Space Weather and Insurance

Jason Reeves – jreeves@zelle.com
Three Kinds of Insurance

1. Liability / Casualty Insurance
   Third Party Insurance
2. Property Insurance
   First Party Insurance
Liability / Casualty
Third Party Insurance

Protects policyholder against claims by third parties
Insurer has a fiduciary duty to policyholder

Duty to:
1. Defend
2. Indemnify
3. Settle

- automobile
- professionals (doctors, lawyers, architects, etc.)
- commercial general liability ("CGL")
Property / First Party Insurance

Protects policyholders against themselves
Fire policies
  - home
  - businesses
Property Damage
Business Interruption
Insurance of specific property.
Global Property Program (All Risk Property incl. Business Interruption)
June 30, 2012 - August 31, 2013

Self Insured Retention Combined Single Excess
PTFI $200,000,000 each occurrence, All other locations $100MM each occurrence. Overall annual aggregate stop loss of $200MM applies. Upon exhaustion of the aggregate, separate maintenance retentions apply.
Comprehensive All Risk Form General Conditions

Section I

A. Insuring Agreement - This policy insures against all risks of physical loss or damage, except as excluded, to covered property while on Described Premises, provided such physical loss or damage occurs during the term of this policy.
Scope – What is Covered

One location or multiple locations

Physical / Property Damage
  Actual Cash Value
  Replacement Cost Value

Business Interruption
  Extra Expenses
  Expediting Expenses
  Sue and Labor
  Contingent Business Interruption
Deductibles / Excess

Physical Damage = minimum monetary unit
Business Interruption = minimum time elapsed

Conditions

Limits and Sublimits

Exclusions
Typical Exclusions

Design Defect, Wear and Tear, Gradual Deterioration, Corrosion, Inherent Vice, Latent Defect...

Biological / Chemical materials

Microorganism

Radioactive

Terrorism

War

Nuclear Weapons and Electromagnetic Pulses
I'm busy but I'll forward this on to our department that handles "low frequency" "high impact" events...
Did your boss buy that "Space Conference in Rome" email?
disruptive
UNINSURABLE
Three Core Business Lines

Power (risks which have power generation infrastructure)
Property (energy to retail and satellites too!)
Liability
Space Weather – Key Insurance Issues

Property Damage
Business Interruption
Extra Expenses
Expediting Expense
Sue and Labor
Contingent Business Interruption
Two Kinds of Losses

Large scale damage
Attritional losses
Halloween Storm 2003

Eskom Power Network in South Africa
29-31 October 2003
Superstorm
GIC prematurely ages electrical infrastructure (insulation, windings, connections, transformers)

Old equipment is particularly at risk
High voltage lines are particularly at risk
Exclusions may apply
Is this on the insurance claims radar?
U.S. Power Grid
Uniquely Vulnerable

Northern latitude

Areas of relatively high resistive igneous rock

High voltage interconnected transmission network

Proximity to oceans (conductivity of ocean salt water)

Catastrophic Power Infrastructure Damage

Grid collapse
Blackout Question
Three Insurance Questions

Is the loss covered?
How much do I have to pay?
Can I make someone else pay?
First Party Coverage Analysis

Was the loss caused by an insured peril?
What is the applicable deductible / waiting period?
Is there an applicable exclusion?
What was the value of the property damage?
Does the loss exceed a PD sublimit?
Is the value paid on cash or replacement cost basis?
What was the value of the business interruption?
Does the loss exceed a BI sublimit?
Was the loss caused by a third party’s negligence?
Space Weather – Liability

Who has a duty?
Engineers, Architects, Construction, Insurance Brokers

What was the breach?
You knew / should have known about space weather

Causation?
If you had told me I would have handled it
and my stuff wouldn’t have melted!

Damages?
Blackout PD / BI costs
Three Kinds of Insurance

1. Liability / Casualty Insurance
   Third Party Insurance
2. Property Insurance
   First Party Insurance
3. Reinsurance
   Facultative
   Treaty
Reinsurance

The insurance of insurance companies:
- “facultative” reinsurance (specific risks)
- “treaty” reinsurance (entire books of business)

Financial product or insurance product?
Spreads risk
Based on modelling, statistics and formulas
Suggestions

Involve the (re)insurance industry
Property, power, energy, satellites, telecoms, aviation, anything that relies on or makes electricity…

Exclusions
Sublimits
Bespoke Space Weather cover?
Space Weather Impacts a Risk to Society?

Economic Aspects from an Insurance/Reinsurance Point of View
Table of Contents / Agenda

• Swiss Re
• Insurance Reinsurance value chain
• Nat Cat losses and the Insurance gap, PPP and the need for country risk management
• Emerging Risk view from various stakeholders
• Scenarios, financial impact estimates
Swiss Re at a glance

Swiss Re is a **leading and highly diversified global reinsurer**, founded in Zurich (Switzerland) in 1863.

The company offers **traditional reinsurance products and related services** for property and casualty, as well as for life and health businesses.

These traditional products are complemented by **insurance-based corporate finance solutions** and supplementary **services for comprehensive risk management**.

Swiss Re is the **industry leader in insurance-linked securities**.

**Our financial strength** is currently rated:
- Standard & Poor’s: AA- (stable)
- Moody’s Aa3 (stable)
- A.M. Best: A+ (stable)

Swiss Re was listed as **one of the World’s Most Ethical Companies** in 2009 by Ethisphere, a leading international think tank.

<table>
<thead>
<tr>
<th>Key statistics (USD billions)</th>
<th>FY 2009</th>
<th>FY 2010</th>
<th>FY 2011</th>
<th>FY 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total revenues:</td>
<td>31.0</td>
<td>28.8</td>
<td>28.0</td>
<td>33.6</td>
</tr>
<tr>
<td>Net income:</td>
<td>0.5</td>
<td>0.9</td>
<td>2.6</td>
<td>4.2</td>
</tr>
<tr>
<td>Shareholders’ equity:</td>
<td>25.3</td>
<td>25.3</td>
<td>29.6</td>
<td>34.0</td>
</tr>
</tbody>
</table>
Risk holders, risk takers
Risk holders, risk takers
Risk holders, risk takers

Public

Insurers

Reinsurers

Pools
Risk holders, risk takers
Risk originators/holders, risk takers

Complexity of products increases
When risk strikes…

Public

Insurers

Pools

Reinsurers

Capital markets
When risk strikes…

- Insurers
- Pools
- Reinsurers
- Capital markets
When risk strikes…

Public

Insurers

Pools

Reinsurers

Capital markets
When risk strikes…

Public

Insurers

Reinsurers

Capital markets

$$$

$$$

$$$

$$
Massive gap between total and insured losses shows insurance potential

Natural catastrophe losses 1970-2013, in USD billion (2013 prices)

Source: Swiss Re Economic Research & Consulting, sigma catastrophe database
Natural catastrophes

Changes

Population Growth Rates (1960-2000)

All US 57%
Florida 223%

Ocean Drive, FL, 1926.
Disasters place a significant burden on the public sector

- Despite prevention and mitigation efforts, no country can fully insulate itself against extreme natural disasters
- The brunt of economic losses from natural disasters ends up with individuals, corporations and governments, both on national and sub-national level
- Government budgets are impacted by:
  - Primary effects include immediate expenses for emergency relief efforts, costs for rebuilding public infrastructure or loss of capital and durable goods
  - Secondary effects, for instance, include lower economic growth, lower tax and non-tax revenues, budget deficits, increased indebtedness and costs from refinancing, higher inflation or currency movements
Risk financing – Who gets the bill?

1. What are the risks?

2. Who will pay?

A significant portion of the largest risks ends up with the public sector.
Systematic risk management approach for natural disasters

Identification ➔ Assessment ➔ Prevention and Mitigation ➔ Adaptation

Severity (in USD)

- Tsunami
- Earthquake
- Pandemic
- Typhoon
- Coastal flooding
- Drought

- Preventive and mitigation strategies must be the first priority in order to reduce the extent of any economic loss.
- However, sovereign natural disaster management includes also the financial preparedness for the residual risk.
- Hence, the deployment of public funds should be well balanced between prevention/mitigation and adaptation measures.
- Adaptation measures include ex-ante disaster financing instruments, such as reserve funds and a variety of risk transfer instruments.
Threat scenarios Switzerland
derived from Risk Analysis Catastrophes and emergencies Switzerland Version 1.03

*1 occurrence every xxx year
The search for Black Swans

- Earthquakes & Tsunamis
- Vulcanos and Super Vulcanos
- Floods
- Typhoons
- Droughts
- Pandemics
- Terrorism events
- Systemic risk / financial crisis
- and more? prolonged power black outs?

the severity of the events is the surprise factors
Nat Cat large loss potentials

Peak risks:
- Earthquake or storm
- In industrialised countries
- With high insurance density

Loss potentials from events with a return period of 200 years (100 years for Hurricane North Atlantic)

Nat cat events at 2009 prices

all figures in USD bn
Risk transfer: efforts required on all fronts
Macro, micro and pooling

How to close the gap?

<table>
<thead>
<tr>
<th>Solution type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macro</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Risk transfer solutions for (sub)sovereigns to cover their direct or indirect costs</td>
</tr>
<tr>
<td></td>
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<tr>
<td><strong>Pooling</strong></td>
<td></td>
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<tr>
<td></td>
<td>Insurance schemes and pools to increase insurance penetration</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td><strong>Micro</strong></td>
<td></td>
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<tr>
<td></td>
<td>Simplified products distributed via aggregators such as MFIs, NGOs, and corporates</td>
</tr>
</tbody>
</table>

- Economic loss
  - insured loss
  - economic loss
  - gap

- Damaged public physical assets
- Clean up costs
- Emergency relief
- Damaged uninsured private assets
- Foregone revenues
- Livelihood assistance, rehabilitation of the poor
Case study Mexico: MultiCat - Funding for immediate relief efforts after disasters

Solution features
• Insured perils: Earthquake and hurricane
• Payments to be used for immediate emergency relief after a disaster
• Parametric catastrophe bond: USD 315 million
• Trigger type: Index
  – Earthquake: physical trigger (quake magnitude)
  – Hurricane: physical trigger (barometric pressure)
• Time horizon: October 2012 – November 2015
• Renewed cat bond launched through the World Bank’s MultiCat facility and third cat bond for Mexico

Involved parties
• Insured: Fund for Natural Disasters (FONDEN) of Mexico
• Reinsured: AGROASEMEX S.A.
• Arranger: World Bank Treasury
• Swiss Re: Co-lead manager and joint bookrunner
Case study Uruguay: Largest Energy Risk Transfer to Protect Against Drought Risk

Solution features

• Insured peril: Drought
• Payments to be used to purchase energy from alternative sources when drought conditions cause lack of hydro power
• Derivative contract: between UTE, Uruguayan state-owned hydro-electric power company, and World Bank Treasury. Risk is then placed in the market
• Payment mechanics:
  – Trigger: Level of rainfall monitored at weather stations
  – Settlement: Market price of brent crude oil
• Time horizon: January 2014– June 2015
• Transaction Size: USD 450 million
• Largest of it’s kind in the weather risk management market

Involved parties

• Client: UTE (Uruguayan state-owned power company)
• Arranger: World Bank Treasury
• Risk Takers: Swiss Re and Allianz
Case study United States:
Alabama – First parametric cover for a government in an industrialized country

Solution features

- Insured peril: Hurricane
- Payments to offset economic costs of hurricanes
- Trigger type: Disaster occurring within a defined geographic area ("box") along coast ("cat-in-the-box")
- Trigger based on wind speed of hurricane eye as it passes through pre-determined box
- Payout in as little as two weeks
- Time horizon: July 2010 – July 2013
- First parametric catastrophe risk transfer for a government in an industrialized country

Involved parties

- Insured: State Insurance Fund of Alabama
- Swiss Re: Lead structurer and sole underwriter
Emerging Risk overview
why are we interested in extended power outage?

• sources
• examples
• characteristics
• process
Exemplary emerging risk topics featured in the latest SONAR publications

- Cyber vulnerability
- Prolonged power blackout
- New forms of mobility
- Toxic substances and workplace safety

- The future of medicine
- Regulatory fragmentation
- Big data
- Global talent crunch
WEF GRR

- short summary
- methodology
- Top risks
- Interconnections map
- Risk and trends to watch
WEF Global Risk Report: Understand the drivers of global changes and trends to be able to manage the risks

<table>
<thead>
<tr>
<th>World population</th>
<th>Economic disparity</th>
<th>Demographic challenges</th>
<th>Sovereign debts</th>
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<tbody>
<tr>
<td><img src="Image1.png" alt="Image" /></td>
<td><img src="Image2.png" alt="Image" /></td>
<td><img src="Image3.png" alt="Image" /></td>
<td><img src="Image4.png" alt="Image" /></td>
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</tbody>
</table>

- **Democracy & dignity**
- **New powers & governance**
- **Policies & regulation**
- **New technologies**

<table>
<thead>
<tr>
<th>Urbanisation</th>
<th>Climate change</th>
<th>Social interaction media</th>
<th>Intellectual property</th>
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<td><img src="Image5.png" alt="Image" /></td>
<td><img src="Image6.png" alt="Image" /></td>
<td><img src="Image7.png" alt="Image" /></td>
<td><img src="Image8.png" alt="Image" /></td>
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</tbody>
</table>

- **Twitter**
- **Facebook**
- **You Tube**
The evolving global risk landscape

The top 5 global risks in terms of impact:

1. Asset price collapse
   - 2007: Asset price collapse
   - 2008: Asset price collapse
   - 2009: Asset price collapse
   - 2010: Asset price collapse
   - 2011: Fiscal crises
   - 2012: Major systemic financial failure
   - 2013: Fiscal crises

2. Retrenchment from globalization
   - 2007: Retrenchment from globalization (developed)
   - 2008: Retrenchment from globalization (developed)
   - 2009: Retrenchment from globalization (developed)
   - 2010: Retrenchment from globalization (developed)
   - 2011: Climate change
   - 2012: Water supply crises
   - 2013: Climate change

3. Interstate and civil wars
   - 2007: Interstate and civil wars
   - 2008: Slowing Chinese economy (<6%)
   - 2009: Oil and gas price spike
   - 2010: Oil price spikes
   - 2011: Geopolitical conflict
   - 2012: Food shortage crises
   - 2013: Chronic fiscal imbalances

4. Pandemics
   - 2007: Pandemics
   - 2008: Oil and gas price spike
   - 2009: Chronic disease
   - 2010: Chronic disease
   - 2011: Asset price collapse
   - 2012: Chronic fiscal imbalances
   - 2013: Diffusion of weapons of mass destruction

5. Oil price shock
   - 2007: Oil price shock
   - 2008: Pandemics
   - 2009: Fiscal crises
   - 2010: Fiscal crises
   - 2011: Extreme energy price volatility
   - 2012: Extreme volatility in energy and agriculture prices
   - 2013: Failure of climate change adaptation

6. Critical information infrastructure breakdown
   - 2014: Critical information infrastructure breakdown
ERI – Risk Radar Update 2012

Timeline Horizon
First significant impacts expected within 1-5 years
First significant impacts expected within 5-10 years

Swiss Re
Major Industry Risk Trends
Power utilities

- Ageing infrastructure
- Growing energy demand
- Integration of renewables
- Smart meters

Casualty relevance within the respective industry:
- Getting more relevant in the next 1 to 3 years
- Getting less relevant in the next 1 to 3 years
- Same relevance in the next 1 to 3 years
Power utilities
Smart meters – gaining ground

• EU Directive requests the member states to equip 80% of its meters with smart meters by 2020

• e.g. 35 million smart meters to be installed in France, starting 2014

• So far mostly pilot projects, now full-scale implementation

What does it mean for us?

Complexity of these projects is high with prototype character

Failure of smart meters could result in interrupted power supply, faulty measurements of electricity, loss of data, property damage
green building:
- sustainable design
- sustainable architecture
- zero-energy building
- water conservation
- indoor environmental quality enhancement

- internal power supply: solar system
- internal power supply: wind turbine
- roof park
- constant information exchange
- inhouse vehicle recharger
- traffic connection

urban farm
urban farm
urban farm
Risk Management Cycle

Risk Perception
- Risk Identification
- Risk Assessment/Quantification
- Risk Mitigation
- Risk Evaluation

Risk Policy

- A threat to me?
- What is it?
- How often, how severe? Exposure?
- Avoid, reduce, transfer*, build resilience
- What do others think, are we good enough?
- How much risk are we willing to accept

* buy insurance

prevention > intervention > postvention

derived from Christian Brauner pers. comm.
Solar storms, and what they mean for us.

So what are solar storms?
Solar storms release large amounts of energy in the form of radiation and plasma. If directed accordingly, these particles can reach Earth in less than two days and distort its magnetic field.

What will be the first to go?
There are about 700 operational satellites in space. Plasma particle clouds and radiation can damage vital components of satellites and other spacecraft. This will have knock-on effects on communication and transportation infrastructure.

Charged particles penetrating the Earth’s outer atmosphere create polar lights.

Would domestic flights be affected?
Communication and navigation disturbance affects air traffic near polar routes. Flights have to be re-routed and airports have to change operating procedures, causing large delays. Passengers and crew are exposed to increased radiation levels.

Would we still have power?
Solar storms can cause geomagnetically induced currents, which could damage high-voltage transformers despite existing protective measures. Multiple transformer damage could cause a large-scale and prolonged power blackout with up to 18 months recovery time.

How could the loss of satellite activity impact us on earth?

Power
Long delays with knock-on effects throughout the supply chain.

Cash
Cash machines are out of power and banks are closed.

Stock exchange
Electronic trading suspended due to loss of satellite signals.

Communication
Complete breakdown of all communication that relies on electric power.

 Ports & Cargo
Long delays with knock-on effects throughout the supply chain.

How would the effects be felt on earth?

Mobile devices

Travel

Communication

Navigation

1859
Carrington event, one of the biggest geometric storms on record.

1921
Solar storm induced currents disable part of New York Central Railroad.

1940
Solar storm knocks out long-distance phone communication across some US states.

1972
Solar flare causes major blackout in Canada with six million people affected.

1989
Solar flare causes satellite to short-circuit and leads to radio blackouts.

2000
Solar flares cause communications and GPS navigation failures.

2003
Intense solar storm causes extreme solar flares.

2006
Major solar flare triggers satellite communication and GPS navigation failures.

So what can be done to help prevent this?
1. Raise awareness among governments, industry and the insurance industry.
   Develop a common understanding of the risk and the necessity of risk mitigation.

2. Develop cross-border standard operating procedures.
   Improve space weather forecasts and ensure that grid operators act jointly across borders.

3. Enhance power infrastructure to increase resilience.
   Apply engineering solutions to increase the ability of electrical components to withstand disturbances.

For more information and contact details, please visit www.swissre.com/solarstorm

Swiss Re
Impact Factors

- Solar storm severity
- Geomagnetic latitude
- Proximity to coast
- Ground conductivity
- Line voltage
- HV Line length and orientation
- Transformer core type
- Power grid operation mode
- Value concentration
- Vulnerability in a hyper connected world, cascading effects of power outages
- Non linear effects of prolonged power black outs

Blackouts: non-linear effects

PD and/or BI involved for e.g. the following industries
- Aluminium (e.g. smelter)
- Steel (e.g. furnace cooling)
- Mining (e.g. pumps, air)
- Food & beverages (e.g. cooling, animal farming)
- Financial services (e.g. monetary transactions)
- High-tech industry – wafer fab (e.g. filters)
- Petrochemical / Chemical industry (storm surge Gulf of Mexico)
- Nuclear power plants
- Cement industry
- Utilities
- Transportation
- Hospitals
- Communications … Telecom, wireless services
Prolonged Power Blackout
Executive Summary - Scenario

- Increased dependency makes today’s society much more vulnerable to power supply interruptions (e.g. services, production, communication)
- The energy infrastructure is exposed to a variety of potential causes of interruptions (e.g. nat cat, solar storm, cyber attacks, human errors)
- A severe solar storm may damage transformers and lead to a
  - large scale power interruption,
  - affecting large areas, and
  - lasting from several days to months
- Cyber attacks on critical infrastructure may also result in a - more regional - prolonged power blackout
- Main lines of business: Property Business Interruption and CBI
- Event goes beyond the scope of insurance and requires collaboration across governments, businesses and society as a whole
## Assumption grid to build scenarios to estimate economic loss. Proxi: Impact on GDP

<table>
<thead>
<tr>
<th>Transformer % affected</th>
<th>GDP affected</th>
<th>Total Blackout days</th>
<th>Recovery days Services</th>
<th>Recovery days Production</th>
<th>Accumulation of regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>1%</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>No</td>
</tr>
<tr>
<td>3%</td>
<td>3%</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>Local</td>
</tr>
<tr>
<td>10%</td>
<td>5%</td>
<td>7</td>
<td>14</td>
<td>14</td>
<td>Europe</td>
</tr>
<tr>
<td>20%</td>
<td>10%</td>
<td>14</td>
<td>28</td>
<td>28</td>
<td>US/CDN/Europe</td>
</tr>
<tr>
<td>35%</td>
<td>50%</td>
<td>21</td>
<td>56</td>
<td>56</td>
<td>US/CDN/Europe/Japan</td>
</tr>
<tr>
<td>50%</td>
<td>100%</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>Germany</td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td>365</td>
<td>365</td>
<td>365</td>
<td>US/CDN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>730</td>
<td></td>
<td>730</td>
<td>UK</td>
</tr>
</tbody>
</table>

* applied assumptions
Severe solar storm ("Carrington"-type event) Best - worst case Economic loss estimates

- "Carrington"-type event; return period of 150-500 years (now rather <100 yr)
- Geomagnetic Induced Current will damage 10% of transformers in a specific region (e.g. USA/Canada, Scandinavia/UK, or Japan)
- Total blackout: 3 weeks
- Regional impact: 10% of GDP affected
- No accumulation among regions due to area and grid independency, except Europe
- Recovery of GDP
  - Services within 4 weeks
  - Production within 8 weeks
- Split GDP in Services/Production: 70%/30%

Economic loss calculation

<table>
<thead>
<tr>
<th>Economic loss calculation</th>
<th>Total blackout</th>
<th>Recovery services</th>
<th>Recovery production</th>
</tr>
</thead>
</table>

- Production best
- Services best
- Production worst
- Services worst
### Severe solar storm ("Carrington"-type event)
Best - worst case Economic loss estimates

<table>
<thead>
<tr>
<th>Regions</th>
<th>Economic Loss</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Best</td>
<td>Worst</td>
</tr>
<tr>
<td>US &amp; Canada</td>
<td>128'808</td>
<td>163'866</td>
</tr>
<tr>
<td>Scandinavia &amp; UK</td>
<td>28'903</td>
<td>37'210</td>
</tr>
<tr>
<td>Germany, France, Italy,</td>
<td>73'934</td>
<td>95'185</td>
</tr>
<tr>
<td>Switzerland, Austria</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Accumulation Europe</strong></td>
<td><strong>102'837</strong></td>
<td><strong>132'395</strong></td>
</tr>
<tr>
<td>Japan</td>
<td>41'746</td>
<td>53'745</td>
</tr>
<tr>
<td>Australia</td>
<td>7'617</td>
<td>9'806</td>
</tr>
</tbody>
</table>

Potential global impact: accumulation has not been considered in this example!

Figures in mUSD
Regional impact – Minor/Frequency Event

- "Hydro-Quebec + findings from Auckland"-type event
- Geomagnetic Induced Current will damage 3% of transformers in a small region
- Total blackout: 2 days for the region plus 8 weeks for a smaller area Regional impact: 3% (2 days) respectively 1% (4/8 weeks) of GDP affected
- Europe mainly country impact, but accumulation due to grid connectivity possible
- Recovery of GDP
  - Services within 4 weeks
  - Production within 8 weeks
- Swiss Re impact estimates based on the major event factors
## Regional impact – Minor/Frequency Event

<table>
<thead>
<tr>
<th>Regions</th>
<th>Economic Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scandinavia &amp; UK</td>
<td>192</td>
</tr>
<tr>
<td>Germany, France, Italy, Switzerland, Austria</td>
<td>492</td>
</tr>
</tbody>
</table>

Figures in mUSD
# Validity check with historical events

<table>
<thead>
<tr>
<th>Event</th>
<th>Cause</th>
<th>Duration</th>
<th>People</th>
<th>Economic loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro Quebec 1989</td>
<td>Solar storm</td>
<td>9 hours</td>
<td>6m</td>
<td>CAD 10m</td>
</tr>
<tr>
<td>USA/CDN 2003</td>
<td>Various</td>
<td>4 days</td>
<td>50m</td>
<td>USD 4bn-8bn</td>
</tr>
<tr>
<td>Italy/Swiss 2003</td>
<td>Natural event</td>
<td>1.5 hours up to 2 days</td>
<td>56m</td>
<td>unknown</td>
</tr>
</tbody>
</table>

Estimates of Swiss Federal Office of Energy\(^1\): A blackout may result in an economic loss between CHF 2bn and 4bn per day

\(^1\) electrosuisse Bulletin 12s/2011
Prolonged Power Blackout
Executive Summary  - Mitigation

- Loss prevention and emergency measures by Governments (CII defined as strategic assets) and Electric Power Industry (e.g. shut down/circuit break) possible and in discussion

- Raising awareness by Insurance Sector (e.g. CRO Forum publication and Task Force, collaborative industry workgroup under Geneva Association, workshops, forums

- Swiss Re internal risk mitigation steps, a study commissioned, due to be completed end of 2013, looking at power grids worldwide, the different types of transformers and impacts on generating sites

- The size of the economic loss goes far beyond the capacity of the insurance industry

- Is the risk of a prolonged power black out in a metropolitan area a tolerable risk, considering the fact that corresponding technical mitigation and adaptation measures are available?

  - We think no! This should not be "a bearable residual risk" (as stated by some stakeholders)
Modelling - 4 box principle applicable for power black out???

- Hazard
- Vulnerability
- Value distribution
- Insurance conditions

How often? How strong?
What damage degree?
What is covered ... where... and how?

Example Hurricane “Charley” Aug 2004

- Deductibles
- Covers
- Shares
- Exclusions
- ...
Solar Storms
what can be done to prevent this?

So what can be done to help prevent this?

1. Raise awareness among governments, industry and the insurance industry.
   Develop a common understanding of the risk and the necessity of risk mitigation.

2. Develop cross-border standard operating procedures.
   Improve space weather forecasts and ensure that grid operators act jointly across borders.

3. Enhance power infrastructure to increase resilience.
   Apply engineering solutions to increase the ability of electrical components to withstand disturbance.

• prevention > intervention > postvention

Share a common understanding of the problem to find a mutually agreed solution

Forecasting/Communication/Operational procedures.
Invest in a fit for purpose space infrastructure including the model development for forecasting the energy spectrum of SEP and CME events. Set up cross nation communication protocol and SOP's

Harden the space and ground based infrastructure.
Resilience engineering; increasing reserves on the active and reactive power side to compensate for increased reactive power consumption.
Combined response by private and public sector

The effective reduction and financing of catastrophic risks requires a combined response by both private and public sector players.

**Public sector**
- Political and legal power to set framework conditions that facilitate adaptive responses by individuals, the public and the private sectors.
- Typically operates under significant financial constraints. As costs of disasters rise, the ability of governments to cope with natural disasters will be stretched even further.

**Private sector**
- Financial resources but lacks the power to set up the required frameworks.
- Broad geographical diversification which is required to absorb these risks in a cost-efficient way.
- Valuable knowledge and experience in dealing with catastrophe risk management.
Country Risk Management: Making societies more resilient

- Societies are becoming more vulnerable as the risks they face become more interconnected
- Integrated risk management approaches can help countries to identify and prepare for risks

![Flowchart showing the process of Country Risk Management: Identification, Assessment, Prevention and Mitigation, Adaptation]

- Such an all-hazard approach demands a high level of coordination across government, political and private sector bodies
- A Country Risk Office or Ministry could be responsible for managing such a prioritized risk landscape, taking an holistic approach to risks before events occur and ultimately reducing the risk burden to society
Contacts
let's work together
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Space Weather: A Space Insurer’s Perspective

David Wade

Space Underwriter
Atrium Space Insurance Consortium

Space Weather Workshop
Boulder CO, April 2014
Contents

• Space Insurance Market
• Space Insurance Coverage
• Space Weather and Satellite Anomalies
• Space Weather and Satellite Claims
• Satellite Resilience
• Satellite Testing
• Realistic Disaster Scenarios
• Future Developments
• Summary
Space Insurance Market

Exposure (USD billions)

Number of satellites

Ref: XL Insurance
Space Insurance Coverage

Frequency

Severity

Multiple total loss claims

Total loss claim

Partial loss claim

No claim

Example anomalies:

- Generic defect
- SEP event
- Debris cascade
- Dual / multi launch failure

- Single launch failure
- LAE failure

- Solar array drive failure
- Multiple s/a circuits
- Delivered short of apogee

- Single event effects
- Loss within margin
- Loss of redundancy
Space Insurance Coverage (cont)

Frequency vs. Severity:
- Multiple total loss claims
- Total loss claim
- Partial loss claim
- No claim

SW experience:
- No events / claims
- Anik E1 / Telstar 401
- No events / claims
- S/A circuits / strings
- S/A degradation
- SEU’s / SEE’s

Not to scale
The ASIC database includes over 3,200 anomalies on more than 1,000 satellites with data from 1986
The ASIC database includes over 3,200 anomalies on more than 1,000 satellites with data from 1986.
Total claims (1994 – 2013) = USD 12,640m
Space Weather and Satellite Claims (cont)

Total claims (1994 – 2013) = USD 12,640m

- Launch Failure: 40.3%
- Power: 31.0%
- Payload: 10.5%
- Propulsion: 9.3%
- T&C / Data handling: 4.6%
- Other: 2.8%
- ACS incl computer: 1.4%

Space Weather Claims
- Anik E1: USD 142.5m
- Telstar 401: USD 132.0m
Satellite Resilience

SPACE WEATHER EFFECTS:

- Degradation of materials
- Degradation of solar arrays
- Single Event Effects
- Surface charging
- Deep dielectric charging
- Orbital decay
- Saturation of instruments and sensors
- Spurious switch offs
- Loss of orientation
- Phantom commands
- Memory upsets

Ref: ESA
Satellite Testing

RATBERT, MY COMPANY IS HIRING FOR OUR QUALITY ASSURANCE GROUP. YOU’D BE PERFECT.

WHAT WOULD I HAVE TO DO?

YOU WOULD FIND FLAWS IN OUR NEW PRODUCT, THUS MAKING YOURSELF AN OBJECT OF INTENSE HATRED AND RIDICULE.

BUT THEN YOU’D FIX THOSE FLAWS... AND YOUR RESPECT FOR ME WOULD GROW INTO A SPECIAL BOND OF FRIENDSHIP, RIGHT?!

NO, THEN WE SHIP.

Ref: http://ijenn.me/wp-content/uploads/2011/03/483545-Dilbert_RatbertQA.jpg
# Realistic Disaster Scenarios

<table>
<thead>
<tr>
<th>Category</th>
<th>Scenario</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Weather</td>
<td>Solar proton event</td>
<td>Anomalously large proton event degrades solar arrays</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Widespread partial losses affecting all GEO satellites</td>
</tr>
<tr>
<td></td>
<td>Design defect</td>
<td>Design defect resulting in sensitivity to space weather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small number of total losses of particular satellite type</td>
</tr>
<tr>
<td>Generic Defect</td>
<td>Spacecraft generic defect</td>
<td>Supply chain consolidation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generic defect in supplied component</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of “Western” built satellites affected by defect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of satellites at risk depends on coverage period</td>
</tr>
<tr>
<td>Space Debris</td>
<td>Collision with space debris</td>
<td>Considered for different altitude ranges in LEO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of satellites within each range at risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of satellites at risk depends on coverage period</td>
</tr>
</tbody>
</table>
Future Developments

Ref: Medium Earth Orbit (MEO) as a Venue for Future NOAA Satellite Systems, Dittberner, G.J. et al
Summary

• Covered the space insurance market and the coverage provided
• Anomalies and claims related to space weather
• Looked at the space weather related Realistic Disaster Scenarios
• Consider developments in the industry that we need to monitor
• Risk of over-engineering a solution
• Satellites need to remain competitive against alternative terrestrial solutions
• Our increasing reliance on satellites means we need to be prepared