Solvency II & Cat Models

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1. Why am I here?

2. What are the issues facing firms?

3. What can you do?

4. The six SII Pillar I tests in a Nat Cat context

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1. Why am I here?

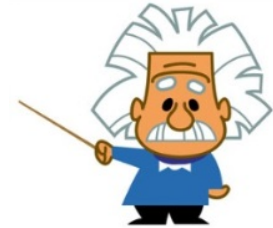|	
Evolving role of the broker – Risk Analytics	Duplication of efforts
Wisdom of the (expert) crowd	Prohibitive costs of validation

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1. Why am I here?

…observed or perceived:

- No shared language

- No access to model documentation or models

- No internal specialists / poor understanding
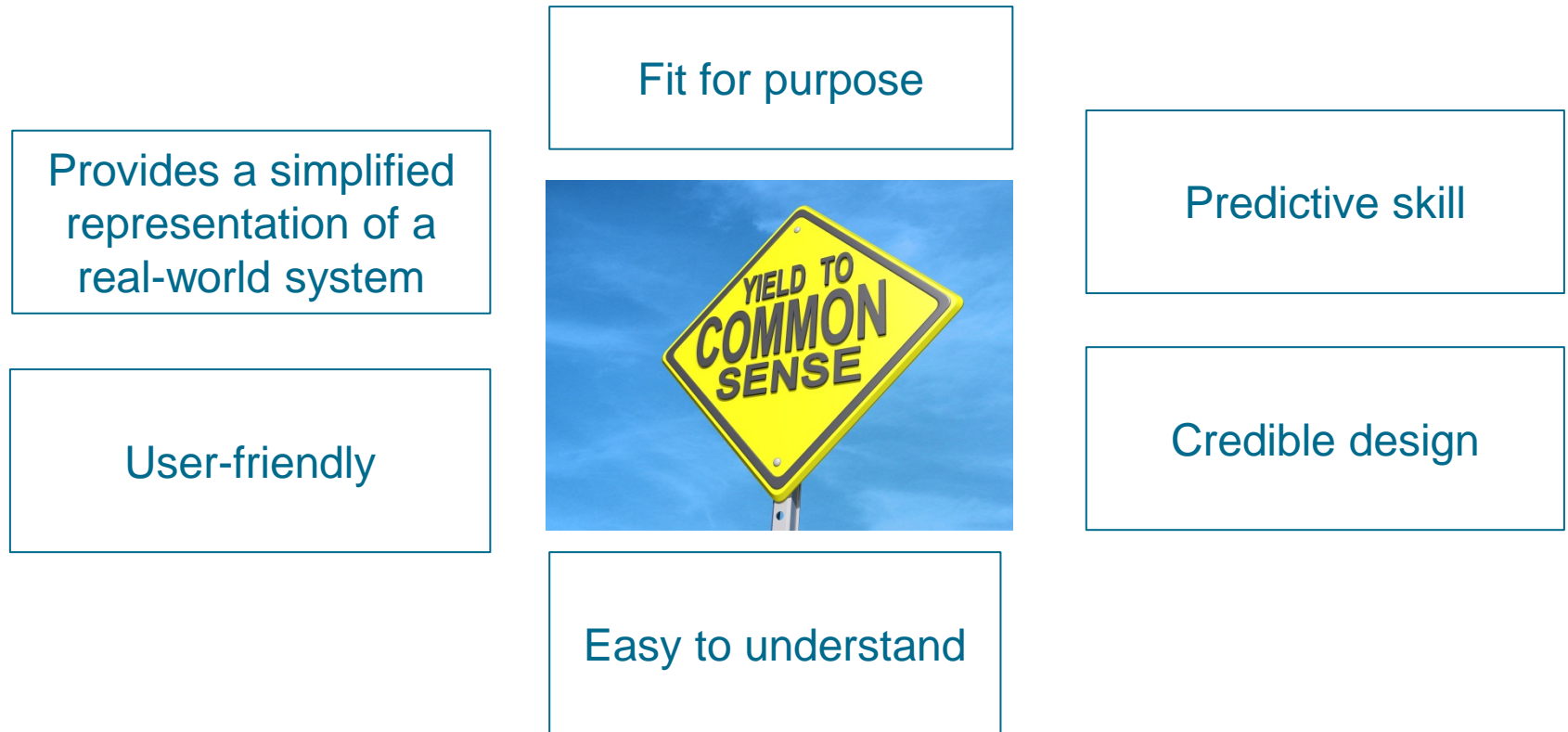
- Broker over-reliance

No shared language
## What are the issues facing risk carriers?

Keep it simple
Building a shared language

Fit for purpose

Provides a simplified representation of a real-world system

Predictive skill


User-friendly

Credible design

Easy to understand

- Some systems are too complex to model in its entirety – what then?
  - Should we strive to model each risk factor in detail in our aim for predictive success?

Model "completeness"
Building a shared language
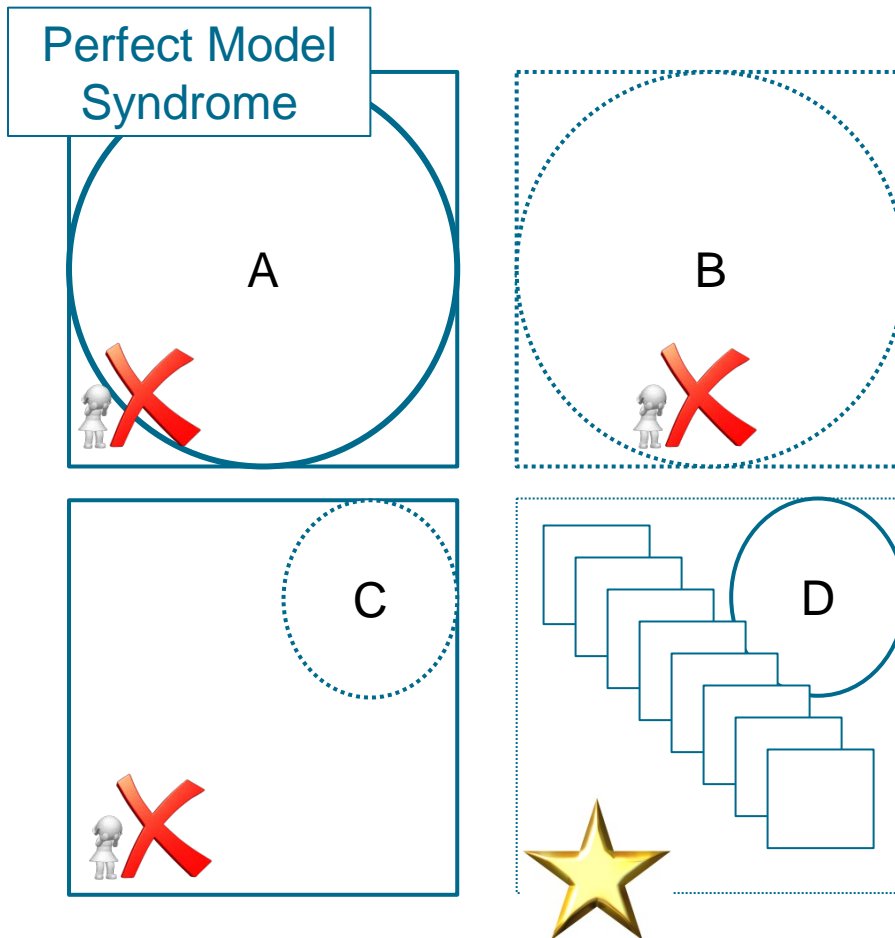
- Model scope relates risk universe (square) to model universe (circle).
- Uncertainty relating to either/both risk and model universe (Scenario B-D)
- High evidential bar in Scenario A and B
- Scenario C and D recognise that all systems cannot be represented comprehensively by a model – tends to lead to more frank, transparent engagement with regulators
- Scenario D recognises that it's not good enough to represent only the model perspective
- Scenario D incorporates various views from cat modelling, UW, claims, actuarial and academia
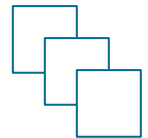
What can you do? / What do you do?

1. Understand Solvency II requirements in a Nat Cat context

2. Engage widely to build a shared language between stakeholders:
   - round-tables
   - thought leadership
   - Market presentations
   - Solvency II e-learning

3. Serve on expert judgement panels

4. Help clients create frameworks that allow clients to adopt / amend / reject your recommendations:
   - Model evaluation guidelines
   - Model change guidelines
   - Validation guidelines

5. Support firms in following their validation test plans

5. Link up with other regulator-facing teams helping clients evidence how they have a handle on their cat risk

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This is an important topic

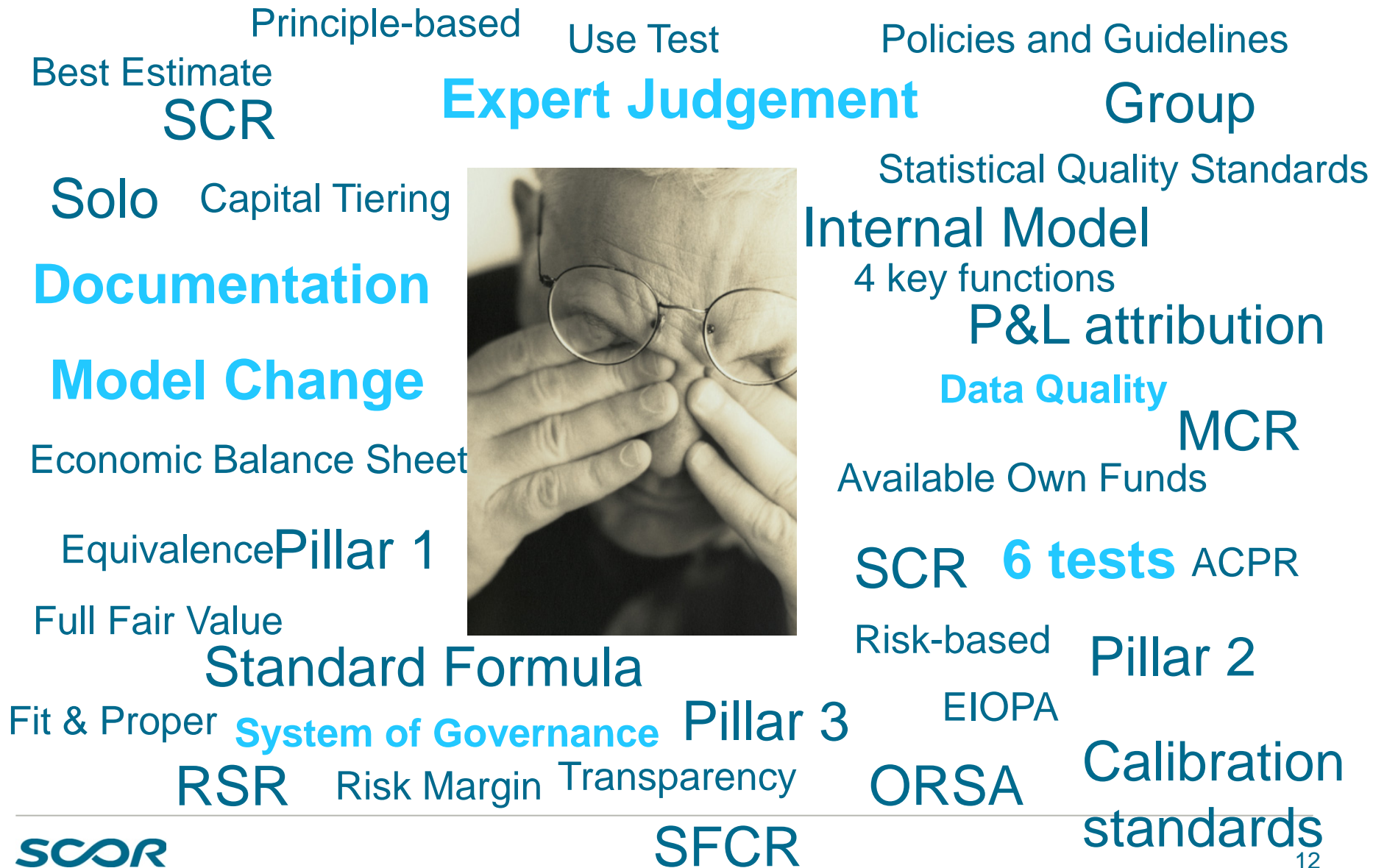# How does it all fit together?

SII requirements (cf. Appendix 1)

Extract key principles

Identify areas of potential challenge

Tackle via validation framework

Let's try to break it down…

Principle-based

Use Test

Policies and Guidelines

Best Estimate

Expert Judgement

Group

SCR

Statistical Quality Standards

Solo   Capital Tiering

Internal Model

Documentation

4 key functions

P&L attribution

Model Change

Data Quality

MCR

Economic Balance Sheet

Available Own Funds

Equivalence Pillar 1

SCR   **6 tests** ACPR

Full Fair Value

Risk-based   Pillar 2

Standard Formula

Fit & Proper   **System of Governance**   Pillar 3   EIOPA   Calibration

RSR   Risk Margin   Transparency   ORSA   standards

SFCR

Solvency II Pillar I Requirements
Level I – Solvency II Directive (2009/138/EC) and supp. Level II Delegated Acts (2015/35)

Pillar I

L1 Chapter 6:

Rules relating to A&L valuation, SCR, TP, OF, MCR and investment rules

Section 4:

Solvency Capital Requirement

Subsection 3:

SCR (Full and Partial Internal Models)

Art. 126:

External Models and Data

"The use of a model or data obtained from a third party shall not be considered to be a justification for exemption from any of the requirements for the internal model set out in Articles 120 to 125"

Solvency II Pillar I Requirements
Level I – Solvency II Directive (2009/138/EC) and supp. Level II Delegated Acts (2015/35)

❑ L1 Art. 120: Use Test

❑ L1 Art. 121: Statistical Quality Standards

Seemingly manageable?

❑ L1 Art. 122: Calibration Standards

❑ L1 Art. 123: Profit & Loss Attribution

❑ L1 Art. 124: Validation Standards

❑ L1 Art. 125: Documentation Standards

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Solvency II Pillar I Requirements
Level I – Solvency II Directive (2009/138/EC) and supp. Level II Delegated Acts (2015/35)

- ❑ L1 Art. 120: Use Test
  - ▪ L2 Art. 223 Use of the Internal Model
  - ▪ L2 Art. 224 Fit to the Business
  - ▪ L2 Art. 225 Understanding of the Internal Model
  - ▪ L2 Art. 226 Support of Decision Making and Integration with Risk Management
  - ▪ L2 Art. 227 Simplified Calculation
- ❑ L1 Art. 121: Statistical Quality Standards
  - ▪ L2 Art. 228 Probability Distribution Forecast
  - ▪ L2 Art. 229 Adequate, Applicable and Relevant Actuarial Techniques
  - ▪ L2 Art. 230 Information and Assumptions Use
  - ▪ L2 Art. 231 Data Used
  - ▪ L2 Art. 232 Ability to Rank Risk
  - ▪ L2 Art. 233 Coverage of all Material Risks
  - ▪ L2 Art. 234 Diversification Effects
  - ▪ L2 Art. 235 Risk Mitigation Techniques
  - ▪ L2 Art. 236 Future Management Action
  - ▪ L2 Art. 237 Understanding of External Models and Data

- ❑ L1 Art. 122 / L2 Art. 238: Calibration Standards
- ❑ L2 Art. 239 Integration of Partial Internal Models
- ❑ L1 Art. 123 / L2 Art 240 Profit & Loss Attribution
- ❑ L1 Art. 124: Validation Standards
  - ▪ L2 Art. 241 Model Validation Process
  - ▪ L2 Art. 242 Validation Tools
- ❑ L1 Art. 125: Documentation Standards
  - ▪ L2 Art. 243 General Provisions
  - ▪ L2 Art. 244 Minimum Content of Documentation
  - ▪ L2 Art. 245 Circumstances under which the IM does not work effectively
  - ▪ L2 Art. 246 Changes to the Internal Model
  - ▪ L2 Art. 247 External Models and Data

Don't forget about L2

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Solvency II Pillar I Requirements
Level I – Solvency II Directive (2009/138/EC) and supp. Level II Delegated Acts (2015/35)

- ❑ **L1 Art. 120: Use Test**
  - ▪ L2 Art. 223 Use of the Internal Model
  - ▪ L2 Art. 224 Fit to the Business
  - ▪ L2 Art. 225 Understanding of the Internal Model
  - ▪ L2 Art. 226 Support of Decision Making and Integration with Risk Management
  - ▪ *L2 Art. 227 Simplified Calculation*
- ❑ **L1 Art. 121: Statistical Quality Standards**
  - ▪ L2 Art. 228 Probability Distribution Forecast
  - ▪ L2 Art. 229 Adequate, Applicable and Relevant Actuarial Techniques
  - ▪ L2 Art. 230 Information and Assumptions Use
  - ▪ L2 Art. 231 Data Used
  - ▪ L2 Art. 232 Ability to Rank Risk
  - ▪ L2 Art. 233 Coverage of all Material Risks
  - ▪ L2 Art. 234 Diversification Effects
  - ▪ *L2 Art. 235 Risk Mitigation Techniques*
  - ▪ *L2 Art. 236 Future Management Action*
  - ▪ *L2 Art. 237 Understanding of External Models and Data (can demonstrate compliance in response to Art. 225)*

- ❑ **L1 Art. 122 / L2 Art. 238: Calibration Standards**
- ❑ *L2 Art. 239 Integration of Partial Internal Models*
- ❑ *L1 Art. 123 / L2 Art 240 Profit & Loss Attribution*
- ❑ **L1 Art. 124: Validation Standards**
  - ▪ L2 Art. 241 Model Validation Process
  - ▪ L2 Art. 242 Validation Tools
- ❑ **L1 Art. 125: Documentation Standards**
  - ▪ L2 Art. 243 General Provisions
  - ▪ L2 Art. 244 Minimum Content of Documentation
  - ▪ L2 Art. 245 Circumstances under which the IM does not work effectively
  - ▪ L2 Art. 246 Changes to the Internal Model
  - ▪ L2 Art. 247 External Models and Data

For some requirements, evidence of compliance **may be** provided outside the Nat Cat team

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Selected Solvency II Pillar I Requirements
Level I – Solvency II Directive (2009/138/EC) and supp. Level II Delegated Acts (2015/35)

L1 Art. Ref	Description	Requirements
120	**Use Test**	• L2 Art. 223 Use of the Internal Model • L2 Art. 224 Fit to the Business • L2 Art. 225 Understanding of the Internal Model • L2 Art. 226 Support of Decision Making and Integration with Risk Management
121	**Statistical Quality Standards**	• L2 Art. 228 Probability Distribution Forecast • L2 Art. 229 Adequate, Applicable and Relevant Actuarial Techniques • L2 Art. 230 Information and Assumptions Use • L2 Art. 231 Data Used • L2 Art. 232 Ability to Rank Risk • L2 Art. 233 Coverage of all Material Risks • L2 Art. 234 Diversification Effects
122	**Calibration Standards**	• L2 Art. 238: Calibration Standards
123	**Profit & Loss Attribution**	• L2 Art 240 Profit & Loss Attribution
124	**Validation Standards**	• L2 Art. 241 Model Validation Process • L2 Art. 242 Validation Tools
125	**Documentation Standards**	• L2 Art. 243 General Provisions • L2 Art. 244 Minimum Content of Documentation • L2 Art. 245 Circumstances under which the IM does not work effectively • L2 Art. 246 Changes to the Internal Model • L2 Art. 247 External Models and Data

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How does it all fit together?

SII requirements
(cf. Appendix 1)

Extract key principles

Identify areas of potential challenge

Tackle via validation framework

Solvency II Pillar I Requirements
Nat Cat Models – Key Principles

Evidence

…understood by a knowledgeable third party.

…results can be replicated with model inputs and docs

Proportionality

…nature, scale and complexity…

Validation testing

Methods of quantification

Governance

Elicitation as important as the result

Processes and controls

Policies / Frameworks

Areas of Potential Challenge
Cat Risk – Solvency II Compliance

Observed Theme	Potential Issue	Possible Remediation
Poor data quality / poorly evidenced data quality	• "Quality" undefined and not monitored • High percentage of unknown / default settings • Sensitivities not understood	• Data quality policy and standards for measuring data quality on a regular basis • Robust primary and independent testing
Material non-modelled risk	• Unaware of model limitations and materiality • Adjustments (if any) lack any justification and confined to linear scaling	• Identify limitations • Assess materiality • Know when to scale • Know when an explicit distribution is necessary
Lack of expert judgement ownership	• Broker owned • Vendor owned • Labelled "own view of risk"	• Elicitation tools • Arbitration and consensus-building (Expert Judgement Panel) • Expert judgement policy in-force
Limited model understanding	• No/limited access to vendor documentation, broker capabilities, internal experts	• Training • Access model documentation • Develop team capabilities
Frequent / disruptive model change	• Vendor/broker driven model change • No framework for evaluating change	• Model change policy in-force • Training • Vendor engagement
SII framework not embedded	• Policies exist in a vacuum • Firms assume policies are sufficient – i.e., user bias left unchecked	• Training • Phased, tactical implementation

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How does it all fit together?

SII requirements
(cf. Appendix 1)

Extract key principles

Identify areas of potential
challenge

Tackle via validation
framework

Validation Framework

Test Topics	Test Structure	Test Tools
Data Model Design Results Governance Key drivers: Expert judgement, key assumptions, key switches/options, key distribution choices	Test description – risk / scope / objective and limitations Quantitative / Qualitative Pass / fail criteria (what is the hypothesis / expectation?) Test result and rationale Recommendation (including escalation procedure where tests fail)	Top-down justification / bottom-up model component analysis Analysis of change Back-testing Sensitivity testing Scenario testing Stress testing Benchmarking Functional testing Reconciliation testing Stability testing Risk attribution testing (variant of P&L attribution)

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Validation Framework

Test Topic	Focus areas	Tools to consider
Data	• Scope of data: hazard data (at source and site), exposure data, vulnerability data, engineering data and financial data. • Data quality standards, checks and remediation • Transparency of data flows • Treatment of data deficiencies (e.g., loadings, use of default settings)	• Reconciliation testing • Sensitivity testing (of primary modifiers) • Sample audit to assess completeness of data (e.g., coverage not captured)
Model Design	• Risk factors identified and how risks were segmented (e.g., region-perils) • Appropriateness of model scope • Appropriateness of quantification methods • Treatment of non-modelled risk / appropriateness of loadings for model limitations and scaling methodology	• Qualitative assessments (including alternative vendor model comparison) • Visual comparison of modelled versus observed • Statistical goodness-of-fit testing • Functional testing • Independent non-modelled calibration (deterministic scenario) • Freq. / sev. sensitivity tests
Calibration Results	• Overall reasonableness of results (across the distribution) • Model performance for specific loss components (e.g., storm surge, PLA, ALE) • Diversification effects	• Top-down justification • Analysis of change • Back-testing • Scenario-testing • Stress testing • Sensitivity testing • Benchmarking • Stability testing

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Validation Framework

Test Topic	Focus areas	Tools to consider
Governance	• Processes, Controls and evidence of implementation • Evidence of peer-review, sign-off and escalation	• Sample audit • Qualitative review of controls performed
Key drivers	• Identification of material assumptions and expert judgements • How expert judgements were elicited	• Stress & sensitivity testing • Independent expert test • Qualitative assessment of elicitation process and rationale for judgement

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Current Industry Initiatives – *we need your input!*

Institute and Faculty of Actuaries

Nat Cat Validation Working Party

The working party will investigate what a **proportionate** validation means for Nat Cat risk in the context of:
- Complex external models
- Available vendor validation
- Solvency II requirements

irm Institute of Risk Management

IMIF Nat Cat Workstream

How to improve communication of cat model outputs and its inherent uncertainties to users in specific business contexts: exposure management, business planning, reinsurance purchase, risk tolerance setting, regulatory, rating agency and investor reporting.

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 120: Use Test

L2 Art. Ref	Description	Summary Requirements
223	Use of Cat Models	• Evidence use and consistency between different uses of models • If applicable, justify their non-use with regard to material risks
224	Fit to the Business	• Level of complexity of the modelling needs to be proportionate to the nature, scale and complexity of the risks modelled. • Evidence consistency between model outputs and reporting – both internally and externally. • Ensure model outputs are suitably granular, e.g. US quake results to align to a US business entity. • Ensure the model reflects changes in the underlying risk profile.
225	Model Understanding	• Demonstrate understanding of hazard, vulnerability and financial modules, scope/domain, purpose, modelled and unmodelled risks, quantitative methods, fit to business, integration with Enterprise Risk Management, limitations and diversification effects.
226	Support for Decision-making and integration with ERM	• Evidence how cat models support relevant decision-making (e.g. risk mitigation, setting risk tolerance limits, business strategy) • Evidence engagement on cat model (e.g., its limitations) • Demonstrate key risks are modelled • Show how model results are used in risk management and drive management action • Ensure validation can trigger changes to the model • Have a model change policy in place

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 121: Statistical Quality Standards (1)

L2 Art.	Description	Summary Requirements
228	Probability distribution forecasted (in this case, the projected, adjusted EP curve)	• Ensure the model provides a representative distribution of loss outcomes that captures physical the extremes.
229	Adequate, Applicable and Relevant Actuarial Techniques	• Use market-consistent actuarial techniques and timely information • Evidence understanding of the quantitative methods used in the model (e.g., contrast time-dependent and Poisson approaches to modelling earthquake event frequencies) • Catastrophe models should reflect risk profile changes (for instance, in exposure, or business mix) • Unexplained change should be minimal • The model should represent the key risk drivers (e.g., fluvial and pluvial flood risk) • Techniques should fit data (e.g., use of a Poisson distribution where event rates are dispersive, potentially invalidating a pure Poisson approach) • Adjust the model for errors in sampling, or where modelled results do not converge on those based on vendor's ELT. • Ensure transparent data, quantification methods and results
230	Information & Assumptions Used	• Demonstrate information is realistic (of particular importance, when firms use default/unknown selections when specifying the catastrophe model) • Show how information used to generate the EP curve is credible – that is, show how it is consistent, reliably sourced, objective and generated in a transparent manner. • With regards assumptions used in the catastrophe modelling process, in order demonstrate that these assumptions are realistic, one needs to show that they can be justified considering their materiality, sensitivity and alternatives considered.

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 121: Statistical Quality Standards (2)

L2 Art.	Description	Summary Requirements
231	Data Used in the Cat Model	• Evidence how data is complete, accurate and appropriate. Data here comprises site and source hazard data, vulnerability data, building and location data, values at risk and the insurance structure data. In addition, where applicable, internal claims data or external benchmark data also needs to be included in the scope.
232	Ability to rank risk	• Through the use of multiple catastrophe models, firms can rank region-perils using a consistent risk measure (for instance, 1% AEP TVaR). For an individual catastrophe model, the components of risk may be ranked – for instance, wind risk versus storm surge. • Demonstrate consistency of ranking with risk segmentation, across the business, over various time periods and with capital allocation process
233	Coverage of all material risks	• At least on a quarterly basis, assess the extent to which the Cat model (including adjustments) covers all material risks • This assessment should consider qualitative indicators such as how risks not modelled are treated in the reinsurance programme, the ORSA risk register, or ERM framework. • Quantitative indicators of non-modelled risks should also be considered in the assessment: these include stress testing results, validation testing, financial losses unexplained by the model and allocated capital.
234	Diversification effects	• In evidencing that the methods of representing diversification effects are considered adequate, firms need to demonstrate that they have identified key dependency drivers, considered non-linear dependencies and characteristics of the risk measure used (e.g., 99.5%ile AEP VaR or TVaR)

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 122: Calibration Standards

L2 Art. Ref	Description	Summary Requirements
238 (1)	Choice of risk measure and time period used	• Catastrophe models produce EP curves from which one can extract the 99.5th percentile Value at Risk over a one year period. In these cases, an alternative risk measure or time period is not required. • Where firms use an alternative approach to calibrating the catastrophe loss distribution, the risk measure and time period should be consistent. • Where firms opt to use a different risk measure or time period, additional requirements apply.
238 (2)	Use of Approximations / Simplifications	• Approximations used in the process of generating the SCR should not introduce material error in the SCR. • Similarly, it should not provide policyholders with any less protection than if the SCR was based on the probability distribution forecast derived from the Internal Model. • Generally, for catastrophe models, the SCR is based on the Value at Risk measure derived from the output catastrophe risk loss distribution, rather than calculated by approximation. • However, where a cat model output is adjusted, for instance, for unmodelled risk or an alternative view of the underlying hazard using an approximate approach, firms would need to justify that the approximation of the adjustment does not materially mis-state the resulting SCR and that policyholders are not adversely affected by the adjustment.

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 123: Profit & Loss Attribution

This requirement links the financial statements to the modelled results and assesses the degree to which the financial profits and losses may be explained by the model. Typically, compliance with this article is evidenced at the Internal Model level rather than the Cat Model level. However, these requirements may still be embedded within the Cat Modelling framework in order to support compliance across the internal model.

In addition, there are always lessons that may be extracted from new losses. In these cases, losses could help to identify new sources of risk that changes the way losses are modelled. In this way, actual experience becomes a feedback loop into loss calibration.

Therefore, I outline below four principles that can be considered in the cat modelling context to support the firm's Profit and Loss attribution exercise:

- **Granularity:** cat losses should be able to be generated at the business unit and region-peril level of granularity

- **Categorisation of risks:** there should be a clear distinction between the risks covered by the cat model and those that are not covered by the cat model

- **Consistency:** consistency between modelled losses and reported losses to enable meaningful comparison

- **Relevance for ERM and decision-making discussed:** by ensuring the granularity of modelled risk segments is relevant to the business, model results can support decision-making and risk management (see Article 120)

Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 124: Validation Standards (1)

L2 Art. Ref	Description	Summary Requirements
241	Validation process scope	• The scope of the validation should cover all parts of the cat model, including adjustments for data and model limitations.

241 (2,4)	Independent validation	• Validator should be "free from influence" from those responsible for model development and operation
		• Independence may be assessed by considering:
		   • the responsibilities and reporting structures of those involved in validation
		   • The remuneration structure of the persons involved in the validation process. Independence is likely to be challenged where the remuneration of the person or firm carrying out the validation is linked to the outcome of the validation.

241 (3)	Validation plan	• Specify the validation processes and methods employed and the purpose of the validation • Specify the validation frequency and out-of-cycle validation triggers • Name persons responsible • Outline validation test fail procedure (escalation and resolution)

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 124: Validation Standards (2)

L2 Art. Ref	Description	Summary Requirements

242 (1)	Validation tools	• Test results against experience / other appropriate data (e.g., benchmarks) at least annually – at stand-alone region-peril level and aggregate or portfolio level
		• Justify deviation between assumptions and data and between observed and modelled results. For example, there have been some very large historical losses that when simply inflation-adjusted, could deviate significantly from the firms modelled losses. The justification here may reference:
		    • Changes in exposure over time, but after allowing for this, there may still be changes in the insurance or reinsurance covers provided that still result in material deviation between observed and modelled losses. For instance, firms implemented a number of contractual changes, such as reduced event limits, post the 2011 Thai floods . The pure inflation-adjusted loss may not even be a possible outcome in the current modelled loss distribution of flood losses from this region. In this case, one would need to adjust the loss to reflect the coverage changes.
		    • Changes in the underlying loss potential from a repeat of a historical event could also explain the deviation. For example, flood defence upgrades post Hurricane Katrina results in a lower as-if loss than if one simply inflated the historical loss (assuming the flood defence system holds). For certain Cat Models for certain regions, firms are able to extract the deterministic as-if historical loss reflecting these updates.

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 124: Validation Standards (3)

L2 Art. Ref	Description	Summary Requirements
242 (3)	Statistical testing in the validation process	The statistical process for validating the model should be based on: • Current information including, where relevant and appropriate, developments in actuarial techniques and generally accepted market practice. This may include for example, modelled versus observed comparative plots (QQ plots), goodness of fit testing, etc. • A detailed understanding of assumptions underlying methods used to produce the EP curve. For example, the independence assumption for Poisson distributions used in cat models to model event frequencies.
242 (4)	Key assumptions	• Explain why certain assumptions are sensitive (an example of a sensitive cat model assumption for European risk carriers is the frequency over-dispersion parameters within European Windstorm models) • Explain how sensitivity is considered in decision-making
242 (5,6)	Stability and appropriateness of outputs	• Test the stability of results by recomputing results based on the same data. Cat Models in general will produce the same results if the model is run on the same data. However the results will change where firms change the number of simulation runs. • Test the appropriateness of results, and in particular the tail risk metrics, by identifying the probable stress scenarios that could threaten the viability of the firm. When compared to the modelled loss distribution, one would expect the stress scenario loss corresponds to a remote point on the modelled loss distribution, as oppose to beyond the range of possible loss outcomes.

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 125: Documentation Standards (1)

L2 Art. Ref	Description	Summary Requirements
243	General Documentation requirements	• Design and operational details of the model should be sufficient such that it can be understood by an "independent knowledgeable third party" • The documentation should allow for sound judgement on SII compliance. • The documentation should be appropriately structured, detailed, complete and up-to-date. • Model outputs should be capable of being reproduced using inputs to the model and documentation
244	<u>Minimum</u> documentation requirements	The following documented evidence is required: • An inventory of documents • A model change policy • A description of processes, including risks and controls and staff responsibilities • IT systems and contingencies • A description of relevant assumptions, justification for these assumptions, method for setting assumptions, data used, limitations relating to these assumptions and validation criteria. • A data directory that includes the data source, characteristics and usage • Data flow, including collection, processing and application of data and treatment of inconsistencies and wider data deficiencies. • Indicators used to evaluate model coverage • Details of the risk mitigation • Validation process and results • Role of Nat Cat models, justification for using a vendor model over an internally developed cat model and the evaluation of alternatives.

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Appendix 1: Selected Solvency II Pillar I Requirements
Nat Cat Models – Article 125: Documentation Standards (2)

L2 Art. Ref	Description	Summary Requirements
245	Considerations when assessing model effectiveness	• Consider model limitations: including non-modelled risks, limitations of risk modelling, IT, data and limitations arising from uncertainty in model results • Consider sensitivity of results to key assumptions
246	Model changes	• Record all changes, including descriptions and rationale for changes and implications of change for the model design. • Analyse material changes in model results, but also changes in the quantification methods, data and assumptions.
247	External Models and Data	• Monitor potential limitations of using cat models and external data to ensure on-going compliance with the requirements set out above.

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