MEASUREMENT OF EXPOSURE TO INTEREST RATE RISK

SUBCOMMITTEE ON C-3 RISK COMMITTEE ON INVESTMENT PRACTICE

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MEMORANDUM

To: All Members of the Canadian Institute of Actuaries
From: Robert J. Sharkey, Chairperson
Committee on Investment Practice
Date: June 30, 1995
Subject: Educational Note on Measurement of Exposure to Interest Rate Risk

This document replaces an earlier version distributed to the membership in March 1994 under the title “Guidance Notes – Measurement of Exposure to Interest Rate Risk.” The note is intended to provide actuaries with a framework for assessing the current exposure to interest rate risk in the new money business of a life insurance company.

Questions regarding the paper can be addressed to me at my Yearbook address.

RJS
# Table of Contents

## INTRODUCTION
- Intent of the Paper ................................................................. 4
- Definition of Interest Rate Risk .............................................. 4
- Text of Paper ............................................................................ 5

## CONSIDERATIONS IN ASSESSING THE LEVEL OF EXPOSURE TO INTEREST RATE RISK
- Ai. Numerical Techniques used to Quantify Interest Rate Risk Exposure .......................... 6
- Aii. Frequency of Interest Rate Risk Exposure Reporting ............................................. 8
- Aiii. Quality of Data For Numerical Analysis ...................................................... 8
- Aiv. Asset Defaults/Credit Losses ........................................................................ 9

## RISK MANAGEMENT ISSUES
- Bi. Rebalancing Practices ..................................................................... 10
- Bii. Liquidity Management Practices ................................................... 10
- Biii. Asset Options ............................................................................. 11
- Biv. Embedded Liability Options .......................................................... 11
- Bv. Use of Derivatives ....................................................................... 11
- Bvi. Equity Investments ....................................................................... 12
- Bvii. Long Duration Liability Cash Flows ............................................... 13
- Bviii. Tax/Legislative Implications .......................................................... 13

## ORGANIZATIONAL ISSUES
- Ci. Asset/Liability Management (ALM) Process ...................................... 13
- Cii. Investment Policy ...................................................................... 14
- Ciii. Asset/Liability Management Expertise .......................................... 14
- Civ. Segmentation of Assets .................................................................. 15
- Cv. Liability Pricing Practices ............................................................. 15

## APPENDIX 1 – SCENARIO-BASED TECHNIQUES TO QUANTIFY ABSOLUTE DOLLAR GAIN/LOSS EXPOSURE TO CHANGES IN INTEREST RATES
- 1. Accumulated Cash-Flow Techniques ............................................... 17
- 2. Discounted Cash-Flow Techniques .................................................. 19
- 3. Market Value Technique .................................................................. 21

## APPENDIX 2 – SUMMARY OF KEY SHORTFALLS OF COMMON NUMERICAL INTEREST RATE RISK MANAGEMENT TECHNIQUES ........................................... 23

## APPENDIX 3 – SELECTION OF SCENARIOS FOR SCENARIO-BASED TECHNIQUES .......... 27
EDUCATIONAL NOTE ON
MEASUREMENT OF EXPOSURE TO INTEREST RATE RISK

INTRODUCTION

Intent of the Paper

This note has been prepared as educational material to assist actuaries who are practising, or seeking to practise, in this area. It does not represent a standard of practice of the Canadian Institute of Actuaries.

The intent of this paper is to provide actuaries with a framework for assessing the current exposure to interest rate risk in the new money business of a life insurance company. As such, an analysis of the organization’s interest rate risk exposure using this framework is intended to:

a) help the actuary set the appropriate margins for interest rate risk in their valuations
b) help the actuary identify specific actions to reduce this exposure

Other actuaries may also wish to consider this paper’s applicability to their own work.

It is not the intention of this paper to educate actuaries in detail on techniques available to manage interest rate risk. A significant amount of academic literature is already available to fulfill this need. The Investment Practice Committee of the CIA can provide references to interested actuaries.

While the focus of this paper is on new money products where the concepts are well understood and developed, we hope this paper will also prove useful to the actuary in the context of other product lines.

Definition of Interest Rate Risk

Although, strictly speaking, interest rate risk arises whenever cash is invested, it is in connection with the relationship between asset and liability flows that it deserves the attention of the appointed actuary. For this reason, it is sometimes called “mismatch” risk. It is also commonly referred to within the actuarial profession as “C-3 risk.”

Interest rate risk is the risk of potential economic losses arising from the disinvestment or reinvestment of cash flows. These losses can affect the solvency position. Although the risk is primarily due to changes in investment yields, a risk can also exist when there are no interest rate changes.

Losses may arise because changes in the level and term structure of interest rates may adversely affect interest that the cash flows can be reinvested at. Conversely, changes in the level and term structure of interest rates may adversely affect the value realized when assets must be liquidated (disinvested), or the cost of borrowings necessary to meet immediate liability cash-flow requirements.

The expected timing and amount of asset and liability cash flows can also change due to changes in the level and/or term structure of interest rates in such a way that reinvestment or disinvestment of asset cash flows could take place under adverse conditions. Changes in cash-flow patterns as interest rates change can generate substantial interest rate risk exposure because the changing cash flows often represent election of opportunities to change the cash-flow pattern at other than true theoretical market prices. Examples of this include full or partial book value options, and contractual prepayment options on mortgages.
Even when future interest rate changes are not considered, interest rate risk can exist. To the extent that there is uncertainty in the timing of expected asset and liability cash flows, interest risk will exist simply because the expected timing of the cash flows will frequently be wrong. This risk is particularly significant if the uncertainty is linked to the ability to receive/make payment at other than true theoretical market prices (i.e., book value options).

In addition, there may be an embedded deficiency in the adequacy of asset cash flows to support liability cash flows when net reinvestment/disinvestment of expected cash flows at today’s interest rates is fully modelled.

For companies whose investment strategy includes actively trading between different securities/sectors of the fixed income market, there is an additional interest rate risk. This is the risk of spreads between different securities/sectors of the market changing even if the overall level and term structure of rates in the market do not change.

Text of Paper

Management of interest rate risk is not purely a mathematical exercise. In addition to quantifying the potential loss, it is also critical to evaluate the company’s exposure to interest rate risk qualitatively as well. Things such as a company’s organizational structure, investment policy, management style, investment philosophy, the ability to optimize product design and solid interdepartmental partnerships are critical elements in the management of interest rate risk.

A thorough review of the interest rate risk within an organization therefore requires both:

a) Numerical scenario-based analysis of the dollar exposure of the organization to interest rate risk
b) A thorough review of the organization’s practices and capabilities in all areas that impact interest rate risk management

The main text of the paper discusses each of the considerations that are important in assessing the level of interest rate risk in an organization. “Ideal” low risk practices are identified for each area. For areas where a company’s current practices do not meet the low risk definitions in this note, the actuary should determine to what degree, if any, the practices actually being followed are creating interest rate risk exposures. For instance, a practice may be followed that does not meet the low risk definitions of this note, however, the impact of the practice actually followed on the risk exposures may not be materially significant enough to create a high risk exposure for the company.

The considerations covered in the text are:

a) Interest Rate Risk Measurement
   i) Numerical techniques used to quantify interest rate risk exposure
   ii) Frequency of interest rate risk exposure reporting
   iii) Quality of data for numerical analysis
   iv) Asset defaults/credit losses

b) Risk Management Issues
   i) Rebalancing practices
   ii) Liquidity management practices
   iii) Asset options
iv) Embedded liability options
v) Use of derivatives
vi) Equity investments
vii) Long duration liability cash flows
viii) Tax/legislative implications
c) Organizational Issues
   i) Asset/liability management process
   ii) Investment policy
   iii) Asset/liability management expertise
   iv) Segmentation of assets
   v) Liability pricing practices

The actuary should investigate the desirability/practicality of changing any high risk practices identified, and should analyze carefully how any identified high risk practices impact the overall level of exposure to interest rate risk of the company’s new money business.

In addition to the main text, the paper has three appendices:
1. Appendix 1 discusses scenario-based techniques to quantify the expected dollar gain/loss exposure to changes in interest rates.
2. Appendix 2 outlines key shortfalls of the different common numerical interest rate risk management techniques.
3. Appendix 3 provides guidance on selection of scenarios for scenario-based techniques.

CONSIDERATIONS IN ASSESSING THE LEVEL OF EXPOSURE TO INTEREST RATE RISK

Ai. Numerical Techniques used to Quantify Interest Rate Risk Exposure

There is a wide range of numerical techniques available to help quantify and manage interest rate risk exposure. These techniques generally quantify interest rate risk exposures by use of:

• Price sensitivity statistics:
  • Traditional (Macaulay) modified or effective duration
  • Convexity (“D2”) or higher order derivatives, used in conjunction with duration
  • Nonparallel and partial (key rate) duration analysis.

• Cash-Flow Techniques:
  • Maturity gap management
  • Period-by-period cash-flow matching of assets and liabilities

• Combination of price sensitivity and cash-flow matching:
  • Horizon analysis
- **Scenario-based quantification of the dollar gain/loss on interest rate movements:**
  - Accumulated and discounted cash-flow techniques.

All of these techniques require explicit identification of the individual assets supporting the new money liabilities, and the ability to reasonably model the underlying asset and liability cash flows.

The actuary should be aware that the techniques described quantify interest rate risk only. It is possible that some strategies taken to minimize interest rate risk exposure can result in increased asset default and/or liquidity exposure. A complete analysis of investment related risks also requires analysis of asset default and liquidity risk.

**Price Sensitivity and Cash-Flow Techniques**

It is accepted practice to use price sensitivity statistics/cash-flow matching techniques in the day-to-day management of interest rate risk as they can be readily calculated, and are easy to interpret. However, there are limitations or shortfalls to these techniques.

Some of the simpler duration measures, such as Macaulay, and modified or effective duration do not measure exposure to a nonparallel move in interest rates, and do not always capture the effect of options. Using convexity in conjunction with duration does reduce, but not eliminate, exposure to nonparallel interest rate movements.

Cash-flow matching techniques that match “expected” cash flows can’t manage option exposure. Further, using these techniques does not put a potential dollar value on the interest rate exposure that exists, and the results are generally sub-optimal from a total return perspective.

Partial and nonparallel duration analysis are excellent for understanding the impact of changes in the shape and level of yield curves, but the methods require complex calculations and are hard to understand and communicate.

Appendix 2 contains a detailed discussion of the shortfalls of the common price sensitivity and cash-flow techniques. No one price sensitivity statistic/cash-flow mismatch technique provides enough information to understand all the interest rate risk exposures for a new money annuity product line and their potential interactions. Further, it is extremely difficult to interpret these measures to understand what the potential dollar losses to the company are under a wide range of future interest rate scenarios, and many methods don’t reflect option-adjusted cash flows.

**Scenario-Based Techniques**

Scenario-based techniques have the significant advantage that they quantify the dollar gain or loss on interest rate movements, and by doing so, identify the specific scenarios that put the company at risk of loss. They are required for valuation of single premium annuities under VTP 9. They generally fall into two broad categories. First are techniques that measure exposure on a projected future surplus basis with explicit assumptions for reinvestment and/or disinvestment of cash flow. The second broad category is discounted cash-flow techniques that do not involve explicit reinvestment/disinvestment of cash flow. Scenario-based techniques are described in more detail in Appendix 1, with some commentary on their shortfalls included in Appendix 2. Appendix 3 provides guidance on the selection of scenarios for these techniques.

These tools are very useful for understanding interest rate risk exposure for a new money portfolio. However, they are difficult to use as day-to-day management tools as they do not provide key actionable statistics and require an extensive amount of work.
For the appointed actuary, it is important to have available scenario-based techniques that quantify the company’s dollar gain/loss on interest rate movements. These techniques allow the appointed actuary to directly relate the level of interest rate risk exposure in a company’s new money business to the level of statutory margins and surplus available to absorb potential losses. Use of these techniques allow appropriate interest rate risk reserve margins to be established.

In using the scenario-based techniques, the sufficiency of asset cash flows to support the liability cash flows should be calculated under a number of different scenarios.

**Low Risk Factors**

1. A proven scenario-based model is in place in the organization (see Appendix 1 for discussion of techniques).

2. The scenario-based model is appropriate for the investment and interest rate risk management style of the company (see Appendix 1 for discussion of where different techniques are appropriate).

3. A wide range of scenarios covering changes in level, term structure, and sector spread of interest rates, as well as variability in asset default rates and variability of interest sensitivity of cash flows are tested in the modelling (see Appendix 3 for a discussion of scenario selection).

4. The scenarios tested in the modelling include scenarios that test the maximum interest rate risk exposures permitted under the company investment policy.

5. A sufficient combination of numerical techniques are in place to accurately measure interest rate risk exposure for day-to-day management of this risk. This would include techniques to measure exposure to parallel and nonparallel movements in the term structure of interest rates, exposure to options embedded in the liabilities and assets, and exposure to shifts in interest spreads between different asset sectors (see Appendix 2 for a discussion of the shortfalls of different techniques).

6. Consistent numerical measures should be used on an ongoing basis to measure interest rate risk exposure, set the objectives for rebalancing actions undertaken, and set interest rate risk management guidelines in the investment policy.

**Aii. Frequency of Interest Rate Risk Exposure Reporting**

The exposure to interest rate risk can change very quickly. This commonly occurs for two reasons:

a) the current structure of interest rates changes, or

b) significant repositioning of the asset position takes place.

**Low Risk Factors**

i) Reporting of the risk position is frequent (monthly or, ideally, weekly).

**Aiii. Quality of Data For Numerical Analysis**

An integral part of a strong interest rate risk management process is to have high quality data for numerical analysis of the interest rate risk position.
**Low Risk Factors**

i) Consistent techniques and measures are used to value all assets and liabilities. Since interest rate risk exposure is created by the net difference between assets and liabilities, differences in measures/techniques can introduce systematic distortion in the reported A/L exposure. An example of where this commonly occurs is in duration mismatch management, where different systems often use different definitions of duration.

ii) Liability and asset profiles reflect up-to-date liabilities/assets (i.e., no lags)

iii) Underlying asset and liability cash flows are reasonably determined. In particular:

   - any grouping of assets or liabilities for cash flow or present value calculation purposes does not materially distort the accuracy of the values
   - asset commitments and liability rate guarantees are reflected in the asset and liability values
   - asset and liability values reasonably reflect the impact of book value options as interest rates change
   - cash-flow impact of asset defaults are reasonably modelled
   - non-contractual liability practices are reasonably modelled in the liability values (e.g., discretionary commutation of various forms of annuities)
   - liabilities reflect expected expense and tax costs as well as basic benefits. All taxes should be included except possibly income taxes, where there is still no consensus within the actuarial community as to how they should be treated in modelling
   - mortality is appropriately reflected on deferred annuities (particularly high attained age policies) as well as immediate annuities

**Aiv. Asset Defaults/Credit Losses**

An often overlooked factor associated with asset defaults is the impact of asset default risk on interest rate risk. Asset default risk creates interest rate risk by causing uncertainty in the timing and amount of the asset cash flows.

The greater the risk of asset default, the greater the uncertainty created in the asset cash flows. Estimating the impact of defaults on cash flows can be very difficult. Not only must the level of defaults be estimated, but so must what the cash flows will be on an asset that defaults. As an example, the cash-flow impact of an asset default could be any one of a loss of all future cash flows, a loss of all future cash flows offset by some level of reimbursement at date of default, or a restructuring of the original cash-flow pattern.

**Low Risk Factors**

i) There is a low risk of default in the assets being modelled.

ii) Where default risk exists, the level of defaults can be accurately estimated.

iii) Where defaults are expected, the cash-flow impact of the defaults can be accurately anticipated and modelled.
RISK MANAGEMENT ISSUES

Bi. Rebalancing Practices

Rebalancing the asset/liability position to stay within desired risk tolerances is a key part of interest rate risk management. A company should have the systems in place to facilitate this rebalancing.

Low Risk Factors

i) Interest rate risk position reports are available at frequent intervals, and a process is in place to execute rebalancing, if necessary, at these times.

ii) Computer optimizing software is available to aid in the analysis of rebalancing alternatives.

iii) The asset management function has a liquid fixed asset trading capability/capacity or derivative trading capability in place to execute the required rebalancing.

iv) The organization has a history of efficiently and quickly implementing desired rebalancing to eliminate unwanted exposure (i.e., corrective actions are not implemented over a period of months or on an irregular basis).

Bii. Liquidity Management Practices

Liquidity management practices should take into account any need for liquid assets within the organization to manage the interest rate risk position. Establishing minimum liquid asset positions should cover both this “interest rate risk management” requirement as well as requirements to manage cash outflow demands. Ensuring that adequate minimum liquid asset positions are maintained for interest rate risk management purposes is particularly important for companies that do not have sophisticated derivative management operations to facilitate ongoing management of interest rate risk, or facilities in place to raise liquidity externally.

Low Risk Factors

i) MIS is in place to understand the impact of different cash outflow scenarios on the potential future asset/liability matching profile of the in-force.

ii) There is no reliance on writing future business to generate liquidity to facilitate interest rate risk management.

iii) Sufficient liquid assets are in the existing segmented assets to facilitate ongoing interest rate risk management even if adverse cash outflow demands are placed on the existing in-force asset portfolio. This can occur due either to higher than expected liability outflows or higher than expected fixed asset renewals (e.g., mortgages).

iv) Derivative expertise exists within the organization or the company has proven programs in place to access liquidity in the capital markets that can be used to facilitate interest rate risk management (note that a company need only have one of (iii) or (iv) in place to be low risk).

v) The company takes a disciplined approach to investing in illiquid assets:

   • Illiquid invested assets (including mortgage renewals) match the volume/cash-flow characteristics of the illiquid assets assumed in pricing.

   • The term of any illiquid assets used in pricing does not exceed the term of the liability being priced.

   • Sufficient liquid assets are used in the pricing to match potential liability outflows (including nonrenewals) over the term of the liability being priced.
Biii. Asset Options

Asset options represent opportunities to either sell or buy assets at other than true theoretical market prices (i.e., the holder of the option will potentially be able to exercise it to make a risk-free arbitrage gain on interest rates). Insurers can either hold asset options (e.g., putable bonds), or hold assets where options can be exercised against them (e.g., callable bonds or mortgage-backed securities). The latter is by far the more common exposure. Any options that can be exercised against the company potentially introduce substantial interest rate risk.

Low Risk Factors

i) No options exist in assets that can be exercised against the company.

ii) Potential election of options against the company are accurately modelled and hedged. This includes modelling of not only efficient economic utilization, but also the impact of asset-specific factors and general economic conditions. Practically, this can demand substantial expertise and be difficult to execute.

Biv. Embedded Liability Options

Liability options represent opportunities for policyholders to select against a company by having the ability to make discretionary withdrawals from a policy on a nonfully market value adjusted basis (i.e., a policyholder can make a risk-free arbitrage gain on interest rates). Withdrawals can be in the form of both surrenders and loans. Any options that allow selective withdrawal or transfer of funds on a nonfully market value adjusted basis can potentially introduce substantial interest rate risk, as they allow policyholders to antiselect against the company to benefit from market interest rate movements.

Low Risk Factors

i) No discretionary withdrawals are allowed.

ii) If discretionary withdrawal opportunities exist, they are all fully market value adjusted. (Note that if they are at the lesser of book or market, they are even lower risk.)

iii) Potential election of options against the company are accurately modelled and hedged with assets that have offsetting characteristics. Practically, this demands substantial expertise and may be difficult to execute.

iv) Existing/prospective policyholders do not have the ability to selectively utilize quoted rate guarantees at issuance/rollover of a contract (i.e., quoted rates are not guaranteed unless the recipient of the quote is obligated to undertake the transaction for which the quote guarantee is given).

v) Policyholders do not have the ability to mature deferred annuity contracts into immediate annuities at book value at a time of their choosing.

Bv. Use of Derivatives

Derivative assets are powerful tools to aid in the management of interest rate risk. They are particularly useful for correcting structural asset/liability mismatch positions when liquid asset trading cannot sufficiently control the risk, and for hedging the net book value option exposure created by an asset/liability portfolio.
Managing using derivative instruments can introduce significant risks into the overall asset/liability management of a portfolio. This risk occurs for two reasons. First, derivative assets can be complex and their impact on interest rate risk positions difficult to accurately model. Second, they are a highly leveraged instrument from an interest rate risk management perspective – significant derivative positions with extremely large impacts on interest rate risk exposure can be entered into with minimal up-front cost/cash outlay.

Low Risk Factors

i) Rigorous controls are placed on the derivative positions that can be entered into without prior senior management approval.

ii) Significant expertise exists within the organization for managing derivative positions and for “auditing” the positions taken by active derivative managers.

iii) The ability to accurately model derivative positions exists within the asset/liability management (ALM) process.

Bvi. Equity Investments

Equity investments in real estate and common stock are occasionally used to support some portion of new money liability cash flows. For new money business, most frequently, these are used to support long-tail cash flows on immediate annuities and statutory margins/required surplus associated with new money liabilities. Use of equity investments within a new money annuity segment introduces risk in three ways.

i) The liabilities have contractually guaranteed returns, while equity investments do not have corresponding guaranteed returns.

ii) The expected return and volatility of these asset classes is often difficult to determine.

iii) The volatility of this return is often uncorrelated to interest rate volatility.

Because of the above risks, not only is the ability of equity investments to support fixed interest liabilities difficult to determine, but their integration with basic interest rate risk management tools is extremely difficult to manage.

The actuary should be aware that many of the risks described for equity investments also apply to high yield (i.e., below investment grade) fixed interest investments. Although these investments contain a promised cash-flow pattern, high potential defaults, which can be volatile, make the determination of the expected cash-flow pattern extremely uncertain. As a result, in addition to introducing credit risk, use of below investment grade fixed interest investments can significantly increase interest rate risk exposure.

As a result of the above concerns, equity and high yield investments are generally considered high risk investments to back fixed interest new money liabilities.

Low Risk Factors

i) No equity investments are used to back new money liability cash flows.

ii) If equity investments are used, a separate segment is set up for these assets and the liabilities that they are backing, and the liabilities represent only statutory margins/required surplus or expected cash-flow liabilities beyond the horizon for which fixed interest assets can currently be purchased.

iii) Below investment grade fixed interest assets are not used or are used in very limited amounts to back expected liability cash flows or are used in a similar manner as equities as described in (ii) above.
Bvii. Long Duration Liability Cash Flows

Long duration liability cash flows create unique interest rate risk management concerns because of a lack of suitable assets for directly matching the cash-flow characteristics of these liabilities. This concern most commonly arises with vested annuities which generate substantial cash flows more than 30 years into the future, the longest term for which fixed interest investments are commonly available. Three approaches to managing this risk are to (i) discount the liability cash flows beyond 30 years to duration 30 at a conservative interest rate and manage them as a time 30 cash flow, (ii) separately manage these cash flows in a total rate of return segment, and (iii) use derivative instruments or other techniques to leverage the asset interest sensitivity to match the liability sensitivity.

Low Risk Factors
i) No liabilities with cash flows beyond year 30
ii) Interest rate risk management procedures are in place that recognize the unique interest rate risk management concerns associated with managing these long duration cash flows

Bviii. Tax/Legislative Implications

Theoretically sound interest rate risk management strategies should not be put in place when the practical day-to-day effectiveness of these strategies is limited by tax/legislative concerns. For instance, trading of investment portfolios to mitigate interest rate risk may trigger capital gains and result in undesirable tax consequences. As another example, legislative requirements in some jurisdictions may limit the use of certain asset instruments/classes to manage interest rate risk.

Low Risk Factors
i) The actuary thoroughly understands the regulatory/legislative environment within which the organization operates and believes the interest rate risk management strategy of the organization is consistent with this environment.

Organizational Issues

Ci. Asset/Liability Management (ALM) Process

It is important for assessing interest rate risk to understand the ALM process being employed throughout the company by all departments – investments, pricing, valuation, quotation, and administration. An efficient process requires an integrated approach between all these areas and efficient communication of information between these areas.

Low Risk Factors
i) The actuary understands the ALM process.
ii) Responsibility for all aspects of the ALM process is clearly delineated, and there is good central co-ordination of this function.
iii) The cash-flow characteristics underlying new business being written are stable by product/term as are the characteristics underlying surrenders.
iv) Any seasonality in liability inflows/outflows is anticipated and accounted for in the management process (e.g., heavy RRSP inflows in the first quarter of a year).
v) There are good systems in place to communicate the cash-flow structure of both liability cash inflows and cash outflows to the investment division/ALM function. Good communication would involve at least weekly dissemination of accurate information on the product/term/rates/cash-flow structure on both liability inflows and outflows.

Cii. Investment Policy

The investment policy followed by a company can significantly impact the potential level of interest rate risk within the company. A well documented investment policy should define an interest rate risk neutral position for the organization, should set limits on the permissible deviations from this neutral position, and generally outline how interest rate risk will be managed within these constraints. Investment policies that allow greater discretion in the management of interest rate risk (i.e., greater permissible deviations from an interest rate risk “neutral” position) in order to enhance investment returns will normally result in increased levels of exposure to interest rate risk. In assessing the impact of a company’s investment policy on the level of interest rate risk exposure, it is important that the actuary review not only the written investment policy, but also the practical way that the policy is implemented on a day-to-day basis.

Low Margin Factors

i) Written investment policy has rigorous guidelines for management of interest rate risk (i.e., neutral positions, permissible deviations from a “neutral position,” and appropriate management styles are clearly articulated).

ii) The defined “neutral” position minimizes plausible exposure to each of parallel movements in interest rates, nonparallel movements, book value option elections, and changes in sector spreads.

iii) Only minimal deviations, if any, from this neutral position are allowed.

iv) Compliance with the investment policy through measurement of the actual interest rate risk position versus the articulated investment policy “neutral” position is actively and frequently (at least monthly) monitored.

Ciii. Asset/Liability Management Expertise

It is important that the appropriate expertise is available to manage asset/liability risk. Asset/liability risk management requires skilled professionals who understand in detail not only the techniques used to measure the risk, but also the characteristics of the assets, the characteristics of the liabilities, and most importantly, the appropriate management actions to take to reduce or alter the exposure to interest rate risk.

Low Risk Factors

1. Current asset/liability risk managers have proven track record of efficiently managing interest rate risk within the organization, including execution of corrective actions.

2. Asset/liability risk managers, either collectively, or individually, understand in detail the nature/behaviour of both the asset and liability sides of the balance sheet.

3. Asset/liability risk managers have strong technical knowledge of techniques to manage
interest rate risk.

Civ. Segmentation of Assets

Segmentation offers the advantage of improved interest rate risk management since investment strategies and MIS for different segments can be selectively geared to the investment management techniques being used for the segment. Efficient interest rate risk management requires this segmentation in order to have an integrated ALM process. Assets backing statutory margins (i.e., the statutory liabilities in excess of no-margin liabilities) can either be managed with the no-margin liabilities, or separately. Both are valid approaches. It should be noted that the argument is often made that over-segmentation can be sub-optimal from an asset yield perspective since it is often viewed as limiting investment opportunities. This factor should be considered in determining the optimal level of asset segmentation for the organization.

Low Risk Factor

i) Segmentation of the general account where assets are segmented based on the interest rate risk management strategy that is assumed for different blocks of liabilities

Cv. Liability Pricing Practices

From an interest rate risk management perspective, the key requirement is to ensure that the required yields to support the liabilities being written/renewed are in practice attainable when the actual asset/liability management practices of the company are considered.

In the extreme, liability pricing can be either purely liability driven (a price “taker” approach) or purely asset driven (a price “maker” approach). A purely liability driven strategy sets liability prices based solely on the rates needed to be competitive and produce the desired volume of liability sales. Under a purely asset driven strategy, liability prices are based solely on the yields of the assets being used to price the liabilities. The majority of organizations fall somewhere between being purely liability driven and purely asset driven.

Generally, an asset driven company should find it easier to follow low risk practices than a liability driven company, provided that the interest rate risk management strategies implied in pricing (either explicitly or implicitly) are consistent with the interest rate risk management practices actually followed by the organization. Two areas that can be exceptions to this are when illiquid assets are used to back liabilities being written, and when liabilities are priced on a “collective” basis. For companies that have fixed commitments to writing pre-set volumes of illiquid assets (e.g., new mortgage commitments or mortgage renewals), a pricing strategy that is at least partially liability driven will generally allow the company to more efficiently manage interest rate risk by controlling the volume/mix of the liabilities being written to optimally match the new illiquid asset characteristics. Similarly, for companies that price liabilities collectively (i.e., priced assuming a certain term/product mix is written), a purely asset driven strategy makes it difficult to ensure with any degree of confidence, that the required term/product mix will be written.

Low Risk Factors

i) The interest rate risk management technique assumed in pricing is consistent with the technique used in managing the in-force business.

ii) The volume/mix of illiquid assets assumed to be invested in pricing matches the investments actually made in these assets.

iii) Liabilities are priced on a stand-alone basis for each product/item combination, or if priced on a collective basis, the term/product mix can be predicted with a high degree of confidence.
and the downside exposure for deviations from this mix is known and acceptably low.

iv) There is frequent ongoing interaction between the asset managers, liability managers, and active interest rate risk managers to coordinate the pricing, investment and interest rate risk management functions.

v) Allowance is made in pricing for expected delays in investing cash flows appropriately.

vi) Liability quotations are valid for only a short period of time (e.g., 24 hours), or if longer quotation periods are offered, a process is in place to hedge outstanding quotes.

vii) Interest rates used to set liability rates are reviewed on an ongoing basis (e.g., regularly at daily/weekly intervals as well as whenever investment market conditions change).

viii) Large quote procedures are in place that limit amounts that can automatically be written
at published rates.

APPENDIX 1

SCENARIO-BASED TECHNIQUES TO QUANTIFY ABSOLUTE DOLLAR GAIN/LOSS EXPOSURE TO CHANGES IN INTEREST RATES

Descriptions of some of the techniques that are used to quantify the absolute dollar gain/loss exposure to changes in interest rates are contained in this section. Three techniques are described:

1. **Accumulated Cash-Flow Technique**

   Under this technique, future surplus is projected by accumulating net cash flows expected under a variety of investment scenarios.

2. **Single Curve Discounted Cash-Flow Technique**

   Under this technique, the present value of surplus is modelled by discounting expected asset and liability cash flows at a single interest curve. This curve is then “shocked” through a variety of scenarios.

3. **Market Value Technique**

   Under this technique, a current “market value” of surplus is determined by comparing the current market value of publicly traded assets to the present value of net liabilities, where net liability present value is the liability less illiquid asset cash flows discounted using a single conservative interest rate curve. The values are then redetermined by “shocking” the current investment market curve through a variety of scenarios.

For all the techniques described, the scenarios that are tested can be determined either deterministically or by use of stochastic model generators. It is recommended that a minimum number of deterministic scenarios broadly covering the different potential movements in market interest rates that could take place should always be run. Selection of deterministic scenarios is described in Appendix 3.

The techniques described are appropriate for quantifying the dollar interest risk exposure in the current in-force business only. They do not attempt to reflect the impact of future business, since, by definition, the current interest rate risk exposure of an organization in the new money business relates to the guaranteed rates implicit in its current block of business.

Of the techniques described, only the first technique, the accumulated cash-flow technique, is expandable to include future business and rollovers.

1. **Accumulated Cash-Flow Techniques**

   Under accumulated cash-flow techniques, the net cash flows generated by the assets and liabilities are projected forward period by period under a specific scenario of future interest curves and economic conditions in each period. A terminal wealth/surplus figure is generally calculated at the point at which the last liability cash flow is paid out. The investment or disinvestment action taken at each period in the projection should be consistent with the company’s investment philosophy for this business. When doing the projections with the explicit intent of understanding interest rate exposure, the following key factors should be noted:

   a) Liabilities should not be projected past the next rate reset date if the company practice is to reset the rates at that date to a then current investment market interest rate (i.e., they should be assumed to mature at the reset date). If the company practice is not to reset at an appropriate investment market interest rate, then rollovers should be included in the
projection. Similarly future premiums should not be included if the intent is that these premiums be credited with a then current market rate of interest.

b) Assets in the starting portfolio with a rate reset date should initially be projected only to the reset date if the company practice is to reset the rates at that date to a then current investment market interest rate (i.e., reinvestment action should be handled according to the reinvestment algorithm assumed in the projections). If the company practice is not to reset at an appropriate investment market interest rate, then rollovers should be included in the projection.

c) Asset cash flows should be projected adjusting for their interest sensitivity. In other words, options should be appropriately modelled in the projection (e.g., asset calls should be modelled in the projection if it is expected that an asset will be called given the interest scenario being modelled). Although modelling of asset options can theoretically start by assuming efficient economic election, consideration should be given to asset specific/general economic conditions in determining the final option adjusted cash flows.

d) Liability cash flows should also be projected on an interest-sensitive basis (e.g., if premature surrenders are expected to increase as interest rates rise, these should be modelled), and the cash flows should accurately model any book value payment features (e.g., limited market value adjustments). Liability cash flows include policyholder benefits, expenses and taxes.

e) Asset cash flows should reflect the expected impact of defaults. An often overlooked fact with respect to defaults is that in addition to the actual cost of the default in terms of interest/principal loss, a significant level of expected defaults will change the underlying cash-flow pattern of the assets.

f) Investment expenses should be accounted for in determining the asset cash-flows.

g) To understand the interest exposure, a wide variety of future interest scenarios should be used. These scenarios should cover both increases and decreases in the overall level of interest rates, and equally importantly changes in the shape of the yield curves, including curve inversions. If the reinvestment/disinvestment action modelled involves more than one sector/asset class, the scenarios should also cover changes in spreads and yields between different sectors of the investment market. Interactions of all these assumptions should also be tested.

h) The asset cash flows expected to be generated from the opening asset portfolio should be adjusted if the actuary believes that the opening asset portfolio mix is not representative of the portfolio that will be held over the balance of the projection period. This is particularly important if the asset portfolio is temporarily of lower quality than it is expected to be over the balance of the projection period, since this situation could lead the actuary to overestimating the asset cash flows expected to be generated if there is any net yield pick-up after allowance for default margins. As a minimum guideline, the actuary should adjust the initial asset portfolio whenever its current holdings are outside the guidelines specified in the company investment policy and this situation is expected to be temporary.

An advantage of accumulated cash-flow techniques over discounted cash-flow techniques is that accumulated cash-flow techniques usually explicitly model asset reinvestments and liability renewals, and, therefore, allow a good understanding of how the general asset and liability
portfolio characteristics will change over time. Discounted cash-flow techniques do not generally facilitate this type of analysis.

The primary drawback with accumulated cash-flow techniques is the difficulty in appropriately modelling the period-by-period investment action for a company that actively manages (i.e., trades) its existing investment portfolio. Dynamic management is commonly done for two reasons: (a) to actively manage the asset/liability price sensitivity relationship (e.g., maintain a duration and convexity match), and (b) to try and enhance the portfolio asset yield. Unless such activity can be accurately modelled, the results produced by the modelling will not accurately reflect the true interest rate risk exposure. The same issues with respect to using this technique to model interest rate risk exposure exist on a lesser scale with respect to companies that have a buy-and-hold philosophy with respect to assets already purchased, however, have a dynamically managed approach to new investments/required disinvestments (i.e., the reinvestment/disinvestment strategy can change).

While accumulated cash-flow techniques are theoretically the best approach to use, the modelling difficulties indicated above result in their use, for practical purposes, being most appropriate for companies that have a buy-and-hold investment philosophy, and are either closely cash-flow matched or follow a simple reinvestment philosophy. As more advanced computer software becomes available to model reinvestment/trading philosophies, accumulated cash-flow techniques should become more broadly applicable for quantifying new money annuity interest rate risk.

2. Discounted Cash-Flow Techniques

Discounted cash-flow techniques quantify the present value of cash-flow sufficiency/deficiency of the assets backing new money liabilities without explicit modelling of future asset reinvestment/disinvestment. The techniques implicitly consider only exposure to shocks in current interest rates. They, therefore, measure only the potential risk created by the current interest rate risk position, and do not attempt to make assumptions as to the future interest rate risk positions that the organization will take. These techniques, therefore, assume that the organization is able to prospectively control its exposure to these risks (i.e., dynamic management of the interest rate risk position where you are always actively managing your exposure to current interest rate movements). As a result, they are generally appropriate for companies that dynamically manage the interest rate risk exposure in their new money annuity business on an ongoing basis.

Discounted cash-flow techniques as described in this section should not be used for liabilities where the future rate resets that take place are at other than then current market rates or for liabilities where future premiums are credited with a rate other than a then current investment market rate. This is because the techniques described do not project liabilities past rollover or consider future new premiums.

Two common discounted cash-flow techniques are described: a single curve discounted cash-flow technique, and a market value technique.

Single Curve Discounted Cash-Flow Technique

The discounted cash-flow technique described below is particularly appropriate for a company that dynamically manages its asset/liability matching position but otherwise generally limits trading and maintains an asset mix within the portfolio that is fundamentally stable. In other words, asset/liability management is not focused on managing the day-to-day fluctuations in
yield curves but on immunizing the long-term ability of the existing asset portfolio to meet the payout requirements of the net benefits.

The technique is applied as follows:

a) Determine a single interest rate spot curve to be used to discount all asset and liability cash flows. This curve represents the assumed reinvestment/disinvestment curve. The spot curve should be derived from a current market yield to maturity curve. This underlying yield to maturity curve is typically set as either the current cost of funds curve for writing new money annuity liabilities (i.e., the gross rates required to write new business) or a prudent investment curve for cash flows. A “prudent” investment curve would represent conservative current yields for a class of fixed interest investments that the actuary believes will be available in the investment market on an ongoing basis and that the company would always be willing to invest in if other fixed interest asset classes were not available. The curve should represent appropriate yields net of default and investment expense costs (intuitively, this makes sense when one considers that when this curve is used for discounting, it also represents the implicit reinvestment curve).

b) Project the period-by-period future cash flows of the existing asset and liability portfolios without reinvestment. Future premiums are not considered and liabilities/assets that have rollover dates (i.e., rate reset dates) are assumed to mature at rollover. The projections should adjust for the following:

i) Interest sensitivity of the asset and liability cash flows based on the forward interest rates implied by the underlying yield to maturity curve being used. The interest sensitivity modelled should reflect any option exposure (e.g., asset calls or liability book value withdrawals expected).

ii) Expected asset defaults. The asset cash flows must reflect the expected asset cash flow patterns after any defaults and default recoveries.

iii) Investment expenses.

c) The asset and liability cash flows are then discounted back to the current date at an interest rate spot curve to generate a present value cash-flow surplus figure.

d) Exposure to interest rate changes is quantified by making sudden “shock” changes to the base yield to maturity curve and then recompiling the discounted cash-flow surplus using spot rates derived from the “shocked” curve. Asset and liability cash flows in each “shocked” scenario should reflect the interest sensitivity implied by the “shocked” yield to maturity curve.

e) In using a discounted cash-flow technique, it is important that the sudden shocks consider not only changes in the overall level of interest rates, but also changes in the shape of the yield curve, including curve steepenings, flattening curves, and curve inversions. Particular attention should be paid to modelling curve movements that you feel have a reasonable chance of occurring in the short- to medium-term future.

f) The asset cash flows expected to be generated from the opening asset portfolio should be adjusted if the actuary believes that the asset mix of the opening asset portfolio is not representative of the portfolio that will be held over the balance of the projection period. This is particularly important if the asset portfolio is temporarily of lower quality than it is expected to be over the balance of the projection period, since this situation could lead the actuary to overestimating the asset cash flows expected to be generated if there is any net yield pick-up after allowance for default margins. As a minimum guideline, the ac-
tuary should adjust the initial asset portfolio whenever its current holdings are outside the
guidelines specified in the company investment policy and this situation is expected to be
temporary.

Effectively, the technique measures the expected surplus assuming that the current asset mix,
or an adjusted asset mix if an adjustment is made in line with (f), is maintained until the assets
expire, and that any reinvestment/disinvestment is done at rates on the assumed single curve.

3. Market Value Technique

The second discounted cash-flow technique described below is particularly appropriate for
companies that both dynamically manage their asset/liability matching position and also allow
very active management of the asset mix to take temporary positions in different asset sectors/
classes.

This approach effectively manages surplus on a daily basis, and, as such, manages day-to-day
fluctuations in yield curves. It is consistent with managing the day-to-day market value of
assets.

The discounted cash-flow valuation technique described below attempts to reflect this manage-
ment of day-to-day market values.

The technique is applied as follows:

a) Segregate the liquid publicly traded interest-sensitive assets from the illiquid or noninterest
sensitive assets.

b) For the liquid publicly traded interest-sensitive assets, present value the individual asset
cash flows or asset sector cash flows at separate rates/sector spot curves to approximately
or exactly reproduce asset market values. Gross asset cash flows before investment
expenses or defaults are used.

c) Determine a single interest rate spot curve to be used to discount all the remaining illiquid/
noninterest sensitive asset cash flows and the liability cash flows. The spot curve should
be derived from a current market yield-to-maturity curve. This underlying yield-to-
maturity curve is typically set as either the current cost of funds curve for writing new
business (i.e., the gross rates required to write new business) or a “prudent” investment
curve for cash flows. A “prudent” investment curve would represent conservative current
yields for a class of fixed interest investments that the actuary believes will be available
in the market on an ongoing basis and that the company would always be willing to invest
in if other fixed interest asset classes were not available. It should be net of default/
expense costs. This curve should represent the target/benchmark return curve for your
active asset managers.

d) For the illiquid assets, determine the period-by-period expected cash flows without
reinvestment to the earliest of contract expiry or renewal, adjusted for expected defaults,
investment expenses, and interest sensitivity of the cash flows for the interest scenario
being modelled.

e) Project the period-by-period future cash flows of the liability portfolios without
reinvestment. Future premiums are not considered and liabilities/assets that have rollover
dates (i.e., rate reset dates) are assumed to mature at rollover. The projections should
adjust for the interest sensitivity of the liability cash flows for the interest scenario being
modelled.
f) Determine the net liability cash flows as the liability cash flows in (e) less the illiquid/noninterest sensitive asset cash flows in (d), and present value these at the single interest rate curve in (c).

g) The present value of surplus is the approximate or exact asset market value of the liquid interest sensitive assets in (b) less the net liability discounted cash-flow value in (f).

h) Exposure to interest rate changes is quantified by making sudden “shock” changes to the asset sector and liability yield-to-maturity curves and then recompiling the present value of surplus using these “shocked” rates and the method outlined in (a) to (g).

i) In using this technique, it is important that the sudden shocks consider both scenarios where changes in the overall level and shape of interest rates of all interest curves move together, and scenarios where different sectors move differently. Particular attention should be paid to modelling scenarios that you feel have a reasonable chance of occurring in the short- to medium-term future.

Effectively, the technique measures the surplus that could be realized assuming that you liquidate your asset portfolio for its current market value and reinvest it immediately at the curve assumed
for liability valuation (as described earlier, this liability curve should represent your asset benchmark/target return curve). The surplus that results from this method, therefore, represents the immunizable surplus level if you were to go back to your benchmark/target asset classes.

APPENDIX 2

SUMMARY OF KEY SHORTFALLS OF COMMON NUMERICAL INTEREST RATE RISK MANAGEMENT TECHNIQUES

Descriptions of the techniques commonly used as interest rate risk management tools are available in a wide range of the actuarial and general financial literature. While it is not the intent of this paper to discuss these techniques in detail, the actuary should be aware that nearly all of the techniques widely used have some shortfalls as measurement tools of overall interest rate risk exposure.

Methods reviewed include:

a) Macaulay and modified duration matching
b) Effective (option adjusted) duration matching
c) Convexity
d) Matching “D3” and other higher order derivatives
e) Maturity gap management
f) Cash-flow matching
g) Horizon matching
h) Partial duration analysis
i) Nonparallel duration analysis
j) Scenario-based techniques quantifying dollar exposure

It is worth reiterating that the effectiveness of any of these techniques is wholly dependent on the ability to reasonably model the underlying asset and liability cash flows.

The appointed actuary should regularly review the interest rate risk management techniques in place in his/her organization, and ensure that a broad enough range of techniques and measures are being used so that adequate management of all interest rate risk exposures is taking place.

a) Macaulay and Modified Duration Matching

The most commonly used measures of interest rate sensitivity are Macaulay and modified duration. These measures concisely summarize the price sensitivity of an asset or liability cash flow profile to interest rate changes with two key assumptions: first, the interest curve is flat and interest rate movements are in a parallel fashion, and secondly, the underlying asset and liability cash flows do not change as interest rates change. Because of the above assumptions, when Macaulay or modified duration is the key measure being used for management, there is potentially a substantial unmanaged exposure to both changes in the shape of the yield curve (i.e., nonparallel curve movements), and to sensitivity of asset and liability cash flows to changes in interest rates. The significance of this latter exposure is directly related to the level of options in the assets and liabilities. In addition to the above exposures, Macaulay and modified duration are only reasonable estimates of exposure to small parallel interest rate
movements, and these estimates can quickly become inaccurate as interest rates move from their current level. Mathematically, if one considers the function that gives the present value of a cash-flow stream as a “price” function, duration is a measure of the first derivative, or slope, of this price function.

b) Effective (Option Adjusted) Duration Matching

Effective duration is similar to modified/Macaulay duration in that it summarizes the price sensitivity of an asset or liability cash-flow profile to a parallel movement in interest rates, however, it uses option-adjusted interest sensitive cash flows and does not necessarily assume that the interest curve is flat. As such, its primary shortfall is that it does not in any way measure exposure to nonparallel interest rate movements. It is also only an approximate estimate of parallel movement exposure and it can become increasingly inaccurate as interest rates move from their current level.

c) Convexity Matching or Management

Mathematically, convexity measures are a measure of the second derivative of the price (i.e., present value) function for a cash-flow stream. Convexity analysis is often used as a secondary interest rate risk matching constraint in conjunction with one of the three duration measures described above, and when used in this context will primarily ensure a better match of the exposure to parallel interest rate movements. Matching the convexity of asset and liability portfolios will also serve to somewhat reduce the exposure to nonparallel interest rate movements (particularly changes in the slope of yield curves), however, it is important to note that substantial nonparallel interest rate movement exposure will frequently remain in a duration and convexity-matched portfolio even if the measures are option adjusted.

d) Matching “D3” and Other Higher Order Derivatives

A recent technique that has begun to emerge is to manage the matching of not only first order derivative (duration) and second order (convexity) price sensitivity measures but also to manage the matching of higher order derivative measures, often known as “D3” matching for third derivative matching, “D4” matching for fourth derivative matching, etc. As successively higher order derivative measures are matched, the exposure to changes in the level and shape of interest rates is progressively further reduced. Ultimately, when enough derivatives are matched, the result merges to a cash-flow matched approach. Drawbacks of this approach include that the measures may not be option adjusted, that it may be difficult to understand exactly what interest rate risk exposure remains after matching the measures, and that the measures may not be widely understood by management. In addition, identification and execution of appropriate corrective actions with this technique may be difficult without sophisticated asset/liability management software. A final concern that the actuary should be aware of is that the matching of higher order derivatives may give a false sense of comfort that the aggregate exposure is minimized if there is no corresponding degree of accuracy in the assumptions or model used to determine the underlying cash flows.

e) Maturity Gap Management

This is a technique traditionally used in banks, where asset and liability maturities are matched by amounts. The primary advantage of this tool is that it provides an easy to interpret visual picture for management. The four main drawbacks of the approach are that:

i) It gives no insight into how options in the assets and liabilities (including surrenders) can change the cash-flow match.

ii) It ignores the reinvestment/disinvestment implications of prematurity cash flows such as bond coupons and mortgage payments.

iii) It is not applicable for liabilities with no principal rate reset or maturity date (vested
iv) Maturity matching analysis cannot put a potential dollar value on the interest rate exposure that exists.

f) **Cash-Flow Matching**

Cash-flow matching of assets and liabilities is conceptually the easiest interest rate risk management technique. Cash-flow matched positions where the asset and liability cash flows are fixed (i.e., have no embedded options and no default exposure) would have little or no interest rate risk exposure to any parallel interest rate movements, nonparallel interest rate movements or sector movements. In practice, cash-flow matching presents three drawbacks:

i) Matching is rarely perfect resulting in some interest rate risk exposure because the yield cost of going to a perfectly matched position is too high (i.e., there are more restrictions on asset selection).

ii) Cash-flow matching “expected” cash flows does not in any way manage option exposure in the assets or liabilities. It is easy to construct scenarios where increasing the degree of cash-flow matching of assets and liabilities can lead to increased exposure to interest rate risk if assets or liabilities with embedded options are used to increase the match.

iii) The cash-flow match analysis cannot put a potential dollar value on the interest rate exposure that exists.

g) **Horizon Matching**

Horizon matching is a combination of cash-flow matching for an initial period (usually five years or less) combined with a total overall duration match. It tries to add the flexibility of broad duration management to the better interest rate risk minimization characteristics of cash-flow matching on the basis that the majority of changes in the underlying shape of yield curves occur at the short end. The main drawbacks of the approach are that substantial exposure to changes in the shape of the yield curve beyond the cash-matched horizon may remain, that parallel movement protection may be limited to small intervals (unless there are also overall convexity constraints), and that depending on the definition of duration, there may be no measurement and management of book value option exposure. Even if options are reflected in the overall duration management, it is unlikely that they are reflected in the initial “horizon” cash matching.

h) **Partial Duration Analysis**

There are several techniques known as key rate duration analysis, directional duration analysis, or partial duration analysis that focus on measuring the price sensitivity of asset or liability portfolios to changes in the level of interest rates independently at different points along the yield curve.

Partial duration analysis is an excellent tool to understand exposure to changes in the underlying level and shape of yield curves. By providing detailed information on exposures to changes in interest rates at each point along the yield curve, the impact of any combination of interest rate changes along the yield curve can readily be determined. This makes partial duration analysis a flexible and powerful analytic technique.

There are, however, some practical concerns with the technique as often applied. Price sensitivities are often not option adjusted and the sensitivities are generally appropriate for only small changes in interest rates. In addition, the method produces a large number of indicators rather than one or two key measures and the method is complicated and hence difficult to
understand. Because of its complicated nature, partial durations are often used as a risk analysis tool to supplement other less complicated techniques. Implementation of a partial duration approach as the primary risk management technique may be difficult without fairly sophisticated asset/liability management software being available. Use of partial durations may be most appropriate for short duration liabilities, which is where volatility of the yield curve is greatest.

i) Nonparallel Duration Analysis

Nonparallel duration analysis is similar to effective duration analysis, as described earlier in this appendix, except that it summarizes the price sensitivity of an asset or liability cash-flow profile to a specified nonparallel movement in interest rates rather than parallel movement. It may or may not be option adjusted. The primary drawbacks of this approach are that if only a very limited number of nonparallel durations are calculated, it may not give a broad enough measurement of the potential exposure to nonparallel interest rate movements, it may not be option adjusted, and it may not provide key actionable measures to investment personnel.

j) Scenario-Based Techniques Quantifying Dollar Exposures

These are excellent tools for understanding risk exposures for an asset/liability portfolio, particularly for option risks and for large changes in interest rates. For companies that manage asset mix to take temporary positions in different asset sectors/classes, discounted cash-flow techniques that measure asset market value sensitivity are also a very good tool for understanding the exposure to changes in interest rate spreads between different sectors. The principal drawback of using these techniques as active management tools is that they do not provide concise and actionable key statistics, and are, therefore, difficult to use as day-to-day management tools. To be effective, these techniques should include the impact of embedded asset and liability options.

A recurring theme in many of the above techniques is the difficulty in measuring exposure to asset and liability option utilization. There are two approaches to managing the interest rate risk created by interest sensitive cash flows. The first is to manage all interest rate risk, including this risk, together as a single risk. The second approach is to manage the risk created by interest-sensitive cash flows separately from the risk created by the mismatch of current expected cash flows. Both methods are acceptable; however, it should be emphasized that under any approach where these risks are managed separately, the capability should still be retained to numerically quantify the overall interest rate risk exposure created by the combinations of these risks for different interest rate scenarios.

In doing interest rate risk analysis using any of the techniques outlined above, rather than analyzing gross assets versus gross liabilities, an alternative is to analyze liquid assets versus net liabilities.
(net liabilities are gross liabilities less mortgages, private placements and any other assets generally considered illiquid). The advantage of this approach is that it clearly isolates the liquid position (i.e., the position that can actively be managed by trading to mitigate interest rate risk) against the illiquid position (the position that basically cannot be changed).

APPENDIX 3

SELECTION OF SCENARIOS FOR SCENARIO-BASED TECHNIQUES

The key to scenario selection is to ensure that the range of scenarios modelled adequately reflects the broad possible range of economic conditions that could emerge.

i) Modelling Software

The principal requirement for analyzing a broad range of economic scenarios is to ensure that the software being used allows this broad analysis.

The primary economic variable that should be modelled is future interest rates. Ideally, the modelling software being used should allow the following interest-related economic assumptions to be varied:

a) The yield curve of risk-free government bond interest rates
b) The spreads of different grades of bonds/other fixed interest investments over government bond rates
c) Inflation rates (primarily for modelling expenses and inflation-linked benefits)

Modelling software should allow the different points on the risk-free yield curve to move with some independence. As a minimum, at least a short-, medium-, and long-term rate should be defined that can change independently. Although correlation does exist historically between movements at different points along the yield curve, this correlation is much less than perfect. The flattening, steepening, and inversion of yield curves are very common historical occurrences.

If equity investments in stocks/real estate are part of the existing asset portfolio or are contemplated as possible future investments, the modelling software should make allowance for these asset classes. The software used should allow stocks and real estate returns to move in a manner uncorrelated to fixed interest asset returns, ideally with a random distribution around an expected mean return. Software that assumes equity and fixed interest investments can only move in a correlated manner, should not be used (i.e., it is dangerous to do modelling assuming stock/real estate movements are always correlated in some defined manner with fixed interest asset returns).

Modelling software must allow for the interaction of the future economic assumptions being modelled with any book value options in the underlying assets/liabilities (e.g., bond calls). Modelling software that does not specifically link the expected utilization of book value options to the economic scenario being modelled should not be used. It can produce dangerously misleading analysis.

ii) Deterministic versus Random Scenarios

It is legitimate to model interest rate risk exposure using both deterministic and randomly determined scenarios. Deterministic scenarios are best used to model a basic range of possible scenarios in order to establish the range of plausible financial outcomes. A good random
generating model allows generation and analysis of a large number of scenarios to establish what the overall expected outcome and probability distribution of different outcomes is.

While good random generating models can be extremely useful, it should be noted that these models are often complicated, and must, therefore, be used with caution.

A characteristic of many good random generating models is that they are “arbitrage free.” In layman’s terms, an arbitrage-free model ensures that if the scenario-generating model uses current market interest rate yield curves as a starting point, the scenarios it generates are consistent with the future interest rates implied by the current market curve unless specifically constrained to have a bias away from this curve (i.e., there is no unexpected systematic bias away from the starting curve).

Arbitrage-free pricing using today’s market curve is consistent with the assumption that the forward rates implied by today’s market curve are the best estimate of the mean distribution of future interest rates over the time horizon being analyzed. This is usually an appropriate assumption for a short time horizon analysis. If it is not felt that the current forward rates are the best estimate of future rates over the time horizon being analyzed, it may be appropriate to introduce a systematic bias to a different level of mean return. It is most common to introduce such a bias when modelling a mid- to long-term time horizon by having a mean reversion to historical average interest rate levels.

Before using a random generating model, the actuary should ensure that there is a thorough technical understanding within the organization of how it works.

It is strongly recommended that as part of any interest rate risk analysis, a minimum number of deterministic scenarios always be run, including scenarios that test the maximum permissible interest rate risk position permissible under the company’s investment policy.

iii) Deterministic Scenarios

To develop a broad understanding of interest rate risk exposure ideally requires the running of a large number of deterministic scenarios.

The actuary may well find that time/resources do not allow analysis of the full list of scenarios that follow and their potential interactions. The actuary will, therefore, need to decide very carefully which scenarios should be tested given the time/resources available.

As a guide to making these choices, the actuary should ensure that the scenarios tested give him/her good guidance in answering the following questions:

a) How would an immediate increase/decrease or change in the term structure of interest rates impact surplus?

b) How would a long-term increase/decrease or change in the term structure of interest rates impact surplus?

c) How would decreases/increases in the spreads between other fixed interest investments and government bonds over time impact surplus?

d) How would an under-performance/over-performance in equities relative to long-term expected equity yields impact surplus?

e) How would surplus be impacted if the interest sensitivity of asset/liability cash flows was materially misestimated?
f) How would surplus be impacted if the asset default rates were materially misestimated?

g) How would surplus be impacted if the organization adopted a more conservative asset investment strategy?

h) How would surplus be impacted if the company moved to a position that reflected the maximum interest rate risk position permissible under the company’s investment policy? Note, this is a particularly important question for companies where the current interest rate risk position is more conservative than the maximum permitted under the company’s investment policy.

Scenario Selection When Doing “Sudden Shock” Analysis (i.e., One-Period Analysis)

The following is an example of the variety of scenarios that would generally need to be tested in order to obtain a good understanding of the interest rate risk in a portfolio.

a) Movement of current yield curve (i.e., risk-free government rates)

• Parallel movement in current market interest rates up and down 25 basis points (i.e., small parallel move)

• Parallel movement in current market interest rates up and down 300 basis points (i.e., large parallel move)

• Flattening of yield curve (short rates unchanged, long rates falling)

• Steepening of yield curve (short rates unchanged, long rates rising)

• Upward movement of yield curve with overall flattening (short rates rise, long rates rise less)

• Upward movement of yield curve with overall steepening (short rates rise, long rates rise more)

• Downward movement of yield curve with overall flattening (short rates fall, long rates fall more)

• Downward movement of yield curve with overall steepening (short rates fall, long rates fall less)

• Yield curve inversion (short rates rise to higher than long rates, long rates unchanged)

• Reverse flattening of yield curve (short rates rise, long rates unchanged)

• Reverse steepening of yield curve (short rates fall, long rates unchanged)

It should be noted that, historically, volatility increases as you go out along the yield curve (i.e., the long end of the yield curve is much more volatile than the short end).

In determining the magnitude of interest rate movements to model in one-period scenario testing, consideration should be given to the company’s practices with respect to the frequency of risk position reporting and frequency of active rebalancing of this position. Generally, the less frequently a company measures the risk position and/or rebalances, the larger the potential interest rate movements that should be considered. For example, if a company’s practice is to determine its risk position on a quarterly basis and to rebalance at that time, then the scenarios should be selected taking into consideration historical changes in interest rates from quarter to quarter. Thus, the range of plausible changes in
e) Changes in the underlying interest rate risk position and/or portfolio asset class composition

Often, a company’s current interest rate risk position does not reflect the maximum risk position that the investment policy allows to be taken. If the current interest rate risk position is less risky than the maximum risk level permitted under the investment policy and the company has the capability of executing transactions to quickly alter the risk level, then scenarios should be tested that include the company moving to the maximum permissible interest rate risk position.

In addition, if the investment policy permits some discretion in the selection of asset classes, and the company has the capability of executing transactions to quickly change the asset mix, scenarios tested should include the company changing its portfolio to different asset mixes. In particular, a change to a more conservative reinvestment policy should be tested since this will generally reduce asset adequacy.

Testing would ideally also include interactions of the different variables covered above.

Scenario Selection When Doing Multi-Period Analysis

Testing would ideally also include interactions of the different variables covered above.

The possible choice of deterministic scenarios for multi-period modelling is virtually unlimited. The text that follows highlights a broad range of scenarios that could ideally be tested. In addition, potential interactions of these scenarios could also be tested.

a) Movement in yield curve (i.e., risk-free government bond rates)

• Immediate sudden movements in the yield curve, unchanged thereafter
• Immediate sudden movements in the yield curve, gradual return to original level or
• Gradual movements in the yield curve to new level, unchanged thereafter
• Gradual movements in the yield curve to new level, gradual return to original level or long-term expected
• Yield curve movements in full cycles over the projection period (i.e., sine curve or wave patterns)
• Market expected future reinvestment rates (i.e., implied forward rates)

Ideally, the above scenarios should be run for parallel interest rate movements of up to 300 basis points, nonparallel yield curve steepening and flattening, and yield curve inversions. In addition, it can be very useful to run scenarios that duplicate some of the more extreme paths that interest rates have actually followed during the last 25-year period. This allows analysis of how well the interest rate risk management strategy being followed would have withstood historic shocks/paths that actually occurred.

b) Movement in other fixed interest asset spreads
Changes in the spreads on other fixed interest assets over government bonds should be modelled covering the same sudden shock, gradual movement, and cycle patterns outlined above in (a).

c) Variation in equity returns
Equity modelling should generally be based on models that have a random element around a mean return and limited, if any, correlation to fixed interest yields. Even here, however, a minimum number of deterministic scenarios should be modelled covering sudden “shock” gains/losses as well as misestimation of the expected long-term mean return.
• Sudden 20%-30% increases/decreases in equity values with expected returns thereafter
• Sudden 20%-30% increases/decreases in equity values with gradual recovery of initial gain/loss in addition to expected returns over following years
• Mean returns higher/lower than the long-term expected level

d) Changes in interest sensitivity of asset/liability cash flows to changes in interest rates.
This is again an extremely important analysis that can easily be overlooked. One of the greatest risks of modelling assets/liabilities with interest sensitive cash flows is misestimation of the interest sensitivity. The actuary should know how much the interest rate risk exposure is increased by such potential misestimation.

e) Changes in Investment/Disinvestment Strategy
• A conservative reinvestment strategy should be tested (i.e., reinvestment strategy in assets with a lower net spread over government bonds than the base assumption being used)
• If the base modelling is done by assuming borrowing to cover negative cash flows, an analysis should be done also with an explicit disinvestment strategy since borrowing may not always be available
• Scenarios that assume the company takes the most aggressive interest rate risk positions permissible under the company’s investment policy should be tested

f) Changes in asset default expectations
Asset defaults result not only in losses of principal, but also result in interest losses and changes to the underlying asset cash-flow pattern. It is important to model different levels of asset defaults in order to understand the exposure to misestimating the future level of these defaults.