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Insurance Concentration Risk Charge
Natural Perils

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Abstract

APRA's proposed approach for determining the insurance concentration risk charge (ICRC) for General Insurers involves both a vertical (VR) and a horizontal requirement (HR). This paper provides guidance to Actuaries and others on the availability of data, models and approaches that will enable them to take an informed view of any Perils modelling undertaken for this purpose. This is particularly relevant in Australia as more reliance is placed on catastrophe model output, through the regulatory regime, particularly at the higher frequency end of the curve. Cat models do not replace common sense, the old adage of garbage in garbage out is still applicable, but can be harder to judge.

"All models are wrong, some models are useful" (G.E.P.Box).

Keywords: Catastrophe modelling, Insurance Concentration Risk Capital Charge, Vertical Requirement, Horizontal Requirement

1 INTRODUCTION

Catastrophes occur at the intersection of an extreme event with a concentrated exposure. In insurance we typically mean a single event that generates a large number of claims. The events are usually individually rare and can be either man made (e.g. Terrorism) or Natural (Earthquake, cyclone, flood etc.).

Due to the rare nature of events (i.e. small probability) the usual actuarial methods of using past data cannot be relied upon. To quantify the expected outcome and surrounding uncertainty of these events catastrophe models (cat models) have become a useful tool, even to the extent that insurance regulators (e.g. APRA, SII) specify some capital parameters in terms of catastrophic event return periods(e.g. the top limit of a cat programme).

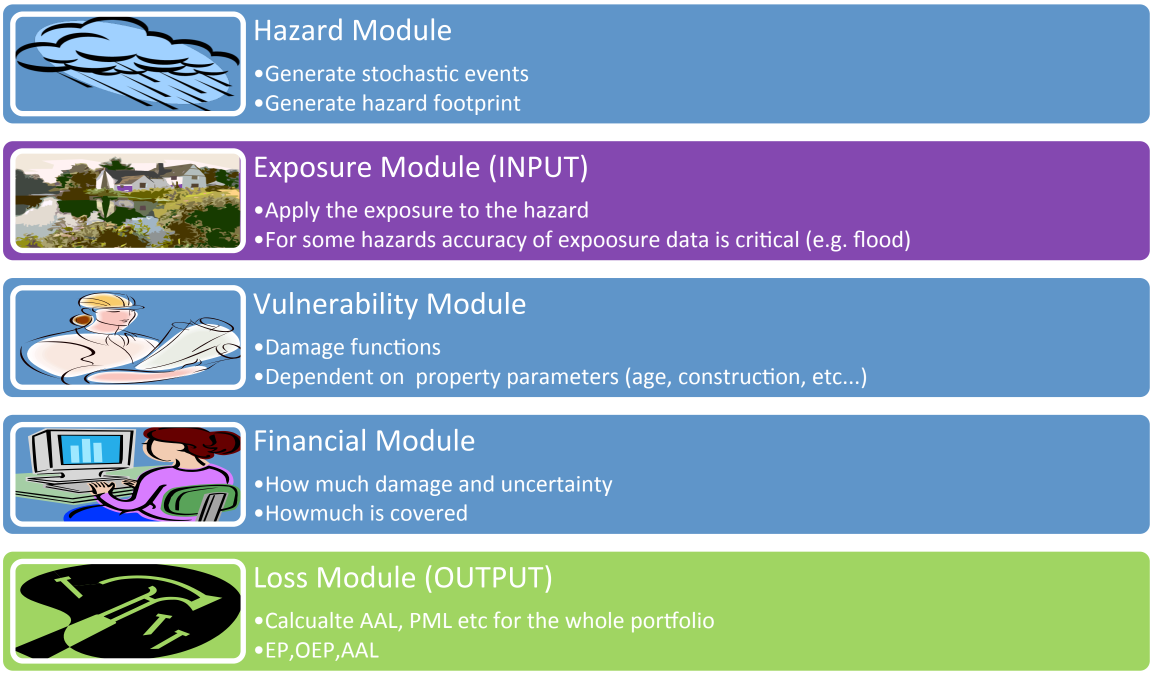
Catastrophe modelling (also known as cat modelling) is the process of using computer-assisted calculations to estimate the losses that could be sustained due to a catastrophic event such as a hurricane or earthquake. Cat modelling is especially applicable to analysing risks in the insurance industry and is at the confluence of actuarial science, engineering, meteorology, and seismology.

A cat model can be viewed as an extension of the historical event scenario method. The history of events is smoothed and interpolated (and, to some extent, extrapolated) to create a large number of might-have-been events of comparable realism.

1.1 How the models work

- Exposure data defines locations, risk characteristics and financial terms of at risk exposure (i.e. insurance policies protecting assets)
- A database of stochastic events are simulated, with event details, hazard measurements and damage levels determined for each location in the portfolio (i.e. the event set)
- Insurance terms are applied, allowing for calculation of loss under different metrics (ground up, gross insured, retained, net of reinsurance etc.)
- Results from database of events are analysed to estimate probabilistic measures such as Probable Maximum Loss, Exceedence Probabilities, Average Annual Loss and Tail Conditional expectation

This can be represented pictorially as:-



Cat models cannot replace common sense. The model outputs can be financially significant and highly sensitive to the inputs.

For an Actuary to opine on the results of a cat modelling exercise (e.g. to say that the 1 in 10 event is $xm say) then the Actuary should have an overall understanding of the areas relevant and material to the company, knowledge about:

- general principles of catastrophe modelling and building blocks of stochastic models
- key measures to define the company's risk appetite: the concept of return period (and, if relevant, Value at Risk – VaR – versus Tail Value at Risk –TVaR), occurrence Exceedence probability and annual Exceedence probability
- publicly available data about the company's exposures (for a sense check)
- the catastrophe exposures modelled, areas and perils modelled, peak zones of exposures, lines of business (LOB) or products modelled and a view on variability of the models' results
- the catastrophe exposures not modelled:
    - identification of 'cold spots', and the reasons for them in terms of areas, perils, model limitations and data limitations
    - how the exposures are assessed and controlled if not run through a cat model
- sensitivity of the model results with regard to assumptions, parameter calibration, and the quality of underlying input data (portfolio information)

The remained of this paper goes through some of the details on how to form a view on cat modelling results.

1.2 APRA specific comments on Catastrophe models

1.2.1 General Prudential Standard 116

APRA acknowledge that it is common practice for an insurer to use computer-based modelling techniques, developed either in-house or by external providers, to estimate likely losses under different catastrophe scenarios. They suggest that if an insurer uses such a model, the model must be conceptually sound and capable of consistently producing realistic calculations, the following criteria are suggested. The insurer must be able to demonstrate:

(a) That the model has been researched and tested. This is discussed in section 3.

(b) That the insurer has taken measures to ensure that the data used to estimate its losses is sufficiently consistent, accurate and complete, and there is appropriate documentation of any estimates of data used. This is discussed in section 2.

(c) An understanding of the model used in estimating losses, including;

   I. Perils and elements that are not included in the model.
   II. Assumptions and any estimates used in the modelling process.
   III. The sensitivity of the model outputs as a result of the factors in (i) and (ii).

(ii) & (i) are discussed in section 2 & 3 while (iii) is discussed in section 4.

1.2.2 General Practice Guide 113

GPG 113 provides guidance for ECM (Economic Capital Modelling) where cat modelling is an important component. Here we give the specific comments regarding Cat modelling.

APRA is aware that the management of catastrophe risk is a core business competency of most insurers, and is generally done in conjunction with a reinsurance broker and (directly or indirectly) one or more external catastrophe model vendors.

Since each of the proprietary catastrophe models has its limitations and the exposure information of the insurer is usually imperfect, APRA will consider how the insurer's ECM makes allowance for perils that are not modelled, for demand surge in the cost of repair, for exposure information that is incomplete or of uncertain quality and for other known limitations.
In reviewing the catastrophe module of the ECM, APRA may wish to meet with the reinsurance broker (or other risk modeling adviser) as well as the insurer and will consider the governance and use test criteria as they apply to the catastrophe module of the ECM separately.

This paper raises many of the weaknesses of cat models and discusses considerations around cat modelling, so may also be helpful background to those involved in ECM models generally.

1.3 Reader guidance

All models need to be considered for appropriateness and applicability; Cat models are no exception, but due to the black box nature may appear less challengeable. This paper aims to raise our consciousness regarding specific areas to consider before relying on any loss estimates produced by a cat perils model. Not all of the issues raised have specific easy answers, but an awareness of this is necessary in order to make appropriate actions regarding catastrophe risk management.

This paper is targeted at those that are interested or required to take action or make decisions using cat models and their output. In some cases this could be senior management, Actuaries or Cat modellers themselves. With a general audience such as this the paper goes quickly over a range of issues and does not delve to deep, there are many specific papers on many of the areas mentions and in some areas there need to be more.

The key theme of this paper which resonates with the APRA guidance, is an acknowledgement of the uncertainty of a range of issues around cat models and how these have been handled by the insurer.

2 EXPOSURE DATA

Modelled results are only as robust as the exposure data entered into them. In fact, when missing or incorrect information is enhanced, it is not uncommon to see loss estimates change by a factor of four on a single building. This can either increase or decrease loss estimates, but it significantly increases the uncertainty when magnified across a portfolio, particularly so at the lower return periods.

2.1 Raw data

The data for catastrophe models begins with the data used to price the risk. Some of the data entered into the system may need to be enhanced to get more refined levels of detail as for some perils this can make a material difference in event consequences (e.g. consider a flood peril and a sloping plot of land, the precise location of the insured buildings will impact the nature of the claim given a specific event). There may be additional data that can be deduced from the location data which may not be gathered at the initial underwriting stage (e.g. such as the type of roof, identified from aerial photography).

2.1.1 Data Principles

Data integrity is a key issue there are several high level principles that can be applied to data, for example:-

- Understand the data – ensure the cat modellers understand any data coding used and the operation of the policies (e.g. is the Additional Living Expenses (ALE) included in the Sum Insured or in addition to it)
- Define the data quality requirements – and implement the controls to ensure they are met
- Monitor the controls
- Improve poor data (e.g. collect addresses and ensure they are valid)
- Asses change impacts before implementing
- It is also a sensible precaution to have an individual responsible for data management.

2.2 Data details

Cat models have a number of factors and a variety of levels within these that can be used to differentiate between many types of risk. The main factors (common to most models are) are:-

- Location of the risk (see 2.2.2)
- Sum Insured (Buildings, Contents, BI, ALE)
- Construction Class
- Type of occupancy
- Number of floors
- Existence of a basement
- Type of roof
- Insurance terms
- Reinsurance terms

Often for complex commercial risks the insurance and reinsurance parts of the cat model can't adequately reflect the actual coverage and approximations are used.

Some of this data may not be collected when the risks are underwritten, either an approximation can be used perhaps based upon industry data or other methods can be used to collect the data. Materiality should be considered if the data is missing, perhaps sensitivity testing the results.

2.2.1 Data representation

Prior to a catastrophe model run typically a data audit report is prepared this contains the details and high level assumptions used. The actuary should view this report and be aware of the materiality and accuracy of any assumptions made. The following points will give more depth on the kind of data issues that can occur, and the Actuary may need more information than the data audit report contains.

2.2.2 Input Data Types

Modelled results are only as robust as the data entered into them. There are three main levels of detail.

Aggregate Data

Aggregate data is typically summary level data where many risks are aggregated into a smaller number of "model points", for example total Sum Insured and risk count by postcode. This data is enough for the catastrophe models to produce a result, but as the data is summarised in some way does not contain risk specific details (location, financials) then the results should be treated with some caution.

Reasons to use aggregate data could include situations where:

- no detailed model exists from the model vendor
- no detailed data is available from the insurer
- aggregate data provides a cross-territorial or cross-peril consistency of data quality
- the aggregate model is simply judged to be the best fit for the business being modelled

Policy Data

Policy data represents a one to one correspondence with the policies written by the insurer. However for many classes of commercial insurances a policy can cover many locations (could be thousands). For example a commercial policy may cover a wide range of retail outlets, each with its own specific risk parameters (e.g. location, construction etc...). The policy detail may contain a single sums insured (with specific sublimit by perils) this may be intended to represent a PML (Probable Maximum Loss), the address on the policy may be a defined location (e.g. the head office). The cat model will not know that the risks are spread and thus the answer produced could be misleading.

Policy data for a personal lines book may need to be split into brands if there exist differences in coverage (e.g. flood included or excluded) or even distribution method selection impacts for the same coverage.

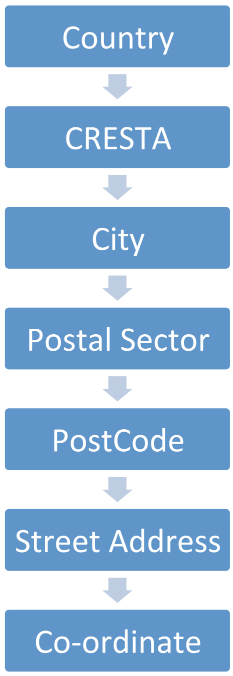
Risk Data

Risk level data is where there is a one to one correspondence between the risk written (a policy may contain many risks) and the cat level data. To produce data at this level for some commercial portfolios can be time consuming for insurers and underwriters alike. This level of data would represent the best level of detail that catastrophe models can accept.

The actuary should be aware of the data type and accuracy of how the subsections of the portfolio in question have been modelled. Note that all three levels of detail could produce results either higher or lower than the models "best estimate" depending on the specific portfolio.

2.2.3 Geo-coding

Geo-coding resolution levels can be visualised, as shown below:-



Geo-coding is the process of finding associated geographic coordinates (often expressed as latitude and longitude) from other geographic data, such as street addresses, or postal codes. The geographic coordinates can be entered into Cat modelling software.

There can be issues with finding addresses, especially if they come as free text from a legacy system. Also even if addresses are found the geo-coded co ordinates may be the centre of the block and not the actual buildings, for some perils (e.g. flood) and some risks (e.g. a university campus) this can be material.

If geo coding has been used, then the following should be considered in assessing the appropriateness of the cat model output:-

- What percentage has been successfully geo-coded?
- Who did this?
- Is it Material?
- Is it accurate?

2.2.4 Individual Large policies

Many classes of commercial insurance contain complex and specialised insurance policies that may cover under a single policy many locations, many types of property (e.g. buildings, plant and machinery, stock etc), some of which can move (e.g. rolling stock) and several types of coverage (e.g. property damage, reinstatement, consequential loss, theft, money).

These individual large policies need special treatment, the data contained in the policy system or provided to cat modellers may be a summarised version. For example the policy sum insured may be at a head office location, assumptions will need to be made about how the risk is actually spread. These assumptions may need to be tested and the model sensitivity tested to ensure a reasonable result. The data may also be in different currencies or have sub-limits per location.

It is not unusual to find bespoke reinsurances in operation which mitigate the risk not all cat models can deal appropriately with all kinds of reinsurance possible thus significant assumptions may need to be made and tested.

2.2.5 Unknowns

Where there is an "unknown" value for a parameter, then the cat models typically assume an average value. This is unlikely to be a conservative assumption, as half the time it may be to light and half to heavy. In reality an unknown parameter increases the uncertainty. For example, an unknown construction type input by the company might be interpreted by the model as the average construction type in the city where the building is located. The impact of missing information on the loss estimates is model-dependent and needs to be understood by the people using the catastrophe model. Sensitivity testing of incomplete data is advised, with most appropriate tests likely to be specific to the model being used.

Those using the catastrophe model should also be aware of the connection between the modelled results and common underwriting practice. More uncertainty in the results in general implies a higher price, but may require a commensurately conservative view on capital allocation.

2.2.6 Reinsurance

For many insurers, reinsurance is a significant asset (in Australia around 25% of the industry GEP is spent on Reinsurance). Reinsurance can be complex in its operation, and changing reinsurance coverage from one period to the next is not uncommon (especially after loss activity). Features of reinsurance that may need to be considered (and any changes in them over the lifetime of the risks exposed):-

- Treaty vs. Facultative (the mix can change)
- Basis of cover (Claims made vs. risk attaching)
- Retention (is there an interlocking clause)
- Exclusions
- Inuring covers
- Aggregate covers (particularly those containing an inner aggregate deductible that is partially burnt)
- Event limits (in Proportional and non proportional)
- Event definition
- Hours clause
- Reinstatements available

All of these issues are well documented in Actuarial literature, but these are things that need to be considered if looking to form a view on the magnitude of a net event with a low return period.

Not all of these features can be allowed for appropriately within a cat model, this could be due to the data granularity not reflecting the policy details (say using aggregate data when a deductible applies at a location or policy level), or the deductibles and reinstatements not able to be reflected(e.g. Top and Drop covers).

2.2.7 Other Common Assumptions

Underinsurance	Has an assumption been made? Can it be tested by past events? Does it vary by brand/distribution method? Does it vary by size of property? Would this apply to all properties for a small return period event?
Additional Living Expenses	Coverage under a homeowner's, condominium owner's or renter's insurance policy that covers the additional costs of living that are incurred by the policy holder should the policy holder be temporarily displaced from their place of residence. Such coverage is usually at about 10% to 20% of the insurance that covers the dwelling. Additional living expense insurance can cover things like the increase in a monthly food bill due to having to eat-out at restaurants or even the loss of income that might be incurred if the insured person were renting out part of their space to a tenant. Essentially the insurance is intended to cover the insured person for the extra expenses he or she may incur due to being temporarily displaced from their home, such as in the case of a fire or flood. This often is in addition to the sum insured, and can add up to the limit allowed in the policy. How has this been applied? If a simple loading then is this appropriate for low return period events?
7	
Insurance Tax Credit (ITC)	This assumption is usually supplied and is a significant percentage of potential claims costs allowing for the offsetting of insurance tax paid on the premiums, and the tax due on the claims. Is it up to date? Who owns the assumption?

Demand Surge	Some cat models allow the user the option of including demand surge in the loss estimates, which is post-event inflation. After a large disaster, construction material and labour can temporarily be in short supply, so construction costs are inflated. The larger the impact of the event on the local economy, the larger the effect of demand surge. For example, an event that causes a $5 billion insurance industry loss might cause demand surge to increase construction costs by 5%, while an event that causes a $40 billion insurance industry loss might cause demand surge to increase construction costs by 25%. Has this been included? If so how? (e.g. is it a function of event size or location or a simple x% loading across the curve) For simple loads are they appropriate for small events such as 1 in 6 and 1 in 10. There may be some element of demand surge included implicitly due to the cat model calibration using historical data, this then requires consideration when making a further allowance over and above the implicit allowance.

2.3 Data high level considerations

The Actuary that is signing off on a Horizontal Requirement number should form an opinion as to the data quality used as input to the catastrophe modelling process, and highlight any issues to management should the data appear inadequate. Below are suggested some broad guidelines to consider when reviewing input data.

Consistency

Assessment of the extent to which data is presented in a consistent format and in the appropriate units for input into catastrophe risk models

Completeness

Assessment of the resolution (or granularity) of the data as well as amount and significance of unknown data

Accuracy

Assessment of data correctness as well as the following:

- Credibility: Whether the data is believable and logical
- Objectivity: Whether the data is coded in a manner that is unbiased, unprejudiced and impartial
- Comparisons with reputed sources: How well the data compares with data ascertained from reputed independent/third party sources.

2.3.1 Bespoke issues

Preparing data input files can take cat modellers some time, so that at the time of the run the data used does not correspond to the live risks. This is a particular issue if the company is changing size (number of risks) or shape (type of risk), this could be for a variety of reasons. The Actuary should consider if there are any issues that need special attention and comment on the suitability of any allowance made for these features.

For example when deciding how much reinsurance cover to purchase (or if the amount purchased is adequate), the Actuary should be aware that the APRA test is continuous, but the reinsurance purchase is most often annual, so that for a rapidly growing company the most recent cat model run will always understate the catastrophic loss potential, the method of projection should be considered in the light of the company's growth strategy, and the actuary should consider whether anti selection could be occurring (this may be related to the pricing variables used).

2.3.2 Data - actual or assumed

Poor data quality will ultimately affect the results of the Cat Model, so companies should decide how to take incomplete data into account and justify the methods applied and assumptions made.

One example could be scaling exposure to compensate for non-geo-coded data. There are several viable options to achieve appropriate modelling of gross exposures. For example, the company could:

- decide to use 'percentage captured' based on premium income, and load catastrophe data accordingly, per peril
- use more sophisticated techniques, depending on the level of confidence in the existing data and its level of overall completeness – could be bespoke

It may be necessary to make assumptions for certain items of data that are known but may not be available (e.g. policy deductibles), but will be appropriately applied at the time of a claim. If assumptions have been made, they can be material and they should be considered for reasonableness. It is of course better to use the actual data.

2.3.3 Classes not modelled

The actuary should be aware of classes not modelled and the reasons for them in terms of areas, perils, model limitations and data limitations. The flooding in Thailand in 2011 is a good example of highly significant exposures that were not modelled. The flood peril itself was not well understood in Thailand, this was further complicated by the supply chain losses due to Thailand's growing prominence as a manufacturing hub.

How have the exposures that are not modeled been assessed? Alternative approaches such as Realistic Disaster Scenarios could be employed. How have non modeled exposures been controlled, if there is no controls in place is there evidence of anti selection, or rapid growth.

2.3.4 Non-modelled risks (Classes-Motor, Marine, Engineering etc; demand surge inflation, etc)

For other risks, including life and workers' compensation, motor, aviation and some marine risks, there are additional challenges related to the issues of time-variable value, location, as well as specific risk themes relevant to those types of risks and their vulnerability. In many of these lines of business there are specific issues that need consideration (e.g. workers in some location may only be exposed from 9am to 6pm – so could scale down the results of a cat model that does not consider time of day).

For these lines of business dependent on the materiality simpler approximations may be appropriate, such as:-

- decide to use 'percentage captured' based on premium income, and load catastrophe data accordingly, per peril
- use more sophisticated techniques, depending on the level of confidence in the existing data and its level of overall completeness

It is not likely to be possible to develop a single methodology and the Actuary should be aware of what has been done and for understanding the method used and justifying the assumptions made, especially if this is potentially a material exposure.

2.3.5 Projections

Cat models simple create the potential losses for a given portfolio. If the portfolio is changing size (e.g. growth or shrinking) or shape (e.g. mix) then in order to estimate what a cat loss could be then assumptions will need to be made.

There are a variety of methods used to construct the input files to be used for projected cat runs. The data collection and preparation can run for several months, so that to create the portfolio at a required date would require assumptions. Who owns these assumption, have they been applied correctly or realistically.

This is likely to be a key issue for rapidly growing companies for low return period loss events (e.g. 1 in 6 and 1 in 10), as the loss at the lower return periods is more in proportion to sums insured that the extreme events.
Growth assumptions for rapidly growing companies can be difficult to estimate realistically.

2.3.6 Data reconciliation

As with all actuarial work it is sensible to reconcile the input data with other sources. Does the company have a specific data individual who assumes this responsibility or is this left to the cat modellers? Can any changes since the last cat exercise be explained? Do the sum insured totals looks reasonable when compared to the premium income? Have they grown in a controlled way? Has unexpected growth occurred?

2.3.7 Common data issues

Low-resolution location data	properties identified only at ZIP Code level
Incomplete building characteristics	Unknown year built/construction class
Inaccurate coding of risks	Unreinforced Masonry coded as reinforced concrete buildings light metal construction coded as steel

	frame Specific high value risks coded approximately (e.g. floating casino as mobile home)
Miscoded policy information	Coverage limits being used instead of actual values

3 MODELLING

3.1 Models used

There are three major international model vendors, and a whole host of bespoke models available, as well as specific models built for specific purposes. The models are continually updated, below shows the release schedule for 2012/13 for the three major vendors, of the changes most likely to be relevant for APRA licensed Insurers/Reinsurers:-

AIR	EQE	RMS
2012	**2012**	**2012**
Australia Bushfire Australia Cyclone Australia Earthquake	180 peril/region models Includes 77 aggregate models **RQE Platform – I**	Japan Earthquake v11 Service Pack 4
2013	**2013**	**2013**
Japan Earthquake **Japan Tsunami** Japan Typhoon **Pandemic**	Japan Earthquake (Event Rates) **RQE Platform – II**	Japan Earthquake (updated hazard map) New Zealand Earthquake (Liquefaction hazard map)

The actuary should be aware of the model version used and why (especially if it is not the latest).

3.1.1 Catastrophe model validation

There are two main types of catastrophe model validation:

- Model vendor validation to ensure that results are appropriate for the specific peril at a country-wide level
- Individual company validation that the model is suitable for its actual portfolio

Companies should do sufficient work to provide evidence that their catastrophe models are validated and appropriate to their own portfolio. The amount of work will depend on the materiality of the likely catastrophe risk, and the availability of suitable catastrophe models.

This means establishing that the model is appropriate to use for this portfolio. Is the Insurer able to conclude that the external cat model used in this way is an appropriate fit for the cat risk of this insurer?
For an appropriate validation the following items may be considered:-

1) What is the relative measure of cat risk relative to the whole risk of this entity
2) How has this been assessed, on what basis?
3) Is there a dominant region or perils or portfolio?
4) How has this been determined, does this involve subject matter experts?
5) Is there a process guiding this exposure and risk, has it been followed is it monitored?
6) How is the materiality of cat risk monitored?

The vendor cat models are believed by the vendors to be appropriate, but are they appropriate for this entity at this time, this would typically also need to consider that data that goes into the cat model as Cat Model + Cat data leads to cat model output.

3.1.2 Model approach

The approach to modelling catastrophic risk will vary for each company, depending on a number of factors.

The materiality of the risk exposure involved

Where there are high concentrations of exposure and risk, it is advisable to use a catastrophe model. However, some catastrophe models do not cover every peril in every part of the world, which may limit their use, depending on the business written by a particular company.

The models available

Catastrophe models may be available in both aggregate and detailed versions. The choice of one or the other should be proportionate, reflect the company's risk profile, and take into account the availability of exposure data on the risk a company insures.

3.1.3 Model Selection

The first criterion for selecting a catastrophe model or models is the materiality of risk exposure involved. Where there are high concentrations of exposure and risk, it is advisable to use a catastrophe model. However, some catastrophe models do not cover every peril in every part of the world, which may limit their use, depending on the business written by a particular company.

Secondly, catastrophe models may be available in both aggregate and detailed versions. The choice of one or the other should be proportionate, reflect the company's risk profile, and take into account the availability of exposure data on the risk a company insures.

Once a company has decided to use a catastrophe model, the following points may be relevant when choosing the most appropriate one:

- the adequacy of the model for the company's risk profile, including the company's ability to collect the appropriate data required in order to run the model effectively
- whether the model has passed an objective and unbiased validation process in line with the company's own validation process, which may include certain adjustments to the model to comply with the company's book of business
- the expertise and experience of the model developer
- the level of support and transparency the company receives as it develops an understanding of the theory and assumptions applied to the model
- the experience of the company's staff with both the model and its provider, either directly or through an outsourced service provider such as a reinsurance broker
- if licensed directly, the usability and fit within the company's workflow and business processes, and integration into their Internal Model
- an analysis of the strengths, weaknesses and limitations arising from the use of a particular model, as well as any potential restrictions to the on-going fulfilment of the Solvency II requirements

It is advisable to review the model selection criteria regularly, in order to ensure that it remains appropriate for the business. New information, such as a major event or new alternatives coming to the market, may also trigger a review of the model.

3.1.4 Multi modelling

There is no requirement to use more than one catastrophe model or more than one approach in order to estimate cat event losses. The overriding consideration is for the company to form their own view of their catastrophe risk, using whatever methods are appropriate for the portfolio and business. This may be a single model or a multi-model approach or a variety of bespoke approaches. There is no single correct approach and there is no "right" answer.

It can be expensive to own/run several models. Multiple models can be engaged to help narrow the uncertainty band. Multi-model techniques include:-

- Single model with assumptions and/or data - i.e. pick the most appropriate model and data, suitable validated
- simple weights, common approach - simply weight the results together, avoids over reliance on a single model, and can smooth the results of model changes over time
- model decomposition - weight different components of models differently
- 'shoehorning' – creating a distribution of return period losses using the individual cat model return period loss as inputs – could create event loss table to allow better application of policy conditions from aggregated output.

If an insurer is using multiple models it must ensuring that output selected from the range of multiple models should not be used to cherry-pick a commercially desirable outcome.

These approaches may vary across the company. For example, in some cases, a single model might be used for underwriting and portfolio management, but several models could be used for capital management.

It may be sensible to aim for consistency across an insurer's processes. However it is not unreasonable to use more prudence for solvency purposes. What is more important is that an approach has been selected and its strengths and weaknesses are known by senior management.

3.1.5 Age of models

Developers will, from time to time, release updates to their catastrophe models as a result of:

- new scientific research
- learning from past events
- the release of new data

When this happens, companies using a catastrophe model should be familiar with the reasons for the update, the new information and data used, and how the vendor has validated the updated version of the model.

Whether or when to change should follow a validation exercise, and the insurer should be aware of any impacts on the business prior to changing the model.

3.1.6 Underlying science and engineering

The Actuary (and APRA) is not required to replicate and understand all the science and engineering that goes into a model, but enough about it to make an appropriate choice for modelling the cat risk of the entity considering the materiality of the risks.

In order to become comfortable the Actuary or management may want to see runs from other models, or sensitivity tests of key parameters, this would help to understand the scale and sensitivity of the catastrophic risk. Judgment can then be applied appropriately to ensure that the results are broadly sensible and as sensitive as expected.

3.1.7 Comparison with published research from non-insurance industries

Companies should fully document the validation process, and clearly demonstrate the reasoning behind why they feel that the model they have chosen is appropriate for their business portfolio.

Companies should be able to demonstrate the independence and impartiality of the validation process, and prove that robust challenge exists in relation to the validation of the model. The uncertainty in the model, limitations and required future developments should also be documented.

It may be reasonable to rely on secondary research, if appropriate.

3.1.8 Policy specific details

Policy specific detail can be complex for multi-location commercial policies. Can the model used make allowances for this or have approximations been used. If Approximations are used how sensitive are the results to these approximations.

3.1.9 Model use

Cat models have been widely used in the industry, for estimating the loss that could emerge from catastrophic events. The results most frequently used have been

- The extreme event amount such as the 1 in 200 year loss to help set reinsurance purchase limits.
- The Annual Average loss, to help set direct insurers pricing

The lower return period losses have been less relied upon, but in Australia APRA have implemented regulatory change which relies on lower return period losses. APRA have stated The Horizontal component to be the greater of:-

a) Three one in ten year events
b) Four one in six year events

Assuming independence then (a) has a probability of 1 in 1000. APRA have made an allowance for correlation and they believe that (a) and (b) both have a probability of 1 in 200.

For frequency typically cat models use a Poisson distribution. A Poisson distribution is suitable if the probability of the events is small (with a known average rate), proportional to time and crucially independent. For extreme events this may be reasonable, but this is unlikely to be the case for more frequent return periods. A one in ten chance is not small in this case, and at lower return periods there is likely to be some correlation. Thus Cat models would tend to understate the likelihood of the one in six and one in ten events.

A cat model can be viewed as an extension of the historical event scenario method. The history of events is smoothed and interpolated (and, to some extent, extrapolated) to create a large number of might-have-been events of comparable realism. For lower return periods the frequency assumption and inherent correlation may be understated within the black box. Using industry data appropriately scaled should also be considered and compared. The ICA provides a catalogue of catastrophe claims in Australia going back over forty years. When using historic events it is important to consider the method of revaluation, allowing for time value of money, population growth and building codes.

3.1.10 Statistical versus geophysical models

The greater use by the world's regulators of cat model output (or reliance upon estimating cat return periods at small probabilities) has not necessarily gone together with a greater understanding of the limitations of the cat models or the common sense applications. The results are often taken at face value. In particular for lower return periods say one in ten and one in six, then using more traditional historic losses is appropriate as a check and perhaps as a more primary method or part of a blended result (to avoid too much reliance on models or past losses).

Traditional statistical approaches of estimating means and variances from suitably re-valued past experience can highlight areas of perhaps over reliance of cat models, particularly where the past losses of from "non-modelled" perils. Or even the results of the loss is due in part to some further nuance on a modelled loss that the model does not allow for (e.g. liquefaction in NZ, quake plus Tsunami in Japan, flooding in dam controlled areas in Australia).

3.1.11 Event Clustering

Evidence appears to be growing that earthquakes are not completely random and therefore independent. Earthquake clusters appear to have occurred in the Pacific Rim in recent years. In some cases an earthquake may reduce the probability of a further earthquake by reducing the stress on a fault line; in other cases one earthquake may trigger another causing a cluster. The clearest evidence of earthquake clustering is found in the aftershocks following the main shock.

For other perils then if the weather conditions are appropriate a whole series of events is perhaps more likely.

Often cat models event sets consider an event with a given magnitude with a given probability, other events in the event set would be independent and thus no allowance for clustering. In interpreting cat model output and OEP (Occurrence Exceedence probability curve) may be used this would give the maximum cat loss over a given time period (usually one year) with a specified return period. Although this could be used to sample from without a correlation structure it would assume independence.

Care needs to be given to considerations of clustering on a peril specific basis, particularly for lower return period events where there is no standard vendor model.

3.1.12 Model performance post event

Post an event and early estimates of the result of an event can be obtained by running the most similar event from the event set through the most recent exposure data. Post an even human interpretation should also be applied and also used as a sense check. Post event catastrophe reports are often produced by the model vendors; this can be a useful check on the potential market size of the event, to ensure that an individual insures loss is in an expected range or a good reason why it isn't.

3.2 Modelling process

3.2.1 Responsibility

To make proper and timely decisions on risk management issues, senior management must have an overall understanding of where the company is exposed to catastrophe risk, and what its key drivers are. This can be obtained through regular, transparent reports and presentations that highlight changes in exposure and modelling approach. Depending on the nature of the cat risk to the company, it may be necessary to have a formal regular process with an individual (e.g. the CRO) taking responsibility to keep the board informed as necessary.

3.2.2 Models documentation

Senior management should understand the strengths and weaknesses of catastrophe risk models. The following issues should be formally addressed if the cat perils is significant to the company:-

- Are there any potential gaps and quality differences in the company's catastrophe risk modelling landscape, are all perils modelled in sufficient detail allowing for materiality?
- Obtain enough information to confirm that the process and results are robust enough and fit for use

3.2.3 Result ownership

The ultimate responsibility for ensuring prudent and effective management of insurance concentration risk rests with the Board of the insurer. Most regulators and rating agencies expect the Board to review the insurer's exposure to catastrophe risk. Is this clear from the way the process is handled?

3.2.4 Governance meetings

Senior managers do not need to have the same level of knowledge about catastrophe risk models as the members of the catastrophe risk management team, but there should be regular, transparent and evidenced exchanges of information between the two groups. Is the board regularly kept informed regarding cat exposures and losses? Is this information used proactively to steer the companies risk exposure? Is this more frequent than regulation requires?

3.2.5 Modelling process

This could either be in house or outsourced (most often to a reinsurance broker). The Cat risk management team should ensure that the models they use continue to be appropriate and to reflect the risks within the Company and ensure that adequate changes in the modelling approach are implemented as a result of changes in the scope or nature of the company's business, data or any relevant change in the perception of the risk or company strategy.

Does the model risk vary by peril, for example some perils probability changes as conditions vary e.g. bushfire risk changes as vegetation changes (e.g. a very dry spell after a period of heavy rain) and flood risk changes due to infrastructure.

4 OUTPUT

The output from a cat model is typically estimates of the losses that the model predicts would be associated with a particular event or set of events. This can be in a variety of forms. When running a probabilistic model, the output is either a probabilistic loss distribution or a set of events that could be used to create a loss distribution; probable maximum losses (PMLs) and average annual losses (AALs) are calculated from the loss distribution. When running a deterministic model, losses caused by a specific event are calculated; for example, a Sydney Earthquake could be analysed against the portfolio of exposures.

Almost all catastrophe models have options (e.g. a choice between detailed or aggregate modelling) and settings (various tick boxes e.g. secondary uncertainty) that allow their users to calibrate the outputs. Companies using a catastrophe model should have an appropriate level of familiarity with the available options and settings, and any vendor recommendations concerning their use. Any user of the output should be aware of the assumptions used in the results they are using.

The use of individual options and settings may be highly interdependent, and all choices made in the modelling process should be regarded as part of a holistic modelling approach rather than the choice of individual and independent options or settings. This should be documented as part of the model validation and model selection policies and, when appropriate, for model change policies as well.

Those individuals within a company that have defined technical responsibilities for model use and interpretation under the risk management function should be aware of, and understand:

- the options and settings available for the territory and peril under consideration
- what causes of loss and risk processes these represent
- any recommendations made by the vendor modelling company regarding their use, the context of these recommendations in relation to the company's own risk profile, and any implications for loss results

4.1 PML and other metrics

The output from a cat model can come in a variety of forms:-

Exceeding Probability (EP)

The probability of exceeding specified loss thresholds. In risk analysis, this probability relationship is commonly represented as a curve (the EP curve) that defines the probability of various level of potential loss for a portfolio from natural hazards.

OCCURRENCE Exceeding Probability (OEP)

This is a measure of the probability that a single occurrence will exceed a certain threshold. OEP is the single largest occurrence in a year. This is useful in determining how likely a loss will be ceded to a per occurrence reinsurance layer. This distribution is used in pricing of catastrophe risk reinsurance.

PML (Probably Maximum Loss)

This represents the loss that is likely with a given level of probability over a defined time frame (usually annual), such as the one in two hundred PML over the next year, and can be taken to be the 0.5% (1/200) loss estimate from the OEP curve. This figure may need to be adjusted to allow for a variety of factors (e.g. growth, ALE, Demand Surge, etc...)

AGGREGATE Exceeding Probability (AEP)

A measure of the probability that one or more occurrences will combine in a year to exceed the threshold. AEP is the annual losses from all events in a year. This is useful if there is an annual aggregate cover (stop-loss) or in analysing reinstatement requirements. It is also useful for pricing insurance business as it gives the distribution of annualised cat losses, given that more than one event can occur in the same year. This can be used in determining appropriate cat loads for insurance premiums.

The AEP is always larger than the OEP (as more than one event can occur per year).

Rating agencies and reinsurers tend to look at individual peril OEP, as this is the distribution of the max cat event losses in a year. Reinsurers are viewing this in regards to pricing catastrophic cover. Rating agencies can use this to estimate insolvency probabilities given capital and reinsurance constraints.

4.1.1 Understanding output

Relying on the results of a cat model without reference to the inherent uncertainties, can lead to a material misrepresentation of risk. A false confidence can be gained from a belief that the risk is managed as it has been modelled.

Uncertainty can be described as the imperfect knowledge of a process or system and is a natural consequence of any complex process such as natural or anthropogenic hazards. This means that 'prediction' of events is impossible. Uncertainty underpins the concepts of probabilistic and stochastic modelling and, if properly understood, is a positive factor in improving risk assessment above and beyond deterministic approaches. All risk assessment is inherently uncertain, and catastrophe models provide methods to treat risk uncertainty through stochastic means.

As such, models are a useful way of characterising the type of high-severity, low frequency events that may not exist in a company's own claim history. While catastrophe model vendors try to reduce uncertainty in their models, these models themselves are simplifications of complex physical phenomena. This simplification, the scarcity of data, and incomplete understanding, may introduce material sources of uncertainty into the models. It is important to understand that although some of the uncertainty in the modelled results are characterised in current catastrophe models, many sources of uncertainty are not fully represented or understood.

For high frequency and low severity events, the cat model may well have certain black box assumptions such as independence, Poisson probabilities. They may also not have been updated to allow for recent changes to climate/urbanisation or legislation (impacting claims costs or building codes), so that it may be sensible to use more low level data driven methods such as industry data and company specific experience to validate or blend with cat model output at lower return periods. It may also be sensible to estimate confidence intervals for high frequency events.

4.1.2 Forms of error

There are different kinds of error that can occur in cat modelling:

Specification (model Error)

How specific and detailed the model parameters are? Higher level of detail in a model may reduce uncertainty in loss estimate.
Is it the right model for the hazard, and the specific portfolio?

Vulnerability (Parameter/Model Error)

Amount of damage a building sustains given a specific local hazard condition. How detailed is the model input? How valid are the damage curves, have they been validated post recent events? How appropriate are the damage curves for high frequency events (i.e. smaller events)?

Hazard (Parameter/Model and Stochastic error – a chaotic hazard)
Wind: is a function of

- Windfield + Terrain effect, measuring the impact of roughness

Flood: is a function of

- Rainfall duration/ Intensity (how much rain)
- The length of time between consecutive events (i.e. potential cumulative effect)
- The direction of the storm (where does the rain fall).
- The soil conditions (what happens when it lands)

4.1.3 Uncertainty

Uncertainty arises from four types of potential errors:

- Sampling error: Inaccuracy arising from a limited data sample.

- Model specification error: Uncertainty as to whether the correct type of formula has been chosen. Included in this concept is the lack of understanding of physical chaotic phenomena underlying catastrophic behaviour and the lack of understanding of building structure behaviour under severe loads?

- Non-sampling error: Uncertainty as to whether all relevant factors have been considered. This includes the still debated effects of the El Niño-La Niña cycle and global climate change on the rate of land falling hurricanes. It also includes known managing catastrophe model uncertainty and phenomena not modelled (for example, tree damage, cleanup costs, looting), novel legal interpretations of liability or post event regulatory actions, interaction of follow-on events such as freeze following a hurricane and the disruption and slow economic recovery that follows a very large disaster.

- Numerical error: Arises through the use of approximations in calculations. The Monte Carlo technique, which involves running thousands to millions of simulated events and is widely used in cat modelling, is one such approximation.

4.1.4 Uncertainty Judgement

Typically, uncertainty is handled in the stochastic event set and resultant Exceedence probability (EP) curves, where the EP curve represents the range of losses (i.e. a probability distribution of loss sizes) that could be experienced for the modelled peril.

It is important to note that when looking at a single point in an EP curve, uncertainty becomes significant. The point on the EP curve has a distribution around it and the point represents the mean of this distribution. Focus on individual points on the EP curve from a single model may encourage optimisation of portfolios around weaknesses in the model. Biases relate to systematic mis-statements of the risk by a model.

For example, a company may use one model, without reference to additional risk measures, for all risk decisions from pricing to capital management. That model may understate vulnerability of an occupancy type as no claims data is available, and frequency of events in a location as there are limited observational records in the area. As the model may favour these occupancy types or regions, there is a reasonable likelihood the resultant portfolio is skewed towards accounts with these characteristics. If the same model is then used to assess the amount of reinsurance to purchase, these deficiencies will not be identified, and the suggested level of reinsurance protection may be inadequate. Typical sources of bias include:

- non-modelled perils, coverage's and LOB
- by geography
- by peril
- as a consequence of building characteristics
- financial policy structure

Although catastrophe models follow the same basic model structure (e.g. Hazard (Event set), Vulnerability, Financials)
Each modelling firms' Stochastic Event Sets are structurally different, due to:-

- different methodologies to generate the spectrum of potential storms
- They rely on different historical data
- They are generated based on different assumptions

So that the results can vary, perhaps materially so.

4.1.5 Uncertainty Generalised

In reality there is further uncertainty which can be classified as one of three types:-

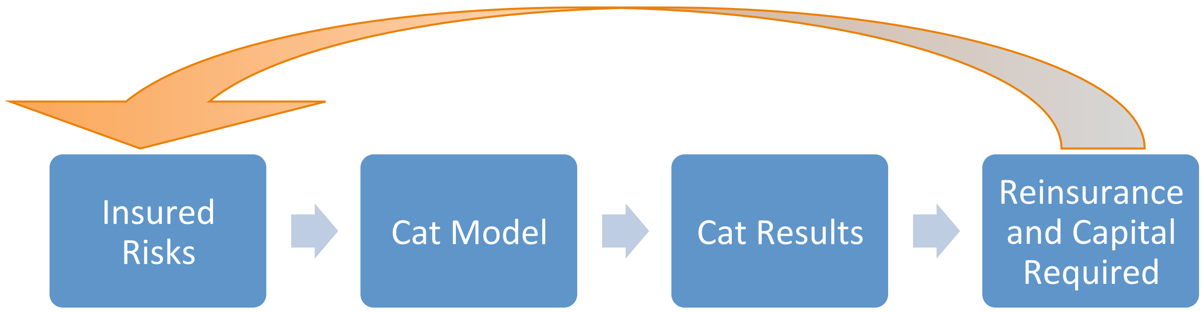
- Aleatory uncertainty – irreducible uncertainty due to natural unpredictable processes (e.g. weather is chaotic)
- Epistemic uncertainty – uncertainty in our knowledge about the world (model uncertainty – in creating the events sets)
- Ontological uncertainty – uncertainty due to things we didn't even know existed.

Additional, external, uncertainties come in to play when one uses a model. These principally arise from the quality of the data being fed into the model, but also include the use of "switches" (model option settings) that might not be set appropriately for the analysis at hand.

There are also other uncertainties regarding contingent events post a catastrophe such as:-

- Liquefaction
- Fire following earthquake
- Business interruption
- Contingent business interruption
- Landslides
- Paying for claims not covered due to reputation risk
- Court challenges over advice given pre sale or wordings used
- New fault lines not included in EQ models (other than background seismicity)
- Buildings not being constructed as stated

4.1.6 Risk Management Cycle



One use of cat models is to take a current/projected portfolio and calculate the estimated losses and use this as in input into the capital management process. There is also a more proactive approach where the cat modelling can be used to assist the underwriting of risk and help set a strategy.

The cat modelling results can influence the business written in terms of pricing into and out of certain areas, and in effect get the cat loss profile desired rather than writing the business and seeing what the cat loss profile is and then dealing with it.

4.1.7 Reasonableness of Model Output

While models have considerable uncertainty associated with them, they are still valuable tools, taking their place with scenario analysis and exposure accumulation studies. In fact, they can be viewed as extensions of both of these types of analyses. Coping successfully with cat model uncertainty involves a number of approaches. In many cases, multiple models can be engaged to help narrow the uncertainty band.

The issues of model uncertainty and change pose many difficult challenges for the industry. The "black box" should no longer be left to make the decisions. Rather, it should be considered a tool to help inform decisions made by (human) professionals. This is an intuitive and straightforward prescription, but making it happen will require the consideration and engagement of virtually every group in the industry.

4.1.8 "Secondary uncertainty"

Primary uncertainty:

Uncertainty around whether or not an event will occur and if so, which event it will be. Primary uncertainty is therefore related to the occurrence or non-occurrence of unknown events and to the probabilistic nature of the studied phenomenon.

Secondary uncertainty:

This represents the uncertainty in the size of the resultant loss, given that a specific event has occurred. Secondary uncertainty is therefore related to the ability of the model to represent the hazard. It combines in statistical terms the parameter error and the specification model error. Some Cat models allow this to be turned on or off. It is typically represented by a beta distribution. Losses at given return periods are increased, as losses below this are allowed to become larger with the additional variability.

4.1.9 PML – Vertical Requirement

APRA states that an insurer that has exposures to natural perils (NP) must determine a Probable Maximum Loss (PML) for its portfolio (NP PML). NP PML is the gross loss arising from the occurrence of a single event, where that loss is not less than the whole-of-portfolio annual loss with a 0.5 per cent probability of occurrence. NP PML must not include any allowance for potential reinsurance recoverable.

The calculation of NP PML must include:

(a) the impact of the event on all classes of business of the insurer;
(b) an allowance for non-modelled perils; and
(c) potential growth in the insurer's portfolio.

4.1.10 PML error bands

The loss (L) at a given return period given by a cat model can be thought of using the following formula:-

$$L = \sum_{i=1}^{N} \sum_{j=1}^{M} a_j D_j\, (S_i)$$

Where
L = Annual Loss
N = Number of events in the event set
M = is the number of assets (e.g. Properties)
aj = Asset value (j)
Dj(x) = Damage for asset aj, depends on the size of the event (S_i)(for the damage curve), with secondary uncertainty described by a beta distribution)

Form the above we can see that there is considerable uncertainty in the loss amount, due to three stochastic uncertainties:-

- The frequency where typically cat models use a Poisson distribution. A Poisson distribution is suitable if the probability of the events is small, proportional to time and crucially independent. For extreme events this may be reasonable, but this is unlikely to be the case for more frequent return periods.
- The Severity of the loss event
- The Damage function and the secondary uncertainty distribution associated with it

The means that the OEP curve represent the mean of the values for a given return period and not the maximum, this there are “funnels of doubt” surrounding any given OEP curve. These can be estimated from cat model output using a variety of statistical techniques (e.g. bootstrapping).

4.1.11 Rules of thumb

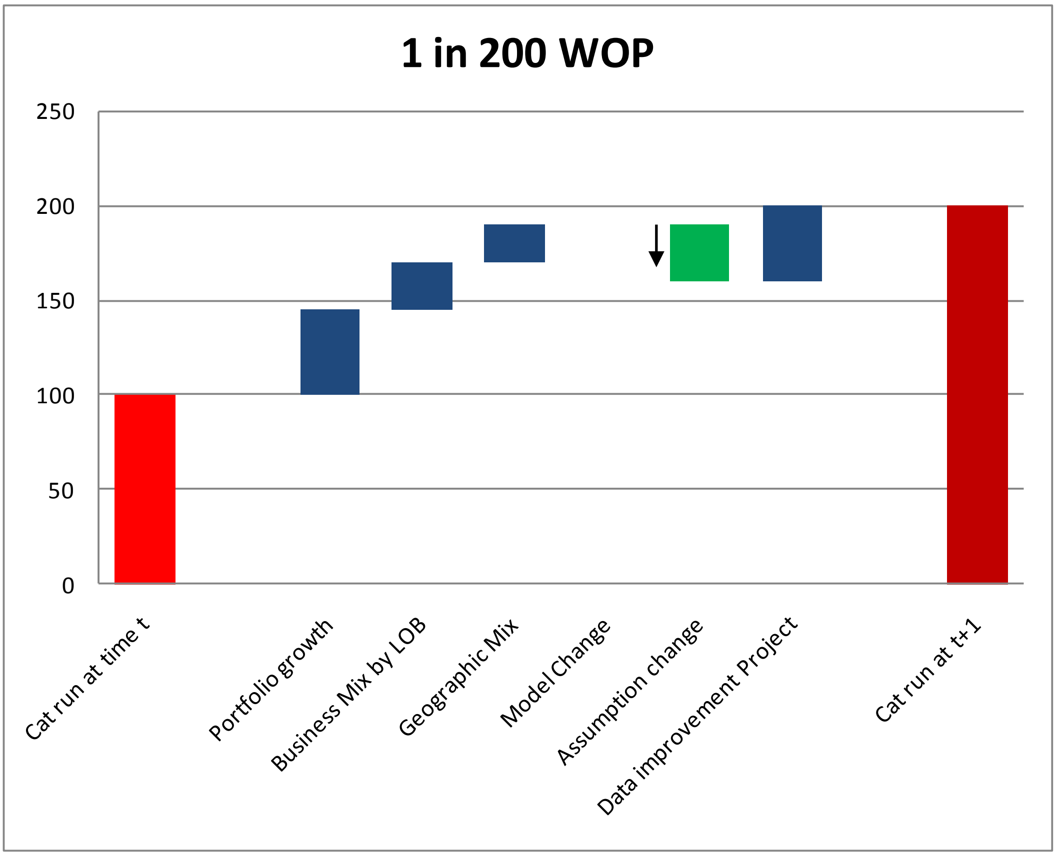
For a national portfolio of exposures and a typical return period of interest, a reasonable two standard error interval for a probable maximum loss (PML) could go from 50 percent to 200 percent of the PML estimate produced by the model. This interval can be understood as representing a 66.6 percent chance of the true answer lying within the indicated range.

So, in other words:

For a loss of X at a given return period then two thirds of the time the loss will be within the range of (0.5X, 2X). For smaller portfolios the uncertainty can be higher.
These probabilities can be estimated from the event loss table which is an output to some catastrophe models.

4.1.12 Reasonableness of Results

Model results can vary from one period to the next for a variety of reasons, it is often aids understanding (and is a useful check) to break down the change into its component parts. The waterfall diagram below shows an example of this:-

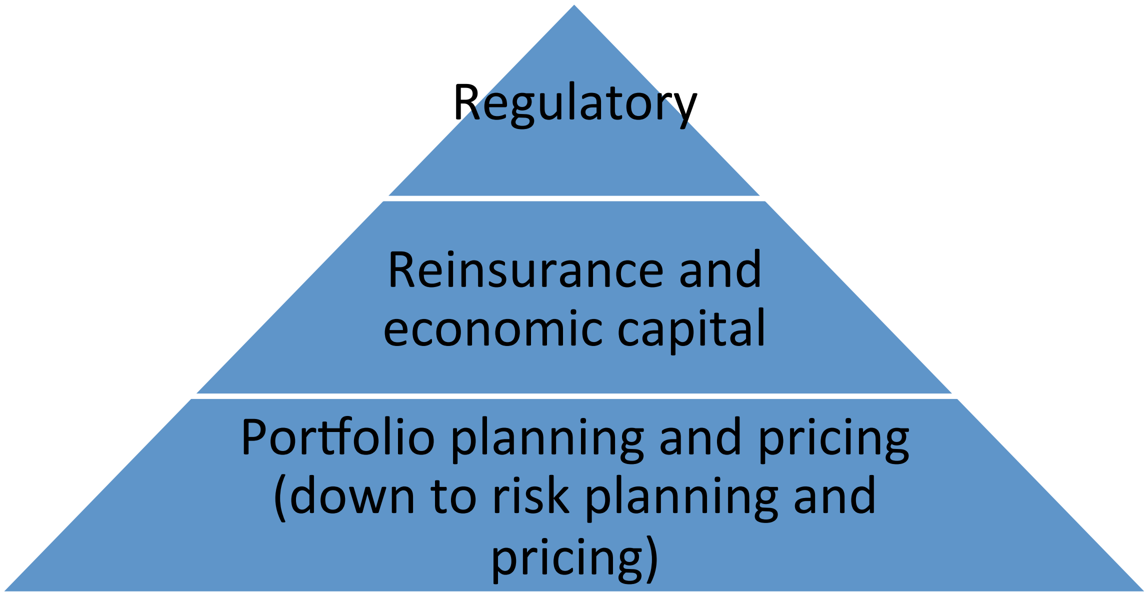


In this example the data improvement project actually made the 1 in 200 whole of portfolio increase. A question may be was the assumption change valid and naturally less cautious assumptions can be used due to improved data quality, or was this made so as to offset the increase caused by the improved data?

4.1.13 Output Usage

The cat models can be used and integrated in company processes in a variety of ways, from purely regulatory driven, through to fully integrated and used proactively in the individual risk rating and portfolio planning process.

The more integrated a model is then generally the more challenge and testing will have taken place. There is a risk of observer bias, where the cat risk may have been managed with respect to a particular model or process. This is akin to the re-underwritten portfolio that simply excluded all the accounts that made a loss.



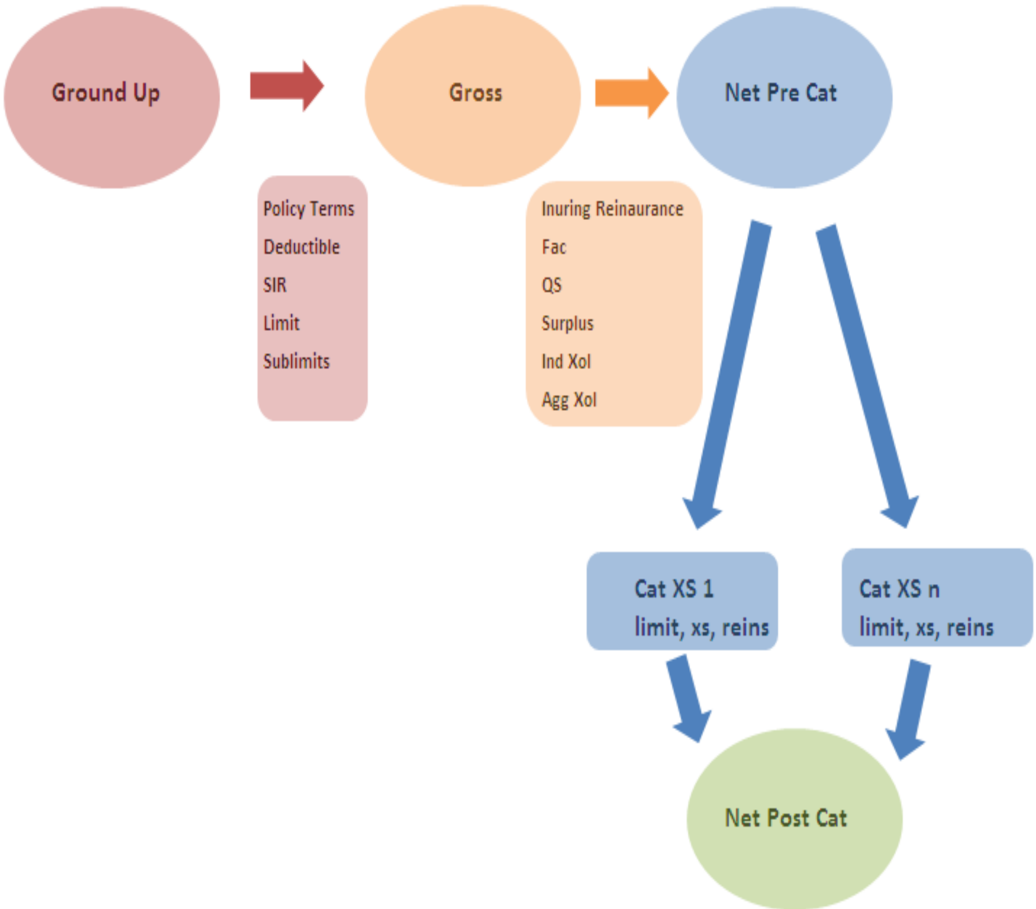
The key uses can be seen as:-

- Managing exposures
    - Regional limits of exposures
    - Scenario testing
    - Capital costs and allocation
    - Reinsurance purchasing
    - Rating agency/regulatory
- Pricing
    - Direct
    - Reinsurance

Many of these activities can be holistically linked.

4.1.14 Modelling Process Diagram

The basic modelling process is shown below:-



4.1.15 Reinsurance purchasing

There are two main aspects to reinsurance purchasing, what to buy and how much is a fair price. Reinsurers use cat model output extensively.

Large reinsurers and reinsurance brokers may have their own models for certain perils. The key to the negotiations will be the understanding of the cedant's risk specifics and the applicability of the models.

4.1.16 Cat XoL Pricing

As part of the modelling process it is possible to estimate the risk premiums under a range of limits, deductibles and reinstatement provisions, allowing for policy and inuring reinsurance details. The model derived risk premiums are an important part of the final cat XoL premium. Further cedant specific factors such as underwriting standards, claims handling, coverage, past experience and the nature of the reinsurer relationship also play a significant part.

4.1.17 Cost allocation

Depending on the granularity of the cat model results, the component parts of the reinsurance costs can be allocated to individual lines of business or even policies. There are many ways to estimate the allocation but the key components are capital and risk premium further detail is available in other actuarial papers.

4.2 Documentation and reporting

4.2.1 Statutory reporting

From the APRA specific guidance from GPS 116 (January 2013), the NP HR must be calculated at the reporting date on or prior to the inception date of the insurer's catastrophe reinsurance program and then held constant for the remaining duration of the catastrophe reinsurance program.

According to this guidance the NP HR calculation must only include potential reinsurance recoverables that were contractually agreed on or before the relevant reporting date. This is made even clearer even if the first reporting period is part way through the catastrophe reinsurance program treaty year. If this is the case, the insurer must determine NP HR as if the requirement to determine NP HR applied at the inception date of the catastrophe reinsurance program (ignoring any events that may have occurred between the inception date of the current catastrophe reinsurance program and the effective date of this Prudential Standard).

For aggregate covers this may not reflect the economic reality, as if an aggregate deductible is used then the loss activity during the period of cover can have a material impact on the potential recoveries due. For example the reinsurance cover it may not be expected (in the mathematical sense) to burn (thus keeping the cover affordable) once an event or series of events occur then the value of the cover may be "in the money" and thus its value changed. Thus the cover may have a real economic value, but no regulatory capital value. This is different treatment to the VR.

NP VR must be calculated and reported to APRA as at each reporting date. The calculation of NP VR, at a reporting date, must take into account the reinsurance program in place for the next reporting period. The NP VR calculation at each reporting date must only include potential reinsurance recoverable that were contractually agreed on or before the reporting date. However for the NP VR an insurer must regularly monitor the level of NP VR during the reporting period, including determining the impact of a catastrophic event. Where an event occurs during the reporting period, the insurer must determine the impact of that event on the level of the NP VR.

Any changes made to the NP VR as a result of the catastrophic event are then to be applied until the end of the current reinsurance treaty or the occurrence of another event that impacts the NP VR, whichever occurs first, unlike the NP HR.

4.2.2 Insurance Concentration Risk Charge formula

APRA states that the Insurance Concentration Risk Charge for an insurer is the greatest of the following amounts:

(a) the natural perils vertical requirement (NP VR) determined in accordance with paragraphs 18 to 26 (See Appendix A);
(b) the natural perils horizontal requirement (NP HR) determined in accordance with paragraphs 27 to 43 (See Appendix A);
(c) the other accumulations vertical requirement determined in accordance with paragraphs 44 to 52 (See Appendix A); and
(d) where applicable, lenders mortgage insurer concentration risk charge determined in accordance with paragraph 53 (See Appendix A);

An insurer does not need to calculate amounts for each of sub-paragraphs (a) to (d) above if it is able to demonstrate that the amount determined for one or more of those sub-paragraphs is always expected to be materially lower than the amount determined for one of the other sub-paragraphs.

4.2.3 Impact on capital requirements

Cat models can provide a wide array of answers, depending on:-

- Data inputs
- Options and settings
- User demands
- Historical data used to parameterise models and assumptions made to project past experience to the future
- Probabilities given to the event sets, the hazard curves used

They have been widely used in the industry, for estimating the loss that could emerge from catastrophic events. The results most frequently used have been

- The extreme event amount such as the 1 in 200 year loss to help set reinsurance purchase limits.
- The Annual Average loss, to help set direct insurers pricing

The lower return period losses have been less relied upon, but in Australia APRA have implemented regulatory change, which relies on lower return period losses. APRA have stated The Horizontal component to be the greater of:-

- Three one in ten year events
- Four one in six year events

Assuming independence then (a) has a probability of 1 in 1000. APRA have allowed for correlation and they believe that (a) and (b) both have a probability of 1 in 200.

Most Australian Catastrophe programmes retentions have a return period between 2 and 10 years (based on cat modelled results); this has been increasing due to price increases after loss events. Thus for most insurers the maximum net impact of a Vertical loss and the Horizontal loss will be the horizontal loss impact as shown below (in this simple example we have assumed that a $xm retention represents an x year return period to illustrate the principle) the loss amount:-

Probability	Loss ($M's)
1 in 10	**10**
1 in 6	6

($M's)						
Retention	Old APRA	VR	HR(4:6)	HR(3:10)	New APRA	New/Old
2	2	2	**8**	6	**8**	400%
3	3	3	**12**	9	**12**	400%
4	4	4	**16**	12	**16**	400%
5	5	5	**20**	15	**20**	400%
6	6	6	**24**	18	**24**	400%
7	7	7	**24**	21	**24**	343%
8	8	8	**24**	**24**	**24**	300%
9	9	9	24	**27**	**27**	300%
10	10	10	24	**30**	**30**	300%
11	11	11	24	**30**	**30**	273%
12	12	12	24	**30**	**30**	250%

From the above we can conclude that for the majority of insurance companies, their capital requirements will be driven by the Horizontal component of the ICRC formula.
Depending on the retention purchased, the HR may be driven by a multiple of either the retention or the estimated loss amount itself. Thus the loss amount itself becomes more important and in some cases the ICRC will be a multiple of 3 or 4 times the loss estimate. The ICRC is now a significant multiple of the old MER requirement so that it is crucial that low return period numbers are reliable.

Any conservatism in the lower return period number may be magnified by either 3 or 4.

This will be offset to some extent by the Premium Liability offset that is the amount that insurers have set aside for cat risk in their premiums (plus the risk margin plus the risk capital charge).

4.2.4 The Premium Liability Offset

Some of the cat risk will already have been allowed for in the Premium liability, so to avoid double counting APRA have specified a calculation to determine this amount, so that it can be subtracted in order that it is only reserved once.

The Appointed Actuary of the insurer must determine the portion of the net premiums liability provision, which relates to catastrophic losses (PL offset). The PL offset is estimated by class of business and the APRA formula is to be determined by:

1) Estimating the amount of the insurer's net premiums liability central estimate provision that relates to catastrophic losses.

Assuming that Catastrophe risk is actually priced for then it is possible to quantify this amount. *Call this CPL (Cat Premium Liability)*

2) Annualising this amount.

When annualising the non-uniformity of catastrophe risk would need to be considered (e.g. there is a storm season). It is annualised as H3 and H4 are annual estimates. Could be estimated by multiplying by an annualised factor, the factor is a function of time (t). *AF(t)*. Note that this may need to be done by peril within a class, and consider any changes in coverage or business mix.

3) Adding the diversified risk margin to this amount.

This is due to the PL including the diversified risk margin, thus we need to estimate the total amount. This could be estimated by multiplying by a diversified risk factor, DRF.

4) Adding the Premiums Liability Risk Capital Charge

The Premiums Liability Risk Capital Charge is added to the Premium liability so that we must allow for this amount also when estimating the double count. Could be estimated by multiplying by a risk capital charge factor, RCCF.

The Appointed Actuary must then total these amounts by class of business to determine the total PL offset.

$$\text{Total PL Offset} = \sum_{i=1}^{Number\ of\ classes} \left((CPL_i \times AF(t)_i) \times (1 + DRF_i) \times (1 + RCCF_i)\right)$$

The Appointed Actuary must include details of the determination of the PL offset in the Insurance Liability Valuation Report.

In determining the actual amount to set aside in premiums the insurer may use the AAL distribution from a cat model (exposure method) blended with other practical methods perhaps based on re-valued past experience. This may vary depending on recent experience and how old the cat model is.

It will be important for the actuary to understand the method and assumptions used, as reliance on purely a cat model exposure method is unlikely to be sufficient especially when taking recent experience of lower return period losses into account.

4.2.5 Internal processes

The following section is Australian specific, and states the draft guidance that been issued by APRA:-

The ultimate responsibility for ensuring prudent and effective management of insurance concentration risk rests with the Board of the insurer. APRA expects the Board to review the insurer's exposure to insurance concentration risk, the effectiveness of the proposed reinsurance arrangements and the residual risk. The Board is expected to use analysis and recommendations from management and relevant experts to assist its understanding of the concentration risk to which the insurer is exposed.

The analysis would often include the use of catastrophe models, scenario analysis, stress testing, advice and analysis provided by reinsurance brokers or reinsurers, and regional specific information (such as meteorological records) that provide a greater understanding of a region and the perils the insurer is exposed to in that region.

This analysis is also expected to be used to assess the suitability and adequacy of reinsurance arrangements. The Board is expected to ensure that it understands the shortcomings and weaknesses associated with any modelling used (as explained further in this PPG).

The outcomes of the analysis are expected to be considered in the context of the insurer's risk appetite and, in particular, the tolerance set for insurance concentration risk. The tolerance would be based on a range of considerations, including the insurer's Internal Capital Adequacy Assessment Process (ICAAP) (e.g. its target capital and access to additional capital), the cost and availability of reinsurance, the insurer's strategy and the Board's general view of an acceptable return period. This tolerance should not automatically be set at the minimum return period set out in GPS 116 (i.e. less than 0.5 per cent probability of occurrence in one year), as this is only the minimum used for regulatory purposes and does not consider the insurer's own circumstances.

APRA expects the insurer to regularly review its insurance concentration risk exposure, including the ongoing suitability and adequacy of its reinsurance arrangements, against its risk tolerance.

APRA expects the insurer to have in place documented processes and procedures for the Board and senior management to assess and manage the insurer's exposure to insurance concentration risk.

5 Summary and Conclusions

In Australia APRA have implemented regulatory change which considers the net financial impact on an insurer of either a single large event (either from a natural peril or other accumulation), this is known as the Vertical requirement (VR) **or** a series of smaller events known as the Horizontal Requirement(HR). The Insurance Concentration Risk Capital Change (ICRC) will be the greater of the HR or the VR (natural Peril or other accumulation), or if applicable the LMI concentration risk change.

Most Australian Catastrophe programmes retentions have a return period of between two and ten years.

GPS 116 (January 2013) states the HR to be the greater of:-

- Three one in ten year events
- Four one in six year events

Less any PL offset.

Many insurers will purchase reinsurance limits allowing for a gross loss arising from the occurrence of a single event where that loss is not less than the whole of portfolio annual loss with a 0.5 per cent probability of occurrence (i.e. the new regulatory minimum). So that the maximum net impact of a Vertical loss and the Horizontal loss will be the horizontal loss impact, due to the multiplication impact.

Thus the ICRC for many insurers is likely to become a function of an estimate of the net impact of event sizes with a return period more frequent than a one in ten period. The estimate of this figure is difficult and a cat model cannot be relied upon, and a range of other methods and considerable judgement may be required. Any conservatism in these estimates could have material regulatory capital consequences, due to conservatism being multiplied up by three or four.

An actuary required to give an opinion (formal or otherwise) should consider a wide range of factors discussed in this paper and its sister paper which addresses the "other accumulations" part.

6 APPENDIX A (NATURAL PERILS HORIZONTAL REQUIREMENT)

Natural perils horizontal requirement

27. The natural perils horizontal requirement (NP HR) for an insurer that has exposures to natural perils is calculated as:

(a) the greater of H3 requirement and H4 requirement defined in paragraphs 29 and 36, respectively; less

(b) PL offset (if any) defined in paragraph 43. An insurer does not need to calculate both H3 requirement and H4 requirement if it is able to demonstrate that one of these amounts is expected to be materially lower than the amount determined for the other.

28. NP HR must be calculated at the reporting date on or prior to the inception date of the insurer's catastrophe reinsurance program and then held constant for the remaining duration of the catastrophe reinsurance program.

If the catastrophe reinsurance program of an insurer has multiple inception dates, the insurer should agree with APRA the reporting date that will apply to the calculation of NP HR. The NP HR calculation must only include potential reinsurance recoverables that were contractually agreed on or before the relevant reporting date.

The first reporting period after the effective date of this Prudential Standard may be part way through the catastrophe reinsurance program treaty year. If this is the case, the insurer must determine NP HR as if the requirement to determine NP HR applied at the inception date of the catastrophe reinsurance program (ignoring any events that may have occurred between the inception date of the current catastrophe reinsurance program and the effective date of this Prudential Standard).

H3 requirement

29. The H3 requirement is calculated as:
(a) the greater of:
    (i) three times the H3 loss defined in paragraph 30 less H3 reinsurance recoverables defined in paragraph 31; and
    (ii) three times the net H3 loss defined in paragraph 32; less
(b) H3 aggregate offset defined in paragraph 33; less
(c) H3 reinstatement premiums defined in paragraph 33; plus
(d) H3 reinstatement cost defined in paragraph 35.

An insurer does not need to calculate amounts for sub-paragraphs 29(a)(i) and
29(a)(ii) if it is able to demonstrate that one of these amounts is expected to be materially lower than the amount determined for the other.

30. An insurer that has exposures to natural perils must determine the gross loss arising from the occurrence of a single event, where that loss is not less than the whole-of-portfolio annual loss with a 10 per cent probability of occurrence (H3 loss). This amount must not include any allowance for potential reinsurance recoverables. The calculation of H3 loss must include:

(a) the impact of the event on all classes of business of the insurer;
(b) an allowance for non-modelled perils7; and
(c) potential growth in the insurer's portfolio.

31. An insurer that has exposures to natural perils must determine the level of potential reinsurance recoverables should there be the occurrence of three H3 losses over the catastrophe reinsurance program treaty year (H3 reinsurance recoverables). The reinsurance recoverables must not include any amounts due from aggregate reinsurance cover as this is provided for under paragraph 33.

32. An insurer that has exposures to natural perils must determine the net loss arising from the occurrence of a single event, where that net loss is not less than the whole-of-portfolio annual net loss with a 10 per cent probability of occurrence (net H3 loss).

33. An insurer may reduce its H3 requirement for potential reinsurance recoverable from aggregate reinsurance cover (H3 aggregate offset). The insurer must not Where certain perils are material but not included in its computer-based modelling techniques, an allowance for losses in respect of these perils would need to be estimated and added to the H3 loss. The net loss is the gross loss less potential reinsurance recoverable allow for any reinstatements of aggregate reinsurance cover unless these have been contractually agreed with the reinsurer(s). If reinstatements are included, the cost of reinstatement must be netted from the offset. The insurer must agree with APRA a methodology for the determination of this adjustment. This methodology may reduce the retention on any aggregate reinsurance cover for any portion of paid and outstanding claims and premiums liabilities that contribute to the insurer's retained losses, provided it does not result in a double-count between this offset and the PL offset determined in accordance with paragraph 43.

34. An insurer that writes reinsurance may receive inwards reinstatement premiums from cedants as a result of the events that give rise to three H3 losses or three net H3 losses determined in paragraph 32, as appropriate (H3 reinstatement premiums). H3 reinstatement premiums must only be included in the H3 requirement if the reinsurance contract specifically stipulates that offsetting with the cedant will occur at the time of the payment of the reinsurance claim.

35. An insurer that has exposures to natural perils must determine the cost (if any) of reinstating catastrophe reinsurance cover after the occurrence of the first two H3 losses or the first two net H3 losses determined in paragraph 32, as appropriate (H3 reinstatement cost). In determining this cost, if the insurer does not have contractually agreed rates for the reinsurance cover, the

insurer must estimate the cost based on the reinsurance market conditions that would
Prevail after the occurrence of the events. The amount must not be less than the
full original cost of the cover, with no deduction for the expiry of time since the inception of the reinsurance arrangements unless the insurer is able to demonstrate to APRA that the amount materially overstates the cost that would prevail in the market after the occurrence of the events.

H4 requirement

36. The H4 requirement is calculated as:
(a) the greater of:

(i) four times H4 loss defined in paragraph 37 less H4 reinsurance recoverables defined in paragraph 38; and
(ii) four times the net H4 loss defined in paragraph 39;less
(b) H4 aggregate offset defined in paragraph 40; less
(c) H4 reinstatement premiums defined in paragraph 40; plus
(d) H4 reinstatement cost defined in paragraph 42.
An insurer does not need to calculate amounts for sub-paragraphs 36(a)(i) and 36(a)(ii) if it is able to demonstrate that one of these amounts is expected to be materially higher than the amount determined for the other.

37. An insurer that has exposures to natural perils must determine the gross loss arising from the occurrence of a single event, where that loss is not less than the whole-of-portfolio annual loss with a 16.7 per cent probability of sufficiency (H4 loss). This amount must not include any allowance for potential reinsurance recoverables. The calculation of H4 loss must include:
(a) the impact of the event on all classes of business of the insurer;
(b) an allowance for non-modelled perils9; and
(c) potential growth in the insurer's portfolio.

38. An insurer that has exposures to natural perils must determine the level of potential reinsurance recoverables should there be the occurrence of four H4 losses over the catastrophe reinsurance program treaty year (H4 reinsurance recoverables). The reinsurance recoverables must not include any amounts due from aggregate reinsurance cover as this is provided for under paragraph 40.

39. An insurer that has exposures to natural perils must determine the net loss arising from the occurrence of a single event, where that net loss is not less than the whole-of-portfolio annual net loss with a 16.7 per cent probability of occurrence (net H4 loss).

40. An insurer may reduce its H4 requirement for potential reinsurance recoverable from aggregate reinsurance cover (H4 aggregate offset). The insurer must not allow for any reinstatements of aggregate reinsurance cover unless these have been contractually agreed with the reinsurer(s). If reinstatements are included, the cost of reinstatement must be netted from the offset. The insurer must agree with APRA a methodology for the determination of this adjustment. This methodology may reduce the retention on any aggregate reinsurance cover for any portion of paid and outstanding

claims and premiums liabilities that Contribute to the insurer's retained losses, provided it does not result in a double-count between this offset and the PL offset determined in accordance with paragraph 43.

41. An insurer that writes reinsurance may receive inwards reinstatement premiums from cedants as a result of the event that gives rise to four H4 losses or four net H4 losses determined in paragraph 39, as appropriate (H4 reinstatement premiums). H4 reinstatement premiums must only be included in the H4 requirement if the reinsurance contract specifically stipulates that offsetting with the cedant will occur at the time of the payment of the reinsurance claim.

42. An insurer that has exposures to natural perils must determine the cost (if any) of reinstating catastrophe reinsurance cover after the occurrence of the first three H4 losses or the first three net H4 losses determined in paragraph 39, as appropriate (H4 reinstatement cost). In determining this cost, if the insurer does not have contractually agreed rates for the reinsurance cover, the insurer Where certain perils are material but not included in its computer-based modelling techniques, an allowance for losses in respect of these perils would need to be estimated and added to the H4 loss. The net loss is the gross loss less potential reinsurance recoverables. must estimate the cost based on the reinsurance market conditions that would
prevail after t he occurrence of the events. The amount must not be less than the full original cost of the cover, with no deduction for the expiry of time since the inception of the reinsurance arrangements unless the insurer is able to demonstrate to APRA that the amount materially overstates the cost that would prevail in the market after the occurrence of the events.

PL offset

43. The Appointed Actuary of the insurer must determine the portion of the net premiums liability provision which relates to catastrophic losses11 (PL offset). PL offset by class of business is determined by:

(a) calculating the amount of the insurer's net premiums liability central estimate provision that relates to catastrophic losses;
(b) annualising the amount from sub-paragraph (a); and
(c) adding the diversified risk margin12 to the amount from sub-paragraph (b); and
(d) adding the Premiums Liability Risk Capital Charge13 to the amount from sub-paragraph (c).
The Appointed Actuary must then sum the outcomes from sub-paragraph (d) by class of business to determine the total PL offset. The Appointed Actuary must provide this determination to the insurer in a timely manner that allows the insurer to lodge reporting forms to APRA within the timeframes specified by the Reporting Standards made under the Financial Sector (Collection of Data) Act 2001. The Appointed Actuary must include details of the determination of the PL offset in the Insurance Liability Valuation Report.

7 BIBLIOGRAPHY

Lythe et al (2008), Guide to Catastrophe Modelling, The Review Worldwide Reinsurance
Gupta (2007), State of Catastrophe Modelling Capabilities, RMSI
Boss et al (2011), Industry Good Practice for Catastrophe Modelling, ABI
Lloyds (2012), External Cat model Validation, LMA/Lloyds

Major (2011), Managing Catastrophe Model Uncertainty issues and challenges
APRA (2012), Draft GPG 116 Insurance Concentration Risk

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