ILA LRM Model Solutions
Fall 2016

1. **Learning Objectives:**

    2.   The candidate will demonstrate an understanding of the various sources of risks faced by an insurer.

    4.   The candidate will demonstrate an understanding of the principles of modeling, cash flow testing and asset-liability matching, and perform related calculations.

Learning Outcomes:

(2a)   Identify, categorize and evaluate potential sources of risk in products including but not limited to mortality, morbidity, and lapse.

(4a)   For an ALM model
        (i)   Select appropriate assumptions and scenarios
        (ii)   Model dynamic behavior of both assets and liabilities
        (iii)   Model and explain various strategies, including hedging
        (iv)   Analyze and evaluate results (including actual v. projected differences)
        (v)   Recommend appropriate strategies

(4c)   Evaluate the principles of Cash Flow Testing to help in understanding the underlying risk and to assess their impact on capital and surplus

Sources:

LRM-105-14: Mapping of Life Insurance Risks, AAA Report to NAIC

LRM-119-14: Lombardi Ch. 13

LRM-114-14: ALM For Insurers

LRM-116-14: Life Insurance Forecasting and Liability Models

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a)   Describe the reserve adequacy risk that has been introduced in this acquisition, as defined in the AAA report to the NAIC on the mapping of life insurance risks.

1. Continued

Commentary on Question:
About half of candidates were able to define reserve adequacy risk, but few candidates described the risk as it related to the acquisition.

Reserve adequacy risk is the risk that the final insurance claim or annuity payment obligations will be greater than the booked reserve values. This risk is introduced in the acquisition through:

1. Risk that the liabilities will be underestimated because the products were sold and underwritten by another carrier. The actuary may not have complete information to appropriately assign a new mortality assumption.
2. For the Whole Life policies, the risk is that the valuation assumption for mortality is lower than how actual experience emerges, resulting in reserve amounts that are too low to properly fund the benefits.
3. For the Immediate Payout Annuities, the risk is that the valuation assumption for mortality is higher than how actual experience emerges, resulting in reserve amounts that are too low to properly fund the benefits.
4. There is a risk that the reserve liabilities have not been backed with appropriate assets. This could result in mismatched cash flows.

(b) Cash Flow Testing will be required for the acquired inforce block.

   (i) List the steps involved in the Cash Flow Testing process.

   (ii) Determine the 10 year treasury rate at the end of year 5, assuming the current 10 year treasury rate is 8.00%, for each of the seven cash flow testing interest rate scenarios defined by NAIC Standard Valuation Law.

Commentary on Question:
Overall candidates did well on part (i) and poorly on part (ii).

   (i) The following group of activities is an example of a common approach to cash flow testing:
   1) Identification of the assets and liabilities included in the cash flow analysis
   2) Selection and validation of models for asset and liabilities cash flows
   3) Selection of appropriate scenarios
   4) Projection of the selected assets and liabilities cash flows under each scenario
   5) Development of conclusions based on analysis of the cash flow projections

1.   **Continued**

OR

These are the five major parts of a cash flow testing system:
1) Extract data
2) Description of assets, liabilities, scenarios and other criteria
3) Calculation modules
4) Cash flow testing results
5) Reports

(ii)   The following are the 10 year treasury rates at the end of year 5 in each of the cash flow testing scenarios:

Level:	8.0%
Increasing:	10.5%
Cap:	13.0%
Pop-Up:	11.0%
Decreasing:	5.5%
Cup:	3.0%
Pop-Down:	5.0%

(c)   You have been tasked with the responsibility of building an ALM model.

(i)   Describe modeling simplification methods for the acquired inforce block and their validation methods.

(ii)   Consider the following model output:

T	1	2	3	4	5
FreeCashFlow(*t*)	1.7	-0.3	1.4	0.9	0.7

1. Describe two methods to handle the free cash flows output at t=2.

2. Describe two methods to handle the free cash flows output at t=3.

Commentary on Question:
Most candidates did well on part (i). Some candidates listed ways to validate the inforce file before the simplification methods to the inforce file after the simplification method. Partial credit was given to these candidates for describing a static validation approach.

Overall, candidates did not do well on part (ii). Few candidates listed holding cash as an option for positive free cash flow in (ii) part 2.

1. **Continued**

    (i)   Modeling simplification methods:

        Issue age modeling - assume contracts within a range of issue ages are represented by one issue age (such as mapping ages 43-47 to age 45)

        Plan modeling - treat plans with similar characteristics as if they were all the same plan

        Issue day, issue month, issue year - group plans issued over a range of periods into a single period (ex: assume all plans issued on 15th of the month)

        Premium mode modeling - assume plans follow same premium payment frequency/method

        Validation methods:

        Static validation:
        -Compares certain known and modeled values as of the date from which the model projects
        -Fails to capture the effect of interactions among variables
            -Synonymous with balance sheet validation

        Dynamic validation:
        -Prospective dynamic validation compares trend in actual historical results with model's projected results
        -Retrospective validation or back-cast starts with the current portfolio of business and running the model backwards through time
        -Looks at many assumptions at once and measures the accuracy of their interaction
        -Synonymous with income statement validation

    (ii)   Methods of handling free cash flow:
        1. Negative free cash flow – sell assets (or buy negative assets) or borrow cash
        2. Positive free cash flow – buy assets or hold cash

(d)   Assess the appropriateness of the following two ALM techniques to reduce the interest rate risk of the acquired inforce block. Justify your answer.

    (i)   Immunization

    (ii)   Dynamic Financial Analysis

1. Continued

Commentary on Question:
Most candidates did not consider how the ALM techniques applied specifically to the acquired blocks of Whole Life and Immediate Payout Annuities. Some candidates did not describe/define immunization and DFA. Full points were awarded for doing both of these things.

An argument for or against either technique would receive credit if it was justified appropriately.

The question asks about reducing the interest rate risk for the acquired inforce block. Most candidates listed analyzing the full company's exposure to multiple risks as an advantage to using DFA. Although this question specifically asked about the inforce block and about interest rate risk alone, credit was given for this response.

(i)   Immunization is matching the duration of assets and liabilities such that a change in interest rates will change liability values and asset values by the same amount. Two drawbacks to this method are that the asset and liability durations may drift apart once interest rates change, and traditional duration metrics assume parallel shifts in the yield curve. Managing convexity can help with the first risk, and key rate durations can help with the second.

Immunization is not appropriate for acquired block of Whole Life and Immediate Payout Annuities for the following reasons:
1. Liabilities have long duration and it is difficult to find assets with similarly long duration.
2. Cash flows used to calculate duration should be known with certainty, otherwise the interest rate sensitivity of the business may not be reflected appropriately. Since this is an acquired block and we do not have historical experience, underlying modeling assumptions for policyholder behavior may not be accurate.
3. Traditional duration matching may not work if either the assets or liabilities have embedded options.

(ii)   DFA assesses how the company would fare under a range of scenarios. It is a good mitigation tool because it analyzes how the company's prospects would change in response to different strategic moves. There are five main components: initial conditions, scenario generator, financial calculator, and optimizer.

1.   **Continued**

DFA is not appropriate for the acquired block because:
1. It targets an institution-wide analysis so that an assessment of just the acquired block would be of limited value. The method also includes multiple risks, so the focus of the results may not be completely on interest rates.
2. DFA is a complicated technique. Immediate Payout Annuities are not very interest rate sensitive, and may not need such a sophisticated approach to manage the interest rate risk.

OR

DFA is appropriate for the acquired block because:
1. Interest rate risk can be assessed under multiple scenarios with probabilities assigned to each scenario.
2. Results can be viewed under different accounting bases.
3. DFA takes a holistic view so the interest rate risk of the entire company is considered, including diversification benefits between lines of businesses and correlations amongst interest rate and other risks.

2. **Learning Objectives:**
1. The candidate will demonstrate an understanding of the principles of Risk Management.

Learning Outcomes:
(1a) Define and evaluate risk.

(1d) Describe how risk management techniques may be used to manage capital deployed by insurers and how they impact strategic decision making.

Sources:
CIA: Dynamic Capital Adequacy Testing Ed. Note, Nov. 2013

Commentary on Question:
Overall, individuals did not refer to the case study which was required to get full marks.

Solution:
(a) Describe the goals of stress testing.

     Commentary on Question:
     This was a retrieval question. The candidates were able to the list the goals of stress testing but most did not describe the goals. In order for the candidate to get full credit, they needed to also include a description of the goal of stress testing

- Identity Risk and Control – particularly to address institution-wide risks
- Complimentary risk perspective - assess models' robustness to possible changes in the economic environment
- Support Capital Management - identify severe events that could adversely impact the financial health of the institution
- Improving Liquidity Management - assessing the institution's liquidity profile in stress events

(b) Assess the appropriateness of the four proposed adverse scenarios.

     Commentary on Question:
     This was an analysis question. To obtain full credit candidates needed to provide more than one assessment on each scenari;, generally candidates did better on the first two scenarios. For the last two scenarios candidates forgot to refer to the case study.

2. **Continued**

    a) Adverse Mortality Scenario
- The scenario is not adverse for SPIA; mortality assumption should be less than 100% SPIA since product risk is longevity
- The scenario should also include the impact for Variable Annuity since the product include a death benefit

    b) Adverse Lapse
- The scenario is not adverse; different lapse shocks are required by line of business (Term, UL, Variable Annuity) as some products are lapse supported
- The scenario needs to consider some level of anti-selective lapse

    c) Large Increase in Sales
- The scenario needs to increase Term insurance sales since the product is not profitable
- The scenario needs to increase variable expenses in line with the increased sales

    d) Increase Expenses
- The scenario needs to increase expenses for all products
- In particular, increase UL as the administration is heavily manual

(c) Evaluate the appropriateness of the following management actions suggested by the SVPs:

(i) Adverse Mortality – Cede additional business with Aggressive Re

(ii) Adverse Lapse – Increase the COI on inforce UL policies to offset the lapse experience

(iii) Increased Expenses – Outsource some administrative functions with a resulting 50% drop in expenses

Commentary on Question:
This was a knowledge utilization question. In this part of the question many candidates forgot to refer to the case study. In order to get full marks the candidates needed to refer to the case study and the context of the management actions.
Candidates did better with part iii of the question.

(i) This is not an appropriate management action since, for the Level Premium Term Insurance, using Aggressive Re reinsurance will make the product unprofitable.

2. **Continued**

    (ii)   This is not an appropriate management action since the COI can only be increased based on change in expected mortality. Also, any change in COI has to be approved by the regulator.

    (iii)   This is an appropriate management action since competitors have reduced cost by outsourcing with UL Admin Co for their UL product. However, the 50% drop in expenses may be aggressive for SPIA and the Variable product since the outsourcing company referred to UL.

3.   **Learning Objectives:**
1.   The candidate will demonstrate an understanding of the principles of Risk Management.

2.   The candidate will demonstrate an understanding of the various sources of risks faced by an insurer.

Learning Outcomes:
(1b)   Evaluate the role of risk management within an insurance company.

(1c)   Articulate the economic incentives for applying risk management.

(1d)   Describe how risk management techniques may be used to manage capital deployed by insurers and how they impact strategic decision making.

(2c)   Describe and evaluate the other risks an insurance company faces including operational, marketplace and expense risks.

Sources:
Risk Appetite: Linkage with Strategic Planning

ERM Specialty Guide, May 2006– Chapters 1-6

A New Approach for Managing Operational Risk - SoA Research 2008

Commentary on Question:
The purpose of the question was to test if the candidate understands the risk appetite framework. The knowledge of the modern operational risk approach was fundamental to answer part of this question. Additionally, it was also important to understand how various assets can be used to manage interest rate risk and why they might not be appropriate in all cases.

3. **Continued**

The candidates did well on parts (a) and (c) overall; however they did not provide enough details when answering parts (b) and (d), and hence performed poorly on these sections.

Solution:
(a)   Describe the three levels of a risk appetite framework:

      (i)   Enterprise risk tolerance

      (ii)   Risk appetite within each risk category

      (iii)   Risk limits

Commentary on Question:
In general, candidates performed well on this part. Specifically, the candidates who defined the three levels of risks while keeping in mind the subtle differences between them did relatively well. However, some candidates confused the descriptions of the three levels of risk and performed poorly as a result.

Enterprise Risk Tolerance
- The aggregate amount of risk the company is willing to take
- Can be expressed in terms of capital adequacy, earnings volatility, and credit rating target
- It represents the company's long-term target and shall be revised only if there are fundamental changes to the company's financial profile, market situation and strategic objective

Risk Appetite within each Risk Category
- Enterprise risk tolerance needs to be allocated to risk appetite for specific risk categories and business activities
- By doing this, the company's resources, such as capital, can be allocated to the areas in which the company feels comfortable or has competitive advantage
- Risk preference is normally stated quantitatively and qualitatively

Risk Limits
- Translate enterprise risk tolerance and risk appetite for each risk category into risk-monitoring measures
- The consistency between risk limit and enterprise risk tolerance helps the company realize its risk objective and maximize risk-adjusted return

3. Continued

(b) Describe the actuarial approach to use for measuring and assessing operational risk.

Commentary on Question:
Candidates who provided enough substance on how the actuarial process works performed well in this part. Candidates who didn't perform well were not able to provide enough depth on the actuarial approach, and instead defined how operational risk can be measured and assessed in general terms.

- Actuaries decompose the aggregate loss distribution into its two integral components: frequency and severity

- Frequency represents the number of events, and severity represents loss magnitude per event

- $$\text{Aggregate Loss} = \sum_{i=1}^{N} X_i$$

- One frequency and one severity distribution are needed to create an aggregate loss distribution for one risk class

- A theoretical requirement is that the Xs be independent and identically distributed (i.i.d.) and that the frequency and the severity be independent

- With this information, the actuary can build a distribution and establish quantitative VAR, CTE, etc limits

(c)

   (i) Determine if the interest rate risk profile of the company is consistent with its risk appetite.

   (ii) Calculate the maximum duration mismatch allowed under the current risk appetite assuming the liability duration is constant.

Commentary on Question:
Candidates generally did well on this part. The candidates who performed well recognized the differences between asset and liability duration when calculating the impact on asset values. Candidates who concluded the duration of assets to be 11.68 instead of 10.08 received a majority of marks. Candidates who only did high level approximations lost significant credit.

3. **Continued**

Part (i)
Change in assets = $750 \times 10 \times 0.02 = 150$
Change in liabilities = $680 \times 12 \times 0.02 = 163.2$
Change in Surplus = $150 - 163.2 = -13.2$
The current interest rate exposure is not consistent with the company's budgeted risk appetite for interest rate risk (13.2 EaR > 12 Risk Limit)

Part (ii)
Change in assets = $750 \times D \times 0.02 = 15D$
Change in liabilities = $680 \times 12 \times 0.02 = 163.2$
Change in Surplus =
$\quad -12 \leq$ Change in assets – Change in liabilities ≤ 12
$\qquad -12 \leq 15D - 163.2 \leq 12$
$\qquad 10.08 \leq \; D \leq 11.68$

D (duration of assets) has to be at least 10.08 years.

Hence, the maximum mismatch between assets and liabilities is $12 - 10.08 = 1.92$ years.

(d) Explain the advantages and disadvantages of using the following assets to manage interest rate risk:

- Equity
- Interest Rate Swaps

Commentary on Question:
To perform well on this question candidates had to make a clear connection between how a particular asset helps to manage the interest rate risk. Candidates who did not do well on this question simply stated the pros and cons of each asset class without connecting it to the interest rate risk.

Equity
Equity does not have duration so including it will not make the portfolio compliant with IR limits.
If equity is added, a framework discussing non-fixed income risks must be added.
Equity could offer the required diversification for an insurance company; however, it is not a good asset class generally to manage interest rate risk.
Moreover, it may increase the capital requirement.

Interest Rate Swaps
IR swaps can be purchased at longer durations, bringing the duration of assets closer in line with the duration of liabilities and reducing the duration mismatch; hence, the interest rate risk of the portfolio.

3.   Continued

IR swaps increase the spread exposure of the company; this needs to be addressed in the risk framework.
Derivatives also introduce counterparty risk; this needs to be considered in the framework.

4. **Learning Objectives:**
2. The candidate will demonstrate an understanding of the various sources of risks faced by an insurer.

Learning Outcomes:
(2b) Identify, categorize and evaluate potential sources of risk in investments including but not limited to credit risk, liquidity, equity-based exposure and asset-liability matching.

Sources:
Chapter 8, Credit Exposure, Credit Risk, Gregory

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a) List three considerations in using collateral to reduce the exposure to credit risk.

Commentary on Question:
Most candidates did well on this part. Some students answered that collateral creates liquidity risk/legal risk/operational risk which was considered to be a valid point and eligible for credit.

Considerations for using collateral to reduce exposure to credit risk:
- Granularity effect - because it is not always possible to ask for all of the collateral required due to parameters such as thresholds and minimum transfer amounts. Should also consider the amount of collateral an institution themselves must post
- Delay in receiving collateral - operational component of requesting and receiving collateral, and possibility of collateral disputes
- Variation in the value of the collateral itself - if not posted as cash, so there may be volatility in collateral amount posted

(b) Calculate the following credit risk metrics at year 3:

    (i)   Expected future value

    (ii)   Expected positive exposure

    (iii)   Effective expected positive exposure

4. **Continued**

(i)   Expected Future Value = $\sum$ (probability × expected value for each scenario) = $(0.3 × 60 + 0.6 × (-5) + 0.1 × (-15)) = 13.5$

(ii)   Expected positive exposure is defined as the average of expected exposures and expected exposure is the average of all exposure values (only positive values are considered exposures, i.e. negative values are floored to zero)

Step 1: calculating expected exposure (EE) at each time point

Year 1: EE = $0.3 × 20 + 0.6 × 15 = 15$
Year 2: EE = $0.3 × 45 + 0.6 × 10 = 19.5$
Year 3: EE = $0.3 × 60 = 18$

Step 2: Expected Positive Exposure = $(15 + 19.5 + 18) ÷ 3 = 17.5$

(iii)   Step 1: Calculating effective EE which is the non-decreasing EE measured from year 1:

Year 1: Effective EE = max $(15) = 15$
Year 2: Effective EE = max $(15, 19.5) = 19.5$
Year 3: Effective EE = max $(15, 19.5, 18) = 19.5$

Step 2: Effective expected positive exposure = average $(15, 19.5, 19.5) = 18$

(c)   Explain how forward rates contribute to differences between current future value and expected future value.

4. **Continued**

Expected future value depends on the forward rates and the forward rates can be very different from the current spot rates. This is the main reason why expected future value may vary significantly from current value.

(d)   Assess the impact of netting exposures on DEF's swap portfolio.

Commentary on Question:
Many candidates didn't floor the negative value for impact of netting and, when calculating the overall impact, missed considering the probability factor when calculating the net benefit (i.e. 60% × 5 = 3). Some candidates correctly identified that the netting impact would be relatively small because of the correlation of the two swaps.

Netting benefit is a diversification benefit that will allow positive and negative exposures in a portfolio to "net" each other. The netting benefit is lower when the assets are positively correlated.

Comparing the exposures in "no netting" and "netting" scenario, the benefit of netting is 3 = 33-30, which occurs in year 3.

Exposures (No Netting)	Probability	Year 1	Year 2	Year 3
Scenario 1	30%	30	65	90
Scenario 2	60%	35	30	**10**
Scenario 3	10%	0	0	0
Expected future value = ∑ (probability × value for each scenario)		30	37.5	33

Exposures (Netting)	Probability	Year 1	Year 2	Year 3
Scenario 1	30%	30	65	90
Scenario 2	60%	35	30	**5**
Scenario 3	10%	0	0	0
Expected future value = ∑ (probability × value for each scenario)		30	37.5	30

5.

Learning Objectives:

3. The candidate will demonstrate an understanding of important risk measurement techniques along with their uses and limitations, and be able to perform risk measurement calculations.

Learning Outcomes:

(3a) Analyze and evaluate risk measures & estimators (e.g., Value-At-Risk, Conditional Tail Expectations, etc.)

Sources:

Getting to Know CTE , Ingram, Risk Management Newsletter, July 2004

LRM-111-14: Value-At-Risk: Evolution, Deficiencies and Alternatives - Vozian

LRM-121-14: Value at Risk - Uses and Abuses - Chew

LRM - 127 - 15: Chapter 2, Measures of Financial Risk, Dowd, Ch. 2, pp 19 - 32

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a)

(i) Describe the process of estimating the value at risk (VaR) of a portfolio of assets.

(ii) List possible shortcomings of using VaR as a measure for risk management purposes.

Commentary on Question:

In part (i), the candidate was expected to describe how a distribution of outcomes can be generated (via methods such as stochastic scenarios, etc.) and then how this distribution of values can be used to calculate VaR (e.g. ranking all outcomes from worst to best, then taking percentile etc.) Some candidates interpreted the question as asking how VaR can be approximated formulaically, which was also acceptable. This part of the question was mostly well answered, with some exceptions where candidates neither described how a distribution of values can be generated nor described VaR in a way consistent with its definition.

In part ii, the candidate were expected to list criticisms of VaR as a metric as described in any of the syllabus source material. Full credit was given as long as at least 4 different criticisms were listed. Most candidates did well and received full credit and were able to list the most important shortcomings of VaR (e.g. gives no information about the risk in the extreme tail)

5. Continued

    (i)   A distribution of future outcome is needed in order to calculate VaR. To model future outcomes, set assumptions regarding components such as projection horizon, volatility, etc. and run stochastic model through a large number of scenarios. Results from these scenarios then form a distribution from most to least adverse. VaR(X) is the loss outcome such that the probability of the loss in the portfolio over the given time horizon exceeds this loss value is 1-X. For example, in a distribution of 1,000 scenario outcomes, VaR(95) of $1 million means that loss on the portfolio exceeds $1 million 5% of the time, or in 50 scenarios.

    (ii)   The following are some shortcomings of VaR as a risk measure:
- VaR provides no indication of the size of the tail
- Agency concerns such as providing an opportunity to hide risk in the far tail beyond the threshold of the reported VaR level
- VaR is not coherent and does not generally satisfy the condition of subadditivity, i.e. that $VaR(X+Y) = VaR(X) + VaR(Y)$
- VaR may understate the risk of aggregating different portfolios or entities within a group
- VaR is based on the premise that there is no change to the portfolio over time
- VaR may place more emphasis on historical results, which may not be representative of current / future risk exposure
- Often assumes a normal distribution of events

(b)   Your department manager has recommended the following reduced risk monitoring process:

- *Maintain monthly calculation of 99% VaR for an immediate drop in market value*

- *Reduce to quarterly calculation of CTE(95) for an immediate drop in market value*

- *Reduce scenario testing to once every two years, over a 5 year projection period*

Critique this recommendation.

5. Continued

Commentary on Question:
Some candidates did not provide rationale for their critique, and instead merely provided statements such as "quarterly is not often enough". Some candidates focused on the security levels, e.g. 99% VaR vs 95% VaR instead of addressing the differences arising from the recommendation. Many candidates demonstrated understanding of particular risk characteristics of VA as a product, by specifically commenting on common risk management techniques to monitor VA risk, and how those actions require frequent risk reporting.

VA guarantee represents a significant tail risk, with heavily skewed losses. Although 4 of the most volatile funds have been closed to new deposits, there may still exist significant risk in the current deposits, and the inforce block overall is still subject to future volatility and the macro environment. Recent improvements in MV/GV ratio can be adversely affected by future market changes. In short, VA is a high risk product that requires careful ongoing risk monitoring.

The manager proposes to continue current emphasis on using VaR and de-emphasize the usage of CTE by reducing its reporting frequency. This is not desirable. VaR only measures exposure at a given probability threshold, and does not provide information on the tail risk beyond that point. VaR cannot serve as an early indicator of increasing exposure or "in the moneyness". It would be a better idea to continue to monitor CTE(95) on a monthly basis and eliminate VaR. If VaR must be used, it would be more informative if VaR can be measured at several probability levels, so that the potential tail exposure can be better understood.

The manager's proposal to reduce scenario testing to every two years is not appropriate. Scenario testing provides a view to how the risk exposure changes over time. VA risk exposure can change very quickly, and having results every 2 years is not nearly frequent enough. In order for management to react to changes and take action, such as evaluating the possibility of closing more funds to new deposits or implementing a hedging program, frequent risk monitoring is appropriate. A projection horizon of 5 years may potentially limit the usefulness of scenario testing results, as VA liability can be much longer dated (e.g. income benefits, prolonged periods or future timing of equity market decline)