A PUBLIC POLICY PRACTICE NOTE

Scenario and Cell Model Reduction

September 2010

American Academy of Actuaries
Modeling Efficiency Work Group

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Developed by the Modeling Efficiency Work Group
of the American Academy of Actuaries

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17,000 members, whose mission is to assist public policymakers by providing leadership,
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2010 Modeling Efficiency Work Group

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1. **Introduction**

This practice note was prepared by the American Academy of Actuaries' Modeling Efficiency Work Group. It is not a promulgation of the Actuarial Standards Board, is not an actuarial standard of practice, is not binding upon any actuary and is not a definitive statement as to what constitutes generally accepted practice in the area under discussion. Events occurring subsequent to publication may make the practices described in this note irrelevant or obsolete.

1.1 The Purpose of a Practice Note:

> *The purpose of practice notes is to provide information to actuaries on current or emerging practices in which their peers are engaged. The notes are intended to supplement the available actuarial literature, especially where the practices addressed are subject to evolving technology, recently adopted external requirements, or advances in actuarial science or other applicable disciplines (e.g., economics, statistics, or enterprise risk management). Practice notes are not interpretations of actuarial standards of practice nor are they meant to be a codification of generally accepted actuarial practice. Actuaries are not in any way bound to comply with practice notes or to conform their work to the practices described in practice notes*. (Guidelines for the Development of Practice Notes, as adopted by the American Academy of Actuaries Board of Directors September 25, 2006)

1.2 Scope

This practice note is intended to provide information on common practices and approaches related to the use of reduced scenarios or reduced cell models for purposes of principle-based approaches to reserves and capital. The focus of this practice note is not to provide detailed examples of techniques used to create such reduced cell models or scenario sets; rather, the primary goal is to describe key considerations for testing and applying such techniques.

In the absence of runtime or data-size constraints, actuarial forecasts might involve:

- A seriatim cell model, that is, one in which each cell represents a single liability policy or asset cusip. (For certain types of business, such as contracts with elective living benefits, setting up a projection might involve splitting individual policies into several cells, each representing a different future election. This practice note considers such models seriatim models as well.)
- A large number of stochastically generated scenarios, such that adding further scenarios would be very unlikely to materially affect results. This practice note refers to such a set of scenarios as a "full set." Determining the number of scenarios needed for a full set is a matter of actuarial judgment, and the number may vary based on the nature of the business, the results being utilized, and the method used to generate the scenarios.

Because of practical constraints, actuaries often employ smaller models, such as:

- A reduced cell model intended to approximate the seriatim model; and/or
- A reduced scenario set intended to approximate the full set.

The examples presented in this document do not represent the official position of any company, regulatory body, or the American Academy of Actuaries (Academy).

1.3 Current References and Regulatory Guidance

Very little guidance exists regarding the testing of techniques used to create reduced cell models or scenario sets. Actuaries have been guided by the general principle that such techniques, like any approximation techniques, should not result in a material difference from the "true" result – that is, the result that would be obtained by using the seriatim model and full scenario set. (For solvency purposes, the criterion may be that the techniques must not alter the result in the direction of a material understatement in reserves or capital, whereas errors in the direction of increasing such amounts may be acceptable.)

The increasing importance of stochastic analysis is largely a result of the increasing heterogeneity of typical blocks of business, combined with the prevalence of embedded financial options. These same features have the potential to increase the risk of error introduced by grouping a seriatim model into a smaller number of model cells. This has raised concerns among some regulators and other observers about the level of distortions introduced by the use of such techniques.

The NAIC currently packages a set of 10,000 economic scenarios, which may become, at least de facto, the "full set" of scenarios on which reduction is performed for some statutory applications.

2. Reduction Techniques

The following efficiency techniques are used by many actuaries though this list is not intended to be prescriptive or exhaustive. For most of these techniques, the intent is that the reduced scenario set, reduced cell model, or proxy model be "unbiased" in the sense that the estimate it provides for any quantity of interest (such as a contingent tail expectation (CTE) or mean amount) should not be systematically higher or lower than the "true" value that would result from the seriatim model and the full set of scenarios. For the last technique, the intent is that an adjustment be made to eliminate any bias in the reduced scenario set.

2.1 Using a Reduced Scenario Set

A reduced scenario set may be generated from the full set using some information related to all scenarios in the full set. Some actuaries may select a subset of the scenarios such as scenario "m" through scenario "n." Some actuaries may rank the scenarios in the full set by a particular dependent variable such as the year-10 accumulation factor for the S&P index, and then use that ranking to take a stratified sample of the full set. Other actuaries

may use more sophisticated methods that might involve multiple variables, some of which may need to be generated from a projection (presumably from a much smaller "test" block of business).

2.2 Using a Reduced Cell Model

A reduced cell model may be generated using rules that define how policies or cusips are to be grouped to create a set of model cells that reasonably represent the original policies or assets in total. The actuary may analyze several (or many) variables for this purpose, ranging from policy characteristics like issue date or issue age to projected values such as periodic cash flows.

2.3 Using a Proxy for a Model of the Business

A collection of instruments may be used as a proxy for the cash flows from the liability or asset model as a whole. In general these are non-insurance instruments (and may be hypothetical, not actual instruments), often with cash flows or market values that can be determined for any economic scenario using closed form solutions.

2.4 Using a Reduced Scenario Set and a Reduced Cell Model

Both a reduced scenario set and a reduced cell model may be used.

2.5 Using a Reduced Scenario Set and a Reduced Cell Model, with Adjustment for Estimated Error

Both a reduced scenario set and a reduced cell model may be generated. The desired quantity (e.g., the CTE amount at the desired percentile) may be calculated for each of the following runs:

A. The seriatim model, run with the reduced scenario set
B. The reduced cell model, run with the full scenario set
C. The reduced cell model, run with the reduced scenario set

Finally, the true amount is estimated from the quantities above (for example, as A+B-C). The intent is not that the reduction along each dimension yield an unbiased estimate of the true amount, but rather that the estimate of error introduced by each reduction be sufficiently independent that the true result can be estimated from them. This approach is sometimes known as the "control variate" approach.

3. Validating Results

3.1 Static and Dynamic Validation

Actuaries have been validating reduced cell models for many years. A typical static validation method is to compare selected model data items such as formula statutory reserve or premiums in force generated by the model to corresponding actual values from

the underlying block of business. Dynamic validation techniques often include a comparison of projected cash flows such as premiums and claims to trends in actual cash flows.

3.2 Validating with Reduced Cell or Reduced Scenario Sets

The only way to know, with full confidence, the error introduced by a reduction technique is to perform additional runs using the full scenario set and seriatim model. If such an exercise can be performed in a timely manner, there may be no need for the reduced cell model or reduced scenario set in the first place.

When this is not practical, the actuary may gain sufficient confidence in a reduced set of scenarios by developing a reduced cell model and running it on both the reduced and the full set of scenarios. For this purpose, the reduced cell model need not be a sufficiently close representation of the seriatim model to warrant using it as a replacement. Rather, the actuary should take care that the reduced cell model adequately represents the risks inherent in the business for the purpose of the intended calculation. For example, the reduced cell model should usually consider the extent to which a guarantee is in the money.

In a similar manner, the actuary may validate a reduced cell model by comparing results from the reduced model with results from the seriatim model over a subset of scenarios. Here, the subset may be chosen randomly from the larger set, or it may be chosen systematically in an attempt to approximate the range and characteristics of the full scenario set. As noted above, it is not necessary that the subset of scenarios be suitable as a full replacement for the larger set; only that it be sufficiently representative to assess whether the reduced cell model is appropriate.

Note that it may not be sufficient to compare a single CTE number from both sets of projections. The CTE, or any other single measure, may match by coincidence even though the smaller set is not in fact a good representation of the larger set. The actuary should examine other points of the distribution as well. Additionally, the actuary should ensure that the methodology used to test a reduced set is independent of the process used to generate the reduced set in the first place.

3.3 Validating as of an earlier projection date

Frequently, the primary reason for not using a seriatim cell model and full scenario set is that there are not enough computer resources and/or staff to perform the necessary runs in the time available. In such a case, the actuary may validate the technique at an earlier date (“test date”) using one or more of the methods in section 2.

Using an earlier projection date gives the actuary the opportunity to perform a more thorough validation, but it has a disadvantage in that the actuary would need to consider whether conditions changed from the test date to the valuation date that would decrease

confidence in the validation. Circumstances that could impair the validation may include the following:

- The composition of the business has changed significantly between the test date and the valuation date (due to sales, terminations, unanticipated changes in economic conditions or policyholder behavior).
- Financial markets have changed significantly between the test date and the valuation date in a manner likely to affect the block. In this case, sensitivity tests reflecting similar changes could be run as of the test date to validate the continued use of the reduction method under such altered circumstances.