Report on Principle-Based Reserve Modeling
for Long-Term Care (LTC) Insurance

The American Academy of Actuaries'[1] LTC Principle-Based Reserves Work Group

Presented to the National Association of Insurance Commissioners'
Health Actuarial Task Force

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[1] The American Academy of Actuaries is an 18,500+ member professional association whose mission is to serve the public and the U.S. actuarial profession. The Academy assists public policymakers on all levels by providing leadership, objective expertise, and actuarial advice on risk and financial security issues. The Academy also sets qualification, practice, and professionalism standards for actuaries in the United States.

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I. Introduction

A. Overview

This report describes the work performed by the American Academy of Actuaries' (Academy) LTC Principle-Based Reserves Work Group on modeling of long-term care insurance under a principle-based approach (PBA). This work serves to demonstrate the feasibility of one modeling method and to provide a resource for future modeling investigation. A Monte Carlo approach is used to model process risk associated with morbidity and persistency. Further research is needed on how to integrate parameter risk into the model in order to calculate principle-based reserves.

B. Background

The LTC Principle-Based Reserves Work Group was formed as a part of the Academy's effort to assist the (then) Life and Health Actuarial Task Force of the National Association of Insurance Commissioners (NAIC) in exploring a principle-based approach to LTC insurance.

The work group was divided into two subgroups. The Issue Subgroup examined the challenges in implementing a PBA to LTC reserves. The list of issues contemplated by the Issue Subgroup is shown in Appendix 1. The Model Subgroup was charged to construct a prototype model under such an approach. This report focuses on the work of the Model Subgroup.

For the purpose of demonstration, the work group developed a stochastic model in Microsoft Excel® that generates scenarios of future cash flows for a hypothetical block of in-force LTC policies. On a seriatim basis, the model simulates policies in active, disabled, and out-of-force states as well as movements among these states.

This report first describes the objectives of the model, its functionalities and structure, assumptions employed, and the modeling process. Results from simulation and analysis of such results are then presented. Also included is a discussion of the potential areas for refinements.

The Excel model is available from the Academy.[2]

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[2] This model is a prototype version and is not designed or intended to be relied upon for any purpose other than creating illustrative examples of its use. This model is provided on "AS IS" basis without warranty of any kind. The American Academy of Actuaries will not provide any debugging or other repair or technical support due to possible coding issues in this prototype.

II. Model Objectives

A. Principle-Based Approach

PBA reserving has been a focus of regulators and the Academy for several years. According to the Academy's Life Practice Council Consistency Work Group,[3] which had analyzed application of PBA to life and other reserves, this conceptual approach:

1. "Captures the benefits and guarantees associated with the contracts and their identifiable, quantifiable, and material risks, including 'tail risks' and the funding of those risks;

2. Utilizes risk analysis and risk management techniques to quantify the risks and is guided by the evolving practice and expanding knowledge in the measurement and management of risk;

3. Incorporates assumptions, risk analysis methods, and models and management techniques that are consistent with those utilized within the company's overall risk assessment process;

4. Utilizes company experience, based on the availability of relevant company data and its degree of credibility, to establish assumptions for risks over which the company has some degree of control or influence;

5. Incorporates assumptions that, when viewed in the aggregate, reflect the appropriate level of conservatism and, together with the methods utilized, recognize the solvency objective of statutory reporting; and

6. Reflects risks and risk factors in the calculation of the PBA minimum statutory reserves and statutory risk-based capital (RBC) that may be different from one another and may change over time as products and risk measurement techniques evolve, both in a general sense and within the company's risk management processes."

The Consistency Work Group also provided input to Academy work groups on the purposes and risks associated with reserves and risk-based capital for life and annuity products under PBA. The input is equally applicable to accident and health products.

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[3] Academy of Actuaries' Life Consistency Work Group Report to the NAIC's Life and Health Actuarial Task Force, September 5, 2007. The work group has since been disbanded.

Unlike formulaic reserving, principle-based reserving involves holistically assessing all relevant risks specific to the policies and the company in the quantification of future liabilities. Such a PBA to reserving has been adopted by the NAIC and advanced for life and annuity products much more so than for accident and health insurance. Life and annuity principle-based reserving approaches have a strong investment risk focus. In contrast, accident and health policies are primarily concerned with benefit risk. LTC insurance is the first attempt to focus on the potential issues of principle-based reserving specific to accident and health insurance.

In recognition of the product complexity, the LTC PBR work group identified the following desirable objectives for a principle-based model to evaluate LTC liabilities:

1. Quantify the degree of variability of results,

2. Address the major categories of risk associated with LTC insurance,

3. Account for dynamic changes of the actions taken on the policies, and

4. Serve as a prototype with adequate functionality from which refined models can be developed.

It should be noted that the stochastic model developed by the work group analyzed the morbidity and persistency process risk of LTC insurance. To address all of the items noted by the Consistency Work Group above, additional modeling would need to be completed that analyzed parameter risk and layered in interest rate risk. As such, this model should be looked at as a first step in the process.

B. Risk Categories

The above objectives formed the basis for specific requirements of the model. A stochastic model that simulates the future financial performance of a block of LTC insurance policies over a range of scenarios can produce more useful results for a principle-based analysis than the traditional point estimates from a deterministic model.

Major risks associated with such a block would need to be considered in the model. The major risk drivers for LTC insurance are mortality, morbidity, lapse, expense, and investment return. Mortality risk involves both active lives and disabled lives. Morbidity risk consists of claim incidence, claim termination, and benefit utilization.[4] Several of these risks are volatile and subject to trends. They are also path dependent and the risk distributions are skewed, generally toward long policy durations and old attained ages. A stochastic model can provide good insight on the "tail" of the aggregate risk distribution.

A block of LTC in-force business consists of an active population and a disabled population. In the course of the lifetime of the block, active policyholders will claim benefits, lapse, or die, and the disabled claimants will either die, recover, or reach the benefit maximum. The model should capture the financial impact of these activities and their interaction as realistically as possible.

A principle-based reserve under stochastic modeling is a relatively new concept and has mostly been applied to life insurance investigating interest rate sensitivity. The work group recognized at the onset that stochastic simulation of multiple risk drivers is a complex task. Its charge is not to develop a fully functional model but to demonstrate that such a model is feasible. The work group hopes the model can serve as an example from which more sophisticated models can be developed.

C. Model Limitations

While expense risk can be material, it is fairly predictable and controllable. Accordingly, the work group decided not to model expense risk.

Even though there is no strong evidence, correlation can exist between interest rate and other risk factors, namely, claim incidence, claim severity, and expense. Conceptually, investment risk can be modeled to interact with the other risks. However, simulating investment risk stochastically along with these risks would greatly complicate the model. Therefore, the work group decided to exclude investment income simulation. Assuming independence among the interest rate and other risk factors, investment return sensitivity can be incorporated into the valuation

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4 Many LTC policies reimburse actual expenses subject to limits. Utilization refers to difference between actual daily (or monthly) benefit payments and the daily maximum as specified in the policy contract.

by combining asset cash flow scenarios provided by an economic scenario generator with the liability cash flow scenarios.

As guaranteed renewable policies, LTC insurance premiums can be adjusted based on emerging experience so that a proper relationship between premiums and benefits is maintained. The process of premium rate adjustment involves the timing of the rate adjustment from management's decision, the amount of adjustment, as well as the time period between rate filing for regulatory approval and implementation of the rate action. For simplicity's sake, the model does not simulate rate adjustment actions. As described later, the model can be modified to account for the effect of such activities.

For each of these risk drivers, there is both process risk and parameter risk. Process risk is the risk that actual results will vary from model assumptions due to statistical fluctuation. Parameter risk is the risk that the underlying assumptions fail to represent the true characteristics of the risks. For LTC insurance, parameter risk has been elusive to quantify for individual companies. It is the work group's opinion that modeling of parameter risk is highly individualized to the companies and is best left for the companies to implement. Thus, the work group made no attempt to model parameter risk. It is expected that companies will incorporate their own specific treatment of LTC parameter risk[5] for a comprehensive modeling system.

Because this model is a demonstration, simplifying assumptions have been made without loss of generality. Excel was chosen as the modeling platform in order to make the model usable to all potential users while maintaining transparency. The drawback is that run time is relatively long even for a few thousand policies. This is the case even with simplifying assumptions.

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5 As an example, a company may fit its assumptions (e.g., incidence, claim recovery, etc.) to probability distributions. Alternatively, it may create discrete probability distributions to represent the ranges of potential risk scenarios.

III. Model Description

The model is intended to examine process risk for key variables. Several simulation techniques (described below) were proposed and compared with respect to their capabilities to achieve the stated objectives. The waiting time technique was chosen and simulation routines were programmed in Excel. The results of the routines are the components for liability cash flow projections. As with any model, it has its strengths and weaknesses and these are discussed further below.

A. Model Alternatives

The work group's task was to construct a stochastic model that simulates financial results for a block of LTC policies. The work group assessed the following four simulation techniques that could potentially accomplish this goal.

1. Random Walk by Policy

   Under this method, each policy is processed individually. According to a set of probabilities for each state (i.e., active, lapse, death, claim incurrence, claim recovery, or death during claim),[6] a random number is generated at each time interval to determine whether a policyholder enters into a new state. This process is repeated for all other policies in a trial for a pre-determined number of trials.

2. Random Walk by Duration

   This method is similar to Random Walk by Policy except that every policy is processed within a time interval. At the first time interval, every policyholder's state is determined by a random number that tests the probability of change in status during the interval. This process is repeated for all subsequent time intervals within a trial.

3. Simulation with Pre-Process Look Up

   Instead of processing each policy for each time interval sequentially, this method first determines all possible paths of states for all policies. Then, using a random number, a specific path for each policy is picked.

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[6] Lapse and death are terminal states. The model assumes that premiums are waived when the policyholder is on claim. Thus, there is no lapse while on claim. Once recovered, the policyholder may claim again.

4. Waiting Time

This method involves a two-step process to determine the state of a policyholder, where one random number is drawn to determine the timing of the next change in state, and another is drawn to determine the new state.

From a programming perspective, the random walk models and the pre-process model are fairly straightforward. Either by policy or by time interval, the random walk involves looping through the respective elements. Once all the paths are specified, the pre-process approach is even simpler. The waiting time model is the most complex to program because each decrement involves two steps to determine its outcome.

On the other hand, coding complexity reduces the run time in Excel. The waiting time model is the fastest to process. However, it is still quite time consuming to simulate a block of a few thousand policies. Next fastest is the pre-process model because a significant amount of work has been prepared. The random walk models are the slowest as each policy and each time interval are processed sequentially.

One of the more important considerations in choosing a simulation technique is the ease to simulate management actions due to experience. This effectively rules out the pre-process model because the pre-processed paths would need to be re-determined for every management action. In a similar manner, the random walk by policy model also would require re-determining future events for all in-force policies whenever an action is to take place. The remaining two techniques are more readily adaptable to accommodate management actions.

The Model Subgroup ultimately selected the waiting time model due to its time efficiency and versatility in meeting the most model objectives.

B. Functionalities

The model is designed to project a series of liability cash flows over a pre-determined number of random trials of a block of in-force policies on a seriatim basis. The approach follows a stochastic process to determine when each policyholder will have his/her next active event (i.e., lapse, death, or incidence). The model calculates the premiums, commissions, and other expenses for the period prior to the event date. If the event is a lapse or death, the model closes that trial and moves to the next trial. If the event is a claim, another stochastic process begins to determine when the next disabled event (i.e., death, recovery) will occur. Again, the model calculates the claim payments, commissions, and other expenses for the period prior to the next event date. If this second event is a death, the model closes that trial and moves to the next trial. If the event is a recovery, the policy is returned to active status and the process for active event begins again. The approach as described was used due largely to its efficiency with respect to run time. It relies on the use of hazard rates for each of the decrements.

Depending on the incidence and recovery rates, a policy may change from active state to disabled state a number of times. The model includes a fail-safe limit that prevents this from happening. One would ideally assume that an individual who recovers from being on claim may have different active mortality, lapse, and incidence rates. The work group did adjust the lapse, mortality, and incidence assumptions for the recovered population; however, the deterministic tool used to validate the stochastic results could not make such adjustments. Accordingly, these assumption differences were removed from the stochastic model.

The final product of the model is a monthly liability cash flow projection statement for each trial summarizing the premiums, commissions, claim payments, and other expenses for all policies. Typically, 1,000 trials were run for each analysis described in the latter portion of this report. This information was transferred to a separate Excel workbook that calculates present values, means, variances, conditional tail expectations, and other statistics for analysis.

C. Model Structure

The model is an Excel workbook that consists of a series of worksheets and underlying Visual Basic codes. There are worksheets for run control, policy records, model assumptions, stochastic modeling, and trial results and model summaries. All actuarial calculations are in the worksheets. The Visual Basic codes deal only with looping routines for the trials and policies. Appendix 2 provides a description of the worksheets.

The run control worksheet specifies the number of simulations per policy, the set of model assumptions, and the set of policies to be modeled. Policy records provide relevant information on policies being modeled. It includes policyholder and policy feature data.

The assumptions used for stochastic projections of policy activities are contained in separate worksheets unique to each class of assumptions. The assumptions are in the form of rate tables for active life mortality, lapse, claim incidence, recovery, and disabled mortality. There are also worksheets for benefit utilization, interest, regional factors, and other items. Claims can be either for facility care[7] or home health care. Thus, separate facility and home care assumptions are supplied for claim incidence, recovery and benefit utilization. Expense assumptions are expressed as per policy in force and percentages of premiums and paid claims.

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[7] The model assumptions can be readily expanded to distinguish between nursing home care and assisted living facility care.

Stochastic trials are created in the modeling worksheets for active lives, disabled lives, and recoveries. The outcome of each trial and each policy are recorded in other worksheets. Financial results from the trials are calculated in the Stochastic Active, Stochastic Claims, and Stochastic Recoveries worksheets and summarized in the Trial Summary worksheet.

The assumptions used in the model are high-level estimates developed by committee members using data from the 1984-2007 SOA Intercompany Experience. As the focus of the committee work was to develop a prototype model, the assumptions are only illustrative. A summary of assumptions is provided in Appendix 3.

Morbidity and mortality improvement were not included in the base set of assumptions. Future model refinement can incorporate these items.

D. Process

1. Active Lives Simulation

A pre-selected number of stochastic trials are performed for each policy that is in force at the beginning of the projection period. No policy is assumed to be in a disabled state at the beginning. For a given policy and for each trial, a random number is generated to determine when the next event will take place. This is accomplished by combining the survival rates for each contingency (facility care incidence, home care incidence, lapse, and active life mortality). The probability of survival for a contingent event *m* of an individual with issue age *x* at time *t* is represented by ${}_{t}p^{m}{}_{x}$. The probability of survival is monotonically decreasing from 1 to 0 through future time periods. These probabilities can be aggregated and the probability of survival of all contingent events is also monotonically decreasing from 1 to 0 as time passes. A random number between 0 and 1 can then designate the timing of the occurrence of the next event.

The probabilities are provided on an annual basis. These are converted to monthly probabilities using the Uniform Distribution. The timing of the event is linearly interpolated to a specific day.

The survival rate of an event *m* for a short interval *k* can be converted to a hazard rate as follows:

$$H^{m}{}_{x+t} = \log {}_{k}p^{m}{}_{x+t}.$$

The hazard rates are additive to arrive at the total hazard rate. Thus, the conditional probability that a specific event occurs, knowing that an event has occurred, is:

$$H^{m}{}_{x+t} \;/\; \Sigma_{\text{all } s} H^{s}{}_{x+t} \,,$$

where all *s* refers to facility care incidence, home care incidence, lapse, and mortality.

Based on the cumulative probability distribution of this set of probabilities, another random number between 0 and 1 is generated to determine which specific contingent event has occurred. Appendix 4 is a detailed description of the worksheet "Stochastic Active" where the model simulates events for active lives.

Lapse and death are terminal states. When the stochastic process determines either of these events, the model records the cash flow to the event date and moves on to the next trial for the policy.

2. Disabled Lives Simulation

For each claim that the active life stochastic process deems to have occurred, a similar two-stage stochastic process determines the timing of the next event during claim based on the aggregate survival probabilities. The aggregate survival probabilities are the combination of recovery and mortality survival probabilities while on claim. These probabilities vary by care setting (i.e., facility care or home care) and are also monotonically decreasing.

Once the date of the event is selected, it is compared to the date at which benefits could be exhausted due to a lifetime benefit maximum expressed either in dollars or days. The trial will be terminated at the benefit exhaustion date if it precedes the date of the next event. At that point, the model records the cash flow to the exhaustion date and moves on to the next trial for the policy.

If benefits are not exhausted, a second random number determines whether the event is death or recovery. This is accomplished by forming the probability distribution of claim termination events based the ratios of the hazard functions:

$$H^{r}_{x+t} \,/\, (H^{r}_{x+t} + H^{d}_{x+t}) \text{ and } H^{d}_{x+t} \,/\, (H^{r}_{x+t} + H^{d}_{x+t}),$$

where *r* is the recovery state and *d* is the death state.

If the event is death, the trial for that policy is complete and as before, the model records the cash flow and proceeds with the next trial. If the event is recovery, the policy becomes active again and the model repeats the active lives simulation for this policy from the recovery date. This process continues until the end of the policy's coverage period or until the maximum number of recoveries for a trial is reached. Then a new trial for this policy begins. When the maximum number of trials is reached, the model moves on to the next policy record.

Appendix 5 is a schematic illustration of the stochastic simulation in the model.

3. Cash Flow Projection

For each trial, all future activities of each policy are determined. Cash flow as a result of such activities can then be calculated for premiums, claim payments, and expenses. Cash flow for a given trial for the entire block of policies is the sum of the cash flow for each individual policy.

E. Strengths and Limitations

Strengths and limitations of the Monte Carlo approach as employed in the model:

1. Strengths:

- Correctly captures the benefits and guarantees of the insurance contracts, even for path-dependent benefits.
- Facilitates the quantification of process risk.
- Logical framework for integrating parameter risk.
- Can be used to calculate prediction intervals, which can be used to define the triggers of rate increases.

2. Limitation:

- Simulation software is required.
- Additional calculation time.
- Results can be influenced by number of trials run.

Strengths and limitations of Excel model:

1. Strengths:

- Formulas are transparent.
- Handle multiple risks in multiple states on a stochastic basis.
- Easily understood by anyone with Excel knowledge.
- Can be enhanced to handle many other features, such as disabled lives at the start of the projection, policyholder behavior, and so on.

2. Limitations:

- Excel has little ability to automatically distribute processing over a server farm. This caused very lengthy run times (e.g., a single trial

for 6,000 policies took approximately one hour on most workstations).
- Excel workbook size limited the number of trials run at one time
- Only process risk is measured.
- Stochastic interest rate generators could not be easily integrated.
- Validation of the model by comparison to a deterministic model was a lengthy process.

IV. Modeling Results

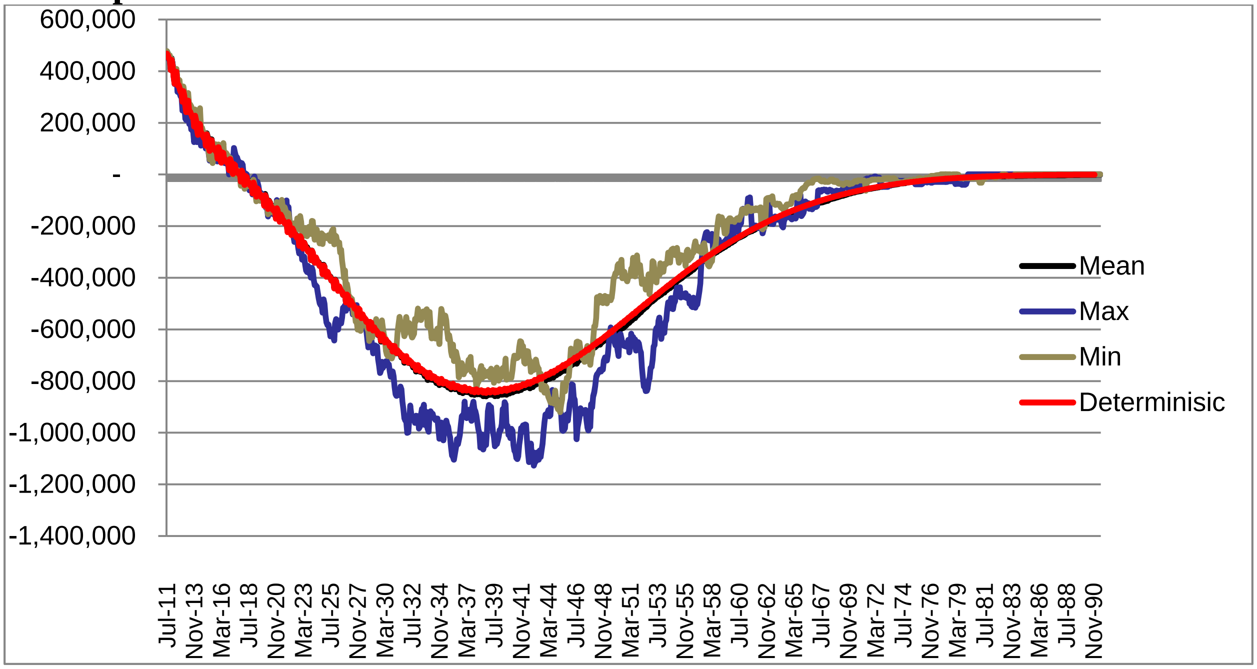
A. Calibration

The mean of the tested stochastic scenarios is expected to be close to the deterministic run—particularly as more scenarios are run. This is the result of a model that is designed to test process risk for an assumed known stochastic process. To the extent that the parameters are unknown, there is an additional level of variability that should be taken into account. The prototype model accounts for the stochastic process and variability around the distributions for key variables. Additional variability around the parameters of each distribution is discussed briefly in the section on Sensitivity Runs below.

The results of the calibration of the deterministic and stochastic processes are shown in Figure 1 below. As expected, the mean of the deterministic run aligns well with the mean of the stochastic run. The variability in cash flows for the minimum and maximum scenario is also shown.

Figure 1

Comparison to Deterministic In-force Block of LTC Insurance Cash Flows



Based on Calibration Model

The mean, min, and max are calculated as a present value over the life of the block. Therefore, the min and max may be outside the mean at specific calendar points in time.

B. Discussion of Results

1. Stochastic Run Base Statistics

The base run contains approximately 6,000 policies. The mean of 1,000 scenarios run is $87 millon (discounted liability cash flows at 4 percent). The model also produces several summary statistics. These include CTE values, maximum scenario, minimum scenario, variance, skewness, kurtosis, and standard deviation (see baseline in Figure 2).

Skewness is a measure of symmetry, or the lack of symmetry, of a distribution. A distribution is symmetric if it looks the same to the left and right of the center point. Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. Data sets with high kurtosis generally have a peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis generally have a flat top near the mean rather than a sharp peak. A uniform distribution would be the extreme case.

2. Sensitivity Runs

Several sensitivity runs were made from the base case. They include changes to incidence rates, lapse rates, mortality rates, and claim termination rates. The results are presented in Figure 2.

In one example, the run with incidence rates increased 10 percent produced a higher mean. The standard deviation relative to the mean is decreased for this scenario. This might be expected, as higher frequency will result in statistically less variability. Similarly, the CTE as a percentage decreases for this scenario. The remaining sensitivities provided results consistent with expectations. For example, a decrease in claim termination rate resulted in an increase in the mean cash flow.

Simulation on a block with approximately 20,000 policies also provided results as expected. The block of 20,000 policies is a different block with different demographic and policy characteristics from the block of 6,000 policies from Figure 2. The block of 20,000 policies was used to examine the impact of different numbers of trials as well as the impact of only using a subset of the 20,000 policies. The results are shown in figures 3 and 4.

Figure 2

	Base	Incidence Plus 10%	Incidence Minus 10%	Active Mortality Minus 10%	Active Mortality Plus 10%	Lapse Minus 10%	Lapse Plus 10%	Termination Rates Minus 10%	Termination Rates Plus 10%	Disabled Mortality Minus 10%	Disabled Mortality Plus 10%
Mean	87,130,339	99,228,164	74,036,463	94,746,011	79,743,854	89,059,886	84,990,723	106,441,036	64,875,578	89,193,139	86,127,410
Max	106,262,080	117,344,432	92,581,823	110,851,459	95,971,859	104,612,658	103,492,245	130,144,228	78,913,250	106,992,158	102,153,501
Min	72,487,960	80,432,369	59,192,117	80,400,667	65,097,151	73,983,402	66,699,952	84,682,723	51,163,421	73,497,992	67,437,356
Skew ness	0.138	0.058	0.21	0.089	0.114	0.003	0.15	0.128	0.207	0.221	0.074
Kurtosis	0.168	-0.146	0.278	-0.05	-0.064	-0.39	0.209	0.345	0	-0.02	-0.053
Std Dev	5,261,055	5,638,591	4,949,694	5,292,701	5,059,687	5,305,730	5,396,088	6,203,420	4,886,085	5,283,433	5,207,034
Std Dev / Mean	6.00%	5.70%	6.70%	5.60%	6.34%	6.00%	6.30%	5.80%	7.50%	5.90%	6.00%
CTE 0	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
CTE 10	101.20%	101.10%	101.30%	101.10%	101.21%	101.10%	101.20%	101.10%	101.40%	101.10%	101.10%
CTE 20	102.10%	102.00%	102.30%	101.90%	102.19%	102.10%	102.10%	102.00%	102.50%	102.00%	102.10%
CTE 30	102.90%	102.80%	103.20%	102.70%	103.15%	103.00%	103.10%	102.90%	103.60%	102.90%	103.00%
CTE 40	103.80%	103.70%	104.20%	103.60%	104.10%	103.90%	104.00%	103.70%	104.70%	103.70%	103.90%
CTE 50	104.80%	104.50%	105.30%	104.40%	105.07%	104.90%	105.00%	104.50%	106.00%	104.70%	104.90%
CTE 60	105.80%	105.50%	106.40%	105.40%	106.13%	105.90%	106.10%	105.50%	107.30%	105.80%	105.90%
CTE 70	107.10%	106.60%	107.80%	106.50%	107.37%	107.00%	107.50%	106.70%	108.90%	107.00%	107.10%
CTE 80	108.60%	108.10%	109.50%	108.00%	108.98%	108.30%	109.10%	108.30%	110.90%	108.70%	108.50%
CTE 90	110.80%	110.20%	112.30%	110.10%	111.41%	110.30%	111.50%	110.60%	114.10%	110.90%	110.70%
CTE 95	112.80%	111.70%	115.00%	111.80%	113.52%	111.70%	113.70%	112.60%	116.60%	112.80%	112.70%
CTE 99	117.80%	114.70%	119.90%	115.10%	117.62%	114.80%	118.40%	117.10%	120.20%	116.60%	116.20%

Based on model developed by the work group

Figure 3

	20,000 Policies 1,000 Trials	20,000 Policies 500 Trials	20,000 Policies 250 Trials	20,000 Policies 100 Trials	20,000 Policies 50 Trials
Mean	992,070,433	991,767,487	991,756,622	989,376,591	991,123,731
Max	1,066,800,584	1,066,800,584	1,054,178,361	1,059,162,106	1,043,051,499
Min	909,037,318	917,701,703	909,037,318	934,938,481	928,280,979
Skewness	-0.100	0.012	-0.253	0.019	-0.207
Kurtosis	-0.143	-0.329	-0.152	0.171	-0.078
Std Dev	23,909,914	24,154,071	25,302,861	23,858,725	25,644,063
Std Dev / Mean	2.41%	2.44%	2.55%	2.41%	2.59%
CTE 0	100.00%	100.00%	100.00%	100.00%	100.00%
CTE 10	100.47%	100.45%	100.49%	100.48%	100.53%
CTE 20	100.86%	100.84%	100.93%	100.85%	100.92%
CTE 30	101.22%	101.21%	101.30%	101.17%	101.30%
CTE 40	101.58%	101.59%	101.68%	101.52%	101.66%
CTE 50	101.95%	101.98%	102.05%	101.90%	102.07%
CTE 60	102.33%	102.39%	102.42%	102.29%	102.45%
CTE 70	102.77%	102.87%	102.84%	102.75%	102.87%
CTE 80	103.32%	103.42%	103.37%	103.33%	103.42%
CTE 90	104.09%	104.13%	104.11%	104.24%	104.39%
CTE 95	104.71%	104.67%	104.72%	104.93%	105.04%
CTE 99	106.09%	106.03%	105.87%	107.05%	N/A

Based on model developed by the work group

Figure 4

	20,000 Policies 1,000 Trials	10,000 Policies 1,000 Trials	5,000 Policies 1,000 Trials	2,000 Policies 1,000 Trials	1,000 Policies 1,000 Trials
Mean	992,070,433	503,831,131	253,600,470	99,760,062	51,250,402
Max	1,066,800,584	568,549,998	294,470,249	126,929,230	73,465,524
Min	909,037,318	440,722,498	215,414,629	77,127,088	34,825,135
Skewness	-0.100	0.055	0.151	0.128	0.260
Kurtosis	-0.143	0.057	-0.154	0.093	0.396
Std Dev	23,909,914	17,678,809	12,605,935	7,756,196	5,511,890
Std Dev / Mean	2.41%	3.51%	4.97%	7.77%	10.75%
CTE 0	100.00%	100.00%	100.00%	100.00%	100.00%
CTE 10	100.47%	100.67%	100.92%	101.48%	101.98%
CTE 20	100.86%	101.21%	101.69%	102.67%	103.61%
CTE 30	101.22%	101.73%	102.44%	103.80%	105.20%
CTE 40	101.58%	102.24%	103.22%	104.97%	106.81%
CTE 50	101.95%	102.79%	104.02%	106.16%	108.51%
CTE 60	102.33%	103.41%	104.90%	107.49%	110.40%
CTE 70	102.77%	104.12%	105.87%	109.04%	112.60%
CTE 80	103.32%	104.98%	107.06%	111.05%	115.37%
CTE 90	104.09%	106.16%	108.90%	114.12%	119.61%
CTE 95	104.71%	107.25%	110.59%	116.58%	123.83%
CTE 99	106.09%	109.73%	113.65%	121.87%	133.63%

Based on model developed by the work group

V. Future Refinements and Other Model Considerations

A. Future Refinements

Refinements of the model can be classified into two categories. The first category will extend the range of policy features in the model. This category expands the assumption set to include the following:

- Spousal and underwriting class discounts,
- Assisted living facility care setting,
- Restoration of benefit rider,
- Joint life coverage, and
- Separate morbidity assumptions for recovered policyholders.

The second category would add functionalities for the model in order to be more realistic.

1. Management Rate Action

The aggregate cash flow for the block in any given trial provides information on financial performance. Using a cumulative loss ratio trigger, the timing of necessary rate actions can be identified by product. The effective date and the level of the rate increase will depend on the assumed loss ratio trigger point, the time period for rate filing approval, and the ratio of requested rate increase over the approved increase.

Rate increases may cause higher lapses (commonly referred to as shock lapses) and election of lower benefits. Both actions also may result in future higher morbidity due to adverse selection. From the effective date of a rate increase in a given trial, these assumptions may need to change as well as the premiums. A new simulation process will start on the rate increase effective date for each affected policy on each trial being subject to the rate increase. When all the trials have been completed, new future cash flows are generated from the effective date and the loss ratio trigger is again tested. Rate decreases would be handled in a similar fashion. The new trigger determination may, in turn, cause further rate actions. This process will repeat until no more rate action is needed.

Simulating future rate increases in a PBR model needs careful consideration. Projecting a rate increase merely when there is an unfavorable scenario may have the unintended consequence of lowering the PBR. The appropriate management action methodology needs to consider and harmonize triggers for rate increases and margins for moderately adverse experience.

2. Other functionalities include the following:

- Accommodate policy feature or benefit changes initiated by the policyholders.
- Incorporate trends (other than those related to rate increases) in the model. This includes, for example, changes in utilization pattern for claimants of policies with inflation protection features.
- Dynamically combine interest rate scenarios with liability scenarios to reflect policyholders' behavior and expenses under various interest rate environments.
- Simulate the existing claims in a block of LTC policies as of the projection date.
- Accommodate combination policies.

B. Other Model Considerations

1. Current valuation standards for LTC include prescribed reserve method, mortality table, lapse rates, and discount rate. Specific morbidity assumptions are not prescribed with current reserving. Due to adverse experience, a number of insurers have periodically performed premium deficiency tests on their LTC blocks, which may involve scenario testing. Such tests, employing best-estimate assumptions as a starting point, can be considered as a deterministic form of a PBA.

2. The Excel model simulates multi-stage claims incurral, recoveries, and disabled life mortality events. Other, simpler models are possible. For example, one stochastic model involves stochastic simulation of incidence only under the presumption that claim severity is relatively stable. Simple models will reduce run time.

3. The stochastic model is naturally dependent on the assumptions supplied. The model provides illustrative assumptions only. In determining PBR, prudent assumptions would be used which may include margins for adverse experience deviation which may or may not include parameter risk.

Appendix 1

Summary of Issues Relating to PBA for LTC

Issue	Description
Ongoing changes in products and marketplace	Valuation model may apply to all in-force policies with assumptions not anticipated in original pricing of recent business.
Management rate adjustment actions	How to reflect rate adjustment potential in future cash flow scenarios? Management policy on trigger points beyond moderately adverse experience.
Probability distributions for morbidity and persistency assumptions	Selection of appropriate probability distributions for morbidity and persistency assumptions. Choices of distribution may depend on model structure and vice versa.
Use of company's and industry experience	Significant variations in morbidity experience and claim practices may exist among insurers. Credibility criteria may limit number of insurers to use their own experience.
Investment modeling	Correlation between interest rate and other risk drivers (claims, persistency, and expenses). Is it material enough to model interactively, or can independence be assumed?
Moderate adverse assumptions and margins in reserves	Consistency between margins in reserves and margins in model assumptions. Model results can assist in establishing appropriate margins for both.
Consistency with life and annuity principle-based approach	Is LTC model measuring the same range of variability of its risk drivers as models for life insurance and annuity with theirs? Does the LTC model capture its riskiness to relatively the same degree as the riskiness inherent in life and annuity products?
Applicability to other accident and health products	Model design should accommodate products with relatively high frequency, low benefit amount, and short-tailed risk.

Appendix 2

Description of Worksheets in Excel Model

Pages	Input/ Calculation/ Output	Description
Notes and Parameters	Input	Enter number of trials and maximum loops
Policy Data	Input	Enter policyholder benefit features
Record Count	Calculation	
Incidence Rates C1	Input	Enter incidence rates for cause 1 per 1,000
Incidence Rates C2	Input	Enter incidence rates for cause 2 per 1,000
Selection Factors	Input	Per 100 First column represents selection factors from issue to be applied to policyholders who have not had a claim. Second column represents selection factors from recovery to be applied to policyholders who have had a prior claim.
Termination Rates C1	Input	Total claim termination rates for cause 1 per 1,000. Subsequently separated by recovery vs. death.
Termination Rates C2	Input	Total claim termination rates for cause 2 per 1,000. Subsequently separated by recovery vs. death.
Salvage C1	Input	
Salvage C2	Input	
Active Mortality	Input	Male and female select and ultimate mortality for use while in active, non-claim status per 1,000.
Claimant Mortality	Input	Male and female ultimate mortality for use while in claim status per 1,000.
Lapse	Input	Per 100 First column represents voluntary policy termination rates to be applied to policyholders who have not had a claim. Second column represents voluntary policy termination rates to be applied to policyholders who have had a prior claim.
Stochastic Active	Calculation	For each trial, first determines time to event, then determines event (lapse, death, or claim).
Active Trial Results	Output	Summarize results for each trial of each policyholder.
Claims	Output	Summarizes results for each trial that results in a claim due to cause 1 or 2. Includes second and later claims following recovery.
Stochastic Claims	Calculation	For each claim, first determines time to event, then determines event (death, recovery).
Disabled Trial Results	Output	Summarizes results of each claim.
Recoveries	Output	Summarizes recoveries from Disabled Trial Results.
Stochastic Recoveries	Calculation	For each recovery, first determines time to event, then determines event (lapse, death, or claim).
Recovered Trial Results	Output	Summarizes results of each recovery.

Appendix 3

Summary of Model Assumptions

	Assumption	Dimension	Description
1	Active Life Mortality Rates	Select & ultimate, gender-distinct	SOA 1990-1995 Basic Table, Age Last Birthday
2	Lapse Rates	Policy duration	Industry average, varies from issue and from recovery
3	Incidence Rates	Attained age with selection factors by policy duration	2014 SOA Study, selection factors vary from issue and from recovery, two sets: one for Care Setting 1 and Care Setting 2
4	Disabled Life Mortality Rates	Attained age, gender-distinct	Multiple of RP 2000 Table
5	Recovery Rates	Claim age x claim month	1984-2004 National Long-Term Care Surveys, one set each for Care Setting 1 and 2
6	Benefit Utilization	Claim age x daily benefit group x claim month (1-36), yearly thereafter	Industry averages, one set each for Care Setting 1 and 2

Appendix 4

Description of 'Stochastic Active' Worksheet

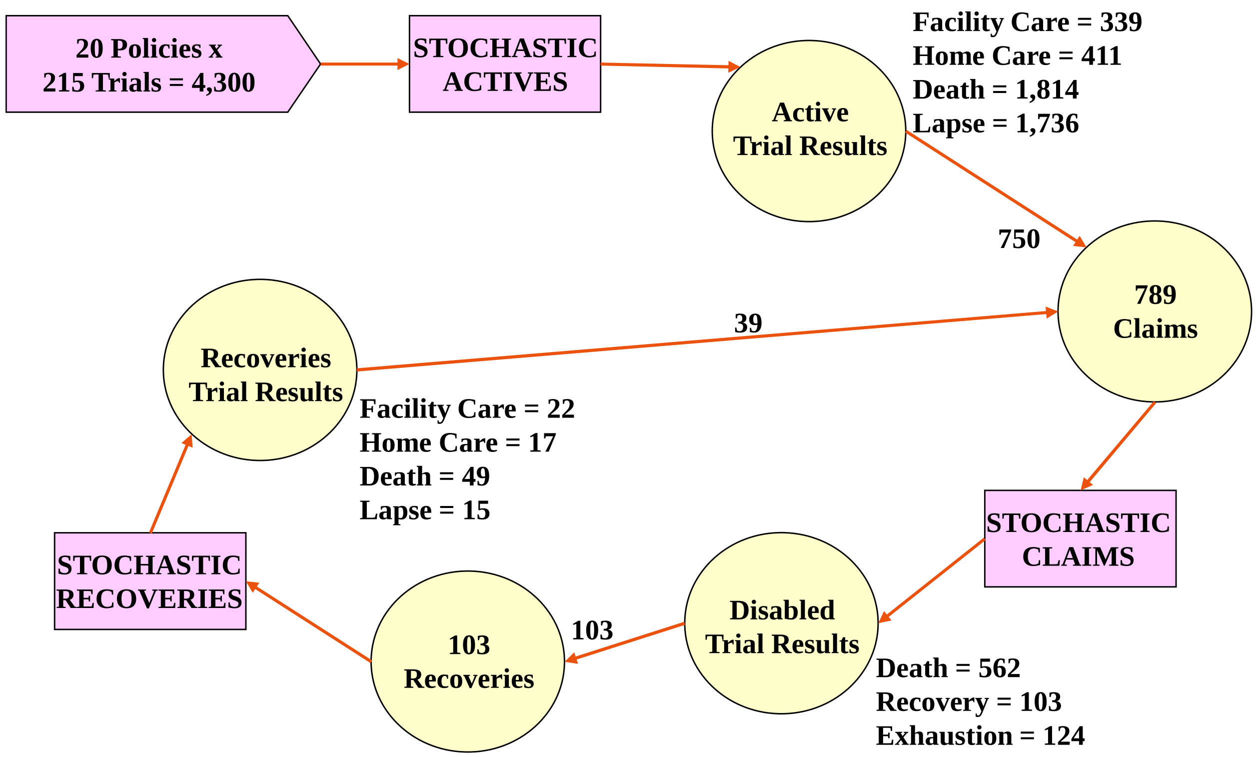
Cell	Title	Notation	Formula	Description
K10	Random number adjusted for survival	R_1	rand( )	Random number which determines time of event, multiplied by the probability of survival to valuation date. Prevents event.
Column	**Title**	**Notation**	**Formula**	**Description**
A	Duration	t		Policy duration in years.
B	Incidence – C1	$q^{(C1)}$		Incidence rate for Cause 1 before scalar or selection factor adjustment.
C	Incidence – C2	$q^{(C2)}$		Incidence rate for Cause 2 before scalar or selection factor adjustment.
D	Selection Factor – C1	$SF^{(C1)}$		Selection factor for Cause 1.
E	Selection Factor – C2	$SF^{(C2)}$		Selection factor for Cause 2.
F	Mortality Rate	$q^{(d)}$		Mortality rate before scalar adjustment.
G	Voluntary Lapse Rate	$q^{(w)}$		Lapse rate before scalar adjustment.
H	Probability of Surviving through the period	surv_per	$[1-\min(q^{(C1)} * SF^{(C1)} + q^{(C2)} * SF^{(C2)},1)]$ * $[1-\min(q^{(d)},1)] * [1-\min(q^{(w)},1)]$	Incidence assumed calculated from a multiple decrement model. Lapse and death assumed calculated from a single decrement model.
I	Date at end of period			Policy anniversary.
J	Survival	${}_tp_x$	${}_0p_x = 1.00$ ${}_tp_x = {}_{t-1}p_x * \text{surv\_per}_t$	Continuance function used in conjunction with random number draw to determine time of event.
K	Date of Event			Date event happens as determined by random number draw placement in survival function.
L	End of PPP after Event			End of Premium Payment Period, used if event type is lapse.
M	*Age Last at Event*		INT(DAYS360(DOB, Date of Event)/360)	Age last at date of event.
N	Inc C1	$h^{(C1)}$	$-LOG[1-(q^{(C1)} * SF^{(C1)} + q^{(C2)} * SF^{(C2)})]$ $* (q^{(C1)} * SF^{(C1)})$ $/ (q^{(C1)} * SF^{(C1)} + q^{(C2)} * SF^{(C2)})$	Multiple decrement incidence rates for Cause 1 converted to hazard rate.
O	Inc C2	$h^{(C2)}$	$-LOG[1-(q^{(C1)} * SF^{(C1)} + q^{(C2)} * SF^{(C2)})]$ $* (q^{(C2)} * SF^{(C2)})$ $/ (q^{(C1)} * SF^{(C1)} + q^{(C2)} * SF^{(C2)})$	Multiple decrement incidence rates for Cause 2 converted to hazard rate.
P	Other	$h^{(d)}$	$-LOG(1- q^{(d)})$	Single decrement mortality rate converted to hazard rate.
Q	Lapse	$h^{(w)}$	$-LOG(1- q^{(w)})$	Single decrement lapse rate

				converted to hazard rate.
R	Total		$h^{(C1)}+ h^{(C2)}+ h^{(d)}+ h^{(w)}$	
S	Inc C1	$f^{(C1)}$	$h^{(C1)} / (h^{(C1)}+ h^{(C2)}+ h^{(d)}+ h^{(w)})$	Marginal distribution of Cause 1.
T	Inc C2	$f^{(C2)}$	$h^{(C2)} / (h^{(C1)}+ h^{(C2)}+ h^{(d)}+ h^{(w)})$	Marginal distribution of Cause 2.
U	Other	$f^{(d)}$	$h^{(d)} / (h^{(C1)}+ h^{(C2)}+ h^{(d)}+ h^{(w)})$	Marginal distribution of Death.
V	Lapse	$f^{(w)}$	$h^{(w)} / (h^{(C1)}+ h^{(C2)}+ h^{(d)}+ h^{(w)})$	Marginal distribution of Lapse.
W	Random Number	R_2	rand()	Random number to determine event type.
X	*Event Type*		If $R_2 <= f^{(C1)}$ then 1 If $f^{(C1)} < R_2 <= f^{(C1)} + f^{(C2)}$ then 2 If $f^{(C1)} + f^{(C2)} < R_2 <= f^{(C1)} + f^{(C2)} + f^{(d)}$ then 3 If $R_2 > f^{(C1)} + f^{(C2)} + f^{(d)}$ then 4	1 = Cause 1 2 = Cause 2 3 = Death 4 = Lapse
Y	*Adjusted Event Date*			If lapse, uses PPP date to recognize lapses occur at modal anniversaries.
Z	*Inflation Adj Benefit Limit*			Benefit limit increased for simple or compound inflation to adjusted event date, if applicable.

* Along with policy characteristics, items carried forward to active trial results and/or claims

Appendix 5

Stochastic Trial Illustration



Based on model developed by the work group