>4020 Diversified Financials</td>
<td>Headquarters and major commercial buildings</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
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<tr>
<td>4030 Insurance</td>
<td>Headquarters and major commercial buildings</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>4040 Real Estate</td>
<td>Headquarters and major construction projects</td>
<td>1 - Low</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>45 Information Technology</td>
<td>4510 Software &amp; Services</td>
<td>Headquarters, Cloud server farms</td>
<td>3 - High</td>
<td>??</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>4520 Technology Hardware &amp; Equipment</td>
<td>Manufacturing/assembly plants, warehousing, despatch</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>4530 Semiconductors &amp; Semiconductor Equipment</td>
<td>Manufacturing/assembly plants, warehousing, despatch</td>
<td>1 - Low</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>50 Telecommunication Services</td>
<td>5010 Telecommunication Services</td>
<td>Control centres, server farms, phone/data exchanges</td>
<td>3 - High</td>
<td>??</td>
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<tr>
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<td>9901 Education</td>
<td>Universities and large educational facilities</td>
<td>2 - Moderate</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>55 Utilities</td>
<td>5510 Utilities</td>
<td>Major water processing plants, sanitation facilities</td>
<td>1 - Low</td>
<td>??</td>
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<td>21</td>
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<tr>
<td>00 Public Sector</td>
<td>0010 National Government departments</td>
<td>Department main offices, storage and operational centres</td>
<td>0 - None</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>0020 Local Authority/Municipal</td>
<td>Admin HQs, Fire/police HQs, emergency facilities</td>
<td>1 - Low</td>
<td>??</td>
<td>3</td>
<td>21</td>
<td></td>
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<tr>
<td>0030 Military</td>
<td>Army navy airforce bases</td>
<td>0 - None</td>
<td>??</td>
<td>3</td>
<td>21</td>
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<tr>
<td>ZZ General Public</td>
<td>ZZZZ Homeowners/Personal Lines</td>
<td>Residential properties &amp; homeowners</td>
<td>0 - None</td>
<td>??</td>
<td>3</td>
<td>21</td>
</tr>
</tbody>
</table>

Checklist of facilities potentially impacted by Business Blackout scenario
CONNECTIVITY: WHAT HAPPENS IF CHINA STOPS EXPORTING?

China Export Value by Economic Sector (US$ Billions 2009)
- Excludes exports to the Rest of World

Total value of Chinese exports: $1.33 Trillion ($US 2009)
MANY CHANNELS OF CONNECTIVITY IN GLOBAL ECONOMY

International Trading Networks

Travel Flows of People and Goods

Business Relationships between Companies

Communications and Social Media
Granularity of loss estimation is important in some scenarios

May not be vital for overall accumulation management

But differentiating by business sector is a common requirement for insurers
  – Usually manage their exposure by business sector

Individual company or account differentiation is not usually a requirement for scenarios
  – More advanced modelling required for risk selection
INSURANCE LOSS BREAKDOWN BY LINE OF BUSINESS

- Important to iterate from the loss numbers back to the scenario design to converge on a useable scenario.
- Variants of the scenario explore different aspects of the threat.
- Impact of scenario on macroeconomy, investment portfolio, and business context is also important for a holistic estimate.

### Power Generation Companies
<table>
<thead>
<tr>
<th>Loss Description</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>Property Damage (Generators)</td>
<td>$633</td>
</tr>
<tr>
<td>Business Interruption (Generator Damage)</td>
<td>$3,817</td>
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<tr>
<td>Incident Response Costs</td>
<td>$3</td>
</tr>
<tr>
<td>Fines - FERC/NERC</td>
<td>$4</td>
</tr>
<tr>
<td>Other liabilities</td>
<td>-</td>
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### Defendant Companies

<table>
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<tr>
<th>Loss Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liability</td>
<td>$2,253</td>
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### Companies that Lose Power

<table>
<thead>
<tr>
<th>Loss Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Perishable Contents</td>
<td>$595</td>
</tr>
<tr>
<td>Contingent Business Interruption - Suppliers Extension</td>
<td>$6,769</td>
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<tr>
<td>Liability</td>
<td>$3,120</td>
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### Companies Indirectly Affected

<table>
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<td>Contingent Business Interruption - Critical Vendor</td>
<td>$2,928</td>
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<tr>
<td>Liability</td>
<td>$749</td>
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### Homeowners

<table>
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<tr>
<td>Household Contents</td>
<td>$465</td>
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### Specialty

<table>
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<tr>
<td>Event Cancellation</td>
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### Total

For variant S1: $21,398
CONCLUSIONS

- The Cambridge Centre for Risk Studies methodology for scenario development has proven versatile and produced many scenarios for a wide range of applications.
- We will be adapting this framework to develop the multi-line clash scenarios for the GEAC project.
- Aspects of this methodology may be a useful framework for others to produce their own scenarios.
- We look forward to getting the feedback of today’s attendees on what constitutes ‘Best Practice’ in scenario development.