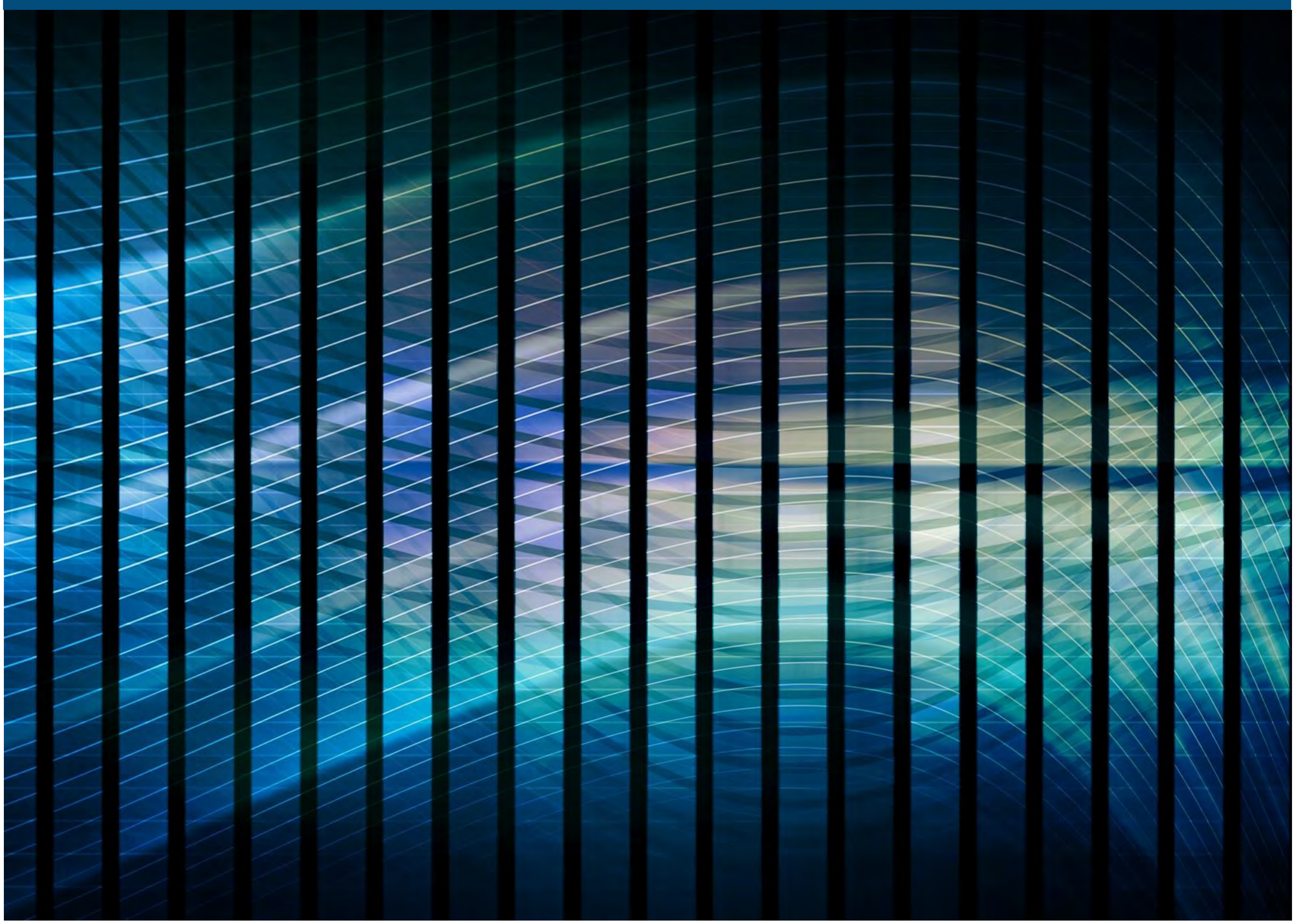
SOCIETY OF ACTUARIES

# Principle-Based Reserves Simplified Methods



July 2020

SOCIETY OF ACTUARIES

# Principle-Based Reserves Simplified Methods

**AUTHOR**

Mark W, Birdsall, FSA, MAAA
Lewis & Ellis Inc.

Stephen J. Strommen, FSA, MAAA
Blufftop LLC

Brian M. Hartman, PhD, ASA
Hartman Analytics LLC

SPONSOR

Smaller Insurance Company Section
Financial Reporting Section
Committee on Life Insurance Research

# CONTENTS

# Principle-Based Reserves Simplified Methods

## Section 1: Background

The original idea of principle-based reserves (PBR) or the principle-based approach (PBA) was to embed risk analysis in reserve calculations to “right-size” reserves through a process like cash flow testing that allows companies to reflect their unique experience in the reserve calculations. (Note: We will use PBR and PBA interchangeably in this report.) Over time, this concept gradually morphed into a set of requirements in the *Valuation Manual*, including Section 20 (VM-20) for life insurance that is more complex than the existing statutory requirements. Because PBR involves an assumption-setting process and stochastic reserve calculations, additional resources will often be required to implement the PBR requirements. While resources are scarce everywhere, they are especially scarce within smaller companies, many of which have stayed away from the more complex product designs and invested assets that have led to the need for PBR in the first place.

It is with these lower-risk asset and liability profiles in mind that the stochastic exclusion test (SET) was included in VM-20. The basic idea was less risk, less work. The SET involves modeling a set of 16 prescribed scenarios to demonstrate that full stochastic valuation is of little or no value for a block of policies because the economic scenario risks are relatively small. It was the success of the SET that started the thought process that led to the Representative Scenarios Method (RSM).[1] Appendix C describes RSM as originally proposed.

Ideally, actuaries would be able to stochastically model all the material risks in a block of business, but this may not be practical from a run-time standpoint for a large model and would be very difficult to audit for the company, its independent auditors and the regulatory reviewers. But what if, like the SET, a small number of specially constructed scenarios could measure not only the interest rate and market risk in a product but also apply multiple-scenario techniques to risks besides investment returns? Doing so would permit a better evaluation of the total risk profile of a product and its supporting assets in the calculation of reserves (and target surplus).

More specifically, RSM was developed in response to the NAIC Life Actuarial Task Force’s (LATF’s) charge to the American Academy of Actuaries (AAA) Annuity Reserve Work Group (ARWG) to develop PBR for nonvariable annuities. In connection with this charge, ARWG was to prepare a draft of VM-22, the section of the *Valuation Manual* that would apply to nonvariable annuities. RSM was developed in response to the challenge of the ARWG chair to think beyond the established VM-20 requirements in developing the best way possible to calculate PBR reserves.

RSM approximates the results that would be derived from full stochastic modeling of all material risks associated with a block of business. However, it addresses the practical issues of run time and auditability by being based on a limited number of scenarios for each of those material risks. The scenarios for each material risk are based on a probability distribution for each risk with each scenario representing a specific probability level for that risk. The dispersion of the scenarios represents the amount of relevant company and relevant industry experience that is applicable to the block of business being valued. Using the scenario results for each material risk, an aggregate margin can be calculated, including a covariance adjustment. Adding this aggregate margin to the scenario results derived from all the anticipated experience assumptions provides an approximation to the fully stochastic reserve as permitted by VM-20 Section 2.G. Since VM-20 prescribed certain assumption limitations, those implicit margins must be considered in the development of the assumptions used with RSM. For example, projecting mortality improvement is not permitted by VM-20 and therefore should not be reflected in the RSM calculations. However, it would be possible to quantify this implicit margin and add it to the explicit aggregate margin and report the margins in the PBR actuarial report required by VM-30.

[1] Birdsall, Mark, and Steve, Strommen. 2015. Introducing the Representative Scenarios Method (RSM)—Part 1. *Small Talk*. 44, no. 9:6–8.

Being a multirisk approach, RSM has the potential to serve as a valuation methodology that could be used for any long-tailed liabilities, including life insurance, variable annuities and long-term care, as well as nonvariable annuities. In fact, RSM was field-tested with several products, including nonvariable annuities with guaranteed lifetime withdrawal benefits (GLWBs), variable annuities with GLWBs, level term life insurance, universal life (UL) with secondary guarantees (ULSG) and long-term care. The reserve estimates to the fully stochastic reserves in the field test were encouraging, but the methodology needed more objectivity in setting assumptions and developing probability distributions.

As the AAA and LATF discussed the RSM approach, two concerns emerged: (1) Distributions around the assumptions for each of the material risks were subjective, with each distribution defined by each appointed actuary; and (2) the assumptions themselves for each material risk were subject to potential manipulation by the actuary. Hence, prescribed assumptions and methodologies emerged in the development of VM-20 that made the PBR process more difficult and added implicit margins to the explicit margins.

As implemented, the *Valuation Manual,* beginning with life insurance in VM-20 and VM-21 for variable annuities, provides a structure for calculating statutory reserves, particularly for long-duration liabilities, as the greatest of three values: the cash surrender value (where applicable), a formulaic floor reserve (the Net Premium Reserve or NPR for life insurance and the Standard Scenario Reserve for variable annuities), and a modeled reserve that uses company experience (at least in part) for projecting future cash flows. In VM-20, the modeled reserve is divided into two separate calculations, the deterministic reserve and the stochastic reserve. The deterministic reserve functions like a premium deficiency reserve, while the stochastic reserve reflects more asset-liability management for the block of business being valued. It is important to note that the more profitable a block of business is, the lower the modeled reserves will be and vice versa.

A deterministic exclusion test and a SET are defined in VM-20 to identify blocks of life business for which the extra work of calculating the respective modeled reserves is likely to be unnecessary. It is significant that the blocks of business being tested for exclusions from the two modeled reserves are grouped based on similar risk profiles. (see VM-20 6.A.2.b.iv and 6.B.3.). In VM-30 3.B.9.a., the risk profile includes the product design features, market description, underwriting, the specific risks that the appointed actuary determines to be significant, and other aspects of a risk profile, which may include the risk profile of the investment strategy supporting the block of business. If the exclusion tests are based on the appointed actuary's determination of groupings of liabilities and supporting assets with similar risk profiles, then the modeled reserve calculations must similarly be based on such risk profile groupings.

The first place that this grouping of liabilities and supporting assets has a material impact on the determination of PBR modeled reserves is in setting assumptions for determining the modeled reserves. The modeled reserves are calculated using prudent estimate assumptions for each risk factor that are developed from the anticipated experience assumptions which, for the material risks (see VM-20 9.B.4), have been adjusted by margins. The anticipated experience assumption for a risk factor refers to the expected future experience for that risk factor based on "available, relevant information pertaining to the assumption being estimated."[2] VM-20 9.A.6. goes on to provide that relevant industry experience can be combined with relevant company experience in establishing anticipated experience assumptions. Where the use of credibility measures is appropriate, such as for mortality and lapses, credibility-weighting relevant company and relevant industry experience can be used to set the anticipated experience assumptions. Where there is not relevant, credible company and industry experience for policyholder behavior risks, VM-20 specifies that the appointed actuary shall establish the margin by determining a plausible range for the risk factors and then moving toward the conservative end of the plausible range. This approach would be sound for other assumptions for which relevant, credible data does not exist, such as for new benefits that have not yet developed experience (see VM-20 9.D.3.). Note that the enhanced RSM described in this report could be used as an objective method for setting the margins on the material assumptions besides interest and equity risks.

[2] National Association of Insurance Commissioners. Valuation Manual, VM-01.6. January 1, 2020, *https://www.naic.org/documents/pbr_data_val_2020_edition_redline.pdf* (accessed March 4, 2020).

The grouping of products with similar risk profiles should be considered in developing the underlying experience studies to determine relevant company experience, in identifying relevant industry experience and in determining margins for the material anticipated experience assumptions. Because industry experience studies may be highly aggregated by including different product types and designs, distribution channels and target markets, industry studies must be used with care in setting anticipated experience assumptions. In some cases, prescribed assumptions may not be relevant to the risk profile groupings, and differences between relevant experience for a risk factor and the prescribed assumption for that factor could be considered an implicit margin in the assumptions (in addition to any explicit assumptions required in the *Valuation Manual*). VM-30 D.11.c. provides an opportunity to disclose the impact of implicit margins. This disclosure could become a part of the feedback loop the NAIC has established to improve the effectiveness of PBR over time.

LATF has been consistent in establishing a target level of statutory conservatism at about the 80th to 85th percentile of the distribution of the present of future cash flows. Structurally, this target has been implemented in the *Valuation Manual* by using CTE 70 (Cumulative Tail Expectation above 70%) for the stochastic reserve, which measures the reserve as the arithmetic average of the highest 30% of the scenario reserves calculated based on stochastic economic scenarios and prudent estimate assumptions (i.e., with margins on the material assumptions and some prescribed assumptions). There is a potential concern about the “stacking” of individual margins, which would imply that the combined impact of the individual margins (including implicit and explicit margins) would create greater conservatism than needed to reach the 84th percentile target. This concern is mitigated by VM-20 9.B.1 that provides for an adjustment of the individual margins “to take into account the fact that risk factors are not normally 100% correlated.” However, this adjustment would only apply to explicit margins on material assumptions; the implicit margins due to prescribed assumptions would not be adjusted in this manner. Another approach to the stacking issue would be to calculate an aggregate margin and calibrate the combined impact of the individual margins to be consistent with the size of the aggregate margin.

So, building on the RSM work of the ARWG and these principles from VM-20, this PBR Simplified Methods Project looks at providing less-calculation-intensive methods for approximating the stochastic reserve while at the same time addressing regulator concerns about the possible manipulation of reserve levels through assumption-setting and helping companies realize the benefits of embedding useful risk information in its statutory reserve calculations.

## Section 2: Introduction

Smaller companies may consider electing the life principle-based reserves exemption due to implementation and operational costs as well as resources needed to report on a VM-20 basis. A result of electing the exemption may be holding higher reserves than what would have been determined under VM-20 had the insurer not elected the exemption. Therefore, the Society of Actuaries (SOA) Smaller Insurance Company Section initiated research to investigate simplifications, approximations and modeling efficiency techniques allowed under VM-20 for determining reserves. Lewis & Ellis Inc. was engaged to perform research to develop a less-intensive approach that would be allowed under VM-20 and that would satisfy the specified demonstration requirement and document the results of the study in a report to be made publicly available. Besides the report, Lewis & Ellis agreed to provide the tools developed that can be used for approximation methods for the VM-20 stochastic reserves. The remainder of the paper discusses these tools needed to approximate VM-20 stochastic reserves and provide regulatory demonstrations. The tools are:

A. A scenario generator for all material assumptions for application in an actuary's cash flow projection software, multi-risk scenario generator.

B. Objectivity measure(s) for material best estimate assumptions that allows independent auditors and regulatory reviewers greater assurance that the models are based on appropriate assumptions and properly reflect the material dynamic risks.

C. Recommendations for approximations techniques by product type, together with corresponding sample regulator demonstrations.

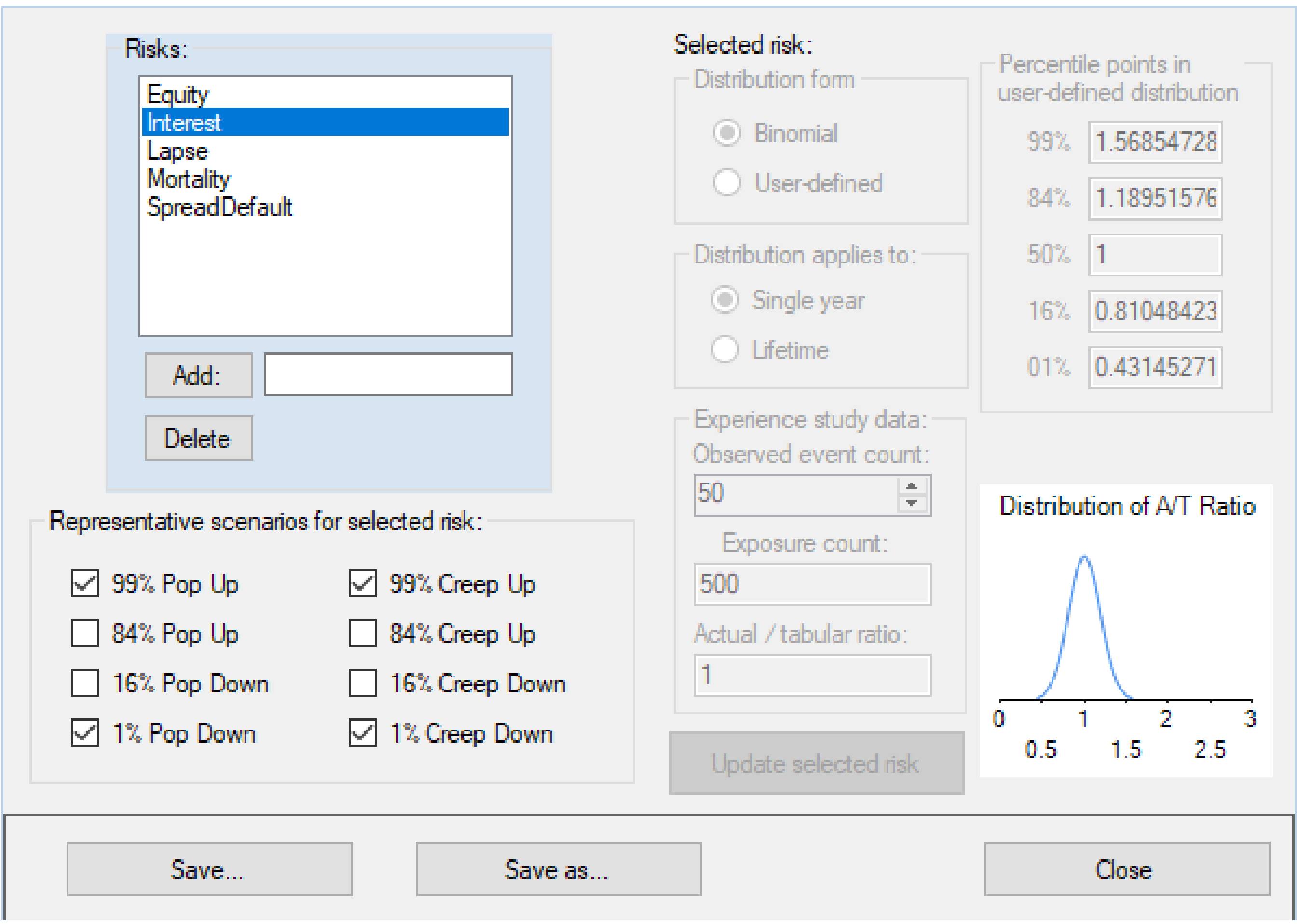
## Section 3: Multi-Risk Scenario Generator

For using the multi-risk scenario generator that accompanies the report, a risk definition file was developed. Please note the figures and explanations that follow.

### 3.1 INTEREST RISK

In the upper left-hand corner of Figure 1 is the user-defined list of material risks. For the interest rate risk, the scenarios are generated using the SOA/AAA economic scenario generator embedded in the multi-risk scenario generator. The probability levels for the shocks to the Treasury rates are indicated in the lower left-hand corner, which reflect extreme scenarios used for developing target surplus (i.e., 99%–1%). The 84%–16% scenarios would be used to represent moderately adverse scenarios. “Pop Up (Down)” and “Creep Up (Down)” are different methods for producing the scenarios at the selected probability levels. For some risks, such as lapses, the adverse direction is not always clear, so deviations in both directions are tested. The pop and creep scenarios differ in the pattern of shocks that are used to create them.

**Figure 1**
INTEREST RATE RISK




The PBR Simplified Methods research team defined the severity of a scenario as being measured by the sum of the cumulative shocks. The pop and creep scenarios have the same sum of shocks over the first 20 years (240 months).

In the creep scenarios, the shocks are the same in every month. In the pop scenarios, the shocks are higher initially and then grade off toward zero.

For a one-standard deviation scenario, the shocks (measured in monthly standard deviations) are as follows in month N of 240:

Creep $1/\sqrt{240}$ (the same every month, independent of N)

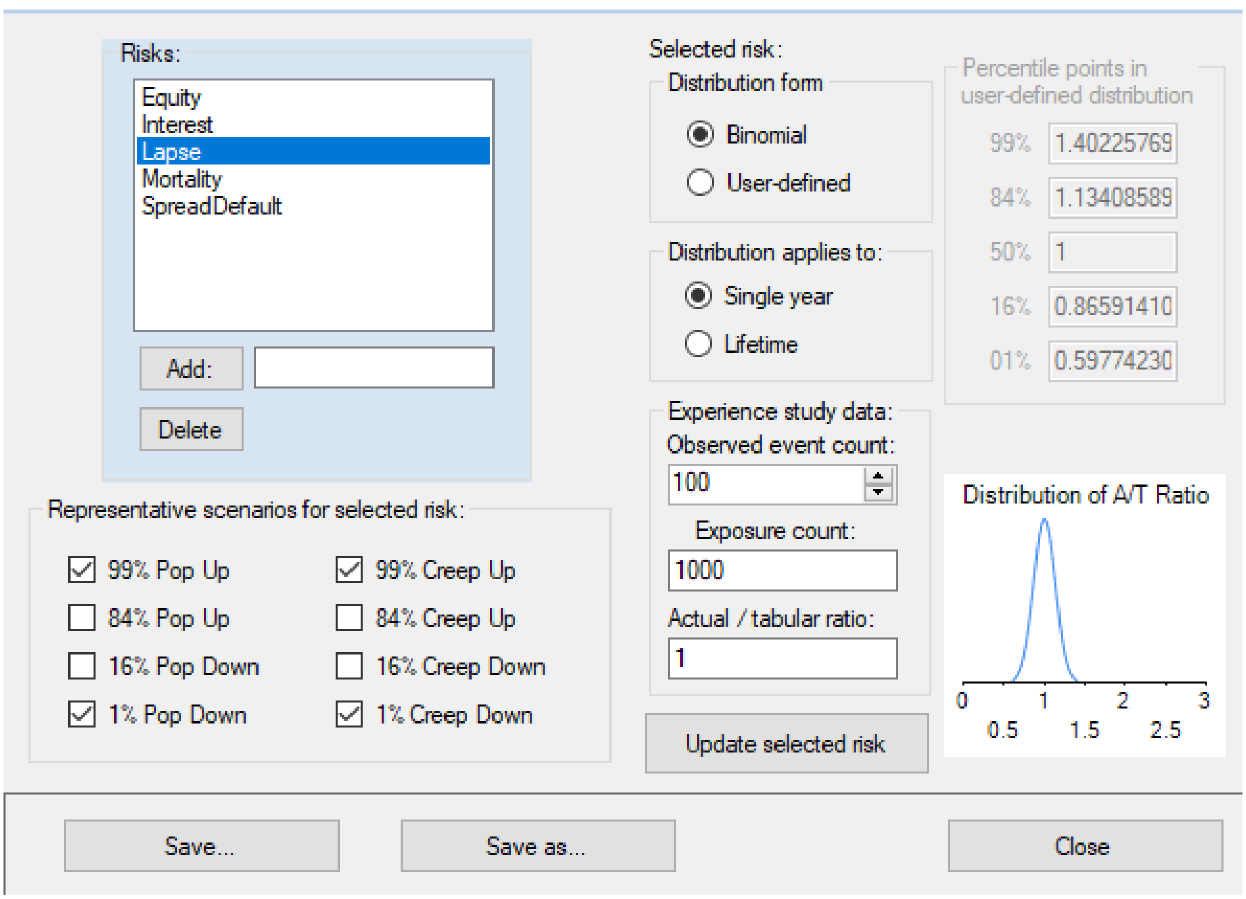
Pop $\sqrt{N}-\sqrt{N-1}$ (starts high then grades off toward zero)

In both cases, the sum of the first 240 shocks is $\sqrt{240}$ .

## 3.2 LAPSE RISK

For the lapse risk definition in Figure 2, note the selected binomial distribution applying to single years. The selection of single years means that the projected actual to expected (A/E) ratios will vary by projection year. In the development of the generator, Brian Hartman developed an approach that permits the use of the binomial distribution for any material risk with a range from zero to one, such as lapse and mortality. The resulting distribution covers both estimation error and adverse deviation, as required by the *Valuation Manual*. The derivation of this method follows.

**Figure 2**
LAPSE RISK



Examine the problem of incorporating both parameter and process uncertainty when simulating life insurance experience. The focus is on binary experience (such as mortality and lapse) but a similar process can be followed for any risk factor.

The most straightforward approach would be to find the posterior distribution of the actual/tabular ratio (in this report it will be called $\theta$) and then simulate the experience many times using draws from the posterior distribution of $\theta$. Both types of uncertainty will be incorporated into $\theta$ to allow for direct application in currently available software.

For ease of discussion, lapse rates will be considered. Assume that the company has $E$ historical exposures of which $X$ lapsed. The tabular lapse rate is $T$. Assign a Beta prior to the quantity $\theta T$ with a mean at $T$ and a reasonable spread.

$$X \sim Bin(E, \theta T)$$

$$\theta T \sim Beta(\alpha, \beta)$$

$$\theta T | X \sim Beta(\alpha + X, \beta + E - X)$$

The posterior distribution of $\theta T$ is also beta distributed. Using the central limit theorem and the information above, derive the approximate mean and variance of $Y$, the future number of lapses out of $n$ policies.

$$Y \sim Bin(n, \theta T)$$

$$E(Y) = E\big(E(Y|\theta)\big) = E(n\theta T) = nE(\theta T) = n \cdot \frac{\alpha + X}{\alpha + \beta + E}$$

$$Var(Y) = E\big(Var(Y|\theta)\big) + Var\big(E(Y|\theta)\big)$$

$$= E\big(n\theta T(1 - \theta T)\big) + Var(n\theta T)$$

$$= nE(\theta T) - nE((\theta T)^2) + Var(n\theta T)$$

$$= n \cdot \frac{\alpha + X}{\alpha + \beta + E} - n \cdot \frac{(\alpha + X)^2 + \alpha + X}{(\alpha + \beta + E)(\alpha + \beta + E + 1)} + n^2 \cdot \frac{(\alpha + X)(\beta + E - X)}{(\alpha + \beta + E)^2(\alpha + \beta + E + 1)}$$

With the approximate (asymptotic) mean and variance of $Y$ accounting for both parameter and process uncertainty, redefine $Y$ as a function of $\theta$, $T$, and $n$.

$$Y = n\theta T$$

$$E(\theta) = \frac{E(Y)}{nT} = \frac{1}{T} \cdot \frac{\alpha + X}{\alpha + \beta + E}$$

$$Var(\theta) = \frac{Var(Y)}{n^2T^2}$$

$$= \frac{1}{T^2}\left(\frac{1}{n}\left(\frac{\alpha + X}{\alpha + \beta + E} - \frac{(\alpha + X)^2 + \alpha + X}{(\alpha + \beta + E)(\alpha + \beta + E + 1)}\right) + \frac{(\alpha + X)(\beta + E - X)}{(\alpha + \beta + E)^2(\alpha + \beta + E + 1)}\right)$$

Draw $\theta$ from a normal distribution with the mean and variance above, then multiply those draws by $nT$. Approximately, these are draws from $Y$ that incorporate both parameter and process uncertainty.

To choose the values $\alpha$ and $\beta$, satisfy the following two conditions:

$$E(\theta T) = \frac{\alpha}{\alpha + \beta} = T$$

$$Var(\theta T) = \frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)} \approx \frac{3}{4}T(1-T)$$

The ratio in the second condition can be anything less than 1. In that case, with some algebraic manipulation, derive

$$\alpha = \frac{T}{3}$$

$$\beta = \frac{1-T}{3}$$

In conclusion, simulate the actual/tabular (A/T) ratio from a normal distribution with the following mean and variance.

$$E(\theta) = \frac{1}{T}\cdot\frac{T/3+X}{1/3+E}$$

$$Var(\theta) = \frac{1}{T^2}\left(\frac{1}{n}\left(\frac{T/3+X}{1/3+E} - \frac{(T/3+X)^2+T/3+X}{(1/3+E)(1/3+E+1)}\right) + \frac{(T/3+X)((1-\mathrm{T})/3+\mathrm{E}-\mathrm{X})}{(1/3+\mathrm{E})^2(1/3+E+1)}\right)$$

Multiply that ratio by the tabular value, $T$, and the current exposures, $n$, and generate observed values that incorporate both parameter and process uncertainty.

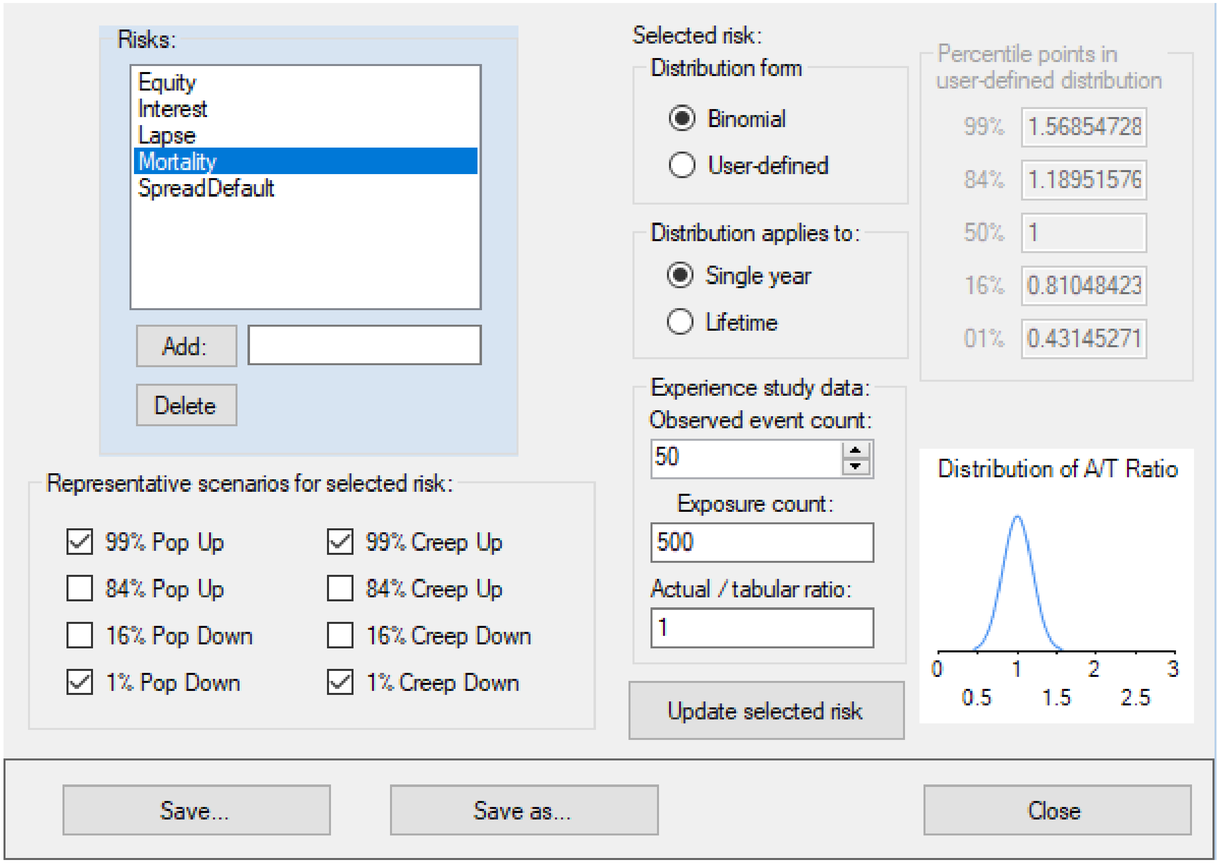
This methodology was peer reviewed by Hartman's colleague at another university and was incorporated in the development of the probability distributions for the binary (0,1) risks in the multi-risk scenario generator.

For the modeling work of this project, the observed lapse event count and exposure count was set to reflect the lack of relevant company experience in developing the starting lapse A/E ratio equal to 1. As before, the 99%–1% scenarios were selected to develop target surplus. The 84%–16% probability levels represent moderately adverse experience.

## 3.3 MORTALITY RISK

The mortality risk definition in Figure 3 parallels the lapse risk definition except for the observed event count and exposure count. The values were chosen to reflect the slower development of mortality experience and results in a wider distribution of A/E ratios relative to the lapse risk.

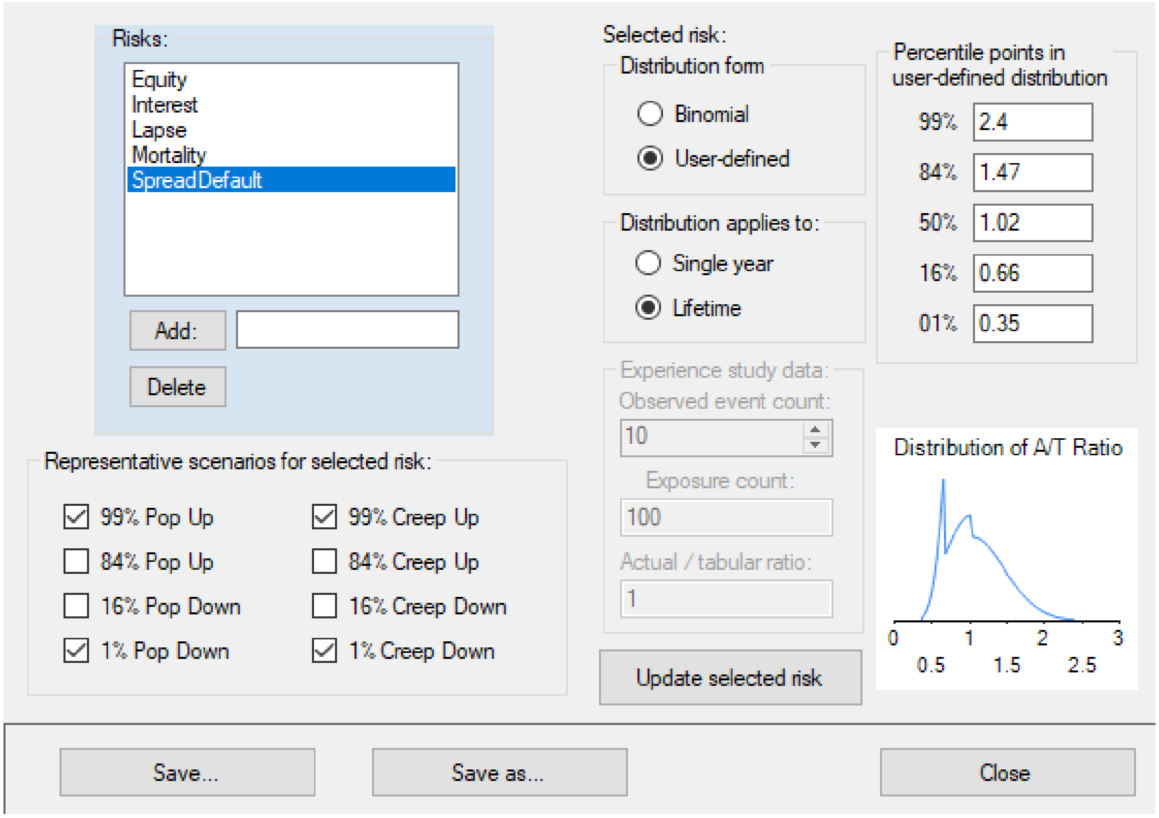
**Figure 3**
MORTALITY RISK




## 3.4 SPREAD NET OF DEFAULT RISK

In Figure 4, note that the spread net of default risk employs a user-defined function that provides a single value for the first 20 projection years rather than varying year by year. After 20 years, the value reverts to the 50th percentile value of 1.02. The percentile points shown in Figure 4 for the user-defined function were based on an AAA presentation to the NAIC. Note the graph of this distribution as shown in the lower right-hand corner of Figure 4. The distribution of A/E ratios is skewed to the right, as one may expect.

**Figure 4**
SPREAD NET OF DEFAULT RISK

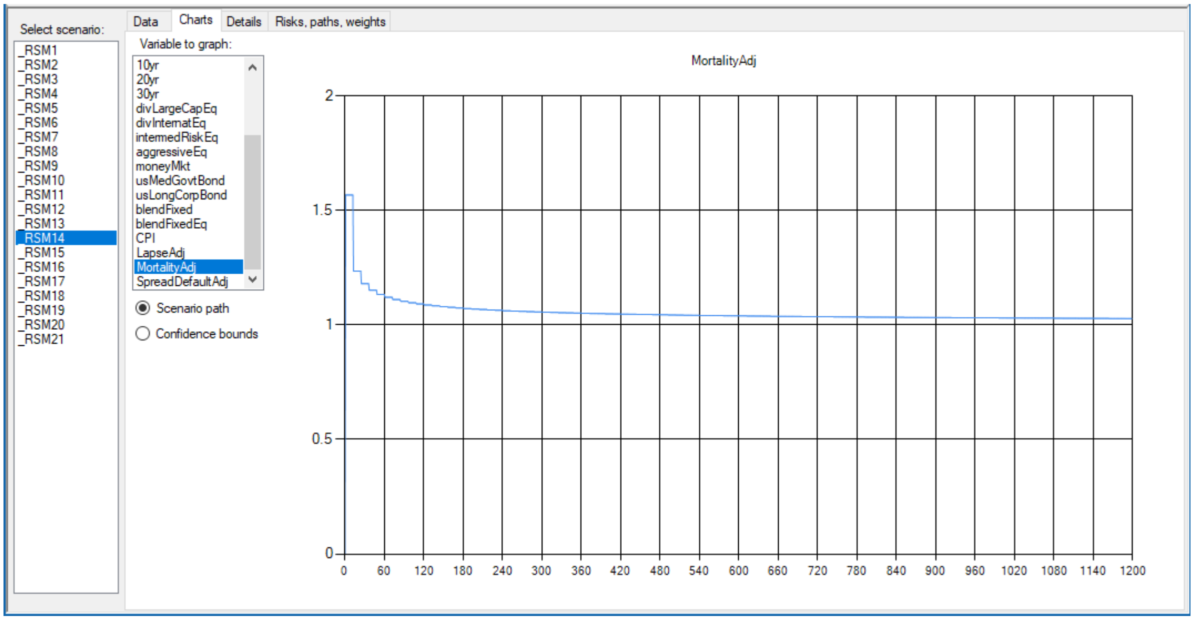



For each of the material risks of interest, lapse, mortality and spread default, four deterministic scenarios were produced, representing combinations of the 99%–1% and pop versus creep. To give an idea of the shape of these scenarios, consider Figures 5–8 for the mortality risk.

In Figure 5, note that the annual shocks in the pop A/E scenario become less severe over the projection period; otherwise, the cumulative effect of the scenario would be more severe than the probability level indicated.

**Figure 5**

MORTALITY A/E SCENARIO 99% POP




In Figure 6, note that the annual shocks in the creep scenario are equal each month for 240 months. After 240 months, the scenario reverts to the 50th percentile A/E ratio based on the most recent experience study.

**Figure 6**

MORTALITY A/E SCENARIO 99% CREEP

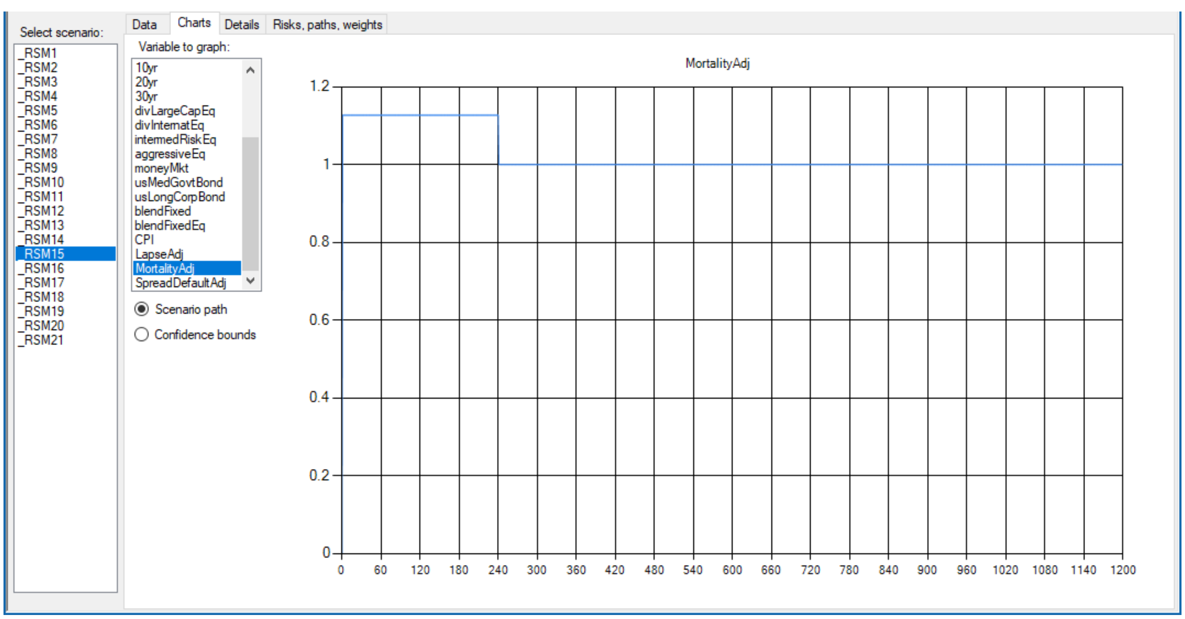


Figure 7 is analogous to Figure 5, but with the stress in the opposite direction.

**Figure 7**

MORTALITY A/E SCENARIO 1% POP

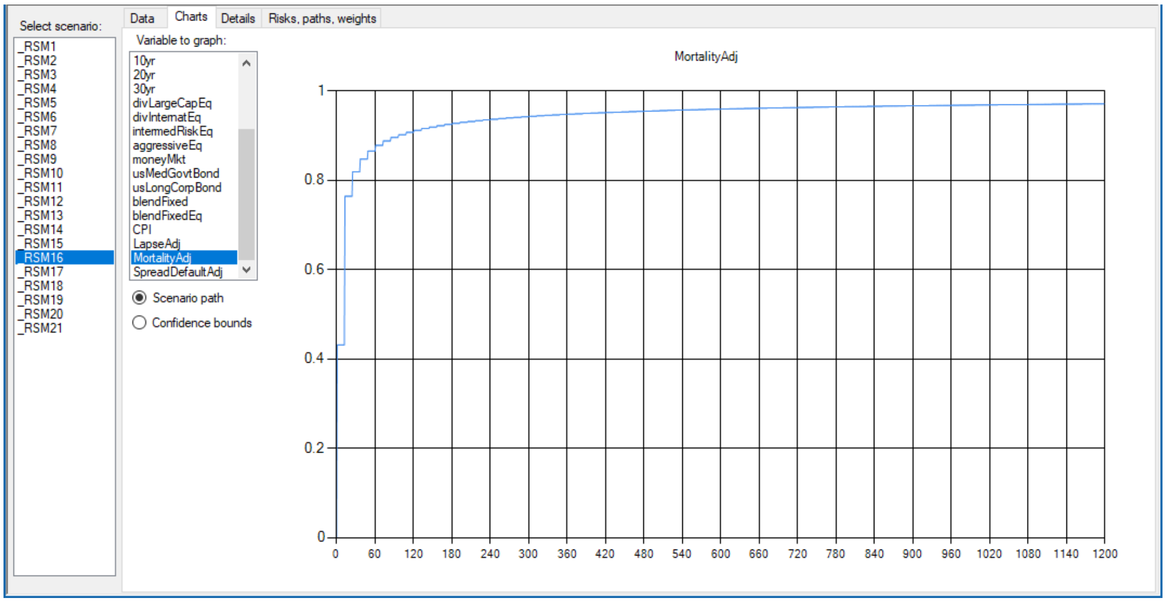
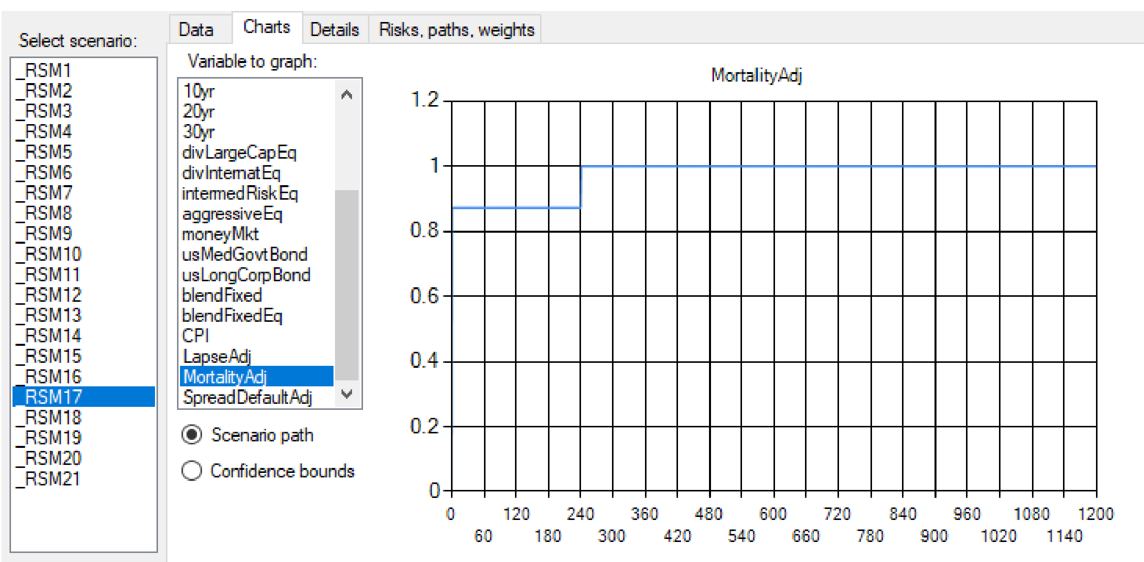



Figure 8 is analogous to Figure 6, but with the stress in the opposite direction.

**Figure 8**

MORTALITY A/E SCENARIO 1% CREEP



The multi-risk scenario generator provides specific scenario values for each of the material risks for application in the actuary's cash flow projection software.

## Section 4: Assumption Objectivity Measures-Output Method

One of the biggest regulatory concerns expressed in LATF discussions about PBR has been the possibility that aggressive assumption-setting by some actuaries would provide a competitive advantage to companies seeking lower reserve levels by manipulating the assumptions used to calculate the deterministic and stochastic reserves. This section describes several measures calculated using the output of cash flow projections produced using central estimate assumptions and the multi-risk scenario generator, which could address this concern. Taken together, these several measures would permit a company to provide independent auditors and regulatory reviewers with greater assurance that the models are based on appropriate assumptions and properly reflect the material dynamic risks. Additionally, a benefit of performing these calculations would be that the information produced would assist the actuary in asset adequacy analysis, calculations of target capital and free surplus, and in ranking risk margins at different points in the tail of the distribution of the present value of future cash flows.

For the purposes of this discussion, "central estimate assumptions" refer to assumptions that combine relevant company and industry experience for the material risks (where company experience is less than 100% credible) to develop baseline assumptions for modeling those material risks in cash flow projection models. Where relevant company experience for a material risk is 100% credible, the relevant company experience for that material risk would be the central estimate assumption, including consideration of possible trends in the experience. When there is less than 100% credibility, the relevant company experience could be credibility-blended with relevant industry experience to establish the central estimate assumptions for a material risk, including consideration of possible trends in both relevant company and relevant industry experience. For the purposes of this discussion, the central estimate assumptions are updated annually and provide a standard of comparison for the actual base assumptions used in the cash flow projection model.

### 4.1 RELEVANT EXPERIENCE

In this context, "relevant" means the experience is directly applicable to the expected experience for the material risk(s) under consideration with respect to factors including underwriting methods, product designs, distribution channels, and target markets. Relevant company and industry experience should be identified based on all the significant predictors of experience for the material risk under consideration. Both company and industry experience studies should be designed to identify those significant predictors. Material assumptions could be identified using targeted sensitivity testing with the company establishing a threshold for determining when a specific risk will be deemed "material." Interdependent risks may be considered together in this determination of materiality.

LIMRA, Medical Information Bureau (MIB) and other data aggregators have been working on the development of enhanced experience studies that identify the significant predictors of experience, including product design elements, specific agent or distribution channels, demographic variables and projected in-the-moneyness of a benefit. These enhanced experience studies could serve as the basis for identifying relevant industry experience. Please see the Appendix that provides references to relevant experience in the draft Actuarial Standard of Practice (ASOP) on setting assumptions and Section 20 of the *Valuation Manual* regarding life insurance principle-based reserves. There are many other references to relevant experience in other ASOPs and the *Valuation Manual.*

If relevant industry experience is unavailable or the actuary does not consider it, company experience alone can be used for a material risk, but the lower credibility of only using the company experience would result in a wider distribution of A/E ratios produced by the multi-risk scenario generator. In this case, the company experience would become the central estimate assumption for that material risk.

In the case of an emerging material risk (like one associated with a new benefit, for example) for which neither company nor industry experience is available, the actuary would use professional judgment in setting the central estimate assumption. However, a very small number of events reflecting this lack of experience would be input into the multi-risk scenario generator, resulting in a correspondingly wide distribution for that risk, appropriate for the level of uncertainty. The principle described in the *Valuation Manual* when there is little data is to establish a plausible range and move to the conservative end of the plausible range.

With the multi-risk scenario generator, scenarios can be defined at specified probability levels for each material risk in a cash flow projection. For example, sensitivity testing can be done at specified levels of adverse deviation from the central estimate assumptions. In developing PBR, LATF consistently indicated that the appropriate level of statutory conservatism is CTE 70 or about the 84th percentile of the distribution of the present value of future cash flows. Similarly, NAIC Life Risk-Based Capital (RBC) Working Group has indicated that RBC represents a minimum capital requirement at about the 95th percentile of the distribution of the present value of future cash flows over a specified time horizon. Perhaps target capital would be considered near the 99th percentile of that distribution. The multi-risk scenario generator provides a tool whereby these percentile levels of the distribution of the present value of future cash flows can be estimated.

Per VM-20, there are two basic methods for calculating credibility: the Limited Fluctuation Method and the Buhlmann Method. The Buhlmann Method requires the company to have access to industry-level information, which the data aggregators and/or reinsurers could help provide. The credibility of the relevant industry experience should likewise be calculated.

With respect to formally including relevant industry experience in the assumption-setting process, VM-20 provides a road map for a credibility-blending process specific to the mortality assumption for the deterministic reserve and the stochastic reserve. Please note that this credibility-blending process can be applied to other material assumptions as well. While VM-20 applies to setting modeling assumptions for the PBR deterministic and stochastic reserve calculations, this credibility-blending process is a sound methodology for developing central estimate assumptions for other risk analysis purposes, including pricing.

## 4.2 FOUR MEASURES OF ASSUMPTION OBJECTIVITY

### 4.2.1 Measure 1: A/E Ratios for the Material Assumptions

The central estimate assumptions would provide the denominators for (1) A/E ratios for the material assumptions in a product or product group. The actual set of modeling assumptions (without margins) used as the basis for the cash flow projections would provide the numerators in the A/E calculations. In many cases, the actuary may choose to use the central estimate assumptions for the cash flow projections.

If the company's experience study software provides for inputting expected values, then the modeling assumptions could be input as the expected assumptions and the A/E ratio (call it AE1) calculated versus company actual. Then, the central estimate assumptions could be input as the expected assumptions and the A/E ratio (AE2) calculated versus company actual. The A/E ratio for the material assumption would equal AE2/AE1 (i.e., modeling/central estimate as you invert and multiply the ratio components).

If the company's experience study software does not provide for inputting expected experience, then an alternate method using the cash flow projection model could be employed. Run the cash flow projection model using all anticipated experience assumptions for a short period, such as three years. Then run the cash flow projection model using all anticipated experience assumptions except for using the central estimate assumption for the material assumption being tested. Either counts or dollar amounts could be used as the basis for the calculation of the A/E ratio for the material assumption. Using dollar amounts weights the impact of different size policies. However, if the distribution of benefit amounts is extreme, using counts may be preferable. Derive the A/E ratio for the material assumption by summing the counts or amounts for the material assumption for the projection based on the anticipated experience assumptions and dividing by the sum of the counts or amounts for the material assumption for the projection based on the anticipated experience assumptions except for using the central estimate assumption for the material assumption being tested.

Recall that the central estimate assumptions are updated annually. A/E ratios can become dated in one of two ways: the experience studies or the modeling assumptions have not been recently updated. In the former case, the actuary could consider trends in experience in determining the central estimate assumptions. Of course, updating experience studies would be preferable and has the benefit of increasing the credibility of company experience input to the multi-risk scenario generator.

If modeling assumptions have not been trued-up recently, the impact of deviations in the modeling assumptions from the central estimate assumptions would be quantified in the other assumption objectivity measures.

#### 4.2.2 Measures 2, 3: Margin Impact, Percent Statutory Margin Impact

An anticipated experience reserve would be calculated as a deterministic reserve from the cash flow projection model using the modeling assumptions without margins. A central estimate assumption reserve would be calculated as a deterministic reserve using the central estimate assumptions without margins.

The anticipated experience reserve minus the central estimate assumption reserve for a block of business would equal the (2) margin impact.

The statutory margin would equal the reported statutory reserve for the block of business minus the anticipated experience reserve.

The margin impact could be positive, zero or negative. A negative number would indicate that the statutory margin has been reduced by the amount of the margin impact (and vice versa for a positive number).

The (3) percent statutory margin impact would equal the margin impact (retaining the positive or negative sign) divided by the statutory margin.

#### 4.2.3 Measure 4: Percent Aggregate Reserve Margin Impact

Using the multi-risk scenario generator based on the central estimate assumptions, the company would produce an 84th percentile scenario for each material risk for a block of business. Sensitivity tests using those scenarios one by one would be run for each material risk. The difference between the scenario reserve for each sensitivity test and the central estimate assumption reserve would be calculated. A square root formula analogous to the Life RBC covariance adjustment calculation could determine the aggregate reserve margin for the block of business. The (4) percent aggregate margin impact would equal the margin impact divided by the aggregate reserve margin. As before, a negative number would indicate that the aggregate reserve margin has been reduced by the amount of the margin impact (and vice versa for a positive number).

The statutory reserve excess could be measured as the difference between the reported statutory reserve and the sum of the central estimate assumption reserve and the aggregate reserve margin. If this excess is negative, then the actuary may consider holding an additional reserve for this block of business, though aggregating blocks of business may eliminate this need. This analysis would be particularly important where there are emerging material risks or other risks with little relevant company or industry experience.

Such benefits of offsetting cash flows (called “product hedging” by some) should be considered, because the calculations described in this document are aggregated at higher levels, including blocks of business with different risk profiles.

Note that this analysis could be considered a method for asset adequacy analysis for compliance with VM-30 requirements.

### 4.3 ASSUMPTION OBJECTIVITY MEASURES CONCLUSION

The use of the A/E ratios for the material assumptions—together with the margin impact, percent statutory margin impact, and percent aggregate margin impact—creates an incentive for the actuary to use the recently updated central estimate assumptions in the cash flow projection models, as well as measuring the impact if other assumptions are used instead. Anchoring the central estimate assumptions to relevant experience and credibility-blended assumptions provides an objective process for the development and documentation of the base model assumptions and their sources.

Where relevant experience is sparse for a material risk, the percent statutory margin impact and the percent aggregate margin impact would reflect the wide distribution of the A/E ratios due to the higher levels of uncertainty for each such material risk.

While not detailed here, it may be evident that the multi-risk scenario generator could also produce scenarios to measure total assets required at a minimum capital level and a target capital level, using thresholds such as the 95th and 99th percentiles of the distribution of the present value of future cash flows. With these measures, comparisons could be made of the risk sensitivity of the cash flow projection in the tail of the distribution as compared with statutory requirements (including RBC) and rating agency measures (such as A.M. Best's BCAR capital measure). These measures would provide additional data points for the actuary to consider in calibrating the dynamic assumptions in the cash flow projection model.

Using the sensitivity testing results produced in developing these measures, the company could also rank the risks embedded in its modeled reserve and modeled total asset requirements. Using the underlying model and the multi-risk scenario generator, risk mitigation strategies could be tested and the impacts quantified.

Taken together with appropriate model validation techniques, the output method for measuring assumption objectivity could increase confidence in the assumptions and the modeling results by regulators, auditors, and other reviewers, as well as providing useful information to the company for asset adequacy analysis and risk management.

## Section 5: Model Building

Cash flow projection models were built using Steve Strommen's workbench modeling tool for the following products: level premium term (level term), universal life with secondary guarantees (ULSG), participating whole life (par WL), and accumulation universal life (accumulation UL).

Appendix A contains the product descriptions and assumptions used for the four products. Since the term and ULSG products had been priced and peer reviewed during the earlier RSM testing, these products were used for the testing related to this PBR Simplified Methods Project. The descriptions of these two products and assumptions are extracted from the actuarial reports with respect to that earlier analysis.

For the par WL and accumulation UL products, the Project Oversight Group helped establish reasonable assumptions for the pricing exercise. Steve Strommen had a long career with Northwestern Mutual, so his considerable experience with par WL products provided many benefits to this project.

For the term product, a post-level premium term lapse function and mortality function was built to represent the interaction between shock lapses and mortality deterioration during the post-level premium period. To build these functions, two datasets representative of industry data were used. The first dataset was associated with the *2014 Post Level Term Lapse & Mortality Report* prepared by actuaries from the Reinsurance Group of America for the SOA, as well as the related pivot tables.[3] A set of sample term life insurance data from the MIB, selected in such a way that it did not represent data from any single company but was representative of industry term life insurance experience, was also used in the analysis.

Using this data, a post-level premium term lapse model was developed using Statistica, a statistical, data mining and predictive modeling software from Dell (now TIBCO).

The lapse and mortality results were checked against the data for consistency. It is important to note that the term product was not originally priced with the post-level premium lapse and mortality functions, and these functions had the impact of reducing the profitability of the term product and increasing the modeled reserves as observed in the modeling results reported in the next section.

[3] See Kueker, Derek, Tim, Rozar, Michael, Cusumano, Susan, Willeat, and Richard, Xu. 2014. Report on the Lapse and Mortality Experience of Post-Level Premium Period Term Plans (2014). *Society of Actuaries*, May, *https://www.soa.org/globalassets/assets/files/research/exp-study/research-2014-post-level-shock-report.pdf* (accessed March 4, 2020).

# Section 6: Model Results and Regulatory Demonstrations

### 6.1 10- and 20-Year Level Term

Tables 1, 2 and 3 present the testing results in three parts, the comparison among the PBR reserves as defined in VM-20, where the fully stochastic reserve represents the CTE 70 reserve based on the projection of scenarios for each material risk using the multi-risk scenario generator.

In Table 1, the NPR reserves are much lower than the deterministic and fully stochastic reserves. Note that the NPR calculations become less reliable as projected to the future because of changing economic environments.

**Table 1**
COMPARISON OF LEVEL TERM NPR, DETERMINISTIC RESERVE, AND FULLY STOCHASTIC RESERVES

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| NPR Reserve | 165,948,966 | 206,790,114 | 244,308,200 |
| | | | |
| PBA deterministic reserve | 229,655,549 | 282,758,948 | 328,792,763 |
| | | | |
| PBA stochastic reserve-30 fully stochastic scenarios | 233,914,118 | 287,142,641 | 332,647,406 |
| PBA stochastic reserve-50 fully stochastic scenarios | 234,195,769 | 287,454,115 | 333,492,289 |
| PBA stochastic reserve-100 fully stochastic scenarios | 237,904,428 | 291,014,299 | 336,808,902 |
| PBA stochastic reserve-200 fully stochastic scenarios | 234,768,411 | 288,006,256 | 334,074,973 |
| PBA stochastic reserve-1000 fully stochastic scenarios | 234,975,904 | 288,046,910 | 333,911,114 |
| | | | |
| Minimum | 233,914,118 | 287,142,641 | 332,647,406 |
| Maximum | 237,904,428 | 291,014,299 | 336,808,902 |
| Ratio | 101.7% | 101.3% | 101.3% |

The deterministic reserves are significantly less than the fully stochastic reserves despite level term passing the SET. This may indicate that additional material risks should be considered for inclusion in the SET, and the threshold ratio of 6% should be refined based on additional testing with those additional risks.

Based on the number of stochastic scenarios, stochastic reserves vary from 1.3% to 1.7%, a narrow degree of variation. For this product, the results are stable enough to allow the fully stochastic reserve using a limited number of scenarios to approximate the stochastic reserve using many scenarios, such as 1000. In presenting the testing results, we will use the 1000 scenario CTE 70 stochastic reserve as the target level for approximation purposes.

One of the approximation methods tested involved adding the standard deviation of the CTE estimator to the CTE70 reserves calculated using different numbers of stochastic scenarios. This standard deviation is based on a 2005 article in the *North American Actuarial Journal* titled "Variance of the CTE Estimator" by John Manistre and Geoffrey Hancock that included the following description on page 131[4]:

> The quantity $1/k \cdot VAR(x_{(1)}, x_{(2)}, \ldots, x_{(k)})$ is an unbiased estimate of the first term above, but it does not capture the second term. It turns out that the second term can be estimated in the large sample limit (as $n \to \infty$). The main result of this paper, which deals with both sources of uncertainty, is:
>
> $$VAR(\hat{CTE}) \approx \frac{VAR(x_{(1)}, \ldots . x_{(k)}) + \alpha \cdot (\hat{CTE} - x_{(k)})^2}{k}.$$
>
> This formula has much intuitive appeal as it gives the well-known variance of a mean estimator $\sigma^2/n$ when $\alpha = 0$. This agrees with our definition for $CTE$ since $\hat{CTE}(0)$ is the unconditional sample mean $\bar{x}$.
>
> Interestingly, the second term gains importance when the probability distribution is light-tailed. An example of a light-tailed risk is an "in-the-money" investment guarantee on an equity-linked variable insurance product. When the distribution is heavy-tailed, the first term for the estimator variance will dominate.

In testing other approximations to the stochastic reserve, including an adjustment for the standard deviation of the CTE estimator (the square root of the variance) as a CTE error adjustment added a degree of conservatism that seemed consistent with the intent of statutory reserving. Adding the standard deviation of the CTE estimator to the approximations in Table 1 produced the results in Table 2.

**Table 2**

LEVEL TERM ADJUSTED STOCHASTIC RESERVE INCLUDING THE CTE ERROR ADJUSTMENT

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| NPR Reserve | 165,948,966 | 206,790,114 | 244,308,200 |
| | | | |
| PBA deterministic reserve | 229,655,549 | 282,758,948 | 328,792,763 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic30 | 233,914,118 | 287,142,641 | 332,647,406 |
| CTE Error Adjustment for Stochastic Reserve 30 | 3,344,061 | 2,861,145 | 1,640,296 |
| Adjusted Stochastic Reserve 30 | 237,258,179 | 290,003,787 | 334,287,703 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic50 | 234,195,769 | 287,454,115 | 333,492,289 |
| CTE Error Adjustment for Stochastic Reserve 50 | 2,242,770 | 2,280,014 | 1,626,403 |
| Adjusted Stochastic Reserve 50 | 236,438,539 | 289,734,130 | 335,118,693 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic100 | 237,904,428 | 291,014,299 | 336,808,902 |
| CTE Error Adjustment for Stochastic Reserve 100 | 2,279,096 | 2,240,272 | 2,092,152 |
| Adjusted Stochastic Reserve 100 | 240,183,523 | 293,254,571 | 338,901,054 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic200 | 234,768,411 | 288,006,256 | 334,074,973 |
| CTE Error Adjustment for Stochastic Reserve 200 | 1,627,000 | 1,568,009 | 1,470,327 |
| Adjusted Stochastic Reserve 200 | 236,395,410 | 289,574,265 | 335,545,300 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic1000 | 234,975,904 | 288,046,910 | 333,911,114 |

The CTE Error Adjustment is larger for the lower number of scenarios and decreases over time. In Table 3, the adjusted stochastic reserve for the lower numbers of scenarios is larger than the fully stochastic reserve using 1000 scenarios.

[4] Manistre, B. John, and Geoffrey H., Hancock. 2005. Variance of the CTE Estimator. *North American Actuarial Journal* 9, no. 2:129–156, DOI:10.1080/10920277.2005.10596207.

As an enhancement to RSM, the percentile level at which RSM was a close approximation to the stochastic reserve calculation was determined using 1000 fully stochastic scenarios. For level term, the 88th percentile produced results as shown in Table 4. The RSM scenario is designated “88-12” because for some material risks (such as lapse), it is not clear which direction will be adverse.

**Table 3**

LEVEL TERM RSM RESERVES AT THE 88TH PERCENTILE AS AN APPROXIMATION TO THE STOCHASTIC RESERVE

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| RSM 88-12 Reserve | 237,980,850 | 293,713,975 | 342,298,529 |
| RSM Margin | 57,935,067 | 58,643,990 | 59,040,255 |
| Central Estimate Reserve | 180,045,782 | 235,069,986 | 283,258,274 |
| % Difference from Stochastic 1000 Reserve | -0.9% | 0.1% | 0.8% |
| $ Difference | -2,167,587 | 412,785 | 2,672,013 |

In Table 3, the central estimate reserve represents the scenario result when all the anticipated experience assumptions are used with a level economic scenario. The RSM margin is the aggregate margin calculated using the deterministic scenario results for each material risk and then making a covariance adjustment using the square root formula analogous to the formula used in the Life RBC formula required for statutory reporting. For 12/2016, the aggregate margin is about 32.2% of the central estimate reserve and increases somewhat by valuation date as the reserve increases.

From the testing, it appears that the accuracy of the enhanced RSM approximations depends to some extent on the shape of the distribution of the present value of future cash flows. For level term, this distribution is skewed to the left with a skewness measure of −0.88775 and a kurtosis of 5.06905. In the testing, the enhanced RSM is a good approximation for the left-skewed products.

## 6.2 ULSG

The reserve calculations include prescribed margins for mortality and for defaults. The mortality margins have values by age that range from 5.3% to 2.3%. These are applicable to an insurer’s own credible experience. The default margins come from VM-20 and depend on credit quality and average life. The VM-20 CTE70 stochastic reserve calculations also include prescribed margins for mortality and defaults and no projected mortality improvement.

Tables 4, 5 and 6 present the testing results in three parts, the comparison among the PBR reserves as defined in VM-20, where the fully stochastic reserve represents the CTE 70 reserve based on the projection of scenarios for each material risk using the multi-risk scenario generator.

**Table 4**
COMPARISON OF ULSG NPR, DETERMINISTIC RESERVE, AND FULLY STOCHASTIC RESERVES

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| NPR Reserve | 511,660,173 | 718,518,760 | 988,835,497 |
| Account Value (from audit file-estimated 12/2016) | 208,046,304 | 475,209,857 | 739,054,422 |
| | | | |
| PBA deterministic reserve | 817,109,657 | 1,155,112,822 | 1,571,600,387 |
| | | | |
| PBA stochastic reserve-30 fully stochastic scenarios | 826,772,021 | 1,162,888,884 | 1,586,081,087 |
| PBA stochastic reserve-50 fully stochastic scenarios | 815,088,789 | 1,156,362,347 | 1,580,836,204 |
| PBA stochastic reserve-100 fully stochastic scenarios | 894,978,297 | 1,232,269,724 | 1,652,183,506 |
| PBA stochastic reserve-200 fully stochastic scenarios | 845,945,905 | 1,184,838,660 | 1,608,882,501 |
| PBA stochastic reserve-1000 fully stochastic scenarios | 856,400,062 | 1,194,287,668 | 1,617,972,825 |
| | | | |
| Minimum | 815,088,789 | 1,156,362,347 | 1,580,836,204 |
| Maximum | 894,978,297 | 1,232,269,724 | 1,652,183,506 |
| Ratio | 109.8% | 106.6% | 104.5% |

As with level term, the NPR reserves in Table 4 are much lower than the deterministic and fully stochastic reserves. The ULSG account values are much lower than any of the reserve numbers. The deterministic reserves are close to the minimum stochastic reserves, particularly in December 2016 and December 2017. The stochastic reserves vary by 4.5% to almost 10% based on the number of stochastic scenarios. This result evokes some concern about the stability of the stochastic reserve based on the number of scenarios selected to be run. The 100 scenario stochastic reserve in this case is the largest CTE 70 reserve calculated.

Table 5 includes the CTE error adjustment to calculate an adjusted stochastic reserve for the different numbers of scenarios.

**Table 5**

ULSG ADJUSTED STOCHASTIC RESERVE INCLUDING THE CTE ERROR ADJUSTMENT

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| NPR Reserve | 511,660,173 | 718,518,760 | 988,835,497 |
| Account Value (from audit file-estimated 201612) | 204,664,069 | 475,209,857 | 739,054,422 |
| | | | |
| PBA deterministic reserve | 817,109,657 | 1,155,112,822 | 1,571,600,387 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 30 | 826,772,021 | 1,162,888,884 | 1,586,081,087 |
| CTE Error Adjustment for Stochastic Reserve 30 | 68,541,747 | 62,353,639 | 56,265,551 |
| Adjusted Stochastic Reserve 30 | 895,313,768 | 1,225,242,522 | 1,642,346,638 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 50 | 815,088,789 | 1,156,362,347 | 1,580,836,204 |
| CTE Error Adjustment for Stochastic Reserve 50 | 47,263,792 | 43,203,956 | 38,295,567 |
| Adjusted Stochastic Reserve 50 | 862,352,581 | 1,199,566,302 | 1,619,131,771 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 100 | 894,978,297 | 1,232,269,724 | 1,652,183,506 |
| CTE Error Adjustment for Stochastic Reserve 100 | 41,726,625 | 41,329,231 | 39,789,438 |
| Adjusted Stochastic Reserve 100 | 936,704,922 | 1,273,598,955 | 1,691,972,944 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 200 | 845,945,905 | 1,184,838,660 | 1,608,882,501 |
| CTE Error Adjustment for Stochastic Reserve 200 | 28,869,600 | 28,566,895 | 28,850,775 |
| Adjusted Stochastic Reserve 200 | 874,815,505 | 1,213,405,555 | 1,637,733,276 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 1000 | 856,400,062 | 1,194,287,668 | 1,617,972,825 |

In Table 5, the ULSG adjusted stochastic reserve is greater than the stochastic reserve based on 1000 fully stochastic scenarios for each of the numbers of scenarios run (30, 50, 100 and 200) and for each of the three valuation dates. Due to the range of differences in the fully stochastic results in Table 5, the degree of conservatism in the adjusted stochastic reserve over the stochastic reserve based on 1000 scenarios varies based on the number of scenarios.

Table 6 presents the results for the enhanced RSM using the 88th percentile in determining the probability levels in deriving the deterministic scenarios to test.

**Table 6**

ULSG RSM RESERVES AT THE 88TH PERCENTILE AS AN APPROXIMATION

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| RSM 88-12 Reserve | 881,512,539 | 1,207,738,313 | 1,627,289,108 |
| RSM Margin | 539,581,704 | 524,716,433 | 513,112,394 |
| Central Estimate Reserve | 341,930,835 | 683,021,881 | 1,114,176,714 |
| % Difference from Stochastic 1000 Reserve | 2.6% | 0.9% | 0.4% |
| $ Difference | 25,112,477 | 13,450,646 | 9,316,282 |

For December 2016, the aggregate margin is about 157.8% of the Central Estimate Reserve. This result reflects the larger number of material risks associated with ULSG versus term, as well as the degree of variability in those risks.

For ULSG, the shape of the distribution of the present value of future cash flows is skewed to the left with a skewness measure of −0.82536 and a kurtosis of 5.37725.

The enhanced RSM approximation using two additional interest rate scenarios was sensitivity tested. The scenarios included the pop up 88th percentile interest rate scenario and the pop down 12th percentile interest rate scenario. Tables 7 and 8 present the results of these sensitivity tests.

Table 7

RSM POP UP INTEREST RATE SCENARIO RESULTS AT THE 88TH PERCENTILE

| RSM Pop Up 88th percentile | 12/2016 | 12/2017 | 12/2018 | 12/2019 |
|---|---|---|---|---|
| PBA deterministic reserve | 817,109,657 | 1,003,884,022 | 1,366,309,070 | 1,728,807,761 |
| PBA stochastic reserve-1000 Scenarios | 856,400,062 | 1,048,353,169 | 1,409,541,381 | 1,766,740,088 |
| RSM 88-12 reserve | 881,512,539 | 1,076,922,488 | 1,438,740,899 | 1,795,084,582 |
| Difference from Stochastic 1000 CTE70 Reserve | 2.9% | 2.7% | 2.1% | 1.6% |

Table 8

RSM POP DOWN INTEREST RATE SCENARIO RESULTS AT THE 12TH PERCENTILE

| RSM Pop Down 88th percentile | 12/2016 | 12/2017 | 12/2018 | 12/2019 |
|---|---|---|---|---|
| PBA deterministic reserve | 817,109,657 | 1,302,195,639 | 1,789,259,687 | 2,244,789,140 |
| PBA stochastic reserve-1000 Scenarios | 856,400,062 | 1,340,102,835 | 1,827,856,235 | 2,282,525,359 |
| RSM 88-12 reserve | 881,512,539 | 1,360,258,283 | 1,827,144,721 | 2,275,140,270 |
| Difference from Stochastic 1000 CTE70 Reserve | 2.9% | 1.5% | 0.0% | −0.3% |

The sensitivity testing demonstrates that enhanced RSM continues to work well as an approximation method as economic conditions change.

## 6.3 Par Whole Life

For par WL, two significant factors enter the analysis: the current CRVM reserve functioning as the NPR for par WL and the cash surrender value, which serves as a reserve floor. At this point, an NPR for par WL has not been defined, so the default for the NPR is the traditional CRVM reserve. As noted in Section 5, the level of the modeled reserves partly depends on the level of profitability of the products being valued. The lower the profitability of a product, the greater the corresponding modeled reserves will be. However, for profitable par WL products, it could be considered an unproductive effort to calculate the modeled reserves under PBR as shown below.

Tables 9 and 10 present the testing results in two parts: the comparison among the PBR reserves as defined in VM-20, where the fully stochastic reserve represents the CTE 70 reserve for 1000 scenarios based on the projection of scenarios for each material risk using the multi-risk scenario generator.

**Table 9**

PAR WL CRVM RESERVE AND CASH VALUE COMPARED WITH MODELED RESERVES

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| CRVM reserve | 9,998,508 | 19,274,837 | 28,208,771 |
| Surrender value (per audit file-estimated for 12/2016) | 5,000,000 | 11,923,756 | 18,712,789 |
| | | | |
| PBA deterministic reserve | −5,292,912 | 3,700,848 | 12,938,537 |
| | | | |
| PBA stochastic reserve-30 fully stochastic scenarios | −4,462,786 | 4,397,445 | 13,519,767 |
| PBA stochastic reserve-50 fully stochastic scenarios | −4,461,235 | 4,393,796 | 13,515,525 |
| PBA stochastic reserve-100 fully stochastic scenarios | −4,293,881 | 4,537,718 | 13,641,077 |
| PBA stochastic reserve-200 fully stochastic scenarios | −4,360,770 | 4,486,710 | 13,604,299 |
| PBA stochastic reserve-1000 fully stochastic scenarios | −4,198,943 | 4,624,924 | 13,722,670 |
| | | | |
| Minimum | −4,462,786 | 4,393,796 | 13,515,525 |
| Maximum | −4,178,335 | 4,642,147 | 13,736,786 |
| Ratio | 106.4% | 105.7% | 101.6% |

The CRVM reserves (and the cash surrender values) are much higher than the deterministic and fully stochastic reserves and continue to be so for 20 years of valuation. Therefore, the PBR reserve equals the CRVM reserve.

The stochastic reserves are higher than the deterministic reserves. The stochastic reserves vary from the 1000 scenario CTE 70 reserve by 1.6% to about 6% of the stochastic reserve based on the number of fully stochastic scenarios. The negative modeled reserves for December 2016 reflect the profitability of this par WL product and the early durations for which the par WL block of business is being valued.

**Table 10**

PAR WL RSM RESERVES AT THE 97.5TH PERCENTILE AS AN APPROXIMATION

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| CRVM Reserve | 9,998,508 | 19,274,837 | 28,208,771 |
| Surrender Value (per audit file-estimated for 201612) | 5,000,000 | 11,923,756 | 18,712,789 |
| | | | |
| PBA deterministic reserve | -5,292,912 | 3,700,848 | 12,938,537 |
| | | | |
| RSM 97.5-2.5 | -3,925,442 | 4,665,690 | 13,562,599 |
| RSM Margin | 1,730,013 | 1,434,132 | 1,190,587 |
| CTE70 Margin | 1,505,613 | 1,434,130 | 1,389,157 |
| Central Estimate Reserve | -5,655,455 | 3,231,558 | 12,372,012 |
| % Diff | 5.4% | 0.0% | -1.4% |
| $ Diff | 224,400 | 2 | -198,570 |

Using the 97.5th percentile for par WL enhanced RSM calculations seems extreme and may reflect the different shape of the distribution of the present value of future cash flows for par WL as compared with level term and ULSG. For the December 2016 valuation the skewness of the distribution is 0.46620 and the kurtosis is 3.16989.

Many different methods to adjust the reserve calculations based on the shape parameters were attempted, but there was no success in finding a suitable adjustment that would account for the right-skewness of the distribution. Using the higher level RSM percentile appears the best option of the alternatives tested. Note that the aggregate RSM margin calculated as of December 2016 for par WL is about 30.6% of the central estimate reserve (in absolute value).

## 6.4 Accumulation UL

Like par WL, for accumulation UL the two significant factors of the current CRVM reserve functioning as the NPR and the cash surrender value serving as a reserve floor enter the picture. At this point, an NPR for accumulation UL has not been defined, so the default for the NPR is the UL CRVM reserve.

Tables 11 and 12 present the testing results in two parts, the comparison among the PBR reserves as defined in VM-20, where the fully stochastic reserve represents the CTE 70 reserve for 1000 scenarios based on the projection of scenarios for each material risk using the multi-risk scenario generator.

**Table 11**
ACCUMULATION UL CRVM RESERVE AND CASH VALUE COMPARED WITH MODELED RESERVES

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| CRVM reserve | 45,293,305 | 69,017,393 | 94,554,225 |
| Cash surrender value (per audit file-estimated 12/2016) | 37,140,510 | 58,361,446 | 81,613,009 |
| | | | |
| PBA deterministic reserve | −6,335,800 | 20,081,760 | 49,906,160 |
| | | | |
| PBA stochastic reserve-30 fully stochastic scenarios | −4,239,534 | 21,849,831 | 51,444,483 |
| PBA stochastic reserve-50 fully stochastic scenarios | −4,176,461 | 21,894,519 | 51,467,686 |
| PBA stochastic reserve-100 fully stochastic scenarios | −3,480,061 | 22,549,624 | 52,079,581 |
| PBA stochastic reserve-200 fully stochastic scenarios | −3,610,796 | 22,459,608 | 51,999,411 |
| PBA stochastic reserve-1000 fully stochastic scenarios | −3,191,981 | 22,830,594 | 52,340,656 |
| Minimum | −4,239,534 | 21,849,831 | 51,444,483 |
| Maximum | −3,191,981 | 22,830,594 | 52,340,656 |
| Ratio | 132.8% | 104.5% | 101.7% |

The CRVM reserves (and the cash surrender values) are much higher than the deterministic and fully stochastic reserves and continue to be so for 20 years of valuation. Therefore, the PBR reserve equals the CRVM reserve.

The stochastic reserves are higher than the deterministic reserves. The stochastic reserves vary from the 1000 scenario CTE 70 reserve by 1.7% to about 32.8% (in absolute value) of the stochastic reserve based on the number of fully stochastic scenarios. The negative modeled reserves for December 2016 reflect the profitability of this accumulation UL product and the early durations for which the accumulation UL block of business is being valued.

**Table 12**
ACCUMULATION UL RSM RESERVES AT THE 99.2% PERCENTILE AS AN APPROXIMATION

| Description | 201612 | 201712 | 201812 |
|---|---|---|---|
| CRVM Reserve | 45,293,305 | 69,017,393 | 94,554,225 |
| Cash Surrender Value (per audit | 37,140,510 | 58,361,446 | 81,613,009 |
| | | | |
| PBA deterministic reserve | -6,335,800 | 20,081,760 | 49,906,160 |
| | | | |
| RSM 99.2-0.8 | -3,012,529 | 22,161,398 | 50,949,547 |
| RSM Margin | 3,820,978 | 2,850,315 | 2,045,085 |
| CTE70 Margin | 3,641,526 | 3,519,511 | 3,436,194 |
| Central Estimate Reserve | -6,833,506 | 19,311,083 | 48,904,462 |
| % Diff | 5.6% | -2.9% | -2.7% |
| $ Diff | 179,452 | -669,196 | -1,391,109 |

Using the 99.2th percentile for accumulation UL enhanced RSM calculations is somewhat more extreme than the 97.5th percentile for par WL and again may reflect the different shape of the distribution of the present value of future cash flows for accumulation UL as compared with the other products tested. For the December 2016 valuation the skewness of the distribution is 0.79471 and the kurtosis is 3.98886.

As with par WL, many different methods to adjust the reserve calculations based on the shape parameters were attempted but there was no success in finding a suitable adjustment that would account for the right-skewness of the distribution. Using the higher level RSM percentile appears the best option of the alternatives tested. Note that the aggregate RSM margin calculated as of December 2016 for accumulation UL is about 55.9% of the central estimate reserve (in absolute value).

## Section 7: Sample Regulatory Demonstrations

See Appendix B for a sample regulatory demonstrations for ULSG. The regulatory demonstration for level term would contain similar elements. Because of the prevailing CRVM reserves for par WL and accumulation UL, the regulatory demonstrations for these products simply need to provide evidence that the modeled reserves are less than the CRVM reserve. The goal is to minimize the extra work of PBR while still providing useful information for a company's risk analysis.

## Section 8: Other Uses

The PBR Simplified Methods Project has resulted in the development of new tools that can be used not only for approximation methods for the VM-20 stochastic reserves per VM-20 Section 2G but may be used for other purposes as well.

VM-20 requires the development of margins for all material assumptions in both the deterministic and stochastic reserve calculations. The multi-risk scenario generator could be a useful tool for the objective development of individual margins that reflect the amount of relevant experience underlying the specific material assumptions. The process of calculating an aggregate margin reflecting the covariance of the material risks can be used to calibrate the individual margins to avoid the stacking problem of just adding up individual margins.

Migrating asset adequacy analysis into a similar multi-risk modeling structure using the multi-risk scenario generator and assumption objectivity measures would improve the analysis of company risk and the consistency of reserve measures among blocks of business. Since the material risks in the multi-risk scenario generator are completely user-defined, the generator could be used for the asset adequacy analysis of all long-tailed lines of business. Ranking of insurance risks could then be accomplished on a legal entity basis.

Many smaller companies use a percentage of RBC as a proxy for target surplus that is needed for pricing and capital allocation purposes. There is no theoretical meaning to a multiple of RBC but may simply represent a rule of thumb with respect to rating agency requirements to achieve certain ratings. With the multi-risk scenario generator, extremely adverse scenarios for each material risk can be selected and the results combined to produce a target surplus level that reflects the company's specific risks rather than an industry-wide average. Free surplus can also be computed consistently, and due to the excessive levels of statutory reserves for some products, the value for free surplus may be larger than previously thought.

Generally Accepted Accounting Principles GAAP reserve requirements require the addition of provisions for adverse deviations. The multi-risk scenario generator could be used to produce those margins on an objective basis at a probability level consistent with GAAP.

The SET is focused on economic scenarios for interest rate and equity risk. As demonstrated in this research, the SET with a threshold of 6% may not differentiate well between products with different risk profiles. It may be that the multi-risk scenario generator could be used to refine the SET as part of the NAIC's feedback loop. Regardless, a company could run tests using the multi-risk scenario generator to determine whether stochastic reserves should be calculated, either as part of the PBR reserves or as a part of asset adequacy analysis.

The use of the assumption objectivity measures is entirely voluntary by the company. In situations where reviewers (independent auditors, regulators or other interested third-parties) may need assurance that assumptions used are appropriately set, the voluntary submission of assumption objectivity measures could help minimize time-consuming communications and increase trust for both current and future projects. Rate increase filings for long-term care and state examinations of PBR are two areas that could benefit from using this approach.

## Section 9: Conclusions

In this research, a multi-risk scenario generator and assumption objectivity measures have been developed. With respect to approximating PBR stochastic reserves, four products were analyzed: level term, ULSG, par WL and accumulation UL. With respect to PBR reserves, these products resolve into two pairs of products: term-ULSG and par WL-accumulation UL.

For level term and ULSG, VM-20 defines a NPR that is generally lower than the prior CRVM reserve for those products. For both products, the reduced numbers of fully stochastic scenarios produced a CTE 70 reserve that, when augmented by the standard deviation of the CTE estimator, produced a good approximation of the CTE 70 reserve based on 1000 fully stochastic scenarios. In addition, the RSM at the 88th percentile produced good approximations for the CTE 70 reserve based on 1000 scenarios.

For the par WL and accumulation UL products, the current definition of CRVM serves as the NPR. This reserve level does not reflect company experience and appears to produce reserves that far exceed the level of statutory conservatism targeted by the NAIC's Life Actuarial Task Force. If the current CRVM serves as the NPR for par WL and accumulation UL, the incremental work to calculate the modeled reserves for PBR may not be useful. However, using the tools developed in this research project, enhanced work may be accomplished in asset adequacy analysis that could set the stage for future PBR developments for these two product types.

## Section 10: Acknowledgments

The researchers' deepest gratitude goes to those without whose efforts this project could not have come to fruition: discussing respondent answers, and reviewing and editing this report for accuracy and relevance.

Project Oversight Group members

Stefanie Porta, ASA, MAAA, Chairperson

Bryan Amburn, FSA, MAAA

Jerry Enoch, FSA, MAAA

Trevor Huseman, FSA, MAAA

Jason Kehrberg, FSA, MAAA

Harold Luber, FSA, MAAA, CERA

Jing Pan, FSA

Corwin Zass, ASA, MAAA, FCA

At the Society of Actuaries

Jan Schuh, Sr. Research Administrator

Ronora Stryker, ASA, MAAA, Sr. Practice Research Actuary

# Appendix A: Product Descriptions and Assumptions

## A. LEVEL PREMIUM TERM LIFE INSURANCE

Level premium term life insurance provides a fixed payment upon death during a stated period. Premiums are level during that period. After that period, the contract is renewable but with higher premiums, up to a maximum age.

### Product features

- Level premium period—model three different products:
  - 10-year term
  - 20-year term
  - 30-year term
- No return of premium feature
- No conversion feature
- Renewable to age 95. High yearly renewable term YRT premiums after the level premium period, with high shock lapse and increase in mortality rates

### Issue ages

- 35 (male only)
- 55 (male only)

### Pricing assumptions

- Mortality:
  - During level period: 60% of 2008 VBT male nonsmoker age last birthday ALB select with improvement from 2003 at scale G. Central year of issue assumed for pricing: 2012
  - After level period: 80% of 2001 CSO ALB ultimate (gross premium will be 100%)
- Lapse rates:
  - 7% first year, 5% thereafter during level period
  - 90% shock lapse at end of level period, then one year at 50% with 20% annual lapse thereafter
- Interest rate earned: 4.00%
- Distribution costs:
  - 120% of premium first year, nothing thereafter
- Maintenance costs:
  - $100 issue cost plus 10% of premium plus $1 per unit
  - $50 annual maintenance cost
  - $120 per death claim
  - $20 per lapse
  - 2.5% premium tax
- Annual policy fee: $75, included in annual premium

### Material risks

- Mortality
  - Statistical uncertainty
  - Uncertain rate of improvement

- Lapses
  - Statistical uncertainty during level period
  - Shock lapse and lapse rates after level period
- Interest rates

Pricing (annual premiums for a $500,000 policy)

- A range of prices was determined using the following ranges of assumptions:
  - Investment return 4.0% to 6.0%
  - Mortality improvement 50% to 100% of scale G
  - Target return on investment (before tax) of 10% to 12%
- For purposes of the pricing ROI calculation, the total asset requirement each month was the sum of:
  - CRMV reserve using 60% of 2008 VBT mortality and 4% interest
  - Capital equal to 50% of expected claims plus 5% of the CRVM reserve
- For 10-year term the distribution cost was reduced to 60% of first year premium. Without a reduced distribution cost, the 10-year contract would almost always cost more per year than the 20-year contract, so it would never be sold.
- The resulting high and low premiums for males are shown in Table 13.

**Table 13**
Range of premiums based on these pricing assumptions

| Issue age | Level term | Annual premium range for $500,000 |
|---|---|---|
| 35 | 10 | $310 to $340 |
| 35 | 20 | $395 to $475 |
| 35 | 30 | $510 to $660 |
| 55 | 10 | $905 to $1020 |
| 55 | 20 | $1590 to $1970 |
| 55 | 30 | Not generally offered |

## B. UNIVERSAL LIFE WITH SECONDARY GUARANTEES

The secondary guarantee we modeled assures that the contract will remain in force even if the account value falls to zero, as long as the amount accumulated in shadow fund is greater than zero. Premiums are set to be sufficient to maintain the shadow fund until death.

Product features

- Universal life contract with secondary guarantee based on a shadow fund
- Parameters for accumulating the account value
  - Interest: 3.00%
  - Cost of insurance: 2001 CSO select and ultimate
  - Expense charge
    - First year: 50% of premium + $1000 per policy
    - Later years: 20% of premium + $100 per policy
- Parameters for accumulating the shadow fund
  - Interest: 5.75%

- Cost of insurance: 110% of anticipated experience
- Expense charge: percent of premium, declining by policy year according to Table 4

**Table 14**
Expense charges by policy year

| Policy year | % of premium expense charge |
|---|---|
| 1 | 35% |
| 2 | 30% |
| 3 | 25% |
| 4 | 20% |
| 5 | 15% |
| 6 | 10% |
| 7 | 9% |
| 8 | 8% |
| 9 | 7% |
| 10 | 6% |
| 11+ | 5% |

Issue ages

- 50 (male only)
- 70 (male only)

Pricing assumptions

- Mortality:
  - 60% of 2008 VBT male nonsmoker ALB select with improvement from 2014 at scale G
- Lapse rates:
  - 5% first year, 2% years 2–5, 1% thereafter
- Interest rate earned: 6.00%
- Distribution costs:
  - 100% of premium first year, 30% year 2, 10% years 3–4, 5% year 5, 2% thereafter
- Maintenance costs:
  - $1000 per policy first year, $75 per policy each year thereafter
  - 2.0% premium tax

Material Risks

- Mortality
  - Statistical uncertainty
  - Uncertain rate of improvement
- Lapses
  - Statistical uncertainty
- Interest rates
- Default costs

Pricing (annual premiums for $1,000,000 death benefit)

- Male age 50: $ 9,912.82
- Male age 70: $35,987.63

## C. PAR WHOLE LIFE

A participating whole life contract is a whole life insurance contract that includes payment of annual dividends if experience is better than that used as a basis for the guaranteed premiums. This sample contract uses a three-factor dividend formula with factors for mortality, interest, and expenses.

Reserve basis

- 2001 CSO male nonsmoker ANB 3.5%

Nonforfeiture basis

- 2001 CSO male nonsmoker ANB 3.5%

Net investment earned rate

- 5% for level scenario
- 8% for pop up, 3% scenario
- 4.5% year 1, 4.2% thereafter for decrease 0.5% for 10 years, then level scenario

Dividend interest rate (actual)

- Same as net investment earned rate

Dividend interest rate (expected):

- 3.5%

Discount rate

- Same as net investment earned rate

Tax rate

- 35%

DAC tax

- 0

Premium tax

- 2%

Inflation rate

- Investment earned rate less 3%.

Commissions

- 90% year 1
- 20% year 2
- 10% year 3
- 4% years 4–10

Acquisition expenses

- $250 per contract

**Maintenance expenses**

- $50 per contract starting in year 1, plus $100 per claim

**Target surplus**

- 7% reserves plus 15% expected claims cost

**Average size**

$250,000

**Mortality**

- 70% of 2008 VBT to age 60, grading to 100% at age 90

**Dividend mortality**

- 104% of actual

**Lapses**

- 7% year 1, 3% thereafter

**Premium mode**

- Annual to simplify modeling. Premium mode is not financially important

**New business distribution**

- Center on issue age 35

**Target profit**

- Return on investment (ROE) equals investment return plus 3%.
- ROE is rate of return on distributable surplus assuming required assets are reserve + target surplus. First year distributable amount is negative because of need to fund initial surplus.
- The ROE calculated at each year end is based on book profits adjusted for increases in required surplus to date.

**Premium rate and dividend expense**

- Premium rate is close to statutory net renewal premium plus renewal expenses.
- Age 35 premium = $12.50
- Age 45 premium = $18.90

**Policy fee**

- $75

Dividend expenses are near actual expenses, adjusted to amortize excess initial expenses.

**Dividend formula**

- Three-factor formula of interest + mortality + expense

Interest (earned rate less 3.5%) x mean reserves x interest policy year factors below

Mortality (reserve basis less 104% of actual) x (face amount less mean reserves) x mortality policy year factors below

Expense (gross premium − renewal net premium less actual expense, somewhat levelized in first 20 years) x expense policy year factors below

- Age 35 gross premium = $12.50 + $75/250 units = $12.80 per unit
- Age 45 gross premium = $18.90 + $75/250 units = $19.20 per unit
- Age 35 renewal net premium = $11.35 per unit
- Age 45 renewal net premium = $17.49 per unit

Actual expenses levelized

Per policy expenses were levelized so that the present value of expenses approximated the present value of the pricing expenses. The $250 acquisition expense and the $50 maintenance expense (with inflation applied) were converted to a level $68 per year per policy expense (with inflation applied). The commission schedule was converted to a level 19.1% commission over the first 10 years.

The three factors have been modified each policy year by the multiples in Table 15. The dividends were also subject to a minimum amount of $0.20 per $1,000 of face per year starting in year 2.

**Table 15**
Dividend factor adjustment multiples used on our modeling

| Policy Year | Mortality | Interest | Expense |
|---|---|---|---|
| 1 | 0.0% | 0.0% | 0.0% |
| 2 | 62.5% | 62.5% | 10.0% |
| 3 | 65.0% | 65.0% | 10.0% |
| 4 | 67.5% | 67.5% | 10.0% |
| 5 | 70.0% | 70.0% | 10.0% |
| 6 | 72.5% | 72.5% | 10.0% |
| 7 | 75.0% | 75.0% | 10.0% |
| 8 | 77.5% | 77.5% | 10.0% |
| 9 | 80.0% | 80.0% | 10.0% |
| 10 | 82.5% | 82.5% | 10.0% |
| 11 | 85.0% | 85.0% | 15.0% |
| 12 | 87.5% | 87.5% | 20.0% |
| 13 | 90.0% | 90.0% | 25.0% |
| 14 | 92.5% | 92.5% | 30.0% |
| 15 | 95.0% | 95.0% | 35.0% |
| 16 | 97.5% | 97.5% | 40.0% |
| 17 | 100.0% | 100.0% | 45.0% |
| 18 | 100.0% | 100.0% | 50.0% |
| 19 | 100.0% | 100.0% | 55.0% |
| 20 | 100.0% | 100.0% | 60.0% |
| 21 | 100.0% | 100.0% | 65.0% |
| 22 | 100.0% | 100.0% | 70.0% |
| 23 | 100.0% | 100.0% | 75.0% |
| 24 | 100.0% | 100.0% | 80.0% |
| 25 | 100.0% | 100.0% | 85.0% |
| 26 | 100.0% | 100.0% | 90.0% |
| 27 | 100.0% | 100.0% | 95.0% |
| 28+ | 100.0% | 100.0% | 100.0% |

## D. ACCUMULATION UNIVERSAL LIFE

An Accumulation Universal Life contract provides a stated death benefit that remains in force as long as the accumulated account value is above zero. The account value is an accumulation of premiums net of periodic charges for expenses and the cost of insurance protection..

Mortality
- 2008 VBT select & ultimate (gender/tobacco-distinct)

Cost of Insurance (COI) charge
- 110% of mortality rate

Lapses
- Issue Age 35: 8.65% (duration 1), 6.8% (2), 6.1% (3), 5.4% (4), 4.55% (5–10), 4.05% (11+)
- Issue Age 55: 6.85% (duration 1), 5.2% (2), 4.9%, (3), 4.6% (4), 3.95% (5–10), 3.45% (11+)

Commissions
- 120% year 1, up to target,
- 3.5% years 2-10 target and excess
- 2.5% years 11+ target and excess

Acquisition expense
- $130 per policy, 24% target premium

Maintenance expense
- $90 per policy, with no inflation

Premium tax
- 2%

Policy expense charge
- 75% of premium (Duration 1), 20% (2), 17.5% (3), 15% (4), 12.5% (5), 10% (6+)

Surrender charge
- Issue Age 35: 50% of premium (Duration 1) grading down 5% per year until 0% in years 11+
- Issue Age 55: 0%

Net investment earned rate
- 4.5%

Interest Crediting Spread
- 1%

FIT rate
- 35%

DAC tax
- 0%

Average size
- $250,000

Statutory reserve basis

- CRVM no deficiency, 2001 CSO ALB, 3.5% approximated by the California Method (average of account value and cash surrender value)

Target surplus

- 0.35% NAAR
- 5.23% Reserves
- 6.01% Premium

# Appendix B: Sample Regulatory Demonstration

This appendix provides a sample regulatory demonstration to approximate PBR stochastic reserves for Universal Life with Secondary Guarantees (ULSG)

## INTRODUCTION

Section 2G of VM-20 states:

> "A company may use simplifications, approximations and modeling efficiency techniques to calculate the NPR, the deterministic reserve and/or the stochastic reserve required by this section if the company can demonstrate that the use of such techniques does not understate the reserve by a material amount, and the expected value of the reserve calculated using simplifications, approximations and modeling efficiency techniques is not less than the expected value of the reserve calculated that does not use them. This does not preclude use of model segmentation for purposes of determining discount rates."[5]

This document provides the required regulatory demonstration for ULSG of the effectiveness of two methods designed to approximate the VM-20 stochastic reserve.

1. Summing the CTE70 reserve based on a limited number of fully stochastic scenarios and the standard deviation of the CTE estimator, the resulting reserve will be consistent with but generally exceed the CTE70 reserve based on a large number of scenarios.

   The terms "fully stochastic" and "fully stochastic reserve" refer to the use of the multi-risk scenario generator that the SOA developed to generate stochastic scenarios for each of the material risks for a block of policies, projecting cash flows with each of the material risks varying stochastically.

   VM-20, Section 9.B.4 states: "A margin is not required for assumptions when variations in the assumptions do not have a material impact on the reserves,"[6] while VM-20 Section 9.A.4 states: "If the company elects to model risk factors in addition to those listed in A.3 above (i.e., interest rates and equity performance), the requirements in this section for determining prudent estimate assumption for these risk factors do not apply."[7] Using fully stochastic scenarios for the material assumptions in developing an approximation to the stochastic reserve means that no additional margins are required other than those embedded in the prescribed assumptions, such as mortality and default rates, and the calculation of CTE70 as the average value of the highest 30% of the scenario reserves.

2. Using the multi-risk scenario generator, develop deterministic scenarios for each material risk at the 88th percentile to calculate an aggregate margin that is added to the deterministic reserve based on anticipated experience assumptions and the level interest rate scenario. The aggregate margin is developed using a covariance adjustment based on a square root formula analogous to the formula used in the statutory Life RBC calculation. This method could be referred to as an enhanced version of the RSM previously discussed at NAIC meetings.

---

[5] National Association of Insurance Commissioners. Valuation Manual, VM-20, Section 2G. January 1, 2020, *https://www.naic.org/documents/pbr_data_val_2020_edition_redline.pdf* (accessed March 4, 2020).Section 2G of VM-20

[6] Ibid., VM-20, Section 9.B.4

[7] Ibid., VM-20 Section 9.A.4

## PRODUCT DESCRIPTION AND MODELING ASSUMPTIONS

The insurance contracts and modeling assumptions used in this demonstration are documented below:

### Product features

- Universal life contract with secondary guarantee based on a shadow fund.
- Parameters for accumulating the account value:
  - Interest: 3.00%
  - Cost of insurance: 2001 CSO select and ultimate.
  - Expense charge:
    - First year: 50% of premium plus $1,000 per policy.
    - Later years: 20% of premium plus $100 per policy.
- Parameters for accumulating the shadow fund:
  - Interest: 5.75%
  - Cost of insurance: 110% of anticipated experience.
  - Expense charge: percent of premium, declining by policy year according to Table 16.

**Table 16**

Expense charges by policy year

| Policy year | % of premium expense charge |
|---|---|
| 1 | 35% |
| 2 | 30% |
| 3 | 25% |
| 4 | 20% |
| 5 | 15% |
| 6 | 10% |
| 7 | 9% |
| 8 | 8% |
| 9 | 7% |
| 10 | 6% |
| 11+ | 5% |

### Issue ages

- 20–70

### Pricing assumptions

- Mortality:
  - 60% of 2008 VBT male nonsmoker ALB select with improvement from 2014 at scale G.
- Lapse rates:
  - 5% year 1, 2% years 2–5, 1% thereafter.
- Interest rate earned: 6.00%
- Distribution costs:
  - 100% of premium year 1, 30% year 2, 10% years 3–4, 5% year 5, 2% thereafter.
- Maintenance costs:

- $1,000 per policy year 1, $75 per policy each year thereafter.
- 2.0% premium tax.

**Material risks**

- Mortality
  - Statistical uncertainty.
  - Uncertain rate of improvement.
- Lapses
  - Statistical uncertainty.
- Interest rates
- Default costs

**Objectivity of assumptions**
Material risks are determined by professional judgment and confirmed by sensitivity testing.

Using the multi-risk scenario generator, the probability distributions of material assumptions are objectively defined for economic scenarios and for mortality and lapses based on company experience studies and relevant industry experience studies.

A user-defined function based on AAA's analysis is used for spread-default risk.

Anticipated experience assumptions have been derived using relevant company experience and relevant industry experience as required in VM-20 Section 9.A.6. The company experience studies for the material assumptions are updated annually, and trends in experience are considered in setting the assumptions.

In measuring assumption objectivity for this demonstration, the concept of central estimate assumptions is used. Central estimate assumptions refer to assumptions that combine relevant company and industry experience for the material risks (where company experience is less than 100% credible) to develop baseline assumptions for modeling those material risks in cash flow projection models. Where relevant company experience for a material risk is 100% credible, the relevant company experience for that material risk would be the central estimate assumption, including consideration of possible trends in the experience. When there is less than 100% credibility, the relevant company experience could be credibility blended with relevant industry experience to establish the central estimate assumptions for a material risk, including consideration of possible trends in both relevant company and relevant industry experience. The central estimate assumptions are updated annually and provide a standard of comparison for the actual base assumptions used in the cash flow projection model.

Four assumption objectivity measures are used.

**Measure 1: A/E ratios for the material assumptions**
The central estimate assumptions provide the denominators for A/E ratios for the material assumptions for ULSG. The actual modeling assumptions (without margins) used as the basis for the cash flow projections provide the numerators in the A/E calculations. Since the anticipated experience assumptions are set equal to the central estimate assumptions, the A/E ratios for mortality, lapses, interest rates and credit-default spreads equal one.

**Measures 2 and 3: Margin impact, percent statutory margin impact**
For this demonstration, an anticipated experience reserve is defined as a deterministic reserve from the cash flow projection model using the anticipated experience assumptions. Similarly, a central estimate assumption reserve is defined for this demonstration as a deterministic reserve using the central estimate assumptions.

The anticipated experience reserve minus the central estimate assumption reserve for a block of business equals the margin impact.

For this demonstration, the statutory margin equals the reported statutory reserve for a block of business minus the anticipated experience reserve.

The percent statutory margin impact equals the margin impact divided by the statutory margin.

Since the anticipated experience assumptions equal the central estimate assumptions, the margin impact equals $0 and the percent statutory margin impact equals 0%.

**Measure 4: Percent aggregate reserve margin impact**

Using the multi-risk scenario generator to produce deterministic scenarios for each material risk at the 84th percentile of the distribution for that risk, an aggregate reserve margin is calculated, including a covariance adjustment. The percent aggregate margin impact equals the margin impact divided by the aggregate reserve margin. Since the anticipated experience assumptions equal the central estimate assumptions, the percent aggregate reserve margin impact equals 0%.

### Approximation Methods for the VM-20 Stochastic Reserve

**Table 17**

METHOD 1: LIMITED NUMBER OF FULLY STOCHASTIC RESERVES PLUS CTE70 STANDARD DEVIATION

| Description | 12/2016 | 12/2017 | 12/2018 |
| --- | --- | --- | --- |
| NPR Reserve | 511,660,173 | 718,518,760 | 988,835,497 |
| Account Value (from audit file-estimated 201612) | 204,664,069 | 475,209,857 | 739,054,422 |
| | | | |
| PBA deterministic reserve | 817,109,657 | 1,155,112,822 | 1,571,600,387 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 30 | 826,772,021 | 1,162,888,884 | 1,586,081,087 |
| CTE Error Adjustment for Stochastic Reserve 30 | 68,541,747 | 62,353,639 | 56,265,551 |
| Adjusted Stochastic Reserve 30 | 895,313,768 | 1,225,242,522 | 1,642,346,638 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 50 | 815,088,789 | 1,156,362,347 | 1,580,836,204 |
| CTE Error Adjustment for Stochastic Reserve 50 | 47,263,792 | 43,203,956 | 38,295,567 |
| Adjusted Stochastic Reserve 50 | 862,352,581 | 1,199,566,302 | 1,619,131,771 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 100 | 894,978,297 | 1,232,269,724 | 1,652,183,506 |
| CTE Error Adjustment for Stochastic Reserve 100 | 41,726,625 | 41,329,231 | 39,789,438 |
| Adjusted Stochastic Reserve 100 | 936,704,922 | 1,273,598,955 | 1,691,972,944 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 200 | 845,945,905 | 1,184,838,660 | 1,608,882,501 |
| CTE Error Adjustment for Stochastic Reserve 200 | 28,869,600 | 28,566,895 | 28,850,775 |
| Adjusted Stochastic Reserve 200 | 874,815,505 | 1,213,405,555 | 1,637,733,276 |
| | | | |
| PBA stochastic reserve without mort improvement-Stochastic Parameter 1000 | 856,400,062 | 1,194,287,668 | 1,617,972,825 |

Note that in the testing results in Table 17, the NPR calculation becomes less reliable as projected to the future because of changing economic environments.

The CTE70 standard deviation is based on a 2005 article in the *North American Actuarial Journal* titled "Variance of the CTE Estimator" by John Manistre and Geoffrey Hancock that included the following description on page 131:[8]

> The quantity $1/k \cdot VAR(x_{(1)}, x_{(2)}, \ldots, x_{(k)})$ is an unbiased estimate of the first term above, but it does not capture the second term. It turns out that the second term can be estimated in the large sample limit (as $n \to \infty$). The main result of this paper, which deals with both sources of uncertainty, is:
>
> $$VAR(\hat{CTE}) \approx \frac{VAR(x_{(1)}, \ldots . x_{(k)}) + \alpha \cdot (\hat{CTE} - x_{(k)})^2}{k}.$$
>
> This formula has much intuitive appeal as it gives the well-known variance of a mean estimator $\sigma^2/n$ when $\alpha = 0$. This agrees with our definition for $CTE$ since $\hat{CTE}(0)$ is the unconditional sample mean $\bar{x}$.
>
> Interestingly, the second term gains importance when the probability distribution is light-tailed. An example of a light-tailed risk is an "in-the-money" investment guarantee on an equity-linked variable insurance product. When the distribution is heavy-tailed, the first term for the estimator variance will dominate.

In Method 1, the sum of the stochastic reserve and the CTE error adjustment (i.e., standard deviation) is called the "adjusted stochastic reserve." The ULSG adjusted stochastic reserve is greater than the stochastic reserve based on 1000 fully stochastic scenarios for each of the numbers of scenarios run (30, 50, 100 and 200) and for each of the three valuation dates shown. The degree of conservatism in the adjusted stochastic reserve over the stochastic reserve based on 1000 scenarios varies based on the number of scenarios.

**Table 18**

METHOD 2: CENTRAL ESTIMATE RESERVE PLUS AGGREGATE MARGIN AT THE 88TH PERCENTILE (ENHANCED RSM)

| Description | 12/2016 | 12/2017 | 12/2018 |
|---|---|---|---|
| RSM 88-12 Reserve | 881,512,539 | 1,207,738,313 | 1,627,289,108 |
| RSM Margin | 539,581,704 | 524,716,433 | 513,112,394 |
| Central Estimate Reserve | 341,930,835 | 683,021,881 | 1,114,176,714 |
| % Difference from Stochastic 1000 Reserve | 2.6% | 0.9% | 0.4% |
| $ Difference | 25,112,477 | 13,450,646 | 9,316,282 |

For December 2016, the aggregate margin is about 157.8% of the Central Estimate Reserve. This result reflects the larger number of material risks associated with ULSG versus term, as well as the degree of variability in those risks.

In sensitivity testing Method 2 in rising and falling interest rate environments, the multi-risk scenario generator is used to produce deterministic interest rate scenarios at specified probability levels. The multi-risk scenario generator produces deterministic interest rate scenarios using either a pop or creep pattern of interest rate shocks.

In the development of the multi-risk scenario generator, the severity of a scenario was defined as being measured by the sum of the cumulative shocks. The pop and creep scenarios have the same sum of shocks over the first 20 years (240 months). In the creep scenarios, the shocks are the same in every month. In the pop scenarios, the shocks are higher initially and then grade off towards zero.

[8] Manistre, B. John, and Geoffrey H., Hancock. 2005. Variance of the CTE Estimator. *North American Actuarial Journal* 9, no. 2:129–156, DOI:10.1080/10920277.2005.10596207.

For a one-standard deviation scenario, the shocks (measured in monthly standard deviations) are as follows in month N of 240:

Creep $1/\sqrt{240}$ (the same every month, independent of N)

Pop $\sqrt{N}-\sqrt{N-1}$ (starts high then grades off towards zero)

In both cases, the sum of the first 240 shocks is $\sqrt{240}$

The Method 2 approximation using two additional interest rate scenarios is sensitivity tested to include the 88th percentile interest rate scenario and the 12th percentile interest rate scenario. Tables 19 and 20 present the results of these sensitivity tests.

**Table 19**

SENSITIVITY TEST-INTEREST RATE SCENARIO RESULTS AT THE 88TH PERCENTILE

| RSM Pop Up 88th percentile | 12/2016 | 12/2017 | 12/2018 | 12/2019 |
|---|---|---|---|---|
| PBA deterministic reserve | 817,109,657 | 1,003,884,022 | 1,366,309,070 | 1,728,807,761 |
| PBA stochastic reserve-1000 Scenarios | 856,400,062 | 1,048,353,169 | 1,409,541,381 | 1,766,740,088 |
| RSM 88-12 reserve | 881,512,539 | 1,076,922,488 | 1,438,740,899 | 1,795,084,582 |
| Difference from Stochastic 1000 CTE70 Reserve | 2.9% | 2.7% | 2.1% | 1.6% |

**Table 20**

SENSITIVITY TEST-INTEREST RATE SCENARIO RESULTS AT THE 12TH PERCENTILE

| RSM Pop Down 88th percentile | 12/2016 | 12/2017 | 12/2018 | 12/2019 |
|---|---|---|---|---|
| PBA deterministic reserve | 817,109,657 | 1,302,195,639 | 1,789,259,687 | 2,244,789,140 |
| PBA stochastic reserve-1000 Scenarios | 856,400,062 | 1,340,102,835 | 1,827,856,235 | 2,282,525,359 |
| RSM 88-12 reserve | 881,512,539 | 1,360,258,283 | 1,827,144,721 | 2,275,140,270 |
| Difference from Stochastic 1000 CTE70 Reserve | 2.9% | 1.5% | 0.0% | −0.3% |

The sensitivity testing demonstrates that enhanced RSM continues to work well as an approximation method as economic conditions change.

## CONCLUSION

For the ULSG product, two methods have been shown to consistently produce reasonable approximations to the CTE70 reserve based on 1000 fully stochastic scenarios and that, as Section 2G of VM-20 states, “the use of such techniques does not understate the reserve by a material amount, and the expected value of the reserve calculated using simplifications, approximations and modeling efficiency techniques is not less than the expected value of the reserve calculated that does not use them."[9] (1) the adjusted stochastic reserve which adds the CTE70 standard deviation to the CTE70 reserve based on different numbers of scenarios; and (2) the anticipated experience reserve (equal to the central estimate reserve) plus the aggregate reserve margin calibrated to the 88th percentile (enhanced RSM).

The underlying assumptions and methods have been shown to be calibrated to objective data as measured by four assumption objectivity measures.

While the two methods considered in this demonstration provide useful approximations to the VM-20 stochastic reserve, we propose to use Method 1 in calculating reserves as approximations to the VM-20 stochastic reserve for this ULSG product. We will use Method 2 (recalibrating the percentile level every 3 years) as a reasonability check on the results of Method 1 and include both in the PBR Actuarial Report.

__________________________________ ______________

Signature of Appointed Actuary Date
Contact Information

[9] National Association of Insurance Commissioners. Valuation Manual, VM-20, Section 2G. January 1, 2020, *https://www.naic.org/documents/pbr_data_val_2020_edition_redline.pdf* (accessed March 4, 2020).

## Appendix C: The Representative Scenarios Method Step by Step

This appendix describes the RSM as originally proposed. As noted in the body of the report, RSM was originally proposed as a simplified method that could be applied universally for principle-based valuation for any kind of insurance contract. However, regulators raised concerns about the degree to which the assumptions and their probability distributions were subject to the actuary's judgment. Therefore, in VM-20, the values of assumptions and margins for investment returns and for mortality are largely specified rather than left to judgment. Nevertheless, the treatment of other risks in VM-20 allows room for judgment. RSM could still be used as a simplified method for development of margins on assumptions for which values are not specified in VM-20.

The development of PBR using RSM involves six steps,[10] each of which will be discussed in more detail below with reference to the UL insurance with secondary guarantees contract modeled in our research.

1. **Identify the key risk drivers for the block of business being valued.** For example, these may include mortality, persistency, expenses and interest rates.

2. **Determine the distribution of assumption values for each key risk driver.** For insurance risks, this may be expressed as the distribution of the A/T ratio based on an underlying table. For investment risks in VM-20, there is a mandated generator that defines the distribution.

3. **Generate representative scenarios for each key risk driver.** These scenarios are representative in that they reflect a selected degree of adversity (probability level) that is defined in advance. The number of such scenarios is small, because they are not stochastic but deterministic in nature. A probability weight is assigned to each representative scenario.

4. **Project asset and liability cash flows along each of the generated scenarios.** Use these projections to calculate the scenario reserve for each scenario. The scenario reserve is the present value of cash flows discounted using the scenario path of the portfolio earnings rate. The portfolio earnings rate for this purpose is defined in the same way as for the deterministic reserve in VM-20.

5. **Calculate the central estimate for the scenario reserve.** This is the probability-weighted average of the scenario reserves.

6. **Add an aggregate margin to the central estimate**. Start by determining a margin for each key risk driver separately, based on the subset of scenario reserves for that risk driver. Then sum the individual risk margins to determine the total aggregate margin. When supportable, the sum of the individual margins can be adjusted downward to reflect noncorrelation of risks per VM-20 9.B.1.

---

[10] These were first documented in Birdsall, Mark, and Steve, Strommen. 2015. Introducing the Representative Scenarios Method (RSM)—Part 1. *Small Talk*. 44, no. 9:6–8.

## CARRYING OUT THE STEPS FOR A BLOCK OF ULSG CONTRACTS

### Step 1. Identify key risk drivers

The key risk drivers are identified as:

- Interest rates
- Equity investment returns
- Default costs
- Mortality (statistical fluctuation)
- Mortality (unknown rate of improvement)
- Lapse rate

### Discussion

One may also list premium payment patterns as another risk driver, depending on the nature of the contract. In this case, the secondary guarantee depends on continued payment of premiums, and the contract terminates with minimal cash value in the event of nonpayment. Very high premium persistency is expected, and any assumption of higher lapses would significantly reduce the reserve. Therefore, the only premium pattern that is projected for reserving is continued regular premium payment.

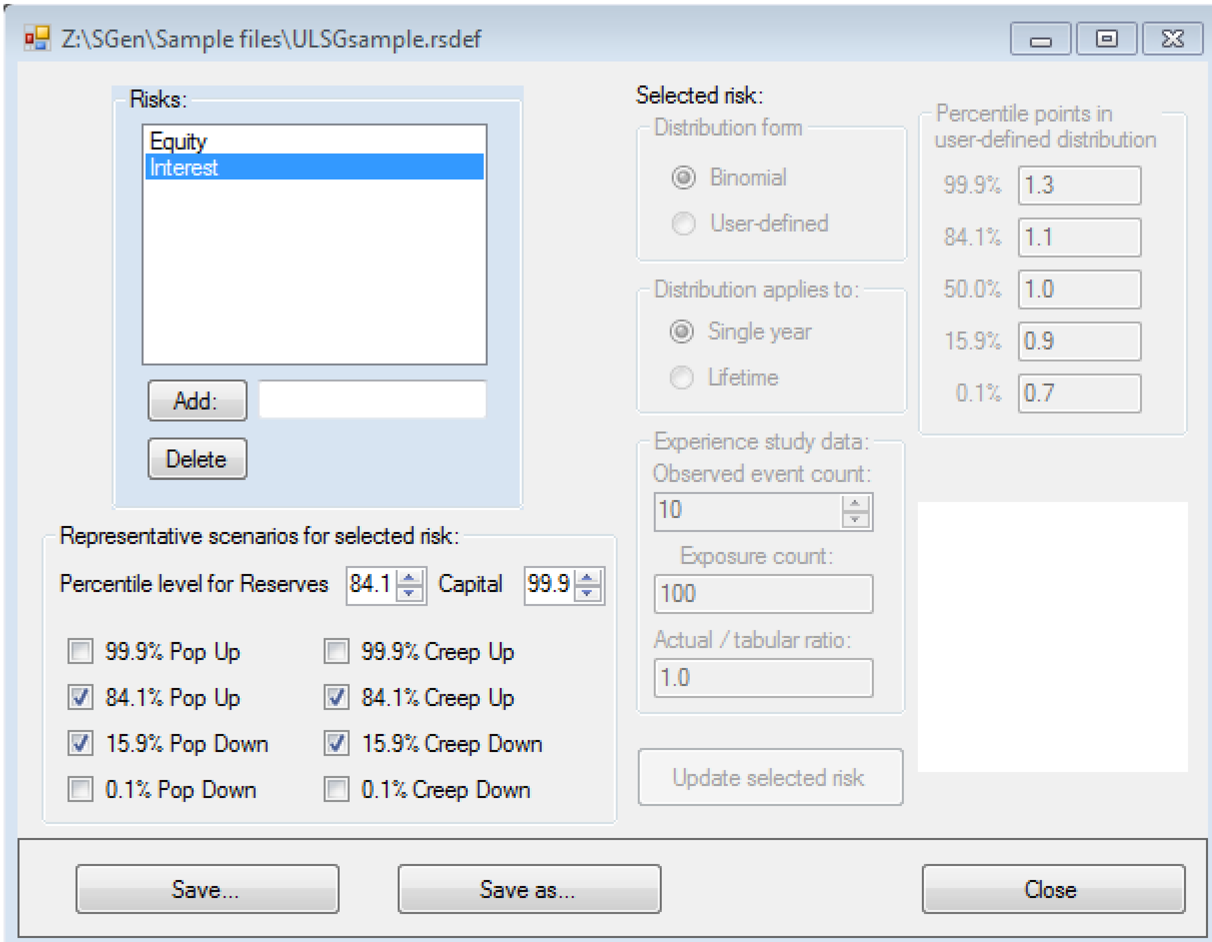
Mortality improvement is mandated to be zero for purposes of VM-20. We include nonzero treatment of it here only because we consider it a material risk. The mandated assumption of zero mortality improvement is in our opinion beyond the 70 CTE level of adversity. Nevertheless, mortality improvement would not be included in any analysis done for VM-20.

Expenses are not listed as a key risk driver because the size of that risk is immaterial for this block of business, based on our own analysis. That may not be the case in general.

To specify our list of key risk drivers in the multi-risk scenario generator tool, do the following:

1. From the top menu, click on “Risks,” then “New risk definition file ….”
2. A dialog appears requesting the name to give the file. Invent a name, enter it and click OK. We used the name “ULSGsample” for this example. The risk definition dialog box then appears, as shown in Figure 9.

**Figure 9**
Risk definition dialog




3. Enter a name for each key risk driver. Note that "Equity" and "Interest" appear automatically because these risks are in the standard generator for VM-20. To enter the "Mortality" risk, type the word "Mortality" in the box next to the "Add" button and then click "Add." The name for each risk driver must not contain spaces. For our list of risk drivers, we enter the following names, clicking "Add" after typing each one:
    a. Mortality
    b. MortImpr
    c. Lapse
    d. SpreadDefault
4. The list of risks should now appear in the box at the top left of the dialog. Note that when you click on a name in that list, information about the distribution for that risk appears in the right-hand side of the dialog, where you can edit it. Editing those distributions is the next step.

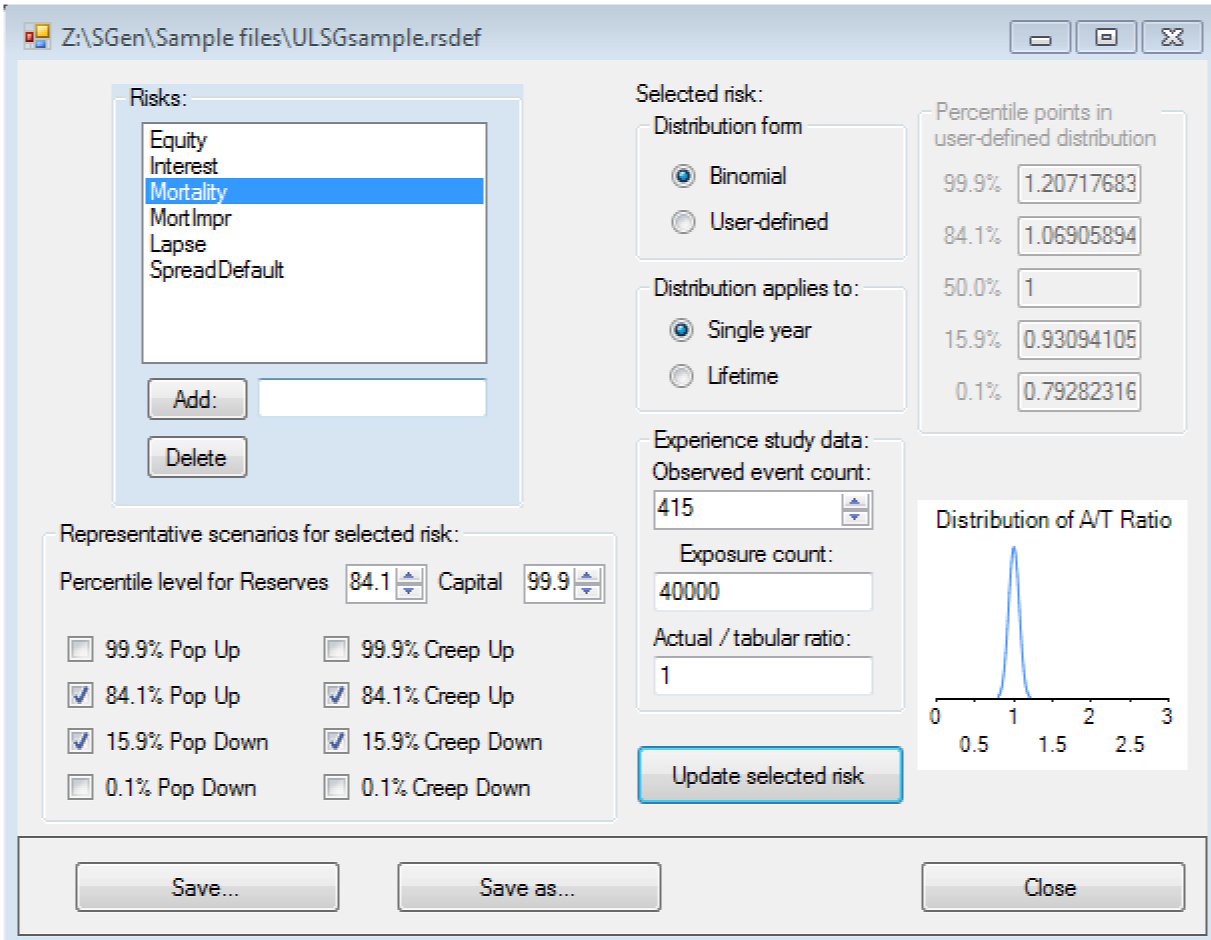
Step 2. Define the probability distribution for each Key Risk Driver

The probability distributions for **interest rates and equity returns** are defined by the VM-20 scenario generator, which is built into the multi-risk scenario generator tool. We don't need to define those distributions. Note that when you click on "Equity" or "Interest" in the list of risk drivers, the right half of the dialog is greyed out.

The distribution for **statistical variation of mortality** costs depends on the characteristics of the block of business. The tool provides one way to estimate the distribution, treating the risk as binomial with a defined number of trials (number of insureds) and a defined average actual to tabular mortality ratio based on an underlying mortality table. To use the tool to define the distribution in this way, follow these steps:

1. In the risk definition dialog, find the list of risks on the top left and click on "Mortality."
2. Under "Distribution form," click on the radio button for "Binomial."
3. Under "Distribution applies to," click on single year.
4. Under "Observed event count," enter 415 as the number of deaths in a recent annual mortality study.
5. Under "Exposure count," enter 40,000 as the number of contracts exposed in the recent annual mortality study.
6. Under "Actual / tabular ratio," enter the A/T ratio from your recent annual mortality study. We assume here that the tabular basis in the experience study is the same as the tabular basis used in your asset/liability model. If not, this should be the expected A/T ratio based on the table used in your model. For our example, we used 1.0.
7. Click on "Update selected risk." After doing this, the right side of the dialog shows the percentile points and a small chart of the probability density function. The percentile points are greyed because you can't edit them when the distribution form is "Binomial." The dialog should now appear as shown in Figure 10:

**Figure 10**
Risk definition dialog focusing on mortality risk




It should be noted that the distribution provided by the tool reflects not just the statistical variation around the mean but also the uncertainty regarding the mean itself. It is wider than the binomial distribution would be if the mean value were certain.

This binomial distribution for statistical variation of mortality cost should be viewed as the narrowest distribution that should be used. Factors that could suggest using a wider distribution include the possibility that policy size is not uniform. Variation in policy size within the block of business could make the distribution significantly wider. To reflect that, one can create a user-defined distribution with more widely spaced values for the A/T ratios. One simple technique for estimating such a user-defined distribution was presented in Harry Panjer's paper "The Aggregate Claims Distribution and Stop-Loss Reinsurance."[11] To apply that technique, one must group the contracts into discrete size bands. Then the only data needed to calculate the distribution of claims costs are the sum of forces of mortality over the entire block and the total expected claims for each size group. Once the distribution is calculated using that technique, the percentile points can be translated to A/T ratios and entered into the tool to define the distribution.

[11] Panjer, Harry. 1980. The Aggregate Claims Distribution and Stop-Loss Reinsurance. *Transactions of the Society of Actuaries* 32:523–545.

**Important:** To save your changes in the risk definition file, you must click on the "Save" button in the lower left. The "Update selected risk" button only saves changes temporarily for use while you make changes to other risks. None of the changes are permanently saved to the file until you click "Save."

The distribution for **mortality improvement** is largely based on judgment. The historical record simply doesn't have enough long time periods to generate such a distribution based a sample of long time periods. And there is the question of whether the conditions that have led to improvement in the past will continue in the future. These issues have been cited as reasons for disallowing the assumption of mortality improvement in VM-20. Nevertheless, if one wishes to quantify a central estimate and a margin, one may use a distribution around the rate of mortality improvement based on a standard table. The distribution would be defined in terms of percentile points for the A/T ratio. One may define the distribution as shown in Table 21:

**Table 21**
Defining the distribution of the mortality ratio by percentile level

| Percentile level | A/T ratio |
|---|---|
| 99% (+3 std errors) | 1.5 |
| 84% (+1 std errors) | 1.17 |
| 50% (median) | 1.00 |
| 16% (−1 std errors) | 0.83 |
| 1% (−3 std errors) | 0.5 |

The percentile points in this table apply to the entire future of the block of business rather than applying separately to each future year. This can be defined in the tool using the radio buttons under the heading "Distribution applies to." When defining this distribution in the tool, select the "Lifetime" radio button. When defining the distribution for most other risks, the "Single year" radio button should be selected (and that is the default selection). Remember to always click on "Update selected risk" to save the changes you have made before going on to the next risk.

To do this in the tool, follow these steps:

1. Click on MortImpr in the list of risk at the top left of the dialog to select this risk.
2. Under "Distribution form" click on "User-defined." Note that the percentile points on the top left are no longer greyed and you can edit them. Also, the items under "Experience study data" are greyed because they are not used to calculate a distribution.
3. Under "Distribution applies to" click on "Lifetime."
4. Enter the A/T ratios from the table above into the percentile points blanks on the top right.
5. Click on "Update selected risk."

The distribution for **lapse rates** can be developed along the same lines as the distribution for statistical variation of mortality. The tool will provide percentile points based on a binomial distribution. As with mortality, there are often reasons for the user to define a wider distribution than the one based on the binomial distribution.

It is a common practice for asset/liability models to implement a dynamic formulaic connection between lapse rates and investment returns or interest rates. It should be understood that the variation in lapse rates being defined in this distribution is in addition to any dynamic variation in lapse rates based on such a formula with a model. As a result, the width of this distribution may appear small compared to historical variations in lapse rates because historical variations could be driven mainly by the dynamic connection. It is the user's responsibility to ensure that all sources of variation in lapse rates are reflected in a model used for valuation.

VM-20 specifies assumptions for **credit spreads and default costs**, and those assumptions are acknowledged to include a margin. VM-20 provides no means to quantify that margin, so it is an implicit margin. Here we illustrate how one may use the tool to define anticipated experience and a margin if one wanted to do so. For purposes of this illustration, we use an asset/liability model that has a tabular sets of expected default costs and credit spreads that vary by credit quality and maturity. These tables are much like the ones in VM-20 but do not include a margin. We then define a distribution of A/T ratios that can be applied to those tables when modeling. The distribution used in this example is based on data we obtained for variation in historical experience by year and has the percentile levels as shown in Table 22.

**Table 22**
Defining the distribution of credit spreads and default costs by percentile level

| Percentile level | A/T ratio |
|---|---|
| 99% (+3 std errors) | 2.40 |
| 84% (+1 std errors) | 1.47 |
| 50% (median) | 1.02 |
| 16% (−1 std errors) | 0.66 |
| 1% (−3 std errors) | 0.35 |

We did not include premium payment pattern as a key risk driver in this example. Had we done so, it would be difficult to define that risk using a distribution with percentile points. One way to approach quantification of that risk is to define several different premium patterns, and consider each one as a separate scenario and assign a probability weight to each such scenario. The multi-risk scenario generator tool does not help in defining premium payment scenarios or quantifying that risk, so the modeler would need to adapt the asset/liability projection model in use to run each of the premium payment scenarios.

### Step 3. Generate scenarios for each key risk driver

The multi-risk scenario generator tool will create a set of scenarios that includes one for anticipated experience and one or more for specified levels of adverse experience. The adverse experience scenarios are separate for each key risk driver. The distributions defined earlier for each key risk driver are used in combination with the user's specified level of adversity (defined by probability level) to generate the representative scenarios.

The multi-risk generator tool allows the user to specify and generate up to eight deterministic scenarios for each risk driver. The eight potential scenarios each have three characteristics where each characteristic has two potential values:

1. The scenario can be either **above anticipated or below anticipated**. Sometimes one does not know which direction is adverse so it can be useful to generate scenarios in both directions.[12]

[12] Some risk drivers, such as lapse rates for level premium term life insurance, have the characteristic that adverse experience is above expected at some durations and below expected at other durations. In such situations, it is important that the underlying anticipated experience table is such that experience deviations above or below it are equally likely at all durations. The multi-risk scenario generator tool cannot generate deterministic scenarios that are above anticipated at some durations and below anticipated at others, so if such scenarios are required, then other tools will be needed to generate them.

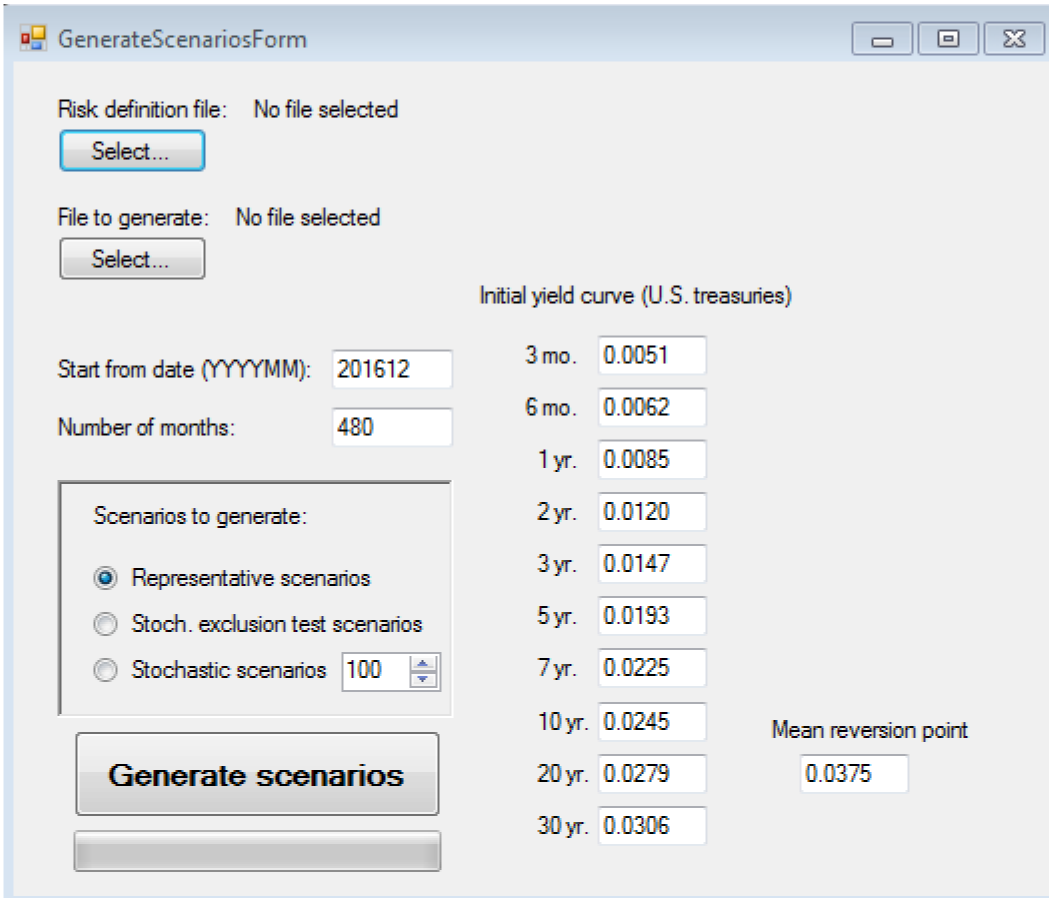
2. The degree of adversity is either at **the reserve level or the capital level**. The user can specify the percentile level corresponding to each of these. The default values are based on the normal distribution and correspond to one standard deviation for “reserves” and three standard deviations for “capital.” The default percentiles for up and down scenarios are 84.1%/15.9% for reserves and 99.9%/0.1% for capital.
3. The pattern of deviations from anticipated experience can be **pop or creep.** The cumulative adversity over the first 20 years is the same, but pop scenarios have greater adversity in early years and less in later years. It is recommended that both patterns be generated and used in the next step.

When using RSM scenarios for reserves (and not capital determination), one would normally generate the four scenarios at the “reserve” level for each key risk driver. These can be called pop-up, pop-down, creep-up and creep-down scenarios.

To use the tool to generate the scenarios, follow these steps:

1. In the risk definition dialog, specify which representative scenarios should be generated for each risk driver. This is done in the bottom left portion of the dialog (as shown in Figures 9 and 10). First, define the percentile level for reserves and for capital. Default values are provided, which represent one standard error (84.1%) for reserves and three standard errors (99.9%) for capital. Then follow these steps separately for each risk driver:
    a. Select the risk driver by clicking on its name in the list at the top left.
    b. Under “Representative scenarios for selected risk,” check the boxes for the scenarios you wish to generate for this risk driver.
    c. Click “Update selected risk.”
2. Don’t forget to click “Save” to save all your changes to the risk definition dialog when done. Then close the risk definition dialog.
3. On the main menu, select “Scenarios” and then “Generate a set of scenarios ….” Figure X shows the dialog that should appear:

**Figure 11**
Scenario generation dialog




4. Click the top "Select" button to select the risk definition file to be used. A file selection dialog will appear. After you've selected the file, its name will appear here.
5. Click the second "Select" button to specify the name of the file to store the generated scenarios. A file selection dialog will appear. The user can specify both the file name and the file format; most will use the default format of .csv. Once the file name has been specified, it will appear here.
6. Specify the start from date, the number of months, the initial yield curve and the mean reversion point for the interest rate generator.
7. Under "Scenarios to generate," click the radio button for "Representative scenarios."
8. Click "Generate scenarios." A message will pop up when scenario generation is complete. Normally this takes only a few seconds.

The result of scenario generation is two new files. If the user specified the filename as MyScenarios.csv, then two files will be created:

- MyScenarios.csv will contain the scenarios. The first row is column headings that list the items included in the scenario. Subsequent rows each correspond to one time step in one scenario. The items included in each row are 10 points on the yield curve (for the interest risk driver), nine different equity fund returns (for the equity risk driver), and one A/T ratio for each additional risk driver that you defined.

- **MyScenarios.index.csv** contains important information about each scenario, including the ID, the risk driver, pattern of shocks, percentile level and scenario weight. Use of this information is described in the next step. Table 23 is a sample of such a file:

**Table 23**

Information contained in MyScenarios.index.csv

| ID | Risk driver | Pattern | Percentile | Weight |
|---|---|---|---|---|
| _RSM1 | Equity | pop | 0.841 | 0.1545 |
| _RSM2 | Equity | creep | 0.841 | 0.1545 |
| _RSM3 | Equity | pop | 0.159 | 0.1545 |
| _RSM4 | Equity | creep | 0.159 | 0.1545 |
| _RSM5 | None | Anticipated | 0.5 | 0.382 |
| _RSM6 | Interest | pop | 0.841 | 0.1545 |
| _RSM7 | Interest | creep | 0.841 | 0.1545 |
| _RSM8 | Interest | pop | 0.159 | 0.1545 |
| _RSM9 | Interest | creep | 0.159 | 0.1545 |
| _RSM10 | Lapse | pop | 0.841 | 0.1545 |
| _RSM11 | Lapse | creep | 0.841 | 0.1545 |
| _RSM12 | Lapse | pop | 0.159 | 0.1545 |
| _RSM13 | Lapse | creep | 0.159 | 0.1545 |
| _RSM14 | Mortality | pop | 0.841 | 0.1545 |
| _RSM15 | Mortality | creep | 0.841 | 0.1545 |
| _RSM16 | Mortality | pop | 0.159 | 0.1545 |
| _RSM17 | Mortality | creep | 0.159 | 0.1545 |
| _RSM18 | MortImpr | pop | 0.841 | 0.1545 |
| _RSM19 | MortImpr | creep | 0.841 | 0.1545 |
| _RSM20 | MortImpr | pop | 0.159 | 0.1545 |
| _RSM21 | MortImpr | creep | 0.159 | 0.1545 |
| _RSM22 | SpreadDefault | pop | 0.841 | 0.1545 |
| _RSM23 | SpreadDefault | creep | 0.841 | 0.1545 |
| _RSM24 | SpreadDefault | pop | 0.159 | 0.1545 |
| _RSM25 | SpreadDefault | creep | 0.159 | 0.1545 |

Note that a probability weight is assigned to each scenario, and the probability weights across all scenarios for a single risk driver add to 1.0 when the “anticipated” scenario is included. Those weights are used in Step 5 to calculate the central estimate reserve for each risk driver as a weighted average of scenario reserves. One should not use the “anticipated” scenario as the central estimate because VM-20 defines the central estimate to be the mean, not the median.

The weights are defined as follows:

1. The list of percentiles for one specific risk driver is determined. Each percentile level is converted to a number of standard errors in the normal or Gaussian distribution. In the illustration above, 0.159 corresponds to −1 standard error, 0.5 is 0 standard error, and 0.841 is +1 standard error.
2. The normal distribution is divided into sections represented by each percentile. The sections are divided exactly halfway between the standard error levels from step 1. In the illustration above, the divisions are at −0.5 and +0.5 standard errors. Percentile 0.159 then represents everything below −0.5 standard errors, percentile 0 represents everything between −0.5 and +0.5 standard errors, and percentile 0.841 represents everything above +0.5 standard errors.
3. The weight for a percentile level is set equal to the area under the normal probability density function represented by that percentile, with the representative areas defined in Step 2. The area below −0.5 standard errors is 0.309. The area between −0.5 and +0.5 standard errors is 0.382. The area above +0.5 standard errors is 0.309.
4. When there are both pop and creep scenarios at the same percentile level, the probability for that percentile level is divided equally between them. In this illustration, 0.309 is divided into two parts of 0.1545.

When scenarios are defined at both the capital and reserve levels, the distribution is divided into five representative sections instead of three, but the same general approach is used to derive the weights for each section.

**Important: The statistical technique used to develop representative scenarios for each key risk driver is the same as that used to define the deterministic scenario for interest rates and equity returns in VM-20 and to define the scenarios in the SET.** The statistical technique is the same in that it uses the same definition to quantify the degree of adversity in a scenario.[13] The representative scenarios for other risks are therefore analogous to the deterministic scenario for interest rates and equity returns that is already a part of VM-20. Because that technique is implicitly mandated for including a margin for interest rate and equity risks in VM-20, it is reasonable to assume that scenarios constructed using the same statistical technique should be acceptable for use in determining margins for other risks under VM-20. When this approach is used, regulatory review can focus on whether the distributions defined by the user appropriately characterize each risk.

**Step 4. Perform an asset/liability simulation for each scenario and calculate the scenario reserves**

This step and all following steps do not make use of the scenario generator tool. All scenarios have now been generated and what follows involves the use of other tools that the actuary must have available.

This step involves the use of an integrated asset/liability model to perform the simulation for each scenario. The model must be adapted so that it can use the A/T ratios by time step defined in the scenario file. The scenario A/T ratios are used to modify the table in use by the model to represent experience for each risk driver. Values from the table are multiplied by the scenario A/T ratio when simulating experience in each time step in each scenario.

[13] For the purpose of developing representative scenarios, the degree of adversity in a scenario is defined using the sum of random shocks in the scenario. We use Gaussian random shocks with a mean of zero and standard error of 1.0 to define a scenario. The sum of random shocks in a 1-standard error scenario after N time steps is the square root of N. We define the degree of adversity of a scenario to be the maximum (over all values of N) of the cumulative sum of shocks over the first N time steps divided by the square root of N. The result is a number of standard errors away from anticipated. With that definition of adversity, we can define deterministic scenarios that meet the definition at any desired level. The exact formulas for the pop and creep patterns of deterministic shocks at each time step are in the body of our paper. While this definition is based on a Gaussian random walk, the scenarios are transformed to reflect other distributions by converting each Gaussian random shock to a percentile and then using that percentile to look up the A/T ratio in the distribution defined by the user, interpolating as needed. That process is repeated to determine the actual scenario value at each time step.

The results from each scenario should include the future cash flows and the discount rates to be used to calculate their present value. The present value of cash flows from each scenario is the scenario reserve. For each scenario, the process is essentially the same as that for the deterministic reserve under VM-20, except that the assumptions used are different from VM-20 and different in each scenario. The set of scenario reserves is the main result of this step.

### Step 5. Calculate the central estimate reserve

The concept underlying the central estimate reserve in a principle-based approach is the average scenario reserve based on a set of purely stochastic scenarios for all risks. In this case, we are using deterministic scenarios with weights corresponding to each, so we calculate a weighted average of the scenario reserves for our deterministic scenarios.

The weighted average is calculated in two steps.

1. A weighted average scenario reserve is calculated separately for each risk driver. The weights in the scenario index file sum to 1.0 across the set of scenarios for each risk driver when the "anticipated" experience scenario is included in the set. These weights are used to calculate the weighted average reserve for each risk-driver-specific set of scenarios. In our illustrative example, there are six risk drivers, and a weighted average reserve is calculated for each of the six.
2. The reserves for each risk driver from Step 1 need to be weighted together in some fashion to get the central estimate. One could use equal weights for each risk driver. Or one could give more weight to the more significant risks by using the range of scenario reserves within each risk driver to determine a set of proportional weights, with greater weight given to risk drivers whose scenario reserves are further apart. The exact weights used in this step are not that important. To the extent that they may affect the central estimate, there will be an offsetting effect on the size of the margin determined in Step 6 for each risk driver, with little to no effect on the final reserve.

### Step 6. Add the aggregate margin to the central estimate reserve

One can use the central estimate to determine the margin for each key risk driver separately. **The margin is the excess of the largest scenario reserve (for that risk driver) over the central estimate**. If we had developed scenarios at both the reserve and capital levels of adversity, the margin would be based on the largest of the scenario reserves at the reserve level, and the capital level scenarios would be ignored for this purpose. Of course, the capital level scenarios could be used separately to determine a capital requirement, but that is outside the scope of VM-20.

The separate margins for each key risk driver must be aggregated in some way. The simplest approach is to just sum them. If they can be shown to be noncorrelated, some reduction in their sum may be justified to reflect that noncorrelation. In that case, one can use either a correlation matrix approach or a simple square root formula such as that used for statutory RBC. The tool does not provide a facility for adjusting for noncorrelation between risks; it is designed to help one determine the margin for each risk separately.

Figure 12 is an example that Mark Birdsall gave in a presentation at the 2018 Valuation Actuary Symposium[14] and illustrates the central estimate reserve and the margins for the key risk drivers in a term insurance model. The

[14] Birdsall, Mark. Simplified Methodologies Under VM-20. Presented at the 2018 Valuation Actuary Symposium, August 27, 2018, Washington, DC

margins for the individual key risk drivers were combined based on different assumptions regarding the independence and dependence of the key risk drivers.

**Figure 12**
Example

## Example: Aggregate Margin for Term

| | 2016 | 2022 |
|---|---|---|
| **Natural Reserve = Central Estimate Reserve** | **-4,309,748** | **113,788,808** |
| 84th Percentile Risk Amounts: | | |
| D=Default cost | 2,942,409 | 2,965,812 |
| I=Interest | 8,346,500 | 4,003,348 |
| L=Lapse | 846,994 | 4,788,541 |
| Mf=Mortality fluctuation | 5,533,611 | 5,058,862 |
| Mt=Mortality trend | 14,990,356 | 8,555,984 |
| Sum of 84th Percentile Risk Amounts | 32,659,870 | 25,372,548 |
| **Percentile margin (adjusted for covariance)** | **18,285,810** | **12,105,780** |
| **Modeled Reserve = Natural Res + Pctile Margin** | **13,976,062** | **125,894,588** |
| *Margin if mortality and lapse are dependent* | *18,540,354* | *13,964,206* |

Percentile Margin = sqrt(D^2+I^2+L^2+Mf^2+Mt^2)
*If Mf and L are dependent, then Percentile Margin = sqrt(D^2+I^2+(L+Mf)^2+Mt^2)*

In the example, note the impact of assuming 100% dependence of the key risk drivers, "Sum of 84th Percentile Risk Amounts"; and the assumption of independence, "Percentile margin (adjusted for covariance)"; and partial dependence, "Margin if mortality and lapse are dependent." The margins were calculated using a square root formula analogous to the formula used for risk-based capital as shown by the two formulas at the bottom of the slide.

For 2016, the assumption of 100% dependence increases the margin by 79% over the assumption of independence and 53% over the assumption of partial dependence. For 2022, the margins are increased by 110% and 82%, respectively.

With potentially significant differences in the margins based on the independence or dependence of the key risk drivers, the following provision of VM-20 9.B.1 must be intended to provide for a reasonable basis for demonstrating the independence of some of the key risk drivers:

> "The company shall determine an explicit set of initial margins for each material risk independently (that is, without regard to any margins in other risk factors and ignoring any correlation among risk factors). Next, if applicable, the level of a particular initial margin may be adjusted to take into account the fact that risk factors are not normally 100% correlated. However, in recognition that risk factors may become more heavily correlated as circumstances become more adverse, the initially determined margin may only be reduced to the extent the company can demonstrate that the method used to justify such a reduction is reasonable,

considering the range of scenarios contributing to the CTE calculation or considering the scenario used to calculate the deterministic reserve as applicable or considering appropriate adverse circumstances for risk factors not stochastically modeled. It is not permissible to adjust the initial margin to recognize, in whole or in part, implicit or prescribed margins that are present, or are believed to be present, in other risk factors."[15]

While VM-20 describes reserve calculations, in terms of principles it may be worth noting that the actuary should consider assuming less independence among certain risk factors when determining target capital using extremely adverse scenarios (as contrasted with moderately adverse scenarios for reserves).

For a demonstration of independence, a simple approach would be to look at historical experience for each key risk and then estimate the correlation coefficient between each pair of risk drivers. In Excel, for example, the actuary could use the "=corr" function for this estimate. While this approach is not perfect, it should work reasonably well to demonstrate the level of correlation among the key risk drivers.

If there is a reduction in the aggregate margin due to noncorrelation of risks, then one must prorate that reduction across the risk drivers in order to report separate margins for each risk under VM-20.

The total reported reserve is the sum of the central estimate and the aggregate margin.

[15] National Association of Insurance Commissioners. Valuation Manual, VM-20 9.B.1. January 1, 2020, *https://www.naic.org/documents/pbr_data_val_2020_edition_redline.pdf* (accessed March 4, 2020).

## About The Society of Actuaries

The Society of Actuaries (SOA), formed in 1949, is one of the largest actuarial professional organizations in the world dedicated to serving more than 31,000 actuarial members and the public in the United States, Canada and worldwide. In line with the SOA Vision Statement, actuaries act as business leaders who develop and use mathematical models to measure and manage risk in support of financial security for individuals, organizations and the public.

The SOA supports actuaries and advances knowledge through research and education. As part of its work, the SOA seeks to inform public policy development and public understanding through research. The SOA aspires to be a trusted source of objective, data-driven research and analysis with an actuarial perspective for its members, industry, policymakers and the public. This distinct perspective comes from the SOA as an association of actuaries, who have a rigorous formal education and direct experience as practitioners as they perform applied research. The SOA also welcomes the opportunity to partner with other organizations in our work where appropriate.

The SOA has a history of working with public policymakers and regulators in developing historical experience studies and projection techniques as well as individual reports on health care, retirement and other topics. The SOA's research is intended to aid the work of policymakers and regulators and follow certain core principles:

**Objectivity:** The SOA's research informs and provides analysis that can be relied upon by other individuals or organizations involved in public policy discussions. The SOA does not take advocacy positions or lobby specific policy proposals.

**Quality:** The SOA aspires to the highest ethical and quality standards in all of its research and analysis. Our research process is overseen by experienced actuaries and nonactuaries from a range of industry sectors and organizations. A rigorous peer-review process ensures the quality and integrity of our work.

**Relevance:** The SOA provides timely research on public policy issues. Our research advances actuarial knowledge while providing critical insights on key policy issues, and thereby provides value to stakeholders and decision makers.

**Quantification:** The SOA leverages the diverse skill sets of actuaries to provide research and findings that are driven by the best available data and methods. Actuaries use detailed modeling to analyze financial risk and provide distinct insight and quantification. Further, actuarial standards require transparency and the disclosure of the assumptions and analytic approach underlying the work.

Society of Actuaries
475 N. Martingale Road, Suite 600
Schaumburg, Illinois 60173
www.SOA.org