ZELLE HOFMANN

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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

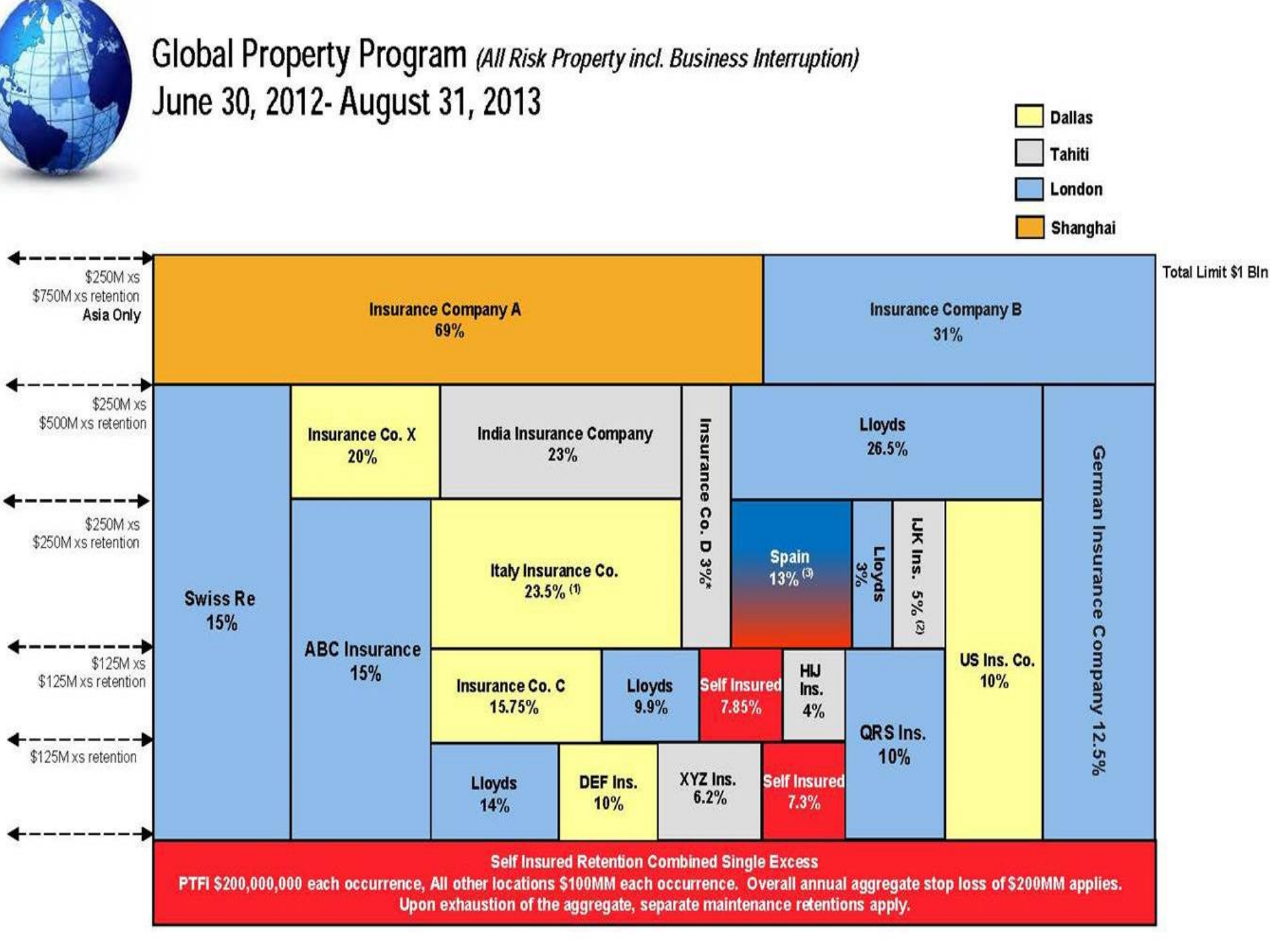
Business Interruption



Insurance of specific property.




Global Property Program *(All Risk Property incl. Business Interruption)*
June 30, 2012- August 31, 2013



“All Risks”

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

Policy Terms

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


Y2K!

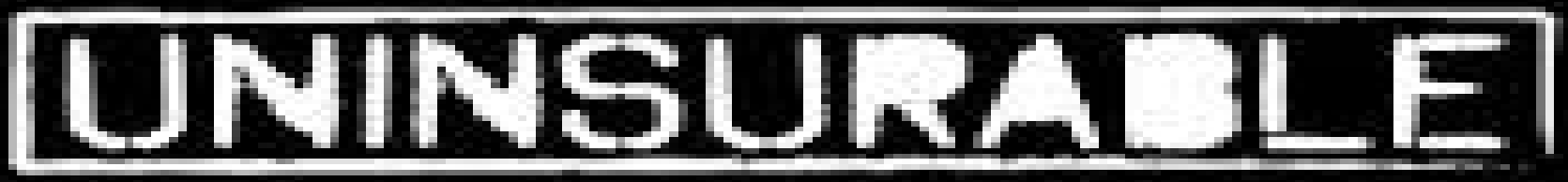
I'm busy but I'll forward this on to our department that handles "low frequency" "high impact" events...

someecards
user card

Did your boss buy that "Space Conference in Rome" email?

someecards
user card

disruption


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

COVERED??

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Two Kinds of Losses

Large scale damage

Attritional losses

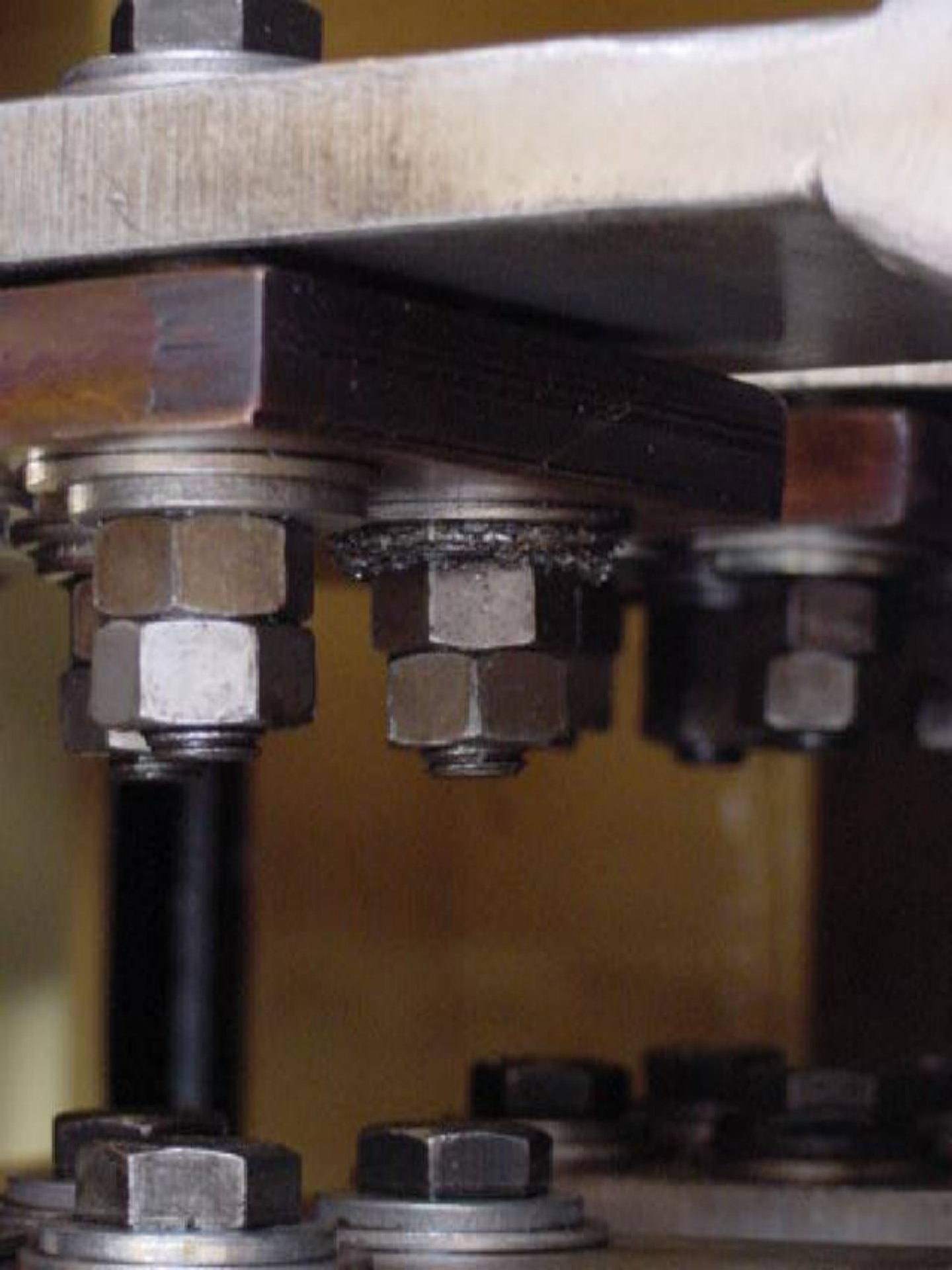
Halloween Storm 2003

Eskom Power Network in South Africa

29-31 October 2003

Superstorm

*In association with ZY & Partners



Space Weather
Power – Attritional Losses

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

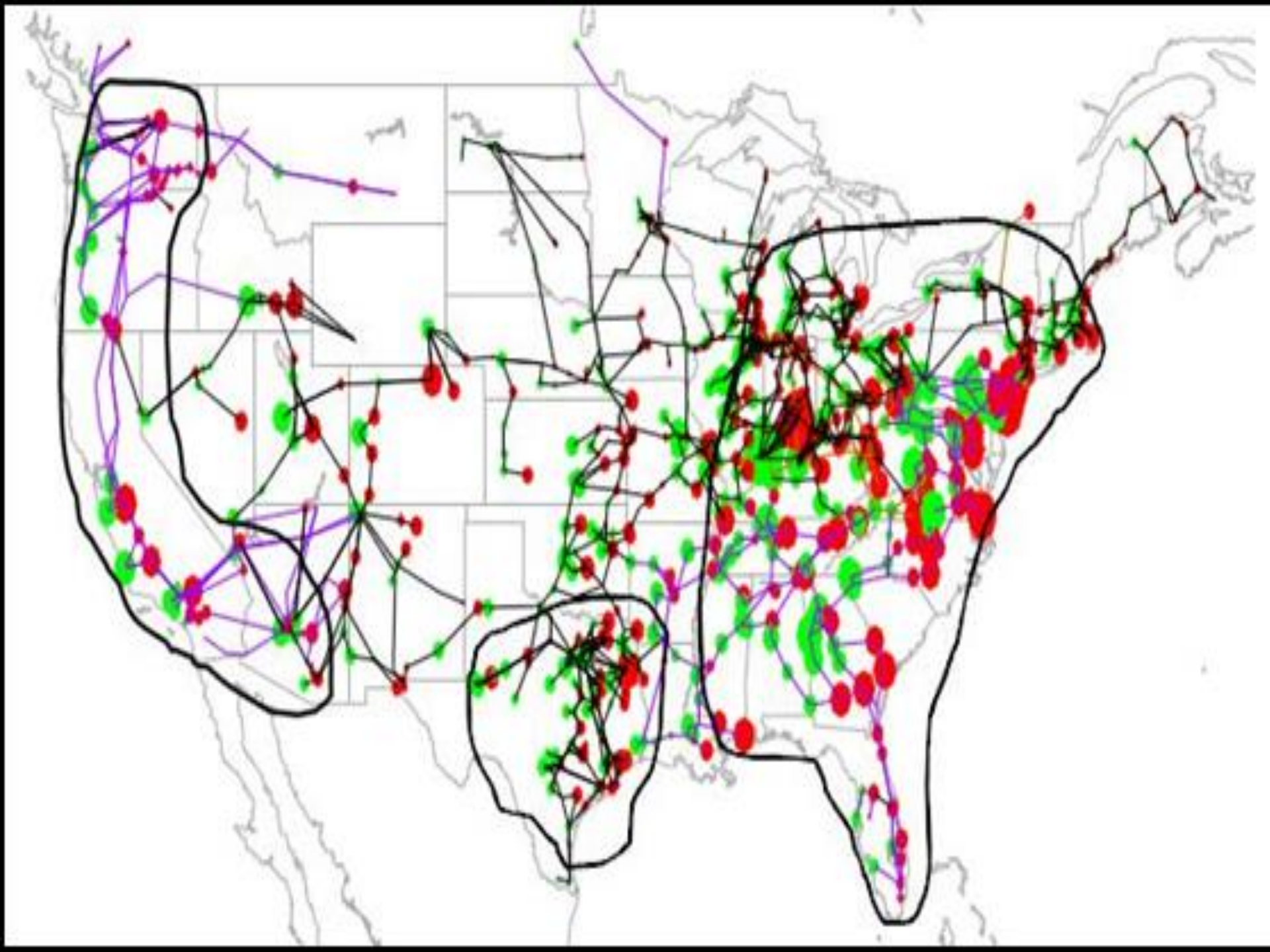
Areas of relatively high resistive igneous rock

High voltage interconnected transmission network

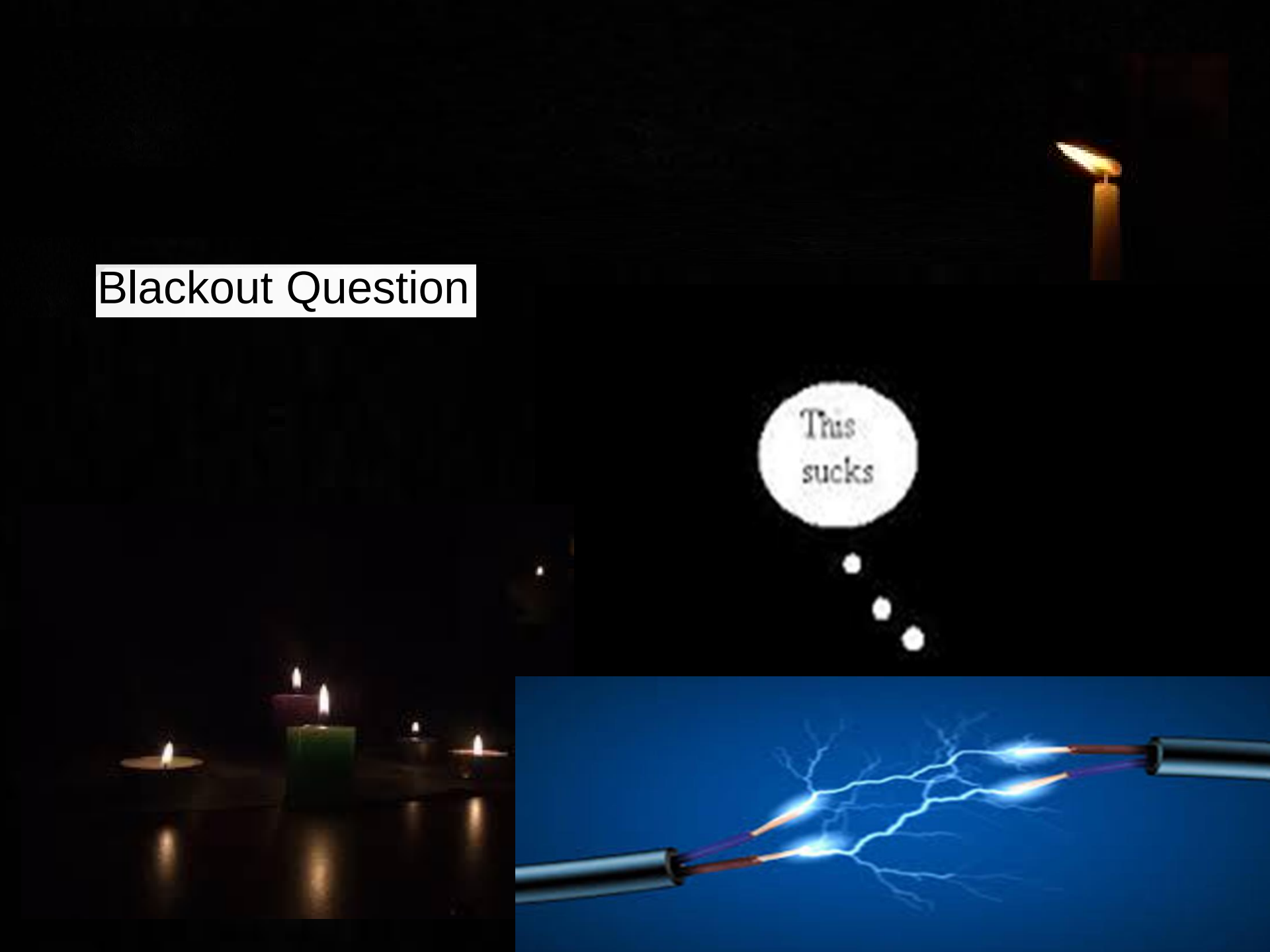
Proximity to oceans (conductivity of ocean salt water)

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

DUTY

BREACH

CAUSATION

\+

DAMAGES

NEGLIGENCE

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?

Swiss Re

General Public Release

Space Weather Impacts a Risk to Society?

Economic Aspects from an Insurance/Reinsurance Point of View

SWISS RE 150 YEARS

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


Headquarters, Zurich

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**


Armonk, New York

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

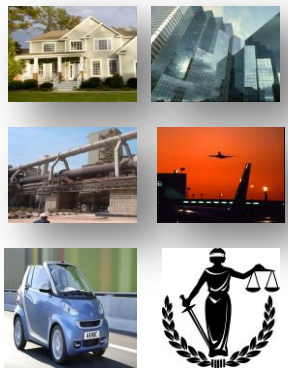
Our financial strength is currently rated:
Standard & Poor's: AA- (stable); Moody's Aa3 (stable); A.M. Best: A+ (stable)

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


The "Gherkin", London

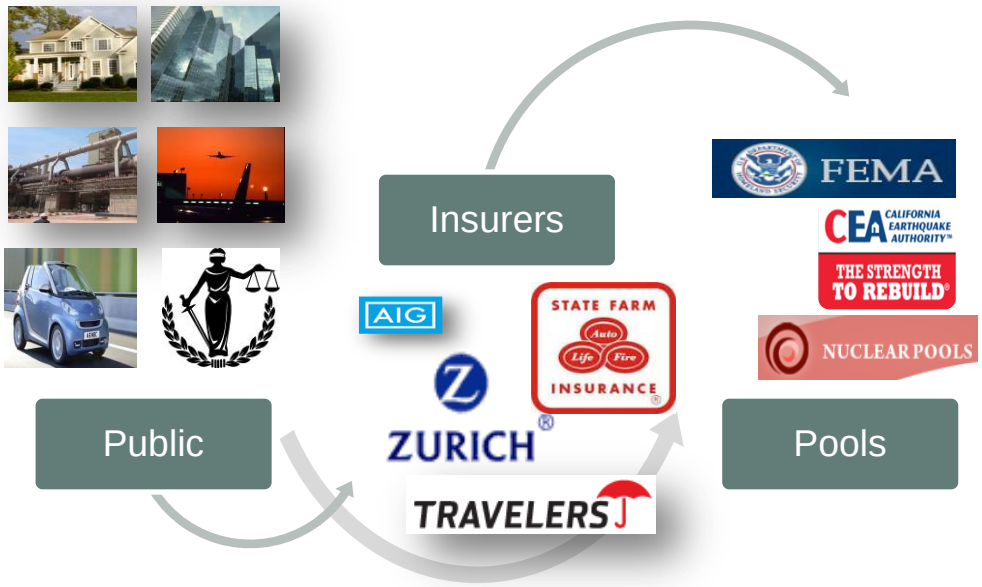
Key statistics (USD billions)	**FY 2009**	**FY 2010**	**FY 2011**	**FY2012**
Total revenues:	31.0	28.8	28.0	33.6
Net income:	0.5	0.9	2.6	4.2
Shareholders' equity:	25.3	25.3	29.6	34.0

Risk holders, risk takers

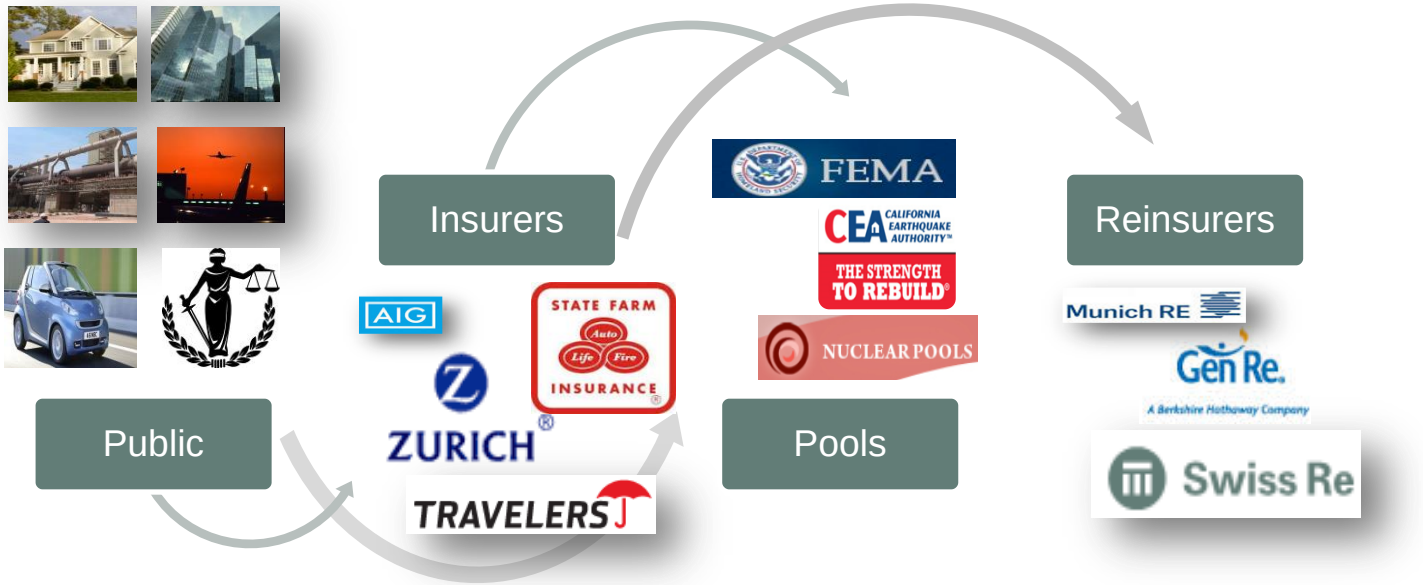


Public

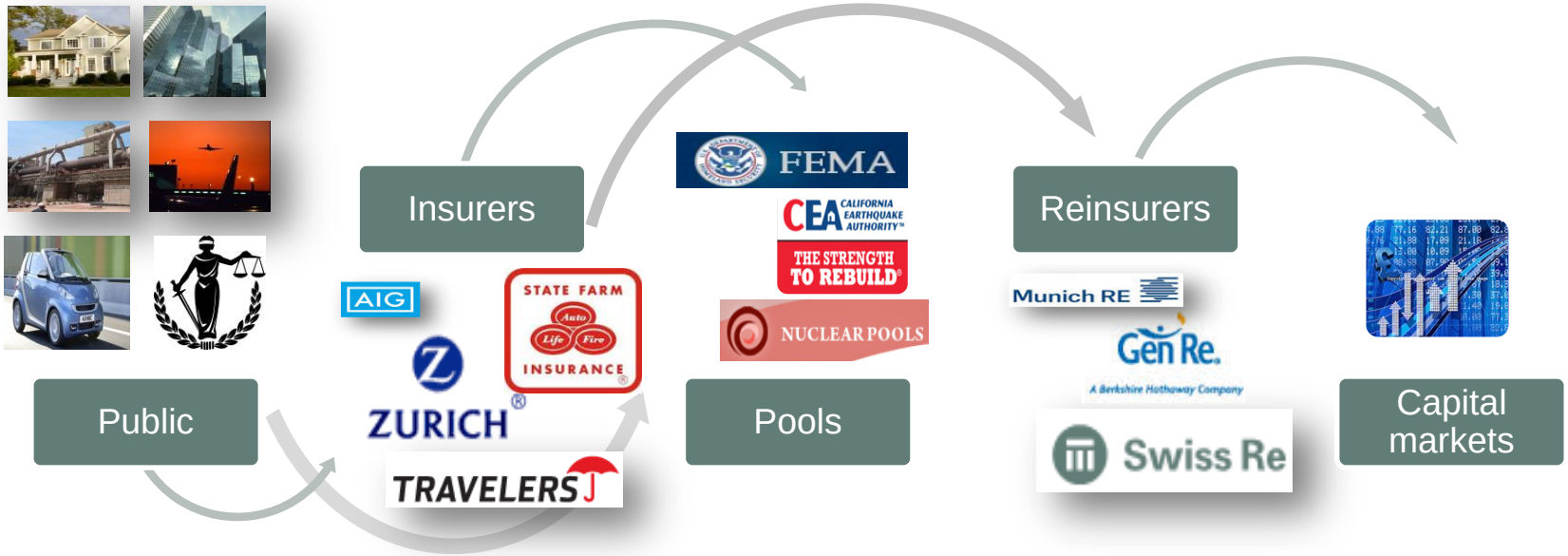
Risk holders, risk takers



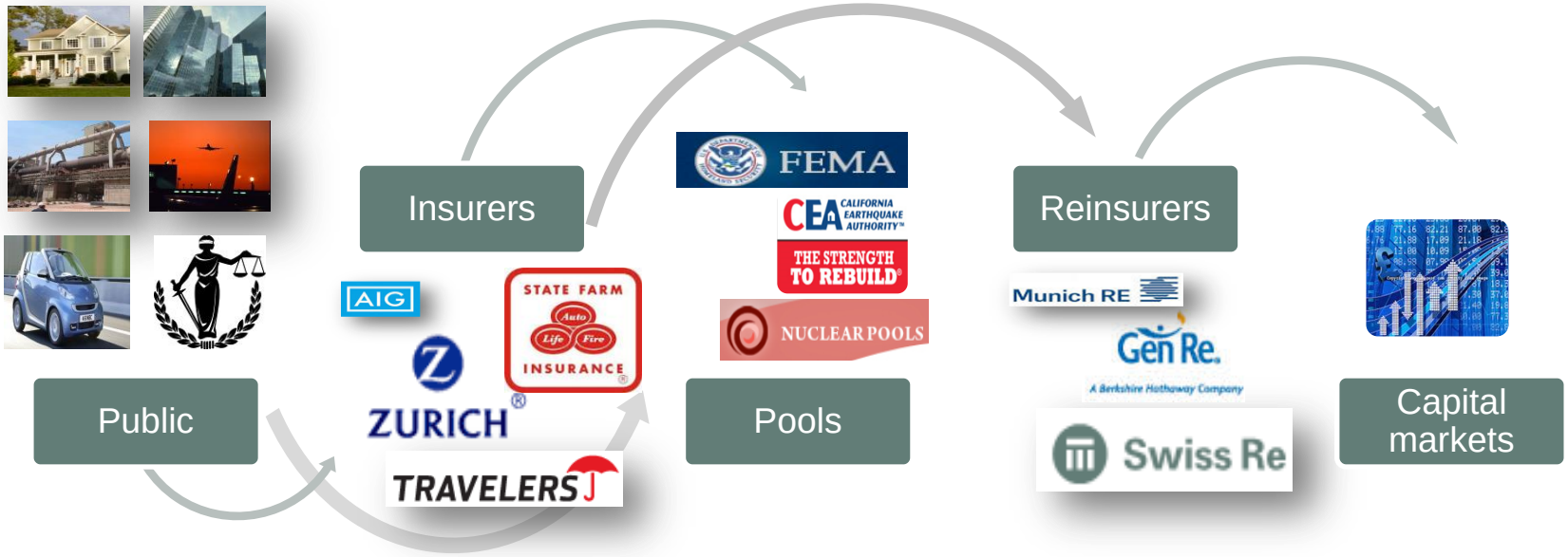
Risk holders, risk takers



Risk holders, risk takers



Risk originators/holders, risk takers



Complexity of products increases

When risk strikes…

Public

Insurers

AIG

STATE FARM INSURANCE

ZURICH

TRAVELERS

FEMA

CEA CALIFORNIA EARTHQUAKE AUTHORITY

THE STRENGTH TO REBUILD

NUCLEAR POOLS

Pools

Reinsurers

Munich RE

Gen Re. A Berkshire Hathaway Company

Swiss Re

Capital markets

When risk strikes…

Public

$$$ $$

Insurers

AIG

STATE FARM Auto Life Fire INSURANCE

ZURICH

TRAVELERS

FEMA

CEA CALIFORNIA EARTHQUAKE AUTHORITY

THE STRENGTH TO REBUILD

NUCLEAR POOLS

Pools

Reinsurers

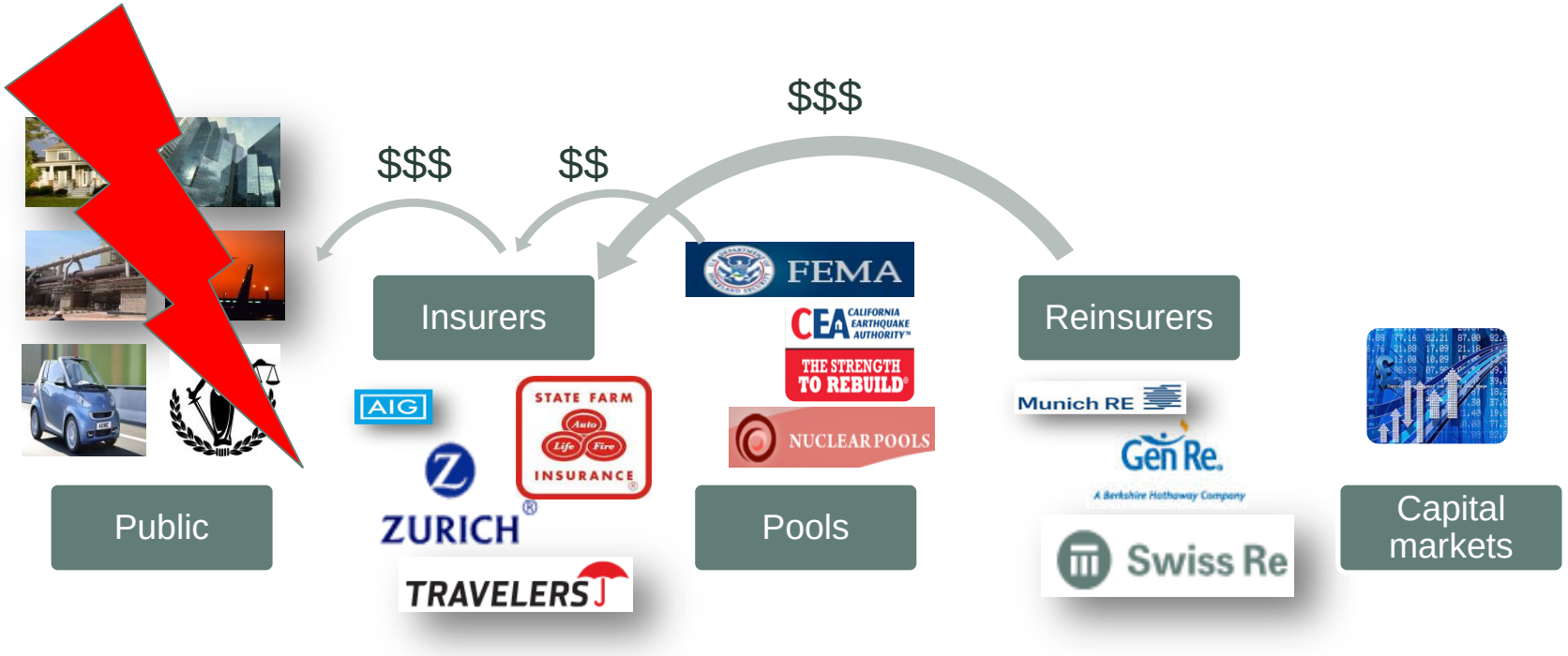
Munich RE

Gen Re. A Berkshire Hathaway Company

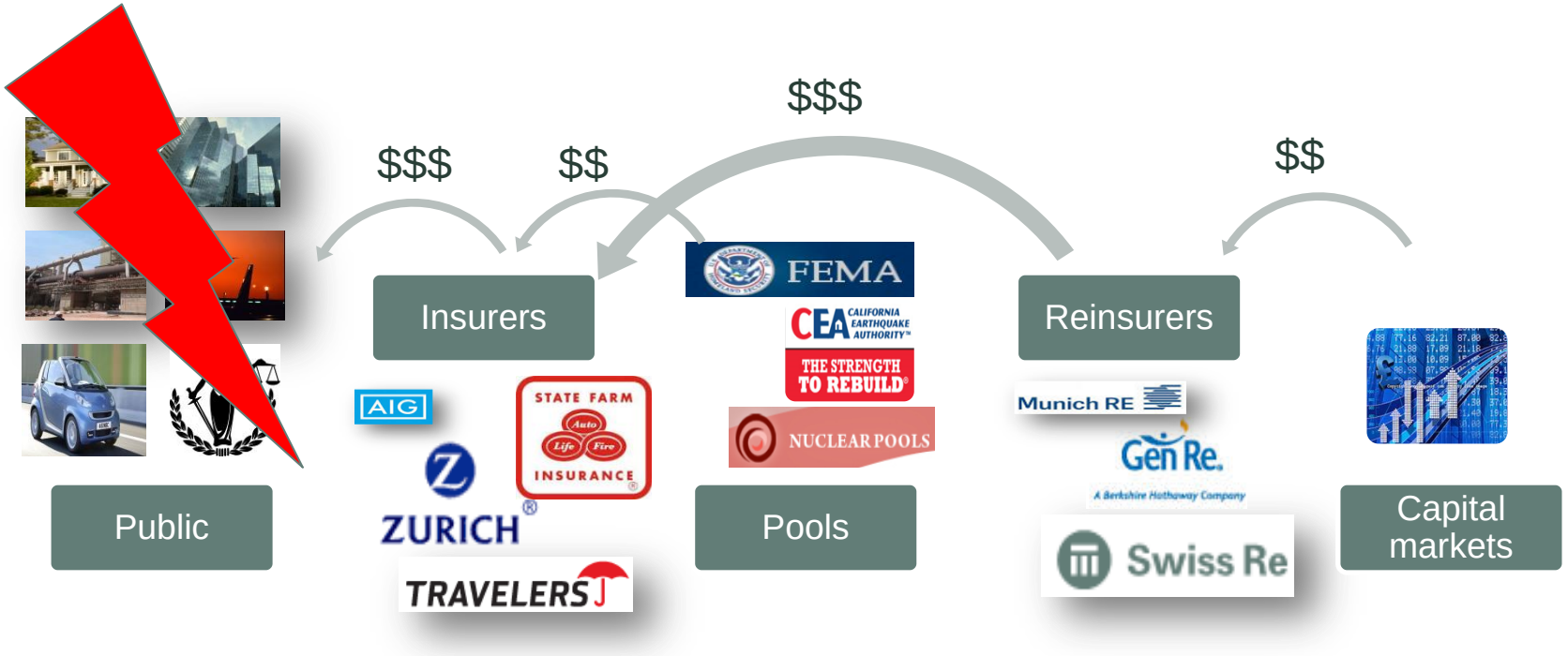
Swiss Re

Capital markets

When risk strikes…

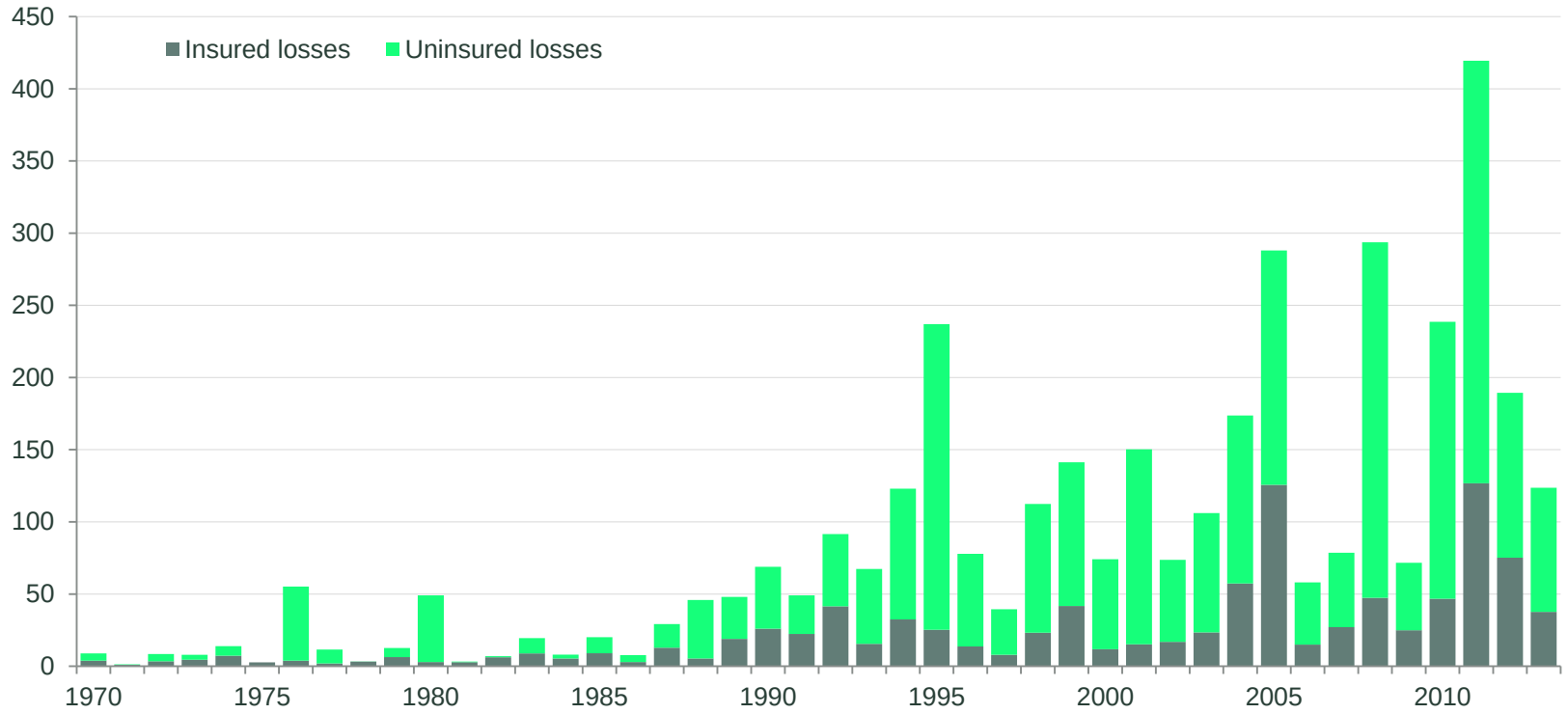


When risk strikes…



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

- Increasing values
- Concentration in exposed areas
- Insurance penetration
- Changing hazard
  - climate variability
  - climate change

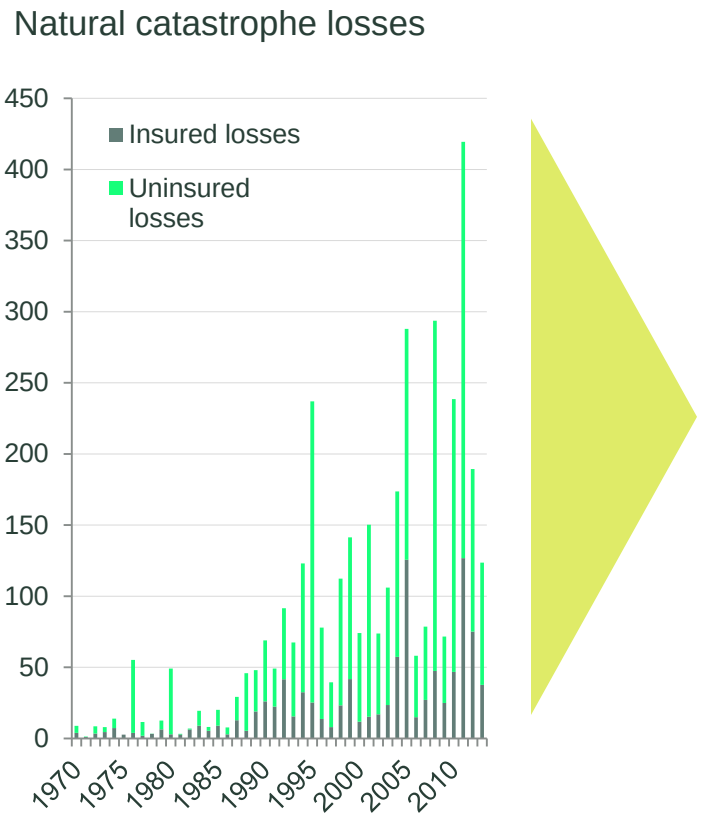
Ocean Drive, FL, 1926.

Ocean Drive, FL, 2000.

Population Growth Rates (1960-2000)

All US	57%
Florida	223%

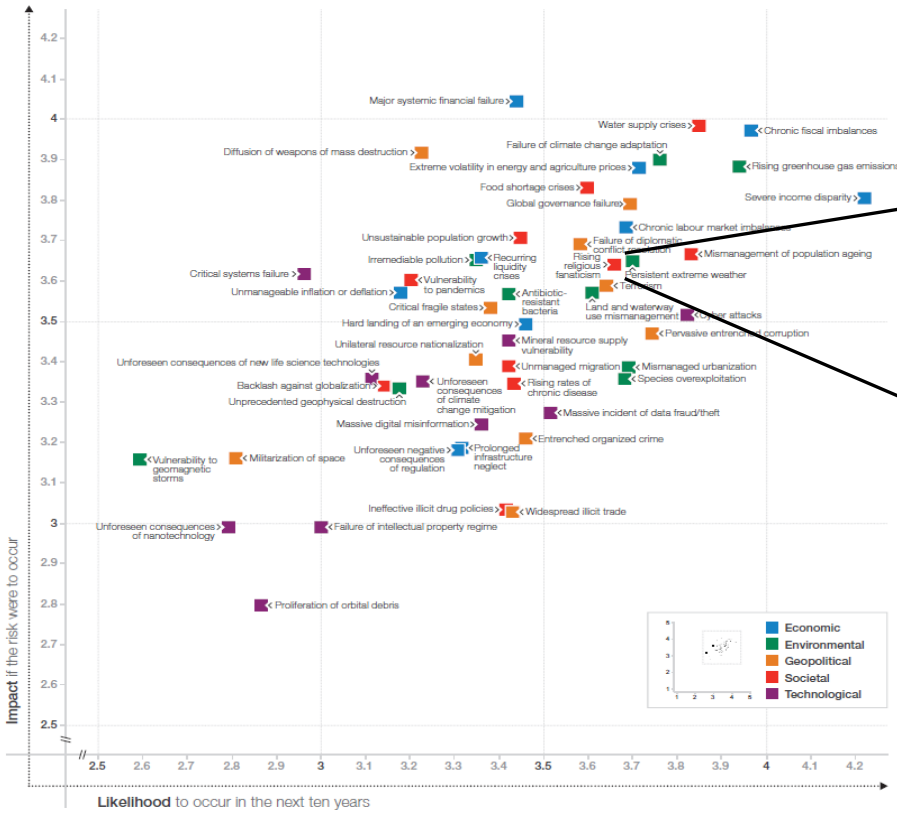
Disasters place a significant burden on the public sector



- 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

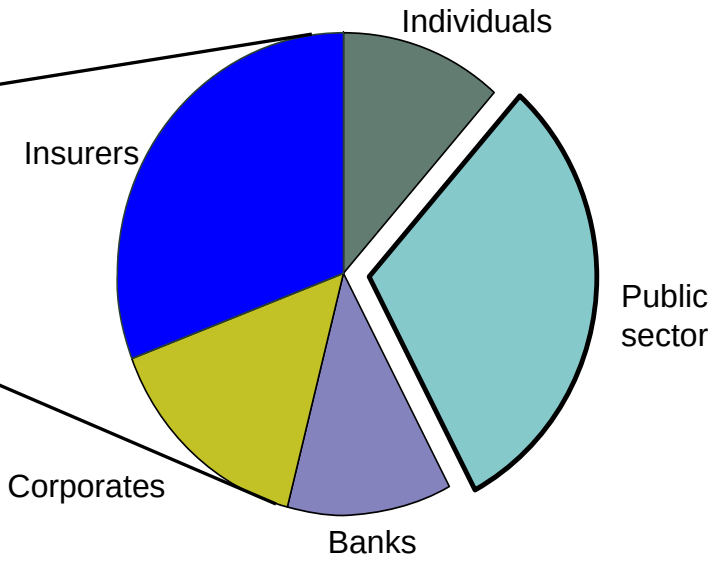
Risk financing – Who get's the bill?

1. What are the risks?



2. Who will pay?

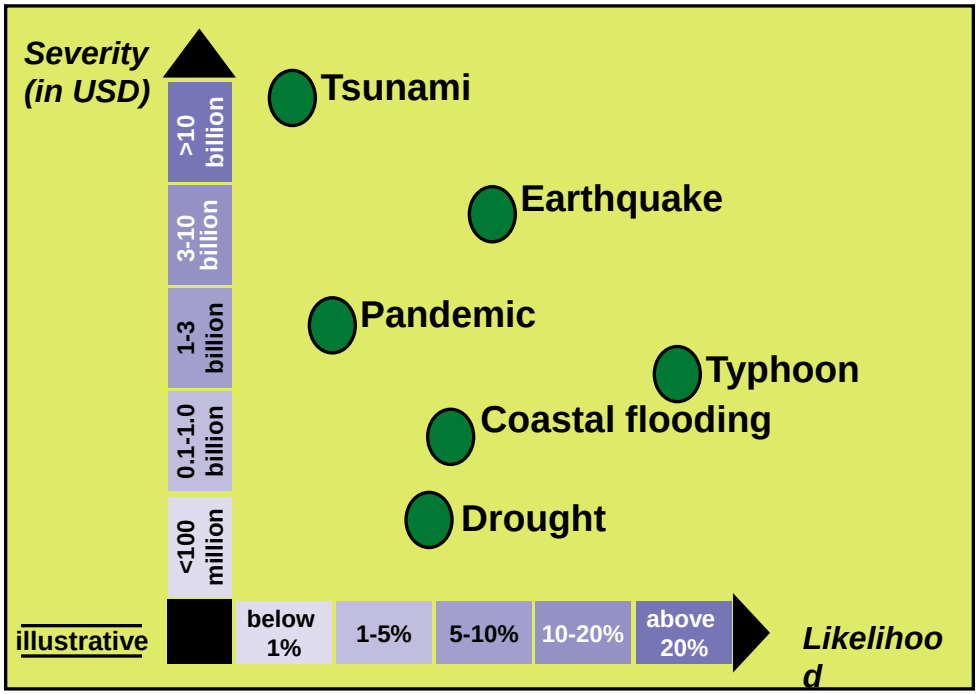
illustrative



A significant portion of the largest risks ends up with the public sector

Systematic risk management approach for natural disasters

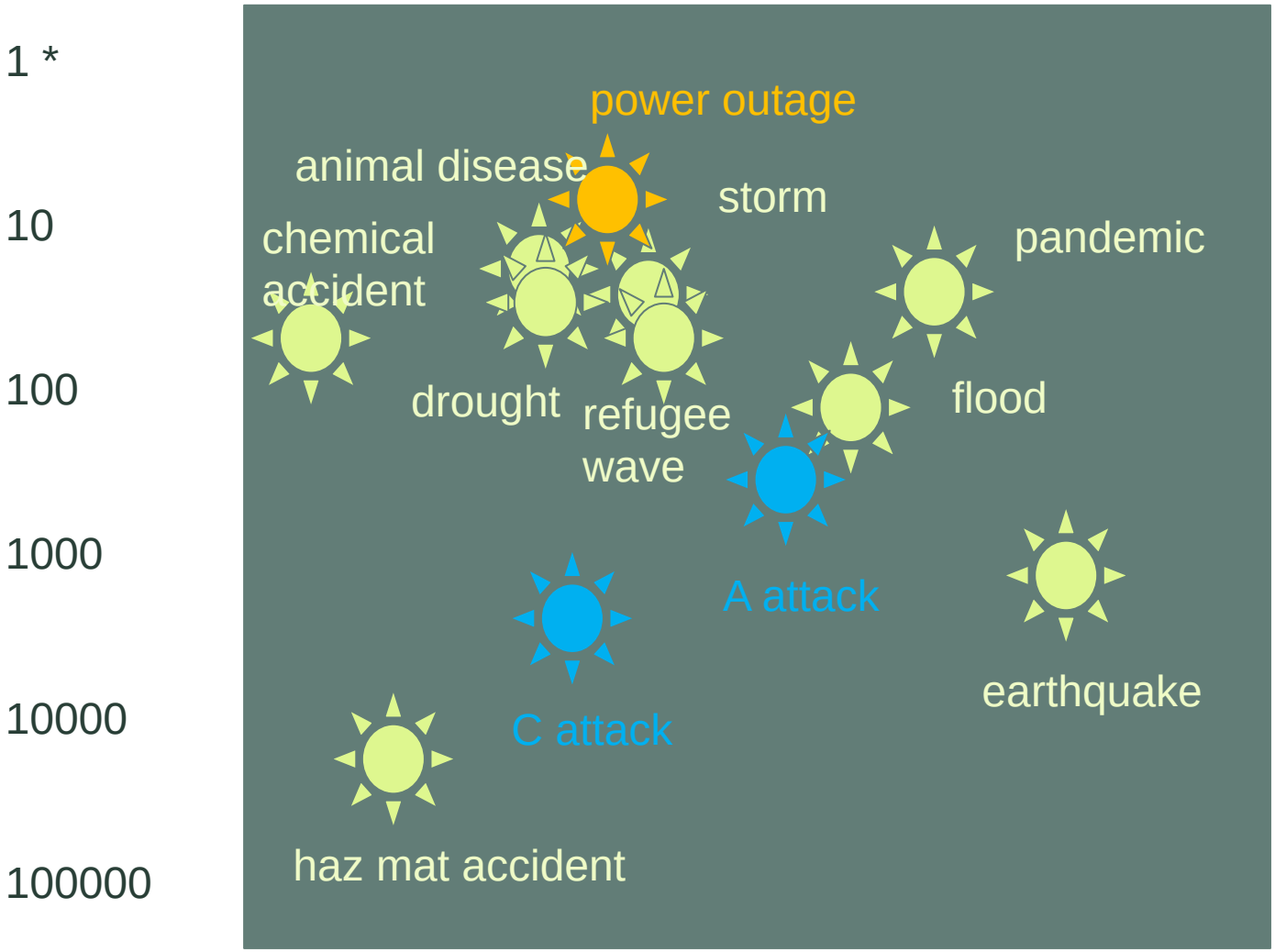
Identification → Assessment → Prevention and Mitigation → Adaptation



- Prevention 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

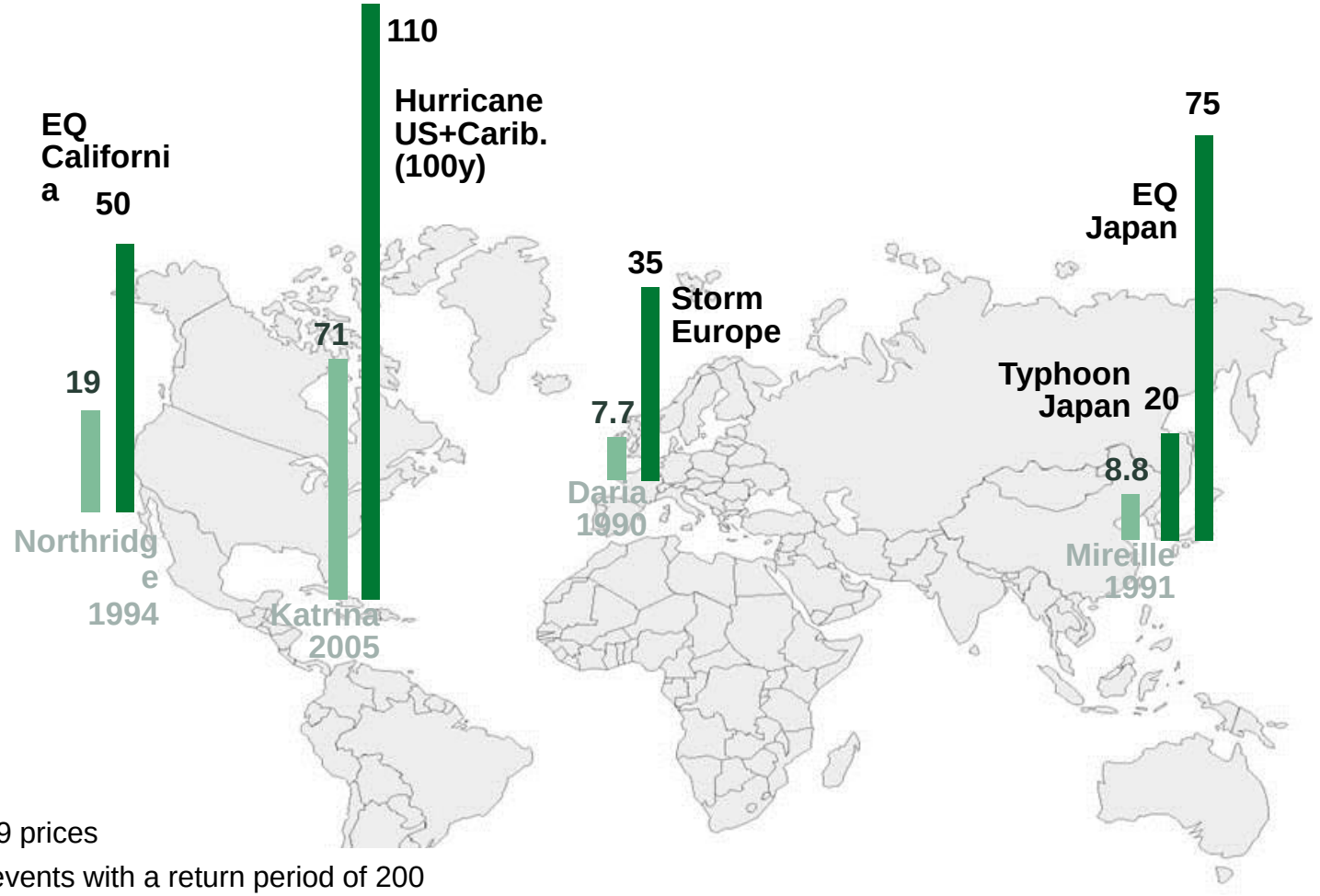
The search for Black Swans

- 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



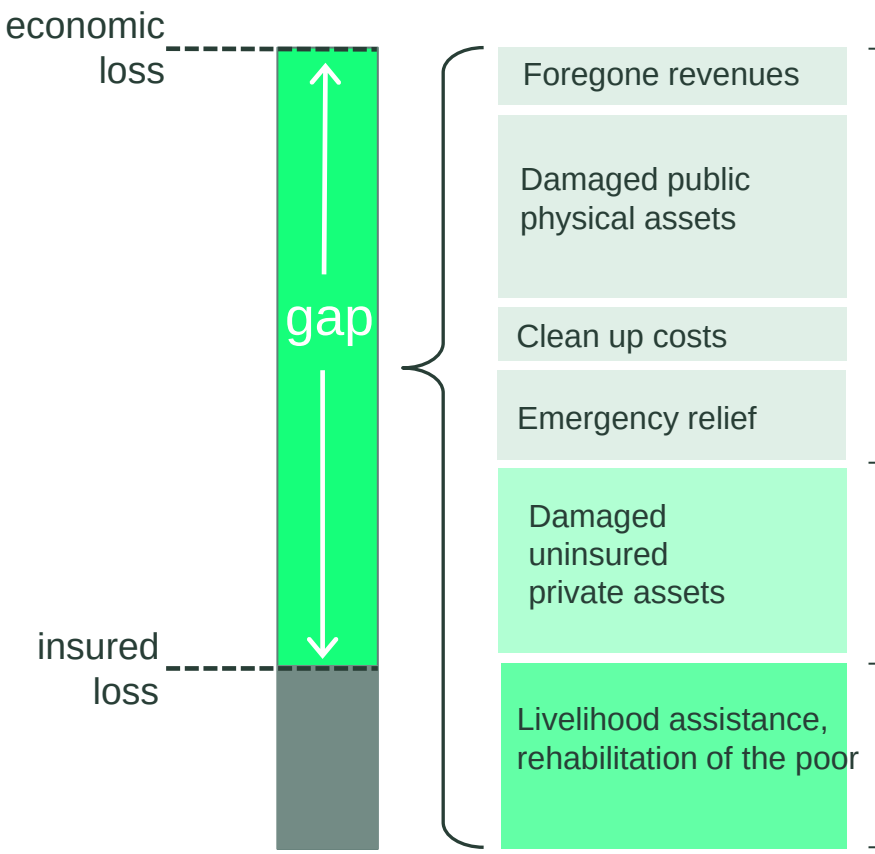
Nat cat events at 2009 prices

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

all figures in USD bn

Risk transfer: efforts required on all fronts

Macro, micro and pooling



	How to close the gap?	
	Solution type	Description
Foregone revenues Damaged public physical assets Clean up costs Emergency relief	Macro	Risk transfer solutions for (sub)sovereigns to cover their direct or indirect costs
Damaged uninsured private assets	Pooling	Insurance schemes and pools to increase insurance penetration
Livelihood assistance, rehabilitation of the poor	Micro	Simplified products distributed via aggregators such as MFIs, NGOs, and corporates

Case study Mexico: MultiCat - Funding for immediate relief efforts after disasters

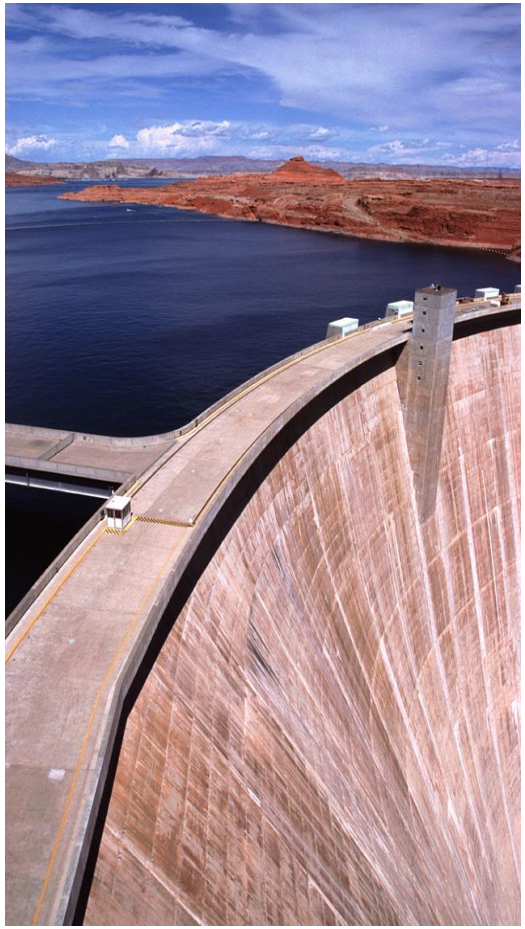
Solution features

- 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

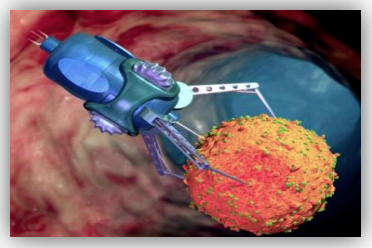
Exemplary emerging risk topics featured in the latest SONAR publications

Cyber vulnerability

Prolonged power blackout

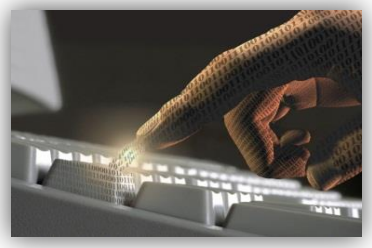
New forms of mobility

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

World population

Economic disparity

Demographic challenges

Sovereign debts

Democracy & dignity

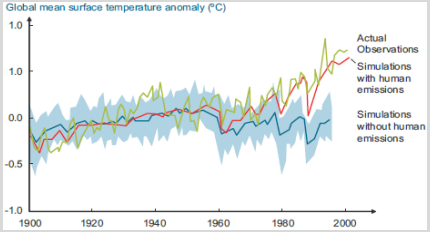
New powers & governance

Policies & regulation

New technologies

Urbanisation

Climate change

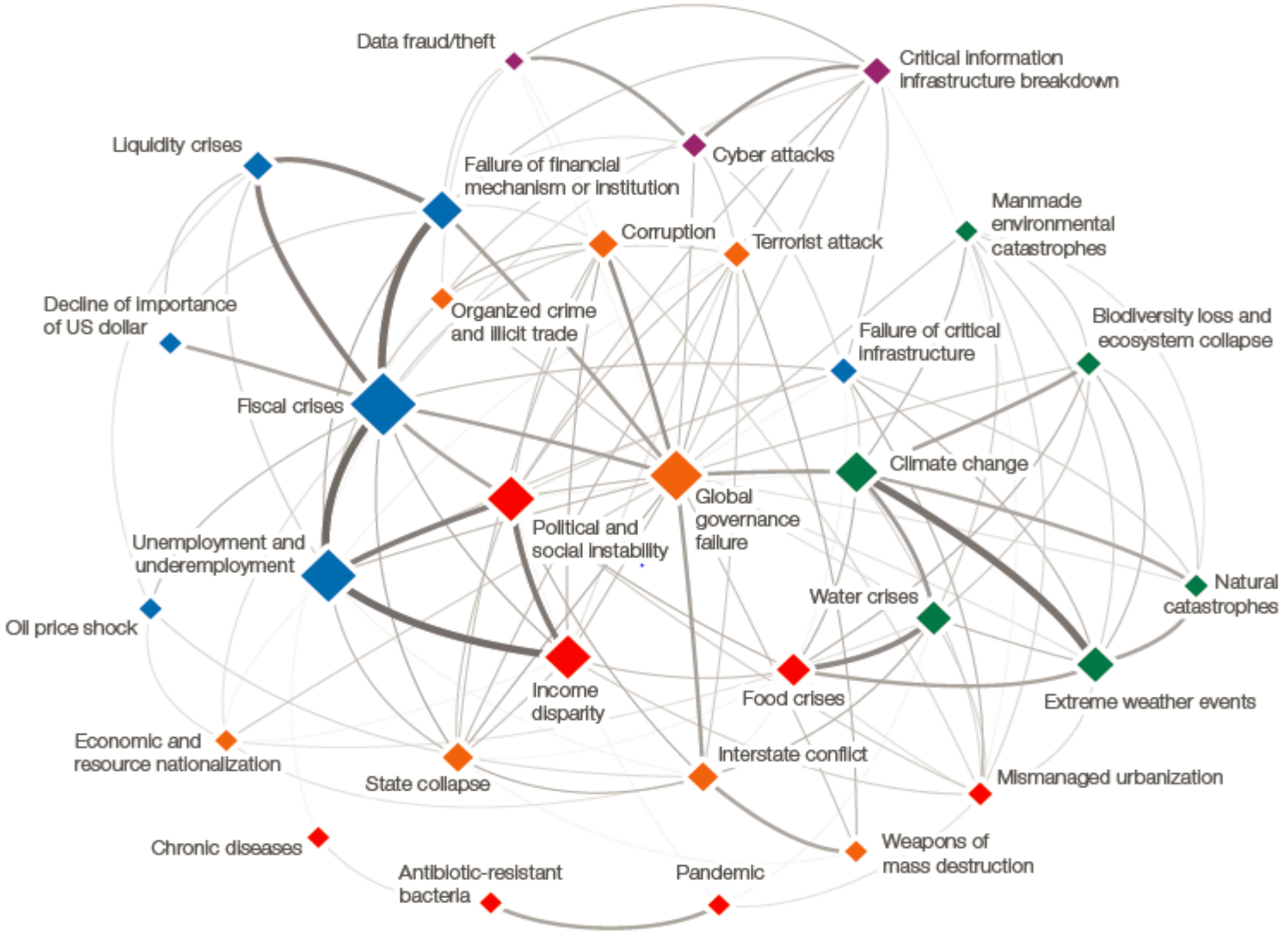


Social interaction media

Intellectual property

The evolving global risk landscape

The top 5 global risks in terms of **impact**



Global Risks 2014
Interconnection Map

Economic Risks

Geopolitical Risks

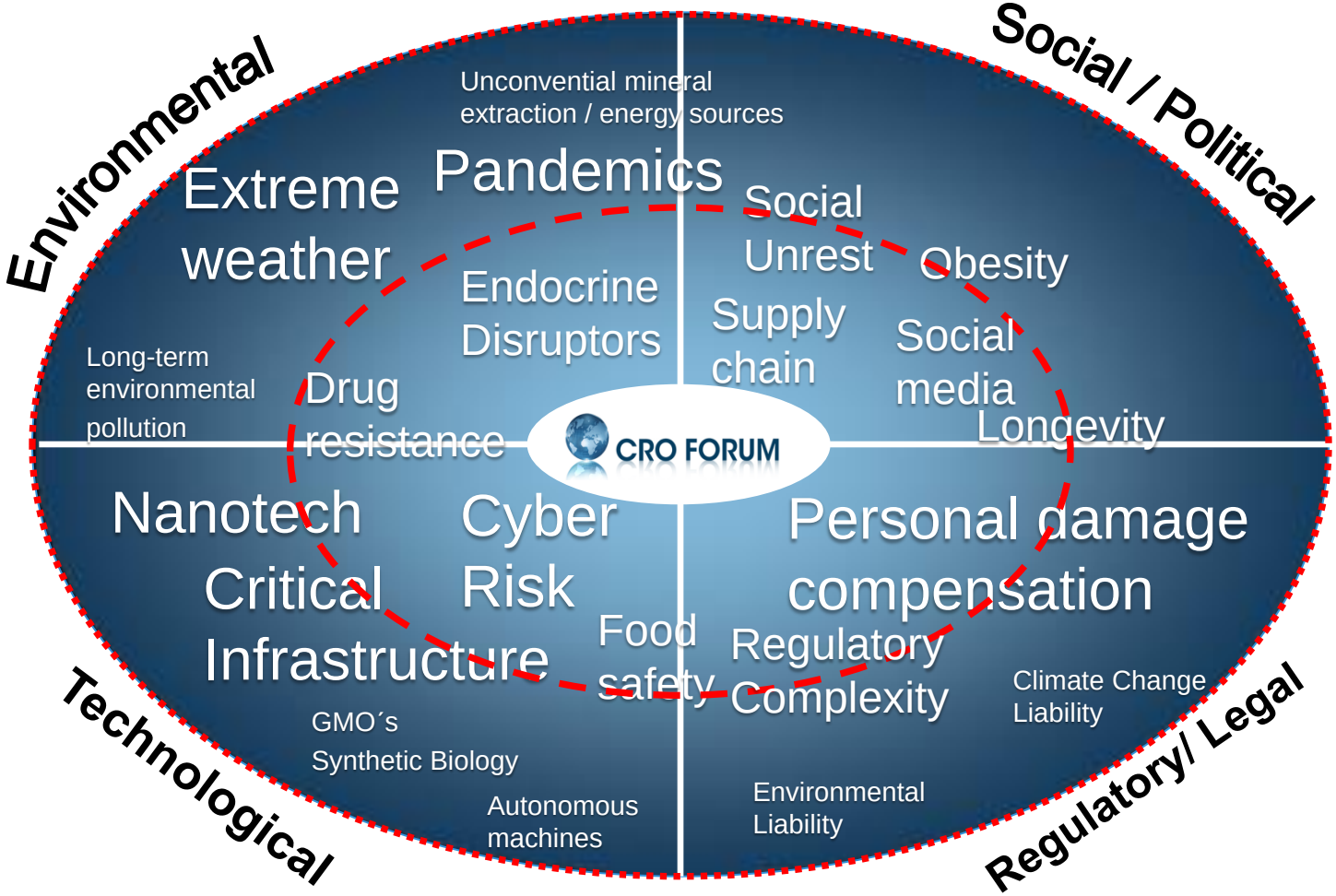
Technological Risks

Environmental Risks

Societal Risks

Number and strength of connections ("weighted degree")

ERI – Risk Radar Update 2012

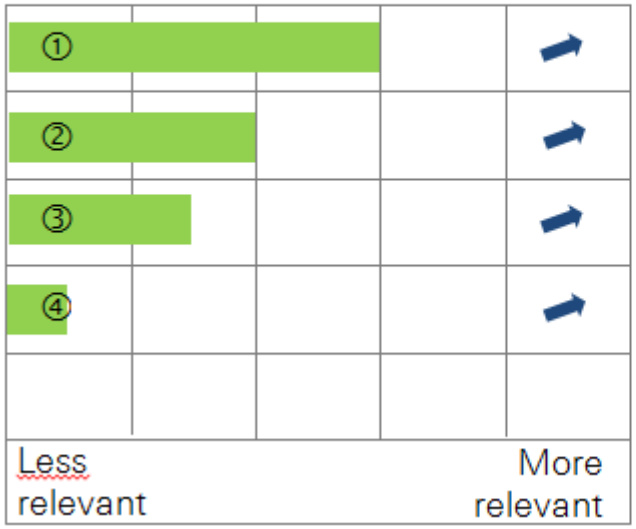


Timeline Horizon

First significant impacts expected within 1-5 years

First significant impacts expected within 5-10 years

Major Industry Risk Trends
Power utilities



Power utilities

Major industry risk trends

① **Ageing infrastructure**

② **Growing energy demand**

③ **Integration of renewables**

④ **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

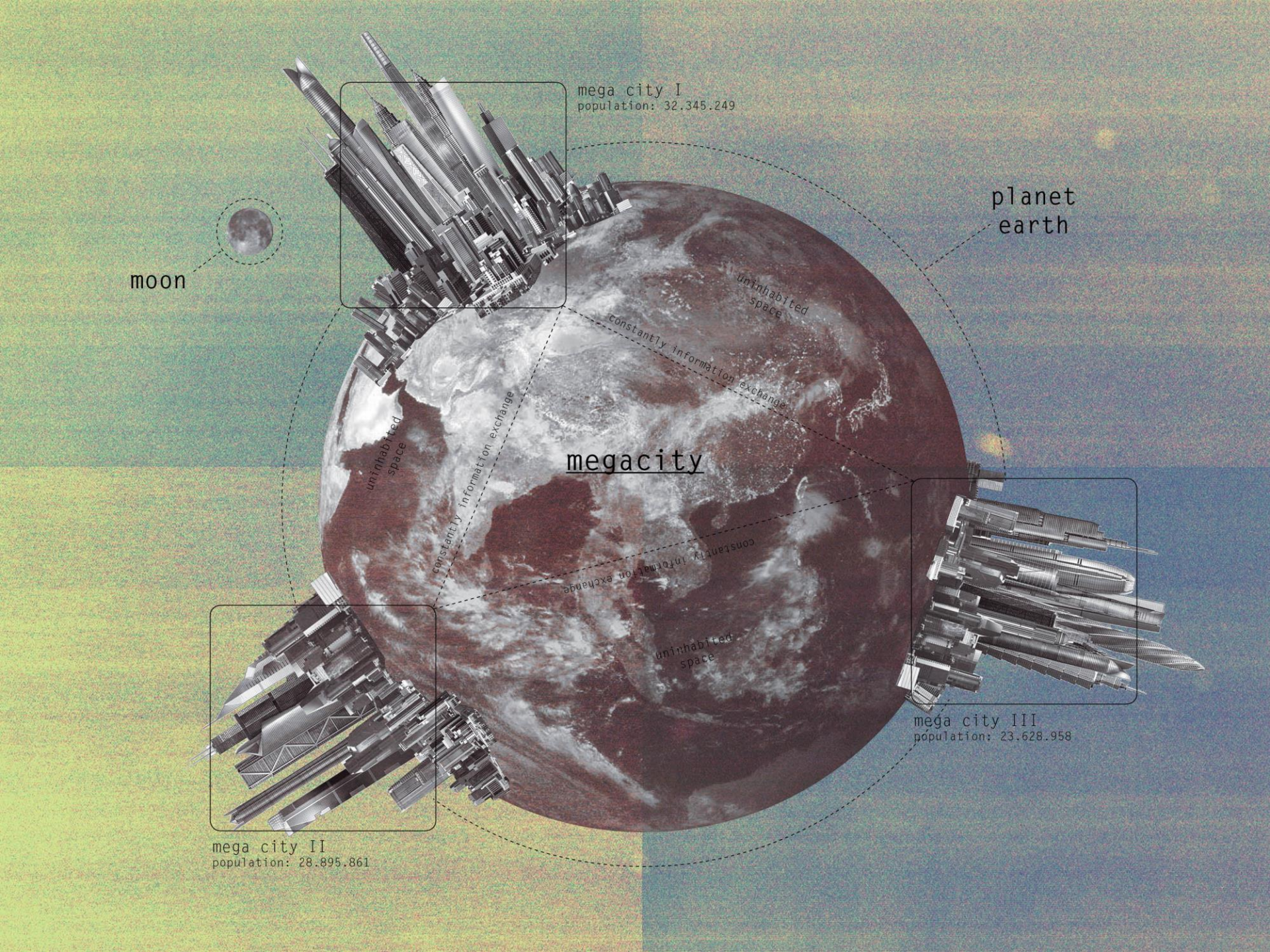
Power utilities
Smart meters – gaining ground

- 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


mega city I
population: 32.345.249
moon
planet
earth
uninhabited
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constantly information exchange
uninhabited
space
megacity
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constantly information exchange
uninhabited
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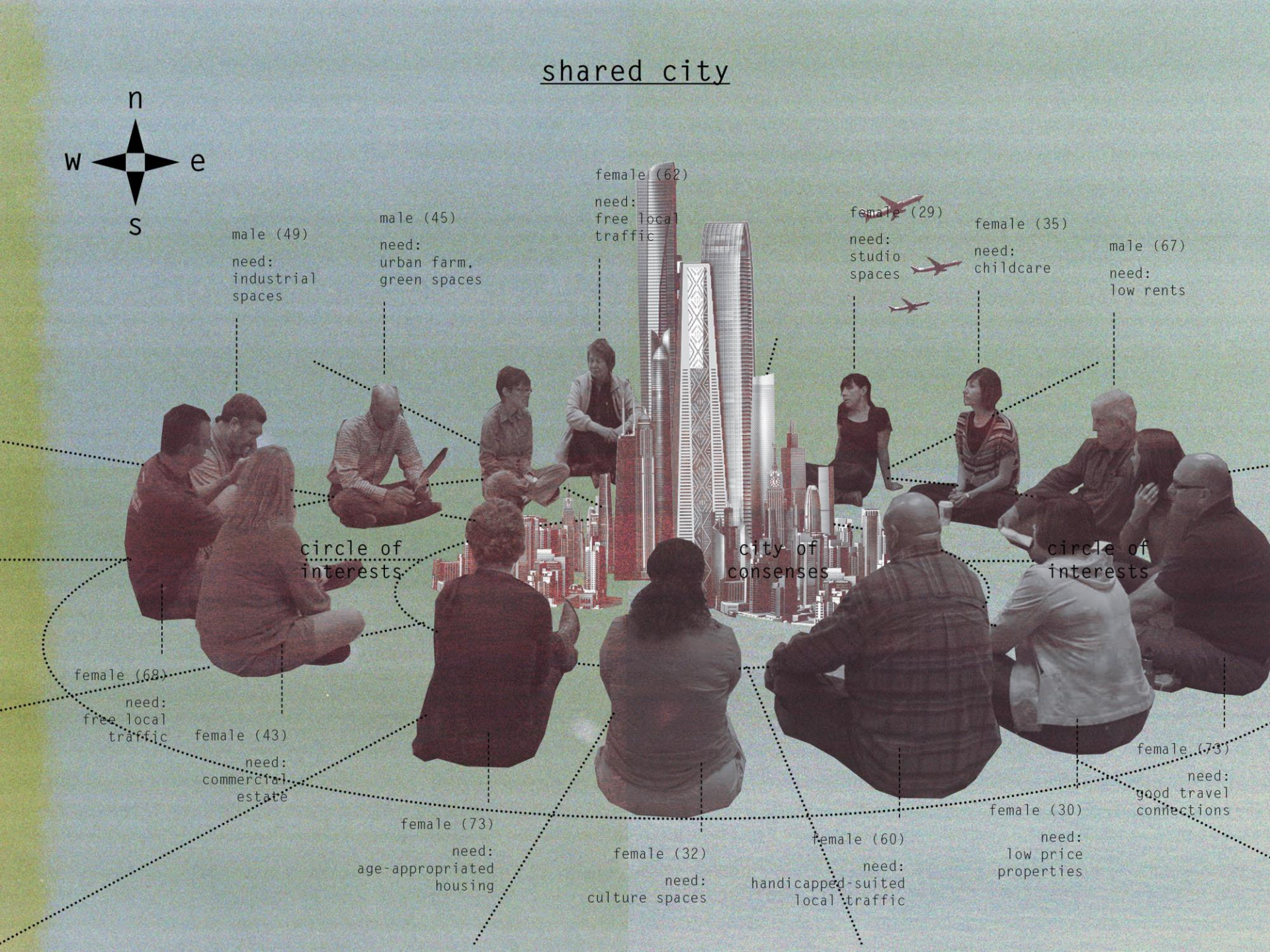
mega city III
population: 23.628.958
mega city II
population: 28.895.861

shared city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culture spaces
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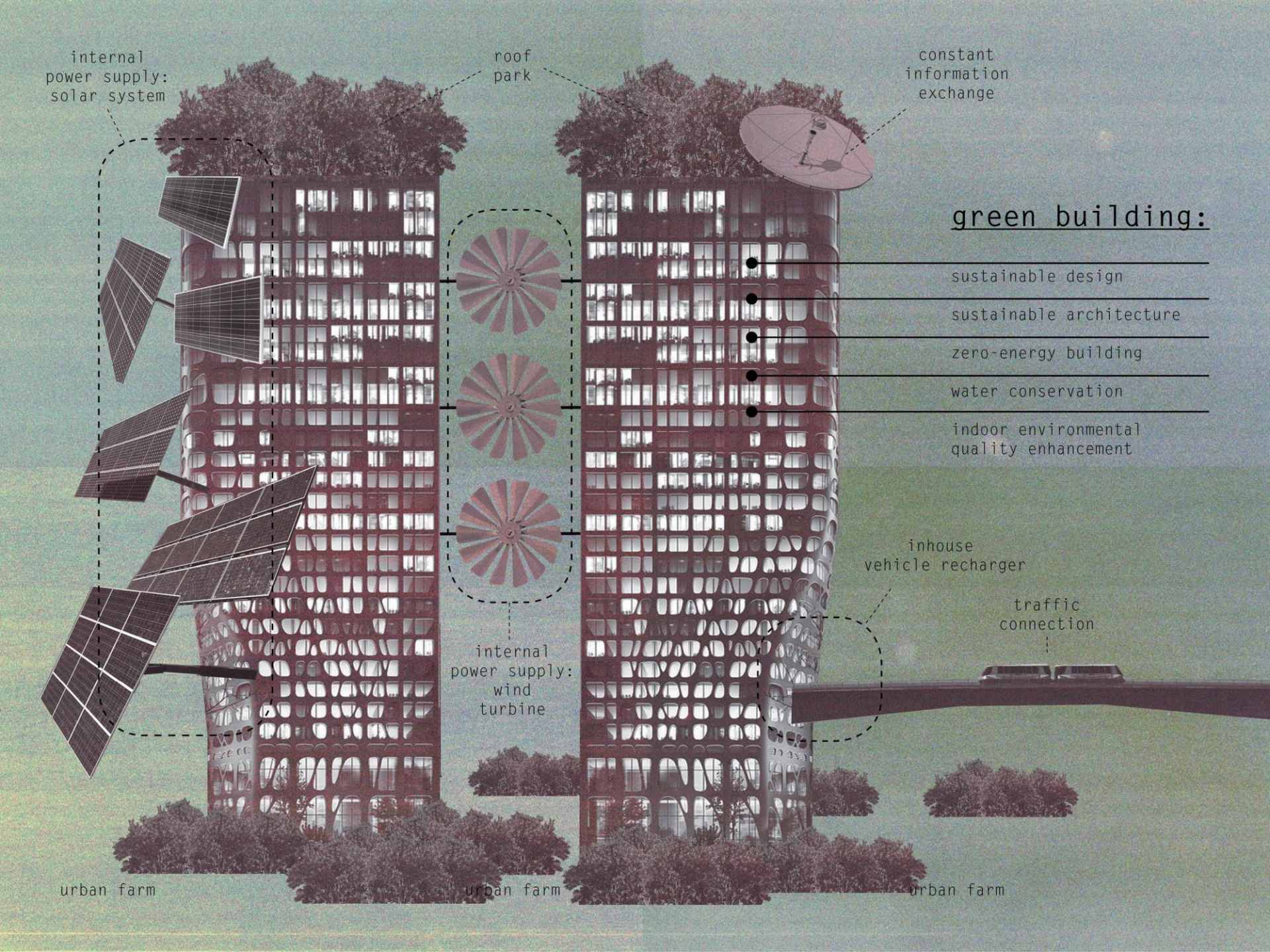
female (73)
need:
good travel
connections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power supply:
solar system
roof
park
constant
information
exchange
green building:
sustainable design
sustainable architecture
zero-energy building
water conservation
indoor environmental
quality enhancement
inhouse
vehicle recharger
traffic
connection
internal
power supply:
wind
turbine
urban farm
urban farm
urban farm

Risk Management Cycle

- 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 flares 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.

Have solar storms affected us before?

1859	1921	1940	1972	1989	2000	2003	2006
Carrington event, one of the biggest geomagnetic storms on record.	Solar storm induced currents disable part of New York Central Railroad.	Solar storm damages telegraph and telephone lines across the USA.	Solar flare knocks out long-distance phone communication across some 48 states.	Solar flare causes major blackout in Canada with six million people affected.	Solar eruption causes satellites to short-circuit and leads to radio blackouts.	Intense solar storm causes extensive satellite problems.	Major solar flare disrupts satellite communication and GPS navigation.

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 upper 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.

⚠ There are a lot of major solar storms, but only few hit earth (the others just blow out into space).

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.

⚠ Not every region on earth is equally susceptible due to different geology (e.g. igneous rock formation), latitude/longitude (the further north the more frequent the geomagnetic disturbance).

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.

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

Mobile devices | Communication | Flights | Travel | TV/News reports | Navigation

How would the effects be felt 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

What would it mean for businesses?

Power generating and distributing sectors would be directly hit by damage to equipment and loss of revenue. All other sectors would suffer collaterally from power outage, leading to business interruption and supply chain disruption.

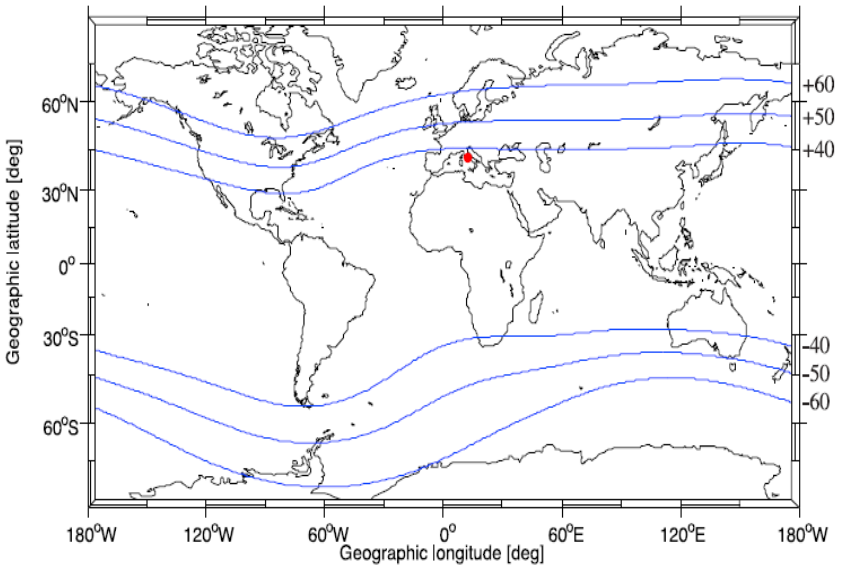
How long would society cope?

- **1 DAY** Emergency generators uphold power supply of critical infrastructure.
- **1 WEEK** Emergency generators run out of fuel, communication is interrupted.
- **2 WEEKS** Shortage of critical supplies give rise to first outbreaks of civil disorder.
- **1 MONTH** Civil disorder gets out of control and looting is commonplace.
- **1 YEAR** Affected areas are abandoned, remaining inhabitants depend on outside aid.
- **LONG TERM** Power is restored, but the economic power balance has permanently shifted.

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

Swiss Re

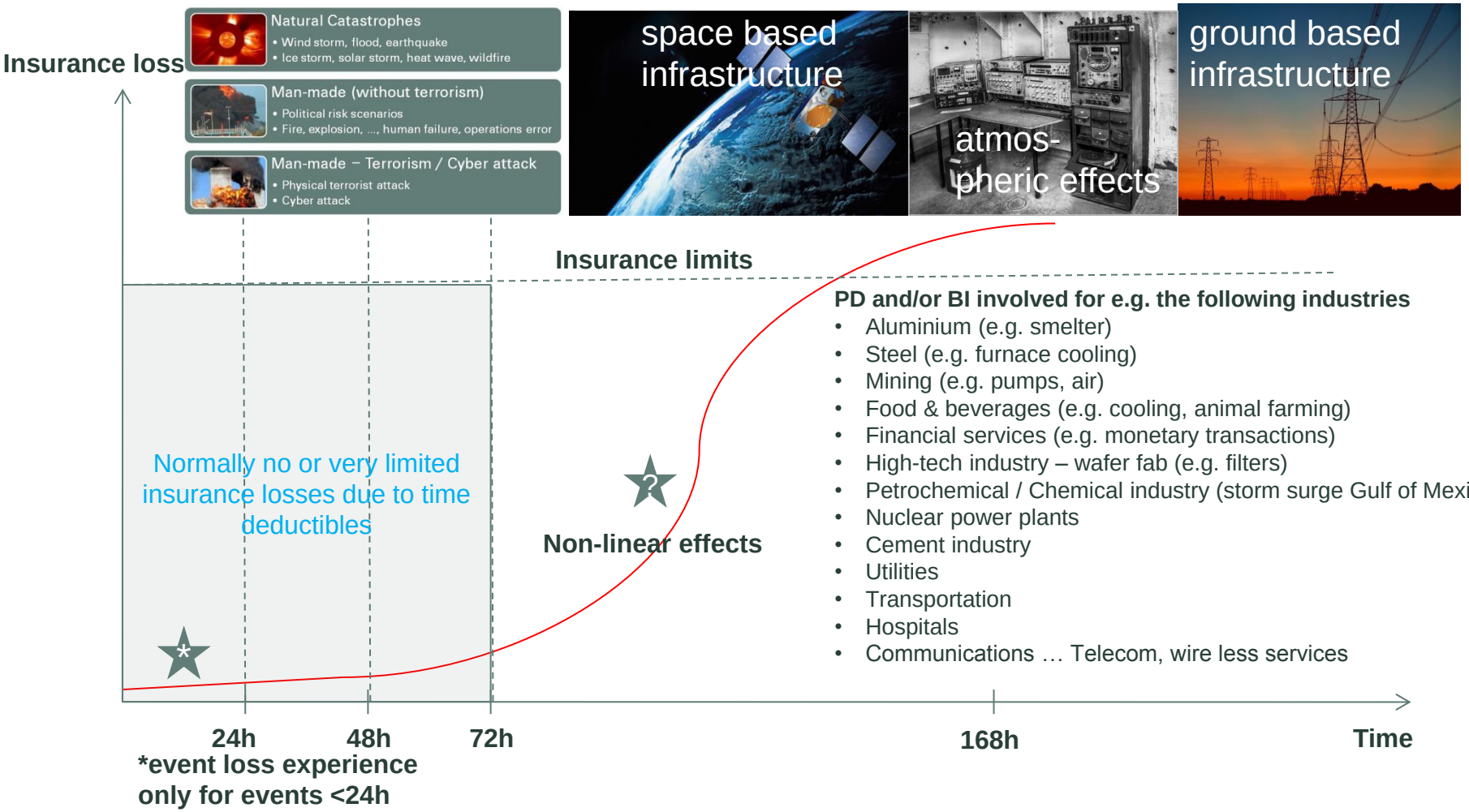
Impact Factors



http://www.aer.com/news-events/videos/geomagnetic-disturbance-scenario

- 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



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

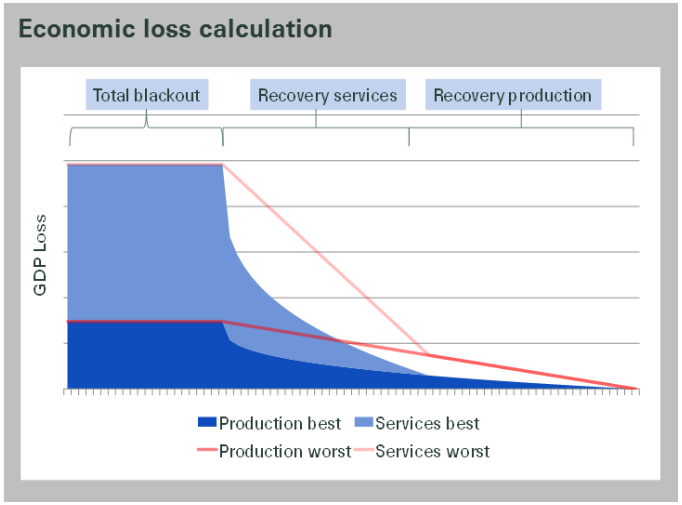
Assumption grid to build scenarios to estimate economic loss. Proxi: Impact on GDP

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

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%



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

Regions	Economic Loss	
	Best	Worst
US & Canada	128'808	163'866
Scandinavia & UK	28'903	37'210
Germany, France, Italy, Switzerland, Austria	73'934	95'185
Accumulation Europe	102'837	132'395
Japan	41'746	53'745
Australia	7'617	9'806

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

Regions	Economic Loss
Scandinavia & UK	192
Germany, France, Italy, Switzerland, Austria	492

Figures in mUSD

Validity check with historical events

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

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

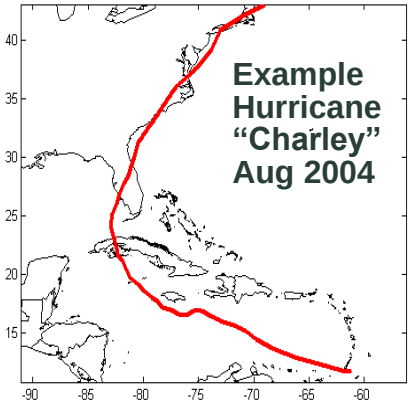
[1] electrosuisse Bulletin 12s/2011

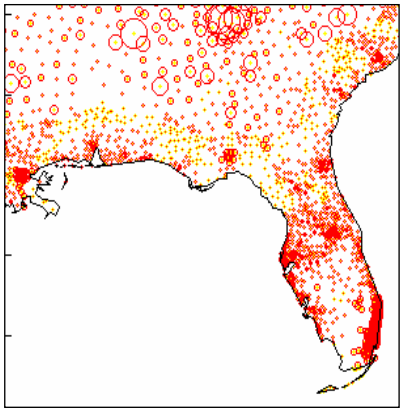
Prolonged Power Blackout
Executive Summary - Mitigation

- 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?	





- Deductibles
- Covers
- Shares
- Exclusions
- …

Solar Storms
what can be done to prevent this?

- **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

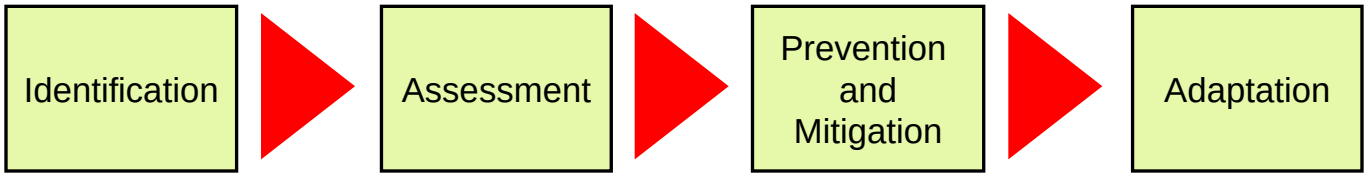
- Political and legal power to set framework conditions that facilitate adaptive responses by individuals, the public and the private sectors
- Typically operates under significant financial constraints. As costs of disasters rise, the ability of governments to cope with natural disasters will be stretched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



- 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

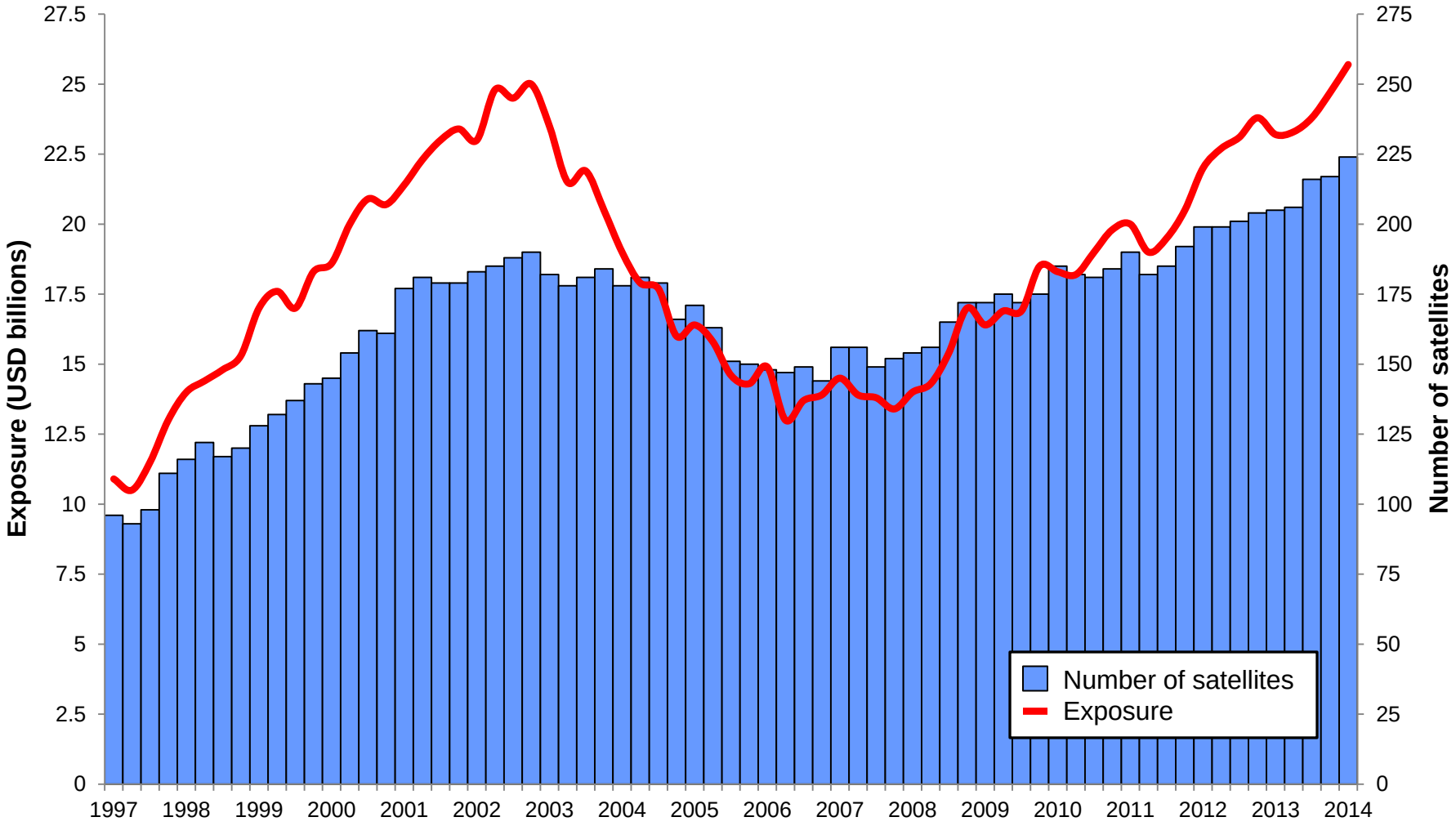
Space Weather Workshop
Boulder CO, April 2014

ATRIUM SPACE INSURANCE CONSORTIUM

Contents

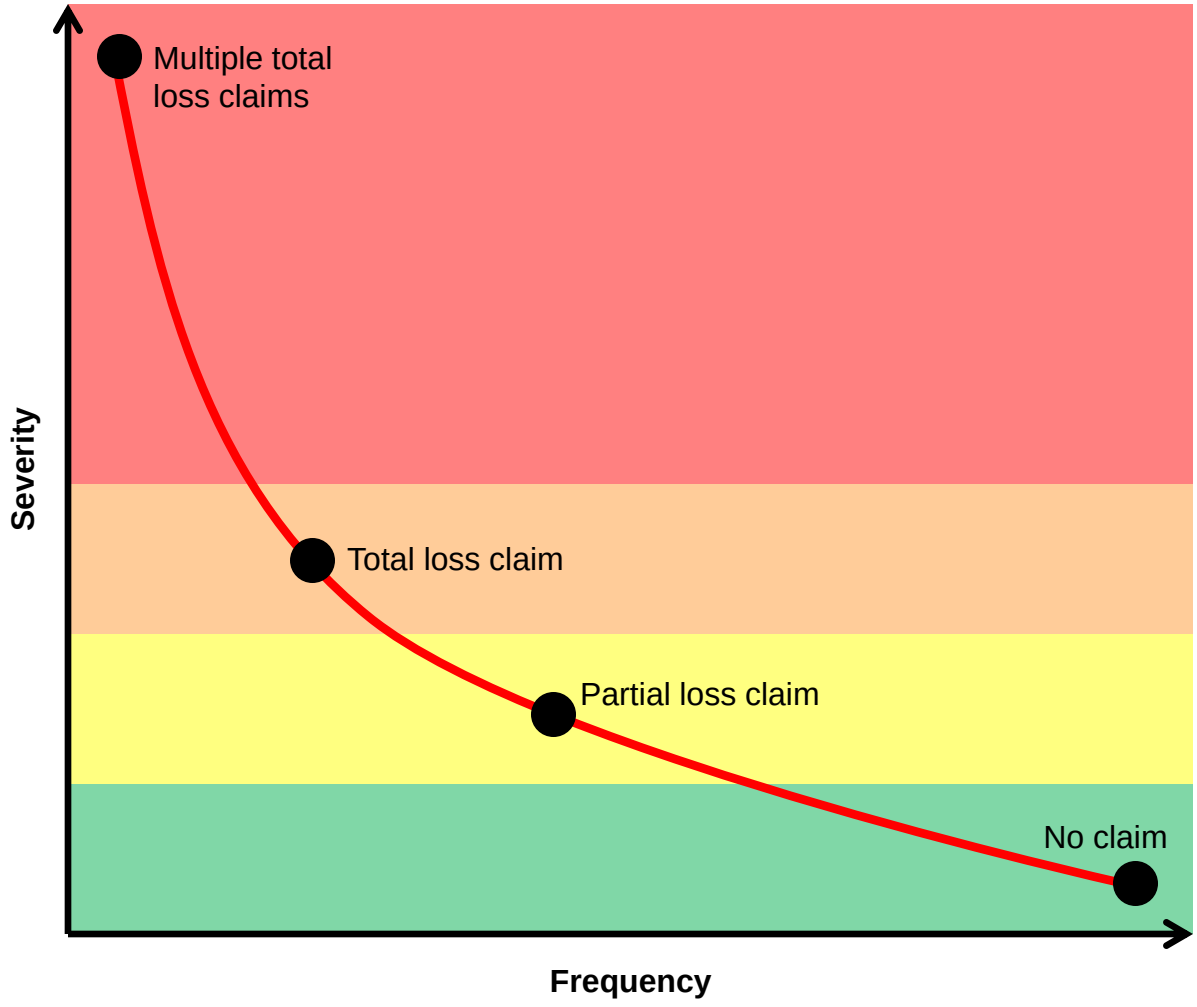
- Space Insurance Market
- Space Insurance Coverage
- Space Weather and Satellite Anomalies
- Space Weather and Satellite Claims
- Satellite Resilience
- Satellite Testing
- Realistic Disaster Scenarios
- Future Developments
- Summary

Space Insurance Market



Ref: XL Insurance

Space Insurance Coverage



Example anomalies:

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

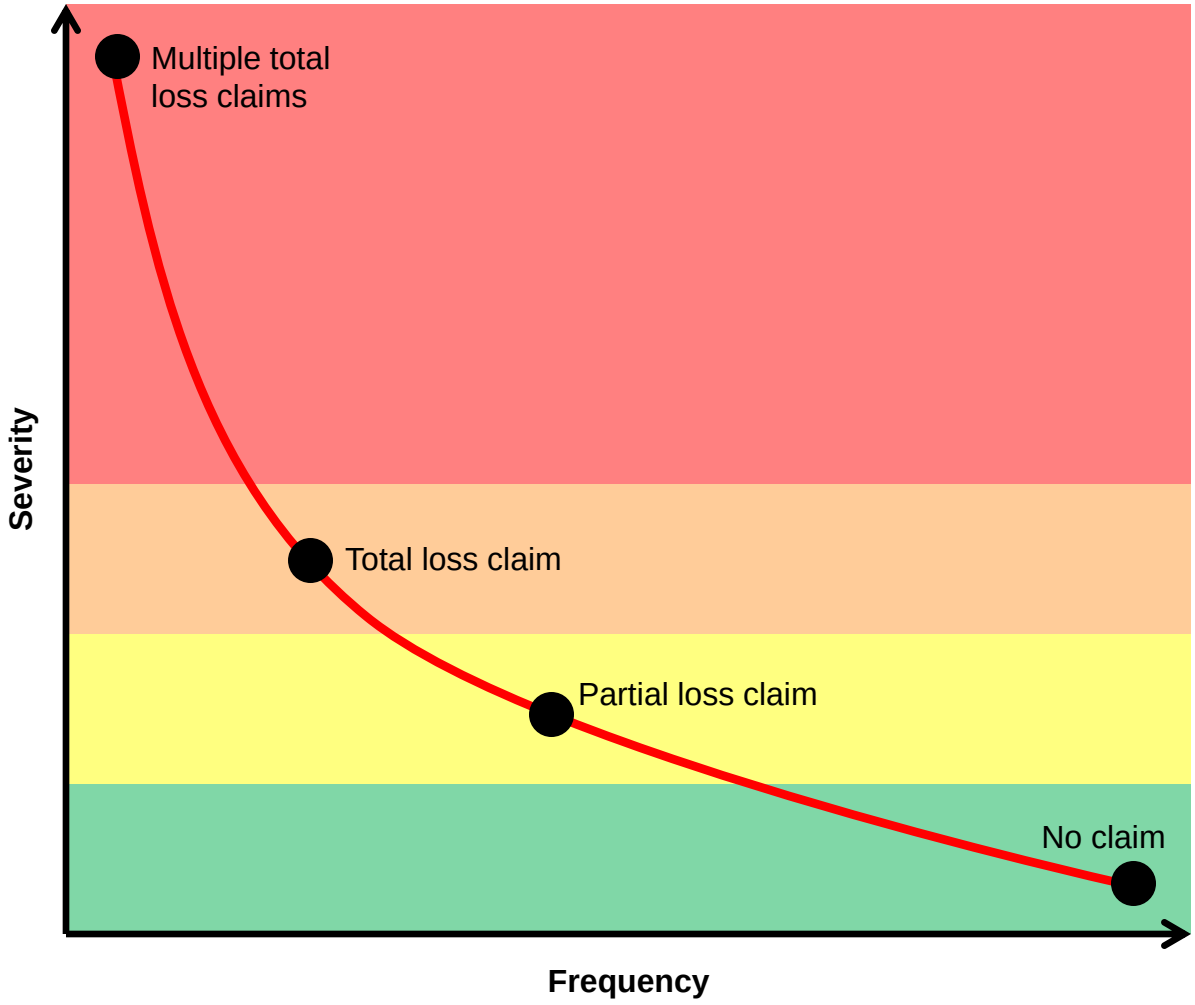
- Single launch failure
- LAE failure

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

- Single event effects
- Loss within margin
- Loss of redundancy

Not to scale

Space Insurance Coverage (cont)



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

Space Weather and Satellite Anomalies

SUBSYSTEM	All Anomalies	%
Communications Payloads	866	26.27%
Optical / Imaging Payloads	17	0.52%
ACS including Computer	765	23.20%
Power	735	22.29%
T&C / Data Handling	379	11.50%
Propulsion	318	9.65%
Thermal	165	5.00%
Mechanisms	14	0.42%
Structure	1	0.03%
Unattributed	37	1.12%
TOTALS	**3244**	**100%**

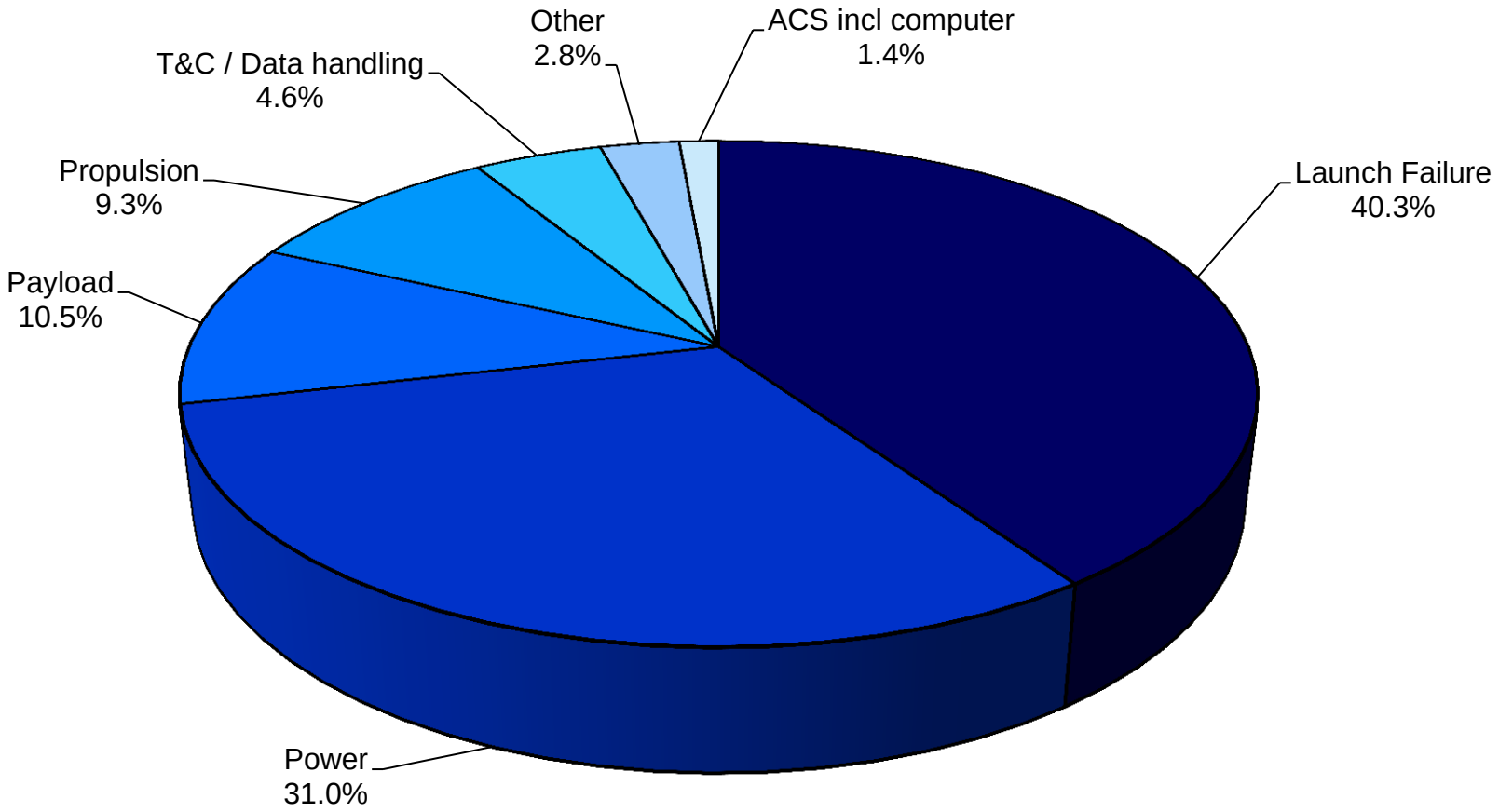
The ASIC database includes over 3,200 anomalies on more than 1,000 satellites with data from 1986

Space Weather and Satellite Anomalies (cont)

SUBSYSTEM	All Anomalies	%	Space Environment	%
Communications Payloads	866	26.27%	274	32.50%
Optical / Imaging Payloads	17	0.52%	4	0.48%
ACS including Computer	765	23.20%	187	22.18%
Power	735	22.29%	169	20.05%
T&C / Data Handling	379	11.50%	173	20.52%
Propulsion	318	9.65%	9	1.07%
Thermal	165	5.00%	27	3.20%
Mechanisms	14	0.42%	0	
Structure	1	0.03%	0	
Unattributed	37	1.12%	0	
TOTALS	**3244**	**100%**	**843**	**100%**
			25.57%	

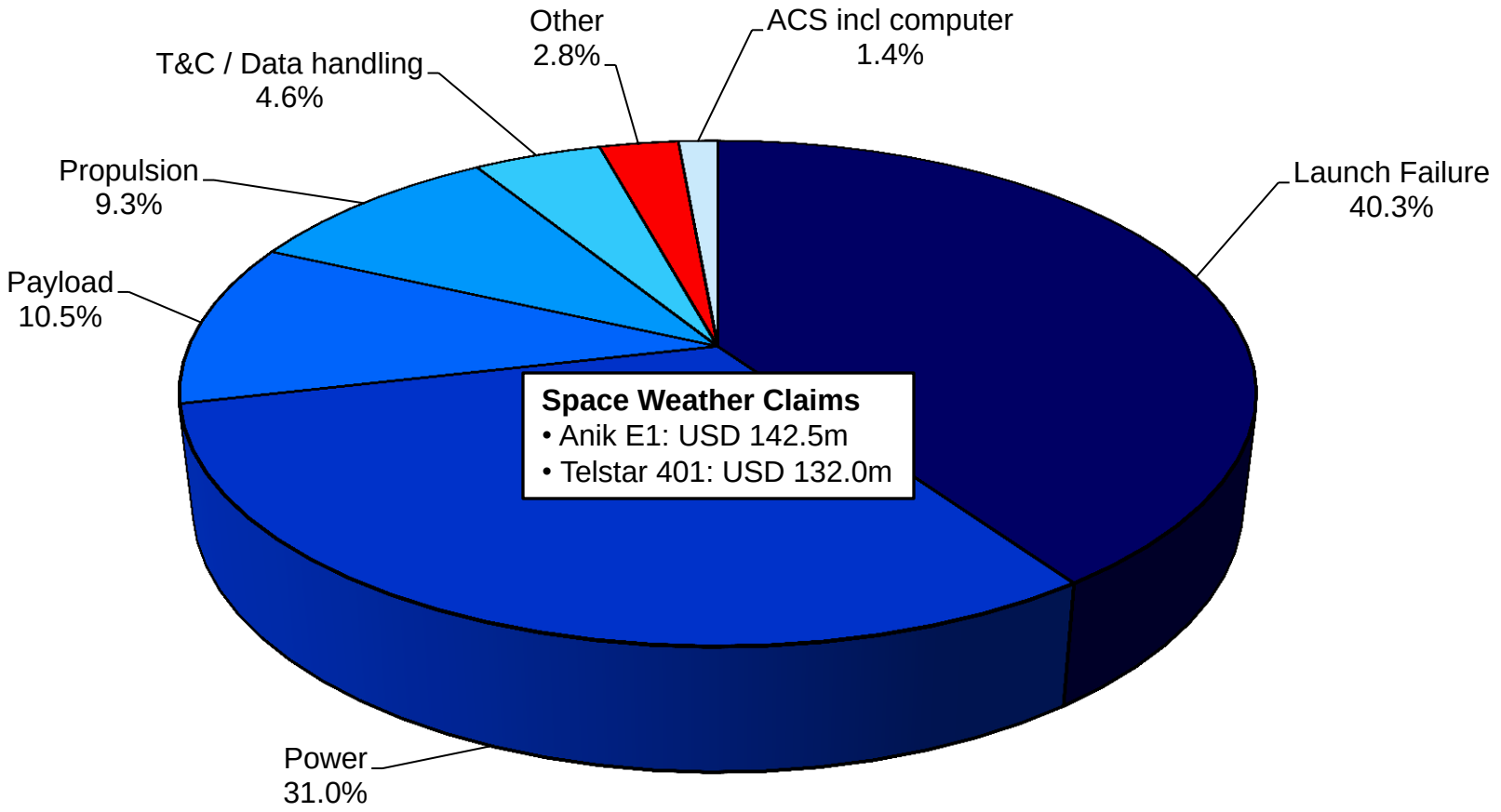
The ASIC database includes over 3,200 anomalies on more than 1,000 satellites with data from 1986

Space Weather and Satellite Claims



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

Space Weather and Satellite Claims (cont)



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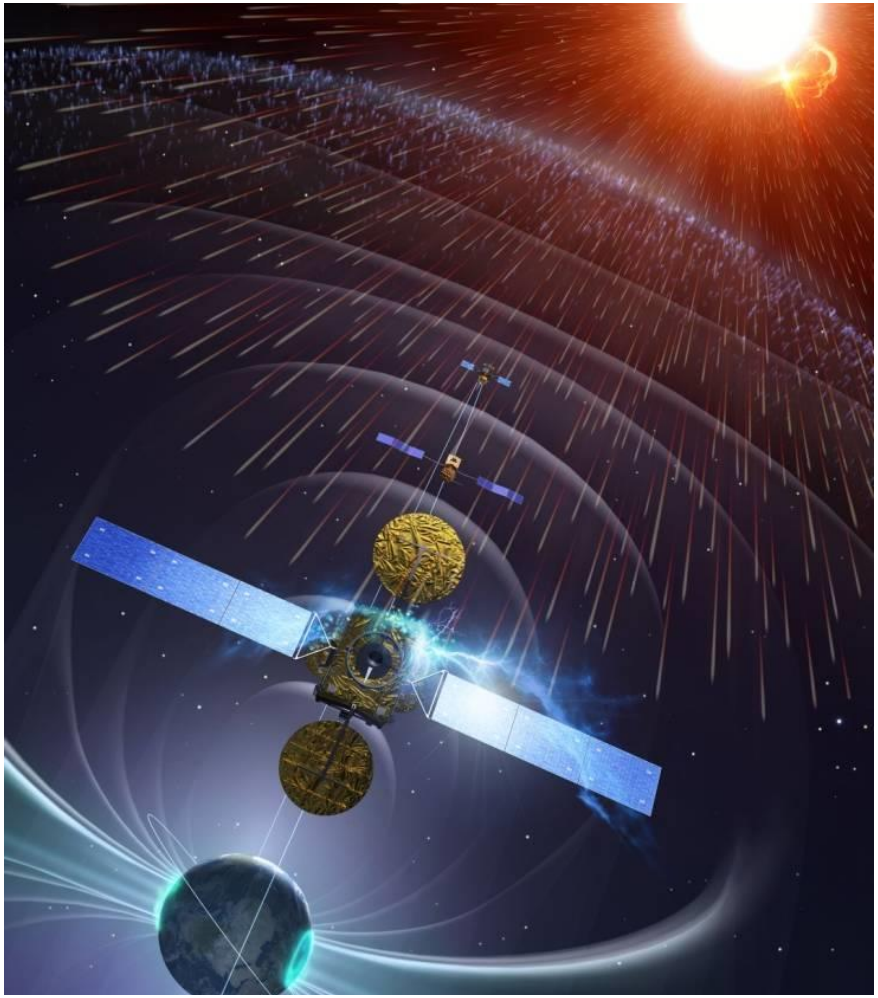
Satellite Resilience



Ref: ESA

SPACE WEATHER EFFECTS:

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

Satellite Testing

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

Realistic Disaster Scenarios

SPACE WEATHER

Solar proton event
- Anomalously large proton event degrades solar arrays
- Widespread partial losses affecting all GEO satellites

Design defect
- Design defect resulting in sensitivity to space weather
- Small number of total losses of particular satellite type

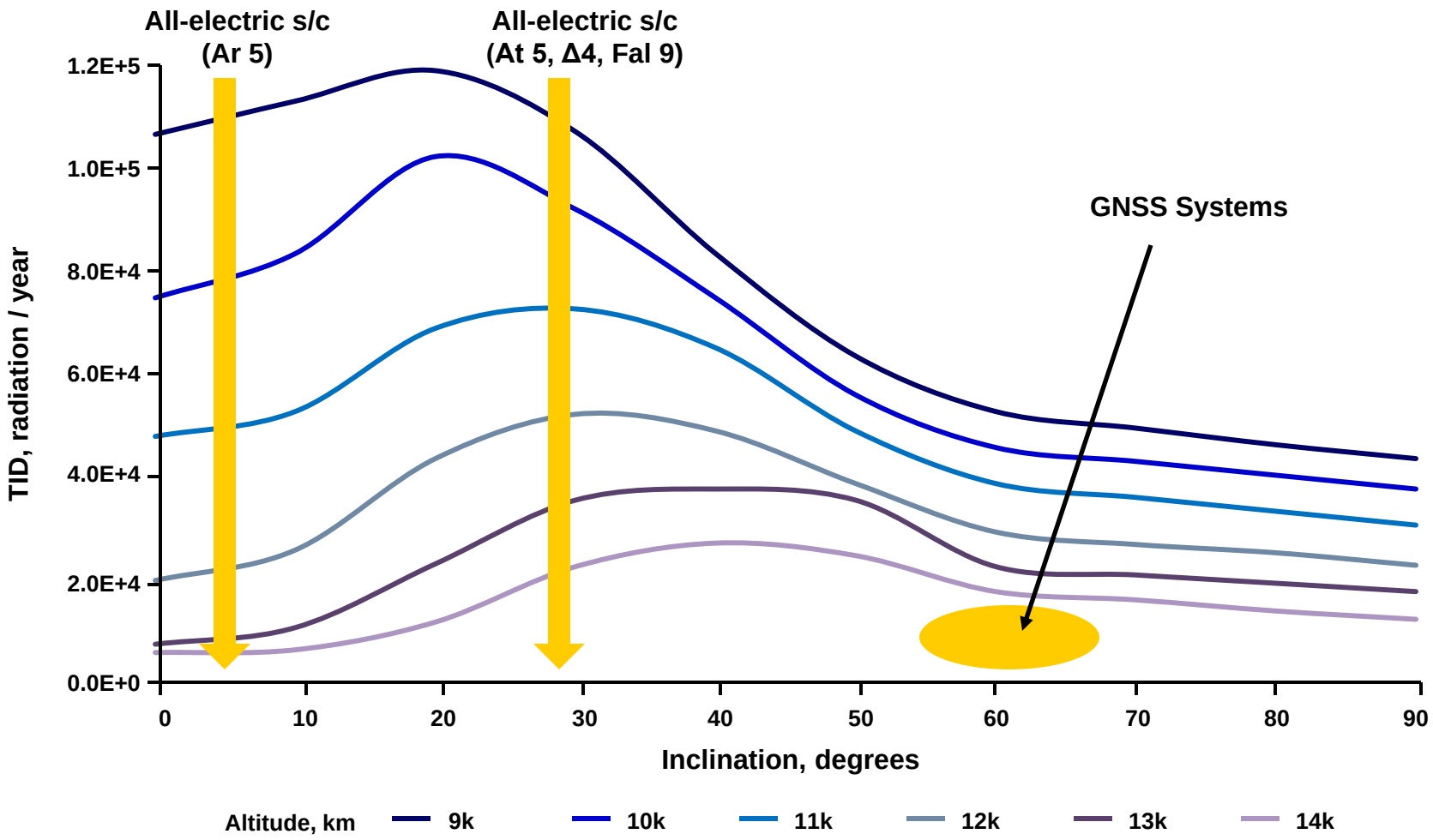
GENERIC DEFECT

Spacecraft generic defect
- Supply chain consolidation
- Generic defect in supplied component
- Number of “Western” built satellites affected by defect
- Number of satellites at risk depends on coverage period

SPACE DEBRIS

Collision with space debris
- Considered for different altitude ranges in LEO
- Number of satellites within each range at risk
- Number of satellites at risk depends on coverage period

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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