STRESS TESTING RESULTS
LR032

Basis of Factors

When the Life Risk-Based Capital (RBC) formula was first adopted by the NAIC, provision for asset/liability mismatch risk (called “C-3 risk” in these Instructions) was in its infancy as reflected in asset adequacy analysis for reserves. At that time, the matching of assets and liabilities was relatively new for actuaries and companies, and adding asset adequacy analysis to these calculations was a major step forward for both the industry and regulators. C-3 risk testing requirements were later added to RBC determination with respect to certain product types, such as single premium life and variable annuities.

Since then, both insurance products and assets have changed to include new features, greater complexity, and additional risks. For some of these products, C-3 risk is no longer the only significant risk that needs to be properly reflected in both statutory reserve and RBC calculations. For example, longevity risk and policyholder behavior risk, including the utilization pattern of certain benefits, have become additional material risks that companies must consider in ensuring that the total assets available are adequate to address both moderately adverse and more extreme future conditions.

With the emergence of the Principle-Based Approach to reserves and required capital, it is appropriate to take a more holistic view of risk, to coordinate the level of statutory reserves and the level of required capital for solvency oversight purposes, and to accelerate the adjustment of those statutory solvency requirements as significant new products, assets, and risks emerge in company asset and liability portfolios. Supplementing the Life RBC formula with a more granular company-specific stress testing approach will provide companies, regulators and other interested parties greater assurance that all material risks have been properly reflected in determining the statutory total asset requirements.

The statutory total asset requirement (TAR) consists of statutory reserves, the Interest Maintenance Reserve (IMR), Company Action Level RBC (CALRBC), less an adjustment for the portion of the Asset Valuation Reserve (AVR) that was not used by the company in the asset adequacy analysis of statutory reserves. Where asset adequacy analysis as defined in the Actuarial Opinion and Memorandum Regulation constitutes a test of the adequacy of reported statutory reserves to meet moderately adverse conditions, stress testing as defined herein constitutes a test of the adequacy of the statutory TAR to meet more extreme adverse conditions.

Both company-defined stress tests and regulatory prescribed stress tests could be useful to test the adequacy of statutory TAR. These stress testing requirements take a two-stage approach to the testing, where the first stage is comprised of stress tests derived by the company starting with its anticipated experience assumptions and defining distributions around those assumptions for the material risks of each block of business. If the statutory TAR is shown to be adequate for passing these stress tests by a sufficient margin, then the company would be exempted from stress testing using the prescribed stress scenarios. If not, then the additional stress testing using prescribed scenarios would be required. If additional assets are needed to pass all the stress tests, then the company’s Company Action Level RBC would be increased by the book value of those additional assets.

Specific Instructions for Application of the Formula

These RBC Instructions describe a principle-based calculation of the Current Estimate Reserve utilizing anticipated experience assumptions and a methodology called the Representative Scenarios Method (RSM). This methodology is a generalized, multi-risk calculation approach that reflects the Key Risk Drivers for each Model Segment being valued. In this context, the RSM produces a result for the Current Estimate Reserve that takes into consideration both statistical variations around the anticipated experience assumptions and the optionality of the subject assets and liabilities. At the same time, the RSM is more practical to calculate and to audit than a stochastic approach would be. For purposes of the RSM calculations, multiple Model Segments may be grouped together in the cash flow projections.
The Anticipated Experience Reserve consists of the present value of cash flows as of the Valuation Date using all anticipated experience assumptions. This single-scenario value is incorporated in the determination of the Current Estimate Reserve; however, it does not reflect the statistical variation of experience around the anticipated experience assumptions, nor does it reflect the optionality inherent in both the assets and the liabilities. Due to these issues, the Current Estimate Reserve will be larger than the Anticipated Experience Reserve.

The RSM provides the basis for calculating a Total Asset Level equal to the Current Estimate Reserve plus Extra Assets Needed, which latter amount is computed based on the Current Estimate Scenario Amounts for the extremely adverse scenario for each Key Risk Driver. A Square Root Formula, similar to that utilized in the Life Risk-Based Capital Formula to adjust for covariance of the individual risk factor amounts, is applied to the maximum differences in the Current Estimate Scenario Amounts for each Key Risk Driver from the Anticipated Experience Reserve to derive the Excess Asset Needs. The Total Asset Level can then be calculated and compared with the statutory TAR defined above.

A. General Modeling Guidelines

1. Stress testing is required as of each year-end, though work may be done as of a period no more than three months prior to a year-end, together with a suitable analysis of the intervening period and its materiality or immateriality with respect to the stress testing results.
   a. An interim investigation may be required if there is a material adverse change in company circumstances. Such a material adverse change must be reported to the company’s domicile regulator.

2. Two separate models will be stressed using this methodology:
   a. An in force model using starting assets and liabilities as of the valuation date. The projection period for this model should be sufficiently long that the remaining assets and liabilities will have an immaterial effect on the present values of cash flows as of the valuation date.
   b. A total business model using starting assets and liabilities as of the valuation date, but for which new business is added consistent with the company’s best estimate operating plan for the five years following the valuation date. The projection period is five years from the valuation date.
   c. Starting assets equal the statutory book value of the TAR.

3. Scenario results equal the minimum assets such that:
   a. Statutory surplus is positive at the end of every projection year for both the in force and total business models.
   b. Market surplus is positive at the end of the projection period for both the inforce and total business models.
   c. The calculations described below are with respect to the in force model only. An adjustment to the Company Action Level RBC is required with respect to the total business model equal to any shortfall in 3a or 3b calculated using the Current Estimate Scenarios for the Key Risk Drivers as defined below.
B. Definitions

The following terms, when capitalized, shall have the indicated meanings for purposes of these RBC Instructions (other key terms may be found in the Valuation Manual):

1. “Current Estimate Reserve” represents the Anticipated Experience Reserve defined above, adjusted for the statistical variation around the anticipated experience of the Key Risk Drivers and the optionality of the subject assets and liabilities as developed in the Representative Scenarios Method.

2. “Current Estimate Scenario” refers to a single scenario determined using the Scenario Generator. For each Key Risk Driver, several Current Estimate Scenarios are determined by the Scenario Generator.

3. “Current Estimate Scenario Amount” refers to the present value of cash flows calculated based on a Current Estimate Scenario. For each Key Risk Driver, the Current Estimate Scenario Amounts must be aggregated using the respective probabilities associated with the Current Estimate Scenarios for that Key Risk Driver. See example A in Appendix 2. The probability-weighted result for each Key Risk Driver is called the “Key Risk Driver Amount.”

4. “Excess Asset Needs” refers to the asset amount needed in excess of the Current Estimate Reserve for the company to be able to meet the extremely adverse scenarios produced by the Scenario Generator, adjusted for covariance.

5. “Key Risk Drivers” represent the material risks of a block of insurance business, including its supporting assets. The Key Risk Drivers for multiple blocks of business included in a Model Segment should generally be the same or substantially similar.

6. “Key Risk Driver Weights” refer to the weights used to aggregate the Key Risk Driver Amounts into the Current Estimate Reserve. These weights are computed by taking the difference in the maximum and minimum Current Estimate Scenario Amounts for each Key Risk Driver, then calculating the sum of these values over all the Key Risk Drivers. Each Key Risk Driver Weight equals the respective difference for the Key Risk Driver divided by this sum. See example B in Appendix 2.

7. “Model Segment” means a group of policies with the same or substantially similar Key Risk Drivers that is modeled together using the Representative Scenarios Method.

8. “Representative Scenarios Method” (RSM) refers to a process (described in C. below) for calculating the Current Estimate Reserve based on anticipated experience assumptions using a limited number of Current Estimate Scenarios produced by the Scenario Generator for each Key Risk Driver, such that each Current Estimate Scenario has an identifiable probability associated with it. The Current Estimate Scenario Amounts are aggregated using these probabilities to compute the respective Key Risk Driver Amounts. The Key Risk Driver Amounts are aggregated into the Current Estimate Reserve using the Key Risk Driver Weights, which reflect the relative contribution to risk of each Key Risk Driver.

9. “Scenario Generator” refers to the process for deriving Current Estimate Scenarios for each Key Risk Driver as described in Appendix 1.

10. “Total Asset Level” equals the sum of the Current Estimate Reserve and the Excess Asset Needs. This value is compared with the TAR to determine whether the insurance entity has sufficient assets to meet extremely adverse experience.
C. Current Estimate Reserve and Total Asset Level

The following represents a series of steps for the Appointed Actuary to follow in calculating the Current Estimate Reserve. These steps together comprise the Representative Scenarios Method (RSM):

1. The Appointed Actuary will analyze the total block of business to be evaluated and identify Model Segments with similar risk profiles for the assets and liabilities.

2. For each Model Segment identified in 1, the Appointed Actuary will identify the anticipated experience assumptions for the assets and liabilities associated with that Model Segment, such that these assumptions represent the Appointed Actuary’s objective best estimate of future experience with respect to each risk factor and that the assumptions taken together comprise a best estimate of expected experience for the Model Segment.

3. The Appointed Actuary will identify the Key Risk Drivers for each Model Segment. For each Key Risk Driver, the Appointed Actuary will assess the statistical independence or dependence with respect to the other Key Risk Drivers for that Model Segment. This statistical independence or dependence will affect the covariance adjustment described in 8. below and illustrated in in example B of Appendix 2.

4. Using the principles contained in Appendix 1, the Appointed Actuary shall use the Scenario Generator to determine the Current Estimate Scenarios for each Key Risk Driver within each Model Segment. Each such Current Estimate Scenario will be categorized by its associated Key Risk Driver for aggregation purposes as described below. Please note that for the Current Estimate Scenarios for investments and inflation rates, the same Current Estimate Scenario sets will be used for all Model Segments in the calculation of the Current Estimate Reserve.

5. The Appointed Actuary shall determine the cash flows for each Current Estimate Scenario according to the guidance in the Cash Flow Models section of VM-20.
   
   a. The projection period for each Modeled Segment should reflect the nature of the liabilities. Generally, the projection period should extend to a point where there is an immaterial amount of liabilities remaining at the end of the projection period. A terminal value representing the present value of future net cash flows at the end of the projection period should be estimated and included in the calculation of the Current Estimate Scenario Amount.

   b. Material reinsurance agreements should be reflected in the projected cash flows, as described in the Reinsurance section of VM-20.

   c. Grouping of Model Segments in the projection is permitted to reflect the natural hedging that may exist among different products.

6. The Appointed Actuary shall aggregate the Current Estimate Scenario Amounts within each Key Risk Driver category by applying the respective probabilities for each Current Estimate Scenario to derive the Key Risk Driver Amount for that key risk category. An illustration of this calculation is provided in example A of Appendix 2.

7. The Appointed Actuary shall aggregate the Key Risk Driver Amounts into the Current Estimate Reserve using the Key Risk Driver Weights derived in the following manner:
   
   a. For each Key Risk Driver, calculate the difference between the highest and lowest Current Estimate Scenario Amounts.

   b. Sum the values from a.

   c. Calculate the Key Risk Driver Weight for each Key Risk Driver Amount by dividing the respective differences from a. by the sum calculated in b.
d. Calculate the Current Estimate Reserve as the average of the Key Risk Driver Amounts weighted by the respective Key Risk Driver Weights calculated in c. An illustration of these calculations is provided in example B of Appendix 2.

8. The value for Excess Asset Needs is computed based on the Current Estimate Scenario Amounts for the extremely adverse scenario for each Key Risk Driver. A Square Root Formula, similar to that utilized in the Life Risk-Based Capital Formula to adjust for covariance of the individual risk factor amounts, is applied to the maximum differences in the Current Estimate Scenario Amounts for each Key Risk Driver from the Anticipated Experience Reserve to derive the Excess Asset Needs. See example C in Appendix 2. The Unadjusted Excess Asset Needs equals the sum of the maximum differences in the Current Estimate Scenario Amounts for each Key Risk Driver from the Anticipated Experience Reserve.


D. Exemption Test


2. Calculate two comparison amounts: “A” equals statutory reserves plus Interest Maintenance Reserve plus Total Adjusted Capital; “B” equals statutory reserves plus Interest Maintenance Reserve plus Company Action Level RBC less portion of Asset Valuation Reserve not used in asset adequacy analysis.

3. If B > (2), report formula RBC results without adjustment.

4. If A>(1) and B<(2), then increase Company Action Level RBC by the amount (2)-B

5. If A<(1) and B<(2), then:
   a. Complete the questionnaire shown in Appendix 3.
   b. Replace the economic scenarios in the RSM with the economic scenarios prescribed in Appendix 4 using equal weighting for each such economic scenario.
   c. Recalculate (2) and increase the Company Action Level RBC by the maximum of 0 and the amount (2)-B.
E. Documentation

An Actuarial Report shall be prepared in accordance with the Actuarial Standards of Practice promulgated by the Actuarial Standards Board and prepared in a standardized format suitable for electronic extraction into a database of key information as prescribed by the state regulators acting through the NAIC. This Actuarial Report shall include documentation of the analysis underlying the identification of Model Segments, the setting of anticipated experience assumptions, the identification of Key Risk Drivers for each Model Segment together with the evaluation of statistical independence of each Key Risk Driver, the derivation of Current Estimate Scenarios based on the principles contained in Appendix 1, and the components of the calculations related to the Exemption Test defined in D. above, together with any adjustment needed to the Company Action Level RBC.
Appendix 2  Calculation Examples

The following spreadsheet example will be used to illustrate the calculations in A, B, and C as follows: (A) aggregating the Current Estimate Scenario Amounts into the Key Risk Driver Amount using probability weights for each Key Risk Driver; (B) determining the Key Risk Driver Weights to aggregate the Key Risk Driver Amounts into the Current Estimate Reserve; and (C) determining the Excess Asset Needs and the Total Asset Level.

### Illustrative Calculation-Current Estimate Reserve and Total Asset Level

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Key Risk Driver</th>
<th>Scenario</th>
<th>Probability</th>
<th>Weight</th>
<th>Current Estimate Scenario Amount</th>
<th>Weighted Key Risk Driver Amount</th>
<th>Max-Min</th>
<th>% Total</th>
<th>Current Estimate Reserve</th>
<th>Excess Asset Needs (EAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>99%</td>
<td>Pop Up</td>
<td>128.642</td>
<td>0.023</td>
<td>1,286,420,000.00</td>
<td>29,587,660.00</td>
<td>286,420,000</td>
<td>91.2%</td>
<td>1,044,604,043.60</td>
<td>241,815,956.40</td>
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<tr>
<td>Interest</td>
<td>84%</td>
<td>Pop Up</td>
<td>107.249</td>
<td>0.286</td>
<td>1,072,490,000.00</td>
<td>306,732,140.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>27,885,956.40</td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>-- Anticipated</td>
<td>100</td>
<td>1,000,000,000.00</td>
<td>0.382</td>
<td>382,000,000.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>16%</td>
<td>Pop Down</td>
<td>105.56</td>
<td>0.286</td>
<td>1,055,600,000.00</td>
<td>301,901,600.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>10,995,956.40</td>
<td></td>
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<tr>
<td>Interest</td>
<td>1%</td>
<td>Pop Down</td>
<td>124.617</td>
<td>0.023</td>
<td>1,246,170,000.00</td>
<td>28,661,910.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>201,565,956.40</td>
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</tr>
<tr>
<td>Lapse</td>
<td>99%</td>
<td>Pop Up</td>
<td>100.533</td>
<td>0.023</td>
<td>1,005,330,000.00</td>
<td>23,122,590.00</td>
<td>12,150,000</td>
<td>3.9%</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
</tr>
<tr>
<td>Lapse</td>
<td>84%</td>
<td>Pop Up</td>
<td>100.211</td>
<td>0.286</td>
<td>1,002,110,000.00</td>
<td>286,603,460.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Lapse</td>
<td>-- Anticipated</td>
<td>100</td>
<td>1,000,000,000.00</td>
<td>0.382</td>
<td>382,000,000.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lapse</td>
<td>16%</td>
<td>Pop Down</td>
<td>99.825</td>
<td>0.286</td>
<td>998,250,000.00</td>
<td>285,499,500.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Lapse</td>
<td>1%</td>
<td>Pop Down</td>
<td>99.318</td>
<td>0.023</td>
<td>993,180,000.00</td>
<td>22,843,140.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>99%</td>
<td>Pop Up</td>
<td>99.268</td>
<td>0.023</td>
<td>992,680,000.00</td>
<td>22,831,640.00</td>
<td>15,420,000</td>
<td>4.9%</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
</tr>
<tr>
<td>Mortality</td>
<td>84%</td>
<td>Pop Up</td>
<td>99.757</td>
<td>0.286</td>
<td>997,570,000.00</td>
<td>285,305,020.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>-- Anticipated</td>
<td>100</td>
<td>1,000,000,000.00</td>
<td>0.382</td>
<td>382,000,000.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>16%</td>
<td>Pop Down</td>
<td>99.031</td>
<td>0.286</td>
<td>991,030,000.00</td>
<td>286,886,600.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>1%</td>
<td>Pop Down</td>
<td>99.518</td>
<td>0.023</td>
<td>995,180,000.00</td>
<td>23,185,300.00</td>
<td>1,048,883,310.00</td>
<td>1,044,604,043.60</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>313,990,000</td>
<td>100.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Excess Assets Needs =\([(I+L)^2 + M^2]^{0.5}\), where I, L & M are the greatest AEN for each Key Risk Driver

| Anticipated Experience Reserve (AER) | 1,000,000,000 |
| Current Estimate Reserve (CER)      | 1,044,604,044 |
| Difference (% of AER)               | 4.5%           |
| Excess Asset Needs (% of CER)       | 23.1%          |
| Total Asset Level (CER + EAN)       | 1,286,420,000 |

Note: The Pct of Anticipated column represents values for Deferred Annuities with GLIBs. Values for term life and USLG will be substituted when available.
A. Aggregating the Current Estimate Scenario Amounts into the Key Risk Driver Amount using probability weights

1. In the example, the Appointed Actuary has determined that the Model Segment has three Key Risk Drivers: interest or C-3 risk, lapses, and mortality. The Current Estimate Scenarios correspond to the indicated percentile and probability levels for each Key Risk Driver. Note that each Key Risk Driver shows the same Current Estimate Scenario Amount for the Current Estimate Scenario equal to anticipated experience.

2. The “Pct of Anticipated” column shows the relative sizes of the Current Estimate Scenario Amounts in the next column, with the anticipated experience showing a value of 100%. The corresponding Current Estimate Scenario Amount of $1,000,000,000 equals the Anticipated Experience Reserve.

3. The values in the “Probability Weight” column correspond to the values in the “Percentile Level” column. These weights are applied to the respective Current Estimate Scenario Amounts to derive the values in the “Weighted Amount” column. Adding the values in the “Weighted Amount” column for each Key Risk Driver produces the values in the “Key Risk Driver Amount” column.

B. Aggregating the Key Risk Driver Amounts to calculate the Current Estimate Reserve

1. The weights for aggregating the Key Risk Drivers are computed in the columns “Max-Min” and “% Total” columns.

2. The “Max-Min” values are derived by taking the largest Current Estimate Scenario Amount for each Key Risk Driver and subtracting the smallest Current Estimate Scenario Amount for each Key Risk Driver. Adding these differences together produces the total of $313,990,000 in the spreadsheet.

3. The relative contribution to risk of each Key Risk Driver is then measured by the proportion of the $313,990,000 that each Key Risk Driver represents. Thus, the relative Key Risk Driver of the Interest Key Risk Driver is 91.2%, while the relative weight of the Mortality Key Risk Driver is 4.9%. Note that the Interest Key Risk Driver produces much more volatile results for the Current Estimate Scenario Amounts than do the other Key Risk Drivers. In fact, for this example, the lowest Current Estimate Reserve Amount for the Interest Key Risk Driver is for the anticipated experience. All of the other Current Estimate Scenarios for the Interest Key Risk Driver produce higher Current Estimate Scenario Amounts. Thus, in this case the anticipated assumption produces a value that is significantly different than the 50th percentile value. The Conditional Tail Expectation reserve measure captures this type of results distribution in the Stochastic Reserve, and the RSM calculation of the Current Estimate Reserve captures the results for this type of distribution as well.

4. The Current Estimate Amount is computed as the weighted average of the Key Risk Driver Weights applied to the Key Risk Driver Amounts as derived in 3. Thus, the Current Estimate Reserve is $1,044,604,044. Note that this value is about $44.6 million or 4.5% more than the Anticipated Experience Reserve.

C. Calculating the Excess Asset Needs and the Total Asset Level

1. The right-most column in the example equals the difference between the Current Estimate Reserve in the prior column and the respective Current Estimate Scenario Amounts.

2. The example assumes that the Appointed Actuary determined that the Interest and Lapse Key Risk Drivers are statistically dependent, while the Mortality Key Risk Driver is statistically independent.

3. The Square Root Formula shown in the spreadsheet takes the greatest EAN for each Key Risk Driver and combines them based on their statistical dependence or independence, squares the terms, and then takes the square root of the sum of the terms. This value represents the Excess Asset Needs due to the sensitivity of the Current Estimate Reserve to the statistical variation around the mean for the respective Key Risk Drivers.

4. The Total Asset Level equals the sum of the Current Estimate Reserve and the Excess Asset Needs.
Appendix 3  Questionnaire

Adapted from EIOPA templates. See file eiopa-216-st14-templates.xls.

Appendix 4  Prescribed Economic Scenarios

Adapted from the Supervisory Scenarios for Annual Stress Tests Required under the Dodd-Frank Act Stress Testing Rules and the Capital Plan Rule. See file bcreg20131101a1.pdf.
Appendix 1-Generating Representative Scenarios

Overview

The representative scenarios method for reserve calculation requires representative scenarios for each major risk. A small number of such scenarios are desired, and they are representative in the sense that they correspond to specified percentile levels in the distribution of all stochastic scenarios for that risk.

This User’s Guide is organized into the following sections:

1. Contents of a scenario, and how the information in the scenario is intended to be used.
2. The input that a user must provide to the generator before creating a set of scenarios.
   2.1 Define the set of scenarios to be generated
   2.2 Define the initial economic conditions
   2.3 Define the list of risks and their distributions
3. How a scenario is generated, including the role played by the user’s input.
   3.1 Generating a scenario path for one risk
   3.2 Combining risks in a scenario and sets of scenarios
   3.3 Assigning weights to scenario paths and scenarios

The following appendices address some more technical details:

To do: Draft the appendices

- Appendix 1: A sample specification of all user input to the generator
- Appendix 2: The software interface used to access scenario data in a model
- Appendix 3: Calculating the reserve (To do: decide if this belongs in this document or a different one)
  - Calculating the present value of cash flows from each scenario
  - Weighting scenarios to obtain the anticipated experience reserve
  - Calculating the aggregate margin
1. Contents of a scenario

A scenario contains month-by-month information to be used in a model that simulates the financial results of a block of business in an insurance company. The scenario information for any one month includes both economic conditions and experience levels (e.g. adjustments to expected experience).

The information for each month of each scenario must span all of the risks that are to be simulated using representative scenarios. A sample list of risks and the corresponding scenario information is provided below:

<table>
<thead>
<tr>
<th>Risk</th>
<th>Scenario information for each month</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interest rate risk</strong></td>
<td>Yield curve for government bonds</td>
</tr>
<tr>
<td><strong>Credit risk</strong></td>
<td>Yield spreads and default rates by credit rating</td>
</tr>
<tr>
<td><strong>Equity investment price risk</strong></td>
<td>Returns for each type of investment or equity index</td>
</tr>
<tr>
<td><strong>Expense inflation risk</strong></td>
<td>Inflation rate</td>
</tr>
<tr>
<td><strong>Mortality risk</strong></td>
<td>Adjustments to tabular mortality rates (see discussion below)</td>
</tr>
<tr>
<td><strong>Lapse rate risk</strong></td>
<td>Adjustments to tabular lapse rates (see discussion below)</td>
</tr>
<tr>
<td><strong>GLIB election risk</strong></td>
<td>Adjustments to tabular GLIB election rates (see discussion below)</td>
</tr>
</tbody>
</table>

Scenario adjustments to tabular decrement rates can take two forms: an additive adjustment and/or a multiplicative adjustment. A model uses these adjustments in the following way to calculate the simulated experience decrement rate for a month:

\[
\text{Simulated experience rate} = [(\text{Tabular rate}) \times (\text{multiplicative adjustment})] + (\text{additive adjustment})
\]

Typically, the tabular rate will come from a table with values that vary by age of insured, contract duration, or other parameters. The adjustments for a particular risk (e.g. mortality) are applied across the board to every value in the corresponding table, possibly subject to a maximum or minimum adjusted value.

The reason for allowing both additive and multiplicative adjustments is that when the adjustments are to be applied to a range of values sometimes one or the other type of adjustment is most appropriate. For example, a multiplicative adjustment will have no effect on tabular values of zero, so an additive form of adjustment might be more appropriate for tables that contain zeroes.

Scenario values for information other than adjustments to actuarial decrements such as mortality rates or lapse rates come from specialized generator formulas developed specifically for each risk. For example, interest rates and equity returns are generated using the formulas in the economic scenario generator adopted for VM-20. In the case of GLIB election risk, the generator provides a “sensitivity factor” that can be used to adjust tabular election rates based on the degree of in-the-moneyness. The adjustment of the tabular election rates based on the sensitivity factor is complex and must be built into the simulation model. (To do: explain how this adjustment is done)
The list of risks for which scenario data is generated can vary from product to product when using the representative scenarios method. Certain risks, mainly investment risks, are always included in the list by default. The user must provide input to the scenario generator to specify the additional risks to be simulated and the scenarios to be generated. This user input is discussed in the next section.
2. User input required to define scenarios

2.1 Define the set of scenarios to be generated

While the scenario generator was created to provide scenario sets for the representative scenarios method, the generator can also provide two other kinds of scenario sets. The user must specify which of the following three kinds of output is desired.

- **Representative scenarios.** A small number of scenarios is generated for each risk, each at a specified percentile level in the distribution for the risk. In each percentile level scenario, the values for all risks other than the one being shocked are at the anticipated (median) level. The total number of scenarios is the sum of the number of scenarios for each risk\(^1\).

- **Grid of representative scenarios.** A small number of scenarios is generated for each risk, each at a specified percentile level in the distribution for that risk. But then risks are combined within scenarios so that the scenario set includes a scenario for every combination of percentile levels across risks. The total number of scenarios is the product of the number of percentile level scenarios for each risk. For example, if there are four risks and five percentile level scenarios for each risk, the total number of scenarios is \(5 \times 5 \times 5 \times 5 = 625\).

- **Stochastic scenarios.** A large number of scenarios is generated using random shocks for each risk in each month. The user must specify the number of scenarios to be generated.

2.2 Define the initial economic conditions

The conditions at the beginning of each scenario must be the same, and the user must specify what they are. Therefore the user must specify the following:

- The date from which scenarios start. Since these scenarios are used for valuation, this date can be called the valuation date.
- The risk-free yield curve (for US treasuries) on the valuation date.
- To do: decide whether initial credit spreads and default rate levels need to be specified.

2.3 Define the list of risks and their distributions

The user must define the list of risks to be simulated. Certain risks (e.g. investment risks) are always simulated by default, so the user only needs to specify the additional risks associated with the product for which reserves are to be calculated. The risks that are always simulated by default are:

- Interest rate risk

\(^1\) Actually, the total number of unique scenarios will be slightly smaller because only one scenario with all risks at the anticipated level is required.
• Equity investment price risk
• Expense inflation risk
• To do: decide how credit risk (yield spreads and default rates) will be dealt with. Perhaps we could use the work of the Academy C-1 Work Group and the NAIC Investment RBC Working Group to guide us here.

Typically, the remaining risks that must be specified by the user are associated with actuarial decrements such as mortality rates or lapse rates. For each such decrement that represents a major risk, the user must specify the risk and the type of adjustment factors and must specify certain percentile points on the distribution for each adjustment factor. In particular, the values of each adjustment factor must be specified at the following percentile points:

- 0.1% (-3 standard deviations)
- 16% (-1 standard deviations)
- 50% median
- 84% (+1 standard deviation)
- 99.9% (+3 standard deviations)

These percentile points correspond to the distribution for an actuarial risk such as mortality rates or lapse rates rate over a period of one year. When specifying these percentile points, one can use a technique developed for use in actuarial experience studies. In evaluating observed decrement rates, an actuary needs to evaluate the likelihood that the rate observed from a limited sample is a statistical fluke or outlier and not representative of the true underlying decrement rate. This can be done by estimating the range within which the true rate must fall with a given level of certainty, based on the observed data.

Methods for estimating this range differ depending on whether the experience study provides only raw experience decrement rates or whether the study provides a ratio to some expected experience rate (Actual / Expected or A/E ratio). The next two subsections discuss each case separately.

2.3.1 When the experience study produces only raw decrement rates

Sometimes an experience study provides only a count of policies exposed to risk and a count of observed decrement events. For example, studies of lapse rates are often reported in this manner.

Confidence bounds with a desired probability level within which the true lapse rate (or other decrement rate) falls can be constructed using simple formulas based on the observed number of policies exposed

---

2 While the percentile points for decrement rates correspond to the distribution of a decrement rate over one year, in cases where mortality improvement is included as part of the mortality risk, it is treated differently. The distribution for mortality improvement corresponds to the distribution over all future time. Typically the adjustment for mortality improvement will be a multiplicative adjustment to a tabular mortality improvement scale. The user must provide values of that multiplicative adjustment factor at various percentile levels in its distribution. When a scenario is generated for mortality at a specified percentile level, the multiplicative adjustment factor for mortality improvement will have the same value in every month in the scenario.

3 Sometimes studies are carried out by amount of insurance rather than by policy count. For purposes of developing statistical confidence bounds, however, it is much more straightforward to work with policy counts.
and the observed number of lapses. Generally, the observed number of lapses is not very small so the binomial distribution can be used as a basis for computing the confidence bounds.

The following formulas can be used to calculate confidence bounds for the lapse rate$^4$:

Lower Bound = \frac{\text{Number of Lapses} - Z\sqrt{\text{Number of Lapses} \times (1 - \text{Lapse Rate})}}{\text{Number of Policies Exposed}}

Upper Bound = \frac{\text{Number of Lapses} + Z\sqrt{\text{Number of Lapses} \times (1 - \text{Lapse Rate})}}{\text{Number of Policies Exposed}}

where:

Z = \text{width of the confidence interval in units of 1 standard deviation}. For a 95% confidence interval, Z = 1.96. For a (1-\(\alpha\)) confidence interval, Z is the value of the inverse normal distribution function at 1-(\(\alpha/2\)).

The same formulas can be used for decrements other than lapse rates by using the number of observed decrements and the observed decrement rate in place of the number of lapses and lapse rate.

Suppose an insurer has established a table of lapse rates by issue age, duration and product. (For example, an issue age, duration, product may have 500 lapses and has 10,000 policies exposed in a calendar year resulting in a lapse rate of 0.05.) Using the formulas above, a 95% confidence interval for the lapse rate is from 0.046 to 0.054. Therefore, we can say with 95% confidence that the true lapse rate falls within this interval.

The values required by the generator can also be calculated for this example. First let’s calculate the values for the aggregate observed lapse rate at the five percentile levels that are required:

- 0.1% Value is lower bound with Z = 3 Lapse rate = 0.0435
- 16% Value is lower bound with Z = 1 Lapse rate = 0.0478
- 50% Value is the observed lapse rate Lapse rate = 0.0500
- 84% Value is upper bound with Z = 1 Lapse rate = 0.0522
- 99.9% Value is upper bound with Z = 3 Lapse rate = 0.0565

The generator requires adjustment factors that can be applied to a tabular lapse rate. If we wish for multiplicative adjustment factors, we can calculate them as follows:

- 0.1% Multiplicative adjustment factor is 0.0435 / 0.0500 = 0.870
- 16% Multiplicative adjustment factor is 0.0478 / 0.0500 = 0.956
- 50% Multiplicative adjustment factor is 0.0500 / 0.0500 = 1.000
- 84% Multiplicative adjustment factor is 0.0522 / 0.0500 = 1.044
- 99.9% Multiplicative adjustment factor is 0.0565 / 0.0500 = 1.130

If we wish for additive adjustment factors, we can calculate them as follows:

- 0.1% Additive adjustment factor is 0.0435 - 0.0500 = -0.0065
- 16% Additive adjustment factor is 0.0478 - 0.0500 = -0.0022

$^4$ These formulas are based on the binomial distribution and are appropriate when the observed number of decrements is reasonably large (e.g. over 35).
50% Additive adjustment factor is 0.0500 - 0.0500 = 0.0000
84% Additive adjustment factor is 0.0522 - 0.0500 = +0.0022
99.9% Additive adjustment factor is 0.0565 - 0.0500 = +0.0065

One can use either or both of multiplicative and additive adjustment factors, but double counting must be avoided. If both adjustment factors are used, then each must be reduced (e.g. use 60% of the multiplicative adjustment factor and 40% of the additive adjustment factor derived above).

The choice of whether to use multiplicative or additive forms of adjustments depends on the nature of the decrement being adjusted. The actuary must use judgment in deciding how these adjustments can most realistically be applied in the model.

2.3.2 When the experience study provides an Actual / Expected ratio

Sometimes an experience study involves comparing the actual number of observed events (e.g. deaths) to an expected number. The actual and expected numbers are compared by calculating an Actual to Expected (A/E) ratio. If the A/E ratio is 1.0 then one has evidence that the mortality experience is consistent with the expected basis mortality, and if the A/E ratio is much different from 1.0 then there is evidence that the mortality experience is something other than the expected basis mortality. One can evaluate the strength of that evidence by determining a confidence interval around the observed A/E ratio. The confidence interval can be calibrated to any desired probability level, that is, to any desired probability that the true A/E ratio falls inside the interval.

For example, suppose an insurer studies a block of life insurance contracts and observes 525 deaths during a calendar year. Based on its pricing mortality table, only 500 deaths were expected. The A/E ratio is 1.05.

The following formulas can be used to calculate a confidence interval around the A/E ratio\(^5\).\(^5\)

\[
\text{Lower bound} = \left( \frac{A}{E} \right) \times \left[ 1 - \frac{1}{9 \times A} - \frac{Z}{3 \times \sqrt{A}} \right]^3 \\
\text{Upper bound} = \left( \frac{A+1}{E} \right) \times \left[ 1 - \frac{1}{9 \times (A+1)} + \frac{Z}{3 \times \sqrt{A+1}} \right]^3
\]

where:

\(A = \text{actual deaths}\)
\(E = \text{expected deaths}\)
\(Z = \text{width of the confidence interval in units of 1 standard deviation} \)

For a 95% confidence interval, \(Z = 1.96\). For a \((1-\alpha)\) confidence interval, \(Z\) is the value of the inverse normal distribution function at \(1-(\alpha/2)\).

Using our sample data with an observed A/E ratio of 1.05, we find that a 95% confidence interval for the A/E ratio is from 0.96 to 1.14. Since 1.0 falls inside that interval, we cannot say with 95% confidence that the mortality experience is something other than the expected basis mortality.

\(^5\) These formulas are based on the Poisson distribution which can be more appropriate when the number of actual deaths (or other decrements) is small.
The values required by the generator can also be calculated for this example. Let’s assume we wish to define a multiplicative adjustment factor. Values for that adjustment factor must be specified for the following percentiles:

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1%</td>
<td>Value is lower bound with $Z = 3$</td>
<td>Value = 0.918</td>
</tr>
<tr>
<td>16%</td>
<td>Value is lower bound with $Z = 1$</td>
<td>Value = 1.004</td>
</tr>
<tr>
<td>50%</td>
<td>Value is the A/E ratio</td>
<td>Value = 1.050</td>
</tr>
<tr>
<td>84%</td>
<td>Value is upper bound with $Z = 1$</td>
<td>Value = 1.098</td>
</tr>
<tr>
<td>99.9%</td>
<td>Value is upper bound with $Z = 3$</td>
<td>Value = 1.195</td>
</tr>
</tbody>
</table>

### 2.3.3 A note on the level of experience aggregation

The experience study should be at a level of aggregation corresponding to the block of business for which reserves are being calculated. Normally, decrement rates will come from a table with values that vary by age or other criteria. All values in the tables will be adjusted using the same adjustment factors when scenarios are run through the simulation model. Therefore, the number of claims or other decrement events used in the formulas above can be the total for the full block of business rather than the much smaller subtotals for subgroups by age or other criteria.

### 2.3.4 A note on dynamically linked assumptions

Sometimes a model will dynamically link one assumption to another. For example, lapse rates on fixed annuities may increase when external market interest rates exceed the rate being credited on the contract. The model may set the experience lapse rate equal to a tabular lapse rate plus an adjustment that is a function of interest rates. The adjustments being discussed here are not a replacement for this dynamic behavior. Rather, these adjustments are to be applied in addition to that dynamic behavior. Recall the formula shown earlier:

\[
\text{Simulated experience rate} = [(\text{Tabular rate}) \times (\text{multiplicative adjustment})] + \text{(additive adjustment)}
\]

In this formula, the “tabular rate” is the dynamically adjusted tabular rate. The multiplicative and/or additive adjustments are applied after the dynamic adjustment.

This is important because in some cases, notably lapse rates for some products, the dynamic adjustments create more variability in simulated experience than the statistical variation simulated by the adjustments being discussed here.
3. How a scenario is generated

A separate document titled “Development of Scenarios for the Modeled Reserve”, discusses the analogy between a scenario path for one risk and a random walk. In this section we will review how a representative scenario path for an actuarial decrement risk (mortality) is generated, and then discuss how all risks are combined in sets of scenarios.

3.1 Generating a scenario path for one risk

The following items are needed to generate a scenario path for one risk:

1. A selected path for this representative scenario (e.g. pop-up or 20-year creep-up)
2. A selected percentile level for this representative scenario
3. The list of adjustment factors that simulate changes from anticipated experience for this risk.
4. For each adjustment factor, the value at each of five percentile points on its distribution (0.1%, 16%, 50%, 84%, 99.9%)

As an example, let’s say that the risk is mortality, the selected percentile level is 99.9% (very adverse) and the selected path is pop-up.

Next, we need the list of adjustment factors. For mortality let’s assume we have two adjustment factors:

- A multiplicative adjustment to the mortality rate
- A multiplicative adjustment to the mortality improvement scale

The scenario consists of a value for each adjustment factor in each calendar month. We will calculate the monthly values for each of the two adjustment factors in turn.

Note that the adjustment factors will be the same for each month within a year and will change on a yearly basis. This reflects the fact that the distribution for each adjustment factor is defined based on variability for an annual time period. The adjustment factor for a year is calculated and then used for 12 consecutive months in the scenario path.

The multiplicative adjustment for mortality for each year is based on the pattern of representative shocks in the 99.9% pop-up random walk⁶. Those shocks change on an annual basis; the first few values are:

<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>3.000</td>
</tr>
<tr>
<td>Year 2</td>
<td>1.243</td>
</tr>
<tr>
<td>Year 3</td>
<td>0.954</td>
</tr>
<tr>
<td>Year 4</td>
<td>0.804</td>
</tr>
</tbody>
</table>

---

⁶ The pattern of these shocks was described in “Development of Scenarios for the Modeled Reserve”
These figures are shocks measured in standard deviations. In an earlier example, we derived the distribution for a multiplicative adjustment for mortality, so let’s use that distribution. Values were:

- 99.9% (3 standard errors) 1.195
- 84% (1 standard error) 1.098
- 50% (0 standard error) 1.050
- 16% (-1 standard error) 1.004
- 0.1% (-3 standard errors) 0.918

The monthly values for the multiplicative adjustment are interpolated from this distribution. The first 12 months correspond to the year 1 shock of 3 standard deviations, so they are all equal to 1.195. The second 12 months correspond to the year 2 shock of 1.243 standard deviations, so they are equal to the interpolated value of 1.10 (which is interpolated between 1.195 and 1.098). Continuing in this fashion, one can compute the multiplicative adjustment factor for the mortality rate for each future month.

The other adjustment – the multiplicative adjustment to the mortality improvement scale – is calculated differently because its distribution is defined differently. Mortality improvement is a special case because the distribution is defined not for a single year but for the entire future. The adjustment factor does not change over time so it has the same value every month. The value does not depend on the scenario path (pop-up or creep-up); it depends only on the scenario percentile level. The adjustment factor for every month is equal to the value at the scenario percentile level in its distribution.

Suppose the distribution for the multiplicative adjustment to the mortality improvement scale were defined by the user as follows:

- 99.9% (3 standard errors) 2.00 (e.g. double the rate of improvement in the improvement scale)
- 84% (1 standard error) 1.20
- 50% (0 standard error) 1.00 (e.g. no change to the scale)
- 16% (-1 standard error) 0.80
- 0.1% (-3 standard errors) 0.10

We wish for a scenario at 99.9% (3 standard errors) so the value from this distribution is 2.00 and is the same for every month.

Note that these values for both adjustment factors appear in the same scenario for this risk. While mortality risk may have two aspects (statistical variability and rate of improvement), we are treating them both together as one risk, not two separate risks.

Note that the anticipated experience scenario for mortality must also specify values for each of these adjustment factors. Based on the user’s input of the distributions of these adjustments, the anticipated experience scenario has values of 1.05 for the adjustment to the mortality rate and 1.00 for the adjustment to the mortality improvement scale. Both of these values are the same for every month in the anticipated experience scenario.

---

Since so much judgment is required when setting this distribution, regulators may decide to specify the values to be used.
3.2 Combining risks in a scenario and sets of scenarios

The way risks are combined in a scenario depends on the kind of scenario set that is requested. There are three kinds of scenario sets.

3.2.1 Representative scenarios

A set of representative scenarios for all risks combined starts from the sets of representative scenario paths for each risk. A representative scenario for all risks combined contains one scenario path for each risk, and all risks except one follow their anticipated path.

That is to say, all of the representative scenarios for mortality risk include anticipated experience for all other risks including interest rates, lapse rates, etc. All of the representative scenarios for interest rate risk include anticipated experience for mortality, lapse rates, and so on.

Suppose one has identified four risks, and one has representative scenario paths for each risk at the following percentile levels:

99.9% pop-up
84% pop-up
50% anticipated
16% pop-down
0.1% pop-down

One therefore has four risks and a total of $4 \times 5 = 20$ scenario paths. However, there are just 17 representative scenarios. These are:

Scenario 1: Anticipated path for all four risks
Scenarios 2-5: Anticipated paths for risks 2, 3, and 4, the four other paths for risk 1
Scenarios 6-9: Anticipated paths for risks 1, 3, and 4, the four other paths for risk 2
Scenarios 10-13: Anticipated paths for risks 1, 2, and 4, the four other paths for risk 3
Scenarios 14-17: Anticipated paths for risks 1, 2, and 3, the four other paths for risk 4

Note that when other risk variables are dynamically linked to one particular risk such as interest rates, then the model results for representative scenarios for the linked risk (e.g. interest rates) include the effect of that dynamic link. The link occurs inside the model, and is not part of the scenario data itself.

For example, if lapse rates are dynamically linked to interest rates, a representative scenario defined as focusing on interest rate risk will include anticipated (or median) lapse rates in the scenario definition. However, within the simulation model lapse rates will be adjusted according to the dynamic link to interest rates in the scenario. The dynamic behavior of lapse rates will therefore be quantified as part of the measure of interest rate risk and not as part of lapse rate risk.
3.2.2 Grid of representative scenarios

To make a grid of representative scenarios, we again start with the set of representative scenario paths for each risk. To generate a scenario for all risks combined, we take one scenario path for each risk and put them together. The term “grid” comes from the idea that a grid of representative scenarios includes all permutations and combinations that can be created by picking one scenario path for each risk and combining them into a scenario for all risks combined.

If there are four risks and five paths for each risk, then the number of scenarios in the grid is $5^4 = 625$.

3.2.3 Stochastic scenarios

In a stochastic scenario, each month’s values are generated using a random shock for each risk. The random shocks come from a random number generator seeded with a value based on the scenario number; they are not the formulaic random shocks used for the representative scenarios. The random shocks for each risk are uncorrelated with one another. There is no attempt to make any single scenario representative of a percentile level for any risk. As a result, a large number of scenarios must be generated in order to get a good picture of the distribution of results.

3.3 Assigning weights to scenario paths and scenarios

One must assign a probability weight to each scenario in a set of scenarios so that the results of each scenario can be weighted together to approximate the “mean”. In the representative scenarios method, the reserve is the sum of this “mean” and a “margin” that is based on variations from the mean.

To calculate the weight for a representative scenario or for each scenario in grid, we need the following:

$w_r$ Weight assigned to risk $r$. The sum of these weights must equal 1.0

$p_{r,s}$ Probability weight for scenario path $s$ for risk $r$. The sum of these probability weights for risk $r$ must equal 1.0 for each risk $r$.

Across all risks $r$:

$$\sum_r w_r = 1.0$$

Separately for each risk $r$:

$$\sum_s p_{r,s} = 1.0$$
The weights $w_r$ assigned to each risk may be subjective. No standard approach has been developed to assign these weights. For the field test we will use equal weights.$^8$

The probabilities $p_{r,s}$ assigned to each scenario path will be defined as follows.

Each scenario path corresponds to a specific percentile level in the cumulative distribution of the risk variable. Call that percentile level $P_s$. Using the inverse normal distribution function, we can determine the number of standard errors from the mean corresponding to $P_s$ and call it $E_s = \psi^{-1}(P_s)$.

We will set the weight for scenario $s$ equal to the total probability under the normal bell-shaped curve from $x$-axis point $(E_{s-1} + E_s)/2$ to $(E_s + E_{s+1})/2$. This probability is easily calculated using the cumulative normal distribution function.

$$weight = \psi((E_{s+1} + E_s)/2) - \psi((E_s + E_{s-1})/2)$$

For the outlier scenarios where either $E_{s+1}$ or $E_{s-1}$ does not exist, the corresponding value of $\psi(E)$ is the limiting value of either 1 or 0.

Here is a table illustrating the calculation of these weights:

<table>
<thead>
<tr>
<th>$P_s$</th>
<th>$E_s$</th>
<th>$(E_{s+1} + E_s)/2$</th>
<th>$\psi((E_{s+1} + E_s)/2)$</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>99.9%</td>
<td>3</td>
<td>+infinite</td>
<td>1.000</td>
<td>0.023</td>
</tr>
<tr>
<td>84.1%</td>
<td>1</td>
<td>2</td>
<td>0.977</td>
<td>0.286</td>
</tr>
<tr>
<td>50.0%</td>
<td>0</td>
<td>-0.5</td>
<td>0.309</td>
<td>0.286</td>
</tr>
<tr>
<td>15.9%</td>
<td>-1</td>
<td>-2</td>
<td>0.023</td>
<td>0.023</td>
</tr>
<tr>
<td>0.1%</td>
<td>-3</td>
<td>-infinite</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

The figure below illustrates the concept used for these weights. The normal bell-shaped curve is evident, and there are vertical black lines rising from the points on the x-axis where there are data points to be weighted, that is, at 3, 1, 0, -1, and -3. There is shading under sections of the curve. The area of the shaded sections corresponds to the probability weights. The shaded area around each data point (vertical black line) corresponds to the weight given to the corresponding data point. For example, the green shaded area between x-axis points 0.5 and -0.5 corresponds to the weight given to the data point at 0. The purple shaded area between 2.0 and 0.5 corresponds to the weight given to the data point at 1.0.

$^8$ Other approaches might assign greater weight to risks that exhibit greater variability between scenario path results, or to risks whose distribution of scenario path results appears most skewed.
Note that while the normal curve is used as the basis for the weights applied to the data points, the data values themselves may be skewed. Because of this, it is not likely that the weighted average of the data points will equal the median of the distribution. This means that the mean reserve (before margin) will not equal the present value of cash flows in the anticipated experience (50th percentile) scenario.

In some cases, there may be more than one scenario that corresponds to a given percentile level. For example, there may be both a “pop-up” and a “creep-up” scenario at the same percentile level. In this situation, the weight for that percentile level is divided equally between the scenarios at that percentile level.

With the weights for each scenario path within a risk determined, we can proceed to specifying the weights to be applied to scenarios that combine multiple risks.

### 3.3.1 Weights for representative scenarios

The weights for a representative scenario (not in a grid), other than the anticipated path for all risks, is the following, where risk \( r \) is the one risk not following its anticipated path in this scenario:

\[
\text{weight} = w_r \times p_{r,s}
\]
In this formula, $p_{r,s}$ corresponds to the scenario path weight for the path of risk $r$ in this scenario.

The weight for the anticipated experience scenario in a set of representative scenarios is the remainder after subtracting from 1.0 the weights of all the other scenarios. Or, more directly,

$$\text{weight for anticipated experience} = \sum_r (w_r \times p_{r,\text{anticipated path}})$$

3.3.2 Weights for scenarios in a grid

The weight for each scenario in a grid of representative scenarios is the following:

$$\text{weight} = \frac{\prod_r (w_r \times p_{r,s})}{\prod_r (w_r)}$$

where $p_{r,s}$ corresponds to the path weight for the scenario path of risk $r$ in this scenario.

3.3.3 Weights for stochastic scenarios

In the case of stochastic scenarios the probability weight of each scenario is the same. If there are $N$ scenarios, the weight for each scenario is $1/N$. 
<table>
<thead>
<tr>
<th>Source</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR029 Business Risk Column (2) Lines (12) + (24) + (36)</td>
<td>(1) RBC</td>
</tr>
<tr>
<td>LR029 Business Risk Column (2) Line (39)</td>
<td></td>
</tr>
<tr>
<td>Lines (59) + (60)</td>
<td></td>
</tr>
<tr>
<td>LR030 Calculation of Tax Effect for Life Risk-Based Capital Column (2) Line (143)</td>
<td></td>
</tr>
<tr>
<td>Line (61) - Line (62)</td>
<td></td>
</tr>
<tr>
<td>LR029 Business Risk Column (2) Line (57)</td>
<td></td>
</tr>
<tr>
<td>LR032 Stress Testing Results Column (1) the greater of Line (8.1) or Line (8.4)</td>
<td></td>
</tr>
<tr>
<td>Line (67) + Line (68)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>L(11)+L(63) + Square Root of [(L(42) + L(52))^2 + (L(20) + L(58))^2 + L(49)^2 + L(55)^2 + L(66)^2]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>LINE (71) x 0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>L(9)+L(61) + Square Root of [(L(40) + L(50))^2 + (L(18) + L(56))^2 + L(47)^2 + L(53)^2 + L(64)^2]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>LINE (71) x 0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>(1)</td>
<td>Current Estimate Results Plus the Unadjusted Excess Asset Needs</td>
</tr>
<tr>
<td>(2)</td>
<td>Current Estimate Results Plus the Excess Asset Needs</td>
</tr>
<tr>
<td>(3)</td>
<td>Aggregate reserves for life contracts</td>
</tr>
<tr>
<td>(4)</td>
<td>Aggregate reserves for accident and health contracts</td>
</tr>
<tr>
<td>(5)</td>
<td>Interest maintenance reserve</td>
</tr>
<tr>
<td>(6)</td>
<td>Total Adjusted Capital</td>
</tr>
<tr>
<td>(6.1)</td>
<td>Total Adjusted Capital, Reserves and Interest Maintenance Reserve</td>
</tr>
<tr>
<td>(7)</td>
<td>Total Risk-Based Capital After Covariance</td>
</tr>
<tr>
<td>(7.1)</td>
<td>Asset Valuation Reserve not utilized in asset adequacy testing</td>
</tr>
<tr>
<td>(7.2)</td>
<td>Formula-Based Total Asset Requirement</td>
</tr>
<tr>
<td>(8)</td>
<td>If Line (7.2) is greater than Line (2), formula RBC result is adequate.</td>
</tr>
<tr>
<td>(8.1)</td>
<td>If Line (7.2) is less than Line (2) and Line (6.1) is greater than Line (1), RBC is adjusted but no further stress testing is required.</td>
</tr>
<tr>
<td>(8.2)</td>
<td>If Line (7.2) is less than Line (2) and Line (6.1) is less than Line (1), complete questionnaire and show the Line (1) equivalent of the required additional stress testing.</td>
</tr>
<tr>
<td>(8.3)</td>
<td>Line (8.2) Adjusted for Covariance</td>
</tr>
<tr>
<td>(8.4)</td>
<td>RBC adjustment based on additional required stress testing</td>
</tr>
</tbody>
</table>