ACTUARIAL ASPECTS OF INTERNAL MODELS FOR SOLVENCY II

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ABSTRACT

The draft paper sets out the authors' views of what good practice for the actuarial aspects of internal models will look like in 2012, the year Solvency II is expected to be implemented. Actuaries working on internal models can expect to have to follow such practices if their internal models are to be approved for use in calculating regulatory capital. The paper is therefore relevant for actuaries who plan to work on internal model implementation for Solvency II.

Moreover, the risk quantification techniques discussed in the paper can also be used in the Own Risk Solvency Assessment (ORSA) process also required by Solvency II. The paper is therefore relevant to actuaries working in companies that are not planning to apply to use an internal model.

The paper covers both life and non-life insurance and reinsurance, and reviews current practice as well as setting out possible future practice. This leads to identification of areas for research by the profession to prepare for 2012 and an indication of the directions this work might take.

The paper is effectively a work in progress, and readers should ask themselves what they should do in response to the ideas discussed.

The authors are in the process of updating the paper and the reference material, which will be completed prior to its publication in the British Actuarial Journal.

KEYWORDS

Solvency II; Regulatory Model Approval; Capital Models; Economic Capital; Diversification and Co-Dependency of Risks; Time Horizon; Extreme Events; Group Risk: Data Quality: Expert Judgement: Model Use Test; Model Statistical Quality Test; Model Calibration Standards: Model Profit and Loss Attribution: Model Validation; Model Documentation

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1. INTRODUCTION

1.1 Approach

1.1.1 The authors (‘we’, ’our’) have considered the actuarial aspects of internal models, anticipating what good actuarial practice will look like in 2012 – the expected implementation date for Solvency II. The authors have compared this with current practice and have highlighted key areas for future research. To the extent that products and business context varies to some degree from country to country, the authors have focused on business underwritten in the United Kingdom (U.K).

1.1.2 The authors include life and general insurances actuaries, with consulting, insurance company and supervisory experience. The authors experience includes work on Individual Capital Assessments (ICAs), realistic balance sheets, and Solvency II gap analysis and implementation. We first identified the elements of internal models that have the most significant actuarial components for discussion in this paper. We then discussed the current situation and possible future directions for actuaries in dealing with those aspects of internal models. We arrived at some conclusions regarding likely good practice in 2012. To focus our discussion and provide a basis, further work in this area we pushed to reach ‘conclusions’ even when the situation is uncertain.

1.1.3 Thus ‘good practice in 2012’ outlined in this paper should be understood in the following context:

(1) It is a framework for further discussion and research.
(2) It is a “working draft”, not a “final product”, as the state of the art does not permit more at this time.
(3) We developed some aspects more fully than others.
(4) While this is a group effort, not every view is fully held by every author.
(5) In all cases, the views are from the authors as individuals, and are not views of their respective employers.

1.2 Key points from the paper

1.2.1 In the view of the authors, the main areas where the profession should focus attention in the immediate future are:

(1) diversification and co-dependency of risks;
(2) time horizon over which to measure risks;
(3) extreme events;
(4) group risk; and
(5) data quality. (Part of statistical quality standards).

1.2.2 During the writing and discussion of the paper, the authors came to the conclusion that:

(1) Life insurance and general insurance are not very different when looked at from a capital modelling / risk management perspective. The approach of modelling cash-flows, as encouraged by Solvency II, brings the two areas into the same modelling space.
(2) A consequence of this is that life insurance and general insurance actuaries have much to learn from each other. During the development of this paper, the authors have definitely learned from the other practice areas, and realised that ideas from each have possible applications in both fields.
(3) That said, there are differences in risk characteristics between products. The paper focuses on the risks that are more problematic, regardless of type of business. For example, underwriting risk is more problematic for general insurance products and asset-related risks are more problematic for life insurance products.

1.3 Background

1.3.1 Some actuaries may have limited knowledge of Solvency II, the proposed new prudential supervision system for insurance companies in the European Union (E.U.). This paper is not an 'Introduction to Solvency II', however, and assumes the reader has a reasonable amount of knowledge of Solvency II.

1.3.2 In particular we assume readers are aware that the draft E.U. Directive titled *On the taking up and pursuit of the business of Insurance and Reinsurance,* July 2007, amended February 2008 ("the Directive", "the Framework Directive" or "Solvency II") provides that, subject to approval from the appropriate supervisors, insurers can use 'internal models' to determine their Solvency Capital Required (SCR), rather than using the Standard Formula, for all or some of their business. A company can choose to use an internal model or the supervisor may require that a company develop and use an internal model.

1.3.3 The Financial Services Authority (FSA) has spent much time and energy explaining the details of Solvency II to the UK insurance industry, for example in their discussion paper "*Insurance Risk Management: The path to Solvency II*" ("DP08/4"). The FSA emphasises that the proposed regime should be considered in its entirety, rather than focussing on one aspect. In particular, the FSA has explained that the regime is about much more than one number – the Solvency Capital Requirement (SCR) – and that governance requirements around risk management are just as important.

1.3.4 Having said that, many UK insurers are interested in the part of the Framework Directive (2008) relating to internal models. This reflects companies' beliefs that quantifying capital requirements themselves, based on their own assessment of their risks, is likely to produce a more realistic, risk-based answer. Many firms are therefore preparing for the implementation of Solvency II on the basis of applying for approval to use their own internal model to assess the SCR.

1.3.5 At the time of writing there is little information beyond the Framework Directive text as to what the approval process or approval standard is likely to be. In DP08/4 the FSA set out its views on the Framework Directive text and propose a "pre-approval" process for UK companies. The Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) has recently published a "Stock-take Report" (2009) on internal models, although this will came too late for detailed discussion within this paper.

1.3.6 There is an expectation that actuaries will be involved in the development of internal models for Solvency II, building on the involvement of many members of the profession in developing models for the U.K. Individual Capital Adequacy Standard (FSA, DP08/04). The draft Framework Directive sets out the responsibility of the risk management function and the Board of Directors for the main aspects of the internal model. However, it would seem reasonable that the actuarial profession will be a key player in the development and implementation of internal models, particularly in the development of the risk quantification elements. The recent publication of the Board for Actuarial Standards (BAS) Consultation Paper on actuarial models (BAS, 2008) provides guidance on models that will affect actuarial practice for Solvency II internal models.

1.3.7 This paper is concerned with technical matters rather than professional ones. The governance issues around internal models, and indeed the governance of an insurance company and its risk management framework fall outside the main scope of this paper, although they are clearly important. When designing and using models, including when applying sense checks to the emerging results and conclusions drawn, the importance of human factors such as the power of incentives and the natural tendency to underestimate the likelihood and severity of tail events should always be borne in mind.

What is an internal model?

1.3.8 The Framework Directive (2008) does not define an internal model. The International Association of Insurance Supervisors (IAIS), however, has provided Guidance and Standards for internal models. The IAIS Standard includes the following definition of an internal model, based on the definition in the Groupe Consultatif / CEA Glossary:

> "[An internal model is] a risk measurement 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. Internal models may also include partial models which capture a subset of the risks borne by the insurer using an internally developed measurement system which is used in determining the insurer's economic capital (IAIS, 2008).

Six tests / standards

1.3.9 The draft Framework Directive (2008) sets out six tests or standards that the internal model must meet for the supervisor to give approval. These are:

(1) use test;
(2) statistical quality standards;
(3) calibration standards;
(4) profit and loss attribution;
(5) validation standards; and
(6) documentation standards

1.3.10 Underlying all of these tests/standards is a requirement for the firm to have adequate risk management systems.

1.3.11 Thus, under the definition above, the overall internal model process is much wider than a capital calculation "engine" and reflects the importance of the methods by which parameters are developed and how the output is used in the company's decision-making and risk management framework. A successful internal model will involve the integration of expertise across many disciplines. By 'actuarial aspects' we mean the areas in which we expect that actuarial input will be an important component of the overall implementation and on-going operation of an internal model.

Own Risk Solvency Assessment (ORSA)

1.3.12 In addition, the draft Directive (2008) creates the requirement for, and CEIOPS plans to develop, implementing regulations, for all insurance undertakings to evaluate their own risks and determine whether they have sufficient capital Own Risk Solvency Assessment ('ORSA'). Internal models are not required for that purpose, but might be used as part of a company ORSA. Thus even companies that do not plan to use internal models for SCR purposes, may still need suitable internal models for ORSA purposes also required by the Framework Directive (2008).

Other work on internal models

1.3.13 Internal models are the focus of attention from legislative, actuarial and industry bodies and there are numerous working papers, guidance notes, etc., from sources including the following:

(1) European Legislation and Regulation - The European Parliament (Draft Directive (February 2008) and amendments (October 2008)), Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS);
(2) global Advisers on Regulation - International Association of Insurance Supervisors (IAIS);
(3) actuarial - the International Actuarial Association (IAA), Groupe Consultatif, and national actuarial bodies;
(4) industry organisations - Chief Risk Officer Forum (CRO) and Chief Financial Officers Forum (CFO), CEA; and

(5) actuarial standard setting bodies, e.g., (U.K.) Board of Actuarial Standards (BAS) and potentially actuarial bodies in other countries.

1.3.14 For example, the IAA is preparing high level guidance on internal models. The most recent material considered by the IAA working group is a draft discussed at the November 2008 IAA Solvency Committee meeting in Cyprus. Groupe Consultatif is preparing guidance for actuaries Europe-wide. The most recent paper from them considered by this working group is a draft prepared in October 2008.

1.3.15 There are new publications on internal models almost daily, from consulting firms, supervisors or in professional or trade magazines. The authors have reviewed as many of these publications as possible in preparing this paper.

1.4 Structure of this paper

1.4.1 This paper is positioned as a first report card on the pertinent actuarial aspects. We recommend that the Profession arrange to continue to update this report card as the practice of internal model implementation continues to develop over the next few years.

1.4.2 In the main body of our paper we have focused on the five key issues identified above that we consider present the most substantial challenges for our profession given the subjectivity in their application and/or materiality to capital assessments. For each issue, we set out:

(1) What we consider good practice might look like in 2012.
(2) Our view of the research required and barriers to good practice.
(3) A description of current practice based on the author's experience.

1.4.3 The authors hope that this approach will be helpful for actuaries developing internal models for Solvency II. In particular, we hope that, by setting out our view of what the world might look like in 2012, we will stimulate debate and discussion about the key issues and best practice for dealing with them.

1.4.4 In Appendix A we consider the elements of an internal model organised as follows:

A - Capital and balance sheet
B - Risks included
C - Model structure
D – Approval Criteria

1.5 The current status of risk assessment in the financial services sector and the relationship to internal models

1.5.1 The recent upheaval in the financial markets has triggered reviews of the risk and capital management practices in the banking community.

1.5.2 While technical issues differ between banking and insurance, there are conceptual similarities.[1] In developing this paper we considered the work presented by groups including the Financial Stability Forum and the Senior Supervisors Group (SSG, 2008)..

1.5.3 The SSG points out the value of models when they are used by a management group that is aware of the models' limitations, and where the management group has a deep understanding of its business.

1.5.4 The Working Party wholeheartedly supports these observations. Financial modelling can be used to investigate and try to quantify risk. It is not an end in itself and requires expert judgement – by senior management, actuaries and other risk professionals – in the use of the model and indeed in the assumptions used in the model.

1.5.5 At the time of writing, the turmoil in the financial world is giving rise to a challenge to many aspects of accepted wisdom, especially in relation to financial instruments, the regulation of financial institutions, and the confidence placed on models of all kinds. See, for example, the lecture given by Lord Turner, Chairman of the FSA, on 21 January 2009 on the financial crisis and the future of financial regulation (2009). Some of the themes of this lecture are clearly relevant to insurance, such as the need to introduce an element of anti-cyclicality, and regulation according to economic substance rather than legal form.

1.5.6 Nonetheless, the authors believe the discussion in this paper on the actuarial aspects of internal models will remain relevant.

[1] For example, there are parallels between the LMX spiral of the early 1990s, whereby an attempt to spread risk resulted in an unintended concentration of risk, and the more recent use by banks of complex instruments to spread credit risk, with disastrous consequences

2. DIVERSIFICATION AND CO-DEPENDENCY OF RISKS

2.l Introduction

> "We would expect firms' internal models to [be able to justify the selected]…correlations, aggregations and dependencies, as well as allowing for diversification benefits in their assessment of capital requirements and also to take account of fungibility restrictions.
>
> Firms should recognise that co-dependencies between risks are not consistent throughout the distribution – in particular, co-dependency is likely to be substantially higher in the tail of the distribution (and indeed, may not exist at all at lower levels)" (FSA, 2008:36).

2.1.1 The analysis of co-dependencies can be built up in stages:

(1) The effect of pooling many similar risks reduces certain types of variability.
(2) The effect of combining different risks can also reduce variability through diversification.
(3) Nonetheless there are systemic connections between similar risks and correlations between different risks so there are limits on the extent to which risk can be reduced.
(4) Then consider the likelihood that risks may become more, or less, correlated as one or both become more extreme. For example, if the equity market collapses to near zero, then the corporate bond market would not be far behind. More plausibly, if the equity market were to fall 30% there may be more likelihood of the corporate bond market falling (or rising) than indicated from an analysis of bond movements when equity falls of 10% or less occur.
(5) Lastly consider whether the co-dependency is affected by the order in which the risks occur.

2.2 Good Practice in 2012

2.2.1 Co-dependencies between long standing risks are rigorously investigated at low stress levels. The confidence interval around the co-dependency is also investigated. Categorising co-dependencies as 'high', 'medium', and 'low' is limited to situations when there is no more accurate approach.

2.2.2 Uncertain co-dependencies for material risks are examined with a causal approach as well as a statistical approach. The causal approach may be judgemental but should rely, where it can, on solid analysis. The approach should consider scenarios that might test whether there will be shifts in co-dependencies that have a material impact on the indicated capital.

2.2.3 These co-dependencies are used in business planning and assessing profit volatility, work that often requires investigation of stresses in the 1 in 10 to the 1 in 25 range.

2.2.4 Co-dependencies between new risks and existing risks are checked by analysis of similarities to other existing risks.

2.2.5 Co-dependencies in high stress situations, 1 in 200 and beyond, consider the following:

(1) analysis of historical or modelled extreme event data to the extent that it exists;
(2) use of the more credible mid-range co-dependencies;
(3) analysis of the possible causal drivers of co-dependencies in the mid range and in extreme events;
(4) experiences in other markets;
(5) the price of market instruments or contracts subject to similar co-dependencies; and
(6) materiality of the assumptions.

2.2.6 Parameter uncertainty is recognised in both the confidence in the results and the reverse tests of the likelihood that the assumption is wrong or another assumption is equally valid.

2.2.7 Scenario and sensitivity tests are routinely produced that investigate shifts in co-dependencies and any associated non-linear impacts.

2.2.8 Where the underlying assessment of liabilities relies on co-dependencies (such as "with profits" liabilities) the internal model uses co-dependency assumptions that are consistent with the liability assumptions.

2.2.9 Co-dependencies are applied in a way suitable to the risks being combined. A covariance matrix is used for risks that are normally distributed or otherwise satisfy the assumptions for use of covariance matrices. Copulas or other techniques are used for risks where underlying distributions do not necessarily satisfy the assumptions for use of covariance matrices, bearing in mind purpose and materiality.

2.2.10 The method of derivation of the co-dependency assumptions is reviewed to determine whether the co-dependency assumptions themselves need to be subject to a further stress, as is any other material assumption.

Co-dependency, Fungibility

2.2.11 Modelling of fungibility constraints becomes part of the economic capital model rather than allowed for as an end piece adjustment. (Fungibility refers to constraints on the movement of capital that can arise within a legal entity, e.g. with-profit funds, or between legal entities in a group. Constraints also include company specific limits on capital movement.)

2.2.12 Fungibility constraints do not affect co-dependency of risks. Favourable effects of diversification, however, do not reduce required capital unless the capital can be freely 'moved' between risks. Adverse affects of co-dependencies, on the other hand, are considered regardless of fungibility.

2.3 Research & Barriers

2.3.1 We consider that more research should be undertaken into theoretical approaches to allocating diversification benefits (e.g., marginal contribution). Such research could set out the mathematics underlying each approach and examine pros and cons.

2.3.2 In addition, it would be interesting to research the interplay between fungibility and liquidity. What kinds of capital does the profession regard as fungible for an economic solvency assessment and why?

2.3.3 Diversification is central to business management, as well as much of the work on optimising capital structure, and it is often very material to the capital calculation. Speculative judgements of where such dependencies could move to in stress conditions would be easily challenged as lacking proof. One approach to assess the effect of stress situations is sometimes referred to as the "big bang" approach. In this approach the effect of individual risks at less than the target level, e.g. less than 99.5% one year stress, are combined[2] to produce an equivalent of a 99.5% effect for all risks combined. Examining the generic theoretical framework underlying "big bang" approaches (subject to sensitivity around intellectual capital) would be an improvement.

2.3.4 By its nature, data for extreme events are scarce. We recommend more analysis credible co-dependencies from more common event conditions may help assessments in the extreme.

2.3.5 Other barriers to good practice include:

(1) Own company experience can be very different from market data – such as lapses and other risks.
(2) Validation is an issue given data uncertainty. For example, do co-dependencies need to change between BBB and, say, AA standard assessments?
(3) Co-dependencies may exhibit a step change process whereby they can fundamentally alter after periods of relative stability – such as equity/bond co-dependencies.

2.3.6 Reports on this subject include the following:

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(1) ABI commissioned work on co-dependencies between life risks in 2005
(2) CRO forum discussed co-dependencies in 2005 and identified co-dependencies altering by the degree of stress.
(3) CEIOPS advice to Solvency II and technical basis of the co-dependencies used.

2.4 Background & Current Practice

[2] We use the term "big bang" to also include variations that are sometimes called "medium bangs".

2.4.1 The two main approaches to analysis of co-dependencies are either:

(1) an investigation of the causes of dependency (the causal approach); or
(2) an investigation of the available data on risks (the statistical approach).

2.4.2 The causal approach has the great benefit of explaining the dependency and thus making it easy to see where, and why, there is an accumulation of exposure to risk. Such analysis, in theory, makes the model more accurate in modelling new risks as the deeper connections are being recognised; a new risk, therefore, is captured together with its real interaction with existing risks. In practice, of course, such accuracy demands a deep understanding of events and, like the statistical approach, can be undermined by shifts in the wider environment.

2.4.3 The statistical approach is an analysis of data to enable the identification of co-dependency. Economic capital assessment requires consideration of co-dependencies in extreme stress scenarios when 'typical' inter-dependencies may break down, partly from the ripple effects noted by the FSA in DP 08/4. However, there is rarely sufficient data so the statistical approach at this stage becomes difficult.

2.4.4 One way of using the statistical approach to understand co-dependency is by implicit checks of the dependencies within the model. For example, an analysis could be carried out on class A, and class B, and also class A and B combined. The output from the internal model that applies a dependency structure to A and B could then be compared to the statistical analysis of A and B combined.

2.4.5 A hybrid approach is common where the statistics are of poor quality, usually from a paucity of relevant data points. In such situations it is common practice to overlay the often contradictory message from the statistics with a judgement of the causes of the connection between the risks. This judgement needs debate with, and challenge from, other participants such as underwriters, senior management and other risk professionals. It is important, therefore, that co-dependencies are presented in a form that is commonly understood. A rigorous scientific approach to the causal part of this analysis is, however, often lacking.

2.4.6 Some GI risks are treated more individually and are assumed to exhibit bespoke co-dependencies. Co-dependencies are mainly developed statistically rather than by cause. The result of the two has been investigated by the GI model dependencies working party.

2.4.7 Life risks are typically correlated as if each risk were normally distributed, as are group-wide combinations of life and GI risks. A few life firms are using more advanced correlation and aggregation approaches. GI risks on their own may have some co-dependencies treated more in line with the assumed distribution of the risks.

2.4.8 It is commonly accepted that co-dependencies change with the degree of stress. The issue has been recognised by the CRO Forum in its 2005 paper, the FSA in its ICA reviews, and now CEIOPS in its analyses for Solvency II. The combined stresses that potentially meet any particular confidence level are likely to include both extreme stresses for some risks and lower stresses for others. The co-dependency factors used should in theory be capable of matching all these variations. The same complex surface of co-dependency factors should in theory also be used in the assessment of the underlying liability where this is based on stochastic analysis that considers inter-relations of risks such as an economic scenario generator. This is clearly very complex, and overly so, given the quality of the underlying analysis. However, one might expect advances here particularly if more subtle causal analysis is built into the modelling.

2.4.9 The capital model design, and the degree to which the liabilities and assets it relies on are properly sensitive to risks, will of course influence the outcome of the application of these co-dependencies. It would be quite possible to have accurate co-dependencies whose impact is distorted by poor, or just pragmatic, capital model design or by approximate, less risk sensitive, liability or asset assessment.

2.4.10 It is common practice in life insurers to combine individual stresses by each risk, performed on the assets and liabilities, through a correlation matrix. This method is used for the standard formula SCR. Some GI assessments use this method, and other GI assessments use more complex capital models that rely on internal mathematical models of co-dependencies, such as copulas. It is not obvious why life capital assessments should continue to use these simple capital models even though they rely on often complex liability assessment.

2.4.11 The use of correlation matrices facilitates the easy addition of further risks – from a new venture or a new subsidiary – and may appear to avoid some of the ‘black box’ nature of integrated models whose co-dependencies may be more obscure. However they may be no more understandable by senior management than a ‘black box’ and often come with significant simplifying assumptions - that the risks are normally distributed and observe a linear relationship so the combined risks are also normally distributed.

2.4.12 If there is to be the benefit one might hope for (advances to more scientific analysis of co-dependencies), then the modelling methods for addressing co-dependencies must also improve to avoid wasting such improved analysis. A move to more integrated capital models may become common, and may be needed to cope with developments in the recognition of co-dependency effects.

Company Specific Issues in diversification and co-dependency

2.4.13 Whether the dependency between the particular risks is symmetrical or not, the risks will impact on a particular company in a unique way.

2.4.14 The diversification benefit will differ from insurer to insurer as liabilities, assets, operational controls or group structures vary. Examples might be where the underlying risks lead to heightened co-dependency - a business interruption portfolio that is particularly skewed to the very flood risks that threaten a household book – or particular capital fungibility effects within the insurer impede the expected diversification.

2.4.15 The interdependency of risks may, or may not, be non-linear in their own right. However, even linearly dependent risks can have a non linear impact. A common example is the interaction between two risks of annuity business - pensioners living longer than anticipated and the long term interest rates in the market rising. The latter is often seen as a minor risk as an insurer would match its expected pension outgo and bond income, making it immune to changes in interest rates. However, after an increase in longevity, the assets and liabilities are now unmatched and interest rate risk cause losses.

Co-Dependency measurement as a risk factor

2.4.16 As the co-dependency between risks is itself a risk, and a major one, it is important to consider whether the co-dependencies used in the model are themselves best estimate parameters rather than assumptions reflecting stress. To date the concept of more onerous co-dependencies for risks in stress, widely recognised as reality, has effectively been taken to represent an appropriate stress of the co-dependency factors themselves.

2.4.17 This assumption may fail to recognise the capacity for ripple or extreme events causing unforeseen dependencies. The paucity of data may mean the current use of more onerous co-dependencies in stress is merely an adjustment to reach a best estimate dependency rather than a 1 in 200 dependency. The analysis must be very judgemental and could be seen as 'over engineering' uncertain factors. However, the current unforeseen effects in the banking industry and beyond could be viewed as a signal that we fail to make a careful judgement of stress co-dependencies at our peril.

2.4.18 Revised 'common' assumptions are forming from the matrix used in the Solvency II impact assessments, and developing practice in other jurisdictions. The interaction with the FSA has set certain co-dependencies – by virtue of ICG – though not necessarily changed market opinion.

3. TIME HORIZON

3.1 Introduction

3.1.1 The Time Horizon aspect of the internal model involves several components as follows:

(1) a period during which new contracts are accepted;
(2) a full or partial run-off period during which no new contracts are accepted; and
(3) a terminal provision to provide for obligations that continue beyond the run-off period.

3.1.2 The terminal provision required by the model might be considered in two ways:

(1) *Run-off*: The terminal value represents the cost of settling insurer obligations as they come due. This terminal value depends on the distribution of ultimate settlement values for policy obligations foreseen as run off commences.

(2) *Transfer Value*: The terminal value is determined from a model representing the cost of transferring the unsettled policy obligations to another entity at the end of the time horizon or projection period. This terminal value depends on two distributions. Firstly, it depends on the distribution of <u>estimates</u> of ultimate settlement values for policy obligations at the end of the projection period. Secondly it depends on the distribution of market risk perception, as measured by changes in cost of capital or other measures. (The one-year runoff of the SCR calibration of Solvency II is a transfer value test).

3.2 Good practice in 2012

3.2.1 Capital models will cover the number of years suitable for the specific purpose e.g., assessing required economic capital, strategic planning, feeding into the ORSA process, calculating the SCR, etc.

3.2.2 We assume the theory underlying transfer values will be better established by 2012 than it is at present. Nonetheless, models will be able to project using terminal values of either runoff or transfer value tests. This is because each of the run-off tests contains useful information and also they provide reasonableness checks against each other.

3.2.3 The model will be able to produce results for various assumptions regarding new business. The Directive specifies new business assumptions. The firm might use those assumptions or alternative assumptions, if the firm can show that the alternative produces a result that is equivalent to the required calibration. Thus for SCR, the model must be able to reflect the new business assumptions in the directive and the assumptions the firm actually uses. In addition, the model should be able to use a longer time horizon (e.g. a full economic or pricing cycle) for other purposes, e.g., ORSA, rating agency analysis, reinsurance and pricing.

3.2.4 The transfer value terminal provision required by Solvency II will use the cost of capital approach specified in the Directive and parameters from related implementing regulations, if such parameters are specified. If other accounting rules apply then the model would also be able to supply values on that basis.

3.2.5 The use of a time horizon along with a terminal provision to calculate the capital requires, in theory, a set of scenarios during the time horizon as well as another set of nested scenarios beyond the time horizon for each of original scenarios. While nested stochastic calculations have been complex and time consuming to run, computing power and improved approximations/efficiency shortcuts will be used (e.g., stratified sampling of 'important scenarios' to reduce the number of scenarios, replicating portfolios). The modeller will justify that the impact of the approximations assumed is not material.

3.2.6 The firm will investigate the impacts of both run-off value and transfer value terminal provisions. The terminal value on a run-off basis is not necessarily higher or lower than terminal value on a transfer value basis (for one year or other time frames). The two aspects of the transfer that cause this will be well recognised. That is, assuming transfer after one year, the transfer value basis requires considering the variation in estimates of ultimate settlement values based on incomplete information after one year. Those estimates after one year may be higher or lower than the ultimate settlement value used in the run-off terminal provision. Moreover, the terminal value on a transfer basis also needs to include the possible variation in market perception of risk from year to year. For a run-off test, depending on the accounting rules, the change in market risk perception might not be relevant or might require consideration of long term changes, not year to year changes.

3.2.7 New business assumptions in the economic capital assessment (not merely the SCR) for life and GI will be process driven from recent business plans, and events. New business profits will rely on expert judgement for a qualitative check on such projections.

3.3 Research & Barriers

3.3.1 Most existing actuarial literature relates to run-off terminal provisions. Development of methodologies for measuring transfer values is an emerging area of practice. Little analysis is undertaken of the transfer value 'market perception' penalty and/or distribution. Overlooking this effect may tend to bias the result.

3.3.2 Research is needed in more fully defining the types of terminal provisions and when they are appropriate. For example, directive treaty risks are either "hedgeable" or "non-hedgeable". As there are degrees of hedgeability, the internal model will need to consider the extent to which hedging should be in the run-off or transfer basis terminal values. Secondly, there may be circumstances in which the analysis of terminal provisions can consider the possibility of re-capitalisation.

3.3.3 More research would be needed on dealing with policyholder behaviour and management actions for run-off terminal provisions, particularly for life insurance products.

3.3.4 The degree of protection afforded by a given confidence level depends on both the length of the time horizon over which it is to be applied and the type of terminal provision. Firms may struggle to reconcile the different measures, and such 'differences' potentially confuse senior management, though in practice the different measures represent the answers to different questions.

3.3.5 Multi-year models add a large amount of complexity to an internal model. In particular, including the risks that are correlated between future years is a complicated process requiring a significant number of judgements. The correlation of insurance risks from one year to the next is of more significance for GI than life. Research is required to more fully reflect this risk.

3.3.6 Methods to estimate liability uncertainty are currently under-developed within internal models. For example, an incurred claims pattern is often used to estimate non-life reserve uncertainty, which is an estimation of the development of the ultimate claims.

3.3.7 Papers discussing this issue include the following:

(1) "The time horizon conundrum", The Actuary December 2006, http://www.the-actuary.org.uk/pdfs/06_12_02.pdf.
(2) Principle 3 of "ISG Expert Groups: Draft ICA Principles and Guidance", June 2006, http://www.fsa.gov.uk/pubs/international/isgdraftica.pdf.
(3) IAA Risk Margin Working Party draft report *Measurement of Liabilities for Insurance Contracts: Current Estimates and Risk Margins* Appendix A5 is one source of information on the issues involved.

3.4 Background & Current Practice

3.4.1 Current ICA requirements require companies to consider internal models to be calibrated to a 99.5% confidence interval over one year.

3.4.2 Most GI internal models already consider at least one year of new business, with a run-off to ultimate. Life models often look at stresses applied as at the capital assessment date, flexing the starting position for the stochastic run off.

3.4.3 Many stochastic internal models will also include the functionality to incorporate more than a single year of new business, although less emphasis is likely to be placed on the new business assumptions in years two onwards from a capital perspective.

3.4.4. Where internal models use a run off terminal value, they are also likely to be able to consider the transfer value basis. However, where an internal model is currently on a transfer value basis, it is less likely to be able to incorporate the full run-off of liabilities. The transfer values are often only rough approximations of possible transfer values, and do not properly account for the transfer value that would be achieved in the market place. For example, looking at the risk premiums that are incorporated in the reserves in QIS4, they are relatively low for GI liability business, and do not adequately reflect the true market risk premium that would be charged by a willing buyer of the liabilities. Similarly the recent credit crisis means life business reserve setting is more cautious with respect to credit – but this effect is not typically captured in a model. These effects mean the model projection is biased to a more favourable outcome.

4. EXTREME EVENTS

4.1 Introduction

4.1.1 Extreme events affect both the expected values and target confidence intervals required to implement internal models. The need for an analysis of those events presents a challenge in that events occurring with this frequency are seldom observed and so have little or no representation in the historical data available.

4.2 Good practice in 2012

4.2.1 This will entail more carefully structured use of currently existing tools:

(1) expert opinion;
(2) models for natural and man-made disasters;
(3) economic scenario generators;
(4) selection of distributions with fatter-than-observed tails;
(5) examination of 'worst historic events'; and
(6) management consideration of events in other sectors/markets.

4.2.2 In addition more professional guidance on realistic disaster scenarios and minimum levels of provision for extreme events may help ensure these events are properly considered.

4.3 Research & Barriers

4.3.1 Modelling extreme events is complicated by evolution in the dynamic systems generating those risks. For example, the occurrence of a significant operational risk loss will likely result in changes to the control environment and mitigating measures in place and these will, in turn, affect the likelihood and severity of the operational risk. Similarly, government interaction in markets will affect market behaviour.

4.3.2 Areas for research include:

(1) Improving the scope and depth of models for natural and man-made disasters.
(2) Developing techniques to reduce the biases in judgment, e.g., preference amongst bets and the Delphi method[3].

4.3.3 Recent research includes the "Modelling extreme market events" Sessional paper by R. Frankland *et al.* (2007)

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[3] The Delphi method is a technique for gathering expert opinion and achieving a consensus view whilst minimising biases. A group of independent experts are individually asked their views through carefully structured questionnaires. The views, and reasons for those views, are reported back to each expert (without attributing who said what). There are then one or more further rounds of gathering views anonymously. The theory is that there will be convergence on the right answer without the bias towards the views of the most respected/senior/loudest.

4.4 Background & Current Practice

4.4.1 For market risk, extreme events are usually reflected through the choice of a model with tails that are fatter than indicated purely by historical data.

4.4.2 Modelling is particularly difficult for risks where the time series of data is short or very volatile – such as credit spreads and implied volatilities.

4.4.3 Models often do not help management understand the causes for the extreme events. The analysis undertaken, and the model design, often focus on the outcomes of a risk rather than the causes, so truly predictive models are unusual. The models generally make limited or no adjustment for the possible evolution of the risk environment (increased globalisation, growth of leverage, increased/decreased regulation/supervisory oversight, electronic trading etc) which may make extreme outcomes more or less likely.

4.4.4 These models often draw on extremely sparse data to determine the potential magnitude of a catastrophic event (e.g. an influenza pandemic or an earthquake in a densely populated area) and then attempts to estimate the impact of such an event allowing for changes in conditions (such as national response plans, medical advances, changes in social habits, changes in building techniques etc). The frequency of occurrence of such events of a particular magnitude remains very difficult to predict accurately and a high degree of judgment is necessarily involved.

4.4.5 Insurance catastrophe risk models are often built separately from the models created to capture more normal fluctuations in insurance claims. These catastrophe models can be built up similarly by considering a particular type of extreme event (e.g. a dirty bomb detonated in central London). The degree of detail and research that is put into such models varies significantly. The assumed frequency of occurrence of the modelled event is usually entirely based on judgment.

4.4.6 Some insurers use operational risk loss data taken from third party databases to fit distributions. The third party losses often include extreme loss events experienced in the banking industry (e.g. the losses that led to the collapse of Barings) and these are usually scaled to a size appropriate to the insurer conducting the modelling by using reference metrics, This approaches introduces its own risk.

4.4.7 Operational risk extreme events are also often developed solely based on discussion among experts within a business, who naturally draw on their own experiences and knowledge of the experiences of other similar companies. This is subject to the biases inherent in the use of judgment[4].

4.4.8 If detailed scenarios are developed then there is a natural tendency to extend these scenarios to consider the causal impacts on other risks (such as stock market falls). Such

[4] Explored further in "How safe is safe enough – an introduction to risk management" by Dartington, Grout and Whitworth http://www.sias.org.uk/siaspapers/search/view_paper?id=RiskManagement

an approach has merits, but may make the assessment of correlation between risks more complex.

5. GROUP RISK

5.1 Introduction

5.1.1 Structures can vary significantly across groups. The term "group" can be taken to mean an insurance group (life, non-life or composite) or a financial conglomerate with insurance subsidiaries (e.g. a bancassurer). For the purposes of assessing methodology for modelling groups, the key practical issues are:

(1) intra-group transactions;
(2) holding company risks (an entity that does not write any insurance business of its own);
(3) group-wide risks;
(4) group diversification effects; and
(5) governance of the group model.

5.1.2 These issues may relate not only to an economic capital model of an entire group but also to a "stand alone" economic capital model of a single entity that is part of a group.

5.1.3 For Solvency II, the Directive (2008) includes several articles relating to insurance groups. At the time of writing, treatment of groups and group supervision is an outstanding area of debate. However, we can summarise the basic requirements as they currently stand in the Draft Directive:

(1) Insurance groups will be required to carry out an assessment of Pillar 1 capital requirements.
(2) A full or partial internal model could be used by a group for its Pillar 1 assessment (subject to supervisory approval).
(3) Allowance for group diversification effects <u>may</u> be permitted in the Pillar 1 assessment.
(4) Member companies of a group <u>may</u> be able to take account of promises to provide financial support ("group support") from the parent company as eligible capital in their own balance sheets. These "group support" promises would need to take the form of legally binding agreements and would be subject to supervisory approval.

5.2 Good Practice in 2012

5.2.1 Good practice is discussed for each of the aspects of group risk identified at the start of this section.

Intra-group transactions

5.2.2 Firms should maintain a central database of intra-group transactions and assumed management actions that is accurate and up to date and accessible by those responsible for the group's internal model. A member company of a group should also apply similar record keeping standards in respect of the intra-group transactions that it is party to.

5.2.3 Each intra-group transaction should be formally documented to a similar standard that would be expected if the transaction were with an external counterparty. Some sound principles include the following:

(1) the transaction has to be valued appropriately;
(2) the risk of the transaction has to be quantified and taken into account appropriately (e.g. credit risk of the guarantor);
(3) the transaction needs to be legally binding;
(4) the wording of the contract needs to be unambiguous; and
(5) the parties to the transaction need to understand its risks and benefits, and they need to be able to implement and monitor it.

5.2.4 A group internal model should allow for the effect of all material intra-group transactions. In some cases it may be practical and appropriate to allow for simple transactions on a purely qualitative basis. Where transactions are modelled quantitatively, the modelling algorithms should be designed with reference to the actual agreements themselves. Accurate and up-to-date data on the size and nature of the exposures should be used in the model. A quantitative assessment of the operational risks arising from intra-group transactions should also be explicitly modelled. The underlying assumptions on any limited liability put option (‘LLPO’) and payment of dividends should be explicit in the model documentation.

5.2.5 When considering a single entity on a stand alone basis, the internal model should quantify the effect of any material intra-group transactions that entity is involved in (even if the transaction “cancels out” to nil for the group as a whole). The primary risk that needs to be assessed here is the counterparty risk of the rest of the group. It may be appropriate to consider the whole group as counterparty (as opposed to the specific legal entity on the other side of the transaction) because in practice the group can provide support to the specific legal entity on the other side of the transaction. Nevertheless, the degree to which capital and risks are fungible within the group needs to be considered. Furthermore, care must be taken not to ‘double count’ the resources of the single entity with the rest of the group in this assessment.

5.2.6 Firms should use the insights from the internal model to develop appropriate contingency plans for management actions in the event of failure of an intra-group transaction.

Holding company risks

5.2.7 The group should have a well documented up-to-date diagram of all companies (including holding companies) within the group as part of its governance. Those responsible for the group internal model should have access to this information for modelling purposes.

5.2.8 Accurate management accounts for the holding companies should be made available so that the risks associated with these companies can be assessed.

5.2.9 Material holding companies (i.e. those where significant amounts of capital are stored within the holding company and/or those that contain material revenues/expenses) should be allowed for in the group internal model

5.2.10 An explicit assessment of the operational risks attributable to holding companies should be carried out, including fiscal and regulatory risks.

5.2.11 Special care should be taken to consider risky non-insurance entities (e.g. SPVs) that form part of a group as well as group companies that are exposed to other financial sectors (e.g. hedge funds).

5.2.12 A qualitative assessment of the risks associated with holding companies and non-insurance entities should accompany a group internal model capital assessment.

Group-wide risks

5.2.13 The extent to which these risks are allowed for in the model should be made explicit in the documentation.

5.2.14 The contagion risk stemming from the failure of other counterparties in the group should be covered by the analysis of risk on intra-group transactions referred to in 2.1. However, it may be somewhat difficult to quantify other forms of contagion risk and reputation risk – a qualitative assessment (both at stand alone level and group level) of these risks would be an appropriate target to aim for (as opposed to quantifying a capital requirement).

5.2.15 For the qualitative assessment of contagion and reputation risk, groups should monitor the ongoing status of these risks at regular intervals. The status of these risks should be recorded in a central register that is accessible to those responsible for the internal model.

5.2.16 Reference should be made to actual market experience of contagion and reputation risk events that have crystallised (particularly over the last year).

Group diversification effects

5.2.17 The method for determining group diversification effects should be documented in detail. Firms should carry out sensitivity analysis on the group diversification benefit to better understand the materiality of assumptions behind this assessment (particularly correlations) and the potential concentration of risks in parts of the Group.

5.2.18 The method for assessing group diversification effects should take into account all material constraints on transferability (e.g. ring-fencing of with-profits funds). A central record of legal transferability constraints by entity should be maintained, with details of the nature of each constraint that exists. The model should be designed with reference to these constraints.

5.2.19 Governance of the group model will include at least the following features:

Governance of the group model

5.2.20 Groups will need to address the very specific group model governance challenges. These challenges may be addressed as follows:

(1) Clear accountabilities and responsibilities for different aspects of the internal model are agreed with business units and documented.
(2) Minimum quality standards for model documentation are agreed across the group and implemented at business unit level.
(3) Regular dialogue on the model is carried out between group and key persons responsible for the modelling in the business units.
(4) A formal change control process is agreed between group and business units.
(5) Results of the group model are communicated regularly to senior management at group level.

5.2.21 How the group-wide approvals process will be addressed will depend very much on how that process is designed by regulatory supervisors. In an ideal world this approach would be tailored to the group in question, taking into account the way in which the internal model is governed for that group. However, supervisors in different jurisdictions may have different requirements (timeliness of submission, different reporting requirements) and these need to be managed carefully within the overall group model context.

5.3 Research & Barriers

5.3.1 A significant body of research into group issues is being conducted by CEIOPS, HMT/FSA (2008) and industry bodies (such as the CEA) as part of the ongoing development of Solvency II policy. A number of working groups exist within CEIOPS, CEA and CRO Forum dedicated to groups issues. The UK actuarial profession should be able to leverage from this work.

5.3.2 The Groupe Consultatif is also conducting research into group issues to support CEIOPS.

5.3.3 There are practical issues about running group models that it would useful to research.

5.3.4 If the group model is developed to support internal decision making, then it should include non-regulated entities if these bear risks. The model will need to be adapted to produce an assessment of regulatory capital, excluding capital from non-regulated companies if the regulatory system excludes these companies completely.

5.3.5 Similarly, if the model covers entities in countries that are not recognised as having an equivalent regime, the regulatory capital assessment will need to exclude them. This has implications for how to adjust model results to remove these entities, and adjust any diversification benefits allowed for in the economic capital assessment.

5.3.6 Tax issues can complicate the analysis of group structures.

5.4 Background & Current Practice

5.4.1 The current situation for each of the aspects of group risk identified in the introduction to this section is discussed below..

Intra-group transactions

5.4.2 These are effectively transactions between different parts of a group (companies or sub-funds) and may involve the parent company. Common examples include:

(1) reinsurance agreements;
(2) administration agreements and investment mandates;
(3) loans from one entity to another;
(4) contingent capital support agreements; and
(5) payment of dividends from one entity to another.

5.4.3 Such transactions create risks for the individual entities involved when those entities are considered on a ‘stand-alone’ basis (i.e. from the perspective of the single entity, excluding rest of the group). The key risk that arises in the stand alone context is that the counterparty to the transaction (i.e. the parent or another part of the group) cannot meet its obligations.

5.4.4 Assuming the same regulatory and tax regime applies across the group, these transactions would usually be structured such that the net economic effect on the overall group may be small. The main benefits arise from increased purchasing power when buying reinsurance, from maintaining higher retentions across a group than would exist if each business unit were buying reinsurance protection to protect their bottom line result, and from the ability to move capital from company to company within the group based on risk needs and business opportunities.

5.4.5 If the group has operations in different regulatory and tax regimes, there may be benefits or costs that arise from those differences.

5.4.6 However, regardless of the financial effect, such transactions can generate some net risk for the group as a whole. In particular, operational risks may arise where intra-group transactions are complex and numerous.

5.4.7 An important concept to consider in relation to intra-group transactions is that of the LLPO. The LLPO in theory has an economic value to the entity that has the power to wield it. Taking credit for the LLPO in a group model would effectively mean that the model assumes that a subsidiary might not be bailed out by the parent in the event of insolvency of that subsidiary. Taking credit for the LLPO could have a material impact on the group result. On the other hand, exercising the LLPO by failing to support a subsidiary could damage the group's ability to attract customers in the future and thus affect its franchise value. Often the potential damage to franchise value exceeds the LLPO. Therefore, it is not surprising that in U.K. ICA models generally assume that any deficit in a subsidiary will be funded in full.

5.4.8 The LLPO approach is in line with the wider view of modelling groups based on analysis of Capital and Risk Transfer Instruments (CRTI) which allows explicit modelling of all relevant intra-group transactions and taking into account the legally limited liability structure. However, intra Group CRTIs can only be considered if they are legally binding and accepted by the regulators involved. The CRTI approach recognises that while a group is likely to support its subsidiaries in normal cases, even without a formal CRTI in place, in case of financial problems, a group may to revert to a more legalistic interpretation of its rights and obligations. Moreover, in case of insolvency, the treatment of subsidiaries may need to follow legal rather than business as usual logic.

Holding company risks

5.4.9 Where the parent company of a group is simply a "holding company" (i.e. it does not write any insurance business of its own) it might be assumed that no explicit modelling of the risks within the holding company is required, and that it is sufficient simply to aggregate the risk from the modelled insurance subsidiaries within the group. In practice, holding companies could give rise to specific risks (albeit non-insurance related) including:

(1) investment risks (if capital is held within the holding company);
(2) expense risks (associated with overheads of the holding company);
(3) debt servicing risks (if debt is issued in the holding company); and
(4) Operational risks.

Group-wide risks

5.4.10 Subsidiaries of a group are exposed to certain "group-wide" risks that would not otherwise be manifest if the subsidiaries were separate entities. The most well known examples are:

(1) contagion risk (i.e. the subsidiary is adversely affected by the failure of other parts of the group); and

(2) reputation risk (i.e. the reputation of the subsidiary is tarnished by its membership of the group).

5.4.11 Both contagion and reputation risks are especially difficult to model. There is debate over how these risks may manifest themselves as well as the severity of losses that have to occur before individual parts of the group not directly related to the losses are affected. Intuitively we also expect there to be some tail dependency between these risks and extreme market risk events (such as a collapse in equity markets), but this is difficult to quantify.

Group diversification effects

5.4.12 A group of companies gives rise to diversification effects ‘between subsidiaries’ where the risk profile of the subsidiaries differs (in terms of the weightings of different risk types). A diversification benefit will arise if the risk types are less than perfectly correlated.

5.4.13 There may also be diversification effects between subsidiaries due to the fact that a single risk type may have opposite impacts on different companies. For example, consider a group with two subsidiaries X and Y, both located in the same territory. Subsidiary X makes an economic loss if interest rates rise while Y makes an economic profit if interest rates rise. In the event of interest rates rising, some of the losses in X will be offset by gains in Y. This form of group diversification could be termed the ‘natural hedge’ effect.

5.4.14 Group diversification effects can arise in a group which transacts all its business in one country, as well as the often cited cross-border group example. The existence of group diversification effects is widely accepted, although there are many questions over precisely how it can be reflected in required capital.

5.4.15 In practice, one barrier to the actual realisation of economic diversification benefits is that of legal transferability constraints on different entities. These transferability constraints may arise primarily due to (a) ring-fencing rules for the benefit of policyholders (e.g. with-profits funds), and/or (b) local regulatory constraints for cross border groups.

5.4.16 Another challenge with group diversification is how they should be allocated down to subsidiary level. Should subsidiaries only benefit from being part of a group if group-level diversification is allocated using an exogenous, arbitrary allocation scheme? Using CRTI, diversification is down-streamed to subsidiaries within the model by CRTIs, and no exogenous allocation scheme needs to be used.

Governance of the group model

5.4.17 The concept of a single central modelling system is a vision, rather than a practical approach. More practically, group models can be viewed as falling at or between two "extreme" positions as follows:

(1) **'***Aggregation Approach':* A group-level aggregation model that uses the output of several different business unit modelling systems; OR
(2) **'***Model Point Approach***:** A simplified model of the whole group using condensed "model points" to approximate business unit exposures.

5.4.18 Both approaches create a number of practical challenges to address from a modelling perspective and a governance perspective.

5.4.19 Under the '*Aggregation Approach'* it is difficult to ensure consistency between the different business unit models. The model may become a patchwork quilt of different modelling techniques and systems. The model may be designed to accommodate the limitations of business unit models rather than drive the modelling requirements in business units.

5.4.20 Under the 'Model Pointing Approach' the key challenge is accuracy. Being based on very cut down approximate data, the model may fail to capture the complexity of the underlying risks (this is particularly important when modelling tail events). The group-level model also becomes somewhat detached from the models used by business units for day to day management of the business, and could in extreme cases produce different results.

5.4.21 In a mixed approach between those 'extremes', each company in a group will have models that operate in sufficient detail for its own purposes, but all companies use common economic models and disaster scenarios. For localised risks the group model is the aggregate of individual company models. For risks that contribute to the tail of the distribution the group models uses details (many model points) from the subsidiaries combined with appropriately designed correlations.[5]

5.4.22 The governance structure of a group will have an operational impact on the group internal model. Groups may organise based on legal entity, product line, customer segment risk time and the like. Groups may have structures that are relatively more or less centralised or decentralised. The group modelling approach needs to reflect those business arrangements without loosing the ability to properly measure risk by legal entity, the overall group and possibly sub-groups within the overall group.

Replicating Portfolio Approaches

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[5]One such approach is described by M. Heep-Altiner and N. Hooker at GIRO 2008 http://www.actuaries.org.uk/?a=137963

5.4.23 In recent years, life groups in particular have looked at ‘replicating portfolio’ technology for group models as it has been considered for many other applications. This involves finding an optimal group, and weighting, of asset and derivative transactions that ‘replicate’ the sensitivity of the liabilities, and thus the capital assessment, to market movements. The process is in the life insurance business, used to investigate hedging and the natural hedges across a group, and to speed up economic capital assessments by enabling rapid recalculation through revaluing the replicating portfolio rather than the entire asset and liability portfolios. The process only captures market risk – or rather only captures risks whose impact can be mirrored through a market transaction – and can be difficult in situations where the portfolio can see significant policyholder reactions or transactions involve market instruments are thinly traded. This technology will have important application in the context of group internal models. Such replicating portfolios do not work very well with non-life business.

5.4.24 Proprietary group models are often regarded as intellectual capital and as a result, detailed technical information is not always easily accessible in the public domain.

6. DATA QUALITY

6.1 Introduction

6.1.1 This section is divided into three main parts. Each discusses one of the following aspects of data quality:

(a) Data requirements for an internal model.
(b) Use of expert opinion.
(c) Use of benchmarking.

6.1.2 Across these areas we note that under the Solvency II internal model approvals process, the use of statistical analysis in an internal model is likely to be scrutinised closely by supervisors. Article 119 ('Statistical Quality Standards') of the draft 'level 1' directive sets out explicit criteria that would need to be assessed as part of the approvals process, including:

(1) Firms must justify the internal model assumptions to supervisors (119-2).
(2) Data used must be *"[reasonably][6] accurate, complete and appropriate"* (119-3).
(3) Data used must be updated at least once a year (119-3).
(4) Internal model should be capable of ranking risk (119-4).
(5) System of measurement of diversification effects must be *"adequate"* (119-5).

6.1.3 The text for Article 119 also contains paragraphs (119-6 to 119-9) relating to the general scope of the model (e.g. that it may include management actions). For the purpose of this section we shall leave aside 119-6 to 119-9, because they are dealt with in other parts of this paper, and are arguably not directly related to the discussion of best practice 'statistical quality standards'.

6.2 Good Practice in 2012

Data Requirements

6.2.1 The main area of good practice around internal data quality is that it is all [reasonably] accurate, complete and appropriate. It should be sourced from systems subject to quality control and audit processes, and there should be a nominated business owner for each piece of data. Data should also be subject to high level checks before being incorporated into the internal model to ensure that it is fit for purpose.

6.2.2 The Board for Actuarial Standards (BAS, 2008) has issued a Consultation Paper on a generic data standard. It is worth quoting the proposed principles for data quality, as these are likely to be a major part of Good Practice by 2012. It should be noted that these Standards are subject to consultation and may not be deemed adequate by insurance supervisors.

[6] Amendments to the February draft added the helpful word "reasonably".

User needs

6.2.3 An overriding consideration in processing data should be the needs of users of the resulting information.

Scope of Actuarial Work

6.2.4 The extent of effort in compiling data should be commensurate with the scope of the actuarial information that has been commissioned.

Materiality

6.2.5 Definition: The exclusion of data is material, and the inaccuracy or incompleteness of data that has been included is material, if it might reasonably be expected to influence the decisions of users of the resulting actuarial information.

6.2.6 Data (or its checking or its adjustment) should only be included if it is material; immaterial details should be excluded.

Proportionality

6.2.7 Definition: An improvement in the quality of data is proportionate if the additional effort to achieve that improvement is outweighed by the consequent benefits to the user of the actuarial information and by the potential benefits to beneficiaries.

OTHER PRINCIPLES FROM BAS

Judgement

6.2.8 Judging what is, or is not, material or proportionate should be done in a reasoned and justifiable manner, and the reasoning behind such judgements should be documented.

Requirements

6.2.9 A list of data requirements should be drawn up to satisfy the user needs and scope of the work, prior to any investigation of sources of that data: the data requirements should take into account materiality and proportionality.

6.2.10 Data requirements and sources of data should be assessed every time actuarial information is required.

Supplementing data

6.2.11 When required data is unavailable or materially inadequate to meet user needs within the scope of the work, investigations should be made into additional sources, proxies and sampling methods that might be used to supplement or substitute for the data.

Checks

6.2.12 A set of data checks should be constructed and performed in order to determine whether or not, taken overall, the data is sufficiently accurate and complete to meet the needs of the user of the actuarial information. The set of checks should take into account the principles of materiality and proportionality in 6.2.5-7.

6.2.13 The responsibility for the design and implementation of these checks should be clearly delineated within the organisation.

Compensating adjustments

6.2.14 To the extent that the data is found to be inaccurate or incomplete, the feasibility of compensating for this by a set of adjustments to the data should be investigated. Taken overall, these adjustments should ensure the resulting actuarial information is sufficiently accurate and complete to meet the needs of the user, within the scope of the work, taking into account materiality and proportionality.

Iteration

6.2.15 If required data is inaccurate or incomplete and satisfactory adjustments cannot be found, as many steps of the data process as are appropriate should be repeated.

Reporting

6.2.16 Those of the following items that apply, together with their implications, should be reported to users:

(1) to the extent the BAS generic data standard conflicts with any applicable law, that the work was performed in accordance with the requirements of the applicable law, regulation, or other binding authority;
(2) that it has been concluded that required data is unavailable or inadequate and that satisfactory additional sources or proxies cannot be found, together with the relevant information the user will need to make the appropriate decision on, for instance, any amendment of the scope of the work;
(3) that reliance was placed on data provided by others and that it has not been possible to check or validate aspects of the data independently;
(4) any material adjustments or modifications made to the data, other than routine corrections made by reference to source documents, including the rationale for any such adjustments or modifications;

(5) any material reservations about the accuracy or completeness of the data, to the extent that they are likely to limit the usefulness of the resulting actuarial information for decision making; and
(6) an indication of the level of uncertainty inherent in the information.

Use of Expert Opinion

6.2.17 Where data analysis is possible, this should be carried out, albeit with the caveat that it has been overlaid with judgment. Good practice does not exclude the use of expert opinion in internal models, but rather ensures that there is a proper process behind its usage.

6.2.18 The BAS data standard consultation paper has a section on the application of judgement in how the standard is applied; "Judging what is, or is not, material or proportionate should be done in a reasoned and justifiable manner, and the reasoning behind such judgements should be documented". This equally applies to good practice in the use of any judgement/expert opinion in the internal model.

6.2.19 The expert should own the inputting of their judgment into the internal model, and should document their thought process. Wherever possible it should also be subjected to a peer review to ensure that it is appropriate to use within the model. Good practice for material judgmental assumptions would be to consider the sensitivity of the model output to these assumptions, and there should be explicit testing of this

Benchmark Data

6.2.20 Benchmark data should be used to supplement internal data where available, or as a substitute where not. The source should be documented and verified as fully as possible, and ideally the level of documentation of external data should be the same as that of internal data. Full consideration should be given to the relevance of the benchmark data to the company's specific circumstances, and if necessary, expert opinion should overlay the benchmarks.

6.3 Research & Barriers

Data Requirements

6.3.1 Much of the 'good practice' is arguably common sense, and as such is not particularly groundbreaking. Furthermore, it is likely that many firms are already either in line with the target or have aspirations to meet it.

6.3.2 In addition to this, in order to develop models that are likely to fulfil the statistical quality standard of Solvency II, actuaries need to:

(1) work to improve data in firms;
(2) look at developing industry databases;

(3) develop heuristic methods to improve existing data;
(4) develop indices of data quality to enable benchmarking of data quality;
(5) better understand how changes to the regulatory, political or economic environment may influence the relevance of available data; and
(6) investigate the drivers for the outcomes seen in the data.

Use of Expert Opinion

6.3.3 Research has been focused on specific assumptions, so there is limited research on the use of expert opinion in insurance modelling. Review of research that may exist in other industries would be useful.

6.3.4 The internal model approvals process will require firms to provide an audit trail of how assumptions are derived. There is a risk that this may develop into an unduly burdensome requirement that requires an objective justification of all assumptions, even those which are inherently subjective. There is insufficient academic evidence to support any one 'universally correct' answer for the items in the adopted answer. Moreover, models may include a large number of such judgements, so construction of a hierarchy of materiality may be necessary.

6.3.5 It is important that the profession, industry and supervisors retain a proper degree of scepticism regarding 'prevailing wisdom' or 'standard approaches' that may emerge to handle particular risk issues.

6.3.6 Providing meaningful and useful documentation of the justification for the more subjective assumptions may prove to be a challenge. For example, a modelling assumption such as mean reversion is based on a 'view' about markets that cannot be proved or disproved (this has been attempted in academia with little success) – it would not add value for a firm to attempt to 'evidence' this kind of assumption.

Benchmark Data

6.3.7 Benchmarks are appropriate where firms lack sufficient experience data and/or expertise to calibrate in-house. However, in situations where firms have the resources to formulate their own calibration, great care should be taken with benchmarks (particularly in the context of '*1-in-N'* shocks). For example, even the shocks implicit in the 'Standard Model' should be used with caution if there is alternative data available for a particular company.

6.4 Background and Current Practice

Data requirements

6.4.1 The Framework Directive (2008) has very stretching requirements for the quality of data underlying an internal model. The current proposal requires data to be *"[reasonably] complete, accurate and appropriate."* From an actuarial perspective this presents a problem – data is often inadequate for the purposes we require it for.

> *"The frequency of poor data quality is one of the most vexing problems for actuaries. Countless hours are expended detecting data problems, remediating the problems and revising analyses after data problems have been revealed*." (Francis, 2005)

Data collection

6.4.2 Data sourced internally to an insurer will usually come from front-line administration, finance, and investment systems. This brings issues of accuracy:

(1) data may not be easily available, for example height above sea level of a property;
(2) data may not be collected, for example location of nearby trees;
(3) data may not be stored, or stored permanently, for example, some meta data around transactions;
(4) data may be inaccurate, for example policyholders may exaggerate;
(5) data may be aggregated, for example claim payments may not be split into payment types;
(6) data may be out of sync, for example as at different dates;
(7) data may be stored on different systems; and
(8) data may be incomplete, for example, front line staff facing competing priorities may not appreciate the need for the completion of all input fields.

6.4.3 There are many causes of inaccuracy, and actuaries are used to spending time checking data and amending methods to compensate for inaccuracy. A GIRO working party survey showed that on average general insurance actuaries spend over 25% of their time on data quality issues. More than a third of projects had been adversely affected by poor quality data – estimates made using poor quality data are generally more uncertain.

6.4.4 Data that is technically accurate can nevertheless become out-of-date because of changes within the environment and therefore become poor quality data. For example, longevity data collected from cohorts prior to the introduction of impaired life data cannot be sub-divided.

External data

6.4.5 Similar comments may apply to external data, although there are additional considerations about the applicability of data for the circumstances or current environment. In particular regulatory, political and economic environment can have had a significant impact on historical data. However, external data may have been cleansed and validated, depending on the source.

6.4.6 Some external data and software suppliers have started to develop systems to analyse the irregularities in data. RMS, a non-life catastrophe model provider, has developed heuristics to find issues with data and rectify them, whilst flagging areas where human intervention is needed. (RMS, 2008).

6.4.7 For both internal and external sources, data already plays a part of an internal model, particularly from the actuaries involved in running the model. This tends to be subjected to a number of control and checking processes, although the level of documentation and sign-off around the data is likely to be insufficient to meet Solvency II requirements.

Use of Expert Opinion

6.4.8 The process of determining the assumptions of an actuarial model involves a significant element of subjectivity. While the innovation of "market consistent" principles is intended to increase the objectivity of actuarial estimates, a significant degree of subjectivity remains.

6.4.9 Subjectivity will be required in the following situations, amongst others, where the data is either inconclusive or unavailable:

(1) no replicating portfolio exists in the market against which the liabilities can be proxied;
(2) new markets or lines of business with limited history;
(3) analysis of extreme events;
(4) dependencies between classes of business, and between risk types.

6.4.10 The old adage 'the past is not a guide to the future' is an important one to put the question of statistical analysis into context. When considering assumptions that require us to take a view about the future, we must recognise that the conditions underlying a historic data time series may not reflect the future. (For example if we are analysing historic 'net of tax' investment returns, the tax regime during the historic period may differ from the current regime – it would obviously be inappropriate to ignore this when making assumptions about the future.)

6.4.11 Table 1 considers some possible examples of assumptions that are either objective to some extent (i.e. based on observable data) or must be subjective by necessity. Most of the decisions in the right hand column are essential in an actuarial model (particularly a market consistent model).

Table 1
Application of Expert Judgement

Item	Objective	Subjective
Risk-free yields	Published yield curve data	Choice of yield (e.g. swaps, gilts) Choice of index (e.g. FT Actuaries) Methodology to construct yield curve Adjustment for credit risk / liquidity Interpolating/extrapolating for unavailable maturities
Option volatility	Quoted implied volatilities	Imputing the volatility from market prices Choice of appropriate option contract Source of quote for OTC options (e.g. banks) Interpolating/extrapolating for unavailable maturities
Long-term volatility	Variance statistics from historic time series	Choice of index on which time series is based Choice of period of observation Adjustment of time series for anomalous data Choice of data frequency for observations Credibility weightings Views about future conditions
Long-term correlations	Correlation statistics from historic time series	Choice of index on which time series is based Choice of period of observation Choice of data frequency for observations Adjustment of time series for anomalous data Credibility weightings Views about future conditions
Demographic best estimate	Published life/morbidity tables Analysis of internal experience data	Choice of published table Derivation of adjustments to the table Choice of basis where no internal experience data available Influence of/ adjustments for new products or new risks (e.g. Bird-Flu)
Operational risk events	ORIC data or other benchmarks	Qualitative assessment to identify the register of relevant risks Internal assessment of likelihood/impact
"1-in-N" stress tests	Empirical analysis: - "worst historic event" - "bootstrapping" - "simulation model" Benchmark CEIOPS stresses (?)	Choice of index on which time series is based Adjustment of time series for anomalous data Credibility weightings Choice of <u>method</u> of analysis (e.g. bootstrap) Type of simulation model Views about future conditions
"1-in-N" co-dependencies	Empirical analysis: - historic correlation point estimate - "rolling" correlation analysis Benchmark CEIOPS correlations (?)	Choice of index on which time series is based Adjustment of time series for anomalous data Credibility weightings Choice of model adopted (VAR/COV, copulas, simulation model) Adjustment for non-linearity
Choice of ESG	N/A	This is entirely subjective. There are several "textbook" models available but deciding which ones we believe is subjective.

6.4.12 In addition, judgement is required in deciding which dataset to use for analysis and then which time period to consider and which grouping of data.

Benchmark Data

6.4.13 Companies already use external data to supplement their own internal data within the capital and risk considerations, for example from sources such as:

(1) commercial surveys (e.g. consulting firm surveys on ICA bases);
(2) FSA guidance (e.g. "Financial Risk Outlook" briefings);
(3) research from other authorities (e.g. Bank of England);
(4) Continuous Mortality Investigation (CMI) tables; and
(5) Catastrophe modelling companies (in addition to the use of those models with individual company data.)

6.4.14 For those assumptions that can be observed from the market, little statistical 'analysis' is required provided the alignment of the market's data with the risk being analysed is well understood. The relevant market data indices/quotes are simply collected by the user and the burden for an audit trail of the derivation of that should data rest with the external provider of the index/quote. It is uncommon (and arguably unnecessary) for a firm to document the detailed derivation of external quotes or indices (e.g. how the FTSE 100 index is derived).

6.4.15 One area where benchmarks are important is stress testing. In this respect we note that the following is available:

6.4.16 CEIOPS have produced papers outlining the rationale behind the 'Standard Model' calibration of 1-in-200 shocks (as the documents show, the shocks do not rely on the output of the data analysis):
http://www.ceiops.eu/media/files/consultations/QIS/QIS3/QIS3CalibrationPapers.pdf
http://www.ceiops.eu/media/files/consultations/QIS/QIS3/CEIOPS-FSC-23-07Calibrationofcreditrisk.pdf

6.4.17 A number of consultancies have produced industry surveys into the assumptions used for ICAS, for example:
http://www.abi.org.uk/Members/circulars/viewAttachment.asp?EID=11303&DID=11555

6.4.18 The Institute of Actuaries Sessional Meeting on modelling extreme events (3rd November 2008) is also a good reference on setting 1-in-200 shocks within an internal model framework. **http://www.actuaries.org.uk/__data/assets/pdf_file/0007/140110/sm20081103.pdf**

6.4.19 The consideration of "1-in-N" events involves two key elements: (1) stresses to risk factors, and (2) co-dependencies between risk factors. Depending on the type of co-dependency model used (VAR-COV matrix / copulas / "big bang" scenario / combination) the precise nature of statistical analysis required will differ. The differences are summarised in Table 2.

Table 2
Approaches to Co-Dependency

Method	**Parameters/Assumptions Required**
VAR-COV	"1-in-N" stresses for each separate risk factor "1-in-N" tail correlations for each cross-risk pairing
Big Bang Scenario- Sometimes called "medium bang" depending on how extreme the assumptions are.	Choice of distributional model for each risk (e.g. Lognormal) Distributional parameters for each risk (e.g. mean and variance parameters for the Lognormal) Cross risk correlation structure and parameters (these may not be "tail correlations") Selection of the "1-in-N" scenario from the Monte Carlo simulation output
Copulas	Choice of copula "family" (e.g. Gaussian) Parameters of the copula function (e.g. dependency parameter for Gumbel copula, degrees of freedom parameter for Multi-variate student-t copulae)

6.4.20 Of the above approaches, the VAR-COV matrix approach can be the least labour intensive (in terms of statistical analysis). A view can be taken on the "1-in-N" stresses without going through the statistical process of explicitly fitting and calibrating a distributional form for the risk factor. Possible "distribution agnostic"[7] approaches include:

(1) extreme historic events ("worst" or a multiple of a highly adverse scenario);
(2) bootstrapping;
(3) single estimate of correlation over historic periods; and
(4) 'Rolling' correlation analysis over historic periods.

6.4.21 The "distribution agnostic" approaches have the advantage of being practical and cost effective. A complex distributional model fitting process may not be well understood by lay persons and could be viewed as spurious accuracy – the simplicity of the "distributional agnostic" approach partly addresses these problems. However, it is not useful for a direct assessment to a 1-in-N standard.

6.4.22 Another way of choosing the "1-in-N" shocks is to choose a distributional form and use Monte Carlo simulation to generate the event (this process would generally require more involved analysis of historic data). Fitting a distribution is also necessary under the "big bang" and "copula" approaches.

6.4.23 The process of choosing a distributional model is highly subjective, and is also biased by other practical constraints (e.g. cost and availability of an ESG system that simulates the desired distribution). For some risk factors it will be difficult to find an academic consensus on the "correct" distribution. Some firms will include innovative features (e.g. "jumps") in their chosen distribution. It is fair to say that there is a healthy

[7] We use the term "distribution agnostic" very loosely to mean a process that does not require us (for practical purposes) to explicitly fit a distribution to the historic data. Clearly the approaches do make implicit assumptions about distribution.

diversity between firms in the choice of distributional models for risks, and that diversity and innovation should be promoted.

6.4.24 The process of fitting the chosen distributional form to data is somewhat more objective, although subjectivity remains over choice of historic period and adjustments made to the data series (e.g. for anomalous data points).

6.4.25 As a reality check, we should note that while the actuary may go through a very sophisticated in-depth process to derive a '1-in-N' event, commercial stakeholders may 'override' this by suggesting adjustments to the shocks (justified by their expert opinion). Also, stakeholders may be inclined to anchor the calibration to the 'worst historic event' (while this is theoretically flawed, it has some superficial common sense appeal).

6.4.26 Finally, the notion of a '1-in-N' event leads to an interesting question (particularly relevant at the time of writing) – if an extreme event has already happened, how should this affect the calibration of our '1-in-N' event going forward?

6.5 Practical proposals – A path to 2012

6.5.1 Between now and 2012, actuaries can become data advocates, and work to improve data quality in insurers. Some of the areas where actuaries can usefully assist have already been highlighted in the above discussion on data standards, and following are some further miscellaneous thoughts on data aspects that should be considered by actuaries (in general, as well as specific to internal models).

(1) Perform an exploratory data analysis. This is typically the first step in analysing data. The purposes are to explore the structure of the data; find outliers; find drivers; and find errors. This can be done using simple descriptive statistics and / or multivariate screening techniques and or graphical techniques.
(2) The audit trail (including process documentation) of how assumptions are derived should clearly flag where expert opinion is used, and describe the governance process used to reach that consensus (e.g. "it was decided by the investment committee, see minutes dated DD/MM/YYYY").
(3) Prioritise decisions based on materiality. A clear matrix of the different assumption setting processes identifying what analysis has been carried out for each item will enable decision makers to put this all into context.
(4) Senior management and supervisors may benefit from having a simple summary of the core subjective 'views/beliefs' on which the internal model assumptions are based.
(5) Where a 'view/belief' is being taken firms should sensitivity test the impact of that view being incorrect (e.g. "what is the impact if we do not assume mean reversion?").
(6) All external data and (particularly) internal data should be maintained according to good principles of data management.
(7) In line with Article 119-3 of the Solvency II Directive (2008), the statistical analysis should be reconsidered each year (or more frequently if necessary).

(8) Given the potential commercial impact of the assumptions made in a capital model (e.g. discount rates), actuaries should take care to consider potential conflicts of interest and any other professionalism issues that might arise in the process of their derivation. A clear distinction needs to be made between those responsible for advising and the committees responsible for choosing the assumptions.

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APPENDIX A

7.1. This appendix contains our detailed review of the actuarial aspects of internal models that the working group considered. The section numbering continues from the main body of the paper as follows:

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8. CAPITAL AND BALANCE SHEET--OVERVIEW

This section covers the following five subjects:

8.1.1.	**Economic capital**
10.	**Assets**
11.	**Technical provisions-At Valuation Date**
12.	**Technical provisions- Projection Periods**
13.	**Guarantees and options**

9. Economic Capital

9.1 Introduction

9.1.1 Under the Framework Directive (2008), the Pillar 1 SCR is calibrated to a 99.5% level of sufficiency over a 1 year timeframe (Article 101(3)). This is defined as an adequate level for the protection policyholders and creditors of insurance firms.

9.1.2 It is somewhat less clear as to what is required for Pillar 2. This is referred to as 'economic capital' in the introduction to the Directive, but there are many alternative ways to determine economic capital[8]. There are also are a number of alternative uses for which an internal model may be calibrated. The most common ones are:

(1) Rating agency capital - Amount of capital rating agencies expect firms to maintain a particular rating level. This may be calculated using a rating agency factor-based model or approximated within a firm's internal model. Some rating agencies are exploring ways to give weight to a firm's internal model in their capital assessment process.
(2) Economic capital level - Amount of capital required to protect against economic insolvency which generally reflects overall risk appetite of the firm. This is generally calculated within an internal model and is calibrated at a different confidence level than regulatory and/or rating agency capital.
(3) Economic impairment earnings level – Amount of losses for which the firm is placed in danger of economic impairment. This "earnings at risk" measurement is often assessed within an internal model at a lower return period (e.g. the 90%

[8] The core reading for Institute of Actuaries subject SA2 defines economic capital in a similar manner but without making any assumption about the purpose of the capital employed, as follows: *"… the capital required to ensure that a company has sufficient assets to meet the needs of its on-going strategy."* With less generality, Porteus & Tapadar (2005) recognise the lack of a concise definition and suggest the following: *"Economic capital, for the business of a firm, is the amount of capital (or excess assets) that this business requires to ensure that its realistic (or market value) balance sheet remains solvent over a specified time horizon, with a prescribed probability or confidence level, following events that are unexpected, yet not so unlikely that they might never occur in practice."*

level of sufficiency), and is used to help define risk appetite more often than target capital.

(4) Protection of franchise value – An amount capital such that adverse events will not decrease franchise value beyond a level of tolerance with a selected probability level.

9.2 Good practice in 2012

9.2.1 Where possible the different capital metrics can be expressed as different points of an earnings distribution that is produced by the model. For example:

(1) “Normal Volatility/quartiles (e.g. 1 in 5)
   a. ‘At-risk’ thresholds for earnings volatility
   b. ‘At-risk’ thresholds for cashflow volatility
(2) Tail (e.g. 1-in-200)
   a. ‘At-risk’ threshold for fluctuations in regulatory solvency
   b. ‘At-risk’ threshold for fluctuations in economic solvency
(3) Extreme tails (e.g. 1-in-500)
   a. Target confidence level for economic capital
   b. Use in stress testing (e.g. test to destruction, the “Reverse Stress Test”)
   c. Target confidence level for ratings agency capital

9.2.2 By ‘at-risk’ threshold, we mean a tolerance limit for risk appetite.

9.2.3 In an ideal world, the above calibrations of the levels of capital the firm monitors and manages the business with are determined consistently within the same internal model with consistent assumptions. However, for reasons that are elaborated upon below, this level of consistency is not always practical given the different uses of the metrics. In this case, alternative calibrations are utilised in the internal models with clear articulation to explain the differences in the assumptions and approach. It is good practice that the different metrics are utilised and differences well explained to the Board and senior management of the firm.

9. 3 Research & Barriers

9.3.1 The main area of concern is whether the internal model is able to be utilised to assess the capitalisation levels for a number of different purposes. This is related to how embedded the internal model is with respect to the various aspects of the firm’s strategic decision making. The IAIS vision of “a single internal model that is used for ERM, economic and regulatory capital” may pose some practical challenges, depending on how this vision is interpreted. While a single firm-wide modelling philosophy is sensible, a single firm-wide internal model that is used for all applications (ERM, operational and capital assessment being the main ones) may not be practical. For example:

(1) A company level internal model may be (necessarily) simpler than product specific internal models, such as those used for pricing or bonus setting in a life company. Typically the company level internal model would use fewer model points.
(2) Day-to-day business decisions (such as product approvals and pricing) are difficult to make with a company level internal model that has a long run-time. Therefore a different internal model will be required for these specific applications. Even upgrading modelling technology (e.g. the use of variance reduction techniques) in order to reduce the run-time may not be sufficient to make the model applicable for some of the day-to-day business decisions.
(3) Groups may have a variety of models in use where the Group is managed on decentralised lines. The group aggregation of such results will be an amalgam of models.
(4) Methods for reconciling a company-level economic capital assessment against other methods (e.g. the modular stress testing approach used in the Solvency II "Standard Formula") are not well established. Furthermore, allocating back the company-level assessment to individual lines of business sensibly (e.g. using a marginal contribution approach) can be computationally intensive, and sometimes impractical due to the lack of granularity in such models.

9.3.2 Different economic capital metrics may be used for different purposes, and there is no single consensus "right answer" for the design of such a metric. A firm's economic capital assessment is very much an in-house concept owned by the firm, rather than being determined by external requirements. Possible drivers behind using different measures are:

(1) Balance sheet basis of asset and liability recognition could be different (e.g. depending on jurisdiction).
(2) Time horizons may differ (e.g. considering business planning horizon vs. view on long-term solvency).
(3) Regulatory view vs. management view (e.g. level of volatility in business, level of margins).
(4) Regulatory view vs. Industry view (e.g. co-dependencies between certain generic risks, degree of industry operational risk).
(5) Modelling limitations (e.g. co-dependency assumptions).
(6) "Solvency management" vs. "Business strategy".

9.3.3 Where the model is used for a number of purposes, questions will be asked about the internal consistency of the internal model. For example, should the same set of capital modelling results be used for solvency calculations and underwriter reward based on risk based capital allocation? It may be the case that some aspects would differ, e.g., risk tolerance (e.g., 99.5% VaR), and features such as inputs, assumptions, modelling approach need to be the same.

9.3.4 Another barrier to consider is the communication and educational aspects of alternative calibrations to management and wider business in the firm. It needs to be made clear that some of the economic capital assessment measures (e.g. 1 in 500) will suffer from significant limitations.

9.3.5 There are a number of research areas looking at economic capital assessment arising from internal models:

(1) ICA working party
(2) Extreme events working party
(3) CEIOPS papers on risk margin, risk free rate, calibration.

9.4 Background & Current Practice

9.4.1 Table 4 below identifies some of the main characteristics of alternative metrics that are used to address different economic capital objectives within the insurance industry.

Table 4
Comparison of Metrics

Feature	**Possible approaches**	**CEIOPS Pillar 1 standard formula**
Objective of metric	- Target balance sheet solvency: (assets > liabilities) - Target balance sheet + capital solvency: (assets > liabilities + required capital) - Target cash flow solvency - VaR	VaR
Balance sheet definition	- Market consistent - Regulatory - Realistic/economic (using real world discount rates) - Accounting / book value/revaluation	Market consistent (CEIOPS interpretation): - swaps as risk-free rate - market value margin (6% of cost of capital) Revaluation of technical provisions
VaR	- Percentile - CTE / Expected Shortfall / TVaR	Percentile
Time horizon	- 1 year - Multi-year - Terminal value on run-off or transfer value basis	1-year - Terminal provision on transfer value basis
Confidence level	- Dependent on objective/purpose of assessment	99.5%
Future new business	- Exclude (run-off) - Assume closure as early as is practical - Include business plan (going concern)	- Life: exclude - Non-Life: include for 1 year

	- Extrapolate business plan to end of projection	
Free assets	- Total balance sheet (incl free assets) - Excl free assets -Total market cap (net assts value plus franchise value)	Total balance sheet (incl free assets)

9.4.2 The free surplus backing a capital requirement will itself fall in a market stress scenario (e.g. if invested in equities). One way of addressing this is to ‘gross up’ the capital requirement itself to allow for the effect of such a fall.

9.4.3 Further capital can be assessed after stressing all the assets and liabilities (total balance sheet approach) or just the assets backing the liabilities and the necessary capital (the typical UK ICA approach). The directive recognises that there are other solutions and allows firms to model (for Pillar 1) based on alternative capital metrics, providing that they can demonstrate that their approach provides an equivalent degree of protection (see Article 120(1) of the directive). However, there is a danger that Solvency II will lead to the one year VaR measure being viewed by some as the only “right” answer for an economic capital assessment. Although one year VaR is established as the regulatory requirement for Solvency II Pillar 1, it should not (as a result) be treated as the single multi-purpose measure for all circumstances.

10. Assets

10.1 Introduction

10.1.1 Article 74 provides that assets are valued at the amount they could be exchanged between knowledgeable willing parties in an arm's length transaction.

10.2 Good practice in 2012

10.2.1 Asset classes that can be marked-to-market are valued on this basis.

10.2.2 Other material asset classes valued based on a mark-to-model approach, and models are analysed regularly for their consistent treatment with other classes.

10.2.3 Stress and scenario tests continue to capture the lessons learned from the financial difficulties of the period 1929 to 1934 inclusive and the more recent 2008.

10.3 Research & Barriers

10.3.1 The financial markets performance during 2008 showed that markets can become illiquid, and indeed effectively cease to trade. Mark to model in such circumstances, to overcome a lack of market values, is similarly challenged as the 'market instruments' needed to mark to in parameterising the model may be exhibiting effectively stale prices.

10.3.2 Even in more normal times assets such as private equity, collateralised loans, catastrophe bonds, mortality swaps, and some reassurance and/or financing arrangements can be hard to value and hard to stress in a consistent manner to more 'vanilla' assets. Similarly participations in non-quoted insurance subsidiaries will need bespoke treatment.

10.3.3 More generally, the market consistent valuation of assets such as a material bespoke derivative position need to be consistent with the liability valuation. The derivative will usually be valued by the banking counterparty while the liabilities may be valued using a model parameterised from more general, and inconsistent, market instruments. Similar effects will be seen in the valuation of catastrophe bonds, mortality swaps, financing and reassurance positions. The 'market value' may not align with the firm's own valuation of the benefit of such instruments.

10.3.4 There are a number of research areas looking at asset valuations:

(1) FASB is currently discussing rules for dealing with market values when markets are unstable, an immediate issue as we are preparing this paper.
(2) The SEC is debating guidance on the approaches to valuing assets that may be impaired.
(3) The IASB work including its September 2008 paper.

10.4 Background & Current Practice

10.4.1 Experience from ICA and realistic balance sheet work provides a useful starting point. Where a market exists for an asset, the value of the assets is currently (usually at least) based around the actual market value, although special rules that vary by territory can apply and the historic and/or implied volatility of the market value.

10.4.2 Where there is no market, ad-hoc methods of stress-testing marked to model assets are used.

10.4.3 Some assets, such as non-life reinsurance assets, are valued in a consistent manner to the gross technical provisions (which are discussed in the next section).

10.4.4 IFRS reported values may be deemed to be a reasonable proxy for the market valuation. Not all insurance companies have adopted IFRS and, for such companies, more adjustment may be needed from the reported accounts.

11. Technical provisions (at valuation date)

11.1 Introduction

11.1.1 The proposed Solvency II Framework Directive (Article 76) sets out the approach required to calculate technical provisions:

(1) Firms will be required to calculate the technical provisions either as the market hedgeable cost or as:

(a) The best estimate "equal to the probability-weighted average of future cash flows,
(b) Taking account of the time value of money (expected present value of future cash-flows),"
(c) Plus a risk margin.

(2) The discounting should be done "…using the relevant risk free rate term structure…"

(3) The directive further specifies the use of the cost of capital (CoC) method for determining risk margins (except where insurance liabilities can be replicated using financial instruments where a market value is directly observable).

(a) Capital in the CoC method is the amount of SCR from the internal model.
(b) 'Cost' in the 'cost of capital method' should be the same for all insurance and reinsurance companies.
(c) The 'cost' should equal the spread over risk-free interest and should be the amount appropriate for companies holding capital equal to the SCR.
(d) The legislative 'comments' say that the 'cost' should be the rate for borrowing by BBB-rated entity. This is consistent with the spirit of a 99.5% confidence level, but the BBB-standard is not explicitly stated within the Articles of the Directive.
(e) In QIS3 and QIS4 the cost of capital was set at 6%.

(4) The above applies to direct liabilities (Article 76) and to recoverables from reinsurance or special purpose vehicles (Article 80).

11.1.2 Whilst all companies have to calculate their technical provisions in line with Article 76, those who use an internal model to calculate the SCR are likely to include the estimation of their technical provisions in the internal model framework to some extent. The technical provisions and the risk margin might be produced together from the internal model. Alternatively, the technical provisions could be produced outside the capital model, but with the same underlying assumptions used to assess the risk margin. We consider that the former case will constitute good practice in 2012.

11.2 Good practice in 2012

11.2.1 Good practice is discussed below with respect to best estimates, discounting and risk margins.

Best estimate

11.2.2 "The calculation should be based upon current and credible information and realistic assumptions and be performed using adequate actuarial methods and statistical techniques." (Article 76). This can be broken down into a number of areas of good practice:

(1) Several methodologies are used in the valuation of the liabilities
(2) Concepts such as the Unearned Premium Reserve and Deferred Acquisition Costs have disappeared.
(3) Assumptions are tested and tests of actual to expected experience are applied routinely at each valuation period.
(4) The technical provisions selected by management are subject to a documented governance process to manage the 'judgmental' aspects of the methodology
(5) Balance sheet items that depend on operating results, e.g., profit commissions, are determined so as to be consistent with the liability estimates. Failing this, any margins held above the best estimate liabilities should be explicit management adjustments.
(6) As required by Article 80, reinsurance estimates are prepared independently and as rigorously as the direct estimates.
(7) Whilst reserving carried out stochastically to consider explicitly all scenarios is likely to be beyond normal company capabilities at 2012, specific consideration of extreme event scenarios should be included on a judgmental basis as necessary.

Discounting

11.2.3 Liquid or short term liabilities are discounted using rates used in other financial sectors for such liabilities – likely to be swap rates. Illiquid long term liabilities are valued using an illiquid version of swap rate.

Risk Margins

11.2.4 For non-life business, the SCR by line of business, from the internal model, is used for determining capital for risk margins. The techniques for determining the SCR are similar to those used to determine ICAS, i.e., companies assess their best estimate deterministically and judgementally, and then use a separate method, calibrated to a mean of the best estimate, to determine reserve uncertainty. Such methods include Mack's method, bootstrapping and stress testing.

11.2.5 The change in required capital as claim portfolios age is considered using a 'shape curve', something other than a constant percentage of the best estimate, unless that is shown to be correct for a particular line of business. The shape curve is established by separate analysis and the result used in the internal model. Note that this is different from that proposed within the current Solvency II framework.

11.2.6 The 'cost' in the CoC method is based on the assumption commonly used, without independent study by the company.

11.3 Research & Barriers

11.3.1 There are a number of areas that are barriers to implementing best practice in reserve valuation by 2012. Some of the key ones are discussed below, separately for best estimates, discounting and risk margins.

Best estimate

11.3.2 Group Consultatif had concerns over the application of stochastic methods to GI liabilities which are typically derived from historical analyses instead. On the life side while many liabilities are set using stochastic methods (e.g. the larger with-profit fund liabilities) there are material lines such as annuities where deterministic approaches are used.

11.3.3 There are a number of issues surrounding the treatment of extreme events – tail factors, inflation, Court decision, lapse and renewal rates, pandemics, asbestos, WTC, etc. If these extreme events are not fully assessed, then it is arguably not possible to assess the full distribution of potential claims payments, as required by the Directive to assess the "probability weighted average of future cash flows".

11.3.4 There is little existing literature on assessing the relationship between general insurance liabilities, inflation rates and interest rates.

11.3.5 Further clarity is needed on which expenses need to be included within the Technical Provisions.

Discounting

11.3.6 The directive indicates that for non-hedgeable risks technical provisions should be discounted at the risk free rate. There are several issues related to that requirement. Firstly, the IAA RMWG points out that there are several possible sources of 'risk free' discount rates; government bond rates, government bond rates plus an adjustment (e.g., for 'liquidity' of the liabilities), corporate bond rates minus an adjustment (default risk), swap rates minus an adjustment, and swap rates with no adjustment.

11.3.7 Secondly, the RMWG also suggested that where assets and liabilities are closely associated, it would be more appropriate if the liabilities were discounted based on the earnings of the related assets. The Directive reflects this effect only partially, to the extent that a risk margin is not required for the portion of the liability risk that could be hedged by selecting appropriate assets.

11.3.8 In addition, liability durations can extend beyond the maximum bond maturity available to insurance companies, so that there are no matching risk free assets from which discount rates can be directly determined. Finally, the calculations need to consider foreign exchange rate risk with respect to best estimates, discounting and risk margins when the underlying liabilities and financial reporting currency may be different. Neither of these two is a significant impediment, but further research may be required to better define best practice.

Risk margins

11.3.9 The key issue is whether the overall level of the risk margin is actually appropriate. For both non-life and life business, there are routine cases where the technical provisions including risk margin (which is intended as a proxy for a market-value margin) is much lower than the liabilities could be realistically sold onto a willing third party buyer. There are a number of reasons why this may be the case, and these issues are elaborated on below.

11.3.10 The IAA RMWG approach differs from the Directive, as exemplified by QIS 4 material, in a number of respects:

(1) The required amount of capital is not necessarily a fixed percentage of the best estimate liability, but may vary by the age of the liability, for example the percentage of more ‘toxic’ liabilities in a casualty account will increase during run-off, and these liabilities will typically require more capital per unit of reserve due to their highly uncertain nature.
(2) The cost of capital is not fixed over time, but varies over the settlement period. This is particularly important since liability classes tend to suffer from increased uncertainty as the age of the reserves increases.
(3) The required capital should reflect the effect of diversification between lines of business. The RMWG, identified the ‘reference company’ approach, but did not recommend that approach because of the difficulty in defining the reference company. It also identified two alternatives: own company diversification and own company scaled to reduce process risk, but did not recommend either of those.

11.3.11 There are other issues that may be barriers and/or require research.

11.3.12 Firstly, the ‘cost’ component of the CoC method has been illustrated as 6%(e.g. in QIS 4). A CRO Forum study (Chief Risk Officers Forum, *Market Value of Liabilities* *for Insurance Firms*, Implementing Elements for Solvency II, July 2008, pg8, www.croforum.org/publications.ecp) recently suggested that the 'cost' is between 2.5% and 4%. While the cost element may be treated as a 'given' for internal model purposes, companies may need to give more consideration to the issue for ORSA or other purposes.

11.3.13 Secondly, a market consistent discount rate is likely to look to the swap rate if the banking market is considered – where swap rate was (pre 2008) considered 'risk-free'. Before 2008 the gap between such swap rates and sovereign debt rates was explainable by the factors of sovereign debt can earn a few basis points by repurchase trades, there is credit risk in a swap rate, and swap rate has its own 'bid-offer' spread so non banking counterparties may not be able to earn offered swap rate in any case. Even with these factors swap rates are attractive as a standard due to their typically greater liquidity (pre 2008) and length.

11.3.14 However it is perfectly possible to envisage more than one risk free rate given the banking sector looks to short term and (normally) liquid markets while long term insurance liabilities will often represent more illiquid 'hold to maturity' instruments. This is not to say the discount rate should vary with the backing assets but rather that the market price for long illiquid liabilities could be lower than liquid ones due to the avoidance of the dangers of early settlement.

11.3.15 Thirdly, particularly relevant for non-life business, is how timing risk should be incorporated into the risk margin calculations. Some of the insurance cash flows are highly uncertain, and this risk needs to be incorporated within any meaningful risk margin in some manner, although it is difficult to see how this could be done in practice.

11.3.16 Finally, there is potentially a link between the cost of capital and adverse insurance experience, particularly in the tail of the distributions. Such a link needs to be incorporated to reflect properly what could happen in the market.

11.4 Background & Current Practice

Best estimate

11.4.1 There is already a large volume of work that has been carried out on reserving, and generally most of the best practice areas are covered. The main item missing is the explicit treatment of extreme events in the assessment of the best estimate.

Discounting

11.4.2 Determination of cash flows for discounting is routine for GI and life, although the actual discounting for the purposes of reserving is not necessarily routine for all companies. For life business, a benchmark risk-free rate (swaps/gilts) is usually used for ICA, with the exception of the existing Pillar 1 rules, where the discount rate is based on the backing assets.

Risk Margin

11.4.3 The risk margin is a new calculation, although its formulaic implementation within the QIS 4 spreadsheet is relatively routine, and should not cause any issues for companies to implement as it stands.

11.4.4 The cost of capital has been contentious, as has the risk discount rate. It is expected that the implementing regulations supporting the directive will specify a 'cost' for the cost of capital approach.

12. Technical provisions (in future projection periods)

12.1 Introduction

12.1.1 As well as assessing technical provisions at the start of the projection period, internal models need to consider the level of reserves at the end of future simulated projection periods in order that the future balance sheet can be assessed.

12.2 Good practice in 2012

12.2.1 The projection of future technical provisions should be consistent with the methodology used to assess the technical provisions at the start of the simulation. For example, if a chain-ladder with a Bornhuetter-Ferguson credibility weighting is used for general insurance liabilities, then this should be replicated using the simulated cashflow arising during each future financial year. Similarly the same approach to modelling economic risks, and the same series of future management actions, should be used for life business. The projection should only use the information that is known at that particular time-step, i.e. it should not have perfect foresight.

12.2.2 The proposed Solvency II technical provisions require a risk margin, which is assessed based upon the CoC method. This in turn requires a projection of the future SCR capital requirement, and the expected cashflow of the future liabilities in each of the future time-steps. The projection of the SCR, whether on a standard formula or internal model basis, should become another part of the projections using proxies or replicating portfolios.

12.2.3 Management and policyholder actions in future are codified and modelled to cover a far wider range of possible futures to cope with the demands of nested stochastic work. Such assumptions are tested by scenario analysis.

12.2.4 Ever greater computing power and more extensive use of variance reduction techniques may bring the application of nested stochastic simulations within the reach of larger organisations by 2012. In addition the use of more sophisticated closed form solutions, formulae fitted to the movement in assets and liabilities across a wide range of scenarios and replicating portfolios to capture the behaviour of the technical provisions may all facilitate the use of a single set of stochastic simulations in determining the required capital, which might be accessible to many medium sized organisations.

12.3 Research & Barriers

12.3.1 It is difficult to have a model using forecast data to replicate mechanically what a reserving actuary would do to assess the probability weighted average value of future cashflows, mainly because judgement will be part of an actuary’s review.

12.3.2 Where there are stochastic cashflows being generated within the internal model, it should arguably carry out a stochastic cashflow exercise for each of the stochastic simulations (this is commonly referred to as nested stochastic runs), which has a significant impact on model run-time, possibly to the point where it is not feasible to run the model. The model has also potentially become too complex in that errors will be less easy to identify and correct. Variance-reduction techniques may be useful here, and there is already research, from financial modelling firms, for example

12.4 Background & Current Practice

12.4.1 The current practice for re-reserving in the future differs between non-life and life.

12.4.2 In life business, the application of replicating portfolios facilitates proper nested stochastic internal modelling. For smaller books of business, where the risk is less meaningful, and for life insurance, risks re-reserving is typically carried out deterministically. This, by itself, biases the projection to more favourable outcomes. For example the recent credit crisis means reserve setting after such a period is more cautious over credit – but this effect is not typically captured in a model.

12.4.3 For non-life business, there are three main methods. Firstly, allow the internal model to have perfect foresight, and model the ultimate value of claims at the start of the projection, and then just use a pattern (e.g. incurred) to develop to ultimate. Secondly, deterministically reserve at each of the future time-periods using simple chain-ladder and Bornhuetter Ferguson methods. Finally, carry out full nested stochastic model runs. In each of these methods, it is easy to apply a risk margin, either as a constant load onto the best-estimate provision, or by the proper application of the cost-of-capital methodology.

12.4.4 Whichever method is chosen, appropriate allowance must be made for the variability of claims inflation, latency and the possibility of legislative ‘shocks’.

13. Guarantees and options

13.1 Introduction

13.1.1 Guarantees and options form an important component of the risk within an internal model, more so for life business, although there are some non-life applications as well.

13.2 Good practice in 2012

13.2.1 All material guarantees and options are modelled stochastically and should allow for both the management and policyholder actions appropriately. There should be a robust analysis of change in costs for guarantees and options from one period to the next to enhance understanding of the results especially in relation to the impact management and policyholder actions have on the results.

13.2.2 Robust procedures are in place to ensure that all potential policyholder options and guarantees are identified and understood, especially in relation to legacy portfolios. The range of guarantees and options usually relate to guaranteed annuity rates, mortgage promises, investment related guarantees, convertible/renewable term assurances, guaranteed charges, guaranteed surrender values and guaranteed minimum benefits.

13.2.3 For non-life business features such as “no claims discount for life” should be allowed for, particularly in light of emerging Treating Customers Fairly practice.

13.3 Research & Barriers

13.3.1 There is currently little research being carried out into the application of guarantees and options for internal modelling purposes, mostly because it is already assessed as part of life insurance realistic balance sheets and ICA's already. The main barrier to implementing guarantees and options is the level of complexity of the model, and therefore model run-time. This barrier is mitigated through simplifications in the model, although the impact of such simplifications is not fully understood at the moment, and some research is needed in this area, for example into the drivers of policyholder behaviours.

13.4 Background & Current Practice

13.4.1 Modelling of options and guarantees is already undertaken for Peak 2 reporting, ICA's, Economic Capital and Embedded Value calculations as well as Peak 1 reporting. It is often carried out stochastically, although for small blocks of business approximations are made where materiality doesn’t necessitate complex modelling.

14. RISKS—OVERVIEW

14.1.1 The sections below cover the following risk elements of internal models:

15.	**Insurance - Underwriting risk**
16.	**Insurance - Cat models**
17.	**Insurance - Reserving variability**
18.	**Insurance – Future business/future profits**
19.	**Insurance - Risk not in the standard formula SCR**
20.	**Insurance - Pricing cycles**
21.	**Market risk**
22.	**Credit—Including Counterparty and market credit risk**
23.	**Cash-flow modelling, including liquidity**

15. Underwriting risk

15.1 Introduction

15.1.1 Underwriting risk is concerned with the assessment of risk at the underwriting stage, the assessment prior to acceptance of new risk.

15.1.2 Managing and measuring underwriting risk has been more problematic for general insurance than life insurance. The material in this section is focused more heavily on general insurance, although the issues and practices apply to life insurance as well.

15.1.3 Underwriting risk arises from four main sources and it has become generally accepted that an internal model should model each of the components below separately.

Premium adequacy

(1) Pricing – the risk that the premium paid is inadequate, largely due to market pressures including the so called pricing or underwriting cycle

Claim variability

(2) Attritional claims – the risk that there is a higher frequency of small claims or that these claims have a higher average cost than expected.

(3) Large claims – the risk that there are more large claims than expected or that the large claims received are more severe than expected.

(4) Catastrophes – the risk that a catastrophe may occur causing much higher claim frequency and/or severity than expected

Other

(5) In addition, modelling requires considering of correlations, latent exposures and expenses.

15.1.4 We now turn to modelling the four risk components highlighted in Key Issues above.

15.2 Good Practice In 2012

Premiums

15.2.1 In some lines of business, large motor and group term assurance books being typical, claims costs per unit of exposure are not hugely variable from year to year. Instead much of the volatility in underwriting result arises from changes in the rating environment driven by the market place. So in considering premium risk it is important to avoid the mistake of assuming loss ratios are independent from year to year, as this over-simplifies the true composition of underwriting risk.

15.2.2 This means that the model should include an input for the expected rating environment and some limited volatility around the mean selected. This volatility should increase over the new business projection period. Appropriate correlation between premium rating movements for different projection years and between different classes is necessary.

Attritional losses

15.2.3 This component of the model will comprise the bulk of 'small' claims that the insurer will experience. In principle each claim could be modelled individually but this will increase the length of the model run-time and will not usually add any material accuracy to the model. So instead these claims will often be modelled as a cost per unit of exposure. This cost will be stochastic and the shape and parameters of the distribution will be estimated from the data. Note that if the exposure measure used is premium it will be important not to double count attritional risk with premium risk.

15.2.4 One further complication arises from attritional losses, particularly from longer tail business. These clams will often involve bodily injury. Such claims are sometimes subject to legislative change, whereby all cases settled after a particular date will be materially higher than previously experienced. This risk will correlate across years and business classes, affecting both underwriting and reserving risk. It is important that such "shocks" are modelled and that appropriate correlations are captured.

Large losses

15.2.5 The need to model large losses separately frequently arises from the insurer's reinsurance program, as often some of the large losses will be ceded to a reinsurer. As the model will often be used to provide information on the efficiency of an insurer's reinsurance program it is important that the model is sufficiently granular in this area.

15.2.6 Large losses will usually be modelled using an appropriate skewed distribution whose shape and parameters are fit to the data. It must always be remembered that very large losses in particular will occur infrequently and therefore the data will be necessarily incomplete. An additional issue that arises from infrequent very large losses is that identifying trends is challenging, with the risk that the distribution used may be incorrect. Therefore due allowance should be made of any available external data and input from the underwriting community.

15.2.7 Simulated large losses should be put through the insurer’s reinsurance program. Full allowance should be made for all aspects of the program including any reinstatement premiums payable. If the program contains any options, e.g. the option to reduce a retention following a loss, assumptions should be made about the likely management action in this case. It is usual to assume that the current program remains unchanged throughout the period in which business is written. Issues such as the possible non-collection of reinsurance due to reinsurer failure are outside the scope of this section.

Catastrophe losses

15.2.8 Catastrophe losses can arise in both life and general insurance business. Life business catastrophe losses have historically been less frequent, so there has been less emphasis on understanding the risk compared with general insurance business. However, many of the considerations are similar.

15.2.9 The modelling approach to catastrophic losses is discussed in Section 16. Losses generated by the catastrophe loss model should, where relevant be put through any reinsurance program to generate the net claim. Again all features of the reinsurance program should be included.

Correlations

15.2.10 We have already mentioned correlations arising from claims inflation and shocks to the claims environment both of which are captured by the model. The model should also consider if there are other cross-class correlations that need to be captured. In particular a number of classes, otherwise uncorrelated, may exhibit some dependency in the tail of their distributions. Such dependency may not be contained in the available data so estimates of the level of the dependency will need to chosen using considerable judgement. For further details see Section 2.

Latent risk

15.2.11 A decision the insurer will need to take is the extent to which it models latent risk. In recent years latent risk has been dominated by asbestos related claims, though some more minor causes such as abuse or industrial deafness may be in the insurer’s data. The size of the asbestos “event” is such that an assumption of a reoccurrence, or otherwise, of such an event would materially change the model output. The insurer will need to formulate a view on the likelihood of another such event in the knowledge of its current underwriting stance, and its knowledge of the legal and political background to these exposures.

Expenses

15.2.12 A key component of the underwriting result is the level of expenses incurred by the insurer. Proportionate expenses such as commission should be modelled directly. Profit commissions will be simulation specific. In the short run at least the level of other expenses is reasonably stable so deterministic expense assumptions may be appropriate. Over time expense levels will be linked to inflation and the model should reflect this.

15.2.13 As the period over which business is written is shorter than the full projection period, the model will include a run off period. Clearly if the business was to enter run off there would be a material change in the expense levels. How this issue is dealt with will depend on the purpose of the model.

Other

15.2.14 Models with an ability to project over a multi-year period will become standard.

15.2.15 The accuracy of the planning assumptions decrease with time and this should be reflected through increased volatility of planned results over time. Whilst stochastic models have their part, stress and scenario testing will have been enhanced to complement the stochastic models as they improve accessibility to interpret the results and understand whether management actions are likely to be as appropriate and effective as reflected in stochastic models.

15.3 Research & Barriers

15.3.1 Choosing parameters for correlations and tail dependencies is highly judgemental as data will often be sparse or non-existent. The sensitivity of the results to these parameters needs to be tested. It is important that the inability to "prove" that the chosen parameters are correct does not detract from confidence in the outputs of the model.

15.3.2 The concept that underwriting results are correlated between years is not universally accepted (e.g. Solvency II Standard model).

15.3.3 Allowance for future profits is not always accepted as a legitimate source of capital.

15.3.4 Performance targets are based on optimising competing objectives. This may lead to sub-optimal performances if incentives are not set carefully.

15.3.5 For underwriting risks there should be an increase in research on metrics that can provide early indication that the assumptions underlying the premium adequacy and claims variability continue to hold.

15.3.6 It is desirable that the level of segmentation and granularity used within product pricing will extend through to capital, value and performance measurement, however, there may not be sufficient consistency throughout an organisation in the modelling, and understanding of risks to achieve this.

15.4 Background & Current Practice

15.4.1 Much of the profession's experience in ICA and realistic balance sheet models is applicable to internal models.

16. Insurance - Catastrophe models

16.1 Introduction

Article 104 provides that for risks arising from catastrophic geographic specifications may be used whether or not an insurance undertaking uses an internal model for SCR purposes, it is likely to use catastrophic models for ORSA and other risk management purposes. Companies will find that the treatment of catastrophes is critical for ORSA.

16.2 Good Practice in 2012

16.2.1 The potential for major catastrophes should be modelled explicitly and incorporated within the overall internal model framework. This can either be through proprietary catastrophe models, or through internal analysis to develop potential losses that could arise from specific catastrophes.

16.2.2 Proprietary catastrophe models being independent of a firm provide a useful source of information on potential catastrophe claims development. However, there is a need to avoid dependence on a single model for a risk that contains such uncertainty.

16.2.3 The use of a proprietary catastrophe model does not reduce the responsibility to understand the model, the important parameters and input into the parameters used.

16.2.4 Whilst proprietary catastrophe models will continue to develop there will also be greater appreciation and understanding of their limitations and dependencies. There will be increased consideration of adjusting the proprietary models to make them more relevant to the company, for example incorporating additional levels of demand surge for extreme losses, or including non-modelled perils such as flood following on from a windstorm.

16.2.5 The firms will be expected to fund internal or external development of bottom-up catastrophe models to improve their understanding of the potential catastrophe risk exposure. For example, for windstorm, firms should understand the potential impact from storm paths and intensities that have not been historically observed. This will assist the internal development of realistic disaster scenarios to validate the output from the catastrophe model.

16.2.6 Firms will be expected to more fully understand the key risk drivers for a catastrophe. This will allow firms to provide greater influence on the impact of the frequency and severity of catastrophes rather than being a slave to external events. This will involve a multi-disciplinary approach including using external experts.

16.2.7 The catastrophe model should be used to consider the risks that could impact the business in the short-term, rather than any longer-term trends. For example, the multidecadal frequency of US hurricane exposures should be incorporated so that the potential frequency of events is not understated.

16.2.8 Similarly, all risks that could change the loss cost should be included. For example, demand surge and business interruption losses should be incorporated.

16.2.9 The catastrophe model data should be documented and signed-off by internal experts (typically an underwriter). Quality control processes around data collection and entry should be carried out to ensure that the information going into catastrophe models is valid and appropriate.

16.2.10 Catastrophe model output should be formally reported to senior management. An analysis of change should be carried out so that the key drivers of catastrophe risk are properly understood and communicated to senior management.

16.2.11 Firms will be expected to monitor the catastrophe risk for which there are no proprietary models, as well as risks covered by such models.

16.3 Research & Barriers

16.3.1 Extreme catastrophes are, by definition, rare and individual events. This makes validating the output from catastrophe models difficult. Typically, following a particularly large event, the additional information from that event causes a material change to the underlying proprietary catastrophe models.

16.3.2 There are a number of judgemental assumptions that are required when considering potential uplift factors from a base catastrophe model. These, again, are difficult to validate in the absence of real-life loss data.

16.3.3 Catastrophe models have come under recent criticisms due to them not correctly assessing the value of some of the large natural catastrophes. This makes senior management slightly sceptical of their value and there is the danger that this may cause apathy to reviewing catastrophe model output.

16.3.4 Recent research includes "Report of the Catastrophe Modelling Working Party", GIRO 2006, http://www.actuaries.org.uk/__data/assets/pdf_file/0007/30121/Fulcher.pdf. This includes an extensive reference section in Appendix 1.

16.4 Background & Current Practice

16.4.1 Use of catastrophe models is standard for general insurance and life reinsurers .

16.4.2 The models only cover specific risks, but the extent of coverage is increasing.

16.4.3 The risk of increasing frequency of events due to global warming is recognised but the impact is uncertain.

16.4.4 Catastrophe modelling assists in the application of risk mitigation strategies such as monitoring maximum exposure and purchase of reinsurance or other hedging instruments.

17. Insurance - Reserving variability

17.1 Introduction

17.1.1 Reserve variability is usually one of the most significant general insurance risks.

17.2 Good practice in 2012

17.2.1 The following steps are suggested as one way of overcoming the difficulties posed by the various sources of variability:

(1) Use boot-strap or other techniques to derive a distribution.
(2) Assess the need to overlay stochastic inflation to simulate future cash outflows.
(3) Assess the need to adjust existing data triangle for inflationary effects, i.e. restate all data entries in 'today's pounds.
(4) Consider an adjustment to the emerging results to allow for any 'underwriting/reserving cycle' effects.
(5) When dealing with recent events, assess all results in terms of probabilistic distributions.
(6) Overlay a 'shock' distribution to allow for the possibility of future legislation changes.
(7) Overlay an assessment of the probability and severity of future latent claims not otherwise allowed for in the data.
(8) Estimate 'best estimate' from the adjusted data.

17.2.2 All this will be handled using Monte Carlo methods as no closed form overall distributions can be hoped for.

17.3 Research & Barriers

17.3.1 As shown by the 'General Insurance Reserve Oversight Committee', commonly used existing methods are inadequate to cover the full range of reserving variability. We suggest future research to be devoted to this area in order to improve the analysis carried out by the profession.

17.3.2 Commercially available reserving software includes techniques to assess the statistical patterns within the data with more granularity than is normally applied. The value of this capability in practice should be further researched.

17.3.3 Application of bootstrap and other methods requires analysis of the assumptions regarding the underlying distribution. Some believe that actuaries do not normally investigate those assumptions rigorously enough. Education and research in this area is encouraged.

17.4 Background & Current Practice

17.4.1 Insurance unpaid claim reserves are uncertain because of:

(1) Uncertainty in development, frequency, severity and other parameters.
(2) Under or overstated initial loss ratios due to (undetected) changes in terms and conditions.
(3) Change in inflationary environment.
(4) Changes in company operational procedures.
(5) Statistical variability.
(6) Difficultly in assessing the true cost of an event occurring close to the balance sheet date.
(7) Legislation change affecting all open claims. More often than not adverse.
(8) Emergence of latent claims.

17.4.2 The clear difficulty is assessing the shape of any distribution and its parameters. Considering the sources of possible variability outlined above it is clear that over reliance on available data will not be sufficient since obviously some of the sources may not have occurred within the period to which the data relates. Moreover the data will only record the outcome of one historical inflation path compared with the unlimited number of possible future paths.

18. Insurance - Future business/Future Profits

18.1 Introduction

18.1 Future business, sometimes called new business, refers to cash flows from new contractual relationships. It does not include cash flows from contracts in force at the reporting date, as the effect of those cash flows is included in technical provisions. Future business includes:

(1) GI - New and renewing policies; and
(2) Life - New customers and obligations for existing customers that could not be exercised based on contracts in force at the effective date.

18.2 Good Practice in 2012

18.2.1 The Internal Model should be able to deal with at least the following treatments of future profits/future premium.

Table 5
Treatment of Future Business

Illustrative Uses*	**Treatment of Future Business**
Solvency at the reporting date: for SCR purposes	A. Life - Run-off only, or Run-off plus stress test a ‘shock period’. B. Non-Life – One year of new business In either case-Going forward with new business calibrated to achieve a result no better than a zero profit (present value underwriting results of zero). This tests the run-off as if it were a going concern at the valuation date, but without the effect of gain, assumptions from new business Note: The risk distribution for future business is more difficult to establish than the risk distribution for business under contract. Runoff with zero profit is a reasonableness test for the effect of that future business.
Assessment of solvency at future dates; for ORSA purposes	New business during a short period, 1 year or less, that is expected to be necessary before identifying issues and correcting them and/or Business plan period (1-3 years) and/or Long term (over 3 years).

*The model should also be able to handle issues related to business planning, acquisition/divesture of subsidiaries and risk management.

18.2.2 Also, to help with calibration and validation, the model should also be able to handle:

(1) Scenario testing for unfavourable new business concurrent with other stresses
(2) Tests of historical 'worst case' or related scenarios.

18.3 Barriers and issues

18.3.1 Modelling future premium/future profits requires extending assumptions in areas including the following: volume for new business (perhaps in new territories and/or with new products), expenses (particularly important for life insurance), pricing cycle, reinsurance strategies and costs (particularly for GI), operational risk, latent exposures (particularly GI) asset behaviours, and management actions.

18.3.2 Thus, the degree of uncertainty in forecasts of future business and future profits is often greater than the degree of uncertainty in technical provisions which related to previously underwritten business.

18.3.3 The distribution of possible outcomes from those assumptions is wider, as the assumptions relate to events further into the future.

18.3.4 There is little research on ways to establish how much wider the distribution should be.

18.4 Background & Current Practice

18.4.1 Future forecasts are currently used for various purposes, but none equivalent to use in establishing regulatory minimum capital for life insurance business.

18.4.2 The ICAS for life insurance, as a runoff test, includes the test of whether one year of new business increases the capital required.

18.4.3 The ICAS for non-life insurance includes a single year of new business, run-off to ultimate.

19. Risks not in the standard formula SCR

19.1 Introduction

19.1.1 Not all risks are included in the standard formula SCR, but internal models are expected to be more complete.

19.2 Good Practice in 2012

19.2.1 The background section, below, identifies gaps in the SCR coverage of risks.

19.2.2 Good practice will be to have identified which of those areas is significant for the firm and address those gaps in the internal modelling.

19.3 Research & Barriers

19.3.1 Research on the types of gaps in the SCR, the extent and circumstances in which those gaps can be material and the mitigation steps firms might take for internal modelling purposes.

19.4 Background & Current Practice

19.4.1 The standard formula SCR strives for a balance between simplicity and accuracy and so will almost inevitably exclude some risks that may have be included in internal risk models or, at least, reflect them more crudely than would be the case in a sophisticated internal model.

19.4.2 The SCR is effectively calculated by considering changes to the net asset value of the insurer or insurance group over a one year period. In essence this means that any assumption made in deriving the base balance sheet is a source of potential variation and consequently a source of risk that might be considered under the SCR.

19.4.3 Some risks that are not currently considered in the standard formula SCR (as represented through QIS4), but which might commonly be reflected in an internal model are listed below.

(1) shocks to equity implied volatility;
(2) shocks to interest rate implied volatility;
(3) movements in government bond yields relative to swap rates;
(4) the effect of various risks on staff pension schemes;
(5) shocks to implied RPI inflation;
(6) random variation in observed mortality/morbidity rates; and
(7) random variation in observed persistency rates.

19.4.4 Risks that are considered in the standard formula SCR, but in a less granular way than in typical internal models include:

(1) changes to the shape of the yield curve;
(2) returns on a wider range of asset classes and considering any basis risk;
(3) changes in corporate bond spreads due to rating transition as well as general spread volatility;
(4) mortality/longevity risk split into uncertainty about the base level and about future improvements;
(5) persistency risk by product; and
(6) operational risk.

19.4.5 Finally, some risks that are only modelled by a small number of internal models include:

(1) changes in the shape of the implied volatility surface (across term structure and strike);
(2) shocks to property ‘implied’ volatility;
(3) shocks to credit default rate, transition rate and spread ‘implied’ volatility;
(4) shocks to investment risk ‘implied’ correlations;
(5) shocks to assumed management actions;
(6) shocks to assumed dynamic policyholder behaviour rules (e.g. guaranteed annuity option exercise);
(7) changes in the shape of persistency across terms;
(8) changes in the shape (rather than level) of future mortality improvements;
(9) differentiated changes in rates of policyholders becoming paid up and surrendering;
(10) changes in early/late retirements, partial withdrawals etc;
(11) shocks to the cost of capital.
(12) contagion
(13) reputation risk
(14) tax changes
(15) other regulatory risk; and
(16) funding risk (i.e. ability to refinance commercial paper/debt).

20. Insurance - Pricing cycles

20.1 Introduction

20.1.1 The pricing (underwriting) cycle is a recognised feature, predominately in general insurance business.

20.2 Good Practice in 2012

20.2.1 The pricing cycle is considered in the selection of loss ratios and business volumes.

20.2.2 The potential for adverse reserve development related to the pricing cycle is reflected in both technical provisions (as an impact on best estimates and as an impact on risk margins) and new business.

20.3 Research & Barriers

20.3.1 For reserving, there are currently no established methods of including pricing cycle adjustments to either best estimates or the distributions of outcomes around the best estimates.

20.3.2 The use of pricing indices to measure the current position of the pricing cycle is more effective than in the past, but there may be ways to improve the reliability of those indices for that purpose.

20.3.3 There may be ways other than pricing indices for determining the position and direction of the pricing cycle.

20.4 Background & Current Practice

20.4.1 It has been shown that in some cases there is a correlation between development in unpaid claim reserves and the pricing cycle.

20.4.2 The effect of the pricing cycle is not routinely reflected in ICA modelling that does not include future business (life insurance business)

20.4.3 The effect of the pricing cycle is included in general insurance ICA modelling, either through a simple variability applied to the planned pricing insurance cycle, or by a cascading pricing cycle such as used in the parameterisation of the ECR.

21. Market risk

21.1 Introduction

21.1.1 ICA and realistic balance sheet work has given the profession a great deal of relevant experience in this area.

21.2 Good Practice in 2012

21.2.1 Use an appropriate asset risk model (economic scenario generator) for interest rates, spreads, inflation, equity returns and currency exchange rates.

21.2.2 Use best available model for property value risk, although this is likely to be less robust than for other asset classes due to the relative scarcity of data.

21.2.3 Clearly identify asset classes that are not robustly modelled and develop appropriate tools to measure risks related to those assets.

21.2.4 Use detailed ALM procedures for life insurance to determine bonuses for example.

21.2.5 To the extent that it is material (based on sensitivity testing) apply asset-liability correlations for GI, e.g. inflation impacting upon the liabilities and investment returns achieved.

21.2.6 Monitor concentrations of risk, remaining alert to new ways in which risks can become concentrated.

21.2.7 Reflect correlations between lapse experience and asset value movements in life insurance.

21.2.8 Consider the effect of management actions (see related section).

21.3 Research & Barriers

21.3.1 Research is needed in the following areas:

(1) Inconsistencies between co-dependencies in ESGs and co-dependencies in the capital stress situation.
(2) Concentration risk.
(3) Models for property values and other less-well-studied asset classes.
(4) Basis risk for company portfolios compared to the risks reflected in the ESG or other asset models.
(5) Need for and use of distributions with ‘fat’ tails.
(6) Currency risk, which affects reinsurers and groups (life and GI) particularly.

(7) GI asset liability correlations, e.g. what happens to US equities following on from a material Californian earthquake – would they increase as investment floods into the region, or do they enter a depression?

21.4 Background & Current Practice

21.4.1 Use of economic scenario generators is routine for life insurance firms, and applied where significant for general insurance.

22. Credit Risk – Including counterparty and market credit risk

22.1 Introduction

22.1.1 Credit risk, also referred in the Directive as counter-party default risk is identified in Articles 101(4e), 104(1e), and 105(6).

22.1.2 Article 105(6), describing the elements of the SCR, provides that:

> *"The counterparty default risk … shall reflect possible loses due to unexpected default, or deterioration in the credit standing, of the counterparties and debtors of insurance and reinsurance undertakings over the next twelve months. The counterparty default risk module shall cover risk-mitigating contracts, such as reinsurance arrangements, securitisations and derivatives, and receivables from intermediaries as well as any other credit exposures which are not covered in the spread risk sub-module.*
>
> *For each counterparty, the counterparty default module shall take account of the overall counterparty risk exposure of the insurance or reinsurance undertaking concerned to that counterparty, irrespective of the legal form of its contractual obligations to that undertaking."*

22.1.3 The IAA Global Framework for Insurer Solvency Assessment identifies the elements of credit risk as default, downgrades, variation in spreads between securities of different credit quality, lags in settlement of obligations by debtors, sovereign risk, concentration risk and counter-party risk (in addition to the above), e.g. reinsurance.

22.2 Good Practice in 2012

22.2.1 Each of the risk areas identified by the IAA is considered in the internal model.

22.2.2 Credit quality and concentration is monitored using commercial or proprietary credit models.

22.2.3 The company assesses the results of those proprietary models, so it is has its own view of credit quality not solely reflective of the credit models.

22.2.4 Major correlations between credit risk and other risks are reflected with models or judgment, as practical. For example, linking reinsurance default rates with natural catastrophes that will affect the reinsurers.

22.2.5 'Basis risk', the difference between the company portfolio and the portfolio assumed in the credit model, is monitored and the internal model reflects those differences.

22.2.6 Overlap, if any, between market risk assessment and credit risk assessment is removed (e.g., the risk of downgrade may already be reflected in the projected potential variation of market value of securities).

22.2.7 Credit risk assessment reflects suitable management actions (see management action discussion).

22.3 Research & Barriers

22.3.1 Areas for further research are:

(1) Correlations among credit risks.
(2) Correlations between credit risks and other risk, e.g. catastrophe risk and credit risk on reinsurance.
(3) Concentration risk, which can be difficult to assess, as demonstrated by the degree of concentration arising for recent problems arising from the US mortgage market.
(4) Methods of adjusting for basis risk.
(5) Dealing with the limitations of credit models.

22.4 Background & Current Practice

22.4.1 Credit risk is evaluated based on counter-party ratings from rating agencies and historical default rates.

22.4.2 Economic scenario generators are assumed to include an appropriate amount of risk related to counterparty downgrade and the like on financial instruments.

23 Cash-flow modelling and liquidity

23.2 Introduction

23.1.1 This section considers the modelling of cashflow mismatching risk.

23.1.2 Under the existing **Solvency I** rules, cashflow mismatching risk is currently addressed to an extent in both Pillars 1 and 2:

(1) **Pillar 1:** Firms are required to hold explicit prudent reserves to cover cashflow mismatching risks.
(2) **Pillar 2:** Firms are required to consider explicitly liquidity risk in general (of which cashflow mismatching risk is arguably a subset).

23.1.3 Under **Solvency II**, the Pillar 1 rules do not include any explicit capital/reserve requirements in respect of cashflow mismatching risk. However, the requirement to consider liquidity risk in general under Pillar 2 remains in the new regime (liquidity risk is listed as one of the requirements of a firm's system of governance under Article 43(2) of the draft directive, the compliance against which would be reviewed as part of Pillar 2).

23.1.4 The authors believe that there are areas for improvement in current practice, particularly in relation to accuracy of cashflow modelling and closer scrutiny of the more commonly used simplifying assumptions.

23.2 Good Practice in 2012

23.2.1 A detailed investigation of cashflow mismatching risk is carried out on a regular basis (using the internal model) and reported to senior management. The investigation should be a close collaboration between actuarial and investment management staff.

23.2.2 Any simplifying assumptions in the internal model that might affect the accuracy of modelling (e.g. model point compression) should be clearly flagged in any reports on cashflow mismatching risk. Views on materiality should be stated and justified (where possible with supporting quantitative evidence).

23.2.3 Stress scenarios that consider an increase in specific drivers of cashflow mismatching risk (e.g. mass lapse) should be investigated regularly (using the internal model) as part of a firm's risk management. (The CRO Forum paper on liquidity risk management (2008) suggests a number of useful example scenarios.)

23.3 Research & Barriers

23.3.1 The following topics would be useful avenues of research for industry and/or the profession (some of which also impact market risk assessments):

(1) Modelling of the volatility of bid-offer spreads of commonly held assets (i.e. bonds and equities).
(2) Quantification of the potential impact of commonly used liability model simplifications (e.g. model point compression) on the accuracy of cashflow projections.
(3) Investigation of how the extreme events of 2008 affected the cashflow mismatching risk of insurers and consideration of how this kind of extreme event can be modelled (if at all) as part of good practice liquidity risk management.

23.3.2 The following currently available research is relevant:

1. "Liquidity Risk Management", CRO Forum (2008), http://www.croforum.org/publications.ecp
2. "Liquidity management in UK life insurance: A discussion paper", Kelliher et al (2005), http://www.actuaries.org.uk/__data/assets/pdf_file/0004/27418/liquidity_mgt.pdf

23.4 Background & Current Practice

23.4.1 Insurance company valuations are usually based on the present value of projected cash flows and hence cash flow modelling is at the heart of modern internal models. The advent of market consistent valuations may have placed even greater emphasis on the modelling of cash flows - a founding principle is that two identical sets of cash flows must have an identical value and hence, by finding a portfolio of assets with cash flows that match those of a liability portfolio across a wide range of economic conditions and being able to identify the market value of that portfolio of assets, we can determine the market value of the liability portfolio.

23.4.2 However, whilst the modelling of cash flows as accurately as possible is a necessary goal in determining the value of the liabilities (and some assets), practical constraints relating to computing power, systems sophistication and run times currently necessitate (or are often quoted as necessitating) a number of compromises. These compromises may include:

(1) The use of heavily compressed asset model points.
(2) The use of heavily compressed liability model points.
(3) The lack of granular modelling of different policyholder options that have significantly different effects on cash flow (e.g. policies being made paid up, early/late retirements, ill health retirements, policyholders electing to increase top-up payments, policyholders switching funds, policyholders electing for more lump sum or annuity payments).
(4) The lack of granular modelling of some asset and non-policyholder liability types that may have a significant effect on cash flows (e.g. default and delays in the recovery of proceeds on corporate bonds, early redemption of mortgages,

drawdown of contingent loans, repayment of subordinated debt, reinsurance recapture, derivate collateralisation/margining).

(5) The absence of any liquidity based constraints on the amount and timing of asset allocation changes in management decision rule models.

(6) The use of economic scenarios generators that focus on total returns (rather than separating dividends/rents and capital growth).

(7) The use of economic scenario generators calibrated to a consistent series of prices (e.g. all mid-market prices) that make no allowances for the additional volatility in the bid-ask spread over time.

(8) The use of annual or monthly (rather than daily) projection steps where possible in asset liability models.

23.4.3 Stochastic models, in particular, often also assume that negative cash flows during a period are accumulated at some cash rate of return until the end of the period when some asset sale rules are used to determine the necessary disposals to meet the negative cash flow. This may or may not be appropriate depending on the nature or liquidity of the assets held.

23.4.4 Whilst the approximations listed above may only result in second order inaccuracies in the valuation of assets and liabilities, this assumption is seldom tested and is an area for possible further research. Limited challenge from auditors and supervisors to existing models has not provided great impetus for enhancements to existing cash flow models, but the increasing popularity of replicating portfolio models and heightened market attention to liquidity risk in the wake of the recent banking crisis may lead to some resurgence of interest in this area.

23.4.5 The assessment of liquidity risk under the ICA is currently often a separate quantification of the assets regarded as liquid (sometimes classified by the term buckets over which realisation can be achieved without significant cost/penalty) and the comparison against projected liability cash flows. The consideration of cashflow mismatching risk in stressed liability scenarios (such as a mass lapse or a significant market change in natural catastrophe scenarios) and stressed asset scenarios may be limited. Historical periods of illiquidity are sometimes used as reference points, but data on liquidity (e.g. volumes traded) and movements in bid-ask spreads is very scarce.

24 MODEL STRUCTURE - OVERVIEW

24.1.1 The issues related to model structure covered in the following sections are:

25.	**Use of Stochastic modelling**
26.	**Granularity and Segmentation**
27.	**Modelling and Dynamic Management actions**
28.	**Probability Distributing of Economic Capital/Full Stochastic or combination of risk factors**

25.Use of Stochastic Modelling

25.1 Introduction

25.1.1 This section considers the use of Monte Carlo simulation and other related stochastic techniques in an internal model.

25.1.2 Monte Carlo simulation can be used both to assess the value of technical provisions at a point in time, and to determine capital requirements (by modelling the variability of elements of the balance sheet in extreme conditions). The issues to consider vary according to the application.

25.2 Good Practice in 2012

25.2.1 The process to decide whether risks are modelled using deterministic or stochastic techniques should be transparent and well documented. As part of the process, the extent to which each risk is asymmetric should be considered in depth. A matrix of all risk types, identifying how each risk is modelled with reasons could be kept as part of the process documentation associated with an internal model.

25.2.2 A central register of all options and guarantees (including those on legacy business) is kept and updated regularly, enabling senior management to monitor them more easily. Each option/guarantee should be fully understood, documented and (where material) modelled using stochastic techniques.

25.2.3 Monitoring of the capital position in real time could in theory require firms to roll forward complex stochastic asset-liability models in real time (something which is presently beyond the capability of many firms). It would clearly be inappropriate to suggest a one size fits all solution to this considerable challenge. Good practice will involve making best use of available technology (e.g. variance reduction techniques, replicating portfolio systems, closed form solutions), taking into account the practical constraints of the firm in question.

25.2.4 However, good practice does not equate to the blanket use of computing power and/or replicating portfolio software to address every problem. These techniques should ideally be used intelligently in situations where closed form solutions are not possible.

25.2.5 Where Monte Carlo simulation is required, firms should understand and quantify the sampling error associated with the technique and attempt to minimise it to the extent that this is practical. Increasing the number of simulations or using variance reduction techniques may help reduce the sampling error.

25.2.6 As part of model development and testing, firms should test the results of the model (and in particular any dynamic algorithms in the model) in tail simulations to ensure the results are sensible.

25.3 Research & Barriers

25.3.1 The following topics would be useful avenues of research for industry and/or the profession:

(1) Development of practical methods of projecting capital requirements (i.e. practical alternatives to nested stochastic models).
(2) The following challenges may constrain development of good practice:
(3) The capability to increase the number of model points and/or simulations used relative to current practice will be limited by computing power.
(4) Use of replicating portfolio packages may require a significant front end investment (in terms of both time and cost) to implement or may not be appropriate. For some firms there may already be insufficient time left to implement such systems before Solvency II is introduced.
(5) Convincing stakeholders of the need to invest in new technology for may prove to be challenging. There is likely to be a lack of understanding about the limitations of existing modelling technology amongst non-actuarial stakeholders.

25.3.2 The following currently available research is relevant:

(1) “Practical issues in ALM and Stochastic modelling for actuaries”, Gibbs & McNamara, Institute of Actuaries of Australia’s (Institute) Biennial Convention (2007), *http://www.actuaries.asn.au/IAA/upload/public/1.b_Conv07_Paper__Gibbs%20McNamara_Practical%20Applications%20in%20ALM.pdf*

25.4 Background & Current Practice

25.4.1 Any internal model brings together a representation of the insurance company or group structure – its legal form, its capital structure, the policies it has written, its assets, how management might exercise its discretion, the tax regime in which the company/group sits etc - and its interaction with various uncertain factors. These uncertain factors include the future investment returns, the level of future expenses and the level of future insurance claims paid and premiums received.

25.4.2 In many instances these factors can be broken down further into more granular drivers of uncertainty such as unit linked pensions lapse rates, FTSE100 equity returns, term assurance policyholder mortality rates, European windstorm frequency and severity etc. Nonetheless, uncertainty remains and so these factors and drivers are, by definition, stochastic.

25.4.3 The question that needs to be asked when constructing or applying an internal model is whether or not it is important to capture the stochastic nature of these risks. The answer to this question will depend on the structure of the product, company or group in question and the use to which the internal model will be put.

Calculating technical provisions

25.4.4 In the market consistent frameworks of market consistent embedded value and Solvency II, financial risks are almost invariably modelled stochastically if they have a direct effect on the magnitude and timing of the cash flows and if the structure of the product, company or group (or, arguably, the tax regime) introduces an asymmetry to the effect on the cash flows.

The majority of non-life insurance companies' liability cash flows and life insurance companies' annuity liability cash flows do not depend directly on financial risks and so are modelled using a deterministic (risk-free) discount rate. The approach assumes that inflation does not introduce any asymmetry such that the mean/average of the cash flows across a range of inflation scenarios would no longer equal the cash flows based on the mean/average inflation scenario.

25.4.5 Unit linked liability cash flows are directly dependent on financial risks, but the linear link between investment performance and the liability cash flow means that, under the certainty equivalent principle, the cash flows may be evaluated deterministically provided that the gross earned investment return is the same as the discount rate applied.

25.4.6 For insurance products where financial guarantees or options are present then stochastic techniques are required. For some simple products the mean of the present value of the cash flows (which are driven by stochastically varying financial risks) can be calculated analytically using a closed form solution i.e. a mathematical formula. However, in many cases the mean of the present value of the cash flows can only be determined via simulation. This is particularly true for products where the impact of management discretion is significant and where this discretion is applied based on the performance of the company as a whole (rather than based on factors discernable at the policy level) e.g. where individual policy bonus rates on with-profits policies are influenced by the overall solvency position of the with-profits fund or even the whole insurance company.

25.4.7 At present non-financial risk influences on cash flows are usually applied deterministically. This can be seen through chain ladder techniques in projecting best estimate non-life claims and in using historical experience analyses to determine an estimate of the appropriate mortality or lapse assumption to make.

25.4.8 This approach may not be appropriate if the sample mean is taken from a relatively short historical period and the distribution of the risk is likely to be highly skew. It will also often not be appropriate if there is a significant asymmetry in the cash flows resulting from changes in non-financial risks e.g. guaranteed annuity option pay-offs in response to variations in mortality. In these cases stochastic modelling may be required.

Capital requirements

25.4.9 Attempts to fully apply stochastic modelling raise capital modelling issues such as:

(1) Solvency II and economic capital calculations of required capital specify a target percentile or conditional tail expectation threshold. While the lack of data for some risks has led to expert judgment being used to estimate the risk at the required percentile directly, the majority of risks are evaluated using statistical techniques.

(2) In the case of life insurance companies where a Monte Carlo simulation is required to determine the technical provisions, the lack of computing power that would be necessary to run nested stochastic simulations often restricts the insurer to running deterministic stress tests on a risk by risk basis. Each stress test is derived by adjusting the relevant risk to the required percentile, where this is derived either analytically or by simulation. The capital required under all of the stress tests is then aggregated through matrix multiplication using a matrix specifying the correlations between each of the risks.

   This approach requires a number of assumptions that are unlikely to be borne out in practice:

   (a) Elliptical risk distributions;
   (b) Linear relationship between capital and stress level;
   (c) Constant correlations; and
   (d) Impact of risks is additive.

(3) Non-life insurers do not generally use stochastic simulation to calculate their technical provisions. This makes the calculation simpler and consequently the internal models are able to project forwards their cash flows and technical provisions using stochastic simulation to generate the capital required.

26. Granularity and Segmentation

26.1 Introduction

26.1.1 This section focuses on the level of detail that is output by an internal model (i.e. the "granularity" of its output).

26.1.2 Existing internal models are typically used in a company-level context to model aggregate economic capital requirements, and may not always be designed for reporting at lower levels of granularity. In some cases, there may also be a relationship between reporting granularity and accuracy, with more approximate techniques being employed for models of the consolidated position.

26.2 Good Practice in 2012

(1) Granularity used across internal models is at a sufficient level to allow effective use of the model to run the business. This would include granularity in a number of different respects such as time steps and horizon, policy data, products modelled and level of decision making within the firm.

(2) **Time granularity:** This relates to the frequency of the projection steps within the model, e.g. annual or monthly calculations. Good practice for life firms could include undertaking monthly steps within the internal model and therefore link into the typical monthly management information cycle used to run businesses. For non-life firms, annual calculations with the ability to roll-forward or adjust assumptions on a monthly or quarterly basis are considered good practice.

(3) **Time horizons:** This is covered in a separate section but it is worth mentioning that the time granularity mentioned above is linked to the time horizon used as shorter projection periods may result in smaller steps whereas longer projection periods may need to use coarser granularity.

(4) **Policy data:** For life firms, policy data should be modelled at the individual policy level to allow the maximum understanding of the results where practical. Where grouped data is used the results produced should be validated against individual policy data to ensure appropriateness.

(5) **Products:** All products would be included within the internal model with minimal grouping of similar products for modelling purposes. In this way accurate analysis at the individual product level is achievable.

(6) The internal model would allow analysis and understanding of the firm's business at the level of granularity which supports how the firm makes business decisions as part of the use test.

26.3 Research & Barriers

26.3.1 The following challenges may constrain development of good practice:

(1) The key challenge is to balance the granularity and accuracy required of the results against the cost of producing them. Currently a number of approximations are made in the areas discussed above. To increase the granularity of the models there would need to be a demonstrable benefit to the business to gain the buy-in required to address some of the barriers and issues below.

(2) The processing capability of the models, i.e. computer power and run times are a barrier to undertaking more granular steps (i.e. monthly projections), using less grouped data and modelling more products or product features.

(3) This is particularly a problem when combined with stochastic modelling requirements.

26.4 Background & Current Practice

26.4.1 Some models have the ability to project events on a monthly basis although often even when this is the case the outputs are not set up to utilise this information. For longer time horizon projections (e.g. 40 years) less granular steps are modelled.

26.4.2 Policy data is sometimes grouped for modelling purposes, although individual data may be used for deterministic modelling. For stochastic modelling policy data is grouped to allow sensible run times to be achieved. The approach to grouping can vary from firm to firm in terms of what grouping criteria are used and what testing is undertaken to ensure that accuracy is not impaired.

26.4.3 Currently outputs from models do not form part of the monthly management information / decision making cycles within firms and are only considered for large strategic type decisions or considered less frequently, often annually. Therefore, it is questionable if modelling is at a level which is sufficiently granular (i.e. frequent) to support the decision making within a firm.

27. Modelling Dynamic Management Actions

27.1 Introduction

27.1.1 This section considers the modelling of dynamic management actions in a stochastic asset liability model. The discussion focuses mainly on life business, where modelling of management actions is already a prevalent practice – however, the more general principles could apply equally to non-life business.

27.2 Good Practice in 2012

(1) Both management actions and policyholder behaviour are modelled together and consistently, i.e. in all scenarios both actions by the firm and the behaviour of policyholders are considered.

(2) In this respect policyholder behaviour would be considered explicitly before the management action (in the stressed condition) and after the management action.

(3) An example would be economic conditions and persistency rates. In poor economic environments there may be a worsening of persistency rates that is modelled. However, if a firm then also introduces a management action, e.g. increase charges or cut in bonuses, then additional worsening of persistency may be experienced.

   (a) Need to consider this in conjunction with correlations between risks and non-linearity tests.

   (b) All management actions are included within the modelling.

(4) Moreover, issues regarding continuous management actions such as adjustments to bonus rates will also be considered. As these actions occur more routinely, its impact is more visible and thus lends itself to validation against historical data.

(5) Management actions are modelled dynamically where significant to the business in question. Suitable modelling is carried out for less significant risks, e.g. scenario based.

(6) Data is available to show that management actions have been rigorously implemented in the scenarios that are modelled going forward on both.

   (a) Management actions undertaken by the firm in question, and

   (b) Management actions taken by competitors where known, and the possible impact on policyholders and their advisors.

(7) Management actions cover all business where management discretion is available, not just with-profits business.

(8) Management actions cover the upside scenarios as well as the downside scenarios, including reversal of management actions in good scenarios.

(9) Management actions are used within the business planning process and consistent with the company's view on future strategy and market environment. For example, assumed competitor actions and reactions.

(10) Management actions across a range of future scenarios not just the extreme 1 in 200 year events. This allows it to be more closely aligned to actual historical data and the actions taken by management as a result. Provides a robust link between the base scenario and the extreme scenarios.

(11) Undertake customer research to understand policyholder behaviour in relation to proposed management actions.

(12) Seek legal and other advice on the legality and fairness of proposed management actions.

(13) Policyholder literature reviewed before setting contingent management actions.

27.3 Research & Barriers

27.3.1 The following currently available research is relevant

(1) The Life management actions working party operated during 2006 and 2007 which included a survey of how firms were implementing management actions. *"Management Actions: Myth or Reality – presentation to the 2006 life Convention."*

(2) Management actions are discussed within the CFO Forum MCEV principles include discussion on management actions in relation to the cost of guarantees. *"CFO Forum: Market Consistent Embedded Value Principles- June 2008."*

(3) International Actuarial Association – Guidance paper on the use of internal models for risk and capital management purposes by insurers. *"International Actuarial Association- Draft Guidance paper on the use of internal models for risk and capital management purposes by insurers."*

27.3.2 The following challenges may act as constraints or require further research:

(1) Modelling difficulties around dynamic management actions especially when linking to combinations of multiple variables.

(2) Ability to test the modelled management actions in reality.

(3) Lack of data relating to knock on implications of management actions in stressed scenarios
(4) Difficulties in determining what moves will be made by competitors in stressed scenarios which then impact on the assumed policyholder behaviour in those scenarios. Do you assume that competitors will take similar management actions or different actions?
(5) When modelling upside management actions based on historical data, could this lead to asymmetrical management actions in bad and good times and potential competition and customer fairness issues?
(6) The effectiveness of management actions can be mis-stated when experience changes at a faster or slower rate than assumed in the controls, rapid changing experience leading to insufficient time implement the action, or too slow (drift) so management are not triggered.

27.4 Background & Current Practice

27.4.1 Management actions are modelled mainly for with-profits business for Realistic Balance Sheet, Individual Capital Assessments and Economic Capital purposes.

27.4.2 Some management actions are modelled dynamically, e.g. bonus rates and investment strategies in connection with future investment returns. Others are inserted only in stress scenarios.

27.4.3 Management actions often tend to focus on downside risk and reactions to them.

27.4.4 Many modelled management actions have not been implemented in practice as the extreme events have not actually occurred. There is limited testing on mid-range events and actual management actions undertaken.

27.4.5 Current management actions modelled include:

(1) changes to Market Value Adjustments;
(2) cuts in regular bonuses;
(3) cuts in final bonuses;
(4) changes to equity backing rates (EBR);
(5) increase in charges for insurance benefits;
(6) increase in administration charges;
(7) change in new business levels;
(8) change in new business mix;
(9) change in asset allocation;
(10) change in hedging strategy;
(11) removal of miscellaneous/planned enhancements;
(12) change to charges for cost of guarantees;
(13) change to defined benefit pension schemes; and
(14) Change in reinsurance agreements.

28. Probability Distribution of Economic Capital

28.1 Introduction

28.1.1 This section is a general discussion considering the distributional form of economic capital.

28.1.2 The technically correct approach for the calculation of economic capital is to allow for risks to vary stochastically within an integrated model. This approach automatically allows for non-linear effects between risks and of the impact of risks in the capital required, and accurately allows for diversification effects between risks.

28.1.3 In practice the computational requirements are so great that integrated stochastic modelling of all risks is rarely practical for with-profits business, or the effort necessarily warranted. Such a method is also prone to accusations of spurious accuracy.

28.1.4 An alternative approach for the calculation of economic capital involves setting or determining distributions for capital for individual risks or combinations of risks. The economic capital is then calculated by combining, aggregating the distributions of risk capital. This sections sets out the considerations for the using distributions.

28.2 Good Practice in 2012

28.2.1 Good practice in 2012 will require that companies determine which approach is suitable for their firm and be prepared to defend that choice.

28.3 Research & Barriers

28.3.1 Research in the following areas would be useful:

(1) Developing criteria to determine the circumstances and extent to which the method of combining risks is adequate.
(2) Research on techniques that increase the degree to which models can be constructed on an integrated basis
(3) Best practice in combining risks to determine the overall risk distribution.

28.4 Background & Current Practice

28.4.1 Distributions are used in many areas within the determination of economic capital. It is important to appreciate that the determination of economic capital involves a number of stages and therefore assumptions or approximations made at one stage flow on to further stages.

28.4.2 The real world is considerably more complex than can be fully reflected through the use of distributions; therefore parsimony is an important consideration. Central to the approach and choice of distribution is the purpose they are to be used for. For determining economic capital the tail of the distribution is of greatest importance.

28.4.3 Central to the choice of the distributions is an understanding of how they are to be used. The determination of economic capital involves the aggregation of risks. An inappropriate choice of distribution can lead to either an under or overstatement of the economic capital, however, without a thorough understanding of the assumptions and approximations involved it is difficult to determine the impact.

28.4.4 The type of economic capital calculation, Value at Risk (VaR) or tail VaR is instrumental in the choice of distribution. The ideal is to use a distribution that accurately represents the entire range of outcomes, this is particularly important where there are a number of stages involved to reduce the error introduced through approximations, or if a number of confidence levels are used. Probability density functions generally produce a poor representation of the entire range of real world outcomes. However, they have the important property that by specifying only a few points on the distribution, this allows the values at other points on the distribution to be implied. Probability distribution functions are therefore particularly useful for specifying a potential range of outcomes for input assumptions.

28.4.5 It is generally more difficult to represent the entire distribution of capital requirements for a risk using a probability density function. Some of the particular issues encountered are that the capital requirements depend on management actions and particular contract structures, for example a reinsurance contract would not an impact on capital until the excess level is reached, but above that point level of claims net of reinsurance stays the same until the layer of reinsurance is exhausted. If a probability density function is used to represent the capital distribution then the fitting process needs to focus on providing a good fit for the range of the distributions used for setting capital. For economic capital requirements it is the aggregated distribution of capital that is important at the required confidence level. If a tail VaR approach is used then the entire tail of the distribution is important. If a VaR approach is used then a more limited range is important. However, because of diversification between the risks, the confidence level that is important is lower for the individual risks.

28.4.6 A commonly used approach for the aggregation of risks is called the sum of squares. Underlying the sum of squares approach is a multivariate normal distribution. This approach therefore assumes that each risk is normally distributed. Real world distributions tend to be fat-tailed and therefore a normal distribution can only simultaneously fit a very limited range.

28.4.7 Having generated a distribution of capital for individual risks it is not necessary to represent this as a probability density function, instead the sampled capital values themselves can be used to represent the distribution. This approach avoids introducing approximations to the distribution. The aggregation of capital requires a non-parametric method. Fortunately, this is relatively straightforward to achieve by mapping one distribution to another using the observation ranks. For example, a multivariate normal distribution can be used to generate rank scores to allow sampled values for individual risk distributions to be combined. This approach is a limited form of copula, but can be extended to a full copula.

29. APPROVAL CRITERIA – OVERVIEW

Articles 118-125 of the Draft Directive contain the six standards for approval of an internal model as follows: use test, statistical quality standards, calibration standards, profit and loss attribution, validation standards and documentation standards.

This portion of the paper covers the following:

30.	**Use test: General**
31.	**Use test: Integration with Financial Reporting**
32.	**Use test: Capital allocation**
33.	**Use test: Pricing**
34.	**Statistical quality standards**
35.	**Calibration standards**
36.	**Profit & loss attribution**
37.	**Validation standard**

While actuaries will have a role to play in implementing the documentation standards, we do not discuss that standard in this paper.

30. Use Test: General

30.1 Introduction

30.1.1 Article 118 provides that the insurance undertaking must demonstrate that its internal model is widely applied within the business. In particular the internal model must be used in governance, risk management and own risk solvency assessment functions described by the Directive in Articles 41 -49.

30.1.2 The use test generally is discussed in this section. Three further applications of the use test are discussed in sections 31-33.

30.2 Good practice in 2012

30.2.1 Senior executives and operational managers understand the framework of capital and risk and talk in these terms within their own business units. Regular education programmes on the internal model have developed into challenge and review sessions that consider the model's uncertainties and fitness for purpose.

30.2.2 The risk appetite of the business and the related capital requirement are routine parts of business decisions.

30.2.3 Senior executives are prepared to sanction material decisions <u>only</u> in the light of capital and risk analysis.

30.2.4 Internal models are able to analyse down to granular business decisions. Actual outcomes reported and discussed in the light of actual to expected capital risks and usage.

30.2.5 Capital model results are produced rapidly and regularly by means of proxy methods. Quarterly production of full scale results to validate and recalibrate whatever proxy method is used.

30.2.6 There are only low levels of manual intervention in calculation processes and the use of techniques such as variance reduction techniques to improve run times, and replicating portfolios (if market risk is important) to produce more robust proxies is widespread. Regular analyses of proxy performance are carried out.

30.2.7 Capital risk adjusted performance measures have become part of managers' and underwriters compensation via key metrics calculated by the internal model.

30.2.8 The firm will exhibit an integration of risk management that is similar to the S&P definition, and review, of "Excellent" ERM:

> *"Insurer has extremely strong capabilities to consistently identify, measure, and manage risk exposures and losses within the company's predetermined tolerance guidelines. There is consistent evidence of the enterprise's practice of optimizing risk-adjusted returns. Risk and risk management are always important considerations in the insurer's corporate decision-making. Excellent ERM programs share all the criteria for programs considered Strong but are more advanced in their development, implementation, and execution effectiveness. An Excellent ERM insurer will have developed its process more fully over time, may have implemented it throughout a higher percentage of its group, or may be executing the process more effectively"*

30.2.9 The firm meets the standards set out in the Actuarial Profession's Sessional Paper on ERM[9] in exhibiting the following features:

(1) Well developed process which is robust and timely
(2) Wide range of modelling approaches which provide insight into the relationship between risks and how they arise
(3) Multiple perspectives
(4) Clear and widely understood assumptions
(5) Well understood risk metrics and consideration of economic capital
(6) Good transparency and buy-in to modelling

30.2.10 The internal model is used as part of the ORSA assessment.

[9]ERM for General Insurers, Tripp et al, April 2008, http://www.actuaries.org.uk/__data/assets/pdf_file/0017/132038/sm20080428.pdf

30.3 Research & Barriers

30.3.1 Many aspects of good practice described above do not strictly relate to the actuarial tool box. We observe that training and research on the best ways to advance good communication for actuaries will assist the actuary in helping to educate management and in preparing results in formats that support good practice of the firm.

30.3.2 Many internal models have only been constructed relatively recently and often with a particular focus on meeting a regulatory or business need to assess the level of capital required. Many business areas have not been involved in the internal model's development, which in turn means that the internal model is not immediately suited to their needs and that there is a general lack of understanding and confidence in the internal model. As a consequence, these business areas often continue to use their own models, methodologies and processes to assess the risks relevant to them and to support decision making.

30.3.3 An internal model is complex and many insurers find it challenging to produce results more frequently than half-yearly. This means that it is difficult to use the internal model to carry out the "what-if" scenario analyses necessary to support corporate decision making and strategic planning within a viable timescale and that it is challenging to monitor the performance and risk profile of the business on a timely basis using the internal model.

30.3.4 Insurers have encountered theoretical and practical difficulties in translating high level, aggregate assessments of risk into meaningful measures and limits at a more granular level. In any case a single "risk culture" and "risk language" needs considerable time to settle down and become effective.

30.3.5 There is frequently a lack of awareness of the internal model and its strengths and weaknesses outside of the team directly involved in building and maintaining the model, due to a lack of training and education programmes.

30.3.6 In general, insurers currently use their internal model in high level decisions – such as evaluating strategic options to alter the risk profile of the business such as hedging and deciding on the structure of the reinsurance programme. The influence of the internal model in day-to-day decision making and objective setting is less (and sometimes not at all) apparent.

30.4 Background & Current Practice

30.4.1 The internal model will often influence key activities such as product design, pricing, business planning, acquisitions and ALM, but in a fairly approximate way using simplifications and proxies to derive the projected risk metrics. The International Association of Insurance Supervisors' *Guidance paper on the use of internal models for risk and capital management purposes by insurers* (October 2007) set out a number of key features, which would be expected to form the basis a proposed standard on internal models. In particular, Key Feature 7 states:

> *"In order for an insurer's internal model to be most effective for use as part of its risk and capital management, it should ensure that the internal model, its methodologies and results, are fully embedded into the risk strategy and operational processes of the insurer (often referred to as a 'use test')"*

30.4.2 Rating agencies also typically look to see evidence of some application of the internal model in management decision making before they are prepared to place any reliance on the internal model's results.

30.4.3 S&P's view of role of internal models in ERM is repeated below. A key issue is whether passing the use test is equivalent to the strong or excellent ERM standard or whether the regulatory test will be somewhat lower and more capable of being met by a wider body of insurers:

> *"Risk and economic capital models are an important part of a strong ERM program. Effective risk management requires a smooth flow of information about risk positions and their possible impact on the insurer. Standard & Poor's assesses the insurer's risk models in relation to its risks and to how it processes the information from its models."*

30.4.4 An insurer with effective risk models will be able to show that the models produce the information needed to perform the basic risk-control functions that are needed to sustain losses to within their risk tolerances. Its management should also understand the models clearly.

> *The risk models need to produce information that is sufficiently accurate, up to date, and timely to drive correct and well-timed risk-management decisions and actions. The insurer should also undergo a regular process to validate its models, and a process to update both the data about the business activity being modelled and the assumptions used in the models.*
>
> *If the firm uses different models to meet different objectives, then the two models need to be reconciled regularly. The models need to be sufficiently robust to produce insight into all of the risks that are retained, as well as the risks that are written but not retained. They also need to provide information that is both descriptive of the size of the risk and actionable in managing the risks.*

31. Use Test: Integration with financial reporting

31.1 Introduction

31.1 The internal model will necessarily include analysis on the accounting and reporting basis described in the Directive. We expect that companies will also need to report to stakeholders in IFRS, GAAP and other reporting regimes.

31.2 Good practice in 2012

31.2.1 Data storage, data analysis, and internal models should all be of flexible enough design to generate the desired outputs in each reporting regime.

31.2.2 Internal analysis should automatically include rigorous reconciliation between the external financial reporting figures and Solvency II liability and capital recognition.

31.2.3 Embedded value numbers (on whatever EV basis is the current standard) should be mainly used to interpret and expand on the IFRS reporting for EU subsidiaries and not to replace the Solvency II results. These Solvency II results would be decomposed directly between best estimate and risk margin for presentation to market.

31.2.4 The treatment of non EU subsidiaries would depend on the group structure and could either be restated to a Solvency II basis or expanded on by embedded value analysis. If a group internal model has been approved by the lead regulator then the capital used in such an embedded value basis should be aligned with that allocated from the group internal model.

31.3 Research & Barriers

31.3.1 The lack of certainty on the future requirements of IFRS and to a lesser degree Solvency II combined with the more immediate timescales for MCEV have lead to firms taking a separate approach to the implementation of each element. This is potentially wasteful in the build of different models and methods but more importantly confusing for external stakeholders.

31.3.2 Insurance companies may produce internal model output based on published figures, but the wide variation in GAAP means that these will not be comparable with other companies. Current IFRS requires insurance companies to show some information about the level of risk exposures and risk management in the firm. This may be based on current capital modelling.

31.3.3 It will be challenging to reconcile the fact that management objectives and remuneration will likely need to consider performance measurement on Solvency II and other bases.

31.3.4 Local EU subsidiaries of a wider non EU group will have to report on the wider group's chosen basis and may well find demonstrating the 'use test' challenging if the group's liability recognition (and thus capital) is not the same as for Solvency II.

31.4 Background & Current Practice

31.4.1 Debate continues in various international and European forums on definition and implementation of IFRS for insurers. The project has struggled with some fundamental issues (outside the scope of this paper) and is unlikely to implement new standards before Solvency II is effective. Currently insurance companies produce their report and accounts using IFRS4. This standard is an interim standard that grandfathered various local GAAPs, and so has led to an inconsistent approach to reporting across insurers.

31.4.2 Some firms are beginning to look at how to integrate their modelling of future IFRS, MCEV and Solvency II requirements although this is still in its early stages. This will be able to be reported to the Board and to shareholders and other stakeholders, such as rating agencies. This will give useful information about potential volatility in profits and risk based capital requirements to these stakeholders, plus it should give a consistent and risk based basis for comparison with other companies, who will also be competing for capital.

32. Use Test: Capital allocation

32.1 Introduction

32.1.1 Capital allocation is one of the potential uses for the internal model that is specifically mentioned in the Directive (119(4).

32.2 Good practice in 2012

32.2.1 A single capital allocation process will be recognised within the insurer, and be consistent across all parts of the firm.

32.2.2 The internal model is used for allocating capital to lines of business. This can support pricing and risk adjusted return analysis.

32.2.3 Capital is allocated to risk type in order to rank risks for risk management purposes

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32.2.4 Capital allocation results will be considered in planning, analysis of risk transfer strategies and the like.

32.3 Research & Barriers

32.3.1 There are many different methods of capital allocation, and no one method is "correct". This is mostly because of diversification and co-dependencies, and how such effects should be shared or allocated between entities or business units of the groups which, by themselves, enjoy less diversification.

32.3.2 Guy Carpenter, for example, describes a variety of allocation methods.[10]

32.3.3 Research also includes the recent ASTIN paper on capital allocation, Neil Bodoff, 2008. The paper suggests allocation by looking at the capital at each percentile of the distribution. Insurers need to be pragmatic about allocation and choose a method that reflects their business needs.

32.3.4 Typically, the allocation of capital relates to risk assessment and does not consider fungibility, i.e., the extent to which the capital can actually be transferred within a company or group to provide for those risks. As we have discussed with respect to co-dependency (Section 2) and groups (Section 5), methods of simultaneously assessing risk and fungibility of capital would be valuable.

32.3.5 Other issues may affect fungibility, and more detailed research and assessment methods would be useful. These include:

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[10] Risk Adjusted Profitability by Business Line: How to Allocate Capital and How Not To, Gary Venter, Guy Carpenter, http://www.cap.columbia.edu/Venter.pps

(1) the manner in which the company and group capital derive from a mix of debt and equity
(2) the effect of tax obligations; and
(3) internal group reassurance.

32.3.6 Insurers may wish to allocate capital to reflect market channels, brands, geographies or legal entities, as these might best reflect their decision-making processes. This implies additional layers of complexity to the allocation and fungibility issues.

32.3.7 Capital allocation can be an ‘accounting exercise;’ without business benefit. One of the challenges is to determine the ways to do the allocation and use of the results so that business benefits are achieved and recognised within the firm.

32.4 Background & Current Practice

32.4.1 As indicated in the discussion above, current practices vary widely.

33. Use Test: Pricing

33.1 Introduction

33.1.1 Pricing is an area in which use of the internal model, including use of the capital allocation following from the internal model, can be demonstrated.

33.2 Good practice in 2012

33.2.1 Pricing models and the internal model use the same data sources and parameterisations of risk. While the exact parameterisation will differ (as pricing models typically have more detail than an internal model), there should be close consistency between the overall risk distributions. A good example of this would be the use of the catastrophe model output that goes into the internal model being used directly to price individual property (re)insurance contracts.

33.2.2 If prudence is incorporated in the pricing basis, then this is done explicitly so that the best estimate pricing assumptions and the capital model are still consistent. Examples of this may be the pricing of asymmetric risks such as latent claims or life investment guarantees.

33.2.3 Where capital loadings are applied in pricing models, they are derived from the internal model.

33.3 Research & Barriers

33.3.1 The Pricing function and capital function are often separated. Clear lines of communication will need to be set up for effective use of the internal model in pricing.

33.3.2 It is not uncommon for there to be inconsistency over the assumptions about the risk, e.g., the risk distribution, used by the capital modelling teams and the pricing teams/underwriters. An area for further research is an analysis of the extent to which differences are necessary, if at all, the extent to which the differences can be minimised and practical ways to do so.

33.3.3 Research includes the GIRO working party - Integrating Pricing with ICA models – that presented in September 2008 as well as the GIRO working party - Variable Capital Loads in Pricing – that also presented in September 2008

33.4 Background & Current Practice

33.4.1 The level of consistency between capital modelling and pricing assumptions varies widely among companies.

34. Statistical quality standards: Distributions and Parameters

34.1 Introduction

34.1.1 The statistical quality standards include data quality, which was discussed in Section 5, and choice of statistical methods and assumptions which are discussed in this section.

34.1.2 In a firm's assessment of economic capital and hence SCR, it will have made a series of assumptions regarding risk identification, model structure and parameters.

34.2 Good Practice in 2012

34.2.1 Parameter estimates should be based on:

(1) As much data as possible – the more data, the more reliable the estimate. This means firms should invest in appropriate data systems in order to store the data they will need.
(2) A mix of internal data supplemented by external or industry benchmarks.
(3) A sense check for reasonableness rather than blindly accepting the results of the data analysis.

34.2.2 Firms should attempt to assess the confidence level for each key parameter, by, for example:

(1) applying a non-parametric bootstrap;
(2) using Chi-squared tests;
(3) Kolmogorov-Smirnov Statistic (middle of distribution fitting); or
(4) Anderson-Darling Statistic (tail of distribution fitting).

34.2.3 A firm will be able to assess the possible effect of parameter error by:

(1) Re-running the economic model with different assumptions for key parameters to assess the sensitivity of the result.
(2) Business areas should understand the effect of changing the key assumptions on the results of the economic model.
(3) Critiquing of assumptions within the firm by different functions. No parameter should be used without having been challenged by knowledgeable areas.
(4) Reliance on external data should be documented and go through the same process as internal data.
(5) Having a good audit trail for the decisions to use parameters.

34.2.4 A key test will be whether the internal model reflects reality. Any back-testing of the model must show a reasonable fit and the firm should review enough of the model's outputs at different probabilities to assess how realistically it reflects the world they are trying to model.

34.2.5 In areas where the model does not reflect reality adequately, the firm should decide whether this is material or not, and if not, whether the model can be improved by changing the parameters or model structure.

34.3 Research & Barriers

34.3.1 The ‘good practice’ vision approach is in theory achievable now, but firms are unlikely to:

(1) have enough data to properly test each and every parameter; and
(2) have time / resources to review and critique each and every parameter.

34.3.2 It is therefore important to prioritise which parameters are material to the internal model results.

34.3.3 The parameters are estimates of the underlying reality that the internal model is attempting to reflect. This leads to uncertainty in the result caused by the uncertainty in the parameters, including:

(1) Any systemic bias in the parameters could combine to under or over estimate the result of the analysis, either over the whole probability distribution or at the extreme tail.
(2) If one key parameter is very wrong, the overall result is also likely to be wrong.
(3) The interaction of parameters could combine to exacerbate the error in the results.
(4) The underlying distribution for the parameter, particularly in the tails can significantly impact results exacerbating the error in results.

34.3.4 Tail-VaR measures are more susceptible to parameter uncertainty as tail outcomes generally have a progressively greater amount of uncertainty.

34.4 Background & Current Practice

34.4.1 Parameter uncertainty is reflected on a judgmental basis, if at all.

35. Calibration standard

35.1 Introduction

35.1.1 The directive specifies an approach to time horizon, future business, valuation of assets and liabilities and the like.

35.2 Good practice in 2012

35.2.1 The internal model will produce results on the basis specified in the directive and with alternative approaches if desired by management.

35.2.2 The model will allow management to compare the results of the different bases, so they can be reconciled.

35.3 Research & Barriers

35.3.1 There is currently little research on efficient methods to compare different calibration standards related to confidence levels, time horizons, treatment of new business components, and the like.

35.4 Background & Current Practice

35.4.1 The background with respect to time horizon was discussed in Section 3.

36. Profit and loss attribution

36.1 Introduction

36.1.1 The Framework Directive requirement for internal models states:

> *"Insurance and reinsurance undertakings shall review, at least annually, the causes and sources of profits and losses for each major business unit. They shall demonstrate how the categorisation of risk chosen in the internal model explains the causes and sources of profits and losses. The categorisation of risk and attribution of profits and losses shall reflect the risk profile of the insurance and reinsurance undertakings."*

36.2 Good practice in 2012

36.2.1 Recent results are checked against model results – this could be several years' annual results. Results can be compared to the distribution of results from the model to see whether the assumed probability distribution is still reasonable.

36.3 Research & Barriers

36.3.1 While profit and loss attribution and review of past experience are not new to the profession, the standard necessary to achieve the level required by the directive is uncertain.

36.3.2 Insurers may have to allocate profits and losses to particular risk types in order to explain the causes of results, and hence it is necessary to check that the model design is appropriate.

37. Validation standard

37.1 Introduction

37.1.1 The validation standard requires that insurers have a regular cycle of validation for the model. The validation includes a review of performance of the model against experience, the probability distributions and the data used by the model

37.2 Good practice in 2012

37.2.1 The validation process will be included within an actuarial control cycle.

37.2.2 The process will also encompass a review of other potential data insights to assumptions by a review of new research/benchmarks, expert judgement, etc.

37.2.3 The process will also include a standard review of probability distributions and methods in the model to confirm that the resultant percentiles of capital adequacy remain soundly calculated.

37.2.4 Sensitivity tests of the model to assumptions and data inputs will be regularly performed, probably with key indicators to show areas for further investigation.

37.2.5 The output will be reviewed as whether the model is appropriately risk sensitive; the aim being to identify areas where the model is overly sensitive to less material assumptions or conversely insensitive to material areas of risk.

37.2.6 If model features are developed or updated using historic data, some data is set aside for ‘back-testing’.

37.2.7 Where appropriate, models are tested using simulation data or external data.

37.2.8 The model will be subjected to robust stress and scenario tests.

37.2.9 There will be a risk management and Board oversight process that controls the validation process and challenges the modelling team over the model’s ability to capture and respond to the major risks.

37.3 Research & Barriers

37.3.1 While there are many views with regards to how a model may be validated, there is no commonality on how models should be validated. There is a substantial difference between different levels of assurance – for example the model being ‘materially correct’ or ‘arithmetically accurate and consistent’ will mean different things to different stakeholders. It would be useful for the actuarial profession to develop a set of standard wordings for model validation and what may be required to meet the criteria.

37.3.2 As discussed in the data quality section (Section 6), the industry could set up databases or studies of relevant data.

37.4 Background & Current Practice

37.4.1 Models are currently often still in development, rather than having been in well established production for a number of years. So a stable validation cycle – the model control cycle – is unusual. In particular, the senior management oversight may lack the depth required for Solvency II.

37.4.2 The Solvency II Framework Directive requires the validation process to incorporate the use of new data. At present, a lack of formality and regularity over processing the most recent data means the validation of the model may be weakened.

37.4.3 Validation is an issue given areas of data uncertainty – as revisions of data can move the assumptions significantly. The use of judgement – often to “smooth” such jumps in crude data inputs – is not easily distinguishable between good judgement that smoothes to recognise data uncertainty or bad judgement that delays the recognition of new realities.

37.4.4 The design of a robust model review process within the risk and Board governance process has to be both intelligible to all concerned and also productive and challenging to those that maintain the model and its environment. Formal and regular review of the model needs to become standard, which means models need to move out of development into a production environment.

37.4.5 The desire for stability of the model in the face of new data, and new judgements over old data, needs balancing with the prime requirement that the model is sensitive to the risks the firm faces.

37.4.6 Validation is part of existing actuarial practice, but the extent to which the effort required for an improved internal model is higher is not known.