UNDERSTANDING **EARTHQUAKES**

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PREPARED BY
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VERSION 1.0

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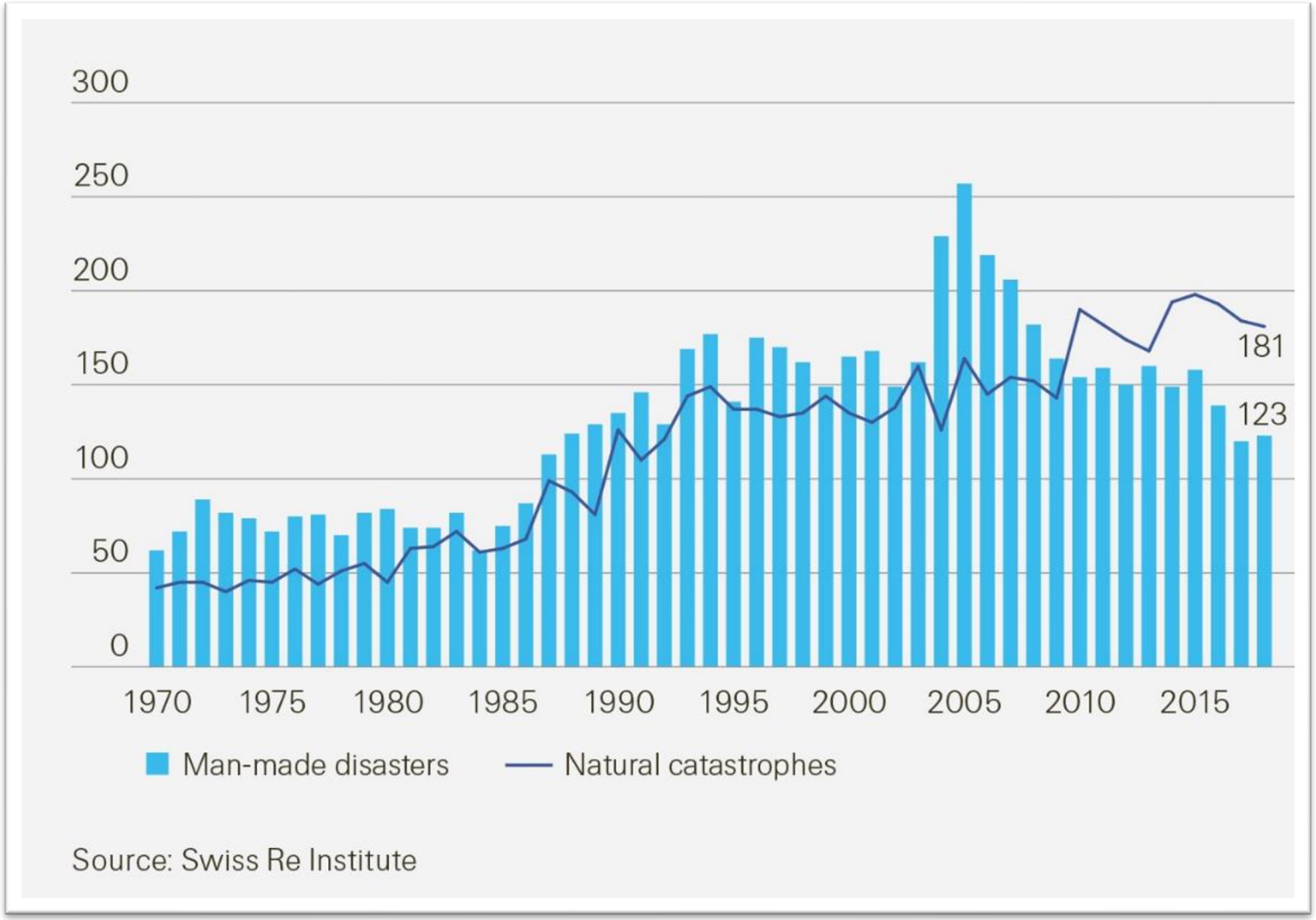
1. EARTHQUAKE 101

A. AN INTRODUCTION
B. HISTORICAL SEISMITY
C. SECONDARY PERILS

1.A.1 CATASTROPHE EVENTS – 1970 TO 2018

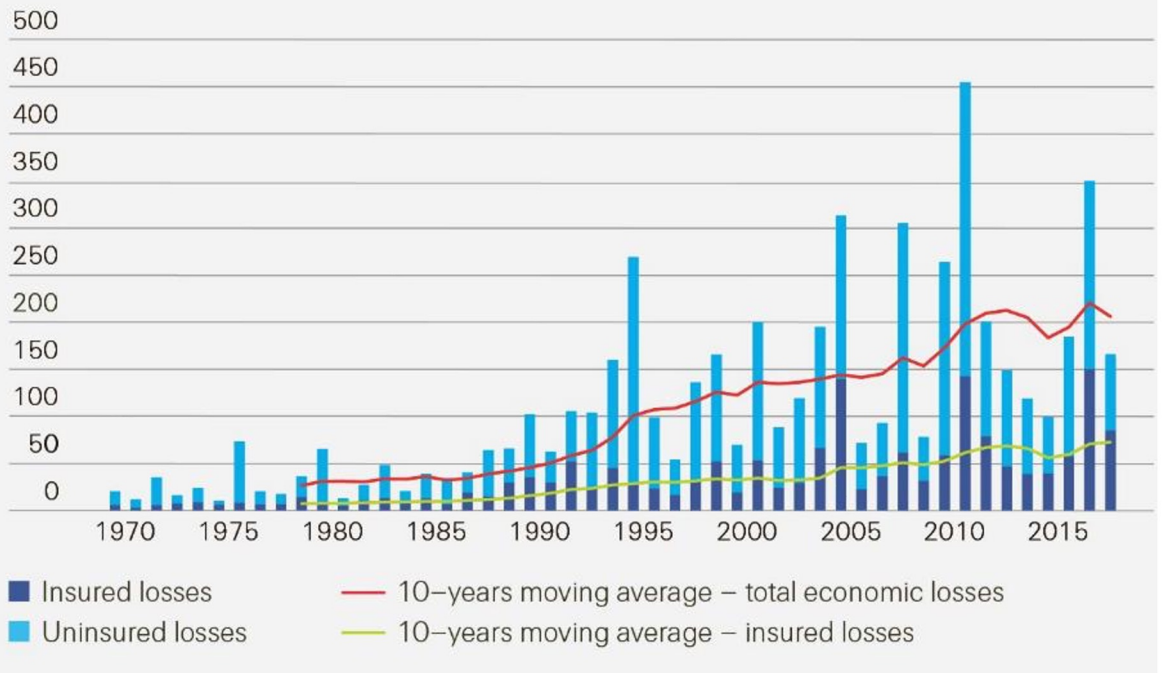


OBSERVATIONS

- Catastrophic events **TRIPLED** in number since from 1970 to 2018.
- Man-made disasters have **DOUBLED** during the same period
- Natural disasters have more than **QUADRUPELED** since 2017.

1.A.3 CATASTROPHIC LOSSES – 1970 TO 2018

Figure 4
Insured vs uninsured losses, 1970–2018, in USD billion at 2018 prices



Economic losses = insured + uninsured losses
Source: Swiss Re Institute

OBSERVATIONS

Catastrophes and disasters have been historically grossly under-insured.

The gap between the total losses and insured losses has been consistently increasing.

1.A.4 FOCUS ON EARTHQUAKE LOSSES (Bn)

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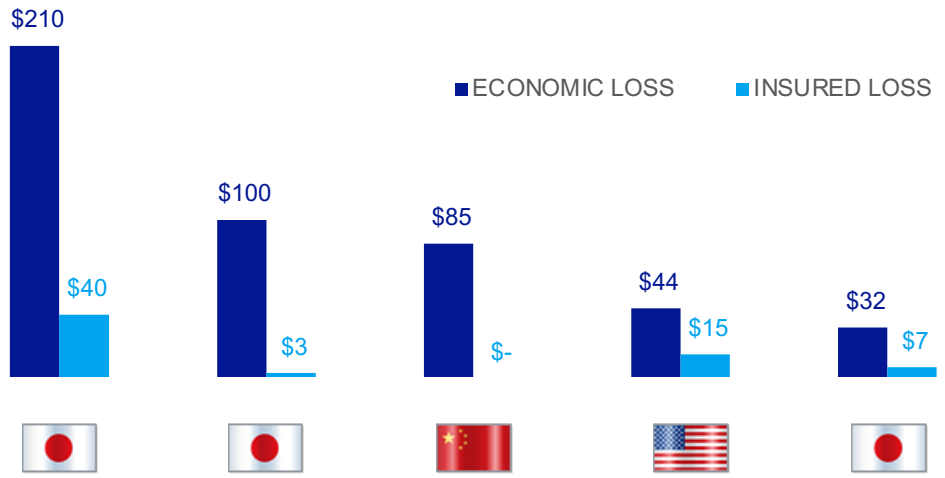
TOP 5 EARTHQUAKES	LOSSES ECONOMIC	INSURED	INSURED %
2011 - JAPAN	$ 210	$ 40	19%
1995 - JAPAN	$ 100	$ 3	3%
2008 - CHINA	$ 85	$ -	0%
1994 - USA	$ 44	$ 15	34%
2016 - JAPAN	$ 32	$ 7	22%
Total	**$ 471**	**$ 65**	**14%**



TOTAL LOSSES OF THE TOP 5 EARHTQUAKES WERE ONLY

14% INSURED

1.B.2 LEVANT GEOLOGY

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NAF - NORTH ANATOLIAN FAULT

Travels through northern part of Turkey, with the last Izmit / Kocaeli earthquakes in 1999, east of Istanbul, earthquake activity through the last century suggests that it is slowly ‘unzipping’ from East to West, with the next potentially occurring nearer to Istanbul.

RED SEA SHIFT

This is a major fault system that runs through the Red Sea and the Gulf of Aden. The fault is responsible for frequent earthquakes in Saudi Arabia, Yemen, and other neighbouring countries. The Red Sea Rift has the potential to cause significant losses in terms of human lives and infrastructure in the region.

DSF – DEAD SEA FAULT / DEAD SEA TRANSFORM

Made up of a series of faults travelling south through Syria, where we experienced the 1138 Aleppo earthquake, M7.1, considered one of the world’s deadliest quakes to date. Lebanon, Israel and Jordan, and Saudi Arabia in the South where it meets the Gulf of Aqaba, and can affect Haql, in Saudi Arabia. There was a M7.3 in 1995 in this region.

1.B.5 RECENT ACTIVITES

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TURKEY AND SYRIA

20th of February 2023

- Economic Loss estimated : **US$100Bn+**
- PERIL insured Loss estimated* : **US$3.5** to **US$5Bn**

**based on 6th Feb 2023 exchange rate.*

KERMANSHAH – IRAN / IRAQ BORDER

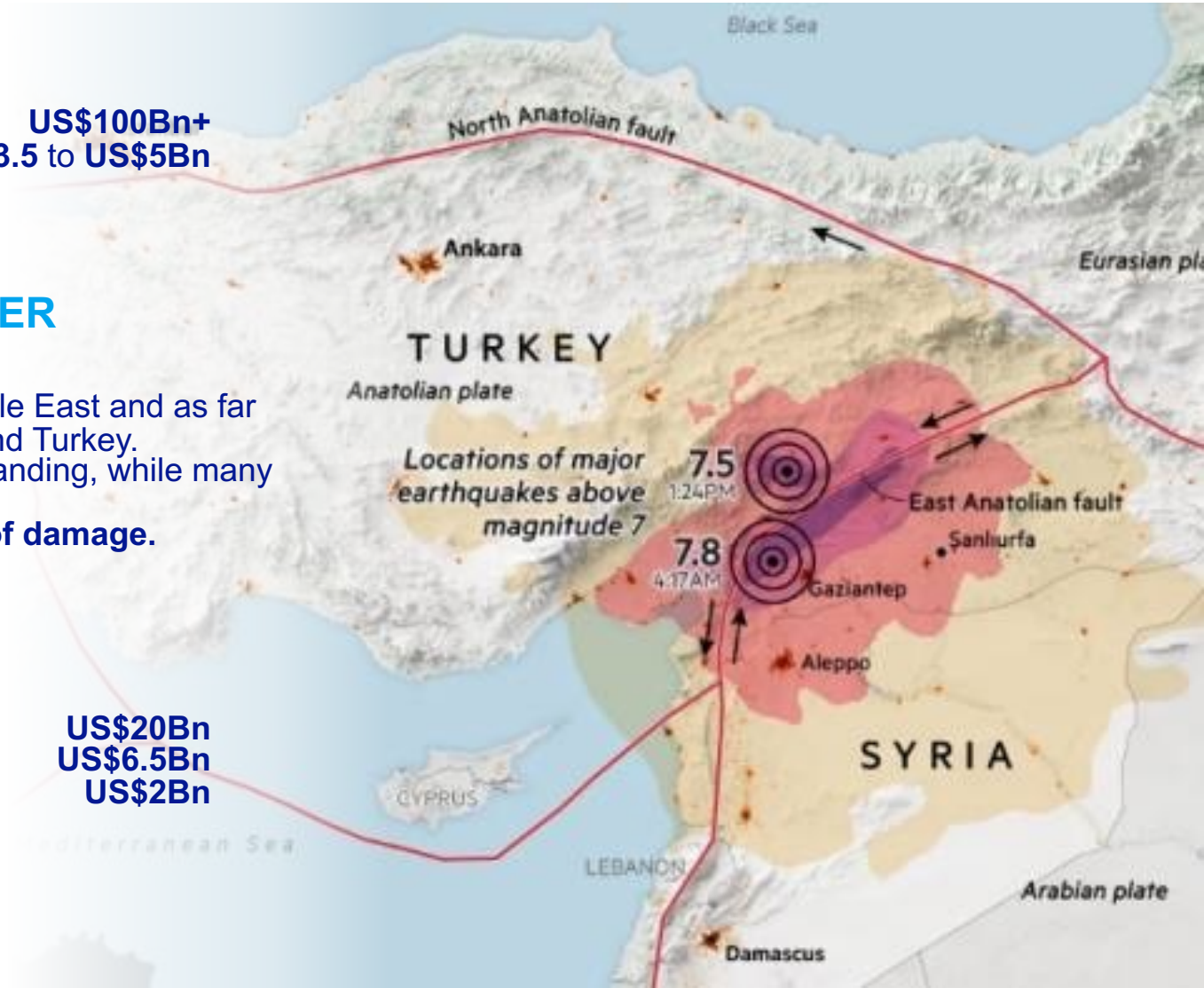
12th of NOVEMBER 2017

- The earthquake was felt throughout the Middle East and as far away as Palestine , the Arabian Peninsula and Turkey.
- It was noted that older buildings remained standing, while many newer blocks collapsed.
- The Iranian government: At least **€5 billion of damage.**

IZMIT – TURKEY

17th of AUGUST 1999

- Economic Loss estimated : **US$20Bn**
- Property Losses : **US$6.5Bn**
- PERIL insured Loss estimated* : **US$2Bn**



1.C.1 SECONDARY PERILS - TSUNAMIS

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CITY	COUNTRY	SEA
Istanbul	Turkey	Black Sea
Marmaris	Turkey	Mediterranean Sea
Samsun	Turkey	Black Sea
Antalya	Turkey	Mediterranean Sea
Bodrum	Turkey	Mediterranean Sea
Alanya	Turkey	Mediterranean Sea
Tel Aviv	Palestine	Mediterranean Sea
Haifa	Palestine	Mediterranean Sea
Aqaba	Jordan	Red Sea
Port Said	Egypt	Mediterranean Sea
Marsa Alam	Egypt	Red Sea
Beirut	Lebanon	Mediterranean Sea
Tripoli	Lebanon	Mediterranean Sea
Jeddah	KSA	Red Sea
Limassol	Cyprus	Mediterranean Sea
Larnaca	Cyprus	Mediterranean Sea
Tartous	Syria	Mediterranean Sea
Latakia	Syria	Mediterranean Sea
Salalah	Oman	Arabian Sea
Muscat	Oman	Arabian Sea
Bandar Abbas	Iran	Arabian Gulf

2. EARTHQUAKE MODELING

A. 1 TRIGGER ; 2 EARTHQUAKES
B. MODELING
C. PROBABILISTIC VS. DETERMINISTIC APPROACH
D. MODELING PARAMETERS

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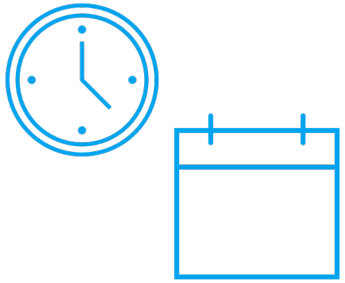
EARTHQUAKE **MODELING**



It used to rely on **historical events** to derive PMLs for Earthquake of a **certain return period.**

Developed into models simulating different events with different return periods in **different locations** within **one country**.

$$X_k = \frac{1}{N}\sum_{n=0}^{N-1} x_n e^{i2\pi k \frac{n}{N}}$$

Models mainly divided into **deterministic** and **probabilistic** approach.

2.A.2 1 TRIGGER ; 2 EARTHQUAKES

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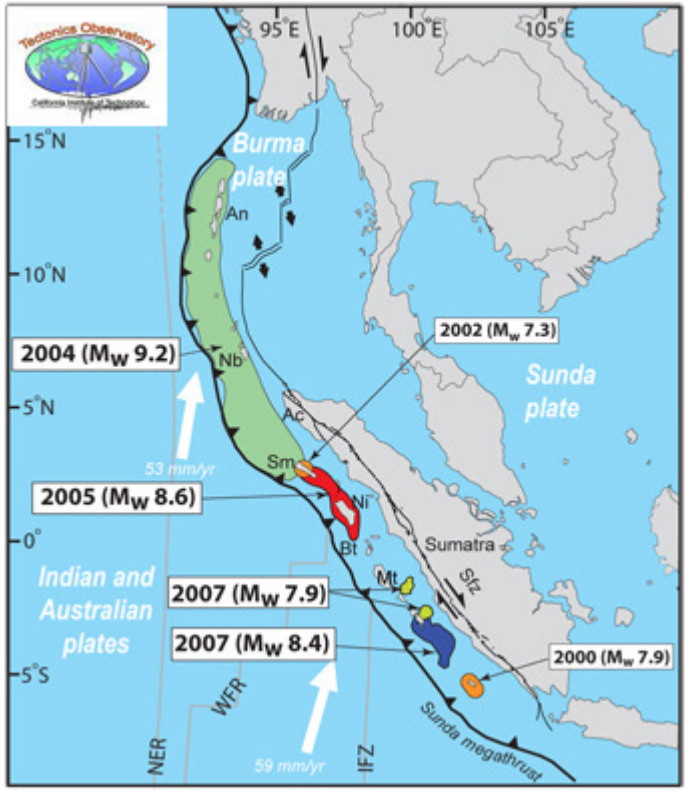
- Earthquakes, particularly large ones, can trigger other earthquakes in more distant locations
- process known as **dynamic stress transfer/triggering**.
- Energy from the seismic wave passing through can cause a new earthquake, usually in already vulnerable locations prone to frequent earthquakes
- 2004 M 9.1 Sumatra earthquake ruptured an area ~1300x200 square km, and triggered aftershocks from northern Sumatra to just south of Myanmar (ca. 2,500KM)
- Center Turkey to Center Jordan is ca. 1,300KM



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METHODOLOGIES

DETERMINISTIC

- Useful to evaluate scenarios of **past earthquake** occurring again
- Benchmark **'what-if'** scenarios, of different severity
- Useful tool in exposure **hot-spots**, but can lead to neglecting areas outside of these.

For instance, the M7.8 main shock event in February didn't occur in a typical 'exposure hot spot', but has proven to be a costly event.

PROABILISTIC

Combines severity, with frequency.

Ex: A small, M5 shallow earthquake right under a heavy urban area could cause as much damage as a M8 occurring in a remote area.

Can combine small-but-severe events, large-and-severe events, and any combination in between.

💡 **The tail of the risk affecting reinsurance purchases and capital requirements, … are adequately captured.**

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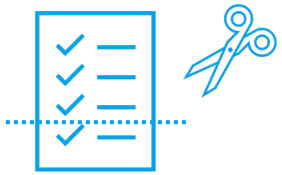
PARAMETERS AND FACTORS



DEDUCTIBLE LEVELS

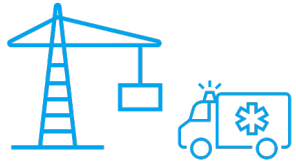
Deductible levels greatly impact simulation outcomes and the illustrated impact on risk carriers.

Examples on the next slides

DATA QUALITY

Portfolio mix, skewness. aggregate data profile, building codes, inflation and other parameters greatly affect modelling and scenario results.

Examples on the next slides



EARTHQUAKE AFTERMATH

The post catastrophe environment also plays a substantial role in modelling earthquakes.

More details on the next slides.

INTERLOCKING CLAUSE EVENT LIMITS

Event Limits from UY to OY basis – Relative reduction of Capacity per event – Data quality becomes crucial

More details on the next slides.

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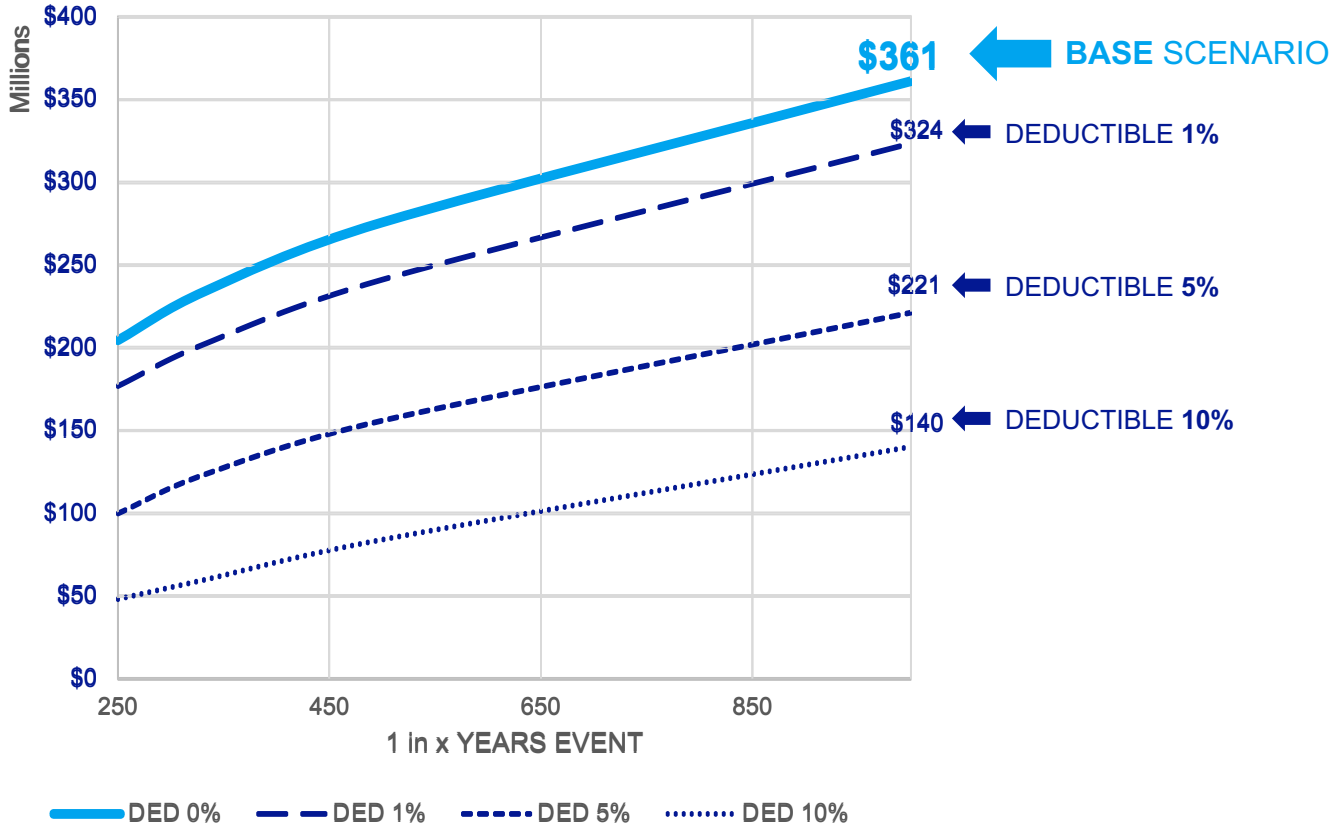
THE EFFECT OF DEDUCTIBLES

DEDUCTIBLE LEVELS

The graph on the right illustrates an exposure given various levels of deductibles from 0% to 10%.

A slight increase in deductible% significantly decreases exposure.



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THE EFFECT OF DEDUCTIBLES

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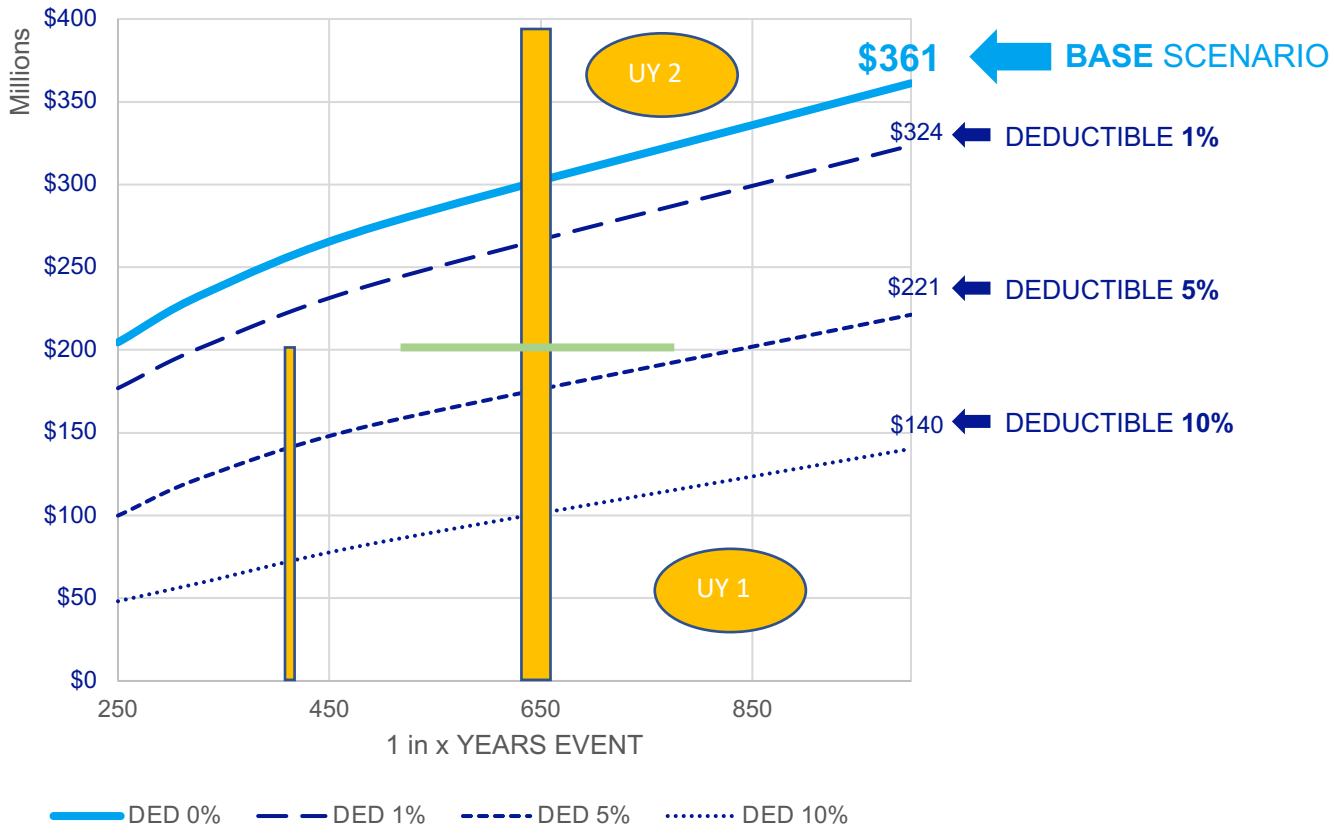

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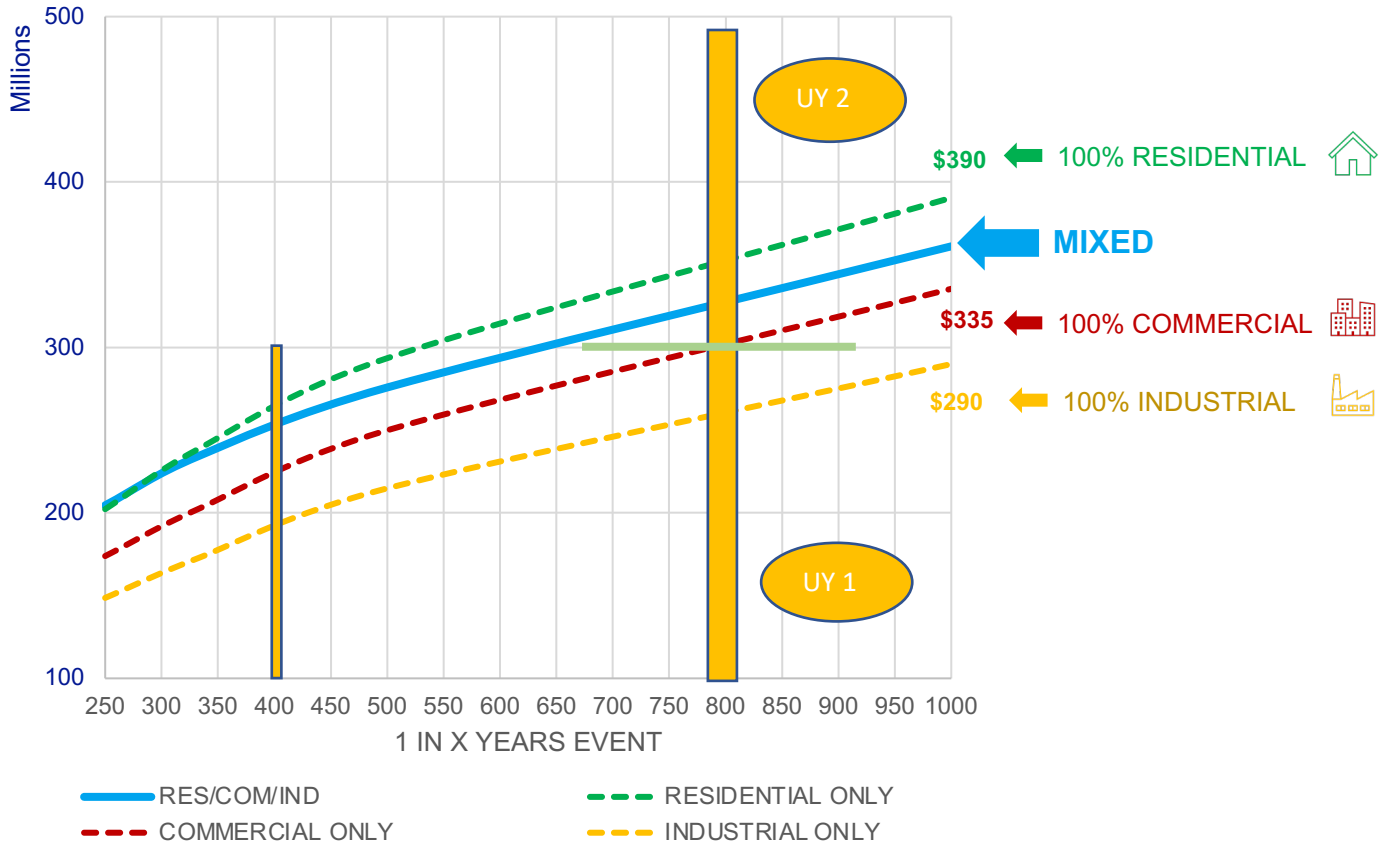
THE EFFECT OF PORTFOLIO COMPOSITION

PORTFOLIO COMPOSITION

The graph on the right illustrates risk profiles based on the type of properties in addition to a mixed scenario

Portfolio composition greatly affects simulated sums at risk.



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THE EFFECT OF PORTFOLIO SKEWNESS

PORTFOLIO SKEWNESS

As an example Large Industrial /Commercial exposures could skew losses, especially where overall the losses are lower.

ISKENDERUN PORT

Initial Estimated Loss: **US$500M?**

Going off a US$3.5Bn total insured loss,
a single US$0.5Bn facility could make up a sizeable portion of the overall loss.

We try our best to capture industrial activity damage, but single large losses can be an issue.

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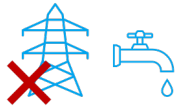
CATASTROPHE AFTERMATH

In the aftermath of an earthquake, the whole ecosystem is disrupted for extended periods of time. Below are the main common and often inevitable “disruptions”.

SHELTER
SHORTAGE



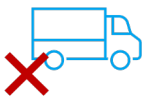
UTILITIES
DISRUPTION

RAW MATERIAL
SHORTAGE

HEALTHCARE
DISRUPTION

BUSINESS
DISRUPTION

LABOR
SHORTAGE



LOGISTICS
DISRUPTION

HYPER
INFLATION

3. MARKET SOLUTIONS

A. CALIFORNIA - CEA
B. NEW ZEALAND – TOKA TU AKE EQC
C. FRANCE – STATE GUARANTEE – CCR
D. TURKEY – TCIP
E. MOROCCO – CAT
F. IRAN

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CALIFORNIA EARTHQUAKE AUTHORITY – CEA

Established in 1996

- Established following the **6.7 magnitude** 1994 Northridge earthquake causing an estimated **$20 billion** in total property damage, including **$12.5 billion** in insured losses.
- The CEA is a publicly managed, privately funded, not-for-profit organization that provides residential earthquake insurance and encourages Californians to reduce their risk of earthquake damage and loss.
- Compulsory to provide minimum Natural perils protection with all property policies

CEA CALIFORNIA EARTHQUAKE AUTHORITY™

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NEW ZEALAND – Toka Tū Ake EQC

- **Automatic EQ Cover for home and land with any private insurance policy for any home that includes fire insurance.**
- The EQCover building cap for a residential building containing one dwelling is **$300,000 + GST.**
- Any building cover above the EQCover cap is provided by private insurers. The EQCover Premium is 16c per $100 of the EQCover amount, up to a maximum of $480 ($552 incl. GST)…
- Private insurers collect the EQCover premium and pay it into the Natural Disaster Fund which is managed by Toka Tū Ake EQC and is used to pay EQCover claims.

Toka Tū Ake EQC

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FRANCE – STATE GUARANTEED COVER BY CCR

- CCR provides the protection with the state guarantee for some perils (including natural disasters).
- It is not mandatory for insurers to reinsure with CCR.
- Compulsory to provide Natural perils with all property policies.
- For natural catastrophes, protection to insurers is made of two treaties, a quota share (50% cession rate) and a stop-loss. Thanks to the State guarantee, the **stop-loss reinsurance treaties offered by CCR are unlimited.**
- The State intervenes if the claims burden for CCR exceeds an amount called the **State Intervention Threshold (SIE)** which depends on the amount of the equalization reserve and the special reserve set up for the natural catastrophe risk.
- To date, the state guarantee has never been requested, as the **threshold has never been exceeded.**

CCR RE

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TURKISH CATASTROPHE INSURANCE POOL – TCIP / DASK

Established in 2000 after 1999 Izmit EQ

- Homeowners (residential) are required by law to purchase earthquake insurance (only) through the TCIP for property damage (only) – Other perils currently considered
- Compulsory but no obligatory implementation (but needed for administrative procedures such as Banking services, etc…)
- Insurance companies act as agents to the pool
- Basic compulsory protection limited to 640,000 TL (33,000 US$)
- Additional protection available (eg;contents…)
- Premium collected through the insurance companies
- Claims are handled by TCIP directly

dask
DOĞAL AFET SİGORTALARI KURUMU

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MOROCCO – Compagnie d'Assurance transport (CAT)

- Covered Perils:
  - Natural Perils: Earthquake, Flood, Tsunami –
    US$ 300M AOO and US$ 900M AGG
  - Man made Disasters: Terrorism, Riots and Civil Commotion:
    US$ 30M AOO and US$ 60M AGG
- Some Insurance Contracys
- Event to be recognised by the state within 3 months of occurrence date
- 2 components: Insurance contracts and public fund (Solidarity Fund against Catastrophic Event)
- Managed by **CAT** as an aggregator

Toka Tū Ake EQC

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IRAN

Cover provided as combined RI capacity purchased to protect the insurance companies in the market.

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2.A.6 MODELING – Country Level Check

CoreLogic

THE EFFECT OF Aggregation

OEP Simulation Results

COUNTRY LEVEL MODELING

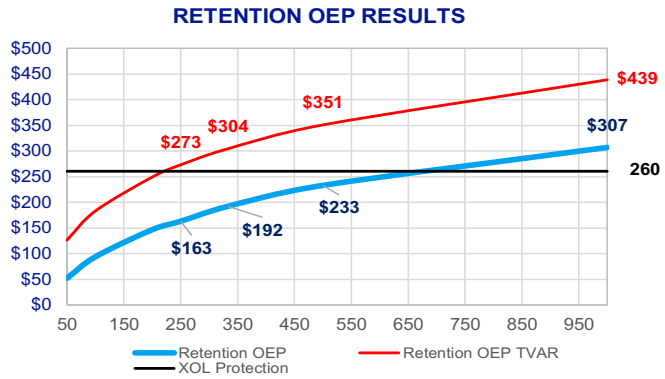
EVENT	GROSS	RETENTION	CESSION	Q/S	SURPLUS
1 / 250	$ 768.23	$ 163.05	$ 607.46	$ 348.50	$ 260.23
1 / 333	$ 899.13	$ 192.01	$ 709.45	$ 407.65	$ 301.60
1 / 500	$ 1,095.83	$ 232.96	$ 860.65	$ 497.97	$ 359.39
1 / 1000	$ 1,455.22	$ 306.84	$ 1,153.68	$ 651.20	$ 499.17

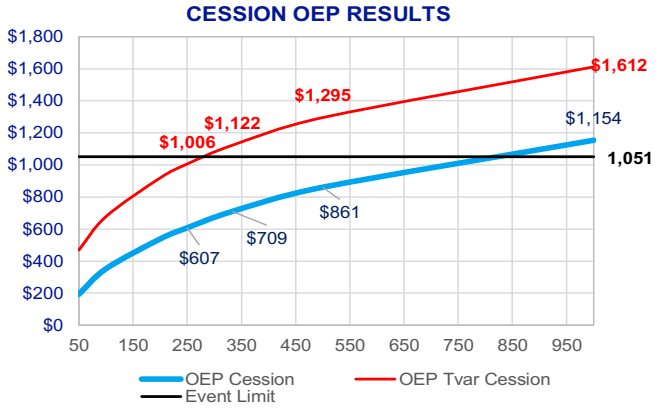
** Figures are in millions*

COUNTRY LEVEL MODELING TVAR

EVENT	GROSS	RETENTION	CESSION	Q/S	SURPLUS
1 / 250	$ 1,278.52	$ 272.98	$ 1,005.91	$ 581.21	$ 428.91
1 / 333	$ 1,425.79	$ 304.31	$ 1,122.05	$ 647.81	$ 478.09
1 / 500	$ 1,645.16	$ 350.79	$ 1,295.27	$ 746.44	$ 554.26
1 / 1000	$ 2,048.64	$ 438.68	$ 1,611.68	$ 933.90	$ 688.83

** Figures are in millions*





2.A.6 MODELING – Country 2 Level Check

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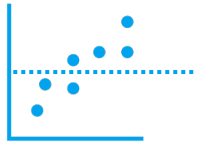
THE EFFECT OF Aggregation



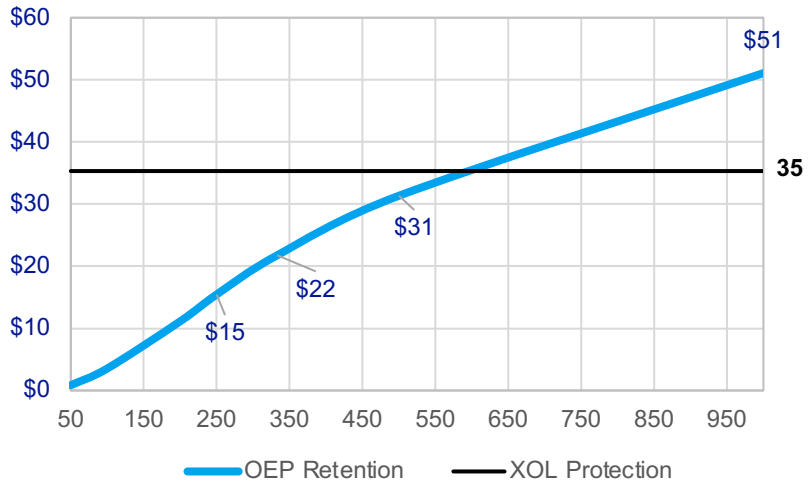
OEP Simulation Results

COUNTRY LEVEL MODELING

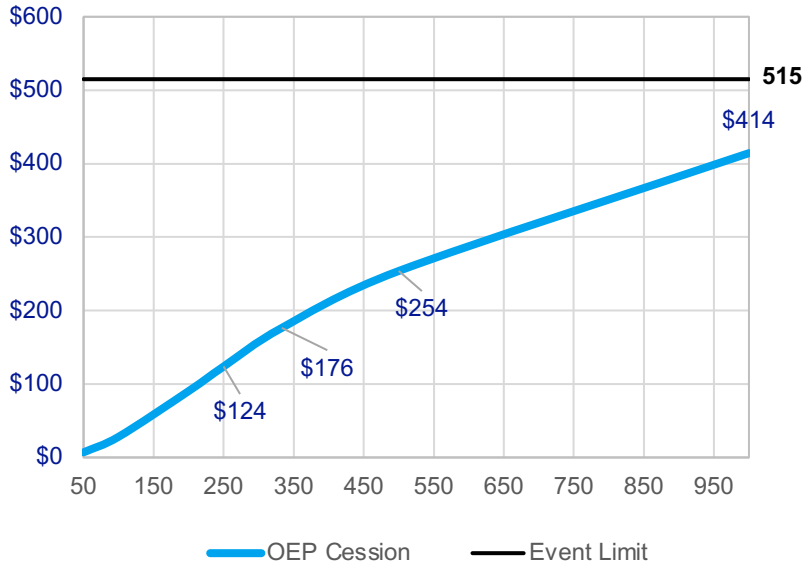
EVENT	GROSS	RETENTION	CESSION	Q/S	SURPLUS
1 / 250	$ **139,34**	$ 15.45	$ 123.59	$ 66.82	$ 57.07
1 / 333	$ **198,15**	$ 21.76	$ 175.86	$ 93.25	$ 83.14
1 / 500	$ **285,26**	$ 31.35	$ 253.75	$ 136.01	$ 117.91
1 / 1000	$ **465,44**	$ 51.09	$ 414.05	$ 221.10	$ 193.24

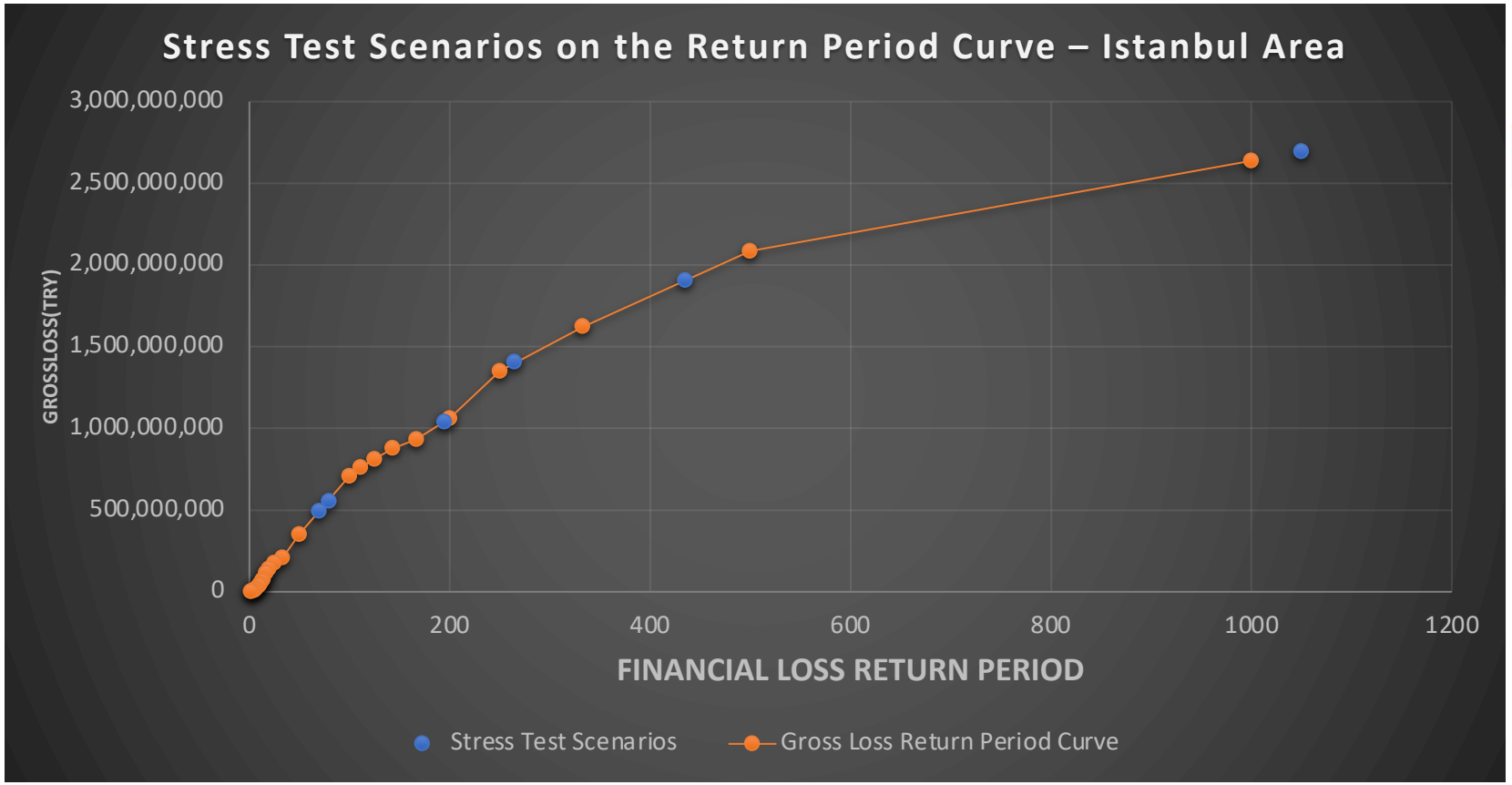
** Figures are in millions*

RETENTION OEP RESULTS – COUNTRY 2



CESSION OEP RESULT – COUNTRY 2





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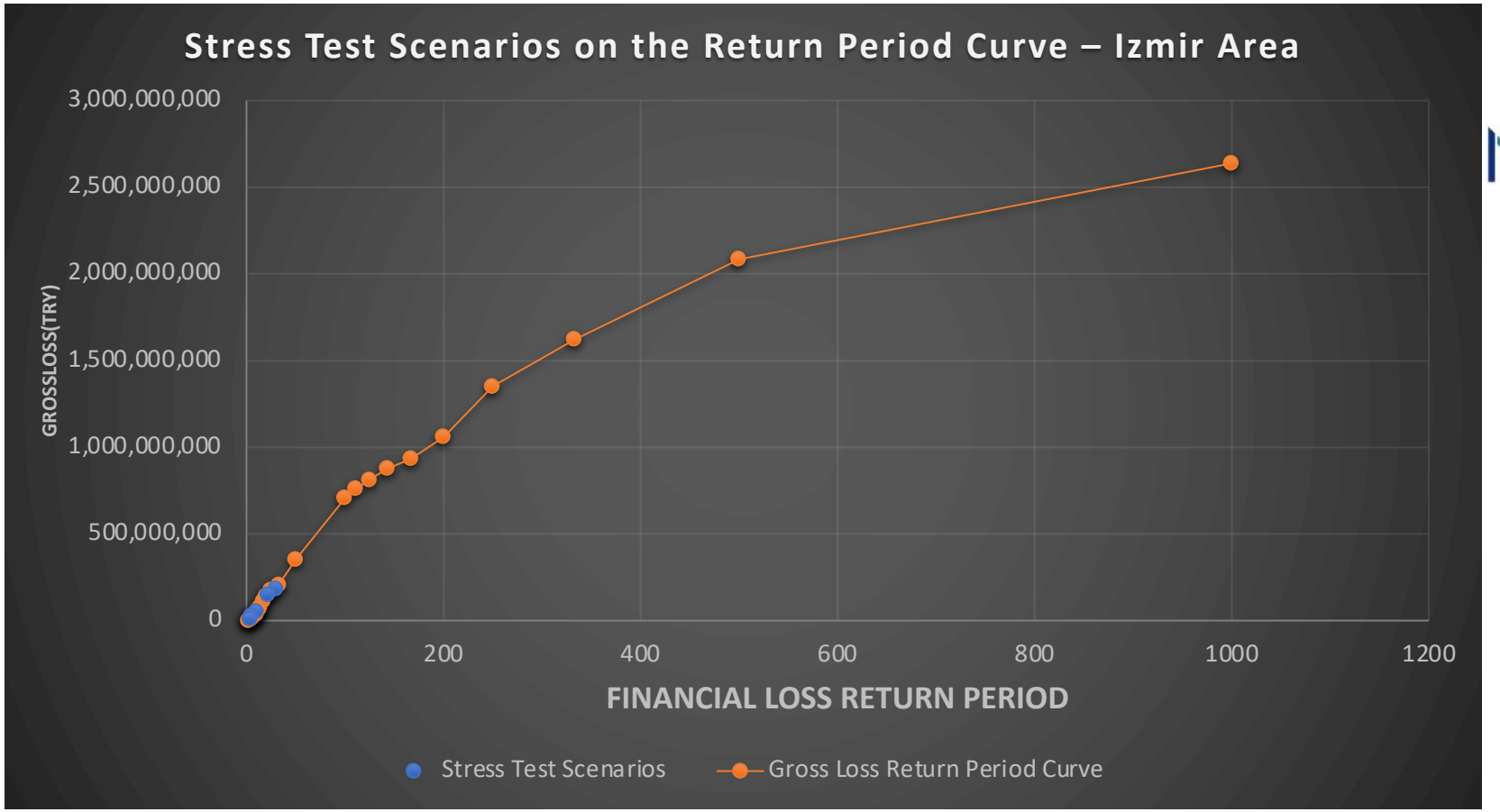
Event ID	Financial Return Period	Stress Test OEP	Fault Type (Long/Lat/Depth)	Frequency	Return Period of the Event Happening	Intensity
127224	1050	2 692 316 361	NNAF-E marmaraFlt1,(40.917,28.816,0.00)	0,0010267	974	7,2
127225	435	1 904 300 958	NNAF-E MarmaraFlt2,(40.87,28.81,0.00)	0,0020533	487	7,2
127226	265	1 406 633 718	NNAF-E MarmaraFlt3,(40.817,28.824,0.00)	0,0020533	487	7,2
127218	80	555 263 674	NNAF-W MarmaraFlt2,(40.887,27.638,0.00)	0,0008333	1200	7,2
127219	70	491 454 049	NNAF-W MarmaraFlt3,(40.826,27.658,0.00)	0,0032900	303	7,2



Event ID	Financial Return Period	Stress Test OEP	Fault Type (Long/Lat/Depth)	Frequency	Return Period of the Event Happening	Intensity
27485	30	183 067 519	Zone 15 (38.418,27.144,2.67)	0,0001500	6666	6,00
27432	22	149 591 231	Zone 15 (38.499,27.221,1.02)	0,00008333	12000	6,25
27608	10	51 849 872	Zone 15 (38.429,27.179,4.81)	0,0003733	2678	5,50
27672	5	24 510 937	Zone 15 (38.45,27.14,5.50)	0,0006067	1648	5,25
27739	4	8 114 260	Zone 15 (38.441,27.21,6.01)	0,0004200	2380	5,00

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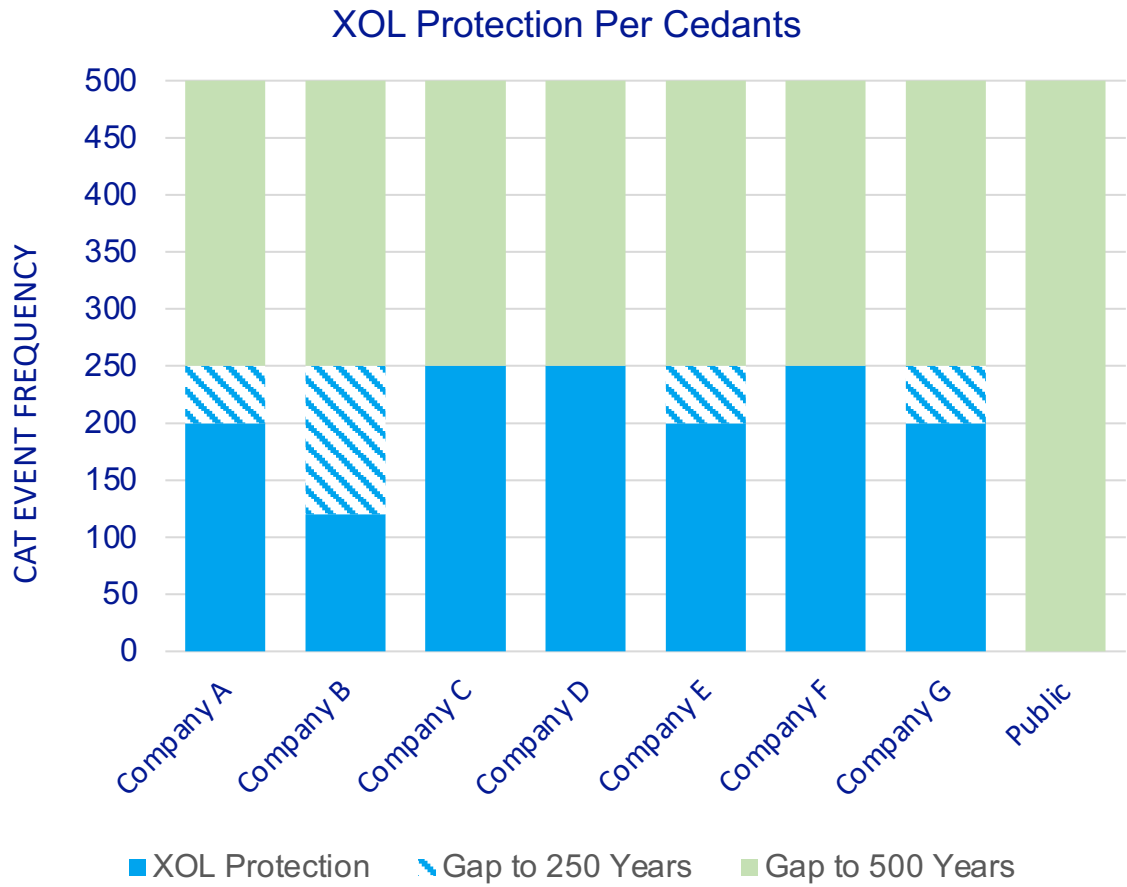
MARKET-WIDE SOLUTION
XOL PROTECTION UMBRELLA

The XOL Protection Umbrella bridges the gap between the exposure of a 1/250 event and a 1/500 event for all cedants operating within the same country.



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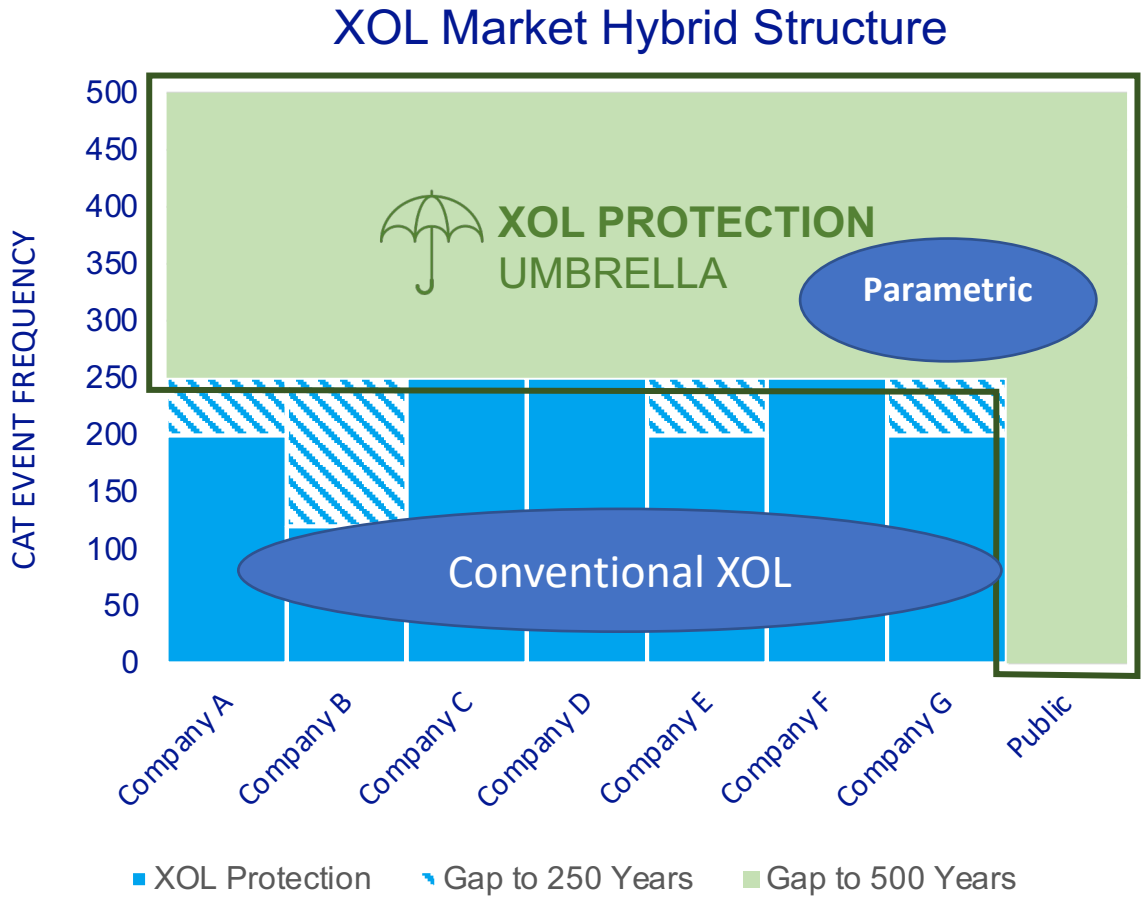
MARKET-WIDE SOLUTION
XOL PROTECTION UMBRELLA

The XOL Protection Umbrella bridges the gap between the exposure of a 1/250 event and a 1/500 event for all cedants operating within the same country on a Parametric Solution.

The XOL Protection could be for
- The protection of the Treaties **OR**
- The Full portfolio FGU if EQ is protected separately outside the treaties



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