



Explanatory Memorandum

Guidance Note: Standards and Application Framework for the Use of Internal Capital Models for Regulatory Capital Purposes - Revised

The Authority has revised its guidance relating to the use of Internal Capital Models (ICM) for regulatory purposes. The proposed revised guidance note, in track changes format, is attached.

The revisions to the guidance note include the following:

1. Additions to the guidance to deal with specific issues associated with insurance risk for Long-Term (LT) insurers (see sections B.84 to B.97). The nature of many of the risks associated with LT insurance business is quite different from Property & Casualty (P&C) business, and the proposals deal explicitly with these areas. This guidance was informed by the LT ICM pilot exercise that the Authority undertook, in association with external consultants, during 2011. As a consequence of the addition of this section, the Authority has made some small presentational adjustments to the corresponding guidance material for P&C insurance, but without making any substantive changes to it.
2. In acknowledgement of the greater relative weight of market risks within LT companies, the Authority has expanded its guidance in this area (see sections B.98 to B.112). The Authority would expect P&C companies to take this guidance into account in their internal models as the same principles would apply, but recognises that application should be proportionate to the level of risk present.
 - o In particular, specific attention should be given to how Economic Scenario Generators (ESG) should be documented within the model (see sections B.102, B.104, B.106, B.108, B.110 and B.112), with similar requirements applying to other types of scenario generators (e.g. property catastrophe models).
3. Additional affirmation statements have been included:
 - o The Use Test section has been expanded to allow the Authority to get a greater understanding of how the ICM fits into the management of the company (see section B.6.4 to B.6.6).
 - o The Statistical Test section has been expanded to deal with issues around the use of "expert judgment" (see section B.7.6)

- o In the Model Governance section, specific consideration has been given to how the company deals with model changes (see section B.11.4). In addition, section B.11.1 has been expanded to confirm that the Board has approved the ICM for use within the business.
- 4. During consideration of issues facing LT insurers, it became apparent that the strict application of the current risk metric (TVaR 99% with one year of new business and the run-off to extinction of all liabilities) would be unreasonably harsh for LT insurers. The Authority has therefore considered the risk metric and concluded:
 - o The 99% TVaR metric remains its preferred approach as it considers the average of the worst one percent of modeling outcomes. Although not used in Solvency II, which uses a 99.5% VaR measure, TVaR is often favoured by supervisors because it is important to understand not only the frequency of insurer insolvency in the tail of the distribution, but also the potential severity of those insolvencies. (The Swiss Solvency Test (SST) currently uses a TVaR metric.)
 - o The projection includes one year of new business because the Authority has required annual reporting of modeling results. Thus it is critical that an insurer holds enough capital to support one full year of new business writings.
 - o The use of a reserve run-off horizon to extinction is unreasonable for LT insurers. In common with Solvency II proposals and the SST, the Authority is therefore proposing to adopt a one year time horizon for the development of reserves.

Thus the Authority will adopt as its preferred risk metric, TVaR 99% with one year of new business and reserve development over a one year time horizon (see sections B.30 to B.33). However, the Authority understands that some insurers are pursuing ICM approval in jurisdictions who currently favour a VaR approach. In such situations, the Authority will accept a VaR metric as long as its calibration is appropriately prudent. More generally, the Authority is prepared to accept any other risk metric or time period that a company may choose to use, provided the company can demonstrate to the Authority's satisfaction that the result is at least as prudent as the preferred approach.

The use of a one year reserve development time horizon implies that a balance sheet will form a central part of the modeling framework. The Authority has specified (B.33) that this should be an economic type balance sheet (in common with Solvency II and SST). Later this year, the Authority will be putting forward its own proposals for an Economic Balance Sheet (EBS) – and would naturally prefer that companies adopt this standard. However, the Authority would be prepared to consider the use of other suitable economic balance sheets that companies may adopt - in particular those specified under Solvency II or SST would generally be considered suitable.

The Authority recognises that for certain types of LT business, this approach may present modeling issues for some companies – in particular in calculating end year balance sheets on a stochastic basis for each scenario. The Authority will look sympathetically at pragmatic solutions adopted by companies to limit model computation times – and would expect companies to be able to demonstrate the suitability and appropriateness of the approach adopted.

5. The Authority has added some commentary to the guidance note regarding ICM fees. The Authority is sensitive to the fees involved in the ICM approval process, and is committed to help control costs when feasible. Specifically, the Authority will place some reliance on work done by other regulators, as well as external validation work that is deemed relevant.
6. Comments on the proposals set out in the revised guidance note should be sent to the Authority addressed to ICM@bma.bm no later than August 1st, 2012.



BERMUDA MONETARY AUTHORITY

INSURANCE DEPARTMENT

GUIDANCE NOTES

STANDARDS AND APPLICATION FRAMEWORK FOR THE USE OF INTERNAL CAPITAL MODELS FOR REGULATORY CAPITAL PURPOSES - REVISED -

April-June 2011-2012

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Purpose and Executive Summary

1. This paper provides guidance on the Bermuda Monetary Authority's (the Authority) standards and application framework for insurers¹ applying to use an internal capital model (ICM) for regulatory capital purposes. This version updates the previous guidance, which the Authority published in ~~June 2009~~[April 2011](#), and communicates the most recent developments made to the ICM review process. Most of the framework and standards remain the same; ~~updates include:~~ However, updates have been made to incorporate additional considerations for long-term insurers and to clarify some items previously outlined.

- ~~• expansion of scope of the ICM framework to include Class 4, 3B and 3A insurers;~~
- ~~• an enhanced pre-application process;~~
- ~~• more detail regarding the information request; and~~
- ~~• additional information or clarification around items previously outlined.~~

2. The main body of the paper establishes the framework for the application and review process and includes provisions relating to pre-application conditions, application and review procedures, and post-approval monitoring and control activities.
3. Attachment A provides guidance on the pre-application process, which takes place before the application and review process. The pre-application process requires an insurer to submit information designed to provide a high-level overview of the ICM and an indication of the insurer's preparedness to undergo an ICM review.
4. Attachment B specifies the affirmation statements, which are part of the pre-application process and require an insurer to affirm that its ICM meets a number of general standards prior to the commencement of an ICM review.
5. Attachment C outlines the Authority's ICM information request and is intended to provide guidance relating to the qualitative and quantitative information needed to determine if an insurer's ICM satisfies the Authority's ICM approval criteria.
6. Enquiries relating to ICM applications or questions on this paper should be directed to the Authority's ~~Risk Analytics Insurance Supervision~~ Department via e-mail to ~~Brant Kizer at bkizer@bma.bm and Navid Zarinejad at nzarinejad@bma.bm~~ICM@bma.bm.

¹ In this guidance note, "insurer(s)" refers collectively to insurer(s) and reinsurer(s) unless otherwise specified.

Background

7. The International Association of Insurance Supervisors (IAIS) defines an ICM as:

“A risk management system developed by an insurer to analyse its overall risk position, to quantify risks and to determine the economic capital required to meet those risks.”²

8. In general, an economic capital model estimates the amount of capital needed to meet future obligations over a specified period of time at a given confidence level.
9. A standard regulatory capital model, by its very nature, can only represent a proxy to an insurer’s specific risk profile. Alternatively, an insurer’s own economic capital model, if subject to rigorous and prudent controls, may be used to more accurately reflect the risk profile of the firm.
10. The IAIS and regulatory agencies worldwide are focused on encouraging insurers to prudently employ internal capital modelling in the risk and capital management processes, and not just as a tool for the determination of regulatory capital.
11. The rationale for encouraging the use of an approved ICM for regulatory capital purposes is to produce a capital requirement that better reflects an insurer’s particular business profile, strategies, operations and risk management processes. This approach should result in more precise measurement and monitoring of solvency and capital adequacy and a more efficient use of capital in the industry, provided it is subject to appropriate prudential controls. The ability to assess an insurer’s unique risk profile more precisely is particularly important in the Bermuda insurance market due to the concentration of large property catastrophe reinsurers and high-attaching commercial liability insurers, which require more sophisticated modelling as a result of the volatile nature of their business, and the lack of homogeneity among insurers for these classes.
12. On 31st December 2008, the Authority issued Rules³ under the *Insurance Act 1978* prescribing a standard risk-based capital formula, the Bermuda Solvency Capital Requirement (BSCR), for the determination of an insurer’s enhanced capital requirement⁴ (ECR). These Rules, which were amended in 2010 to include both Class 4 and Class 3B insurers ([with similar rules introduced for Class 3A and E insurers in 2011](#)), also include a provision allowing an insurer to apply to the Authority for approval to use an ICM in substitution for the BSCR to calculate its ECR.

² IAIS *Guidance Paper on the Use of Internal Models for Regulatory Capital Purposes*, October 2008, Paragraph 5.

³ *Insurance (Prudential Standards) (Class 4 and Class 3B Solvency Requirement) Rules 2008* (formerly entitled *Insurance (Prudential Standards) (Class 4 Solvency Requirement) Order 2008*). ([Similar rules added for Class 3A and Class E in 2011](#)).

⁴ The enhanced capital requirement is defined in Section 1(1) of the *Insurance Act 1978*.

13. While Class 4, [Class 3B](#), [Class 3A](#) and Class [3BE](#) insurers are currently within the scope of the Rules, other classes are not. The Rules will be further revised to include other classes, namely [Class 3A long-term Classes C](#) and [Long-Term insurers D](#), but it is anticipated that the framework outlined herein will remain appropriate. ~~However, for For Class 3A insurers (and Class 3A insurers, C in due course),~~ the standards outlined in this paper will be applied on a ~~proportional~~[proportionate](#) basis, ~~and after further policy development during 2011, the standards will be expanded to include risks appropriate to Long-Term, as well as dual licensed, insurers.~~
14. It is anticipated that some applications will present group ICMs and others will present ICMs at a solo entity-level. The Authority will coordinate with each insurer to evaluate its ICM at the appropriate level with the goal of avoiding duplicative effort. In general, to the extent a group ICM can also provide appropriate entity-level output, then approval of the group ICM will also imply approval at the entity-level. However, there may be circumstances when a group ICM qualifies for approval at the group-level but does not reflect entity-level requirements appropriately, in which case the insurer may need to provide either a group- or entity-specific ICM that reflects entity-level output in order to receive entity-level approval.
15. The Authority is ~~currently developing~~[continuing to develop](#) the supervisory review process for its group regulatory regime and will work with other regulators in formalising the procedures and requirements for group ICM approval. As the Authority further coordinates with other regulatory bodies regarding the ICM approval process, more certainty will emerge in regards to its reliance on ICM reviews performed by equivalent regimes and the harmonisation of ICM review efforts by the Authority and other governing agencies involved in an insurance group's regulatory oversight. Thus, the Authority will provide further guidance regarding this topic in the future.
16. This guidance is intended to assist insurers in understanding the proposed application and review process and supplements Paragraph 5 of the Rules, which provides for the approval of an ICM subject to the following considerations:
- the appropriateness of the ICM for determining the insurer's ECR;
 - the extent to which the ICM has been integrated into the insurer's risk management programme; and
 - the appropriateness of controls applicable to the creation and maintenance of the insurer's ICM.
17. The guidance provided in this paper relates only to the Authority's approval process for an ICM used to determine an insurer's ECR. As such, it does not apply to the use of an ICM for any other purpose.
18. The application framework and criteria established in this guidance have been developed with reference to the standards and guidance papers issued by other

regulators, including the IAIS. Therefore, it is intended to be consistent with international regulatory practices.

19. In addition, the framework and standards outlined in this paper, which is updated from [both](#) the original version published by the Authority in June 2009 [and a revised version published in April 2011](#), follow information received via an industry survey on economic capital modelling⁵, two [general business](#) ICM pilot reviews conducted in 2010, [a long-term business ICM pilot review conducted in 2011](#), and consultation with industry practitioners to determine their appropriateness for the Bermuda market.
20. No model can fully quantify the complexity inherent in real world processes. The Authority recognises that capital modelling is developing in theory and practice, and consequently, this guidance is not intended to be prescriptive. Each application will be considered on its own merits.
21. The Authority recognises that each insurer's ICM will be unique by definition with varying degrees of sophistication, and that certain drivers of risk may be modelled independently and at different levels of complexity. The Authority will take this into consideration during the ICM review process and, on an exceptional basis, review models that incorporate the use of a 'partial' ICM. However, these models will only be considered if the insurer presents clear justification, which is accepted by the Authority, that a full ICM is not reasonable or feasible and a partial ICM provides a better assessment of the firm's risk profile than the BSCR.
22. [As The Authority recognises that the state approach and capabilities of insurers to assess economic capital modelling evolves is evolving. As a result](#), the Authority will [continue to](#) consult with industry to refine the supervisory process and seek to update the ICM review standards [to reflect emerging practice](#) appropriately while maintaining focus on the unique characteristics of the Bermuda market.
23. Due to the resource requirements needed to review an ICM, the Authority may engage external vendors to assist in the evaluation process. The amount of external resourcing needed will be determined during the pre-application process and depend upon the magnitude and complexity of the insurer's ICM. Fees relating to external resource needs, as well as a portion of the Authority's internal resource requirements relating to the review of an ICM, will be borne by the insurer applying to have their ICM approved. The Authority will coordinate with the insurer to select a qualified vendor and negotiate fees during the pre-application process and provide the insurer with an estimate of the ICM review cost before a formal application is submitted. [The vendor selection process will be transparent and final decisions regarding scoping and selection will be made with due consideration of the insurer's input.](#) The Authority recognises the proprietary nature of ICMs and will [coordinate with the insurer in order to](#) execute appropriate confidentiality agreements with external vendors to

⁵ *Survey of Economic Capital Modelling Practices in the Bermuda Insurance Market*, Bermuda Monetary Authority, December 2008.

protect ~~thean~~ insurer's intellectual property. At a minimum, the vendor will be considered an agent of the Authority and required to recognise the constraints imposed by Section 31 of the BMA Act 1969 pertaining to the non-disclosure of information. The Authority also recognises the sensitivity in relation to fees and will consult with industry during 2011 via a separate fees initiative, which will include a discussion relating to an ICM application.

24. In addition to the selected vendor described above, the Authority is committed to relying on other existing validation work to the extent possible. If such validation is performed in line with the Authority's criteria, including the critical requirement that the work be independent, synergies may exist and the Authority will aim to leverage these efforts and potentially reduce the fee to reflect any efficiencies achieved. In these situations, the Authority will require a letter from the relevant parties confirming that they are aware that the Authority will be relying on their work for the purposes of assessing the insurer's use of its ICM for calculating regulatory capital requirements. The Authority may even consider such work performed by vendors who have not been previously approved to conduct model validation by the Authority.
25. Post approval requalification costs may be incurred if an ICM changes materially or if the Authority determines, via post approval reporting and discussions with the insurer, that part or all of the ICM is no longer fit for purpose and merits further review. In such cases, additional fees would only apply to components that need to be reviewed.

Framework for Application and Review Process

Conditions for Application

- | ~~23,26.~~ An ICM will not be considered for approval unless the insurer can demonstrate a comprehensive and effective approach to risk management.
- | ~~24,27.~~ An insurer should also evidence a prudent approach to capital management, which includes establishing and successfully achieving an internal capital target greater than the ECR as indicated by the ICM⁶.
- | ~~25,28.~~ Final versions of documentation provided to the Authority relating to the pre-application submission, formal application form, acknowledgment of the communication of results and agreements relating to ICM approval and use, including conditions and post-approval reporting requirements, will require the signed approval of both the insurer's Chief Executive Officer, defined in Section 1A(7) of the *Insurance Act 1978* as chief executive, and Chief Risk Officer, or the person with responsibilities normally assumed by the Chief Risk Officer. There will need to be evidence provided that the Board of Directors has formally approved the ICM for use within the insurer.

Pre-Application Process

- | ~~26,29.~~ The Authority has developed a pre-application process to provide an indication of the insurer's preparedness to undergo an ICM review and outline criteria that should be satisfied prior to an ICM application. The process, which is described in more detail in Attachment A, consists of the insurer's submission and Authority's review of the following four items:
 - **Self-Assessment** - consists of a number of qualitative and quantitative affirmation statements relating to the ICM with a brief narrative around each;
 - **Overview of Internal Capital Model** - provides the Authority with an introduction to the model and its role within the insurer's risk management function;
 - **Model Demonstration** - provides a high-level overview of the ICM's functionality; and
 - **Documentation Gap Analysis** - initial assessment of an insurer's ability to satisfy the Authority's information request.

- | ~~27,30.~~ The pre-application submission is meant to be provided at or near the inception of

⁶ More guidance relating to the prudential standards in relation to the ECR is provided in *Guidance Note #16 Enhanced Capital Requirement*, Bermuda Monetary Authority, November 2008.

the pre-application process and completed at a summary level. The pre-application submission is therefore not intended to place an unreasonable burden on insurers. The Authority will work closely with the insurer during the pre-application process to provide guidance and to discuss any related issues.

~~28.~~^{31.} The pre-application process aims to provide an indication of the insurer's preparedness to undergo an ICM review and not necessarily an indication of ICM approval. The Authority intends to provide feedback regarding any significant ICM deficiencies as soon as possible during the pre-application and review processes so that an insurer may have the opportunity to resolve these issues.

~~29.~~^{32.} Due to resource requirements associated with the pre-application process, the Authority will charge a fee to enter the process. ~~As mentioned above, ICM fees will be included in a separate fees discussion during 2011.~~

Application and Review Process

~~30.~~^{33.} The ICM application and review process comprises several stages, including the following:

- **Application for ICM Approval** - an application for permission to use a specified ICM for the determination of the insurer's ECR;
- **Provision of Information** - quantitative and qualitative information as specified by the Authority;
- **ICM Review Process** – thorough model review by the Authority on both an on-site and off-site basis, with extensive dialogue and requests for supplemental information; and
- **Communication of Results** - communication relating to the Authority's assessment of an insurer's ICM and response to the application to use the ICM for regulatory capital purposes.

Application for ICM Approval

~~31.~~^{34.} Once the pre-application process is complete and the Authority provides confirmation, an insurer may then proceed with a formal application for the approval of its ICM. The application should include a completed initial information request, including an index of documentation mapped to the Authority's information request, and payment of the ICM application fee.

~~32.~~^{35.} The application fee for the review of an insurer's ICM will be determined during the pre-application process and depend upon the magnitude and complexity of the insurer's ICM. This fee is non-refundable and excludes other fees, such as general licensing fees, that may apply. ~~As stated above, the Authority will consult with the industry regarding ICM fees during 2011.~~

Provision of Information

~~33.~~36. In order for the Authority to properly consider an ICM application, the insurer will need to provide complete and timely responses to all quantitative and qualitative information requests made by the Authority.

~~34.~~37. The information submission process will comprise several stages and include:

- a standardised information request to be completed at the time of application, which is described in more detail in Attachment C;
- a more specific request of information, which will take into account an insurer's unique attributes, to be completed soon after the application is submitted; and
- supplemental requests to be completed at various stages during the review process to further assist in the evaluation of an insurer's ICM.

~~35.~~38. The Authority has and will continue to seek market feedback relating to the information requests but may do so outside the normal consultation process given the specialised nature of this field.

ICM Review Process

~~36.~~39. The review process will involve both on-site and off-site examinations and discussions with the insurer's staff or representatives.

~~37.~~40. In typical situations, the Authority's review process is expected to include the following elements:

- review of responses to information requests;
- review of any documentation related to the ICM;
- detailed model demonstrations; and
- discussions with the insurer's management, staff or representatives.

~~38.~~41. The Authority will assess each insurer's ICM using the criteria set out in this paper by dividing its evaluation over the following four sections:

- **Use Test** – ICM is used to actively support key business decision processes and is an essential component of the insurer's risk management framework, as evidenced by consistent and frequent reports to the Board of Directors (the Board) and senior management of the insurer and the reflection of ICM output in the insurer's operations and decision-making processes;

- **Governance and Controls** – ICM documentation is complete and accurate, model ownership and responsibility are clear and formal processes are in place regarding the operation and maintenance of the ICM;
- **Theoretical Review** – appropriate structure and statistical methodologies are employed for modelling of various risks and aggregation of risks; and
- **Analytical Review** – implementation of methodologies is appropriate with consistent application of data, sensitivity testing and sufficient analysis around parameterisation.

39.42. For the sake of efficiency, the Authority may review and rely upon other independent reviews of an insurer's ICM, including assessments provided by other regulatory agencies, to the extent practical. The degree of reliance placed upon these reviews will be guided by the extent to which their approach is comparable to that of the Authority's, the sufficiency of documentation available, and any other factors that the Authority may consider appropriate.

40.43. Barring any extenuating circumstances, such as an incomplete or delayed application or information request, a large number of applications in relation to the Authority's available resources or any other unforeseen cause, the Authority will render a formal decision regarding the acceptability of an insurer's ICM application within a six-to-nine month period following the receipt of the formal application for approval.

41.44. As part of the ICM review, an insurer will be required to calculate the ECR using both its ICM and the BSCR formula. While comparative output relating to prior reporting periods will be reviewed, an insurer will need to provide an ECR calculation using both methods incorporating the most recent data available at the time of the ICM review.

42.45. Extensive consultation between the insurer and the Authority prior to submission of the formal application is encouraged. This along with accurate and thorough responses to information requests should expedite the review process.

43.46. Upon completion of their analysis, the ICM review team will present their recommendations to one or more internal governing committees within the Authority for consideration. It is envisioned that this will include an ICM Approval Committee and, ultimately, the Authority's Risk Committee. The Risk Committee will then decide whether or not to approve an insurer's ICM application.

Communication of Results

44.47. After the review process is complete, the Authority will send a formal response to the insurer regarding its application to use the proposed ICM for the determination of its ECR.

- 45.48. If the application is approved, the response will state the effective date and any conditions that may apply. The Authority may use the approach of ‘conditional approval’ and allow an insurer to commence using its ICM for regulatory capital purposes if there are areas that require further improvement or review but do not prohibit the approval of an insurer’s ICM application. Conditions may include capital floors based on the BSCR, more conservative model parameters or design features or further review by the Authority, the insurer or a third-party.
- 46.49. If the application is not approved initially, the Authority will outline any ICM deficiencies and cooperate with the insurer while these deficiencies are resolved. If these issues cannot be resolved within a reasonable timeframe, then the Authority will not approve the ICM application.
- 47.50. In the event an ICM application is not approved, the insurer may make written representations to the Authority as provided for under Paragraph 5 of the Rules. If, after taking these representations into account, the Authority confirms its decision not to approve an insurer’s ICM, the insurer may re-apply once all ICM deficiencies have been resolved.

Post-Approval Monitoring and Control Process

- 48.51. Following approval of an insurer’s ICM for regulatory purposes, the Authority will require some additional reporting in regards to the ICM and may conduct periodic reviews to ensure that the ICM continues to assess an insurer’s risk exposures and associated capital requirements accurately.
- 49.52. Post-approval reporting will enable the Authority to monitor ICM developments and conduct industry analysis and benchmarking exercises. In most cases, the Authority will either require an insurer using an approved ICM to continue to report under the BSCR requirements or provide similar benchmarking information which will be outlined during the model review process.
- 50.53. Specific reporting requirements relating to the ICM will be established during the model review process. The Authority will work closely with the insurer in developing data submission templates for post-approval reporting purposes, and while most reporting will be required on an annual basis, some circumstances may require quarterly filings. Reporting requirements may include:
- standard periodic ICM output;
 - narrative discussing previous and future planned changes and developments to the ICM;
 - updated model documentation; and
 - new or updated validation reports, if applicable.

- | ~~51.~~54. While an ICM should be dynamic and adaptive, the insurer will be required to advise the Authority of revisions to an approved ICM, including those caused by changes in third-party vendor models and those resulting from amendments to the design, assumptions or insurer's risk profile. These requirements are in addition to those specified in the Insurance Act 1978, Sections 8A and 30JA, which are not specifically related to ICM reporting.
- | ~~52.~~55. The Authority will cooperate with the insurer near the end of the model qualification process to establish an appropriate policy relating to post-approval monitoring and reporting of major and minor changes, including the threshold of materiality in relation to major and minor model modifications.
- | ~~53.~~56. While the precise policy relating to model changes will be agreed upon during an ICM review, the Authority anticipates that reporting around revisions due to changes in third-party vendor models will include a summary of the revisions made and the resulting impact to ICM results. The Authority will work with individual insurers, vendors and the industry as a whole to understand vendor model revisions.
- | ~~54.~~57. The Authority currently intends to conduct post-approval ICM reviews when the ICM materially deviates from the assumptions, portfolio characteristics, structure and/or parameterisation used in previously approved versions, and will focus the review on the portions of the ICM that have changed. However, the Authority reserves the right to conduct a comprehensive review on an already approved ICM at its discretion.
- | ~~55.~~58. If any conditions of an insurer's ICM approval have been breached, the Authority will allow the insurer a reasonable period of time to correct such breach and work with the insurer in resolving any issues. If these outstanding issues cannot be corrected within the allotted time, the Authority may revoke its approval of the insurer's ICM.
- | ~~56.~~59. In the event that the Authority revokes approval of an insurer's ICM, the affected insurer may make written representations as provided for under Paragraph 5 of the Rules. If, after taking these representations into account, the Authority confirms its decision to revoke the insurer's ICM approval, the insurer may re-apply once all ICM deficiencies have been resolved.

Attachment A: Pre-Application Process

Introduction

- A.1. The first stage of the Authority's ICM application and review framework is the pre-application process, which consists of the insurer's submission, and Authority's review, of the following four items:
- **Self-Assessment** - intended to provide the Authority with a narrative description of each of the [2419](#) self-assessment affirmation statements pertaining to the ICM;
 - **Overview of Internal Capital Model** - intended to provide the Authority with an introduction to the ICM and its function within the insurer's risk management framework;
 - **Model Demonstration** - intended to provide the Authority with a high-level overview of the model and how it works in practice; and
 - **Documentation Gap Analysis** - intended to provide the Authority with an assessment of the insurer's ability to meet the information request or plans to meet requirements by the target application date.
- A.2. An insurer is likely to have management information, procedures and documentation relating to the ICM in place already. The Authority will rely upon an insurer's established procedures to the extent practical and seek to minimise documentation prepared solely for regulatory use.
- A.3. It may take time for an insurer to confirm that all relevant ICM standards set out in this guidance are met. The Authority does not necessarily expect all standards to be met by an insurer's ICM at the start of the pre-application process. The Authority will seek to develop a close dialogue with each insurer throughout the pre-application and application processes, and an insurer is expected to provide a realistic self-assessment relating to any ICM inadequacies and any plans to address these over time. Where some inadequacies remain to be addressed at the time a final decision is required, the Authority may provide a 'conditional approval' that will allow an insurer to use its ICM for regulatory capital purposes while any remaining issues are being addressed. However, an insurer should recognise that the evaluation of an ICM is a rigorous process that will require the dedication of sufficient resources in order to be successful.
- A.4. The Authority anticipates that the pre-application process will typically take two-to-three months to complete depending upon the magnitude and complexity of the ICM, the resources available at the Authority and the insurer and the preparedness of the insurer to undergo the process. There may be exceptional instances when the Authority will require an insurer to have the ICM validated by an independent party prior to formal application.

Self-Assessment

- A.5. The self-assessment process requires an insurer to complete the set of affirmation statements, which are specified in Attachment B. These affirmation statements are intended to reflect the general criteria, or standards, by which an insurer's application for the approval of its ICM will be considered. General guidance is provided for each statement, but this guidance is not intended to be exhaustive.
- A.6. As part of the self-assessment, an insurer should also provide a brief narrative description relating to the ICM's compliance with each affirmation statement, including the identification of any gaps and plans to close those gaps.
- A.7. The self-assessment should involve considerable internal review, and the final version of the affirmation statements will require the signed approval of both the insurer's Chief Executive Officer, defined in Section 1A(7) of the *Insurance Act 1978* as chief executive, and Chief Risk Officer, or the person with responsibilities normally assumed by the Chief Risk Officer, prior to submission.

Overview of Internal Capital Model

- A.8. The ICM overview is intended to provide an introduction to the ICM and its function within the insurer's risk management framework. The pre-application is not intended to place an unreasonable burden on insurers, and therefore the Authority recommends that an ICM overview follows the form of a high-level executive summary.
- A.9. The ICM overview should include a narrative introduction to the ICM and its governance, including high-level summaries (e.g. executive summaries of standard model documentation) of:
- responsible individuals regarding model ownership and governance;
 - business uses and model application;
 - methodology and metric used to determine the ECR;
 - scope of risks and brief description of methodologies to assess major risks;
 - mathematical structure including description of dependency structure, if applicable;
 - logical flowcharts, if available, to be attached as additional pages;
 - use of external models;
 - calibration and parameter estimation;
 - model inputs; ~~and~~
 - model validation; and
 - IT platform and contingency policies.
- A.10. The overview should also include a narrative description of the historical development of the model, prospective project plans, including model developments planned for the next 12 months, project sponsors, milestones, key deliverables, budgets, resource allocation, key risks and mitigating actions in place and contingency plans.
- A.11. In addition to the narrative description, the overview should provide ICM output using the most recent data. Ideally, this should include:
- aggregate group- and/or entity-level output, as applicable, including a breakout by major risk category (i.e. ~~catastrophe, underwriting,~~

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[reserving insurance](#), market, credit, ~~and~~ operational, [and liquidity](#) risk) and line of business (by both insurer-defined business classes and those classes mapped to the Authority's statutory lines of business when possible); and

- standalone (undiversified) output by legal entity, major risk category and line of business.

A.12. As part of the ICM overview submission, the insurer should provide a target date for applying to the Authority for ICM qualification, reasons for making an application for ICM approval and contact information for key individuals, including model owners, and their roles.

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Model Demonstration

- A.13. As part of the pre-application process, the insurer should provide a scheduled high-level demonstration of the ICM, which will ideally be presented in person by the insurer's modelling team, to show the Authority how the model works in practice.
- A.14. The ICM demonstration is expected to include a question-and-answer session that will allow the Authority to gain a high-level understanding regarding modelling practices and processes.
- A.15. The ICM demonstration will most likely take place at the office of the insurer but may be conducted at the Authority's office if the demonstration can be sufficiently effective.

Documentation Gap Analysis

A.16. An insurer will need to provide an assessment of its readiness to provide the standardised documentation request, which is outlined in the information request guidance, including an index of documentation mapped to each aspect of the Authority's request (i.e. evidence that the insurer possesses the requisite documentation to apply for ICM qualification).

A.17. The components of the standardised documentation request are as follows:

- model documentation [including the methodology and calibration underlying the ECR](#);
- reports generated by model outputs;
- Board and senior management presentations and meeting minutes;
- policies, processes and procedures governing model use;
- prospective model developments; and
- independent validation reports.

A.18. Sample documentation should also be submitted to provide examples of level of detail, including detailed model documentation, management presentations and Board minutes.

Attachment B: Affirmation Statements

Introduction

- B.1. These affirmation statements are intended to reflect the general criteria, or standards, by which an insurer's application for the approval of its ICM will be considered. General guidance is provided for each statement, but this guidance is not intended to be exhaustive.
- B.2. The affirmations consist of [4924](#) statements within eight broad categories. An insurer's assessment should be objective and realistic, and management should carefully consider whether or not the insurer's ICM complies with the standards outlined before affirming each statement.
- B.3. The final version of the affirmation statements will require the signed approval of both the insurer's Chief Executive Officer, defined in Section 1A(7) of the *Insurance Act 1978* as chief executive, and Chief Risk Officer, or the person with responsibilities normally assumed by the Chief Risk Officer, prior to submission.

Affirmation Statements

B.4. Checking the box for each item below indicates that the insurer substantially complies with the statement listed.

B.5. A brief narrative description of the ICM's development with respect to each affirmation statement should also be included. The guidance relating to the affirmation statements should be referred to in the development of the narrative description, but the Authority does not expect more than one page for each of the [1924](#) affirmation statements. A description of any gaps, and plans and timing to close these gaps, should also be outlined.

B.6. Use Test

B.6.1.	The ICM is an essential component in the development and evaluation of the insurer's strategies.	☐
B.6.2.	The ICM is relied upon for key management and tactical operating decisions.	☐
B.6.3.	The ICM is an integral part of the insurer's risk and capital management functions.	☐
B.6.4.	The ICM produces information that is sufficiently timely and granular in order to be used in decision making.	☐
B.6.5.	The management actions reflected in the ICM have been approved by the Board or senior management.	☐
B.6.6.	The Board and senior management understand the limitations of the ICM.	☐

B.7. Statistical Test

B.7.1.	The ICM has been developed with due regard to generally accepted actuarial techniques and statistical theory.	☐
B.7.2.	Modelling techniques are appropriate to the nature, scale and complexity of the risks to which the insurer is exposed.	☐
B.7.3.	All material assumptions have been assessed for veracity and suitability.	☐
B.7.4.	Rigorous data validation procedures are in place.	☐

B.7.5.	The ICM has a rigorous approach to modelling dependency structures. <u>interactions and dependencies between risks.</u>	☐
B.7.6.	<u>The areas that rely on expert judgement are known and sufficient challenges have been applied to these areas.</u>	☐

B.8. Calibration Test

B.8.1.	The ICM is calibrated such that the ECR is determined using the Tail Value-at-Risk ⁷ (TVaR) metric subject to a confidence level of 99% with one year of new business and the run-off to extinction of all liabilities⁸. <u>reserve development over a one year time horizon⁹.</u> (An alternative metric may be used as long as it can be demonstrated to be at least as prudent in determining the ECR.)	☐
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B.9. Validation

B.9.1.	The ICM is subject to a regular cycle of validation, which includes the monitoring of performance, review of the on going appropriateness of model specifications, and testing of forecasted results against experience.	☐
B.9.2.	The validation process demonstrates that the ICM remains suitable for the purpose intended during changing conditions.	☐

B.10. Documentation

B.10.1.	Documentation of the ICM provides a detailed description of the structure, design, theory, operational details, input assumptions, parameters, governance process and controls	☐
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⁷ Tail Value-at-Risk, or TVaR, at x% is the expected loss given that the loss exceeds the xth percentile. A 99% TVaR level therefore corresponds to the average of the largest 1% of modelled losses.

⁸ ~~Output from the ICM used to determine regulatory capital is defined as the amount of capital required to meet all obligations using a TVaR metric subject to a confidence level of 99%, inclusive of existing business and business expected to be written over a one year period with the run-off to extinction of all liabilities and losses due to market, credit and operational risks.~~

⁹ Output from the ICM used to determine regulatory capital is defined as the amount of capital required to meet all obligations using a TVaR metric subject to a confidence level of 99%, inclusive of existing business and business expected to be written over a one-year period with reserve development over a one year time horizon and losses due to market, credit and operational risks.

	of the ICM.	
B.10.2.	The documentation is sufficiently comprehensive and instructive such that the ICM can be utilised and maintained by newly-assigned qualified personnel or qualified personnel with limited user experience.	☐

B.11. Model Governance

B.11.1.	Board and senior management of the insurer have overall responsibility for the placement of proper management and controls around the ICM and ensuring its use in an insurer's risk management function. <u>The Board must have formally approved the ICM for use within the insurer.</u>	☐
B.11.2.	There is sufficient understanding of the ICM at the appropriate levels within the insurer, including the implications of ICM outputs and its limitations for risk and capital management decisions.	☐
B.11.3.	The insurer's risk management unit ¹⁰ has responsibility for the on-going maintenance, use, application and validation of the ICM.	☐
B.11.4.	<u>There is a formal assessment and approval process before any major changes to the ICM are implemented.</u>	☐

B.12. Internal Controls

B.12.1.	There are sufficient internal controls in place to monitor and evaluate the ICM's efficient operation and maintenance.	☐
B.12.2.	Strict protocols are in place restricting those persons who have access to the ICM and the ability to make adjustments thereto.	☐

B.13. Risk Categories

¹⁰ In this guidance note, "risk management unit" shall mean the group of employees with day-to-day responsibility for the development, maintenance and operation of the ICM as delegated by the Board or senior management.

B.13.1.	The ICM adequately captures all the material risks facing the insurer, including, but not limited to: catastrophe risk, underwriting risk, reserving insurance risk, market risk, credit risk, operational risk and liquidity risk, to the extent this is modelled by the ICM.	☐
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Guidance for Affirmation Statements

Use Test

- B.14. The Authority will not approve an ICM unless it is satisfied that the model is central to an insurer's decision-making processes and is embedded in its operations. This is referred to as the "use test" and requires that an ICM be widely used throughout an insurer's organisation and serves as a critical input into corporate governance, particularly as it relates to the risk management function and the development, implementation and monitoring of management strategies.
- B.15. The ICM should assist in the measurement and management of material sources of risk and be used to evaluate potential actions to mitigate unsatisfactory risk exposures. The ICM should also be used by the insurer to better understand the alignment of exposures across different risk drivers.
- B.16. In addition to the evaluation of capital adequacy, the Authority will also consider whether an ICM is used for some of the following business purposes:
- allocation of capital to risk categories, business segments and lines of business;
 - determination of hurdle rates of return for pricing and underwriting guidelines;
 - determination of marginal capital or hurdle rates of return for large or special accounts;
 - profit and loss attribution;
 - design and evaluation of risk appetite;
 - management of risk limits and portfolio composition;
 - assessment of outward reinsurance strategies;
 - development and evaluation of business plans, including new lines of business or new areas of risk;
 - capital management;
 - determination of investment policies and strategies; ~~and,~~ including hedging;
 - management actions to be applied in the business;
 - strategic considerations such as M&A and divestitures;
 - objective setting and performance assessment; ~~and~~

- [preparation of Commercial Insurer Solvency Self-Assessment Report or Group Solvency Self-Assessment Report.](#)

- B.17. The ICM should contain processes and reporting that enables the insurer to monitor, manage and report on the individual and aggregate risks, to which the insurer is or could be exposed, as well as the [interactions and](#) dependencies between risks.
- B.18. A broad involvement of a range of business functions should exist in the use of the ICM, including executive management, actuarial, risk management, [investment,](#) finance, underwriting, claims and human resources, particularly for performance-based compensation. Each business function should understand how its areas of responsibility are reflected in the ICM and how past experience will impact capital requirements.
- B.19. There should be an adequate recognition of the limitations of modelling processes, given the range of factors considered in management's decision-making processes and the inherent limitations of ICMs. The Authority would expect the ICM to be used as an input into, rather than the sole determinant of, key management decisions.
- B.20. The frequency of determination of the ECR using the ICM should be consistent with the insurer's needs, but it should be assessed at least annually.
- B.21. The use of and reliance upon the ICM should be extensive enough to result in continuous feedback on the reasonableness of its results and the validity of the model's inputs and critical assumptions.

Statistical Test

- B.22. The methodologies used in the ICM should be based on rigorous actuarial and statistical techniques, be consistent with the methods used to calculate technical provisions and use current and credible data as well as realistic assumptions.
- B.23. The modelling techniques used in the ICM should be appropriate to the nature, scale and complexity of the risks to which the insurer is exposed. Certain drivers of risk may be modelled independently and at different levels of complexity in an insurer's ICM.
- B.24. Processes should be in place to review all ICM inputs and assumptions for reasonableness and consistency, and implicit assumptions should be made explicit where possible. In addition to considering process risk, the model's assumptions and parameters should be determined taking into consideration parameter risk, especially for long-tail insurance classes, and data quality. Where practical, goodness of fit testing of the ICM with historical observations should be conducted to assess the model's efficacy.
- B.25. The data used both as inputs to the ICM and to determine parameters for the ICM, including exposure data from insurer and broker submissions and industry data from which ~~loss frequency or severity~~ modelling assumptions are derived, should be updated frequently and tested for accuracy, completeness, consistency and predictive propensity.
- B.26. Assumptions made in the ICM are sometimes based on insufficient data support and must rely on subjective expert and management judgment or other qualitative adjustments. Examples of such assumptions might include policyholder behaviour, if applicable, or the relationship between risk factors in extreme scenarios. The Authority will aim to confirm that such assumptions are backed by the appropriate level of quantitative analysis (including benchmarking where possible) and made transparent to management in the context of a sound governance framework.
- B.27. Dependencies within and among risk categories or drivers should be adequately considered in the ICM. The insurer should be able to justify diversification benefits between risk categories and provide comprehensive descriptions of the material assumptions and methodologies underlying aggregation and any dependency structures in the ICM. Additionally, an insurer should be able to demonstrate that the ICM adequately captures interactions and dependencies between risks in extreme scenarios, or tail events.
- B.28. ~~Due to the importance of this area, the Authority will continue to explore the topic of dependency structures and discuss theory and practice with industry on an on going basis.~~ The Authority recognises that best practices for building modelling interactions and dependencies ~~into models~~ between risks are fast developing and that there are a wide variety of methodologies in industry practice. The Authority

sees this as a positive trend and has no intention to be prescriptive regarding methodology.

B.29. There is a recognition that in order to support the “use test,” companies have been developing more sophisticated approaches to estimating the capital position on a timely basis and obtaining more information around the distribution of the capital requirements. The Authority again sees this as a positive trend and has no intention of being prescriptive regarding methodology.

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Calibration Test

- ~~B.29.~~B.30. Where practical, the ICM should be calibrated such that the ECR is determined using the TVaR metric subject to a confidence level of 99% with one year of new business and ~~the run-off to extinction of all liabilities.~~reserve development over a one year time horizon.
- ~~B.30.~~B.31. An alternative time period or risk measure different from the 99% TVaR may be used, provided the selected metric can be demonstrated to be at least as prudent in determining the ECR. For instance, the Authority understands that some insurers are pursuing ICM approval in jurisdictions who currently favour a VaR approach. In such situations, the Authority will accept a VaR metric if its calibration is appropriately prudent.
- ~~B.31.~~B.32. If an alternative risk measure is selected, the insurer should give due consideration to its statistical properties. For the purpose of capital requirements, an insurer is encouraged to use theoretically supportable models and risk measures.
- ~~B.32.~~B.33. Ideally, the ICM should be based on an economic balance sheet that reconciles to the insurer's balance sheet used for statutory reporting purposes. The Authority expects to release proposals describing the principles of an economic balance sheet for consultation with the industry during 2012. The Authority would also be prepared to consider the use of other suitable economic balance sheets that companies may adopt; in particular those specified under Solvency II or the Swiss Solvency Test would generally be considered suitable.

Validation

~~B.33.~~B.34. The ICM should be subject to a periodic validation process, which should include a review of its predictive performance, an on-going assessment of the appropriateness of material assumptions and methodologies, and a review of model output for reasonableness.

~~B.34.~~B.35. The completion of an independent internal or external review of the development, operation and interpretation of the ICM is encouraged prior to an insurer's ICM application. An independent review should be performed by parties not directly involved with the development and operation of the ICM.

B.36. Areas that might be subject to validation include data, methods, assumptions and the application of expert judgement, but the Authority recognises other areas could also be subject to validation.

~~B.35.~~B.37. The validation process should also include an examination of the sensitivity of ICM results to changes in key underlying assumptions, an assessment of the accuracy, completeness and predictive propensity of the data used by the ICM, and a statistically valid comparison of results to historical data, adjusted to reflect changes in exposures and conditions, to assess the robustness of the ICM.

~~B.36.~~B.38. The Authority recognises that an insurer's ICM may rely heavily upon the use of third-party vendor models. At a minimum, an insurer should be able to demonstrate a thorough understanding of the vendor models used, including model limitations and their implications, and provide analysis around the selection of the vendor models implemented, including benchmarking and validation exercises. Any customisations to standard third-party vendor models to reflect individual company products, practices and risk profiles should be justified and documented.

~~B.37.~~B.39. The ICM should be subjected to a range of scenario and stress tests in order to assess the reliability of the ICM indications and to test the robustness of the model in the evaluation of extreme but plausible events.

~~B.38.~~B.40. Stress scenarios should be insurer-specific (e.g. concerns with the financial condition of the insurer or claims concentration), industry-specific (e.g. price levels or catastrophic claims) and reflective of market conditions in general (e.g. impaired capital markets). Scenarios considered should also include combinations of interdependent events, such as adverse policyholder behaviour, catastrophic claims and impaired capital markets.

~~B.39.~~B.41. The validation process should demonstrate that the ICM remains fit for the purposes intended under changing conditions and continues to satisfy the criteria outlined in this guidance.

B.42. The validation should include an element of back-testing, which would help validate the extent to which the model generates the movements and extreme positions that have been observed in the past.

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Documentation

~~B.40.~~B.43. Comprehensive documentation should be maintained by the insurer describing the ICM's [methodology, calibration, processes, theory, parameterisation, material assumptions, reliance on judgement](#) and operational details.

~~B.41.~~B.44. The documentation should be sufficiently comprehensive and instructive so as to support an independent review of the ICM as well as its use and maintenance by newly-assigned qualified personnel, including qualified personnel with limited ICM experience.

~~B.42.~~B.45. Documentation should include a detailed outline of the ICM's structure, including a schematic diagram of its main components, the flow of data between those components, linkages between technical and non-technical elements and the theory underlying its design and function. [To the extent the ICM utilises scenario generators \(e.g. economic scenario generators, property catastrophe models\), model documentation should also cover the structure and dependencies of these, as well as how they interact with the remainder of the functionality in the ICM.](#)

~~B.43.~~B.46. An insurer should also be able to provide details regarding key inputs and the assumptions used to determine those inputs as well as the relevant outputs and how those outputs are used in the day-to-day operations and management of the insurer. Documentation should also include details relating to the ICM's governance and internal control procedures.

~~B.44.~~B.47. Documentation should describe the validation procedures applied to any components of the ICM, and an insurer should document the findings from each validation exercise.

~~B.45.~~B.48. Material changes made to the ICM should be documented, and the Authority should be notified of these changes along with any significant policy changes affecting the ICM. A summary of ICM revisions will need to be filed according to the change reporting policy agreed to between the insurer and the Authority, and a catalogue of minor or routine changes should be maintained by the insurer and be available for inspection.

~~B.46.~~B.49. The documentation should identify any weaknesses of the ICM or conditions for which it may not adequately determine the insurer's ECR.

Model Governance

~~B.47.~~B.50. The Board of the insurer ~~should~~^{is} ultimately ~~be~~ responsible for the integrity of the ICM, the placement of proper management and controls around the development and use of the ICM and ensuring that the ICM plays a key role in the insurer's risk management function. An insurer should be able to evidence an appropriate level of discussion relating to the ICM and its outputs at Board-level. [The Board must have formally approved the ICM for use within the business.](#)

~~B.48.~~B.51. The insurer's Board and senior management should have a sufficient understanding of the ICM's key elements, including the implications of its outputs and its limitations for risk and capital management decisions, and ensure that an adequate understanding of the ICM exists at appropriate levels within the insurer's organisational structure.¹¹ [Evidence should be supplied about the nature and extent of training given to Board members and senior executives.](#)

~~B.49.~~B.52. The day-to-day responsibilities relating to the ICM may be delegated to the Chief Risk Officer, or the person with responsibilities normally assumed by the Chief Risk Officer, as head of the insurer's risk management unit. However, the delegation of day-to-day ICM responsibilities, or use of external expertise in the development of the ICM, does not absolve the Board of its responsibility to ensure that the use of the ICM is consistent with prudent risk management and the sound and prudent conduct of the insurer's business.

~~B.50.~~B.53. The insurer's risk management unit should be responsible for ensuring the on-going appropriateness of the design and application of the ICM, and that processes are in place to amend and refine the ICM as an insurer's risk profile changes.

~~B.51.~~B.54. The risk management unit of the insurer should have sufficient resources, technical ability and authority to operate and maintain the ICM effectively and securely. The insurer's emergency management and business continuity plans should include specific provisions for the backup and recovery of all critical systems needed for the continued operation and maintenance of the ICM, and succession plans should be in place to mitigate the risk of departure by personnel key to the ICM's use and development.

~~B.52.~~B.55. The risk management unit should test and validate the ICM on a frequent basis. This unit should also document any subsequent changes made to the ICM, inform senior management and the Board of the insurer about the performance of the ICM, and recommend areas needing improvement.

~~B.53.~~B.56. An insurer should decide on the appropriate balance of in-house versus external expertise relied upon in relation to the ICM, given the nature, scale and complexity of the risks they bear. Any outsourced work should meet the insurer's

¹¹ IAIS *Standard on the Use of Internal Models for Regulatory Capital Purposes*, October 2008, Paragraph 11.

own quality requirements and should be appropriate to the nature of the insurer's business.

B.57. The insurer should maintain written documentation of all ICM governance policies and procedures, including organisational risk limits and tolerances, internal control, internal audit and, where relevant, outsourcing of ICM activities.

~~B.54.~~B.58. Evidence should be available to show the existence of formal policies governing the review, approval, and sign-off processes applicable to the underlying theory and structure, the calibration, and the validation and testing of the various elements of the ICM. The insurer should further be able to demonstrate that these policies have been periodically reviewed and adhered to in all material respects.

B.59. An insurer's ICM governance processes should include controls and documentation around the model change policy and an adequate process should be put in place by the insurer to assess proposed changes to the ICM against the approved model change policy.

Internal Controls

- | ~~B.55.~~B.60. An insurer should clearly demonstrate that adequate and effective controls are in place in relation to the operation and maintenance of the ICM, including strict protocols identifying those parties who have the authority to use and make amendments to the model.
- | ~~B.56.~~B.61. Clearly documented procedures for independent review of the ICM should be developed by the insurer.
- | ~~B.57.~~B.62. The scope of the internal control process should include administrative and accounting procedures, testing and control procedures, reporting requirements and compliance procedures.
- | ~~B.58.~~B.63. The audit function should include procedures designed to verify that the ICM is current, uses reliable and relevant data and is operated and maintained by personnel with adequate expertise and experience.
- | ~~B.59.~~B.64. A specific control policy should also be in effect ensuring that an appropriate segregation of duties is maintained between those who are responsible for building, operating and maintaining the ICM and those who are responsible for making decisions based on the ICM's output. This especially applies to the determination of ~~loss~~ assumptions and the potential for conflicts of interest in this area between conservative estimates and business generation.
- | ~~B.60.~~B.65. The internal control process should also include provisions for the routine review and challenge of material assumptions and parameters in the ICM. [This should also cover compliance with the agreed model change policy.](#)

Risk Categories

~~B.61.~~B.66. The ICM should consider all material and quantifiable risks facing an insurer on a consistent and coherent basis. The risks considered should include the following:

- insurance risk, ~~including catastrophe risk, underwriting risk (non-catastrophe) and reserving risk;~~
- market risk;
- credit risk;
- operational risk; and
- liquidity risk, to the extent captured in the ICM.

~~B.62.~~B.67. The ICM should generate capital allocations that, to the extent possible, appropriately reflect the risks inherent in each area of the insurer's business and improve management's internal reporting capability on measures such as return on risk-adjusted allocated capital.

~~B.63.~~B.68. Risk mitigation actions such as inuring reinsurance should be considered in the ICM provided that associated credit and other risks are properly reflected.

~~B.64.~~B.69. The impact of likely future management actions carried out in response to specific circumstances may be incorporated into the ICM provided that due consideration is given to the likelihood of such action being taken and the time taken to implement these actions.

~~B.65.~~B.70. In order to adequately capture the full extent of the risks outlined, the ICM should consider existing business and business expected to be written over a one-year period from the end of an insurer's relevant year¹² with ~~the run-off to extinction of all liabilities that an insurer is legally obligated to provide coverage for~~reserve development over a one year time horizon and potential losses associated with market, credit and operational risks.

~~B.66.~~B.71. Risks associated with derivatives, guarantees and any contractual options, where material, should be accurately assessed and reflected in the ICM, including any off-balance sheet exposures.

~~B.67.~~B.72. An insurer should be able to provide adequate documentation stating which risks are covered in the ICM and which are not, including those risks considered non-material for the purposes of inclusion within the ICM. In cases where known risks are not evaluated as a component of the insurer's ICM,

¹² Relevant year is defined in the Rules as an insurer's financial year.

including exceptional risks ~~such as terrorism and pandemic~~, the separate review of these risks or support for their exclusion should be available.

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Insurance Risk

~~B.68.~~B.73. Insurance risk is defined as coverage by contract in which one party agrees to indemnify or reimburse another for any fortuitous loss covered under the terms of the contract. [Separate guidance is provided for general insurance risk and long-term insurance risk.](#)

~~B.69.~~B.74. [Insurance](#)For general insurance, insurance risk should be subdivided into three ~~mutually exclusive~~ categories, [where applicable](#):

- catastrophe risk;
- underwriting risk; and
- reserving risk.

~~B.70.~~B.75. Ideally, an insurer should model and present risks separately in these categories. Alternative risk categorisations should be discussed with the Authority.

Catastrophe Risk

~~B.71.~~B.76. Catastrophe risk is defined as the risk of the occurrence of a man-made or natural event that results in significant insurance losses to multiple exposures concurrently. [This is not limited to property catastrophe business, but could cover losses in other lines of business, including casualty business.](#)

~~B.72.~~B.77. An insurer should be able to provide a description relating to all models [\(whether internally developed or external vendor models\)](#) used to evaluate its catastrophic loss exposures. This description should consider the following details:

- identity of all vendor models used;
- identity of all region-peril models used;
- specifications of any internally developed models used;
- per occurrence and aggregate annual loss distributions for the insurer's in force portfolio separately by region and by peril for each type of business¹³ and in total (both gross and net basis);
- practice adopted for the modelling of multiple events;
- method for the modelling of terrorism risks, if applicable;

¹³ Where type of business is categorised as: insurance, reinsurance, retrocession and insurance-linked securities.

- treatment of reinstatement premiums receivable and payable;
- recognition of inuring reinsurance;
- supplemental losses considered by the insurer's catastrophe models (e.g. fire following earthquake, storm surge, demand surge, sprinkler leakage);
- additional loadings included in each of the models used (e.g. allocated loss adjustment expense, insurance to value adjustments); and
- non-modelled losses.

~~B.73.~~B.78. There is potentially systemic risk in the extent of reliance on vendor-provided catastrophe models.¹⁴ An insurer should take precaution and avoid an over-reliance on vendor models without adequate safeguards to monitor and address their limitations.

Underwriting Risk

~~B.74.~~B.79. Underwriting risk is defined as the risk that the insurer's prospective underwriting activities will result in financial loss (both in respect of current in force business and business to be written). For the purposes of ICM construction, underwriting risk should be evaluated separately from, and in addition to, catastrophe risk as defined above.

~~B.75.~~B.80. An insurer should be able to provide a description of the approach to modelling underwriting risk in the ICM, which considers each of the following elements:

- method for the estimation of premium writings;
- consideration of market cycles, which may include changes in premium adequacy as well as terms and conditions;
- methodology adopted for the earning of premiums written;
- treatment of "large" and "attritional" claims, including the method for defining each, the rationale supporting their separate treatment and the parameter risk associated with the estimation of frequency for large claim events;
- treatment of non-catastrophe risk clash (e.g. one event causes loss to more than one exposure);

¹⁴ *Survey of Economic Capital Modelling Practices in the Bermuda Insurance Market*, Bermuda Monetary Authority, December 2008, Section 1.5.2.

- impact of reinsurance on large claims, including per risk or horizontal exhaustion of reinsurance limits;
- likelihood that claims will exceed available reinsurance coverage limits either as a consequence of poor underwriting or an underestimation of potential loss exposure;
- consideration of the variability of attritional losses, including cases where market and economic conditions are more adverse than observed historically;
- details of all material reinsurance programmes, including premiums, limits, reinstatement provisions, commissions, expenses and any other relevant items;
- assumptions regarding the expected cost and availability of inuring reinsurance in future periods; and
- dependency between underwriting risk segments and accident periods.

Reserving Risk

~~B.76.~~B.81. Reserving risk is defined as the possibility that technical provisions for claim liabilities arising from past exposure periods will be inadequate to satisfy their ultimate cost.

~~B.77.~~B.82. An insurer should be able to provide a description of the manner by which reserving risk is considered in the ICM. This description should include the following items:

- likely circumstances for which run-off outcomes could differ materially from held provisions;
- method for modelling the variability in the run-off of liabilities;
- manner in which systemic or extreme issues are treated;
- method for modelling premium-related and claims handling expenses;
- consideration of inuring reinsurance;
- treatment of inflation, particularly with respect to long-tail business;
- impact of changes in future interest rates; and
- consideration of unusual claims that might not be represented in historical claims experience (e.g. latent disease, mass torts, asbestos property damage).

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| ~~B.78.~~B.83. The Authority may consider approving ICMs that utilise varying methodologies to calculate reserving risk which are approved by other equivalent regulatory regimes.

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B.84. For long-term insurance, insurance risk may include the following:

- lapse risk;
- other policyholder behaviour risk;
- mortality / longevity risk;
- disability / morbidity risk;
- expense risk; and
- catastrophe risk.

B.85. Ideally, an insurer should model and present risks separately in these categories. Alternative risk categorisations should be discussed with the Authority.

Lapse Risk

B.86. Lapse risk is defined as the risk of loss due to changes in the level, trend, or volatility of the rates of policy lapses, terminations, renewals, conversions and surrenders.

B.87. An insurer should be able to provide a description of the approach to modelling lapse risk in the ICM, which considers each of the following elements:

- method, source and veracity of data underlying the estimation of the assumed lapse behaviour;
- discussion of the potential drivers of lapse behaviour and how those drivers are reflected in the ICM (e.g. existence of surrender charges or other product features which may drive behaviour, level of “in-the-moneyness” of product options and guarantees, ability to renew or replace the contract with similar coverage, etc.); and
- direction of the adverse exposure (i.e. whether losses are produced by an increase or decrease in lapse rates, and how this might change over the duration of the coverage).

Other Policyholder Behaviour Risk

B.88. Other aspects of policyholder behaviour also have the potential to result in insurance losses, such as:

- timing and level of partial withdrawals;
- election of other optional benefits such as contract annuitisation and reset options;

- policy loan utilisation;
- timing and level of renewal premiums; and
- allocation of policyholder invested funds.

B.89. An insurer should be able to provide a description of the approach to modelling other policyholder behaviour risks in the ICM, if applicable. The description should include the following items:

- discussion of product features giving rise to the potential for adverse policyholder behaviour;
- method, source and veracity of data underlying the assumed behaviour, including reliance on actuarial judgement; and
- direction of adverse exposure.

Mortality / Longevity Risk

B.90. Mortality risk, including longevity risk, is defined as the risk of loss due to changes in the level, trend, or volatility of mortality rates. Mortality risk is typically used to describe the case where higher mortality leads to losses; longevity risk is typically used to describe the case where lower mortality leads to losses.

B.91. An insurer should be able to provide a description of the approach to modelling mortality and longevity risk in the ICM, if applicable, which considers each of the following items:

- identification of products exposed to mortality risk;
- method, source and veracity of data used for the estimation of mortality rates;
- mortality improvement and/or deterioration, including potential anti-selection;
- impact of fluctuation in claims due to both size of policy and number of deaths;
- impact of catastrophic events on ECR (e.g. pandemic, terrorism); and
- treatment of concentration of risk.

Disability / Morbidity Risk

B.92. Disability or morbidity risk is defined as the risk of loss due to changes in the level, trend or volatility of disability or morbidity rates.

B.93. An insurer should be able to provide a description of the approach used to model disability and morbidity risk in the ICM, which considers the following items:

- identification of products exposed to disability or morbidity risk;
- method, source and veracity of data used for the estimation of claim incidence and termination rates;
- geographical differences in claim experience;
- concentration risk;
- impact of benefit offsets; and
- future recovery of overpayments.

Expense Risk

B.94. Expense risk is defined as the risk of loss due to changes in the level, trend or volatility of the expenses incurred in servicing the business in scope for the determination of the ECR.

B.95. An insurer should be able to provide a description of the approach to modelling expense risk in the ICM, which should consider the following:

- expense structure and the allocation methodology adopted, including treatment of one-off expenses;
- possible changes in expenses as a result of management actions modelled in the ICM;
- inflation;
- expense sharing agreements with affiliated entities; and
- impact of changes to arrangements with third party administrator and service providers.

Catastrophe Risk

B.96. Catastrophe risk is defined as the risk of the occurrence of a man-made or natural event that results in significant insurance losses on multiple lives concurrently.

B.97. An insurer should be able to provide a description of the approach used to model catastrophe risk in the ICM, if applicable, covering the following:

- materiality of catastrophe risk;

- treatment of catastrophe risk in the ICM, including whether explicit or implicit allowance for catastrophe risks is included in the modelling of mortality risk; and
- method and data used to model risk, if captured explicitly in the ICM.

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Market Risk

~~B.79.~~B.98. Market risk is defined as the risk that an event or series of economic events will impact the value of an insurer's assets or liabilities. The most common source of this risk type relates to interest rate changes, market price changes, exchange rate movements and counterparty default (excluding reinsurance and intermediary creditors).

B.99. The following are some of the market risks an insurer may be exposed to:

- interest rate risk;
- equity risk;
- property risk;
- currency risk;
- credit spread risk; and
- concentration risk.

~~B.80.~~B.100. An insurer should be able to provide a description of all ~~each~~ material market ~~risks~~ risk to which its assets or liabilities may be exposed ~~to~~ and the ~~manner by which they are assessed~~ approach to modelling the risks in the ICM. ~~The~~ In addition, the following items should also be considered in this description:

- ~~determination of market rate scenarios (e.g. investment asset returns, foreign exchange rates);~~
- ~~details relating to any market scenario generators used by the insurer;~~
- identification of products where the policyholder substantially bears the investment risk (e.g. unit linked business without investment guarantees);
- consideration of adverse economic scenarios on both assets and liabilities simultaneously;
- ~~currency units used for all indicators of~~
- ~~simulated foreign exchange rates applied to assets and liabilities;~~
- ~~whether the credit risk for fixed income securities are modelled separately or as part of market risk;~~
- details of any material dependency considerations (e.g. dependency between market returns and other risks such as credit default losses or dependency between asset classes);

- additional risks from active investment management, [including hedging](#);
- [investment in non-standard asset classes \(e.g. commodities, art, private equity, hedge funds\)](#);
- sovereign risk; and
- credit risk associated with any assets for which this risk is not typically addressed in the credit risk module of the ICM.

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Interest Rate Risk

B.101. Interest rate risk is defined as the risk of loss resulting from changes in the term structure of interest rates, or in the volatility of interest rates.

B.102. An insurer should be able to provide a description of the manner by which its ICM models interest rate risk, as applicable, which should consider the following elements:

- specification of type of interest rate curves modelled by the ICM and discussion of an insurer's actual exposure profile;
- methodology adopted for the generation of interest rate scenarios;
- identity of vendor model used, if applicable;
- data set, time series, and analysis used for interest rate scenario calibration;
- inclusion of interest rate volatility shock if an insurer's asset portfolios and/or insurance obligations are sensitive to changes in interest rate volatility;
- methods used to interpolate and/or extrapolate interest rate curves; and
- method of aggregation adopted to allow for simultaneous changes in interest rate level and volatility.

Equity Risk

B.103. Equity risk is defined as the risk of loss resulting from changes in the level or in the volatility of market prices of equities.

B.104. An insurer should be able to provide a description of its approach to modelling equity risk in its ICM, as applicable, which should cover the following areas:

- categories and markets of equities modelled by the ICM and an insurer's actual exposure profile;
- methodology adopted for the generation of equity scenarios;
- identity of vendor model used, if applicable;
- data set, time series, and analysis used for equity scenario calibration;

- proper reflection by the scenarios of the “fat tail” characteristics often observed from equity returns;¹⁵
- inclusion of equity volatility shock if an insurer’s asset portfolios and/or insurance obligations are sensitive to changes in equity volatility;
- treatment and methodology applied to other financial assets (e.g. private equities, hedge funds, commodities) being modelled as equities; and
- dependency between equity volatility and equity levels of modelled equity markets and categories.

Property Risk

B.105. Property risk is defined as the risk of loss resulting changes in the level or in the volatility of market prices of real estate.

B.106. An insurer should be able to provide a description of the manner in which its ICM models property risk, as applicable. The description should include the following:

- property market sectors and geographic regions of property values modelled by the ICM and the insurer’s actual exposure profile;
- methodology adopted to create the scenarios for real estate values;
- identity of vendor model used, if applicable; and
- data set, time series, and analysis used for property value scenario calibration.

Currency Risk

B.107. Currency risk is defined as the risk of loss resulting changes in the level or in the volatility of currency exchange rates.

B.108. An insurer should be able to provide a description of the approach to modelling currency risk in its ICM, as applicable, which should consider the following items:

- currency exchange rates modelled by the ICM and the insurer’s actual exposure profile;
- methodology adopted to generate the exchange rate scenarios;
- identity of vendor model used, if applicable;

¹⁵ Fat tails are defined as tails of the distribution that have a higher density than that suggested under the assumption of normality.

- data set, time series, and analysis used for exchange rate scenario calibration;
- dependency between exchange rates; and
- exchange rate volatility shock if an insurer's asset portfolios and/or insurance obligations are sensitive to changes in exchange rate volatility.

Credit Spread Risk

B.109. Credit spread risk is defined as the risk of loss resulting changes in the level or in the volatility of credit spreads over the risk-free interest rate term structure.

B.110. An insurer should be able to provide a description of the manner by which its ICM models credit spread risks, as applicable, which should include the following elements:

- asset types and quality ratings for which related credit spread risks are modelled by the ICM and the insurer's actual exposure profile;
- methodology adopted to generate the credit spread scenarios;
- considerations given to credit spread term structure, asset quality migration, and defaults and related recoveries;
- definition of risk-free rates for the determination of credit spreads;
- treatment of sovereign risk;¹⁶
- identity of vendor model used, if applicable; and
- data set, time series, and analysis used for credit spread scenario calibration.

Concentration Risk

B.111. Concentration risk is defined as the risk of a loss resulting from either the lack of diversification in the asset portfolio or from large exposure to default risk by a single issuer of securities or a group of affiliated issuers.

B.112. An insurer should be able to provide a description of its approach to incorporating concentration risk in the ICM, as applicable. The description should cover the following areas:

- diversification of invested assets (e.g. issuers, sectors, countries); and

¹⁶ Sovereign risk is the risk of a government being unable to meet its loan obligations or honour its guarantees on loans.

- [method used to model and calibrate concentration risk.](#)

Credit Risk

~~B.81~~B.113. Credit risk is defined as the risk of loss arising from the inability to realise amounts due from creditors, including reinsurers and intermediaries. Certain credit risks, such as those relating to publicly traded assets, may be captured in the market risk module, in which case they do not need to be addressed as part of the credit risk module.

~~B.82~~B.114. An insurer should be able to provide a description of the manner by which its ICM considers credit risk, which includes the following:

- main sources of credit risk, including premium debtors, financial agreement counterparties, non-tradable assets, related-party exposures and reinsurance receivables;
- capture of assets or any other relevant items, including off-balance sheet items not included in the market risk module;
- residual credit risks that are only partially covered in the market risk module;
- method for assessing extreme credit risk events;
- evaluation of credit risk exposures over the entire holding period of each asset;
- consideration of reinsurance receivables, including unwillingness to pay if appropriate and foreseeable;
- [the ability to collect payments from counterparties resulting from over-the-counter derivative transactions;](#)
- dependency assumptions (e.g. between defaults on different asset classes, between insurer defaults and claims levels); and
- assessment of mark-to-market credit risk impacts, including both the impact of widening credit spreads and ratings migration.

~~B.83~~B.115. In order to fully reflect the risk mitigation benefit associated with outward reinsurance, the ICM should consider the credit risk associated with outward reinsurance counterparties.

Operational Risk

~~B.84.~~B.116. Operational risk is defined as the risk of loss resulting from failed or inadequate internal processes, personnel, systems, or external events.

~~B.85.~~B.117. Operational risk is a key component of an insurer's risk profile. The Authority recognises that quantification of operational risk is a developing discipline. Accordingly, the operational risk module may be developed and operated separately from the other risk modules and differ from those modules in its level of complexity.

~~B.86.~~B.118. The risk management function of an insurer should be able to identify, measure, respond to, monitor and report on all material operational risks, and these risks should be considered in the ICM.

~~B.87.~~B.119. Ideally, an insurer should consider risks arising from each of the following factors, which are described in the Authority's Commercial Insurer Risk Assessment (CIRA) framework, when assessing its operational risk:

- **Business Process Risk** - includes data entry and data processing errors arising from application design misspecifications;
- **Business Continuity Risk** - includes risks that threaten or disrupt an insurer's continuous operations, such as risks arising from natural and man-made hazards;
- **Compliance Risk** - includes legal and regulatory breaches;
- **Information Systems Risk** - includes unauthorised access to systems and data, data loss, utility disruptions, software and hardware failures, and inability to access information systems;
- **Distribution Channels Risk** - includes inexperienced or incapable brokers/agents;
- **Fraud Risk** - includes intentional misconduct or unauthorised activities such as misappropriation of assets, information theft, forgery, and fraudulent claims;
- **Human Resources Risk** - includes key person risk, unethical staff (not including fraud), inexperienced or incapable staff, training, retention, and communication failures; and
- **Outsourcing Risk** - includes communication failures, and incapable outsourcing partners.

| ~~B.88.~~B.120. If operational risk is explicitly modelled using historical data, an insurer should be able to describe the sources of data used for the assessment of operational risk, including:

- internal loss and event data;
- external loss and event data with details of any external data providers; and
- scenario analysis.

| ~~B.89.~~B.121. There may be an overlap between operational risk and other risk categories. If operational risks are considered elsewhere in the ICM, the insurer should be able to provide sufficient documentation to evidence this.

| ~~B.90.~~B.122. Where significant losses have occurred as a result of prior operational events, the insurer should describe practices put in place to mitigate against similar losses in the future.

Liquidity Risk

~~B.91.~~B.123. Liquidity risk is defined as the risk that sources of cash will be insufficient to meet cash needs under current or future conditions. This risk pertains specifically to the circumstances where a given security or asset cannot be bought or sold when needed at the value carried by the insurer in order to fund an obligation or expense.

~~B.92.~~B.124. The Authority requires each insurer to assess the potential impact of liquidity requirements via the Insurance Code of Conduct, which was published in February 2010.

~~B.93.~~B.125. While it may be prudent to assess liquidity risk using an ICM, especially in the context of capital fungibility restraints relating to intra-group reinsurance, the Authority understands that this risk may not call for an explicit capital provision like other risks, and may be assessed outside the ICM. However, to the extent liquidity risk is considered in the ICM, the Authority will aim to confirm that it is done so appropriately [during the ICM review process](#).

~~B.94.~~B.126. When considering liquidity risk, it is important to match the sources of liquidity within the asset portfolio to the liquidity needs of the insurer's liabilities.

~~B.95.~~B.127. Any events that require an insurer to commit assets in support of related-party guarantees, letters of credit, or other agreements requiring some form of security, which may lead to a lack of liquidity, should be considered.

~~B.96.~~B.128. Although the standard approach to economic capital modelling tends to treat legal entity boundaries as largely irrelevant and considers aggregate enterprise risk in relation to aggregate capital resources, an insurer's ICM should consider scenarios where capital may not be transferable across legal entities.

~~B.97.~~B.129. An insurer should be able to provide a description detailing the treatment of liquidity risk in the ICM. The following are examples of possible scenarios that should be considered in this description:

- large claims resulting from a single event or a series of contagion events;
- extreme catastrophic events combined with related financial market stress;
- insurer financial strength ratings downgrade (e.g. full letter downgrade or downgrade to non-investment grade levels);
- impact of the requirement to post collateral to counterparties (e.g. as a result of a ratings downgrade, a single large loss or series of losses or a reduction in surplus);
- [inability to effectively implement planned hedging strategies in an illiquid market](#);

- unexpected termination of a material agreement or relationship (e.g. significant reinsurance programme, credit facility);
- a large operational loss event;
- loss of a key distribution channel; and
- impairment of capital markets.

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Attachment C: Information Request

Introduction

- C.1. In order to properly consider an ICM application, the Authority will rely heavily upon documentation relating to the ICM. The insurer will need to provide complete and timely responses to all quantitative and qualitative information requests made by the Authority. This section is intended to provide guidance on the information that will be requested.
- C.2. While some of the general principles of the Authority's ICM review process are included in this section, the guidance provided below is meant to be used in conjunction with the ICM guidance outlined throughout this document. Each ICM will be assessed using the criteria set out in the guidance relating to the affirmation statements, and therefore it is envisioned that the information submitted to the Authority in relation to an ICM application will address these criteria to the extent possible.
- C.3. The information request will comprise three parts and will include:
- **Documentation** - request to be completed at the time of application aimed to capture existing documentation on structure, use and specifications of the ICM, as well as reports and meeting minutes that are associated with the model;
 - **Numerical tests** - set of tests that the Authority asks all applying insurers to run on its ICM, which should be completed soon after the application is submitted. These tests are aimed to verify the workings and sensitivities of the ICM and to provide a common platform to compare different ICMs; and
 - **Additional tests** - conditional on the type of models the insurer uses, the Authority might ask for additional technical or numerical tests to be run that are more tailored to these models.
- C.4. In addition to the information request outlined above, the Authority reserves the right to post supplementary requests to be completed from time to time during the course of the review process to further assist in the evaluation of an insurer's ICM. The Authority will request these documents as needed for the review process.
- C.5. Ideally, the package to be sent in response to the Authority's information request should exclude irrelevant information in order to ensure that the application is appropriately focused and easily navigable.
- C.6. If the application is not complete in all essential aspects, or if any significant doubt exists in this regard, the application may not be considered complete and therefore may not enter the formal assessment process. Any decision by the

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Authority not to proceed with the formal assessment of the application will be accompanied by the reasons thereof. However, the Authority will aim to provide an indication of the necessary steps the insurer should follow in order to achieve a complete application.

- C.7. While the information request outlined should be applicable in most cases, the Authority understands that there may be unforeseen instances where certain aspects may not be applicable or feasible. In these exceptional cases, the Authority will work with the insurer in determining an appropriate information request.

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Documentation

C.8. The components of the standardised documentation request are as follows:

- model documentation;
- reports generated by model outputs;
- Board and senior management presentations and meeting minutes;
- policies, processes and procedures governing model use;
- prospective model developments; and
- independent validation reports.

C.9. The following paragraphs further clarify what each component of the request should cover and how each piece of information will be used in assessing the ICM against criteria set by the Authority. Each section below includes a description of its context within the ICM review process and its components.

Model Documentation

Context

C.10. Since ICMs often tend to be very complex, sound model documentation is essential to reflect the insurer's commitment to governance, a sense of continuity in the modelling process and a common understanding of the model's strengths and weaknesses.

C.11. The Authority expects the documentation to be sufficiently comprehensive and provide a level of detail sufficient to facilitate independent review and validation, as well as the Authority's review.

Components

C.12. Documentation should include both non-technical and technical aspects, with explanations of the adequate linkages between different parts. It is recommended that documentation be modular in form and provided at the overall level. Components are specified below.

Index of Documentation

C.13. The model documentation should include an index which maps the sections from this information request to the model documentation.

Responsible Individuals

- C.14. The model documentation should include a list of individuals (or a committee) with ownership, responsibility and authority over the model. The intention is to show that there are individuals accountable for the ICM and not a diffused ownership of the model. The individuals' contact information, roles on the team, relevant qualifications and experience should also be included. In addition, the insurer should provide an organisational chart showing the group structure, in particular as it relates to the model. Any relationships between individual entity models should also be described.

Description of Business Purpose

- C.15. The model documentation should include a description of the business purpose of the model. The description should provide insight into how the model is used in the wider context of the insurer's business. Potential uses include:

- allocation of capital to business segments, risk categories and lines of business;
- determination of hurdle rates of return for pricing and underwriting guidelines;
- determination of marginal capital or hurdle rates of return for large or special accounts;
- profit and loss attribution;
- design and evaluation of risk appetite;
- management of risk limits and portfolio composition;
- assessment of outward reinsurance strategies;
- development and evaluation of business plans, including new lines of business or new areas of risk;
- capital management;
- determination of investment policies and strategies; ~~and~~, including hedging;
- management action to be applied in the business;
- strategic considerations such as M&A and divestitures;
- objective setting and performance assessment; ~~and~~
- preparation of Commercial Insurer Solvency Self-Assessment Report or Group Solvency Self-Assessment Report.

Description of Business Covered by Model

C.16. Model documentation should include a description of the liabilities and assets covered by the ICM. At a minimum the description should include the following areas:

- key features of each product line, main risk exposures and treatment of embedded financial options and guarantees;
- summary of liability data split by product line to show the composition of the business and relative proportions of each product; the data may include account values, technical provisions, face amounts, and policy counts;
- overview of new business modelled and any material differences between new business and in-force exposures;
- overview of asset portfolios and description of invested asset types;
- summary of initial asset balances split by asset type, asset quality, and asset maturity; and
- reasoning and justification to support any exclusions of liabilities and/or assets from the ICM.

Scope of Risk

~~C.16.~~C.17. Model documentation should also include a discussion of the risk types covered in the model, as well as the perils and exposures covered by the model.

~~C.17.~~C.18. As outlined in the guidance relating to the affirmation statements, the Authority would like to see the following core risks covered by the model:

- insurance risk ~~(catastrophe risk, underwriting risk, and reserving risk);~~
- market risk;
- credit risk;
- operational risk; and
- liquidity risk, to the extent captured in the ICM;

~~C.18.~~C.19. If certain risks are considered non-material for the purposes of inclusion within the ICM, model documentation should cover justification of their exclusion.

~~C.19.~~C.20. For insurance risk, the modelling should be performed at a granular level. In the spirit of the use test, the Authority will not prescribe the specific lines of business to be modelled. However, the segmentation should be ~~somewhat~~

consistent with how the insurer prices, underwrites and manages its business. The Authority requires that modelling results be submitted at the same level of granularity used to calculate capital requirements within the model. Furthermore, the insurer's lines of business should be mapped to Bermuda statutory lines of business for further analysis and benchmarking purposes.

~~C.20.~~C.21. In addition to these risk types, model documentation should cover other risks that the insurer considers material to its business, and the treatment of these risks should be specified.

Mathematical Structure / Logical Flowcharts

~~C.21.~~C.22. The Authority expects that the model documentation will include explanations and exhibits demonstrating the mathematical structure of the model. Insurers should aim to include the rationale for why a particular structure is chosen. Exhibits should include formulae, distributions and dependencies used in the model.

~~C.22.~~C.23. The insurer's description of the ICM's structure should include an overview of its components and the various steps in the model. Logical flowcharts should illustrate how the different components of the model flow together and include interaction with external models and data.

~~C.23.~~C.24. It will be helpful to include a description of mathematical methods used in the model, [including the models used to generate economic scenarios as applicable](#), and the underlying theories of the methods. An insurer should aim to provide a rationale for choosing a specific method, and the description of the methods used should be in mathematical terms, not excerpts of computer code, except where such code is easily self-explanatory and concise.

~~C.24.~~C.25. A description of ~~dependency structures~~[the way dependencies and interactions between risks are captured](#) in the ICM should also be included. Dependency structures should be described for both the dependency between risk categories (e.g. between insurance risk and market risk) and the dependency between components within risk categories (e.g. between claim costs in different lines of business or between asset classes in market risk). Dependencies between model components, even when there is no statistical dependency structure defined (e.g. causal drivers), should also be described.

[Modelling of Management Actions](#)

[C.26. The model documentation should include details of assumed management actions which are coded into the ICM, for example:](#)

- [investment and disinvestment strategies;](#)
- [establishment of non-guaranteed policy or contract elements \(e.g. crediting rates, non-guaranteed charges, policyholder dividends, etc\);](#)

- [revision of reinsurance or retrocession arrangements;](#)
- [hedging programmes; and](#)
- [changes to revenue, expense and tax sharing agreements with other parties.](#)

[C.27. In addition to specifying the modelling approach, the documentation should also provide justification for the assumed future actions by reference to Board approved policies and procedures, or past evidence of similar actions in similar circumstances.](#)

IT Platform and Contingency Policies

[Є.25.C.28.](#) There should be adequate information about the platform on which the model runs, the storage of the model's previous runs, the storage of model data and contingency plans.

[Є.26.C.29.](#) Information about the ICM version control and an audit trail of internal model changes should be specified, and procedures to maintain systems security should be identified.

[Є.27.C.30.](#) The insurer should provide its plans and procedures for emergency situations, and should demonstrate that the model could return to operations without undue delay. Information about the backup and recovery of the system should also be included.

Calibration and Parameter Estimation

[Є.28.C.31.](#) The documentation should explain [the underlying methodology used to calculate the ECR \(if not 99% TVaR\), definition of the underlying balance sheet \(if not economic\) and](#) how the ICM is calibrated (e.g. metrics used, confidence level targeted, time period considered, assumptions made) as well as how the parameters are estimated.

[Є.29.C.32.](#) The Authority expects the ICM to reflect at least a 99% TVaR metric with one year of new business and ~~the run-off to extinction of all liabilities~~[reserve development over a one year time horizon.](#) If the ICM is calibrated using an alternative risk measure or time period, the insurer will need to demonstrate that the selected approach is at least as prudent.

[Є.30.C.33.](#) If parts of the ICM are designed or calibrated based on expert judgment, the documentation should detail this. The insurer should explain and support any expert judgments made, providing analysis where appropriate. Any documentation or records of approval by senior management on the use of expert judgment in model building should also be included.

[Є.31.C.34.](#) A discussion of the data used in the sample analysis to calibrate parameters of the model should be included in the model documentation.

Credibility of the data used for calibration should be established, and the model documentation should discuss these points.

~~€.32.~~C.35. The Authority encourages firms to consider parameter risk in the ICM, in particular when modelling ~~underwriting risk and reserve risk for~~[risks associated with](#) long-tail classes of business. Ideally, parameter uncertainty should be considered in the modelling process, either through sensitivity testing, explicit modelling and/or other methodologies, for the most material and capital-sensitive model parameters.

~~€.33.~~C.36. Model documentation should cover the techniques used in parameter estimation and results of statistical fit analysis, including ~~;~~[as applicable:](#)

- diagnostics from maximum likelihood estimation, standard errors, p-statistics, as appropriate;
- goodness of fit tests;
- graphical displays showing data; and
- timelines and graphs showing performance through time.

~~€.34.~~C.37. Model documentation should include a list of selected parameters, including brief commentary on justification of selections. This list should include the [relevant data used to calibrate the model \(e.g. loss ratios by line of business used to calibrate the model, where applicable\)](#). In addition to the selected ~~loss ratios~~[parameters](#), the insurer's historical ~~loss ratios~~[experience data](#) should be provided by line of business, as far back as this information is available.

Model Inputs

~~€.35.~~C.38. The model documentation needs to demonstrate what the inputs to the models are and how they are fed into the model. These inputs should cover regular data feeds (e.g. interest rates, exposure data for reinsurance contracts) as well as inputs from third-party vendor tools (e.g. vendor catastrophe models, economic scenario generators).

~~€.36.~~C.39. The insurer should indicate major data items used, including their source, characteristics and model application.

~~€.37.~~C.40. The Authority will pay close attention to the quality of data used and the processes employed by the insurer to clean and verify data. Model documentation should include assessments of data accuracy or exhibits which demonstrate the reasonableness of data accuracy. [The documentation should describe any delays in receiving data, such as market or current exposure data, and discuss what adjustments are made, if any, in the model to account for those delays.](#) It should also include any tests run to demonstrate the accuracy of the data, and any weaknesses of the data should be noted and explained.

€.38.C.41. In addition, the model documentation should indicate where expert judgment plays a major part in determination of the model inputs and controls around these decisions.

Model in Application

€.39.C.42. The model documentation needs to demonstrate the relevant outputs of the model, including intermediary outputs, and how they are applied to business uses. Any links between the output of the model and the risk and capital management of the insurer should be noted. Processes (e.g. underwriting, pricing) that interact with the ICM or use its output should be indicated.

Reports Generated by Model Outputs

Context

€.40.C.43. Output from the internal model is expected to be presented in a concise and organised fashion in reports. It is expected that the output from each major module of the model will be included in order to allow independent reviewers to follow how the final capital requirement is calculated. The Authority will review reports generated to assess how widely ICM outputs are used throughout the insurer's organisation and whether the ICM serves a critical role in the development, implementation and monitoring of management strategies.

Components

List of Reports Generated

€.41.C.44. A list of key reports generated by the model outputs should be provided. As not all business applications demand or need firm-level consolidation, the Authority expects that many reports will focus on particular risk types or lines of business. Although ICM modules may vary from insurer to insurer, modelled risks will typically include at least the following: [catastrophe, underwriting, reserving insurance](#), market, credit ~~and~~, operational [and liquidity, including the relevant sub-categories of risks as identified elsewhere in this guidance](#).

Content of Reports

€.42.C.45. The insurer should include a high-level overview of the content of the reports and what information they are providing for interpreting model outputs.

Audience and Frequency of Reports

€.43.C.46. The insurer should also indicate the audience targeted by the reports and how frequently the reports are published.

Board and Senior Management Presentations and Meeting Minutes

Context

| ~~€.44.C.47.~~ The Authority believes that the ICM should be an integral part of the development and implementation of business strategies and risk management processes of the insurer. Therefore, it is important that the insurer demonstrates the involvement and comprehension of senior management in the design and use of the ICM.

| ~~€.45.C.48.~~ The insurer should also be able to demonstrate that an adequate understanding of the ICM's key elements, including the implications of its outputs and its limitations for risk and capital management decisions, exists at appropriate levels within the organisation.

Components

Approval on Development of Model

| ~~€.46.C.49.~~ Documented approval by the Board or relevant Board committees of the development and use of the model should be included in either presentations or meeting minutes. The Board of the insurer ~~shouldis~~ ultimately ~~be~~ responsible for the integrity of the ICM, the placement of proper management and controls around the development and use of the ICM and ensuring that the ICM plays a key role in the insurer's business. [Evidence will be required of the formal Board approval of the ICM for use within the insurer.](#)

Regular Reporting of Results

| ~~€.47.C.50.~~ Records of Board presentations or Board meeting minutes should demonstrate a regular reporting of results from the internal model to the Board, relevant Board committees, and senior management and an appropriate level of discussion relating to the ICM and its outputs.

| ~~€.48.C.51.~~ The Board should be provided with enough information regarding the design and application of the ICM so that they appropriately understand the nature of the model, what it aims to do and the implications of the results for the business.

| ~~€.49.C.52.~~ It is essential that the Board receives up-to-date information regarding the model's performance and all material amendments. The insurer's risk management unit, or the group of employees responsible for the development, maintenance and operation of the ICM, should be responsible for ensuring the on going appropriateness of the design and application of the ICM, and that processes are in place to amend and refine the ICM as an insurer's risk profile changes.

| ~~€.50.C.53.~~ This section may also include feedback from the Board and senior management on the applications of the model or on future developments of the model.

Use in Decision Processes

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| ~~C.51.~~C.54. The Authority will also aim to confirm that the ICM is used in the decision processes of the insurer, including strategic decisions on capital budgeting and risk management functions.

DRAFT

Policies, Processes and Procedures Governing Model Use

Context

- | ~~€.52.C.55.~~ It is essential for the Authority to have documentation of the insurer's policies, processes and procedures in order to understand the full context of model use and model application.
- | ~~€.53.C.56.~~ The policies, processes and procedures governing model use should be appropriate to the insurer's business and explicitly agreed on to ensure smooth maintenance of the model as the insurer's business and the market environment evolves. They should be in written form with proper approvals and known by all relevant stakeholders. Ideally, the development of these policies, processes and procedures is overseen by a committee of model users, developers and management.
- | ~~€.54.C.57.~~ The insurer should demonstrate or provide evidence that these policies and processes are enforced in practice. This may include potential discussions between the Authority and the insurer's internal audit group.

Components

Detailed Descriptions of Formal Policies

- | ~~€.55.C.58.~~ The insurer should include detailed descriptions of the formal policies governing model use. These may include policies regarding ICM data, security, ownership, change, and validation. The insurer should specify the required authorisations for approving changes in policy, processes and procedures.

Roles and Responsibilities with respect to the ICM

- | ~~€.56.C.59.~~ A specific control policy should be in effect ensuring that an appropriate segregation of duties is in place between those who are responsible for building, operating and maintaining the ICM and those who are responsible for making decisions based on the ICM's output.
- | ~~€.57.C.60.~~ Access rights to the model associated with these tasks (building, operating, and maintaining) should be clearly defined.
- | ~~€.58.C.61.~~ Clear roles and responsibilities should be in place to avoid key person risks, and reporting lines should be reflective of the roles and responsibilities.
- | ~~€.59.C.62.~~ Guidelines with regards to ICM use for certain processes such as underwriting, pricing and capital allocation should be documented. In addition, there should be mechanisms to enforce compliance with these guidelines, and these should be outlined.

Model Maintenance and Change Policy

- | ~~€.60.~~C.63. The insurer should include its policies governing changes in the model. This should include a process for assessing potential changes against the agreed change policy, standards for version control, timelines governing model changes, the process for updating historical data and other relevant information.
- | ~~€.61.~~C.64. This section should also include information on the procedures that are in place regarding the regular day-to-day operations of the model as well as monitoring procedures.

Validation Policy

- | ~~€.62.~~C.65. A clearly documented policy relating to the independent review of an ICM should exist and aim to verify that the ICM is current, uses reliable and relevant data and is operated and maintained by personnel with adequate expertise and experience.
- | ~~€.63.~~C.66. The validation process should demonstrate that the ICM remains fit for the purposes intended under changing conditions.
- | ~~€.64.~~C.67. Mechanisms for reporting validation results to senior management and responsible individuals should also be included.
- | ~~€.65.~~C.68. The validation policy should indicate the frequency of model validation, techniques to be followed and the parties (internal or external) that carry out the validation.

Data Quality Control Mechanisms

- | ~~€.66.~~C.69. The insurer should demonstrate proper data quality control mechanisms for the input data as well as the data used to calibrate the parameters.
- | ~~€.67.~~C.70. Data control and verification steps should be included for all modules of the ICM, and the insurer should ensure appropriate procedures are followed for each of the modules due to the varying nature of input data used in various modules.
- | ~~€.68.~~C.71. The Authority will pay particularly close attention to the steps followed to verify exposure data for insurance and reinsurance contracts. The inconsistency and lack of standards for exposure data poses difficulty throughout the industry. The insurer should implement processes to minimise the effect of inappropriate modeller judgment in reading and interpreting data.
- | ~~€.69.~~C.72. The insurer should have processes in place to identify red flags and issues about questionable data quality, inconsistencies in data reporting, or an excessive amount of secondary modifiers. In addition, the insurer should ideally identify steps to run sensitivity tests to compare the suspect data of one cedant to a submission from a peer cedant.

Risk Management Policy

| ~~€.70.C.73.~~ The insurer should provide relevant information about the risk management function and its role in the ICM management process.

| ~~€.71.C.74.~~ The policy should indicate how the ICM should be used in the measurement and management of material sources of risk and to evaluate potential action to mitigate unsatisfactory risk exposures.

| ~~€.72.C.75.~~ In particular, the risk management policy should mention risk appetite and return on equity thresholds that the insurer uses to manage its business.

Prospective Model Development Process

Context

| ~~€.73.C.76.~~ The Authority expects that an ICM submitted for approval is in a continuous and enduring process of on-going development and evolution. Therefore, an insurer is expected to have plans set in place for future stages of model development.

| ~~€.74.C.77.~~ Given that an ICM is expected to support the development and implementation of business strategies and risk management functions of the insurer, sufficient resources should be devoted to the prospective model development process.

Components

Processes for Model Update

| ~~€.75.C.78.~~ Details on the processes involved in updating a model should be provided in this section. This section may also include information on the components of the model that need to be updated, the rationale for the update, and possible implications of the update.

Planning, Controls and Timelines

| ~~€.76.C.79.~~ Plans for future model development and timelines for the implementation of model updates should be included and detailed, and internal controls and governance around the process should be outlined.

Authorities, Execution and Approval Structure

| ~~€.77.C.80.~~ Insurers should provide details on the authorities responsible for overseeing the processes for prospective model development, the steps involved in executing the model development process and the structure of approval for prospective model development.

Independent Validation Reports

Context

- | ~~€.78.~~€.81. Independent validation reports are an important part of the review process, as the Authority believes that validation is a critical governance measure that can significantly reduce and mitigate model risk.
- | ~~€.79.~~€.82. Validation of an ICM can give the insurer a degree of confidence that the model is appropriate for the purpose it is used and an understanding of the ICM's strengths and weaknesses, which allows the insurer to better utilise and interpret its results.
- | ~~€.80.~~€.83. Validation tests should be conducted by reliable independent parties (internal or external), and the Authority encourages an independent internal or external review of the development, operation and interpretation of the ICM.
- | ~~€.81.~~€.84. The model validation process should be an on-going and iterative process, and validation tools and processes should be both quantitative and qualitative.

Components

- | ~~€.82.~~€.85. This section lays out the components that independent validation reports should ideally cover. In addition to the components listed below, validation processes such as the frequency of review and the update of key assumptions should be covered as part of the validation report unless they are covered as part of the policies, processes and procedures governing model use, which is discussed above.

Purpose and Scope of Validation

- | ~~€.83.~~€.86. In general, validation reports are expected to be modular in form and should specify which parts of the model are validated. Any parts of the model left out of the validation scope, along with the reasons for their omission (e.g. vendor models), should be specified.

Theoretical Validation

- | ~~€.84.~~€.87. The model validation should check the suitability of model structure, data, and estimation within the insurer's business context.
- | ~~€.85.~~€.88. The theoretical validation should assess appropriateness of the ICM foundation within the industry context, including methodological benchmarking to alternatives and industry best practice. The methodologies, distributions, aggregation techniques and dependencies should be consistent and follow rigorous modelling practices.
- | ~~€.86.~~€.89. The Authority will pay close attention to the soundness of the dependency structures assumed in the ICM due to their potential impact on model results. The

insurer should adequately consider dependencies within and among risk categories and should be able to justify diversification benefits. In addition, the insurer should be able to demonstrate that the ICM satisfactorily captures dependencies between risks during stress testing.

~~€.87.C.90.~~ The theoretical validation should also assess the appropriateness of the parameter estimations made within the model. It should be demonstrated that the parameter estimations are appropriate within the market and industry context and parameter uncertainty is addressed to the extent possible.

Analytical Validation

~~€.88.C.91.~~ The model validation should include an effective statistical process for validating the model which demonstrates that the results of the model are accurate and credible within the tolerance level allowed.

~~€.89.C.92.~~ The validation should check the correct implementation of the model given the theoretical basis, goodness of fit for training data, forecasting capability for out-of-sample observations (backtesting), sensitivity to changes in key underlying assumptions and stability of outputs.

~~€.90.C.93.~~ Backtesting should be applied at various levels of the business activity such as loss ratio or equity volatility.

~~€.91.C.94.~~ Sensitivity analysis should examine whether the model output is sensitive to changes in key assumptions. Sensitivity testing is especially important in validating parts of the internal model where expert judgment is used.

~~€.92.C.95.~~ Validation tests should also check the convergence of the model and should demonstrate variance reduction of the model with respect to the Monte Carlo method. Analysis should demonstrate that model outputs are statistically significant.

~~€.93.C.96.~~ Validation tests should also examine the processes for model performance monitoring.

~~€.94.C.97.~~ Where possible, analytical validation should look for ways to compare ICM results and techniques with peers, available literature and research for benchmarking purposes.

Findings and Future Developments

~~€.95.C.98.~~ The validation report should highlight areas on which the insurer should focus attention for future development and enhancement. The methodology and timeline for improvements should be clearly documented, and any critical flaws should be prominently highlighted.

Numerical Tests

~~€.96.~~C.99. Numerical tests that are designed to check the workings and sensitivities of the ICM will be requested of the insurer at the time the standardised information request is submitted.

~~€.97.~~C.100. The components of the standard numerical tests are as follows:

- baseline model run;
- sensitivity to dependency assumptions between major risk categories; and
- sensitivity to dependency assumptions between lines of business.

~~€.98.~~C.101. The format of the output for the standard numerical tests should include:

- 99% TVaR;
- exceedance probabilities (EP curve) found at 1%, 2%,..., 98%, 99%; 99.5%; 99.9%; and
- Monte Carlo trials corresponding to above (if applicable).

~~€.99.~~C.102. The paragraphs below lay out further detail on the context, model settings and output categories of the numerical tests the Authority will ask an insurer to run on their ICM.

~~€.100.~~C.103. Although the numerical tests are constructed with consideration to a typical capital model, the Authority recognises that some of these tests might not be applicable to all ICM structures (e.g. the ICM might not follow a statistically-imposed correlation structure but is instead based on copulas). In this case, the Authority will work with the insurer to define an equivalent test for the ICM's structure.

Baseline Model Run

Context

~~€.101.~~C.104. The Authority will require this output to determine a firm's baseline capital calculation under the ICM approach. This data will also facilitate meaningful comparisons for the tests defined below.

Model Settings

~~€.102.~~C.105. Run the ICM with business as usual settings.

Output Categories

~~€.103.~~C.106. Required output for this run includes:

- aggregate group- and/or entity-level output, as applicable, including a breakout by major risk category (i.e. ~~catastrophe, underwriting, reserving insurance~~, market, credit, and operational risk) and line of business (by both insurer-defined business classes and those classes mapped to the Authority's statutory lines of business when possible).

Sensitivity to Dependency Assumptions between Major Risk Categories

Context

~~€.104.~~C.107. Many capital models incorporate dependencies between major risk categories. This test is designed to assess the degree of dependence, hence diversification benefit, inherent in the ICM's structure and parameterisation with regards to the major risk categories of ~~catastrophe, underwriting, reserving insurance~~, market, credit, and operational risk.

Model Settings

~~€.105.~~C.108. This test builds on results from the baseline run and requires two additional runs:

- dependencies between all major risk categories set to 0; and
- dependencies between all major risk categories set to 1.

Output Categories

~~€.106.~~C.109. Required output for this test includes:

- aggregate group- and/or entity-level output, including a breakout by major risk category, for each run associated with the two specified model settings.

Sensitivity to Dependency Assumptions between Lines of Business

Context

~~€.107.~~C.110. Many capital models incorporate dependencies between lines of business. This test is designed to assess the degree of dependence, hence diversification benefit, inherent in the ICM's structure and parameterisation with regards to lines of business.

Model Settings

~~€.108.~~C.111. This test also builds on results from the baseline run and requires two additional runs:

- dependencies between all lines of business set to 0; and
- dependencies between all lines of business set to 1.

Output Categories

~~C.109.~~C.112. Required output for this test includes:

- aggregate output for relevant major risk categories (i.e. those that are modelled by line of business), including a breakout by line of business (by both insurer-defined business classes and those classes mapped to the Authority's statutory lines of business when possible), for each run associated with the two specified model settings.

Additional Tests

~~C.110.~~C.113. The Authority might ask for additional technical or numerical tests to be run based on the unique model types or risk profile the ICM employs. These additional tests will be based on the insurer's exposures and sensitivities that will be identified after the information submitted is reviewed.

~~C.111.~~C.114. Below are examples of potential additional tests that the Authority might ask to be run based on risk types and model structures:

	Typical risks	Model structure	Anticipated / potential tests
Insurance risk - General	Facultative placements	Simple frequency severity collective risk model	- Goodness of fit metrics - Q-Q plots, graphical comparisons - Impact of parameter uncertainty - Peer review and governance
	Aviation, crop, wildfire, marine, etc.	Bespoke structural models	- Data support - Backtesting - Impact of parameter uncertainty / systematic risk
	Earthquake, windstorm, terrorism, etc.	Catastrophe models	Sensitivity tests
	Long-tail liability exposures	Multi-period casualty reserve run-off	- Goodness of fit - Tests for parsimony - Impact of parameter uncertainty
Insurance risk – Long-term	Adverse policyholder behaviour	Dynamic assumptions (linked to market performance or other potential drivers of behaviour)	Experience analyses, showing goodness of fit Sensitivity analyses (e.g. assuming rational behaviour)
	Adverse mortality / morbidity	Assumptions set according to individual policy attributes	Experience analyses, showing goodness of fit Sensitivity analyses (e.g. alternative trend in older age mortality)
	Management action not achieved	Dynamic assumptions	ECR with no / alternative future management actions in response to adverse conditions
	Hedge ineffectiveness	Varied	ECR with no hedging ECR with 100% assumed hedge effectiveness Sensitivity analyses with alternative hedge strategies (e.g. higher cost, alternative instruments due to market illiquidity) Analyses of historical hedge effectiveness

	<u>Typical risks</u>	<u>Model structure</u>	<u>Anticipated / potential tests</u>
Market risk	Bonds, equities, swaps, commodities, property, etc.	Value-based single-period VaR models	▪ Data support ▪ Implied correlations ▪ Allowance for extreme outcomes
		ESG-based simulation models	▪ Implied Greeks ▪ Calibrations to market ▪ Benchmarking
Credit risk	Accounts receivables, some structured securities, reinsurer / retrocessionaire counterparty exposures	Simple single period PD/LGD/EAD framework	▪ Data support
		Correlated Merton-based structure	▪ Data support
		Multi-period migration models	▪ Data support
Operational risk	People, processes, and external events	Simple factor-based frameworks	▪ Outside-in comparisons
		Internal data driven loss models	▪ Goodness of fit
		Scenario / expert opinion-based frameworks	▪ Sensitivity tests

C.112.C.115. Additional numerical tests may also include model output for a set of specified insurance contracts, or benchmark portfolios, so the Authority may directly compare corresponding measures of standalone risk across various firms' ICMs.

C.113.C.116. Depending on the results of the standard numerical tests and the methodologies employed for aggregation and dependency structures, the Authority may also require additional tests to verify that dependencies between risks are sufficient in extreme scenarios, or tail events.