DRAFT OUTLINE **DD/MM/YY**

International (Experimental, Educational) Actuarial Practice Guideline #X:

Use of Models of Stochastic Processes in Insurance to Support International Financial Reporting Standards

Released by the Insurance Accounting Committee of the International Actuarial Association

2006

(Document No. XXXX)

CONTENTS

Section 0: Background and Scope

Section 1: Introduction

Section 2: Non-Life Insurance

Section 3: Life Insurance

Section 4: Investment Contracts

.
.
.

Use of Models of Stochastic Processes in Insurance to Support International Financial Reporting Standards

Section 0 Background Purpose and Scope

0.1 Background

Insurance is a business founded upon uncertainty of outcomes. Consequently it makes sense to identify the uncertainty and range of potential outcomes as objectively as possible in accounting for insurance business. Such an approach will always offer a better basis for understanding than an approach that relies on selection of a "most likely outcome" and then adding a margin to account for the level of uncertainty.

Traditionally, accounting treatment of insurance processes has focused almost exclusively on single, point estimates. While the aim may be to base such estimates on the mean or expected value, the typical deterministic approach traditionally used to arrive at such estimates typically leads to estimates of most likely (modal) outcomes. Case estimation, in particular, tends to lead to modal values. However, the range of potential outcomes in many insurance situations is not symmetrical and hence the "most likely", (or mode of the distribution of potential outcomes) may differ – quite substantially in most cases – from the mean, or average. It may be argued therefore that a stochastic approach, which provides the average outcome, is a more efficient means by which to satisfy basic accounting requirements. *(See Appendix for a discussion of the different results obtained from deterministic and stochastic approaches)*

Further, stochastic process models deal explicitly with the extent of the uncertainty in any insurance process. A deterministic approach can only allow subjectively for the level of uncertainty. This can create inconsistencies in accounting.

As the disclosure discussion in IFRS4 indicates, there is a need to formalise recognition of the uncertainty inherent in reported amounts (paragraph 26), and the amount, timing and uncertainty of cash flows (paragraph 28). These tasks are most efficiently performed by the use of consistent, standardised stochastic process models where they exist.

IFRS4 makes no specific mention of stochastic processes. However, a standardised recognition of uncertainty is inherent in the concept of "fair value", particularly in relation to elements of an insurer's liability profile, where market values tend to be either biased or non-existent. It can be demonstrated that a consistent approach to the treatment and measurement of uncertainty can be easily transferred to represent a fair assessment of the value of liabilities (and assets) – see paragraph 30 of IFRS4.

0.2 A Stochastic Accounting Framework

(This section to be removed as and when the need for a stochastic framework is recognised by the IASB!?)

In the area of loss recognition in particular, an amendment the current accounting *Framework* is needed if stochastic concepts are to be consistent with standard accounting treatment. A proposal for this change is set out in RA Buchanan's paper "A Probabilistic Accounting Framework" [1]

Essentially, this proposal removes the anomaly caused by the need for each item in the accounts to be both "probable" and "reliably measured" in current conceptual terms. Instead the proposal is to recognise all uncertain items on the basis of expected values. Materiality thus becomes the sole basis for non-recognition of any items and enables consistent treatment of items.

0.3 Purpose

This guideline is intended to provide support to, and evidence for, the use of stochastic techniques in the preparation of accounting information for insurance contracts. It is the belief of the Insurance Accounting Committee that such techniques are, in many cases, more transparent, accurate and efficient than traditional deterministic techniques, when allied with the appropriate disclosure of information. *At this stage, use of stochastic techniques is not consistent with the majority of accounting frameworks around the globe.*

0.4 Scope of This Guideline

This guideline examines the range of existing guidance, standards and other established literature that support stochastic processes for use in insurance. The aim has been to identify the elements of such confirmed methodology into a format that can form part of an audit process in a stochastic accounting framework such as discussed above.

The guideline also examines the disadvantages of using a stochastic approach, how use of stochastic processes tends to highlight such effects, and hence how their downside effects are minimised.

Since there is no clean split between the use of stochastic and deterministic processes in supporting the calculation of non-life insurance liabilities, this note also encompasses the use of probabilistic-based approaches as part of otherwise deterministic methods.

The guideline examines life and non-life insurance separately.

Section 1 Introduction

1.1

1.2 Measurement of options/embedded derivatives/guarantees

1.3 Families of techniques
e.g. regime switching models

1.4 **Interaction between investment performance / expectations and policyholder behaviour** (e.g., through lapse risk)

1.5 **Development of probability distributions** (stocks, other assets, mortality/morbidity, claims distributions, claims development)

1.6 Aggregation of risks in a bundled product, e.g., development of correlations

1.7 Selecting random numbers for use in stochastic testing

1.8 How to make transparent what otherwise would be black-box models

1.9 How to audit / peer review audit values derived from stochastic models

1.10 Difference between in-the-money and out-of-the money calculations

1.11 How to disclose and communicate results

Section 2 Non-Life Insurance

2.1 Background

It has long been recognised that timing and amounts of general insurance liabilities can be estimated stochastically. (*For example, see "Loss Reserving in Non-Life insurance", Taylor GC 1986)*. However, constraints to data and the restricted ability to manipulate data restricted the use of such well-established techniques until the mid-1990's. Since those times there has been rapid development of the application of stochastic techniques to general insurance accounting issues and validation of the criteria for their use.

Use of these techniques does not fit with the loss recognition test as currently understood and as described in the IASB *Framework for the Preparation and Presentation of Financial Statements* – i.e. that any accounts item be both probable and reliably measurable before it can be recognised. Such a binary test implies a point at which an item moves from "unrecognised" to "recognised", which is clearly both illogical and inappropriate where that item is part of the normal business of an accounting entity. It also creates a loophole whereby it is possible to not recognise material liabilities, by applying the letter of standards based on the *Framework*.

2.2 Areas of Use for Stochastic Processes

The areas in which probabilistic approaches to accounting for insurance activities are strongest (and hence for which the revised loss recognition test is likely to be met) include:

Estimation of Outstanding Claim Liabilities: In this area, the modelling could potentially cover the variation in average ultimate settlement costs, the distribution of claim settlements for outstanding claims, changes in the number of claims to be settled (i.e. incurred but not reported – or "IBNR" - claim development and reopened claims etc) or a combination of these effects.

Unearned Premium Liabilities (or Unexpired Risk): This area could be seen as an extension to the outstanding claim liability analysis (i.e. that a range of claim costs can be expected to emanate from a pool of unearned premiums) with the same implied variety of potential methodologies. Alternatively, such a liability may be estimated through an extension of pricing techniques.

Investment Fluctuation Reserves (Including Asset Mismatch):Here the use of stochastic modelling helps identify the differing outcome distributions of assets and liabilities and therefore aids the preparation of appropriate "risk-free" (or at least risk averse) investment portfolios.

Other items of accounts for which stochastic techniques may be used to add value, but for which no widely-used techniques have yet been developed (?) include:

- Creditors – e.g. assessment of bad debts
- Debtors
- Catastrophe reserves (catastrophe-exposures need to be supported by the appropriate stochastically generated projections to avoid accusation of insufficient disclosure on the issue)
- Expenses
- Some types of “payment” (e.g. unclosed premiums etc.)

2.3 Description of Established Techniques

2.3.1 Outstanding Claims Liabilities

A number of stochastic techniques have been used to provide a distribution of the range of projected claim outcomes with regard to the outstanding claim liability projections by class of business (where *“class” is defined in terms of homogeneity of risk)*. Other probabilistic methods contribute towards the selection of assumptions for what are otherwise deterministic approaches. This sub- section is limited to the sub-set of such processes that are established and for which calibrations exist and can be relied upon.

The “Curve Fitting Family”:
These methods rely on the representation of the range of outcomes, typically by mathematical formulae (e.g. the lognormal distribution). The variability is determined by use of least squares regression (or other means of seeking the best fit) to a suitable representation of claim costs (e.g. regression on the log. of the incremental claim costs if the lognormal distribution is used) or by use of an empirical distribution if enough data is available and if the risk is amenable to such an approach (See Appendix A.1)

In practice, use of this family of approaches creates a wide range of potential outcomes for the estimates of both the central estimate of outstanding claims liabilities and an appropriate risk margin to be applied (*not a good advertisement for use as part of an accounting standard?)*. This wide range is as a result of substantial subjectivity applied to:

(a) The choice of risk groupings (i.e. the measure of homogeneity of risk)
(b) The extent and detail of data used for analysis; and
(c) The means of selecting mathematical formulae to fit the distributions.

This variability is reduced by the used of a standardised system of modelling and fitting the available data to mathematical formulae (*such as Insureware’s ICRFS software package - see Zehnwirth reference below?)*

(*Include a practical description of the use of ICRFS as a stochastic modelling aid from one of its users)*

References: *Heine R, Leise J and various co-authors “The Analysis and Estimation of Loss and ALAE Variability: A Summary Report” (Section 3) CAS(draft?) 2005*
Zehnwirth B “Interactive Claims Reserving Forecasting System (ICRFS) 1991

Verrall RJ "Bayes and Empirical Bayes Estimation for the Chain Ladder Model" ASTIN Bulletin No 20 1990 & "On the Estimation of Reserves from Loglinear Models" Insurance Mathematics and Economics V 10, 1991

Generalised Linear Modelling:
GLM techniques can be used to regress incremental claim amounts. (See Appendix A.2)

(Fill in with practical application of GLMs to reserving)

References: *Renshaw AE "Chain Ladder and Interactive Modelling" JIA 116(III)*
Verrall RJ"On the Estimation of Reserves from Loglinear Models" Insurance Mathematics and Economics V10 1991
Mack T "A Simple Parametric Model for Rating Automobile Insurance or Estimating IBNR Claim Reserves" ASTIN Bulletin 22(I) 1991

The Mack Method:
This method emanates from Thomas Mack's derivation of the standard error from application of the chain ladder valuation approach. It is distribution-free and largely automatic to apply, hence increasing its relative transparency when compared with other methods (See Appendix A.3)

The method has been applied (*in Australia*) to derive risk margins for outstanding claims. The Mack Method includes an explicit estimate of both;
(a) the process variance (or the variation related to the underlying randomness in the process being modelled); and
(b) the parameter estimation variance (or the variation related to the choice of parameter values for the model)

There is (of course) no explicit allowance for model error, or the effects of a paradigm shift (i.e. the potential that the underlying system has changed, or is changing, and hence that the experienced data does not describe the appropriate system for the run-off of claims.

In addition to the standard error for each accident year, a formula is provided by the Method for the standard error of the total outstanding claims liability estimate. This takes into consideration the correlations between the estimates for individual accident years. Allowance for correlations between the estimates for each accident year increases the standard error of the outstanding claims liability.

References: *Mack T "Distribution-Free Calculation of the Standard Error of Chain Ladder Reserve Estimates" ASTIN Bulletin No 23 (II) 1993 &*
Mack T "Measuring the Variability of Chain Ladder Reserve Estimates" CAS Spring Forum 1994

Stochastic Bootstrapping Techniques:
Bootstrapping again relies on the chain ladder method. An alternative data set is back-projected from the projected outcomes produced by standard chain ladder application.

The residuals derived from the differences between the original and back-projected data are then used to generate the range of outcomes. (See Appendix A.4)

For the established use (*in Australia*) of the bootstrapping technique, suitably chosen residuals need to be calculated (rather than bootstrapping the observations themselves). The process then involves re-sampling, with replacement, from the residuals. After obtaining the bootstrap sample in this way, the valuation model is re-fitted and the statistic of interest is calculated (i.e. the mean of the distribution of outstanding claims liabilities). The process is then continually repeated, with each simulation creating a new estimate of the mean.

The bootstrap standard error is then calculated to provide a measure of the parameter estimation error. (It is noted that the process error needs to be separately calculated).

References: Lowe J "A Practical Guide to Measuring Reserve Variability Using: Bootstrapping, Operational Time and a Distribution-Free Approach" GIRO Convention Proceedings (UK) 1994
England PD & Verrall RJ "Analytic and Bootstrap Estimates of Prediction Errors in Claims Reserving" Insurance Mathematics and Economics V25 1999
Scheel WC " Reserve Estimates Using Bootstrapped Statutory Loss Information" CAS DFA Seminar Papers 2001

The Stochastic Chain Ladder Method:
For this method chain ladder factors are defined as distributions, rather than point estimates, and simulation is used to generate the distribution of the outstanding claims liability. (See Appendix A.5)

The user of the method needs to make three sets of parameter selections from the data and associated analysis of the outstanding claim liability, namely:
(a) the average incurred chain ladder development factors
(b) the standard deviation of each chain ladder factor; and
(c) the amount of claims paid at each stage of development

Simulation then occurs so that the model for each chain ladder factor assumes a lognormal distribution, with mean and standard deviation as derived above. Each element of the "triangle" of accident year and future developments year is given its own, unique chain ladder factor (and distribution) and a matrix is used to create correlation factors by accident year and projection year. The resulting (deterministic) outstanding claim payment projection is then made stochastic by randomly simulating chain ladder factors from the unique Lognormal distributions.

Reference: Renshaw AE and Verrall PJ "A Stochastic Model Underlying the Chain Ladder Technique" Proceedings of 25th ASTIN Colloquium, Cannes 1994

2.3.1.1 Generally Accepted Actuarial Usage

Australia

Whilst there are no standards as to the choice of methods for application of stochastic processes to outstanding claims liability valuation, two papers stand out as strong guides to the majority of Australian insurers. One of these papers – *Research and Data Analysis Relevant to the Development of Standards and Guidelines on Liability Valuation for General Insurance, by Bateup and Reed* – was commissioned by the Institute of Actuaries of Australia (IAAust). Another paper – *APRA Risk Margin Analysis, by Collings and White* – was drafted for an IAAust General Insurance Seminar. The Australian Prudential Regulation Authority (or APRA) has since confirmed the extensive usage of both papers by insurers in preparing statutory returns.

The Bateup and Reed paper relies heavily upon the Mack method and two Bootstrapping techniques to derive a set of "benchmarks" by class of business and size of portfolio.

Collings and White rely almost exclusively on the Stochastic Chain Ladder Method (utilising the lognormal distribution) to derive a similar set of results.

Whereas the authors are at pains to point out that their conclusions should not be regarded as definitive, the calibrations leading to their findings have gained broad acceptance in the market, although there are increasingly frequent signs of independent analysis, at least by the major players in the market.

2.3.2 Premium Liabilities

As discussed in Section 1.2, the modelling of premium liabilities can be seen as a natural extension to outstanding claim modelling. If the premium liabilities are modelled as an extension to the pricing process, again techniques such as generalised linear modelling can be used. As an alternative, the distribution of historical loss ratios may be used to generate the range of future loss ratios to be applied to the unearned premium.

2.3.2.1 Generally Accepted Actuarial Usage

Australia
The Bateup and Reed and Collings and White papers also provide guidance in the area of premium liabilities, although in this area the support is less strong compared with the area of outstanding claims. Both papers express the calibration of the premium liability models in terms of multipliers of the outstanding claim liability model calibrations for similar classifications of business.

2.3.3 Investment Fluctuation
It is arguable that a specific reserve is needed to account for investment fluctuation and/or asset/liability mismatch. A range of stochastic techniques exists with which to assess the level of such reserves (none of which are yet in "standard" usage?)

2.4 Model Calibration

For accounting purposes, it is essential for the stochastic processes to be represented in a transparent and consistent manner.

2.4.1 Coefficient of Variation

The coefficient of variation ("CoV") – or the standard deviation of the distribution of outcomes divided by their mean - provides a measure of the variability of an outcome in relation to the most likely estimate of that outcome. It can be argued that the CoV provides the most transparent and efficient means of model calibration. Over even the short period of time since the start of use of the methodology (*in Australia*) there is evidence of the beginning of convergence of CoV's by the standard categorisations of the business risks (i.e. largely by class and geography of business).

2.4.2 Process Variance

One of the disadvantages of the use of stochastic process is the difficulty of modelling the uncertainty that relates to random movements (as opposed to the volatility inherent in the characteristics of the business under consideration). Such process variance can be dealt with in a number of ways.

The Mack method includes an estimate of the process variance as part of the overall measurement of the volatility of outcomes and therefore no separate allowance is needed.

Alternatively a quantification of the scale of the appropriate allowance can be gained from scenario analysis and sensitivity testing of the key assumptions in the valuation model.

2.4.3 Correlation Factors

One of the fundamental principles of insurance business is that the spread of risk also smooths outcomes for insurers. In terms of stochastic modelling, this basic characteristic of the business can be represented such that the outcomes for different classes are largely uncorrelated. However, some risks are more highly correlated than others.

In practice these risk correlation issues are dealt with by a relatively limited number of factors, applied in matrix form to the various homogeneous risk categories used in the valuation process.

2.4.4 Other Sources of Uncertainty

In assessing the overall uncertainty of an estimate, it is essential to have regard to sources of uncertainty, other than those estimated by particular actuarial models.

- The data analysed in the formal model seldom covers a long enough period to adequately capture the uncertainty arising from changes in the physical, economic, social and legislative environment. To some extent, this can be estimated on the basis of collateral analyses, based on non-insurance data, but even this gives little help when, for instance, there has been a recent legislative change. It is usually necessary to rely on subjective assessment for at lease some of these uncertainties.

- Some models use a transformation to eliminate the effect of certain variables, most commonly inflation. The model estimates of uncertainty, in consequence, do not reflect any of the uncertainty arising from future the eliminated variables. This uncertainty must be incorporated.

Calibration of these effects is, by definition, highly subjective. However, a well-argued approach to dealing with these sources of uncertainty has developed, driven by the relatively high profile they have achieved due to the existence of stochastic modelling processes.

Section 3 Life Insurance

3.1 Background

…

Appendix A - Technical Support for Stochastic Methods *(include suitable – and suitably accredited – extracts from the actuarial literature)*

A.1 ICRFS

A.2 Generalised Linear Modelling

A.3 The Mack Method

A.4 Bootstrapping

A.5 Stochastic Chain Ladder

Appendix B - Deterministic versus Stochastic Approaches *(to be developed)*

For estimating the most likely value, without any consideration of the degree of possible deviations, there is no need for more than a one point estimation.

For advanced approaches of estimating mean values, especially weighted mean values (weighted with a measure for inherent deviation risk), it is necessary to apply advanced stochastic techniques. The most preferable approach is in any case the direct estimation of the target amount, i.e. of the weighted mean value. If it is possible, based on some knowledge about the distribution of outcomes (often modelled in the form of a distribution function of an idealised stochastic process), to establish stochastic estimators for that amount, that is the preferred way. That is as well a one-point estimate, but of the right point. For that optimal approach we should not use the same terminology as for the estimation of the most likely value. The paper used for both the word "deterministic" approach. That needs to be avoided.

It is clear, that lacking data or unreliable data often cause that the most preferable approach is not available. Hence, especially in life insurance to reflect unpredictable financial market risks and consequential risks resulting from behavior of policyholders, actuaries developed short cut approaches, like the so-called "stochastic models" (approaches using in lieu of non-existing data results from random generators fed with subjective assumptions and simply choosing the average of outcomes). The degree of subjectivity in such approaches is usually extremely high, hence it is biased to say that deterministic approaches are generally more