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CORPORATE MODELING AND FORECASTING (PRACTICAL ASPECTS OF THE VALUATION ACTUARY RECOMMENDATIONS)

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Panelists: JOSEPH J. BUFF
DENNIS L. CARR
STANLEY B. TULIN
Recorder: RUSSELL B. TUCKER

- o Purposes
- o Tools and methods available
- o Scenario testing
- o Updating
- o Special issues and problems

MR. MICHAEL C. BATTE: To begin our program, I'd like to review some pertinent events. In July 1984, the Joint Committee of the American Academy of Actuaries and the Society of Actuaries completed it's final report on the role of the Valuation Actuary in the United States. Our topic is Corporate Modeling and Forecasting, Practical Aspects of the Valuation Actuary Recommendations. Our panelists should be familiar to you. For the past six to eighteen months they've been active in either C3 risk activities, Society of Actuary's sponsored seminars on asset liability matching or other teaching activities. Our panel participants are Joe Buff, Research Associate with Morgan Stanley; Dennis Carr, Consulting Actuary with Tillinghast; and Stan Tulin, Consulting Actuary with Milliman and Robertson. Our recorder is Russ Tucker, Consulting Actuary with Tillinghast.

That report had two recommendations, one of which has brought about the office or title of Valuation Actuary as a suggestion. The second recommendation

without going into detail, has basically set into motion a process whereby standards of practice for a Valuation Actuary are going to be addressed by the Academy and Valuation Principles are going to be addressed by the Society.

In May 1985 at the St. Louis Spring Meeting of the Society, the keynote address was a debate on the role of the Valuation Actuary. There followed some five workshops on this subject. In July 1985 the American Academy of Actuaries published a discussion draft that was developed by the Committee on Qualifications and Committee on Life Insurance Financial Reporting Principles entitled "Standards for Valuation Actuaries." It proposes qualifications for a valuation actuary and proposes standards of practice. More recently the Society published an exposure draft developed by the Committee on Life Insurance Company Valuation principles entitled "Exposure Draft on Life Insurance Company Valuation Principles."

MR. DENNIS L. CARR: The valuation actuary concept appears to be making steady progress. As background the key sources of development were:

> The American Academy of Actuaries issued its discussion drafts in July of 1985. It is my understanding that more than 30 responses were made to these drafts. The financial reporting committee is currently considering these comments.
>
> The Society of Actuaries Committee on Life Insurance Company Valuation Principles in April 1986 released an exposure draft on valuation principles.
>
> Next, there is New York. As is many times the case, New York has taken a lead role in this new legislative area. New York currently has requirements in effect relating to the valuation actuary concept for annuity business. My understanding is that these requirements are to be made more strict for annuity business issued in 1986. Even if your company does not do business in New York, it will be important for you to be aware of New York's progress on valuation actuary legislation.

So much for general background. The title of our panel is "Corporate Modeling and Forecasting (Practical Aspects of the Valuation Actuary Recommendation)." The modeling necessary to do the full valuation actuary analysis will be a modeling of the entire company. To the best of my knowledge, very few analyses of this type have been completed. For preliminary valuation actuary analysis, one might consider looking at a particular product or product line. My presentation is going to focus on this concept: that is, preliminary valuation actuary analysis.

Among the characteristics of preliminary valuation analysis are the following:

- This sort of analysis will involve one product or product line rather than with the entire company.

- Generally, the initial products which a company would study would be their interest-sensitive products.

- The purpose of this preliminary analysis is to smoke out any potential reserve inadequacies as early as possible. To the extent each product line has no reserving problems, the entire company should not have a problem. To the extent a product line has a problem, it may or may not be offset by sufficiencies from other product lines.

In an effort to stay as practical as possible, the remainder of my presentation will involve development of a case study for a Universal Life product. This case study illustrates the preliminary valuation actuary analysis concept just described. Among some of the specifics of our case study are as follows:

- The product studied can best be described as a typical back-loaded Universal Life plan.

- This plan was assumed to be issued for five years -- from January, 1981 to December, 1985. Our analysis is done as of 12/31/85.

- The pattern of sales was as follows:
  10 policies in 1981,
  30 policies in 1982,
  40 policies in 1983,
  50 policies in 1984, and
  55 policies in 1985.

- The initial credited interest rate (as of 12/31/85) was assumed to be 9.8%.

- The projections were done over a 30-year period.

- The surplus was assumed to accumulate at an after tax rate in the model, with the tax rate assumed to be 36.8%.

The initial asset portfolio was assumed to have the following characteristics:

- It was composed entirely of A-rated corporate bonds.

- The average yield on the portfolio was 11.41% effective.

- The portfolio was composed of a mix of bonds ranging from one to fifteen years to maturity. The average maturity was 7.7 years.

- The bonds with ten or more years to maturity were assumed to be callable. In all cases, a four-year call protection period was assumed.

The interest rate scenarios that were tested began with rates which represented the actual rates of 3/31/86. For A-rated bonds, this meant a five-year rate of about 8.1% and a ten-year rate of about 8.5% . With an average portfolio earnings rate of 11.41% , the initial portfolio had a market value equal to approximately 115% of the book value at the beginning of the model -- a nice position indeed.

For this case study, several runs were made of the model. Sensitivity tests were performed on several of the key assumptions. The purpose of these

sensitivity tests was to illustrate the variations in results which might occur in a valuation actuary analysis.

In evaluating the model results, the following two measures were utilized:

- The year-by year statutory surplus. Negative surplus amounts at any point in time would represent potential need for additional reserves.

- The excess of the market value of assets over the statutory reserve amount at the end of the 30th year. If the reserve exceeds the market value of assets at the end of 30 years, this also would indicate the potential need to increase reserves.

The first assumption to be discussed is interest rate scenarios. This is a key assumption, since many of the other assumptions key off the interest rates. When developing a set of interest rate scenarios, one must consider how many scenarios will be tested. A few hand-picked scenarios are easier to deal with but may not give the full picture. Alternatively, a large number of scenarios might be tested -- say 40 or 50 or more. Obviously this creates more work, but when the work is completed, conclusions may be more certain; in other words, one can feel more comfortable that a full range of possibilities has been considered.

In defining the scenarios, there are several additional decisions to be made, including the type of asset used to define the reinvestment rates -- for example, A-rated corporate bonds, treasury instruments, or mortgages. This depends on the type of investment strategy to be used in modeling.

One must also consider the type of interest rate to be used i.e., effective versus nominal. This can be particularly confusing when non-actuaries are involved. Most actuaries think of interest rates as effective; however, many investment people think in terms of bond equivalent yields -- a semi-annual nominal yield. It is important to make sure that everyone understands the type of interest rate being used.

The risk of default may be considered through a deduction from the scenario interest rates. And, finally, investment expenses need to be deducted from the rates in each scenario.

For our case study, 40 stochastically generated scenarios were utilized. Among these scenarios were several which I would define as reasonable, a few plausible scenarios, and a few implausible scenarios. Don't ask me to be too specific on this categorization! Investments were assumed to be in A-rated corporate bonds. Seventeen basis points were subtracted for default risk, and twelve basis points were deducted for investment expenses.

For the next three assumptions, there will be a general discussion of considerations involved in setting the assumptions, followed by the specific assumptions used in the case study and finally a look at some sensitivity test results.

The first assumption is investment strategies; that is, how positive cash flows will be invested and negative cash flows will be funded. Among the considerations in determining investment strategy are:

- The types of assets must be determined; e.g., bonds, mortgages, cash.

- The maturities to be allowed must be determined; e.g., maturities of 1, 3, 5, 10, and 20 years might be allowed:

- The type of strategy must be determined. One might use a target portfolio strategy where cash flows will be invested to move towards a given target portfolio. As an alternative, one might use a strategy where each period's cash flow is invested proportionately in various investments.

- The investment strategy might be static -- that is, constant throughout the model -- or dynamic -- varying over time based on certain parameters. Static strategies are easier to model, but investment people may consider dynamic strategies to be more realistic.

- Finally, the method of funding negative cash flows must be decided. The basic choices include borrowing or selling assets. Borrowing might be accomplished by investing in negative assets -- that is, borrowing from another line of business -- or short-term borrowing might be assumed, which is similar to going to the bank. Alternatively, selling assets could be used, however this is definitely the most difficult assumption to model.

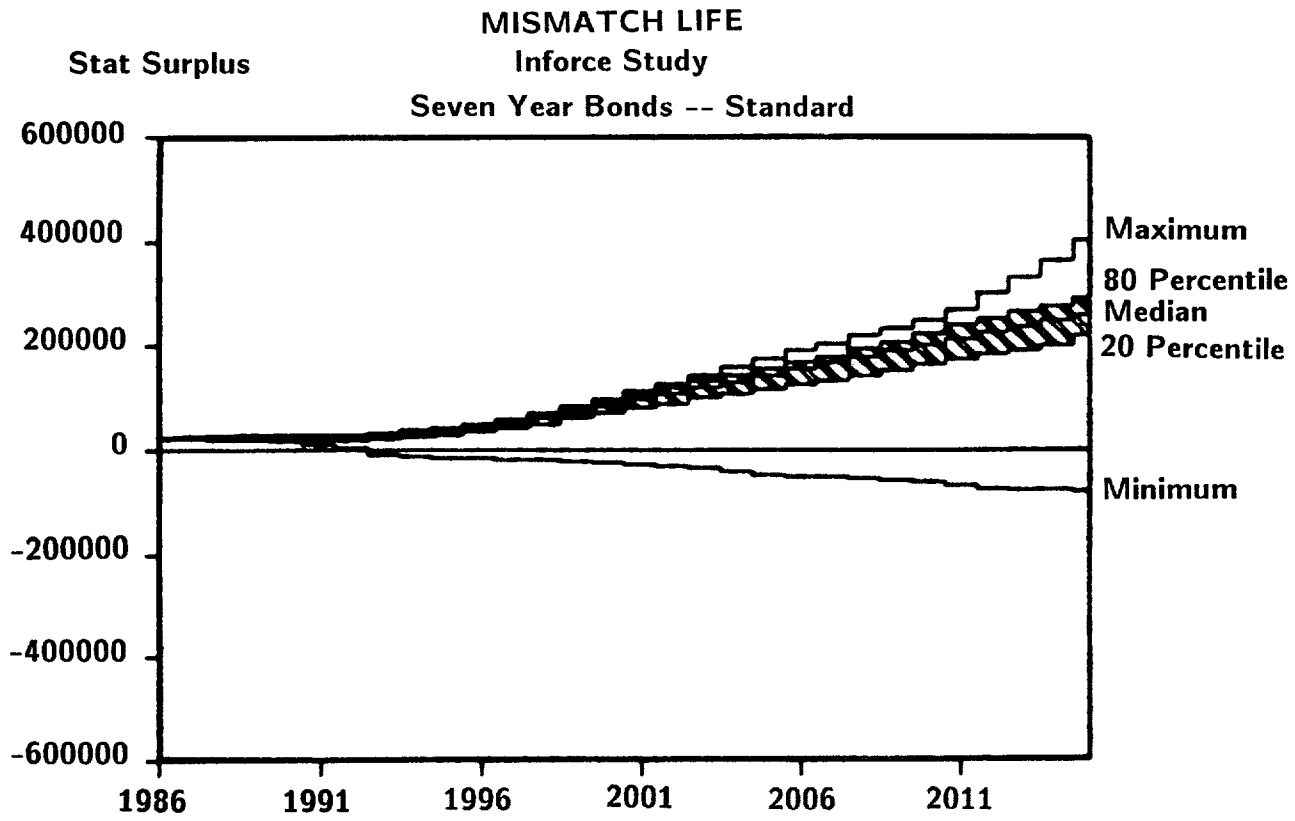
Our sensitivity tests considered two static investment strategies. The standard strategy was to invest all positive cash flows in 7-year A-rated corporate bonds. The second investment strategy assumed all investments were in 15-year non-callable A-rated bonds. For both strategies, it was assumed that negative cash flows would be funded by negative investments, with the negative investment vehicle matching the strategy for investment of positive cash flows.

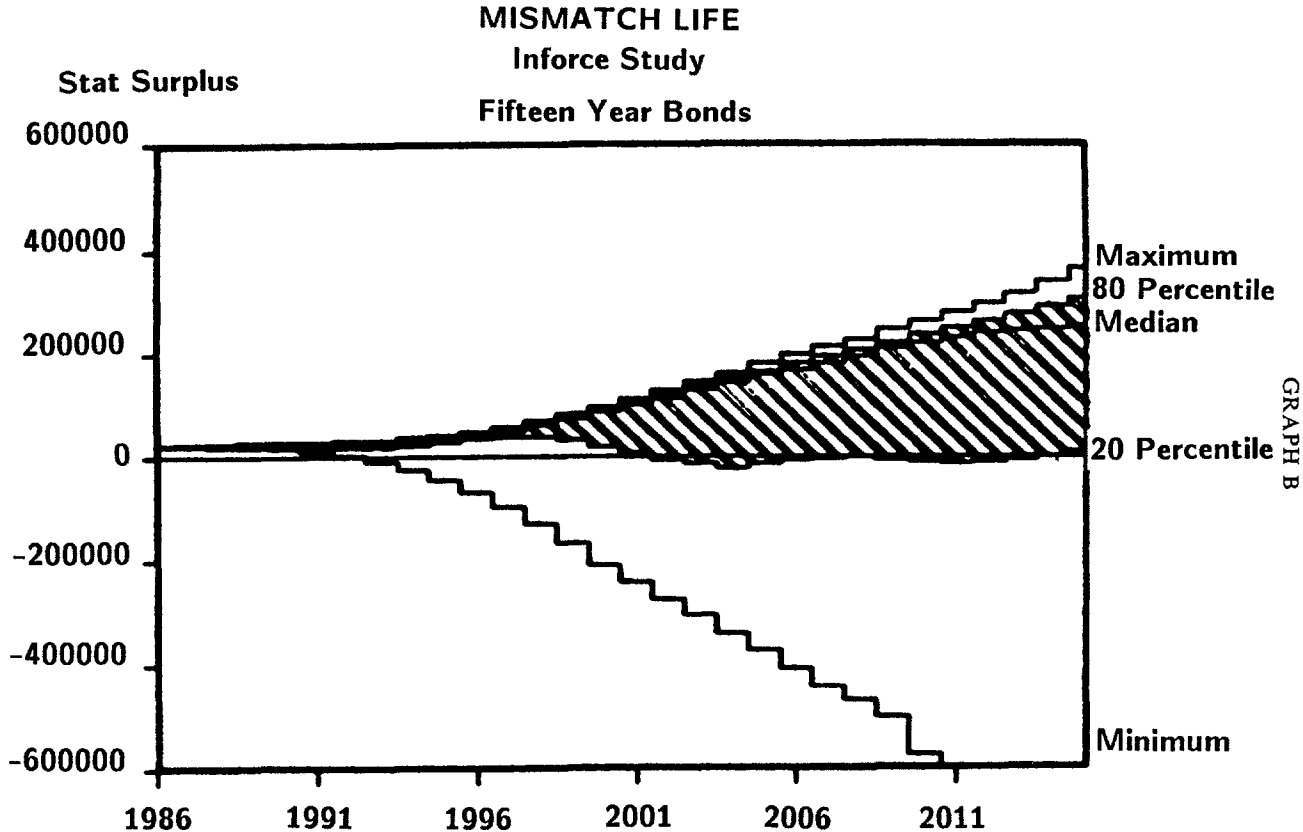
Graph A shows the year-by-year statutory surplus for the standard 7-year bond strategy. Each year, the amount of statutory surplus was ranked from the largest to the smallest for the 40 scenarios. The top line on the graph represents the largest value obtained from the 40 scenarios; the second line from the top represents the 80th percentile; the third line, the median, the fourth line the 20th percentile, and the bottom line the smallest result. The area between the 80th and 20th percentile is shaded with the slanted double lines. The zero line runs through the middle of the sale. Across the bottom are the years from 1986 through 2015, a total of 30 years.

For the 7-year bond investment strategy, the shaded area stays clearly above the zero line, and only a small portion of the bottom 20th percentile area dips between the zero line. Based on the 40 scenarios tested, this would indicate that, in almost all situations, the reserves are adequate.

The results for a 15 year bond investment strategy are shown in Graph B. Obviously, this presents a different picture. The range of results for the 15-year strategy is obviously much wider. Nearly all of the bottom 20th percentile area is below the zero line, indicating that reserves are inadequate for about 20% of the scenarios tested.

GRAPH A


MISMATCH LIFE
Inforce Study
Seven Year Bonds -- Standard
Stat Surplus
600000
400000
200000
0
-200000
-400000
-600000
1986
1991
1996
2001
2006
2011
Maximum
80 Percentile
Median
20 Percentile
Minimum

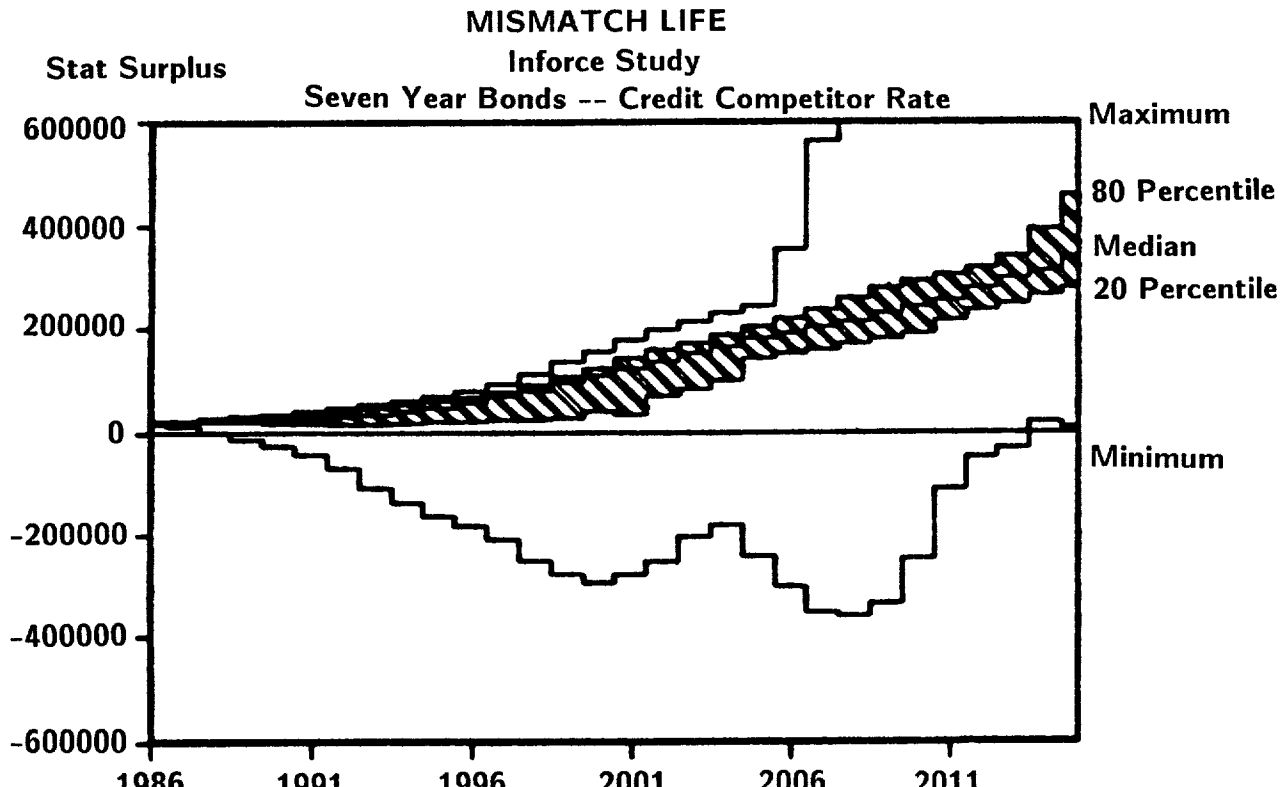

MISMATCH LIFE
Inforce Study
Stat Surplus
Fifteen Year Bonds
600000
400000
200000
0
-200000
-400000
-600000
1986
1991
1996
2001
2006
2011
Maximum
80 Percentile
Median
20 Percentile
Minimum

GRAPH B

The second key assumption is the interest crediting strategy. Among the considerations for determining this assumption are:

- There are two basic extremes in crediting strategy. One might "follow the portfolio." This means that the credited rate would be determined periodically by looking at the earnings on the asset portfolio and deducting an interest spread.
- The second extreme is to "follow the competition." This means that the credited rate would follow the rates credited by other companies without regard to the actual earnings on the asset portfolio.
- A key part of the crediting strategy assumption is a definition of the competition or a competitor rate. Among the choices for a definition of the competitor rate are a new money rate and a rolling average of the past several months' new money rates. The rolling average concept is meant to approximate the workings of a portfolio type strategy. Combinations of new money rates and rolling average rates can also be used as a definition of the competitor rate.
- In building a model, one must consider whether portfolio or generational approaches to crediting interest will be allowed, where generational approaches have different rates for new money and old money and portfolio approaches have one rate for all funds. Generational approaches are quite difficult to model since they involve segmenting assets and liabilities by the various credited interest blocks.

The standard strategy in our case study was to credit the portfolio earnings rate less 1.5%. A sensitivity test was performed assuming that the competitor rate was always credited, where the competitor rate was defined as the greater of the 5-year new money rate on Treasuries less 1% or the 36-month rolling average of that same new money rate less 1% . For both strategies, the credited rate applied to all funds; in other words, there were no interest rate generations created. Graph A shows the year-by-year statutory surplus for the standard assumption -- that is, credit the portfolio earnings rate less 1.5% . Graph C shows similar results for a "credit the competitors rate strategy." Note that the investment strategy is the standard 7-year bond strategy for both cases.


MISMATCH LIFE
Inforce Study
Seven Year Bonds -- Credit Competitor Rate
Stat Surplus
600000
400000
200000
0
-200000
-400000
-600000
1986
1991
1996
2001
2006
2011
Maximum
80 Percentile
Median
20 Percentile
Minimum

GRAPH C

The range of results expands significantly for the "credit the competitor rate strategy," particularly the results for the upper and lower 20% groups. The results for the middle 60% are only slightly more variable for the "credit the competitor" strategy.

Graph D is a bar chart showing the range of results for the 30th year market value of assets less reserve measure. Once again, the top and bottom 20% show more variation. However, the middle 60% show a better result for the "credit the competitor" strategy. One reason for this result is that the competitor rate was defined in a relatively sane manner. I'm not sure our recent experience bears this out. In any case, it is not recommended that you follow the competition without regard for actual portfolio experience.

The third assumption is the withdrawal rate. Among the considerations in developing this assumption are the following:

- One must consider the effect of not only full withdrawals but also partial withdrawals, especially penalty-free type partial withdrawals.

- Generally, the lapse assumption consists of a base withdrawal rate plus an additional withdrawal rate. The base rates apply in a stable interest environment and the additional rates vary with the interest scenario.

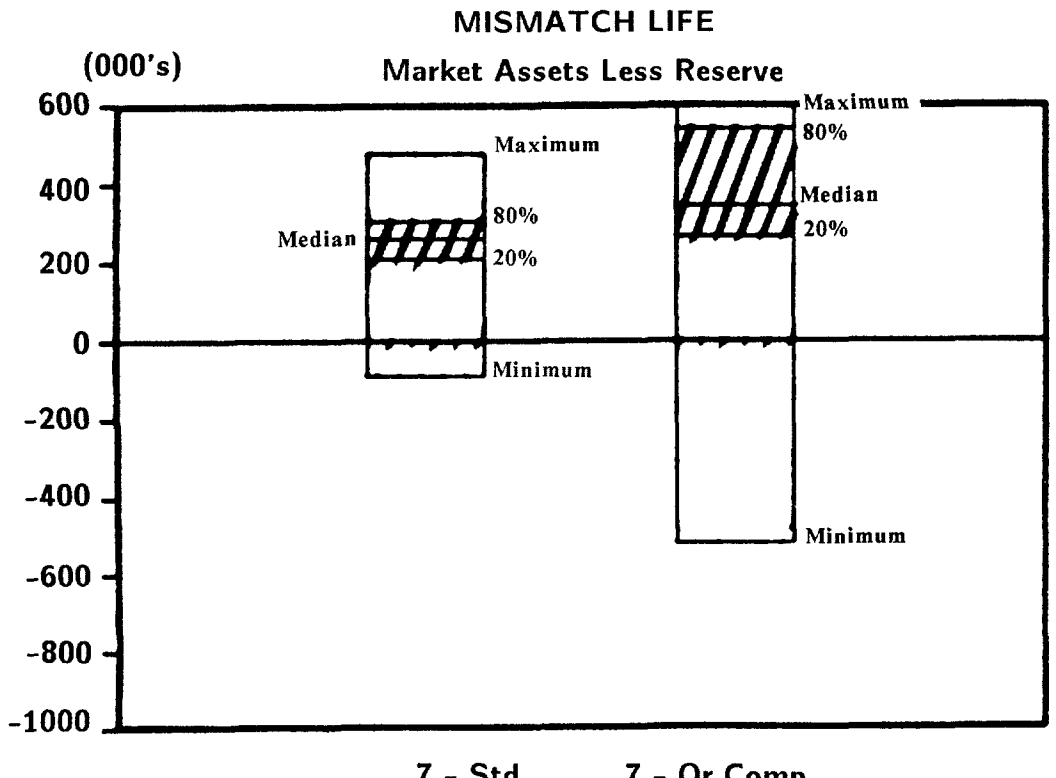
- The key variable used to construct the additional withdrawal rates is the difference between the competition rate and the credited rate. To the extent credited rates fall behind the competition rate, additional withdrawals are generated.

- Surrender charges can have a dampening effect on the additional withdrawals. That is, to the extent there is a surrender charge, additional withdrawals may be discouraged.

In our sensitivity testing, all withdrawals were assumed to be full withdrawals. Additional withdrawal rates were set equal to:

$$(\text{Completion Rate} - \text{Credited Rate})^2 \times 2$$

GRAPH D


MISMATCH LIFE
(000's)
Market Assets Less Reserve
600
400
200
0
-200
-400
-600
-800
-1000
Maximum
80%
Median
20%
Minimum
Maximum
80%
Median
20%
Minimum
7 - Std
7 - Or Comp

for the standard assumption. The sensitivity test assumption was:

$$(\text{Completion Rate} - \text{Credited Rate})^2 \times 3$$

Both assumptions utilized a similar reduction in additional lapses due to the existence of surrender charges. For the standard assumption, the maximum total withdrawal rate was 30%. For the higher withdrawal rates, the maximum was 45%.

Graph A shows the year-by-year statutory surplus figures for the standard withdrawal assumption, while Graph E shows the same for the higher withdrawal rate assumption. The higher withdrawal rates significantly increase the downside risk associated with the bottom 20%. Also, the range of results for the middle 60% is broadened somewhat on the downside.

Graph F is a bar chart showing the 30th year market value of assets less reserve results. The higher withdrawal rate tends to shift all of the results downward in the chart.

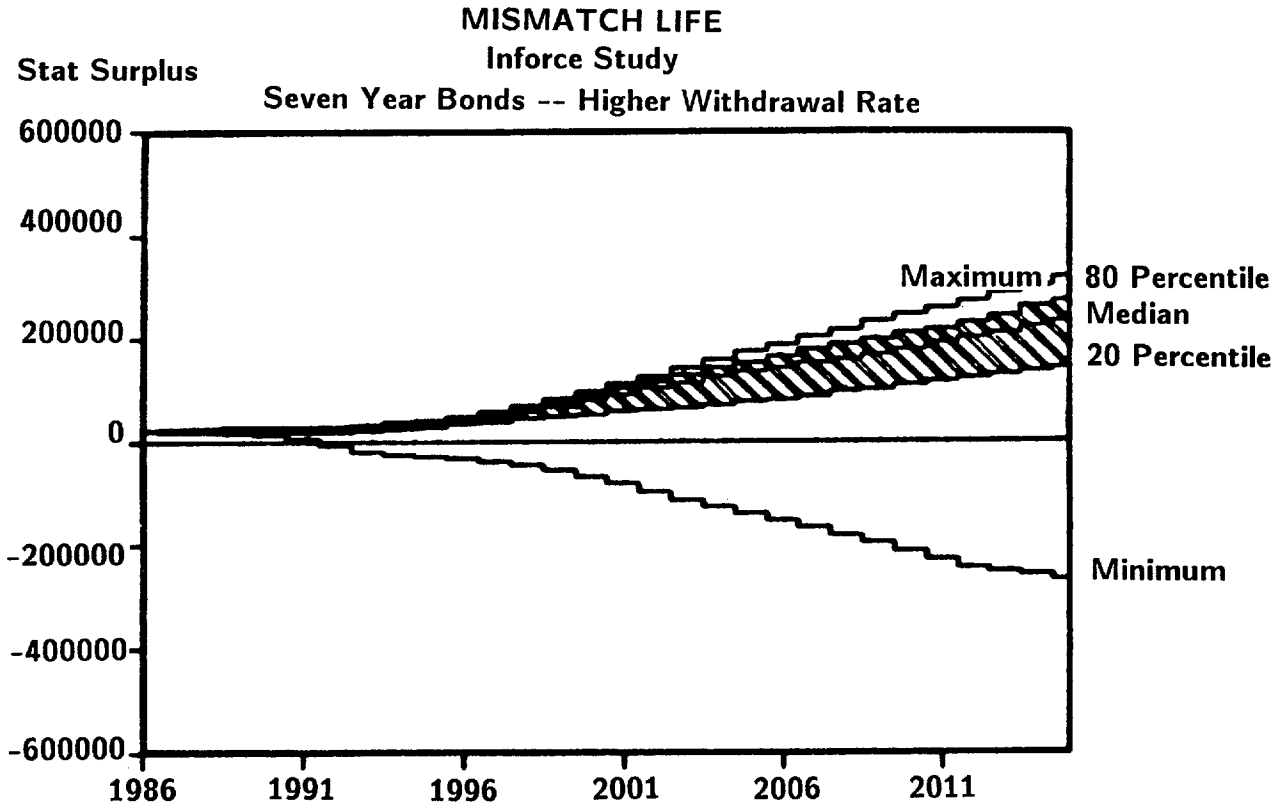
While we have looked at sensitivity test results for these key assumptions, there are other assumptions which also should be considered. Among these are:

- Asset prepayments. Bond calls and mortgage prepayments can have a significant impact on results. We're learning this lesson today.

- Inflation of expenses. Generally, it is anticipated that, as interest rates rise and fall, the inflation rate will follow. This assumption can be especially critical for small policies where expenses represent a larger portion of the gross premium.

- For flexible premium plans, the pattern of premium payment is important. If the credited rate becomes non-competitive, increased premium suspensions are likely.

GRAPH E


MISMATCH LIFE
Inforce Study
Seven Year Bonds -- Higher Withdrawal Rate
Stat Surplus
600000
400000
200000
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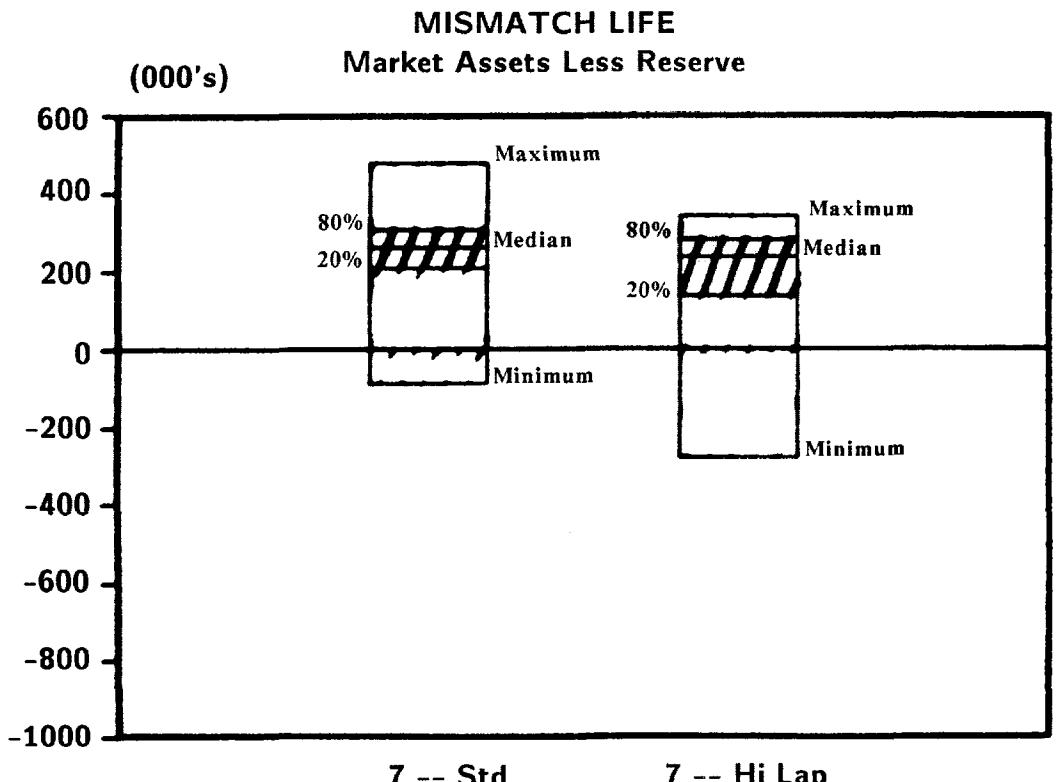
-200000
-400000
-600000
1986
1991
1996
2001
2006
2011
Maximum
80 Percentile
Median
20 Percentile
Minimum

GRAPH F


MISMATCH LIFE
Market Assets Less Reserve
(000's)
600
400
200
0
-200
-400
-600
-800
-1000
Maximum
80%
20%
Median
Minimum
Maximum
80%
20%
Median
Minimum
7 -- Std
7 -- Hi Lap

- Policy loan activity can be expected to vary with changes in interest rates. This is especially important for minimum deposit products and for single premium life products with subsidized loan rates.

Performing preliminary valuation actuary types of analyses, such as the one described in our case study, can provide valuable results. To the extent problems are detected early, they may be addressed. Also, by building models for specific product types, one gets a start on the process of building the full company types of models which eventually will be required.

MR. STANLEY B. TULIN: I'm going to take a slightly different perspective to exactly the same thoughts. I'd like to start with what I consider to be perhaps the most practical aspects of the Valuation Actuary as it's going to hit all of us in the next year. That is that in order to do his work the Valuation Actuary is going to have to talk to a lot of other people within his company. That may sound simple. A few examples will be themes throughout my presentation as well as the themes in Denny's.

First of all is the issue of what I call an investment crediting strategy or a liability management strategy, something that typically the Valuation Actuary is not going to have at his command. The Valuation Actuary is sitting there in his room with this problem. He's got opinions he's going to have to sign and problems he's never looked at before. How does he solve it? The first thing he has to do is talk to somebody about these liability management things. The next thing he's got to do is to go find out what his company does with the money. In some companies that's a real challenge. The process of finding out what the investment strategy is and what the liability management strategy is, is central to the Valuation Actuary doing his job. The good things that can come out of that process properly done are going to be invaluable to companies well beyond issues of just dealing with the Valuation Actuary problem.

I want to start with the idea that we're all working together now and that we're not just a Valuation Actuary off in a room. The first thing is that the Valuation Actuary is going to try and bring all these people together and talk about some terminology. I encourage you as Valuation Actuaries to realize that it may not be simple to the people who set your credited rates, depending on

who they are. Often they are the marketing people as opposed to the actuaries. Also your terminology may be a little bit different from your investment people. For example:

- Reinvestment risk is something that exists where you have assets that are shorter than your liabilities. Reinvestment risks typically only exist when you have money in your hand as opposed to money not in your hand.

- Disintermediation is somewhat the opposite. It exists where the assets have durations that are longer than the liabilities. And of course just the opposite exists. You need money that you otherwise don't have and are going to have to liquidate securities and hope that their market values are going to fit.

Next point is the thing that brings us all here I guess. With respect to interest rate changes, the interest sensitive contracts have liability durations which shorten as the interest rates rise. That compounds the disintermediation risk. I'm not talking about the classic pure definition of duration as much as the actual cash flow. We've all found that Dennis's lapse formula, my lapse formula, and I hope everyone's lapse formula, will be such that surrenders increase as interest rates increase, generally. That, in effect, increases your cash flow, front ends your cash flow requirements on the liability side and shortens your duration, all other things being equal. There are some algebraic reasons why duration shortens, but those are not the one's I'm talking about. The opposite is also true, generally. The liability tends to lengthen or you have more payments to make out at the end of your time when interest rates are falling. That increases the reinvestment risks. This whole thing is not desirable, and it makes for some serious problems in the treatment of most life insurance products.

Most of what the Valuation Actuary is going to have to do is generally applicable not just to interest sensitive products or at least what we call interest sensitive but also to what I'll call traditional products which I believe are also interest sensitive. The traditional non par whole life policy which has guaranteed cash value build up (I don't know how many of those are left in force any where) a fixed death benefit, and a fixed premium, has always been

interest sensitive. Certainly results in the last six to seven years have emphasized that interest sensitivity. The lapse rates and the policy loan utilization rates vary with the external environment. Likewise, par whole life has a lot of the same and has always had the same characteristics as Universal Life, or interest sensitive whole life or some other product variation of that type. Therefore, I object to the notion that the products of the eighties are the reason for the phenomenon that we now have before us. They just may be emphasized more by current environmental situations where interest rates are going up and down a lot. The conclusion we've reached is that classical immunization, where the Macaulay duration of liability is set equal to the Mcaaulay duration of the assets, is not feasible for the large bulk of our product lines. You must do something a little more exotic.

There are some general points that are important again in this process of bringing two people together and talking about this. Any business enterprise accepts risk with the notion that it would get a reward commensurate with the risk it assumes. Business enterprises have limited capital, and they need to manage their risks. This is another practical aspect of what the valuation actuary is going to be doing. He is essentially going to be appropriating capital to reach a conclusion about appropriate reserve levels.

A non trivial point which is important in understanding the evolving process of the Valuation Actuary and beyond the Valuation Actuary is that insurance has traditionally been priced on an expected value basis. We really haven't looked very much at the risk assumed. We have probably thought about it but certainly for the interest risk we have not looked at it very much. Even today, it's my experience that many companies are pricing interest-sensitive products assuming a spread between earned and credited rates rather than with any kind of analysis of the actual probability or likelihood of reaching that spread. Dennis also alluded to the market conditions in terms of insanity of pricing the products today, and I think that some of that is also present. It's hard to simulate today's market conditions and get a positive spread, so it's a lot easier to assume this spread.

Finally, interest strategies for both interest sensitive products and for traditional products are rarely clearly defined. That is why you must bring

your investment people into the process and make them understand what the strategy is going to be because you'll see that, in order to do Valuation Actuary work, you must make assumptions and statements about the investment policy of the company as well as the existing portfolio.

The first conclusion that we reached is insurance business is a risk business. I think we all agree with that. That's certainly why companies can rationalize making a profit or contributions to surplus. There is a risk transfer between the client and the company which is adding value to the client. Management has to do things to analyze it's risk profile and set a quicker posture about it. It has its own hurdle to climb. The notion of managing a life insurance company, at least in an institutional way, and this is consistent with the direction of the Valuation Actuary, is one of containing risk and maximizing profit within that containment. So first, we are risk adverse, and secondly, we're generally profit driven or surplus contribution driven, if we are a mutual. In either event what we're trying to do is make a contribution of surplus or profit, but we want to be risk adverse first. The management process is always going to be dynamic and again this gets back to the need for the Valuation Actuary. It brings people together and understand what their thinkings are. Strategies are going to change and be dynamic, and that means there is no substitute for the judgement of the management. The Valuation Actuary is going to have to try to reflect the judgement of the management in his projections and analysis. Finally, portfolio structuring maybe can, or maybe can't reflect managements' views, but the Valuation Actuary at the point he's going to talk about the investment strategy needs to assess some of that.

I'm going to go though a bunch of things the Valuation Actuary is going to have to think about in order to answer his questions and set his assumptions. The first point I am afraid is going to become a very substantial issue in the Valuation Actuary work. The reason I say I'm afraid is because I think it's an extremely potentially difficult issue to deal with. That is the question of "Is your investment strategy active or passive?" I have some illustrations that I'll get to and Dennis had his that basically show what we call static investment strategy. What we're running into more and more is companies that are going to actively manage their portfolios. They are going to be doing things in response to market changes, in response to yield curve changes, and

in response to the absolute size of interest rate changes and as they learn more and more about their liabilities. What this suggests is a very dynamic process for the actuary who is doing the valuation work. It certainly suggests the static investment portfolio, as if you are just going to buy and hold as the basis for doing the analysis, may come up short. In fact it may generate much higher required reserves than may be appropriate or than your management may feel is appropriate. That's what the question on active versus passive is.

The next questions are about duration matching and whether or not there is going to be an attempt to duration match.

Finally, the Valuation Actuary has to decide if he is going to use a fixed reinvestment strategy or if he going to use what I call a synthetic option approach which again goes to the rebalancing of the portfolio. The next thing he has to do is pull together his model, and that involves doing a lot of things that actuaries haven't done before, although we're all starting to do more and more of this. Within the model the actuary has to build an asset model that has to look at yield curves or scenarios, book values of securities, market values and par values. I want to focus just on the penultimate point there, the call and prepayment provisions. The whole issue of predicting the cash flows, which is really what the process of a Valuation Actuary's work is going to be about, is one that is going to involve assumptions and understanding of the underlying securities on the asset side. Just as an example, many life companies now are starting to invest significantly in mortgage pass though instruments such as Ginnie Maes and Fanny Maes. We recently were looking at a company that had 70% of it's portfolios in Ginnie Maes as of the end of 1985. The investment people in the audience can imagine what happened to them in terms of cash flow during the early part of 1986 with the rapid repayments. The problem is that you end up with a Valuation Actuary type problem on the underlying assets. The projection of the cash flows on, for instance the Ginnie Mae, through interest rate variations is probably as difficult to predict as the projection of the cash flows on the liability side. These projections create the same kind of problem that I described earlier about the liabilities. When interest rates go down and you really are going to be exposed to reinvestment risks, your prepayments on the mortgage pass throughs generally will increase. Alternatively when interest rates are going

up, they are likely to decrease which is just when you'd like to have more cash to reinvest. This whole question of how to model those securities is going to be very important to the Valuation Actuary. It's one of the things for which research is necessary. There is a lot of research being done on this by the Wall Street Firms, in terms of different models for pass through instruments and things like that. The actuary is going to have to understand this and build these models into his Valuation Actuary work.

MR. JOSEPH J. BUFF: Ultimately, the valuation actuary's professional concern is surplus, perhaps the surplus of a single product line and perhaps the surplus of an entire life insurance company. In order to achieve strategic marketing and profitability goals, insurers are led to invest accumulated funds in the risky capital markets. Thus surplus is directly affected by investment risk. The extent of this risk exposure is determined by the characteristics of the liabilities, and of the assets which back those liabilities. Models of the business have to be developed, as a tool for measuring and managing investment risk. My discussion will focus on the modeling of fixed income assets, such as bonds, mortgages, and mortgage-backed securities.

Briefly, these are the three familiar types of investment risk:

1. Default risk: Someone who invests in a fixed income security makes a loan to the issuer of that security. If the issuer becomes financially impaired, and is unable to make payments of interest and/or principal when due, the investor suffers a loss. The market value of the debt of a financially impaired issuer can fall even if the issuer does not actually go into default.

2. Reinvestment risk: Interest rates fall, so the return available upon reinvestment declines. This makes it harder to support interest rate guarantees. Profit goals become harder to achieve.

3. Disintermediation risk: Interest rates rise, so policyholders are encouraged to withdraw their guaranteed cash values for reinvestment elsewhere at higher rates. Negative cash flow can force an insurer to sell

assets below book value, or else to borrow at high rates of interest. Profitability may suffer.

Note that if the insurer uses a portfolio method for crediting interest to policyholders, then reinvestment risk and disintermediation risk can affect new sales as well as in force profitability.

Actuaries generally recognize the drawbacks of traditional statutory accounting for quantifying these risks. Statutory surplus is artificially stabilized. Since surplus is the excess of assets over liabilities, risk assessment needs to address how asset and liability values can change. Since assets and liabilities both derive their values from the cash flows they generate, it helps to concentrate on these cash flows to measure the risks. Estimating these cash flows, and then taking their present values, leads to what has been called "market value accounting." Market value accounting is certainly different from statutory accounting. It derives some of its utility from an ability to "present value" risk exposure or economic losses masked by the annual statement blank. I make the following case for paying careful attention to market value accounting:

1. Market value accounting gives information about risk exposure which is simply not provided by traditional statutory accounting.

2. Market value accounting presents the real economic "worth" of the insurance operation, and shows how that worth can and does change when the external environment changes. This information is valuable on a going-concern basis as well as on a sale or liquidation basis, since an insurance company cannot be managed indefinitely as a pyramid scheme.

3. Market value accounting is a leading indicator for book accounting. That is, loss positions identified by market value accounting would eventually emerge on the statutory books. Present value calculations identify the magnitude of risk exposure or of economic loss.

4. Market value accounting allows calculations that measure risk exposure and suggest ways to control and reduce risk exposure. Thus market value

accounting is proactive, while statutory accounting is reactive. The nature of these calculations will be reviewed in my presentation.

MODELING DEFAULT RISK

In this section I will give a quick overview of the default risk (C-1). Before I begin, I would like to refer you to an excellent paper on this subject recently drafted by Richard L. Sega which will be published in *TSA* XXXVIII. This paper treats some aspects of C-1 risk in much more detail.

Investments with lower credit quality will offer higher nominal yield, but they carry greater potential for default losses. "Default costs" mean the value of the principal and interest payments which are not made when due. Default costs are analogous to insurance claim costs: they are unpredictable as to frequency and magnitude, though they can be estimated from historical experience.

Most publicly traded fixed income investments are assigned quality ratings by such organizations as Moody's and Standard and Poor's. Insurance companies also do their own credit research. The purpose of this work is to categorize the financial standing of different debt issuers, so as to rank the relative chance of losses due to default of different investments. It is reasonable to expect a correlation between these quality ratings and subsequent default experience, and some historical studies have indeed found such a connection.

Let us begin by looking at the "cost of default" for a single asset. Assuming that the insurer holds the asset until it either defaults or matures, then the default cost is an all-or-nothing phenomenon. That is, if the bond is in good standing, then there has been no default cost (yet), and if the bond is in default, then the default cost could be taken as the book value. This is a simplified view, especially since market value can fluctuate as credit rating changes, even if a bond never defaults.

Actually, the loss on default is more complicated than an immediate write-off of the full book value. Defaulted bonds can have a "salvage" market value greater than zero. Sometimes debt payments are rescheduled after default, and the bond issuer may succeed in making the rescheduled payments. A study by

Altman and Nammacher ("The Anatomy of the High Yield Debt Market," Morgan Stanley, 1986) found that a sample of bonds which defaulted in the last few years traded on average at 41% of par shortly after default.

Investors control default risk by diversifying their portfolios. Thus for modeling purposes it could be more relevant to discuss how to reflect default costs on an overall portfolio basis. Diversification can and usually does smooth out default experience over the years. It is therefore reasonable to reflect default costs by reducing the nominal investment yield by a flat amount, when making long-range financial projections for an investment portfolio which is fairly well diversified. This annual default cost assumption should vary by class of investment (bond or mortgage or mortgage-backed security). It should also vary with the average credit quality of the assets being modeled. The default cost assumption could also be made to vary with economic conditions in the model -- higher in recessions and lower in growth periods.

High Yield bonds, that is junk" bonds, will have higher average default costs than investment grade corporate bonds. The Altman/Nammacher study provides some statistics for default costs which I'll review for your information. The average annual default rate on the Altman/Nammecher sample of high yield bonds between 1974 and 1984 was 1.6%. Because of the salvage value of defaulted bonds, total return was reduced by an average of 1%. The valuation actuary might consider reflecting the long range default costs of a pool of junk bonds, by reducing book yield by a flat amount. Although the Altman/Nammacher study would seem to suggest using 1%, you should be very cautious because this statistic is purely historical, and is based on a sample of bonds which may differ from those in your own company's portfolio.

The method I've described might seem appropriate, but I also want to mention its pitfalls. Default experience has shown substantial variance about the average, tending to be higher during recessions than during expansionary periods. It can be difficult to set a default rate assumption for some investments, for example, private placements, where historical experience is limited and public references are of little help. There is no assurance that future default cost statistics will average out close to those of the past. Bonds can be upgraded or downgraded over time. Changing practices of high yield initial

public offerings, and changes in the world of mergers and acquisitions, might mean tomorrow's junk bond market isn't the same as today's.

It would be useful here to discuss the question of prefunding a reserve for default costs. In fact, the Mandatory Securities Valuation Reserve requires such prefunding. For bonds listed by the National Association of Insurance Commissioners as low grade, the contribution rate is generally 2% per year. Insurers might treat required contributions to the MSVR as expenses which offset the amount of book yield available for crediting to policyholders. Some insurers establish "voluntary" reserves to supplement the MSVR. These reserves are meant to be written down when default losses occur, stabilizing financial results. This reserving also helps keep management from making promises to policyholders which cannot be supported by actual investment experience. A voluntary reserve for bond defaults is probably not tax-deductible.

MODELING REINVESTMENT AND DISINTERMEDIATION RISKS

Reinvestment risk and disintermediation risk are two sides to the problem of interest rate volatility. Of course, general concern over the impact of this volatility on life insurers' surplus positions helped give rise to the professional responsibilities that valuation actuaries are meant to oversee. The solvency of an interest-sensitive insurance product line should be reviewed in more detail than is provided by traditional statutory accounting. Professional guidelines, and emerging state regulations, point in the direction of careful analysis of the asset and liability cash flows over a variety of different future interest rate environments.

One approach to the cash flow studies fundamental to market value accounting, applies simulation to project periodic cash flows along a set of interest rate scenarios, and then analyzes profitability across the scenario. The volume of output from a detailed simulations analysis is potentially large. Graphic summaries are very helpful. Simulations are an excellent way to get a feel for the nuts and bolts of a product's behavior, to ask "what if" questions about future financial performance, and to analyze surplus needs under "catastrophe" assumptions.

In the limited context of investment strategy development and interest rate risk control, simulations might have drawbacks. They could be misapplied to obtain downright misleading information.

C-3 risk control is effective if profit (however measured) is relatively insensitive to interest rate volatility. You could say that valuation actuaries might like to see surplus "immunized" against interest rate changes. There are at least two "target accounts" which a company might want to stabilize:

1. Dollar amount of surplus, on a market value basis.

2. Ratio of surplus to liabilities, on a market value basis.

In general these two target accounts cannot be immunized simultaneously. I take these target accounts on a market value basis because, as I will show, market value accounting suggests effective hedging strategies, and it is the market values which respond most directly to this hedging. Remember that market value accounting is a leading indicator for statutory accounting.

The Macaulay duration of a bond, as you probably know, is the weighted average of time to each of the bond's cash flows, where the weights are the prices (present values) of the individual cash flows. Macaulay developed this measurement during the 1930's in order to approximate the change ($\triangle$ P) in market value (P) of a bond, as brought on by a change in yield-to-maturity ($\triangle$ I). (All of the equations I give here will assume $\triangle$ I is a shock to continuously compounded interest rates, i.e. to forces of interest.) So long as the cash flows of the bond in question are fixed and certain as to timing and amount, Macaulay duration (MD) satisfies this approximation:

$$\triangle P = -P \cdot MD \cdot \triangle I \qquad (1)$$

Now, Macaulay duration is not readily applicable to an asset whose cash flows depend on future interest rates. This is because it is unclear how the weighted-average time-to-payment might be directly evaluated. This problem has misled some practitioners into thinking that interest-sensitive cash flows do

not have durations. Other practitioners have suggested that duration of an interest-sensitive asset or liability equals the average of the Macaulay durations, of cash flows taken over a set of interest rate scenarios. I will tell you why neither of these points of view is correct.

Note that equation (1) can be rewritten as:

$$MD = -(1/P) \cdot \Delta P / \Delta I \qquad (2)$$

so that Macaulay duration itself can be estimated from information on how price changes when interest rates change. It has been the practice among many financial theorists for several years, to define the duration D of a security whose price P is given as a function of interest rates I, as follows:

$$D = -(1/P) \cdot dP / dI \qquad (3)$$

Here dP/dI is the derivative of the price function P with respect to a one-parameter model for shocks to interest rates, using any reasonable model of interest rate volatility. The problem of getting the duration for an interest-sensitive asset or liability is solved if we can figure out how to "price" such instruments. In fact, the pricing of securities whose cash flows depend on future interest rates has also been addressed recently by financial theorists. Concepts from modern option pricing theory are directly applicable. Financial options are, after all, perhaps the prototypical assets with interest-sensitive cash flows. Research into their pricing has been very active for quite some time. Once this pricing has been accomplished, duration can be estimated by numerically approximating the derivative.

I recommend the following brief reading list for valuation actuaries who need to learn more about pricing and duration for interest-sensitive cash flows:

1. R. Clancy, "Options on Bonds and Applications to Product Pricing," *TSA* Volume XXXVII, and Discussion by J. Tilley, et. al.

2. P. Milgrom, "Measuring the Interest Rate Risk," *TSA* Volume XXXVII, and Discussion by J. Buff and G. Lord.

3. D. Jacob, G. Lord, and J. Tilley, "Price, Duration, and Convexity of a Stream of Interest-Sensitive Cash Flows," Morgan Stanley, 1986.

My job now is to convince you, whether you are a valuation actuary or some other kind of actuary, or not a member of the Society at all, that the general definition of duration given by equation (3) is really useful to you.

Duration satisfies an "aggregation property." Suppose we have securities A and B with prices PA and PB and durations DA and DB, respectively. Let A+B be the security whose cash flows are the arithmetic sum of the the cash flow of A and of B. Then the aggregation property is:

$$D(A + B) = DA \cdot PA / (PA + PB) + DB \cdot PB / (PA + PB) \qquad (4)$$

Consequently, since surplus equals assets minus liabilities, information about the duration of surplus can be obtained from the durations of the assets and the liabilities. What is more, the duration of total assets or total liabilities can easily be found by aggregating the duration for the individual assets or liabilities making up the block of business in question.

Financial ratios also have duration. For instance, let A equal sets, L equal liabilities, and S equal surplus, all on a market value basis. Then a little differential calculus will show that:

$$D(A / L) = D(A) - D (L) \qquad (5)$$

Now we are ready to write down conditions on duration which approximately immunize the two target surplus accounts I mentioned above:

1. Dollar amount of surplus, S: $D(A) = D (L) \cdot L / A$

2. Surplus Ratio, S/L: $D(A) = D (L)$

Duration studies show management how to plan out attacks against their exposure to interest rate volatility. By structuring assets and liabilities properly, guided by these duration relationships, the chosen target account can

be rendered insensitive to interest rate volatility, at least approximately. If management prefers to bank on an interest rate forecast, leaving the targeted surplus account unhedged in hopes of increasing profit, then duration calculations are necessary for properly arranging this "interest rate bet."

Now that I have shown you the utility of duration according to equation (3), I still need to convince you that "real world" solutions exist for the problem of pricing interest-sensitive assets and liabilities. For a treatment of callable bonds, including a listing of an APL program for pricing options, see reference 1. For a technical discussion on an approach to pricing very general asset or liability cash flows, which I have personally applied to study a number of single premium deferred annuity liabilities, and a number of asset portfolios with callable bonds and Ginnie Maes, see reference 3.

Interestingly, the pricing models discussed in reference 1 and 3 do not require interest rate forecasts. They do in general require two inputs:

1. The interest rate environment on the valuation date.

2. An assumption about the "volatility" of interest rates in the future. This specifies the degree of variability of interest rates, but has nothing to do with the direction in which rates might move.

Generally it is not hard to supply these assumptions. It is useful to do some sensitivity testing as to the volatility assumption.

Skeptics in the audience may ask if equation (3) duration can really help them, since it is dependent on a model which may be imprecise, and needs assumptions which may be incorrect. Certainly all models have weaknesses like these. Experience has shown that duration calculations are robust and relevant. Sensitivity analyses have shown that they often have stability when assumptions are changed, unlike certain optimization models. Most importantly, duration modeling points the way toward practical ways to reduce C-3 risk, without asking the actuary to become a forecaster of interest rates.

INTEREST-SENSITIVE ASSETS

An investment with fixed and certain cash flows is more the exception than the rule in the typical life insurance company's fixed income asset portfolio. Here are some common assets whose cash flows are in fact quite interest-sensitive:

1. Callable bonds: These are bonds where the issuer retains the right to call (prepay) the principal of the bond before the final maturity date. This is valuable to the issuer, and costly to the investor, when interest rates decline.

2. Prepayable mortgages: Some mortgages are self-amortizing (principal is repaid over the life of the mortgage), and some are bullet mortgages (principal all paid at final maturity). In either case, the mortgage (borrower) may have the right to prepay all or part of the principal before it is due. When interest rates decline, this reduces the mortgagee's borrowing costs, but at the same time it reduces investment income for the investor who granted the mortgage.

3. Mortgage pass-throughs: These are ownership shares in pools of residential mortgages which have prepayment rights. Ginnie Maes are popular mortgage pass-throughs which are available with a variety of coupons. The individual mortgagees represented within the pool can prepay all or a part of their mortgage principal at any time. Some prepayments occur when the homeowner dies or sells the house. When interest rates drop, it pays to refinance the mortgage (which amounts to prepaying the original mortgage), but then not all homeowners will bother to do so. Thus the cash flow characteristics of Ginnie Maes are especially complex.

4. Collateralized mortgage obligations (CMO's): CMO's, like mortgage pass-throughs, are fixed income securities with mortgages as underlying collateral. However, CMO's have a different cash flow structure. The principal repayments are divided into several "tranches" that have different priorities for the repayment of outstanding principal. An

investor can choose between these tranches to get a shorter or longer expected average maturity.

5. Options and futures on fixed income securities: These instruments are highly leveraged -- their market values change quickly when interest rates change. For this reason they are very useful for adjusting the duration of an asset portfolio towards a given target duration.

6. Interest rate swaps: An interest rate swap is a contract between two parties. Each party makes interest payments to the other, based on a notional principal that establishes the dollar magnitude of the payments. One party's interest rate is fixed, and the other party's rate is floating. See J. Buff, "Interest Rate Swaps," a two-part article in the April 1986 and June 1986 issues of *News from the Individual Product Development Section*. Swaps are a useful tool for adjusting asset durations without needing to sell existing assets.

A really useful model needs to be able to take account of the interest-sensitive aspects of investments like these, since their market values and their cash flows definitely vary with interest rates. To ignore the variability of call and prepayment experience is to ignore a significant source of investment risk.

SIMULATION MODELS

Developing a detailed and flexible simulation model for assets is a complex task. I will assume your model's basic structure already exists. I will confine myself to an approach for modeling interest-sensitive principal repayments for bonds, mortgages, and Ginnie Maes.

Call options and prepayment rights become valuable when interest rates drop, and it is likely that in some interest rate scenarios call options will be exercised and mortgage prepayment rates will rise. Economically speaking, these early repayments occur when the coupon rate on the outstanding debt is somewhat higher than the new-money rate for comparable debt. For a callable bond, the decision to call is an all-or-none question (ignoring sinking funds)

which applies to the entire bond. For Ginnie Maes and other mortgage pass-throughs, however, some prepayments go on all the time. The problem there is to predict the prepayment rate given current interest rates.

In a simulation model, the calculations proceed sequentially from scenario to scenario, and sequentially from period to period within each scenario. At the valuation date, the actuary has information about the principal outstanding on the various assets he or she needs to model. The actuary also needs information on the call provisions or prepayment rights of all the assets. Thus we can formulate a way to model principal repayments as follows:

1. Keep track of the coupon rate of the asset being modeled, relative to the new-money rate for similar debt for the given period of the given scenario being processed. Also keep track of the principal which remains outstanding at the beginning of this period.

2. Develop a table of principal prepayment rates, between 0% and 100%, based on the difference between the old-money and new-money coupon rates net of a refinancing cost hurdle. This hurdle amounts to an amortization of the costs of closing on the debt refinancing.

3. Once the prepayment rate is determined, multiply it by the remaining principal to get the latest principal prepayment. Reflect this as an additional cash flow to the insurer. Also reflect it as a reduction to the principal outstanding going into the next period of the scenario. For callable corporate bonds, the issuer often has to pay a penalty in addition to the principal if the bond is called before maturity. The latter is named the call premium, and it depends on the call provisions of the bond.

This is a fairly simple approach. It can be made more complex, and perhaps more realistic, if the prepayment table uses information on the history of new-money rates versus the asset's coupon rate from the beginning of the scenario or even from the time of original issue of the bond or mortgage. An assumption about refinancing costs is necessary. For corporate bonds, something like 2% of outstanding principal is not unreasonable, and this might be

amortized over the remaining term-to-maturity of the original debt, or perhaps over a number of years equal to the original term-to-maturity of the bond.

This model can be made more specific by identifying four quantities:

a. Coupon rate of the existing bond, mortgage, Ginnie Mae, etc.

b. New money rate for similar debt in that quarter of that scenario.

c. Annual amortization of refinancing costs.

d. A threshold representing sluggishness or economic inefficiency on the part of the debtor.

Then in general, the quantity a-b-c-d would be used to look up a prepayment rate in the table referred to in step 1. It is reasonable to assume corporate bond issuers are rather efficient economically, so the threshold, d, might be 0, or 0.25% perhaps. It could be assumed that the prepayment rate will be 100% if a-b-c-d $>$ 0 and the bond is currently callable, and 0% otherwise.

Prepayment behavior for mortgage-backed securities is the subject of active research on Wall Street and elsewhere. In the context of simulations, the problem comes down to predicting a prepayment rate, based in part on the comparison between the coupon rate of the asset and the new-money rate for similar debt. Refinancing costs and sluggishness can be treated indirectly using a table of sliding prepayment rates based on the difference in coupon rates. Developing this table can make use of Conditional Prepayment Rages (CPRs). The CPR for a period is simply the percentage of outstanding principal which prepays in that period. For Ginnie Maes with coupons below new-money rates, there will still be a non-zero CPR since some mortgages prepay regardless of the interest rate environment. These non-economic prepayments can occur because people die, relocate, or simply decide to sell their houses. If the coupon rate is well below new money rates, a CPR of maybe 6% to 9% per year might be reasonable. If the coupon rate is well above new-money rates, then economic prepayments will occur, and a CPR of 20 to 40% or more per year is possible. Historical data on Ginnie Mae CPRs is available from some investment houses

or reference libraries. When practical, the actuary should try to review the prepayment behavior of the specific pools his company owns, rather than relying on "generic" data that does not distinguish among specific pools.

Grouping of assets might be convenient or necessary. In that case, the prepayment assumptions I have described above might be modified. A grouping of callable bonds with similar coupons might be treated the way I suggest treating Ginnie Maes. That is, some percentage of all the bonds might be called each period depending on the comparison of old-money and new-money rates.

DURATION MODELS

As I hinted near the start of my talk, in order to properly compute durations of interest-sensitive assets (or liabilities it is necessary to use a proper definition of duration. This section of my talk will focus on how not (!) to compute the duration of an interest-sensitive asset. For a detailed discussion of how one should compute duration for interest-free sensitive assets and liabilities, see reference [3] page 1251.

It is tempting to try to apply the Macaulay duration formula to interest-sensitive cash flows, making use of a simulation model. Every time you run a scenario through your simulator, you get a sequence of cash flows. One might naturally go on to compute the Macaulay duration of each scenario's cash flows, and then subject the resulting set of Macaulay durations over all scenarios to an averaging process. Or, one might simply choose a "best estimate" scenario and take the Macaulay duration along that scenario. This idea is intuitively appealing, but it just doesn't work for interest-sensitive cash flows, whether they are assets or liabilities.

I will first explore the general inaccuracy of Macaulay duration using the case of a put option. A put option is the right to sell a specified bond for a price which is fixed in advance, regardless of the market value of the bond at the time the option is exercised. Thus, put options become more valuable as interest rates rise, since the less the bond costs the more the put is worth. So a put option has a negative equation duration -- price rises when interest rates rise. But it is easy to see that any simulation model using some rule

about timing and magnitude of the put option's payoff, will give a set of cash flows which is non-negative in every possible scenario. Thus the Macaulay durations will all be non-negative, so the average of these Macaulay durations cannot give the correct answer!

I have used the general interest-sensitive cash flow pricing model described in reference 3 to analyze the duration of a simple callable bond. This bond was an A-rated ten-year maturity bond, priced on 3/31/86. The coupon rate was 8.10% semi-annually, so that the underlying non-callable bond would have traded at par. All the principal would be repaid in full at maturity, or all-at-once if called earlier. It was assumed the bond might be called, at par, at any time. I also assumed there was a 2% refinancing cost. The interest-sensitive cash flows were projected and priced with a binomial lattice. Interest rate volatility followed a log-normal model, and volatility was 15% annually for short-term rates and averaged about 10% annually for long-term rates. The bond was assumed to be called at any point in the interest rate lattice where the then current term-structure of interest rates caused the present value of the then remaining cash flows of the bond (to maturity) to exceed par plus accrued interest and the refinancing cost.

If this bond were not callable, its Macaulay duration would be 7.04 years. I ran calculations using a sample of 40 paths through the interest rate lattice, since the call process I've described is path-dependent, and is not the same as the optimal exercise process described in reference 1. The paths as a group were statistically unbiased, using variance-reduction techniques.

The pricing model, applying equation (3), gave a duration of 4.0 years. This is significantly shorter than the 7.04-year Macaulay duration. Intuitively the call option "shortens the maturity" of the bond. More precisely the impact of the call option on the market value of the complete asset is to dampen price volatility with respect to interest rate changes. Portfolio managers are very familiar with this dampening during bond market rallies.

Next, the same 40 paths through the interest rate lattice were used as "scenarios," and the cash flows from each were used to compute 40 different Macaulay durations, discounting by the starting 8.10% yield-to-maturity of the

underlying non-callable bond. These Macaulay duration figures ranged from 0.7 years (bond called quickly in that scenario) to 7.0 years (bond never called in that scenario) with a simple average of 3.7 years. Thus the average Macaulay duration differed from the equation (3) duration using exactly the same assumptions, by more than one year. Note furthermore that using just one of the forty scenarios could have produced a duration anywhere from practically zero up to 7 years.

I recently analyzed a representative single premium deferred annuity product using the same type of interest-sensitive cash flow pricing model that I used to do this analysis of the callable bond. (I plan to document this SPDA study elsewhere in the near future). I obtained a duration of 2.5 years, which I verified to be the "right" duration for C-3 risk hedging, by using a simulation model independent of the cash flow pricing model. Macaulay durations along 40 interest rate scenarios ranged from 4.5 years to 8.3 years, with a simple average of 6.8 years. Not only does the average miss the correct answer by a wide margin, but the correct answer doesn't even lie within the range of Macaulay durations across the 40 scenarios. This can be explained by recalling my point about the the Macaulay duration of a put option being longer than the equation (3) duration (positive when it should be negative). A critical interest-sensitive component of a SPDA liability is the withdrawal guarantee, and this behaves just like a put option. For more on this point about SPDA's and puts, see J. Buff, "Examining the Investment Risk Using Financial Option Theory," *News from the Individual Product Development Section*, June 1985.

I end this section of my talk with a couple of conclusions:

1. The right theory, and software, allows useful pricing of interest-sensitive cash flows. Properly defined, duration can be calculated for any interest-sensitive asset or liability, and then used successfully to measure and manage C-3 risk.

2. Taking Macaulay durations of cash flows along interest rate scenarios does not give correct results for the duration of interest-sensitive assets and liabilities, and can seriously mislead the valuation actuary about his or her company's C-3 risk exposure. In particular, Macaulay durations for

SPDA's tend to be much longer than the correct duration. Thus a valuation actuary who relies on Macaulay duration might be led to recommend the use of assets that are really too long to adequately control financial loss due to disintermediation.

DURATIONS FROM SIMULATIONS

I want to end my talk with a suggestion for how existing simulation models can be used to estimate the duration for interest-sensitive cash flows. This approach should be intuitively appealing and will not require much more work than the customary (and potentially misleading) determination of Macaulay durations.

Note that equation (3) calls for finding dP/dI, the derivative of price with respect to a change in interest rates. Once a simulation model has been run across a set of interest rate scenarios, and cash flows are obtained, this data can be used to roughly approximate the "price" of the asset or liability. Find the present value of each scenario's stream of cash flows on the valuation date. The discount process should use spot rates derived by taking as forward rates the period-by-period short-term rates from the same scenario. Compute the average of these present values. Call it PO. To get a theoretically correct price, the present values must be averaged with a specific set of weights determined by arbitrage pricing theory.

Next, choose a change in interest rates such as 0.5% to use as $\triangle I$, and generate a new set of interest rate scenarios, based on a starting yield curve that has been shifted by $\triangle I$. Run the simulator all over again, and get a new average present value. Call this PI. If the shift $\triangle I$ is applied to the forces of interest, then duration can be estimated as:

$$D = -(1/PO) \cdot (PI - PO) / \triangle I \qquad (6A)$$

If the interest rate shift $\triangle I$ is applied to the annual effective starting interest rate environment instead, use:

$$D = (1 + I) \cdot -(1/PO) \cdot (PI - PO) / \triangle I \qquad (6B)$$

To do all these steps in a theoretically correct manner is a rather difficult undertaking, for which reference 3 provides some guidance. This estimation of the duration will at least get the sign right for put option durations, since it will capture the tendency of P1 to exceed P0 for a put option when I is positive. Thus it will also work much better than Macaulay duration when applied to SPDA's and other interest-sensitive liabilities with guaranteed withdrawal rights.

DR. ALLAN BRENDER: I'm with the University of Waterloo. We've seen an excellent exhibition of construction of models. If I were a regulator, which I'm not, who is comfortable with the idea of Valuation Actuary and willing to go along with him, I think I'd want to have some assurance that you'd use models which are reasonably well constructed. My understanding is that New York got all kinds of models and all kinds of results. Some models used a lot of scenarios and some used a few scenarios. Thinking particularly of the first two presentations I would want to specify, if I were that regulator, that the scenarios should at least cover a certain range or that certain assumptions I'd want to be guaranteed were minimumly sensitive to changes in interest rates or whatever. I'm curious from a very practical point of view, has New York said anything about putting in certain minimum standards for models?

MR. TULIN: I'm not sure I'm going to answer the question, Allan. I do know from some conversations I've had with Bob Callahan there has been a huge range in what New York has received in the past, and I think that's caused some frustration within the Department. I do know that New York has been giving a lot of thought as to the specificity with respect to interest rate scenarios. That is particularly important, but one of the things I wanted to emphasize is this whole concept we're about to fall right into, which is as reasonable and plausible and implausible is very dangerous for us professionally. I have felt and continue to feel, unless the regulators or some other body we can point to defines reasonable and plausible for us, we have a problem that doesn't have a solution. I think I have used the words reasonable and plausible most of my life interchangeably and now I understand they are supposedly very different. As to the model, in effect the underlying accuracy of the model, I have not heard nor do I believe there has been any discussion of the kind of constraints or accuracy of tests on guidelines with respect to the models.

As time passes it's going to be important that at least certain principles may become standard and from what you have seen, for instance the dynamic nature of the lapse rates and things like that, I think that those things are standard. Again, the need to define crediting strategy is also critical.

MR. ALBERT K. CHRISTIANS: I'm with American Guaranty Life. The first two presentations while they were no doubt excellent brought to my mind that quite a number of things seemed to be left out of the model even perhaps some things that were a little bit dangerous, like Denny's suggestion that if each of your products is okay, then in aggregate you're okay. This of course is not right if you take a probabilistic view of things, that is if every product is okay under all but a few scenarios and if the few scenarios that cause trouble are different for the different products, then maybe all scenarios could lead to trouble. Another thing he had in there was that the risk defaults could be modeled by just a deduction from the interest rates which is obviously a tenuous assumption. The defaults will probably be highly correlated with the kind of interest rate phenomenon that caused the C-3 risk as well. In addition a probable large variation in asset prices resulting from changes in the perceived risk of the default will also be highly correlated with the interest rate variation.

In Stan's presentation where he talked about withdrawal assumptions and thinks that withdrawal assumptions should be sensitive too, he omitted entirely the "run on the bank concept" which is almost always involved whenever a financial institution fails. If you are looking at trying to assess the chance of failure of one of your companies and you leave out that phenomenon entirely, I don't see how you've constructed an accurate model. This leads me to my conclusion that my approach to the Valuation Actuary concept is pretty much like Mark Twain's approach to religion, which is, "there are so many things that can cause us to go to hell, so it's not worth the while to try to prevent them all." I think that the Valuation Actuary concept kind of adds a few more things to our list.

This brings me to my question for Joe. He's argued in favor of a simple process of duration matching, duration analysis rather than scenario testing, and I think scenario testing is probably far too complicated for very many of

us to do very well. I wonder if he thinks a more effective Valuation Actuary requirement could be imposed if it were concentrated on simple measures like duration rather than complex scenario testing techniques.

MR. BUFF: I think that's a very difficult question to answer briefly and I want to make it clear first of all that I can't be expected to speak for regulators and I can't be expected to speak for my company because I'm simply an individual who is a practitioner of some technical skills. I would suggest that the industry which is represented in part by the people in the audience and any regulators or acquaintances of regulators who are in the audience actually think about that question. I have been, as some of you know, participating for the last six or eight months on a couple of sub groups in New York State that are working with the State Insurance Department to draft regulations to implement New York's annuity valuation law. I have suggested that safe harbor clauses be included in the language of the regulation that allow a company to use duration under a couple of conditions. First, that it wish to do so, I emphasize that it not be required to do so, but that it wish to do so, and second, that the Department consider that the company's analysis is acceptable to the Department. Presumably for it to be accepted two things in turn would have to happen. First the department would have to understand clearly the techniques that the actuary did use, and second the Department would have to be convinced that the disaster or catastrophe testing was at least as rigorous as what can be done using simulation models. I think those two latter steps may take a little work. I think there is potential.

MR. TULIN: I'd like to put in a little point for both Dennis and me on the question of simulations as it relates to the last question. I believe the assumptions for liability projections with respect that lapse rates and interest credited rates and all of the things that Dennis and I talked about in terms of simulation models also are necessary in order to calculate duration of the liability side in the duration analysis. Any weakness in your assumptions or problems in your assumptions are going to be necessary to be considered anyway. In fact, what everybody is saying is that some of each is necessary. I also want to echo because it's a very, very good point, Joe's point he made at the end about the fact that in Macaulay duration that if you look at it using interest rate scenarios, it's just going to lead you off into oblivion.

That is certainly the point I was trying to make, and it was the point he was trying to make. MacCaulay duration for random variable liabilities isn't going to work any more.

The new thing I wanted to talk about has been hit upon a little bit. The C-3 committee is going to try and do some research on it this year. It's the interaction of various liabilities with each other and in effect what some are beginning to call liability hedge. This is the idea that you can have product lines that have interest rate spike risks and at the same time you have product lines that have interest rate decline risks, just to think of the C-3 risk for a second. The analogy that I've used is that if you can think of yourself as having a beaker filled with GIC's in your left hand and a beaker filled with immediate annuities in your right hand, you take a bigger beaker and start pouring the two of them in. Theoretically at least, you should be able to pour them into the beaker in the middle in such a way you reduce you risk as opposed to increasing your risk.

Back to the point that I either misunderstood or disagree with, that conceivably putting things together is going to reduce your risk as opposed to increase your risk, there are a lot of important things about that that need to be assessed. The direction particularly (if I understand the direction that New York's taking) is one that will end up with redundant liabilities because you're going to look at it on a product by product or segment by segment basis. You conceivably could reach a conclusion about required surplus for instance from an immediate annuity line that loses money though the reinvestment risk and required surplus for a GIC line that loses money due to interest rate rise risk and required surplus for SPDA's that lose due to interest rate rise risk. The point I'm trying to make is that interaction of liabilities with each other can be as an effective protection against interest rate risks as management of the assets, and I think a lot of research is required there. That is one of the things we'll be working on this year in the C-3 committee.