# Session 8OF
# Value-at-Risk, Risk-Based Surplus, and RBC C-3 Prescribed Testing

**Moderator:** Douglas A. George
**Panelists:** Nancy E. Bennett
Anthony Dardis
Michael J. Hambro

*This session explores risk quantification from multiple perspectives, including:*

- *Value-at-risk techniques and their application in the financial service industry*
- *Internal risk-based surplus formulas*
- *NAIC RBC Update*

*This session explains the application of value-at-risk techniques. Company-specific risk-based surplus formulas will be discussed. Finally, the session provides an update of NAIC RBC developments.*

*This session provides a foundation to apply existing and emerging risk evaluation techniques to your company or clients' circumstances. You'll also gain insight into the strengths and weakness of each risk measurement approach.*

**MR. DOUGLAS A. GEORGE:** This session is a combination of three topics. You might look at these and think that they're not related, but, in fact, they are. One of them is more of a regulatory topic where two of them are more in the way of risk analysis, or at least that's what you would guess by the title. I think the common bond is that they are all based on quantitative analysis, and they all have a link to value-at-risk (VAR). The first subject is value-at-risk. The



Note: All charts referred to in the text can be found at the end of the manuscript.

second is risk-based surplus, which is similar to value-at-risk in concept. The third subject is the new C-3 Risk-Based Capital (RBC) calculation which, for those of you that don't know about it, has a real value-at-risk flavor to it. Despite any appearances to the contrary, these topics are related. Let's go ahead and get started.

First will be Tony Dardis. Tony is a consultant with Tillinghast. He is a Member of the Institute of Actuaries, and a Fellow of the Institute of Actuaries (FIA). He specializes in asset/liability modeling (ALM) and mergers and acquisitions (M&A). He has previous experience with reinsurance and as a stockbroker. He's going to talk about value-at-risk.

Next we have Nancy Bennett. Nancy is a senior consulting actuary with Avon Consulting Group. She is head of the Minneapolis/St. Paul office of Avon. Her specialties are financial risk management and ALM, especially with a mutual company setting. Prior to joining Avon, Nancy was corporate actuary at Minnesota Mutual. She's going to talk about the C-3 RBC calculation.

Finally we're going to have Mike Hambro. Mike is a senior consulting actuary with Ernst & Young. He is practice leader of the Boston Office, and his areas of specialty are product development, financial projections and ALM. Prior to joining Ernst & Young, Mike was vice-president and actuary at National Life of Vermont. Mike is going to talk about the risk-based surplus. With that, let me hand it over to Tony.

**MR. ANTHONY DARDIS:** I'm going to be providing a backdrop to this session by discussing value-at-risk. I want to go a little bit beyond just providing definitions and talk about how to calculate value-at-risk and actually talk about how we use this thing in practice. How can it be useful to us? It can involve huge amounts of calculation, so there must be something useful about it.

For that reason, I've entitled my presentation "Value-at-Risk Within an Enterprise Risk Management Approach." Essentially, I'll be laying out a framework for using value-at-risk to help companies make decisions about choosing or rejecting potential strategies based on a true

appraisal of the underlying risk of those strategies. My presentation will involve reference to economic capital, which is a buzzword that's going around the industry at the moment. If it's not at the forefront of every valuation actuary's mind at the moment, it almost certainly will be in a few years. It's going to become easier to do value-at-risk and economic capital calculations. Senior management is going to become more interested in it, and then the rating agencies are also going to become more interested in it.

By the way, there are two good things about my presentation, if I say so myself. One is, it's going to be short, and two is, there are absolutely no formulas. So, although we're talking about a very technically complicated thing—value-at-risk—I've deliberately avoided the formula. You should understand what I'm talking about even if you don't agree with it. That's the hope.

I'm going to talk very briefly about value-at-risk. I'll give a brief history of value-at-risk. I'll then talk about some pros and cons of value-at-risk. Then, I'll get on to talking about using VAR in an enterprise risk-management framework, which I think is a really interesting application of VAR. Then, I'll just say a few things about the benefits of using enterprise risk management?

No financial presentation would be complete without some acronyms, and you'll see that I'm using VAR for value-at-risk and ERM for enterprise risk management.

The real basic definition is value-at-risk is the amount of money that a firm or project or security could lose under extremely adverse circumstances. Actually, both these definitions are borrowed from Bill Panning's recent article in the *North American Actuarial Journal*. I think they're really good definitions. I think we can all understand the first real basic definition. I've said that value-at-risk is an estimate of the maximum loss that could occur under all but a specified percentage of possible scenarios ordered from best to worst.

We can examine the results of a model run under many different scenarios (Chart 1). The result that I focused on is the accumulated earnings at the end of a projection period, which might be ten years. Each of these bars represents the results of a run on your model. We've ordered these from worst to best or best to worst. With that in mind, if we look at the very end of the

distribution, we have all these terrible results, and obviously our value-at-risk is going to be somewhere in that area.

Going back to how we defined VAR, we set a certain probability level, which I'll call x percent, and we can see two bad scenario results below that level. The value-at-risk is the result that's immediately above the x percent. Value-at-risk is represented by the blue bar. It's pretty straightforward. I think this pictorial way of looking at it is quite neat, and it'll also help explain some of the concepts that I'm going to get onto in a few minutes.

What a company can do is keep adding capital so that the value-at-risk gets to an acceptable level, and I'll talk a bit more about that later. It's also worth mentioning that there are a couple of real fuzzy areas of the definition. First, how do we define loss? Second, what is the time horizon over which we look at the loss?

Let's briefly discuss the history of value-at-risk. The concept originates from the banking environment where value-at-risk has a real clear meaning. Banks can lose huge amounts of money in extremely short periods of time. It can be lost overnight, or it can be lost in even shorter periods. Because it's overnight or within minutes, they can lose huge amounts of money. The definition of what is loss is pretty straightforward because we're dealing with a short period of time. We are basically talking about cash losses. In the banking community, it has a real meaning. It's real clear-cut. It's a standard calculation, and the banking regulators look at it.

In recent years, the life insurance industry has become interested in the concept of value-at-risk, and many companies now have gone beyond just talking about it as a concept. They're actually doing value-at-risk calculations and using it for economic capital calculations.

I thought you'd be interested in seeing the results of a question that Tillinghast asked in a recent asset/liability management survey that we did (Chart 2). We asked companies what were the important analytical tools that they were using today and what analytical tools were going to be important in the future. We've asked companies to rank each of these techniques, with 1 being extremely important and 10 being not so important. The value-at-risk today and in the future are

quite high numbers, which means that they're relatively not as important as something like duration and convexity at the other end. What's important to realize is that we have a big change between today and the future. In other words, practitioners see value-at-risk becoming much more important in the future. The techniques are frequently used, and there were a lot of techniques that didn't even make the chart. I think this is a reflection of the growing importance of value-at-risk.

I just wanted to say a couple of things about the pros and cons of value-at-risk. I think one of the main pros is that it's actually easy to understand. It produces a single number, and that's always a good thing. You can compare that single number across different lines of business. Enterprise Risk Management allows us to make strategic decisions based on the real risk/return profile of alternative strategies.

What are some of the bad things about value-at-risk? I think the main thing is that it doesn't say very much about the severity of loss. As you recall from Chart 1, we focused on that blue bar and we said that's your value-at-risk, but there are a bunch of scenarios that were below that blue bar that were pretty catastrophic. Because of the way we've defined VAR here and the way it's defined on a standard basis, it doesn't get to the heart of what those catastrophic losses or scenarios are. We'd really like to have value-at-risk redefined in a way that truly tells you something about the severity of loss. You could have two companies with the same VAR, but the impact on policyholders, if the company goes insolvent, could be very different, guarantee fund considerations aside.

The remainder of my presentation will cover using value-at-risk within an Enterprise Risk Management (ERM) framework. I think this is where the real use of value-at-risk will clearly come out. The first thing I have to do is just define ERM. ERM is managing a business so that you account for both financial and operational risks. Actuaries are real good at dealing with financial risks. We've been doing that forever. We can handle interest rate risk without a problem. The operational risks would include things such as a catastrophe or people leaving your company. I'll elaborate a bit more on those later. We don't really quantify those very well at the moment. A true ERM approach should account for those.

Are major organizations using ERM? It seems to be the case. Even if it's not in the insurance industry at the moment, and certainly outside of the insurance industry, it is becoming a real big thing, and it is a catch phrase generally in the financial world.

What are the stages of using ERM and value-at-risk when making strategic decisions? There are three parts to it. Establish what your material risks are. Allocate capital on the basis of what those risks are. Then use risk-adjusted return in connection with what owners perceive to be risk to determine what are your appropriate strategies. So, it's a three-tiered process.

I'll make a few comments about the risks that are faced by a life insurance company, distinguishing between risks to the portfolio, which are the operational risks (people, distribution, political risks) and risks of the portfolio, which are our financial risks or the risks that we're normally pretty good at measuring and accounting for.

If you've worked out what your risks are, you can then use the value-at-risk approach to determine what your economic capital is. As I mentioned earlier, Chart 3 is an expansion on that previous chart. I'm adding capital such that I eventually get to a value-at-risk at a higher point, which is within an acceptable range. This is a hugely simplistic example where simply adding the capital gets us to the required value-at-risk level. What you'd do in practice is run your model over and over again, pumping in more capital until you find the value-at-risk level that is acceptable. This illustrates the principle, and companies are beginning to use this approach as computers get faster and models become more sophisticated. They're doing this for financial risks pretty well, or at least they are coming up with some preliminary analysis that management can look at. I don't think they're incorporated in operational risk so well so far, but I'm sure that's going to change in the future.

Having established what your economic capital is, you can calculate a return on that economic capital for a given strategy. You also have risk, and for that purpose, we can look at the other end of the value-at-risk distribution. We can look at the part that the senior management is more interested in, which might look at something like a below-target return. For example, if we are below the inflation rate, then senior management is not going to be happy with that. We've

defined risk in terms of what senior management is most interested in, as opposed to what concerns policyholders, which is what we looked at when we established what our economic capital level was.

Then I combine risk and return in Chart 4. As I say, expected return would be return on economic capital on the y-axis. On the x-axis, I have my risk measure, in which there is the probability of not meeting a specified target return. I won't elaborate on the risk-and-reward profile here, but clearly you're going to be able to identify strategies that are giving you an appropriate potential return for a given level of risk within that framework.

Can an ERM approach be useful? It probably will increase your future negotiating leverage with reinsurers, rating agencies, the capital markets, stock analysts, and in mergers and acquisition targets. Although we have to look at the NAIC risk-based capital requirements in establishing capital, economic capital will help us establish appropriate strategies for us to pursue, given the RBC constraints. With that in mind, it's going to keep some of these parties happy, and that has to be a good thing. That's all I wanted to say about value-at-risk.

**MS. NANCY E. BENNETT:** I think value-at-risk and the emerging discipline of risk management is a very interesting and very exciting area. I think it's especially interesting and challenging for actuaries because, as actuaries, we possess some skills and have some experiences that put us in a unique position to help financial institutions understand their risks. In particular, the regulators are starting to recognize that the actuaries can help quantify the risk propensity of a particular organization. I want to talk about a new regulatory development related to risk management. In principle, this new C-3 formula, as Doug mentioned, is really an application of value-at-risk.

Both Tony and Mike will cover how companies can implement a more rigorous risk management process, either through a value-at-risk or enterprise-wide risk management approach. I'm going to discuss how companies will be required to use risk management techniques as prescribed by the regulators. I'm going to provide you with background and a basic overview of the NAIC's risk-based capital change.

Let's talk about some of the history of all these risk-based capital formulas. Many states have had minimum surplus requirements to start a company, and that ranged mostly from $150,000 up to $2 million, depending upon the state of domicile. Once the company was running, the states would use the Insurance Regulatory Information System (IRIS) ratios to monitor the financial condition and the ongoing solvency of the particular company. As the years went by, and as products and assets became much more sophisticated, a lot of constituencies that evaluated the financial condition of insurance companies recognized the need for better capital measures and monitoring systems. Many companies and some rating agencies then developed risk-based capital measures that were more robust in capturing the unique profiles for different companies. In particular, Moody's and Conning developed risk-based capital formulas for use in their evaluation of a company's financial condition. Next, individual states developed measures to supplement the IRIS ratios. In particular, New York had developed a risk-based capital formula that really looked a lot like Conning's formula, and then the State of Minnesota adopted a risk-based capital formula that looked a lot like Moody's. These state formulas were the precursor to the standardized risk-based capital ratio that the NAIC ultimately developed. The NAIC's formula became effective in 1991, and this risk-based capital ratio was part of the annual statement and the filing process.

Essentially, the current NAIC risk-based capital formula delineates four categories of risk: the risk of asset default and associated subsidiary or affiliated company risk, the C-0 and C-1 risks; the risk of pricing inadequacy, or the C-2 risk; the interest rate risk, or C-3; and the general contingency, or the C-4 risk. There is a recognition in the formula that there is a co-variance among the risk categories that reduces the total risk to an organization, depending upon the relative mix of these four different kinds of risk. The risk-based capital formula is entirely formula driven, and entirely based on published statutory financial statements. The calculation emphasizes solvency rather than ongoing financial strength. Since solvency is a regulators' primary concern, the formula makes sense.

Within this particular formula, the current C-3 capital is calculated as a percentage of statutory reserves. The percentage varies by product, and is based on the reporting of reserves in Exhibits 8, 9 and 10. Even when the formula was put out in 1991, the NAIC was aware of the limitations

embedded in this particular formula, yet it was still better than having nothing at all. The C-3 formula is actually counterintuitive because it penalizes the companies that are holding higher reserves. If you're holding higher reserves or you strengthen your reserve basis, then you have to hold an associated higher amount of risk-based capital; this result is counterintuitive, but since the formula is a percentage of statutory reserves, such an outcome is possible.

Since the formula calculates reserves based on statutory reserves, it's only going to capture or hold an associated required capital in direct proportion to the policy options that are captured in statutory reserves. We're all aware of the fact that the statutory reserving guidelines do not reflect the newer product features and product options. There's a limitation. Also, since the formula is based on a percentage of statutory reserves, the formula does not capture the integrated nature of asset/liability management since the asset side is completely ignored. How a company might choose to invest its assets to back these product liabilities doesn't come into play determining C-3. The formula is static. The factors don't reflect the sensitivity of the value of assets and liabilities to changes in the interest rate. Finally, it doesn't reflect the risk reduction or aggregation from different mixes of business.

Let's discuss the proposed formula. Some of these points might be confusing. So, I'll cover the basic points and then go back and add others so that you can get an overview of the framework. Basically, the new C-3 proposal is going to replace the factor based or the formula approach with a more discretionary approach based on the company's asset and liability risk profiles. In this proposed formula, the company's appointed actuary will determine the C-3 capital using the cash-flow testing model based on 50 prescribed interest scenarios. In addition to this, C-3 capital is required for certain kinds of callable assets that will support what are called untested products. The C-3 proposal only applies to annuities, GICs, and single premium life insurance. Then, for all the other products that do, in fact, contain interest rate risk, most notably individual life insurance, the current formula factors on the formula approach will still apply. The C-3 capital for the assets supporting the untested products is equal to half of the excess of the statement value over the call price that's calculated each year.

The total C-3 capital is the sum of three amounts: the tested amount that comes from the cash-flow testing model on the annuities, the factor-based amount on all the other product liabilities, and then a new C-3 amount on certain amounts of surplus. There is a limit that the regulators are placing on the formula. The total C-3 capital is to be capped, as somewhere between half of the current formula approach, and two times the formula approach. Some companies have found that this approach would eliminate their C-3 capital all together. However, the NAIC will require holding at least half of the current formula approach. If you happen to be particularly mismatched, the new formula caps at the C-3 at two times the current amount. The bottom line of all of this is that the C-3 capital is still going to be required on all reserves. What's changing here is the methodology for calculating C-3. It's either going to be based on this cash-flow testing model or it's going to be based on the old factors.

This particular proposal is only recalculating the C-3 capital for products that are deemed to be highly interest-rate sensitive. The value-at-risk flavor is injected through the use of 50 prescribed interest scenarios. These 50 prescribed interest scenarios are actually a subset of 200 scenarios. The committee generated 200 scenarios, and then they culled back to 50.

**FROM THE FLOOR:** Where did those scenarios come from?

**MS. BENNETT:** The committee developed an interest rate generator, and then the 50 were chosen by looking at various combinations of products and product liabilities and investment strategies. There were six products and eight investment strategies, so there were 48 different combinations. The 50 scenarios were chosen out of the 200 because they produced a positive amount of C-3 capital. They eliminated the ones. In other words, they're kind of going with the riskier scenarios or the worst case scenarios, in cutting the 200 down to 50. That's the value-at-risk flavor. The appointed actuary will have the option of using a smaller 12 scenario set, but that is expected to produce an even higher amount of C-3 capital. That's the basic overview.

In terms of submission, procedures, and its current regulatory status, the appointed actuary is going to have to submit the C-3 results for the current or the old formula, then the new formula, both capped and uncapped, and then finally an analysis of the results for a set of specified

benchmark assumptions. The issue of benchmark assumptions is something that has been injected by the regulators. As of now, benchmark assumptions are not part of the proposal, but when I did my slide presentation, benchmarks were still in. The Life and Health Actuarial Task Force wanted to rely on the appointed actuary to determine the best assumptions to be used in determining C-3. The regulators were not entirely comfortable with giving the appointed actuary that amount of discretion. They are trying to put in standardized assumptions or benchmark approaches to give the regulators a check on what the range of C-3 capital would be. The final proposal does not include benchmark assumptions. I think it's very possible that, in the final vote in December, the regulators will put benchmark assumptions back in. That particular issue is kind of a battle between trusting the actuary and making the regulators happy.

The formula change does not apply to companies that are currently not required to do cash-flow testing. There will be some pretty significant disclosure requirements in terms of what assumptions are being used to determine C-3. How much additional disclosure will be required depends on how much the company's appointed actuary discloses along with the cash-flow testing. The formula is a result of four years work by the Life and Health Actuarial Task Force. They did a lot of extensive testing to develop the process to make sure that the methodology was appropriate and really did produce a logical amount of required capital. There will be a final recommendation from the task force made at the October 1999 NAIC meeting; then the vote will be at the December NAIC meeting. It's fairly certain that the formula will be passed. There will be a change, and it will be effective in time for December 31, 2000 annual statements. I think the formula might have some changes, like whether or not benchmark assumptions are in or out, but I think something will definitely change. The formula-based approach will be replaced with this more discretionary approach.

There are exposure documents on all of this work. They're available from the American Academy on its web site. There will be an actuarial standard of practice (ASOP) or a practice note written in the near future to clarify some of the technical points.

I'd like to describe the methodology for calculating C-3 and then go through an example. This gets a little bit complicated. First, let's start with the cash-flow testing model for each segment

of the business. The first thing that you do is project the annual statutory surplus for each scenario and for each year. Let's assume in this example that we have a 30-year testing horizon. What you're going to first do is produce an array of 1,500 values or 50 times 30 values; then you'll project annual statutory surplus, and you will produce 1,500 values. You then take and cull down these 1,500 values so you can calculate 50 values. You're looking for a scenario-specific C-3. For each of the 50 scenarios, you want to determine a scenario-specific C-3. The C-3 for each scenario is determined by discounting the annual accumulated surplus values at a particular rate. The next step is to rank the specific results of these scenarios. You obtained 50 C-3s. Now you're going to rank them by percentile from worst to best. Then in the final C-3 segment, capital is calculated by weighting these scenario-specific results. There are 13 scenarios that get weighted. We started out with 200 scenarios. That was culled down to 50. Your ultimate C-3 is calculated by weighting the worst result, the ones that are in the 98th through the 92nd percentile. That's how value-at-risk flavor comes in. It's a worst-case approach to calculating C-3, unlike cash-flow testing, where the New York 7 are purported to cover the whole interest rate space. The C-3 scenarios are not trying to do that. The C-3 capital is based on the worst scenario results.

In this particular illustration, we're going to run the cash-flow testing model. Assume N is equal to 30. We would actually produce an array of 1500 values. It is 50 times 30 all the way across. For each of these S(t)'s, we'll calculate the present value for each year. We'll then go in and look at the results. For Scenario 2 we'll say, for example, the present value of S(3) is actually the most negative number. You'll select S(3) as the worst or the scenario-specific result for scenario 2. For the 50th scenario, perhaps the 17th value will be the worst number, but you'll select the worst scenario-specific result within each scenario. You then will rank those results. Then you'll weight the scenario results according to these weights shown.

**FROM THE FLOOR:** Where do the weights come from?

**MS. BENNETT:** Those are prescribed weights. The weights reflect the value-at-risk flavor. The formula change applies to those products with the greatest C-3 risk, and it excludes many major products with C-3 risk. This formula was designed to complement the anticipated unified

valuation system. Individual life products were probably excluded because they're going to get brought in after the UVS is passed. The formula does capture the dynamic and integrated nature of asset/liability management. The formula captures interim results and not just the ending results that are emphasized in cash-flow testing. The formula is also based on a retained-profits model.

This formula, of course, will place additional emphasis on the credibility of the cash-flow testing model. In particular, the asset modeling will come into question. You'll have to assess whether or not your current cash-flow testing model credibly reflects call and prepayment dynamics for certain asset classes. Certainly collateralized mortgage obligations (CMOs) have been the subject of many conversations over the years. On the liability side, you'll have to make sure that your policyholder behavior is modeled.

**FROM THE FLOOR:** Is there a standardized projection period that we run the models over?

**MS. BENNETT:** It's all based on whatever your cash-flow testing model uses. If you're running 20, 30 or 40 years for cash-flow testing, that's how long you use for the projection period. The credibility of your liability modeling will come under investigation. I'm particularly referring to dynamic lapses, which are real key in annuity modeling, and transfers to and from your separate accounts. Finally, for those practical procedural issues, which will probably end up taking up a lot of the time, you'll have to take a look at your cash-flow testing schedule, and how long it will take to do this. This is because the formula will have to be filed soon after the annual statement. It will be due with March 1 when the diskette is due. Also, since this is based on 50 interest scenarios, I think this will be a challenge for a lot of cash-flow testing systems today. The practical issue of running and producing 50 interest scenarios will be a run-time drag on a lot of the systems today.

Overall, I think the formula does a good job of capturing the dynamic and integrated nature of interest rate risk. It's a big improvement from the old formula. Granted, not everything is in there, but it's much better than the old formula approach. Implementing this formula change will require additional effort. I would recommend that as companies come upon this implementation

date, they should review the proposed formula. Many of the details are laid out. Just as in the cash-flow testing, some judgment is required in terms of how products should be modeled, and I think it's important that companies understand the proposed formula change. They'll need to set up a process for calculating the new formula. As we went through the example, obviously there were a number of steps, and they can be a bit confusing. You can get your arms around them, but they are somewhat confusing.

I recommend that companies test the change after 1999 cash-flow testing has been completed. We all know that the risk-based capital formula has been an important measure. Rating agencies and a lot of other constituencies have used the risk-based capital ratio in evaluating the financial condition of a company, and I think it will continue to be an important formula measure. I would suggest that companies test their results with 1999 and not be surprised when 2000 comes around. You'll need to review your cash-flow testing procedures and your schedule. Finally, you will have to be prepared to explain the change to the states and the rating agencies.

This formula does provide an opportunity for companies to actually review their exposure to interest rate risk, and it provides an opportunity for companies to demonstrate how effective their practices are. I think that this formula change strengthens the appointed actuary position, and it formally recognizes integrated asset/liability management as a component to valuing the financial strength of an organization. As I said before, I think the new formula does a better job of measuring interest rate risk, and I think companies that have an effective asset/liability management program will, in fact, benefit from this change. I think the other constituencies that evaluate organizations will see this and will be able to recognize this benefit. As I said before, the formula change provides an opportunity for companies to demonstrate the effectiveness of their Asset/Liability Modeling (ALM) practices.

**MR. MICHAEL J. HAMBRO:** What I will discuss is risk-based surplus (RBS) and how a company would develop its own risk-based surplus formula. This is actually a project that I worked on a few years ago. Much of this methodology is going to be very consistent with what the Academy and the NAIC are proposing. One of the questions that used to come up is why develop a company-specific, risk-based formula? After all, the NAIC RBC formula is out there.

It's a well-established formula, and it has a lot of credibility among the rating agencies. Most companies actually use RBC to plan for their surplus management.

Let's discuss the advantages of developing a company-specific RBS formula. First, it does address company-specific risk, which is really important. It takes into account the company's asset/liability practices, and its business practices and the decision-making process. It also provides a bridge between the valuation actuary cash-flow testing and dynamic financial condition analysis. There's a lot of material written on that, but I don't know of any companies that have actually implemented it fully.

What an RBS formula should answer is how much surplus should be held to have X% of confidence that the business on the books will be successfully matured? Individual risks that are to be quantified are the normal C-1 through C-4 risk that we've seen before. The general RBS process is to first establish a methodology for determining each of the individual risks. Decide on the confidence level, in other words the surplus level that will give you a certain degree of confidence that the business on the books will be matured. Then you've got to correlate the risk to establish the total company RBS.

To look at the C-1 risk, we're going to focus on bonds and commercial mortgages, and we're going to look at a detailed description of the process to determine RBS. To get the bond C-1 RBS, the first thing you need to do is have a benchmark of expected bond defaults, and use an interest crediting strategy that already deducts the expected defaults prior to crediting or prior to a dividend determination. This is a good candidate. First, you'd establish break-even default charges by investment grade for each bond category. A default charge equals the probability of default times the loss on default. When a bond defaults, you don't lose everything. There's a certain recovery percentage.

Moody's does a really good job in its annual default study. It has cohort groups formed since 1970. The Moody's study actually goes back to the 1920s, but the information since 1970 is probably most useful. It also has recovery rates. One of the things that you want to take out of it is the cumulative year-end default rate, say the ten-year default cumulative rate. Then you must

convert that to an annual rate using the following formula, and you'd get default rates by rating category. You'd also be able to get the default recovery rates, and that would vary by the seniority and degree at which the asset is secured. It gives the annual percentage recovery rate, as well as the standard deviation. We're going to use these later.

The next thing you want to do is build your bond portfolio model. Generally, with the way computers are, you'd use a seriatim model. You'd want to get PAR value and book value from the asset investment accounting system, projected cash flows, maturity year, coupon rate, the credit rating, and also the seniority of each asset in the portfolio. We projected the bonds for 50 years, did 1,000 projections, and used Monte Carlo simulation. The projection process was done first to calculate the total expected default cost for each year in a projection using the break even default charges and the mean recovery rates. Then we calculated simulated default losses for each bond using Monte Carlo simulation, and for each bond and year, you generate a random number between zero and one. If the random number is greater than the bond's probability of default, the bond survives. It doesn't default. If, however, it's less than or equal to the bond's probability of default, then the bond is considered to default, and you have to figure out how much you lost? We had the recovery rates from before. You're going to now generate another random number and convert that random number to a standard normal distribution and use that to determine how much you're going to lose on that bond defaulting. The bond's loss is its book value minus the simulated recovery, not the recovery rate. That bond is then removed from the projection, and its loss is reported. You're going to then calculate the total simulated losses for each year in the projection for the entire portfolio. Define the excess loss as the simulated loss minus the expected loss. The excess loss could be either positive or negative.

Now we're going to define the RBS measure. We're going to get an after-tax discount rate in which we can discount the results for each year. For each of the 1,000 projections, define the excess loss in year t (ELT) as the excess loss for each year, and then you're going to sum each of these discounted excess losses to get the present value of excess losses. We're going to call this the present value of cumulative losses for each duration for this projection. We're only talking about one projection now. Then you're going to take the maximum of this present value of excess losses at Duration N, for each N, in the projection, and that's the maximum present value of cumulative losses for the projection, and that's the main RBS measure.

The reason you want to do this is because it eliminates future gains making up for early losses. That's not appropriate because once you go insolvent you're not going to recover. You want to capture the high point of the losses, and that's what this does. You're going to capture this measure for each of the 1,000 projections, and rank the maximum present value of cumulative losses over all the projections in ascending order, and then measure the maximum cumulative deficiency between default charges and simulated losses. The way to look at this is, if a company has an amount of surplus equal to the maximum present value of cumulative loss on hand at the start of Projection P, and then surplus is invested to earn the after-tax discount rate that we talked about before, then the default charges, together with the initial surplus, will make sure that the company's bond portfolio remains solvent for Projection P.

Then you're going to rank the maximum cumulative value of projected losses in ascending order. For example, if your 980th result is $30 million for the entire bond portfolio, then the company's bond portfolio will require that much capital to have a 98% confidence rate of not going under. Creating 1,000 scenarios is a lot of work, but it's still not that great a number. You might want to use some smoothing to get, say, the 98th percentile, and take the results of the nearby scenarios. Dividing the actual RBS amount by the initial book value of the bond portfolio produces the RBS as a percentage of the book value of the portfolio. That's the way the NAIC formula is expressed.

In our exercise, we also wanted to determine RBS for each rating category. We did this for each rating category and then summed the maximum present value of cumulative losses across the rating categories. We found that this was greater than the corresponding maximum cumulative loss for the entire portfolio because we have a smaller sample size. There is a lack of co-variance among the different rating categories, so we made the following adjustment. We ratioed the entire portfolio RBS to the sum of the individual rating category RBS. Then we multiplied the RBS for each rating category by that ratio. That's not the only way to do it. It seemed to produce reasonable results. If you look at the 98th percentile, these actually aren't that far off of the NAIC C-1 formula, except for the NAIC 4, and the reason that that is fairly high is because, in this case, the company had very low exposure to NAIC 4. It wasn't that important, and you didn't have enough statistical credibility. I wouldn't take that 24.4% as gospel.

Let's move on to commercial mortgages. There's no standard industry data on commercial mortgages. Each company's commercial mortgage program is unique. The underwriting and the loan characteristics are unique. Because there's nothing commercially available or standardized, we just built a commercial mortgage cash-flow projection system to model deviations from contractual mortgage cash flows. In the early 1990s when all of the bad stuff was happening with mortgages and real estate, the Society of Actuaries, in conjunction with the ACLI, developed a rating scheme. It has 13 underwriting criteria. We rated each criterion from 1 to 5, with 1 being very good, and 5 being a loan that's ready to go belly up. Then, we rated each mortgage annually, and the mortgages were classified by property type, rating, and the mortgage status. Statuses are current, delinquent, restructured, and in the process of foreclosure. We just projected the cash flows out using an APL probability transition matrix where the probability of going from one status to another was developed in conjunction with the investment department. Basically, the type of projection methodology, except for this transition matrix, was similar to what was used in developing the bond RBS. We used this process to not only develop our RBS, but we also used it to develop the actual default charges that would be assumed for commercial mortgages each year.

Let's move on to C-2 RBS. In this particular case, the only interesting RBS was for mortality. The company had long since gotten rid of its other C-2 risks. We considered using parametric distribution functions. That would have been really nice because you get a closed form, and you don't have to really use Monte Carlo, which is kind of a brute force technique. We tested binomial compound, and a couple of others. Unfortunately, we found that there was a poor fit to parametric distribution functions. They didn't really fit our actual experience. We examined 20 years of death claims. Due to the relatively low incidence of claims and the wide dispersion of face amounts, the pattern of results empirically produced a very poor fit to any parametric distribution function. Actually, the parametric distribution functions are more akin to prescription drug group health coverage where there's a fairly predictable utilization pattern and claim costs aren't that dispersed.

We went back and used the Monte Carlo approach. We took 300,000 policies in force, and grouped them into representative cells. We then projected the policies using pricing experience assumptions to obtain expected death claims, lapses, and reserves. We got this out of the model

that we use for our normal projections in cash-flow testing. We took those results and dumped them into an APL-based Monte Carlo projection simulation. We also took into account the reinsurance program that the company had in place. We projected each policy over a 30-year period; we did 1,000 projections, and for each year, the yearly measure captured was the difference between simulated death claims and expected death claims based on retained net amount at risk. That measure is the yearly excess death claims. This formula is very similar to the bond RBS formula, so I won't go over it because, once you get the work done, the ranking and the actual measures are similar to the bond RBS, and this methodology is identical to what was used for bond RBS.

The C-3 surplus is determined by projecting the company's existing assets and liabilities under changing economic environments. It captures the interest contingencies for the asset portfolio, and it actually captures dynamic policyholder behavior. In this exercise, the C-3 projections were performed on one of the well-known, vendor-supplied models. C-3 projections are done in this way to not only quantify the interest rate risk, but to also take into account the inherent product margins and reserve levels. So these are really dynamic gross premium valuations. Looking at it a different way, the asset/liability projections dynamically test product margins and reserve levels. Ideally, you'd want to use the same projections to dynamically test mortality fluctuations and asset default fluctuations, but the current models really have a lot of problems doing that. Therefore, you use this methodology to do C-3 and off-line build supplemental models that test mortality and asset risks.

The good news is that there are projection models that are emerging that can combine all risks. They're not here yet in terms of a company with a lot of diversified businesses, but by the end of next year or the year after, there will be marketable systems that do that sort of thing. The company will be able to determine its exposure to specific isolated risks as well as determine the co-variance between various risk exposures. Right now the co-variance is not really well understood at all. This methodology will enhance both risk evaluation and business planning since companies will be able to optimize their risk profile. If they have a light risk in a certain area, they can beef up that risk by assuming reinsurance and make themselves surplus efficient.

One of the key issues in determining C-3 RBS is having the projections run enough scenarios for statistical credibility, while also getting tractable run time. What we found is we could run 200 to a maximum of 500 scenarios, which really isn't that many. In order to keep the scenarios down, but to retain statistical credibility, we did a lot of looking at low discrepancy sequences. Faure and generalized Faure sequences appear to be the most promising, and this investigation is still ongoing. I think a lot of work has been made in improving and modifying Faure sequences to accomplish a good fit and to keep the number of scenarios down. One of the things I must watch out for in low discrepancy techniques is they first might appear promising and fill up the space, just the way you want it to, without that many scenarios. If you really look into the detailed testing, you'll find that they didn't really do that good of a job. I want to caution people that are tempted to jump to a low discrepancy sequence to just do a lot of testing and make sure that it really is doing what you'd hoped.

Actuaries have developed a lot of complex algorithms that model policyholder behavior. I think that maybe we'd all agree that they've done a pretty lousy job. For example, you have low interest rates, but you're still seeing a lot of disintermediation on fixed interest rate annuities. Our algorithms didn't take into account a lot of things that are really happening out there. I don't think they realistically model policyholders' economic efficiency. We need to also improve the modeling of the policyholder's decision process, taking into account the actual interaction with the distribution systems. We need to do a better job of reflecting substitute products, such as equity-based products.

Finally, much of what we talk about is random or Monte Carlo testing. You ought to also consider stress or disaster scenarios. The 1918 flu epidemic, for example, increased mortality about three deaths per thousand in the U.S. There was also a global economic meltdown. You also need to quantify the C-4 risk, and in the absence of anything else, use the NAIC formula.

Combining risks. How are C-1, C-2 and C-3 risks correlated? Do you use an additive formula or apply some specific co-variance technique? We will see improved projection models that should facilitate combined risk evaluation.

**MR PETER L. SMITH, JR.:** Nancy, I think you said that when you compute the RBC risk, you should do it over a projection period, the same as you do for your asset/liability testing in your memorandum. One of the challenges that most companies would have in trying to do that is developing correlations among all the assets and the variance that you have in your model over that projection period. If it's a 20-year projection period, you'd gather all the data that you would need for all your variables in your model to compute the associated co-variance matrix. The question I have for you is, has anyone in your group or on the NAIC contemplated using standard periods of time, such as by month or other short-term periods of time, so that libraries of co-variances that are available, and things like risk metrics, might be available for developing a risk-based capital calculation?

**MS. BENNETT:** Two things characterize the task force work. One is that the task force was relying or building its work upon other things that were already in place. Cash-flow testing procedures are well established, and they weren't trying to reinvent those procedures. The risk-based capital was trying to take advantage of cash-flow testing procedures that were already in place rather than to create all new procedures. The theory was, if the appointed actuary determined that 20 years (or 30 or 40 years) is the appropriate number, that in determining the adequacy of reserves, the appointed actuary has determined the appropriate number of years in the projection period.

I'd like to address your second question as it relates to standardizing some things or developing a library of information to deal with co-variance. I don't know if that's something that'll come up down the road. I know the task force will be looking to gather some information to see if this current 0.5–2 range, will be changed. It will look at whether it should be narrowed or increased over time. In terms of the amount of data, there has been some discussion of that, but I think it relates more to the practical issue of gathering the data. From the American Academy of Actuaries' point of view, they're reluctant to inject anything that will standardize assumptions or methodologies across companies because I think the task force is trying to get away from a standardized approach. They're trying to go to really relying on the discretion of the appointed actuary.

**MR. ROWEN B. BELL:** There are some products with long-tail claim reserves. I'm thinking of individual disability or group long-term disability. These are things where you could build a case that there's the potential for asset/liability mismatching. However, the current NAIC C-3 formula does not have any provision for that. I was wondering if the task force thought about this issue at all and gave any consideration to including DI and LTD in the C-3 formula, but then rejected it.

**MS. BENNETT:** Yes. Those products, individual disability or the long tail liabilities in particular, contain C-2 risk as well. All products contain C-1 and C-4. Basically, the task force focused on those products that only had C-3. I think the concern about including individual disability and individual life products in this overall testing methodology was that the appointed actuary was now determining the C-3 risk according to cash-flow testing, and the other factors were pulled out. The concern was that the risk-based capital would be reduced too far because, in fact, the risks on individual disability and individual life is captured with the C-2 and the C-3. If those products got wrapped into this methodology, the risk-based capital would be reduced by too much. There's an anticipation that when the UVS comes in, the risk-based capital will then be defined relative to the reserves that are calculated according to the UVS. Risk-based capital will be changed along with the UVS system, and I think that's how the other products will get brought into it.

**CHART 1**
**A Graphical Interpretation of VaR**

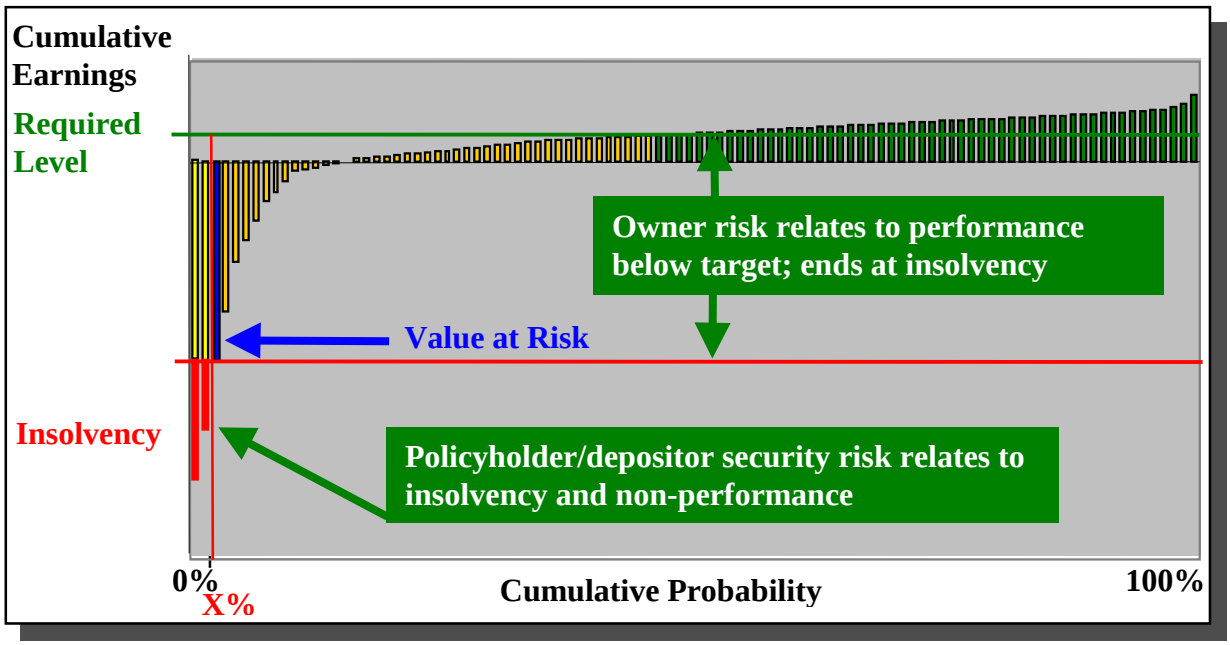



**CHART 2**
**Results of Tillinghast Survey**

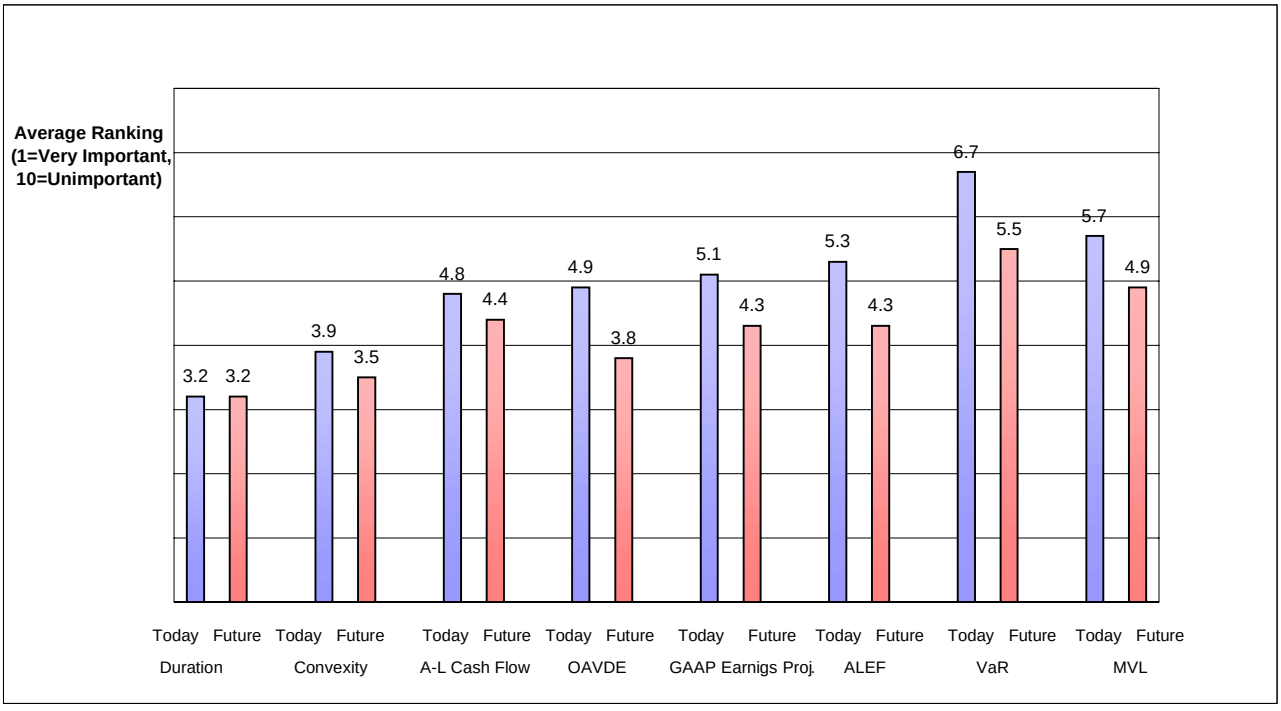


**CHART 3**
**Determine Overall Capital Needed Using VaR**

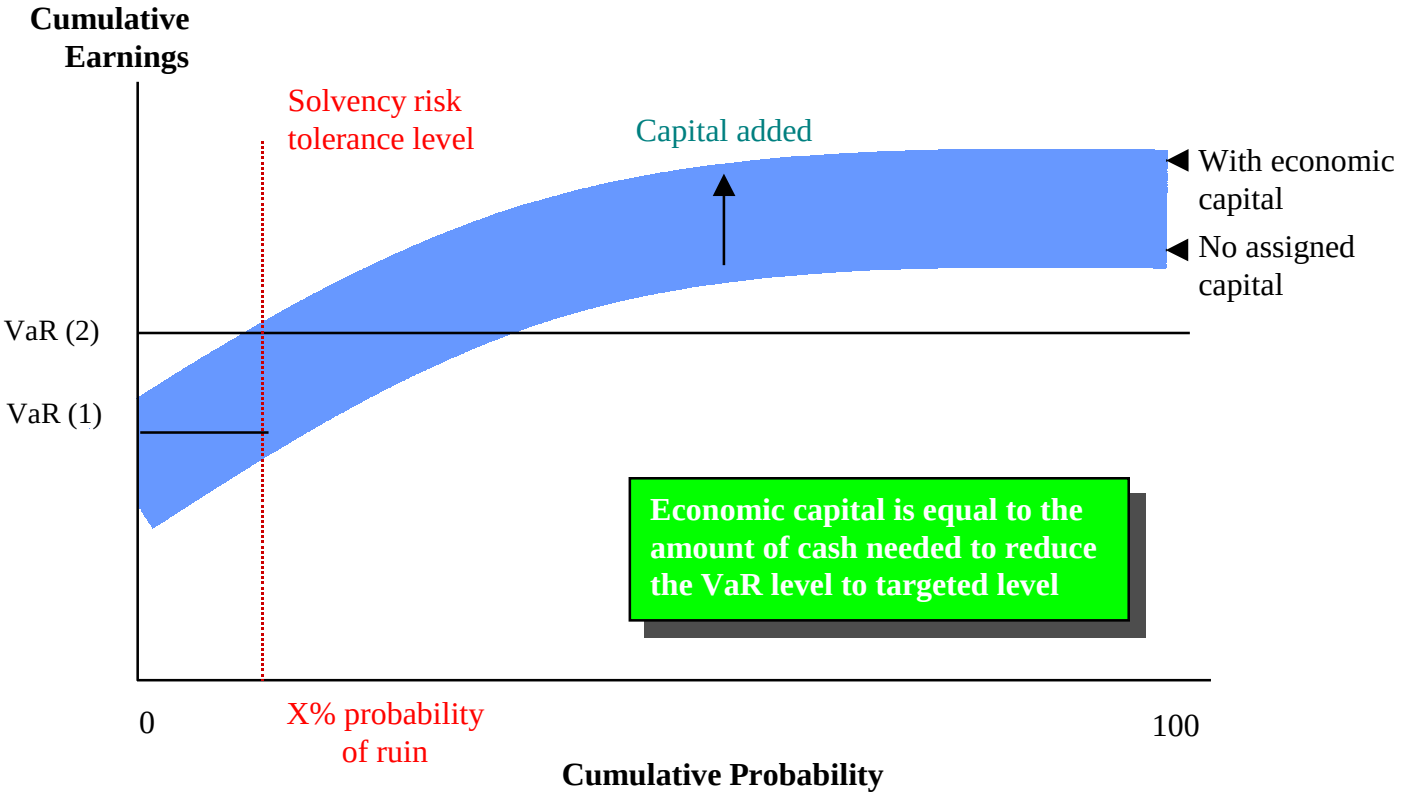
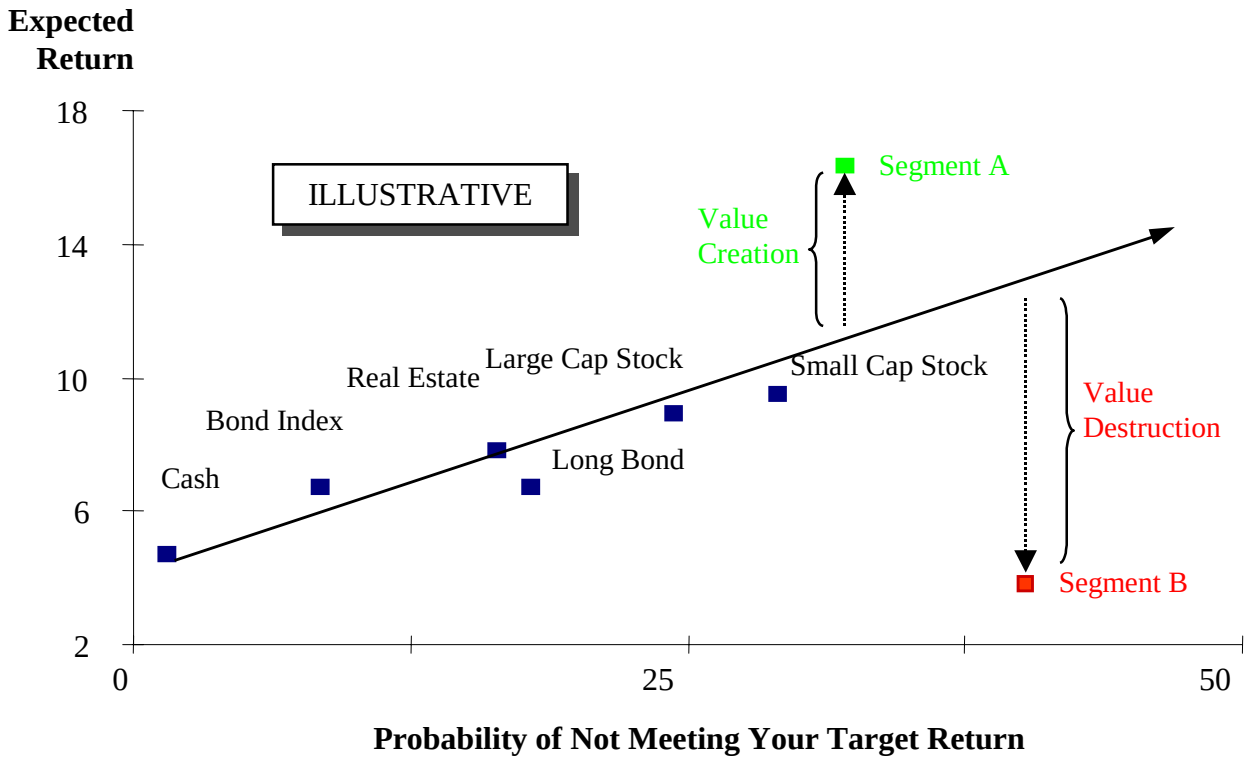


**CHART 4**
**Modified Capital Market Line**




The modified capital market line represents the investor's benchmark rate of return.