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TEACHING SESSION—FORECASTING METHODS

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This is the record of a teaching session on forecasting techniques for evaluating alternative futures, and how to use these techniques in making policy decisions. This session was presented both in Dearborn and in Portland. The basic text of this transcript is from the Portland meeting, including the introduction by Mr. Gary Corbett. A similar introduction was given at Dearborn by Mr. Wil Kraegel.

The transcript of Mr. Becker's presentation at the Dearborn meeting was used in editing this text in order to identify the most important topics and also to supplement where some additional clarification was needed.

MR. CORBETT: We, as members of the Society's Committee on Futurism, hope that this session will both increase your familiarity with futurism and expose you to some of the tools that you can use in current decision making. We chose the particular topic of forecasting techniques, and there's certainly a lot more to futurism than that, for a number of reasons. First, I think actuaries have always dealt with forecasting in some way or another, so the basic concept of forecasting is familiar to the actuarial profession. But I think it's true, to a large degree, that the forecasting methods used in the actuarial profession were developed, by and large, many years ago-and most of us have not followed some of the more recent developments in the forecasting area. I would suggest that the actuarial approach to forecasting has followed rather traditional lines. Forecasting parameters have been largely static; that is, we've tended to extrapolate from the past, assuming there would be no new influences and interactions in the future. We've assumed that phenomena of the past are reliable indicators of the future. There are certainly exceptions to that. I don't want to suggest that the actuarial profession has not been using any new techniques. I think some of the more recent developments in risk theory and some of the materials coming out through ARCH would indicate that there are actuaries, mathematical actuaries perhaps, that are taking into account some of the more advanced concepts.

I would suggest that the concepts of futurism can enhance classical forecasting techniques by adding a greater awareness of the present and future while not diminishing the relevance of the past. Forecasting with this awareness of the future takes into account, in addition to the continuation of past trends, the possible effects of current decisions themselves on future developments, the interactions in the future of significant factors, currently discernible but not reflected in the trends and, very importantly, a possibility of discontinuities in the social, political, and economic climate. There has been some debate about the Society getting into such a supposedly arcane, somewhat psychic field. Some people look at it as futurism. I remember reading a letter in the Actuary that questioned how the study of futurism squared with the Society's motto of the work of sciences, i.e. to substitute facts for appearances and demonstrations for impressions.

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The author of that letter said that futurism certainly doesn't substitute facts for appearances and I would agree with that. Futurism by its very nature, dealing with the future, cannot substitute facts for appearances. There are no facts about the future. Facts exist only about the past. But I would suggest that at least the second mark of the motto, the substitution of demonstrations for impressions, is something that futurism does do well, by trying to substitute demonstrations or well-thought-out probabilities about the future for what are often vague and often inconsistent impressions about the future.

In the real and complex world today, we can't use only analytical techniques. We must now deal with synthesis as well as analysis. Our background and training, and the background and training of many people in business today, have oriented us to see convergent solutions to problems. Futurism requires that we systematically seek out and analyze divergent solutions. To tell us more about the study of futurism, particularly in the forecasting area, we have with us today, Hal Becker, who is a co-founder of The Futures Group of Glastonbury, Connecticut. The Futures Group is one of the most prestigious groups in the country that deals with research in the area of futurism and its practical application to real world problems. As Executive Vice President and Treasurer, Hal supervises company contracts and grants, the marketing, selling and developing of new data services and various business activities for the company. He also is involved in company-sponsored work of systems analysis and decision making techniques and is responsible for personnel management, budgetary planning and administrative activities. Studies for industrial clients under the direction of Mr. Becker have included consumer purchasing patterns, pharmaceutical and health care, socioeconomic change in the country, energy supply and demand, and issues and opportunities for clients' specific products. He also works extensively with industrial and governmental clients to improve their own planning, forecasting and policy assessment techniques. Mr. Becker has taught and lectured for industry, academia and government on policy analysis, technology assessment, forecasting, future's research, community goals and development planning, management and organization concepts and personnel motivation techniques. His publications include numerous technical papers and presentations. Now, I'd like to turn it over to our distinguished speaker for the day, Mr. Hal Becker.

MR. BECKER: I hope the entire session will be relatively informal this afternoon. I don't want it to be a monologue on my part. I prefer that you ask me questions and challenge me. I always learn from the kind of dialogue that evolves in those kind of sessions. That's one of my ulterior motives, you see.

The so-called subject of "futurism," and maybe the way some of us in this profession are going about our thing, has a certain aura of the mystique. There are many of my colleagues who are comfortable with the term futurism or feel comfortable with being called a futurist. I don't. Those kind of terms come and go. For example, in the past we've talked about operations research, systems analysis and systems engineering. My view of all such "disciplines" is that they are on a continuum, and the continuum that we're trying to improve is the continuum of policy analysis. The items I'm going to talk to you about I would not want to offer as a comprehensive discourse or presentation regarding the entire subject of policy analysis. I want to talk with you about some techniques we have developed over the past several years and are increasingly employing for our clients

in both government and industry. These techniques relate to the part of policy analysis that attempts to determine what the future may hold and to give us better insight, in light of those kinds of projections, into the implications of our contemporary actions.

I want to go through the discussion with you this afternoon in essentially two parts. A brief part at the beginning relates to change. Indeed, if we're talking about trying to come to grips with better estimating what the future may hold-and I say may, not will-one of the items that we really have to be concerned about is what we really mean by change. Quite frankly, I'm concerned that, when we talk about change in our society (or at least business organizations) the data we use often are not utilized in the best way to give us an insight into the real dynamics of change. I would be very surprised if many of you here were not already familiar with the enormous amount of literature that has been written in recent years about the changes our society is experiencing. Social values are changing. We've even experienced in the past ten or fifteen years, as you people know much better than I, various kinds of demographic change: major reductions in birth rate that we didn't anticipate, changes in divorce rates, and so on. And just look at all the authors: Al Toffler's Future Shock; Charles Reich's The Greening of America; Dan Bell's Post-Industrial Society, and so on.

I came across this piece recently and it seemed to be particularly contemporary. We've been through a couple of bad winters, we went through Watergate which was a major shock to our 200 year republic. It was the first time people at the top of our government resigned. There are people around the world who now are worried about massive starvation and major ecological disasters. To many it seems to be at the same time, "the best of times and the worst of times". We are wise and we are foolish, we believe and we're incredulous, we have light and we have dark, and we have hope and we have dispair. Indeed, "we have everything before us and we have nothing before us." These thoughts seem to be terribly contemporary. Needless to say, they are from the first paragraph of A Tale of Two Cities by Charles Dickens, which is approximately two centuries old at this point.

I showed you this not because I'm a scholar. I don't purport to be one. But I suspect that those in Socrates' time, and some of the Egyptians and Chinese a few centuries before them, probably felt the same way. The reason I show this to you is because I believe that, in the affairs of individuals, institutions, and even nations, there are at least two kinds of changes that are going on at all times. One is a long term or secular trend, the other is an oscillation about the long term trend. When we look at data, such as the time-series data that I understand actuaries use, we often collapse those two into one trend. As a result of the addition of those two components, we often lose sight of what really is happening. The long term condition often can be very strong. Once an institution, organization, or individual gets into a pattern, it may be difficult if not impossible to break out of that trend, short of some kind of revolution. Impressed upon the long term trend are short term oscillations. In the United States, I think we all recognize that an enormous number of decisions and resulting characteristics of our society are synchronized with our two, four, and six year election cycles. In many areas, it seems impossible to change patterns or behavior of physics and make decisions that go beyond the bureaucrats' perceived

elected-term of office. Indeed, human inertia often seems to be stronger than physical inertia; it seems to defy laws of physics. If we can disaggregate and pull these two components apart, the secular trend and the short term oscillation, our images of the Futures should be improved and our decisions, thus, made better. Clearly, certain decisions have to be based on the short term. And other decisions have to be based on the long term. Typical examples of long term decisions are those for large capital expenditures that many organizations in our society, such as the chemicals and petroleum industries have to make. Many of our demographic trends are really on long-term patterns: for example, birth rate. But just in the past thirty or forty years we have experienced digressions from long term trends. For example, there are strong indications that as societies get richer and move away from an agrarian economy birth rate declines. It may not really have been the pill that was most important in reducing birth rate in the United States in the past one or two decades. When people want to stop having children, they apparently stop having children. They know where children come from, and they can prevent them. The pill may make it a little easier. But if we step back and look at birth rate in America by going back to the end of the 18th Century the curve has been on a long term decline. One transient occurred during the Great Depression when birth rate dropped even further than it otherwise might have. Another occurred after World War II when everybody came home and said, "Wow, you look better than I remember" and they had fun for a while and birth rate increased. Now it has stabilized on the downward trend again.

So, I make this point to you. Often we collapse too much in one trend and don't pull apart the real forcing functions or the basics. And there are other characteristics of attempts to forecast which often doom our efforts to failure before they even are started.

One characteristic, certainly of our contemporary society (often displayed by the media) is a preoccupation with current events-I call it current events hypnosis. We have an oil embargo or some kind of pollution disaster and institute enormous, billion dollar programs. Six months or a year goes by and we often turn our attention to other problems of the moment. This current event hypnosis often sidetracks our efforts to appropriately pursue long term problems and solutions.

Another characteristic of forecasting is that many forecasters, reputable forecasters, do not give their judgment on what they believe is really most likely to happen. Rather, they tell you what they would like to happen. They are attempting to create a "self-fulfilling prophecy". In fact, the individual or institution from whom you are obtaining the forecast may be in a position to largely determine what the Future will be. We all know that there are institutions and individuals in our society who are more effective in causing things to happen that they would like to happen. In the work we do at the Futures Group, we consciously seek out and interview hundreds, maybe thousands of people, throughout the year on the various products for our clients. And in seeking out these images of the future, we consciously look for diversity of opinion.

One important observation about forecasting that I heard a few years ago was from Kai Erickson of Yale. He said that if we examine the item we forecast as being most likely, often its complement, that event which is mutually exclusive, is the next most likely possibility.

We're all familiar with some of these forces of change and the factors that influence forecasting. Indeed there are many things going on in our society that are changing the ballgame for many institutions. Let me mention a few important examples. Legislation in America has experienced an important metamorphosis over roughly the last hundred years as to how that legislation is influencing the marketplace. The first legislation that was enacted in this country that largely impacted the types and prices of products and services that industry could offer to the consumer was the so-called antitrust legislation of the latter part of the 19th Century. That legislation, I offer to you, had one specific focus-protect the competition. It was directed at protecting industry itself; protecting one company from domination by another.

Federal legislation, again directed at influencing what could be offered in the marketplace, took up another focus during the Great Depression. Legislation that then was enacted was directed at protecting the consumer from industry, fair price laws and so on. Now a new focus has emerged in legislation that now is being enacted at the federal level that already has importantly affected people like yourselves. This new legislation, affecting what can be offered to the consumer, is directed at protecting the nation. Let me give you an example. The Auto Fuel Economy Standards now in force specify that the fleet of cars, that GM, Ford, Chrysler and other manufacturers sell in future years must attain certain levels of performance, i.e. 27.5 miles per gallon by 1985. The resulting autos may not provide what the public wants.

Legislation is only one aspect of change in our society. The many areas of technological change have been addressed by many authors in recent years, and uncertainty about economic conditions seems endemic, at least for the next several years.

What do these forces for change do? They create not a fatalistic or deterministic situation regarding our future. They have created a set of alternative futures. If there is one unifying characteristic of "futurism", it is that we are not dealing with a singular future. We, as individuals, and the companies you represent are faced with an alternative set of futures, a range of things that could occur. Our work is directed at providing people like yourselves an improved image of those alternatives and with assessing actions to help you "choose" your future. Step back and ask yourself how happy you would be if future A,B, or C evolved, what's the likelihood of each of those futures, and perhaps more importantly, what you can do today that will ultimately influence what future materializes. We're not proposing that policy choice is a fatalist game; it's a probabilistic game. If you haven't read it, you may be interested in The Art of Conjecture by Bertrand De Juvenelle, a French philosopher. In that book he crystalized this concept of probabilistic futures and the impact of contemporary policy choice.

Let me talk with you now about some ways of peering into the future-of systematically peering into the future that we've developed and use in policy analysis. When it comes to dealing with the future in quantified terms, there are two basic approaches in estimating what the future is likely to be. One is by working with what we (and I suspect people such as yourselves) refer to as time-series data; e.g. birth rate as a function of time, infant mortality as a function of time, life expectance as a function of time. That approach postulates that the variable with which you are dealing is a function of time, that there is no other cause and effect relationship.

The other basic approach to forecasting is modeling, which attempts to simulate the various actors and reactors in the system (social, economic, technological) and to project the parameters and variables in which you're interested. Often these parameters are a function of a series of other parameters that in turn are interrelated.

The first approach, trend extrapolation where the variable is a function of time is based upon the system in motion concept. It presumes that those factors which have largely determined the past will continue to shape the future. Trend extrapolation generally will not illuminate surprises. Here are some ways that people extrapolate trends. When we have a series of historic data we try to fit a curve to those data. There are many ways of curve fitting, as you know. One way is human judgment; coming up with an "eyeball's least squares curve".

In certain kinds of forecasting we may be dealing with things that come in packages. Let me try to give you an example. A technologist working in the area of energy may be trying to estimate what the new energy supply domain may be. Maybe the parameter of importance is output per unit weight of the supply system. We can look at alternative systems used over the centuries (water, wind, wood, coal, petroleum, nuclear) and draw a trend of the above parameter for each one of the systems as it grew in capability. An envelope curve can be drawn that includes all the known alternatives. This envelope can be extrapolated and the technologist often will tell you that he can now spot a domain where some new system has to be.

Remember that this approach presumes that we're dealing with a system in motion. Here is a very famous curve, speed of aircraft in the earth's atmosphere as a function of time. The Pentagon may be interested in specifying what should be built into a new procurement to be operational in ten or fifteen years. One source of advice might pull this curve out of the file and say: I just got some new data about what the Russians were up to, so I'll put another data point on the curve . I don't want to use my eyeball to do it so I'll turn it over to a computer and search a series of equations. Out comes this equation that fits the data best. He uses that equation to project the curve and tells his boss what the specification should be.

This kind of extrapolation can be terribly naive for some very important reasons. Some are physical. If I'm talking about speed with which man can fly in the vicinity of the earth, I can't extrapolate this curve beyond about 18,000 miles an hour. Above that speed we would exceed escape velocity and would no longer stay in the vicinity of the earth. I could make the same general argument about certain institutional barriers that you can't ignore. So trend extrapolation can be terribly naive.

Now, to come to grips with some of these deficiencies that came from using the past as essentially the complete descriptor of what the future will hold. The first technique I want to show you is one we refer to as TIA - trend impact analysis. It's a technique of working with time-series data. Indeed, its a crude way of simulating systems, but still working with time series data. This technique brings into the picture not just past factors, because we can't ignore inertia in our systems and we can't ignore certain laws of physics, but also images of the future. At this point, let me start showing you some actual examples

to demonstrate that what I'm talking about is really an operational technique. Here's a projection that we made working with Northeast Utilities. It is one of the largest electric utilities in New England. We had been working with them for several years. In 1973 they asked us to help them improve and update their load forecasts. New England has been experiencing important changes in demand for electricity, as have other areas. People and industry were leaving, environmental concerns were growing and Public Utility Commissions were increasingly requiring defenses for rate increases. So, we made this projection for them.

The data that we had in 1973 ended with this point. The curve was in a downtrend, creating some very interesting questions. All other things being equal, where would it go from there and what new things would occur--new kinds of energy developments, demographic changes, etc. The final result was this--the mean of the forecast along with the range of uncertainty. In this case I'm showing you the upper and lower quartiles. In other terms we anticipated that, when we made the projection, 50% of all potential future worlds would lie within this band, 25% of the cases lower, and 25% of the cases higher than the band shown. Here's what's happened since then. And here is Northeast Utilities' figures from a forecast it made in 1976-1977. You can see, for all intents and purposes, the actual usage figures lie right on the mean of our forecast. Now, let me mention one thing about this forecast.

I showed you here what I refer to as the range of uncertainty. You remember my earlier comments to the effect that we believe strongly that we're not dealing with a fatalistic world. One of the characteristics of the forecaster is that he often invites the person in the organization he's trying to help to ask for a "single" number describing the future. The forecaster often knows he's uncertain about the number. But for some reason he is compelled to give the client one number. I believe that's an enormous disservice. The possibility of that actual number materializing in the whole scheme of things very often is relatively small. If I provide a forecast and, to the best of my ability, estimate that the number I've given is uncertain, to plus or minus two, three or four percent, there is one set of policies that's most appropriate for that organization to pursue. Alternatively, if I show that the range of uncertainty is plus or minus 25 or 30 percent, there are a different set of policies that are most appropriate. That's the essence of risk and policy analysis-having much better insight as to how certain future conditions are and, in particular, to develop insights as to the sources of those uncertainties.

Here's how we make these kinds of forecasts. The first thing we do is look at the historic data and see what the system in motion is, what the so-called base line is. Then we try to systematically forecast the range of things that, if they were to occur, would be important to that particular parameter. Invariably, whether it's a highly technical parameter like energy, or a sociological parameter like birthrate, there always are a host of things that could be important to that parameter-not just technology, not just legislation, not just economics, not just social values, but all of them. And you see that here. We forecasted, in this case in 1973, a possibility of OPEC increasing its prices from 1974 levels by 25%. And you see the probabilities that we attached to that as a function of time: one chance in six by 1980, one in four by 1985 and not quite one chance in three by 1995.

In the case of this forecast, we also spotlighted technological possibilities-energy-saving techniques, less energy-intensive processes in that sector of consumption-along with their probabilities. Other possibilities included the national economy stagnating for three years, increased government intervention, increased consumer protection demands and pollution control, and so on. We systematically attempt to forecast items that, were they to occur, would be important to that trend, and how likely they seem to be as a function of time.

Where do these estimates of impacts and probabilities come from? They come from any insights we can embrace. The staff reads an enormous amount of material. I mentioned earlier that we interviewed. That's one of the ways these events were obtained, from interviewing people around the country-the bureaucrats, the economists, the technicians working in this area, the legislators. You get them to unload their computers and open up their thoughts. Often you get some surprises. Somebody is ready to take a move that you haven't heard about. Somebody is willing, in confidence, to talk about some proprietary thing that he's up to.

These probabilities come from, then, any way we can rationally get them: reading, interviewing people, our own staff contributing, and so on. You don't always get unanimous opinions. In fact, when we interview people, we look for divergent opinions because there's going to be rich insights from those.

Often we will not structure a forecast in the way I've shown you but will put together alternative scenarios. Some people will say, look, it's not only one chance in three by the '90's, it's almost a certainty. You have a new scenario before you. You might feel, on balance, that one scenario is as likely as another. So you create two worlds.

This kind of forecasting also embodies another concept, that we call cross impact analysis. Cross impact analysis is based upon the presumption that events do not occur independently. What really happens in the world is that, when one event occurs, it makes it more or less likely for other events to occur. Indeed, when people don't ask themselves that cross impact question, what is the probability of the other events if this event occurs?-they often will make estimates of probabilities of events that are inconsistent. Frequently you get forecasts, for example, of two events that are mutually exclusive with high probabilities of occurrence for each event.

Often when you start asking that cross impact question, people have more confidence in conditional probabilities: I know if event one occurs what the probability of event two is. Then you can go back and reassess the initial probabilities. People are often more certain about probabilities when they are coupled than when they are truly independent. That's part of the problem. And often we will systematically run a cross impact analysis before we ever move into the trend impact analysis. The ballgame doesn't stop here. What I've said to you up to now may be the easiest part of the process.

The next thing that we ask is a series of questions about the impact of these events, if they were to occur, on the trend in question. The impact study consists typically of five questions. They relate to the nature of the impact in terms of how long it would

be from the occurrence of the event until the trend would move either up or down from what it otherwise would be, and the magnitude of those impacts. What I show you here is how long it would be until first movement of the trend occurs, how long to the maximum impact, the magnitude of that impact, how long to the steady-state impact. These last two columns refer to the fact that very often the event will occur and you'll have some maximum impact on the marketplace. Then the impact saturates and settles down at some lower level.

We go through the entire process. This lists just one part of the set of events used to project this trend. Here's the rest of the events used in this one analysis. We have found that once you have designed the level of abstraction that you're dealing with, largely by the nature of the events and by the nature of the trend, that ten to twenty events cover the possibilities important to the trend in question. It's very important in this kind of analysis not to double-account. Don't include events whose characteristics are already included in another event at a higher level of abstraction.

Our clients tell us some very interesting things about this type of analysis. Remember, I've been talking with you about policy analysis. This is not forecasting for the sake of putting something in the file so we can come back in 10 or 15 years and say, Aha, look how smart we were. Our clients look at this projection and the events used in the analysis and can ask themselves, us, or whoever is the team some very interesting questions. Someone may believe that the possibility of national allocations of petroleum caused by oil shortages is not 15% for 1990, it has to be at least 75%. The fact that you can see where disagreements may lie and how this can effect the outcome is important. You can put in the 75 vs. 15% and see how important it is, and we can stop arguing. There is an enormous amount of worry in this world, in this ballgame of forecasting and policy analysis, that deals with trivia. We worry about the wrong problem. Translation: we don't know how sensitive the answers are toward differences of opinion. This is one way that sets out the importance of differences of opinion. If we worried about the donut and not the donut hole, we'd be a lot better off.

In making judgmental estimates of impact we find one of two extremes. People typically either overestimate how much one event can do to a trend or they underestimate. When you think about these things they start coming in together. I can remember when we first started trying to project GNP, an enormous parameter, with these kinds of techniques. People would march in the door and say, wow, if we got that kind of increase in energy, GNP would be hit in the head by 5% to 6%. Do you know how many dollars that is? You would have an enormous transient. You really must disaggregate aspects of the future in this way. The other thing that happens through trend impact analysis, in addition to being able to analyse the sensitivity from differences of opinion, is that the whole level of judgment becomes a lot more realistic.

Another thing that people tell us about the technique is that they can better assess whether they can influence the future of that trend. What if I take up more R&D and drop it in the marketplace? Or more lobbying in Washington? Or a new marketing program with my clients? Will I change the likelihood of these events? They start getting insight into how they can affect their future. Alternatively, they say they may be dealing with a situation which doesn't allow them to change it because their own actions are constrained. But now they say they can at least know what to look for so they can respond quicker.

Let me show you another projection made using T.I.A. In 1973 we were using this technique in a data service we were developing for the pharmaceuticals industry called Pharmaceutical Prospects. It now has 120 curves like this in it that cover all kinds of things: incidences of disease, sales of specific items, and so on. I was dealing with economic trends and the Consumer Price Index and interviewing people around the country, by telephone and in person. Common wisdom in America at that time was that inflation will continue through the foreseeable future at 3 1/2 or 4 percent per year. I walked into my colleague's office one day and said, Ted, let me show you something. I have a feeling that inflation in America over the next decade is going to be in the area of six or seven percent. And he said, where the hell did you get that? And I said, where do you think I got it? He said, I'm not going to let you publish it because people will think that we've got a screw loose, and they won't buy our product. So I said, look, we say we've come up with something here that can help insight, all the input data is here, change the inputs if you don't like them. Either put up or shut up. He fussed and fumed for three to four weeks and then said, publish it.

Many eyebrows were raised. Now people look at me and say, why the hell were you so conservative? Actual inflation (i.e. rise in C.P.I.) has been above the upper quartile. Does that mean I was wrong? My answer to you is no, in the following sense. There was an enormous number of decisions that were being made in government and in the private sector of America. They were presuming certain levels of inflation. If those decisions were based on this kind of projection rather than the one that was common wisdom, my argument to you is that certain areas of pain that have existed in our society would have been markedly reduced. One of the bases for trying to improve insights into the future is not on the premise that you can eliminate all surprises, but that you can minimize surprises and thereby minimize pain.

People continuously ask us, if your projections using these techniques are so good, how accurate are they? In dragging out these old projections, I probably have done you a disservice. Because the question about accuracy is the wrong question. The question should not be if you're so good how good are your forecasts? The question really should be, whether the projections you have apparently improved decision making. Indeed, professionally we would be absolutely derelict in our duty if we made a forecast, put it in the file and came back in ten years and said, wow, isn't this a pretty stinky world-just like I said it would be ten years ago?

The thing that we should be doing in forecasting is attempting to improve our insight as to how to improve what the situation is likely to be compared to what it otherwise would be. Here's what I used in making the projection of Consumer Price Index. I was getting signals of a very significant recession in America. I was lecturing at Columbia (at Arden House) about this time and I was talking about inflation rates of 10 to 12 percent and unemployment of 8 to 10 percent in the next several months to a year and a half and I got laughed out. The next time I showed up people were listening because we were on target. I don't purport, by any stretch of the imagination, to be clairvoyant. But there seems to be a way of asking questions about the future that indeed can improve our insights.

Here's how forecasts are made specifically using this one technique. We look at the historic data (after we collect it) and we curve-fit it. We use a computer to search a family of equations, some linear, some nonlinear, in the transformed space. We can put in limits; we may not think it's rational for this equation to go above this number, or clearly you can't exceed 100% here. The procedure tells us which equation best fits the data, within the limits and constraints placed on it. We then step back and ask whether that mechanical process is valid. It may not be. For example, events may already have occurred, such as recent legislation, whose impact on the curve has not yet been felt. But we know that the curve has to digress from its historic trend. You must ask yourself those kinds of questions and judgmentally adjust the baseline projection from the best fit equation if necessary. You have to make peace with what you believe the baseline should be. This is a very demanding process. It causes you to ask some very basic questions about the institution with which you are dealing. There is much forecasting done in America today that worries only about the future and not about the present or the past; such forecasts often have to be discontinuous with the present and thus institutionally incorrect.

The next step in the process is the question of "What could occur that could modify or change the base line?"

GARY CORBETT: I always have trouble with that base line. How do you know that the people you're interviewing are not intuitively forecasting some of the events that you're trying to analyze?

That is a super point. Gary is saying that, often when you ask people to estimate elements of this process, the events and the impacts, they may already have some of these elements built in the base line. Gary raises a very good point in the following aspect: don't forecast the future event whose characteristic is already built in the trend. If you are dealing with demographic trends, don't forecast a continued reduction in birth rates if you feel that that characteristic is already built into the curve. But, a forecast of an increase in the birth rate, that may be a new event. You forecast events, you estimate their likelihood of occurrence vs. time, the impact on the baseline projection. An important point here is the difference between probability and impact. I believe it is very important to ask about future events in the following sequence. First identify those events that, if they were to occur, would be the most important. The first part of the screening process is to pick out the big swingers. Don't worry initially about how likely they are to occur. Tell me about those that, if they were to occur, would be the most important. We typically do it in three categories: of major, of moderate, of little or no importance. Now talk to me about probability. For the ones that have low probability, but are at the highest end of the impact scale, we will have to be a little bit more precise. There's a very strong reason. In the psyche of individuals and institutions, if left to their own devices when they spot something that they view as odious they intuitively ascribe a low probability of occurrence to it. They can't cope with challenge, a threat. I suspect if we had some way of going back in history and looking at forecasts that were made and discarded, many would have that characteristic: low probabilities assigned to events viewed as odious. If you can get people to step back and talk about big swingers first, then you can start to uncover counter-intuitive reasoning about probabilities. The interviewee states that one certain event has a very

low probability of occurrence, but everything else he said indicates it shouldn't be that low. If you find out he's concerned about it as a threat and can point that out, it's often more comfortable for him to back off and revise his estimate of likelihood to a more rational figure.

Don't ignore potential big swingers. We should be attempting to increase the likelihood of those things we view as good and take actions that keep the likelihood of occurrence of odious events low. And that should be positive action, not non-action.

Now, let me return to the impact estimate that I've been talking to you about and how it's used to prepare the final projection. The calculation is quite simple. It's an expected value calculation. For each event, the computer fills out a table. The vertical heading (Y) is "year of event occurrence," the horizontal heading is "impact in year X." The impact is determined by applying the probability of the event occurring in year Y to the impact the event would have in Year X. This gives the expected value of the impact of an event in one year. To get the expected value of the impact of an event in each year, simply sum the expected values for each year based upon the likelihood of the event occurring in each year coupled with the delay time and magnitude of impacts already estimated.

Question: Is there any way you get at probability measurement, other than judgmental?

In certain instances, probabilities can be calculated by using recognized analytic techniques. The way we get impacts and the way we get probabilities, depends upon whether there are economic or engineering-like tools that can be used, or whether it can be obtained only by judgment. Often, when you deal with the future, judgment is, in fact, the best. An important consideration is how much time and money you want to put into it. I could worry five years and spend a million and a half dollars on getting an impact estimate on some kind of engineering problem. But, this technique lends itself to sensitivity analysis. Don't spend a lot of money sharpening up the pencil and improving a number for an event if it turns out that variations of that number are unimportant in the overall picture.

Let's return to the first projection. We now have the expected value of the impact or baseline for each event for each year. These are added algebraically to get the mean, or the expected value of the projection. There are statistical ways, once you have the mean and you know the expected value of each event and its variation around its own expected value, that you can calculate the limits. In fact the limits are not always symmetrical, they may be skewed up or down, which is also a big insight.

You now can see what the big swinger events are and where you should put your emphasis. Remember that typically our "worry bin" is full. Many of these concerns may be trivial. But they often cause decisions to be poorer than need be. Indeed one of the major features of this procedure is that it does identify which concerns are most important and should be dealt with, and what matters may be ignored.

Another use of this type of forecasting is as an early warning signal. Even though a client may feel powerless to effect any change in a given area, he may feel relieved

to know what the important future events may be. On the other side of the coin, if a client does not like the forecast, he can identify the areas that he can lean on to try and influence the course of future events. Indeed, we have certain clients familiar enough with these procedures that they have unmade the forecast: we have seen people interject themselves and change the world.

This last 45 minutes or so dealt with time-series data. Let me now talk a bit about simulating systems, linking variables-but in the same spirit of the output being probabilistic. Jay Forrester, an electrical engineer at MIT, invented system dynamics and has written several books, Industrial Dynamics, and World Dynamics. One of the ways of simulating systems is using Forrester's type techniques. The principle of his simulation modeling is the following.

Let's say we're interested in the population of a city, state, region or country. We ask several questions. What influences population? Clearly, birth rate does. As birth rate goes up, there's positive feedback, and population goes up. What else affects population? Death rate affects population. As death rate goes up, there's negative feedback and population goes down. But now what happens as population increases? Well, as population goes up, you can see many results. Demand, for example, increases on natural resources. How we apply technology of extraction and in using those resources ultimately influences levels of pollution in the atmosphere. Material standards of living can be modified which in turn affects the death rate and the loop closes. As you step through time with the model, using quantified relationships among these parameters, such as atmospheric pollution and deathrate, you can output death rate, birth rate, population. usage of resources, etc.

This type of modeling is very demanding, First, you have to know a good deal about the system with which you're dealing. But the technique also creates some interesting insights because the system has to be broken down into its elemental parts. You've got to be specific about what you're talking about. All assumptions have to be made explicit; what the elements are, what the relationships between them are, and so on. And you also must determine what forces will affect the system; and, indeed, if you're going to affect the system, what's required to do it. You can use it as a tool for experimentation and policy analysis.

One of the items we must recognize is that any simulation, whether it be this analytic kind of simulation or an engineering kind of simulation, still is not the real system. One of the criticisms leveled at modeling is that the real system is not static, it can and does change. We can make new laws that affect resource usage or we can have new kinds of technology that can affect resource usage, and so on. The nature of modeling dictates that the model be reviewed. We should ask ourselves, what are we missing, what's happening that may be outside the scope of the model, what history would dictate the model be redesigned.

Let me give you a primitive example. One of the table functions, the linkages in these models relates sulfurous oxide in the atmosphere to death rate. Presume a researcher in a pharaceutical house is working on an anti-pollution pill which counters the detrimental effects of the sulfurous oxide. When he brings it into the marketplace, we should anticipate a change in the death rate and the curve linking pollution to death rate shifts. Hence,

one type of change in the model is a change in the internal relationship.

Another thing that might happen is that Congress enacts new legislation opening the doors to immigration. That is a direct factor affecting population. So a new input factor is involved from a change in the law. Other events may occur and I now can start asking myself the following questions in relation to how the model changes. What would happen to the probabilities of these events, for example, as population goes up? I would argue that, as population goes up, the probability of inventing that pill is going to go up because there's more pressure for it, government funding of research, and so on. But the probability of immigration opening up goes down. You can estimate judgmentally, or in whatever way, those kinds of impacts. You could also ask the cross impact question. If this event occurs, what's the probability of immigration? and vice-versa.

Now the decision maker can step back and ask himself, what should I do? What's the most effective event or events? Can I get it with legislation, with new R&D, etc.? In terms of this type of modeling technique I would offer these observations. You can account for events that are outside of the structure with which you previously were dealing. You can step over boundaries, institutional boundaries. And, the model itself becomes dynamic. It changes itself as it steps through time.

We've used this technique in many problem areas. The first time we used it was for a government agency in Washington that had us model the Japanese economy. This was before the energy embargo. The agency in Washington was interested in what Japan might be doing in terms of export policy, import requirements, and so on.

There's another element of modeling that relates to the response of decision makers. We call it "decision" modeling. In many regards it can importantly be used to estimate the response of clients such as you have in your marketplace. Decision modeling is based on a couple of basic premises. The first is that when a chooser, e.g. the consumer, has a series of alternatives before him, the alternatives are chosen based upon the degree to which each alternative satisfies the range of needs that the decision makers have. If an alternative does not satisfy the market at all, it's not going to penetrate the market. If the alternative satisfies the range of need to a high degree, you have a high penetration of the marketplace and so on. The other basis is that the behavior of the users can be determined from past actions; i.e. you can estimate how well various alternatives have satisfied criterion and see historically what happened in the marketplace. When you're working with a population of consumers you can, in fact, describe or estimate what is important to them for given products. What does it cost, is there liability in its use, how about it's availability, etc. And you can determine at any point in time how important one criteria is to the others.

One characteristic of our society is that the items that we have to satisfy, as we move through time, change and the relative importance among them changes. Not too many years ago communities in America demanded soot from power stations and smoke from steel mills because they were signs of economic progress.

This modeling technique demands that you define what's important and how important those things are to the population of decision makers. You also must estimate each one of your alternatives and estimate how well they satisfy each of the criterion as a function of time. We were working for Northeast Utilities and trying to estimate for them what would be the penetration of new space heating in homes for their region. We designed a simulation model. One of the main elements of that model was a decision model. The model had a sector for consumer growth that fed new housing units overall. Those new housing units generated consumer choices in terms of space heating. Such choices were based upon initial cost, fuel cost, convenience, safety, availability of fuel, and service support for the Utility. Using historic data we validated the model-an important step in any design and use of simulation models. Using the decision model we estimated what the penetration would be. The total model also estimated "retirements". Retirements include replacement units in existing buildings and abandonments of houses.

Now, how did we build our little decision model? We looked at things historically. How important were things to people in the past. Here you see them on a scale of 0 to 100. We also estimated how important they're likely to be in the future. Fuel costs markedly rising then coming down, convenience staying about the same, cleanliness showing increasing concerns about pollution, fuel availability, starting to get very high in '80 and '90 compared to what it was. And then we took a look at how the alternatives met each one of the criterion. Here those are, on a scale of 0 to 1. Oil was coming down in cost but by 1990 going up rather markedly. Gas was coming down and going back up again. Thus, we estimated how well each alternative met each criteria. And here's the output in terms of penetration. And you must validate with history. In fact, I will observe to you that too many modeliers build models and forget to test them to see if they regenerate the past. If a model doesn't regenerate the past, you're very hard-pressed to argue that you should use it to project the future. You may have to "tune-up" some assumptions. But first regenerate the past before attempting to make a projection for the future.

As we've talked this afternoon you've asked questions about sources of data. There's one kind of data collection about which I want to talk briefly with you. I've already said read everything you can get your hands on, generate some of your own numbers, talk to experts, and maybe even look for a consensus. There's a lot of consensus seeking in America. A recent approach to consensus, and it's not so recent now as it's 10 to 15 years old, is Delphi conferences-i.e. Delphi studies. A Delphi conference is something that has been abused and misused. The concept was generated by some people out on the West Coast in the latter part of the '60's who had been largely working in the area of system analytic approaches and effectiveness studies for the Department of Defense.

Those people were of several convictions. One of them was that standard conference techniques where people around tables come to a joint and mutual decision, have undesirable aspects. One aspect is the bandwagon effect. Another is the stifling of communications: I'll be damned if I want to disagree with the boss because if I do I won't be here next week. Additionally participants feel uncomfortable in backing off from something that they have pursued for twenty years, because of embarrassment.

The Delphi technique has two basic purposes and principles and no more. It collects opinions anonymously for a reconsideration. The way it was originally used was to send out questionnaires.

Remember the curve I was showing you about how fast you can fly in the earth's atmosphere? Let's use that as an example. Let's say I was doing a forecast in 1950. I would put together a panel of so-called experts. If I was doing it in 1950, who would I try to embrace for my panelists? Aero-dynamicists, people who are experts in aircraft propulsion systems, do structures, and maybe some people who are pilots. I'd send them the curve. One of the questions I might ask is, why has the curve moved like it has in the past? The aerodynamicist might tell you that there was a big mental block against flying beyond the speed of sound, but once it was done, the mental blocks went away and we rushed ahead to do it. And the structures man may tell you that in 1950 we invented a new metal, and the engine man would tell you we went from propellers to jet engines. So they all give you the reasons. The next question might be, what do you think the future will hold and why?

You would ask each of them to extrapolate the curve with their reasons. Those data would be collected. We might find that a person that's giving you a low estimate, in comparison with others,believes he is really giving you high estimates. You then feed their data back with all the reasons, the ranges of opinion, and show each respondent the results and where he was-and ask him to reconsider. If we were to do that same kind of inquiry today, there's one expert that we would want on that panel that we probably would have ignored in 1950: the environmentalists. It wasn't technology that turned off the SST; it was the environmentalists.

Delphi is not an attempt to do a poll, statistically, as pollsters do. Delphi is an attempt to create a synthetic expert.

Norm Dalkey used a group of UCLA students several years ago in an interesting study of Delphi. They were given a set of encyclopedia-type questions, answers to which could be looked up in history books to determine if that person was right or wrong. Persons were asked to rate themselves, relative to their own expertise. This can be done, for example, on a scale of one to ten. Dalkey found that people who rate themselves high as being experts are more often likely to have the right answers.

He also found that you should not feed back questions more than once. You get to a point of diminishing returns. Give people one chance to reconsider and then move on to something else. If you have a Delphi, or anonymous conference, after a standard, face to face conference, the typical answer is likely to be improved. If you have an open conference discussion following an anonymous input, the answer is degraded.

We no longer use mailed questionnaires for such inquiries. We conduct interviews. We send out two people who are versed in the subject, after having designed and tested the interview. Where we feel there's important differences of opinion that we want to penetrate further, then we get back with the person, either in person or by phone.

The items we discussed today may sound terribly scientific, and I think I know where the bulk of you people are coming from, relative to fact vs. opinion. But even though you may perceive that many of us are trying to say a lot of this is scientific, it isn't. There are some important caveats that I'd like to leave with you. An example is, the weatherman tells you that there's a 60% probability it's going to rain tomorrow. He isn't telling you it's going to rain, or not going to rain-and he's not telling you to carry an umbrella, or not carry an umbrella. What he's attempting to do is give you a better indication of the risks you're taking so that you can determine your own course of action.

We talked this afternoon about the fact that the methods still are highly judgmental. I will say this though, that we have experienced, in working with a diverse set of people, when you try to be a little bit more systematic about pulling elements of the future apart, individual judgments become a lot more repeatable. Recognize that you may have overlooked something. We're not clairvoyant. The important point here, after having recognized that, is to ask yourself whether you're minimizing surprises.

All this relates to decision making or policy analysis because when you come down to it, when you choose policy, what you're doing is deciding today what's going to be right and proper for tomorrow. What you're deciding is, on balance, what tomorrow's society is going to want. Increasingly, in recent years, we made some pretty bad decisions, based upon what contemporary homo sapiens thought about tomorrow's world. Yet it doesn't mean we should back off, throw up our hands and say policy analysis is a silly ballgame. If we recognize what we're dealing with and if we find some way of assessing what the future is in terms of the disaggregated causes, we have a better ability to track ourselves as we go along and to readjust the plan, or the set of policies we have established.

This brings me to another point. There still is, even in our contemporary planning, the image that once the plan is created, it's the plan, or that it's immutable. If that is the approach to planning, don't ever make the first plan. Don't come up with a plan and say, come hell or high water that plan has to be followed. It should be used as a road map. If indeed it's a good plan, if it's constructed so that the elements of it are before you, you can continuously update it. Indeed you can update such a plan much easier than we've been able to do with our old approaches. The hardest part of making those forecasts I showed you is doing it the first time. Once you've got those events and probabilities listed, for example, it is so easy, by comparison, to work with the list and update it as time unfolds; say, what do I think now. Don't put it in the drawer and forget about it.

In forecasting we should recognize that many things are possible. In fact, the most likely scenario or future may not even be 50-50, it may only be one chance in three, or one chance in four. The future ultimately will evolve as a function of what we do today: its not a fait accompli with which we are dealing. Don't ask for curves so that you can rush ahead ignoring the fact that what you do as a company, as a bureaucracy, will influence the future. Today's action will influence the future, often importantly.

One of the things that makes this ballgame difficult is that language changes and we speak improperly. A story will illustrate. He is an Indian Chief doing the standard,

old-fashioned, proven kind of forecasting. He has his ear to the ground and he tells the Indian standing beside him "Don't tell me, I hear buffalo coming." The Indian hears it not as a question, but a declarative statement. So the Indian considers it an order. He hears the buffalo coming, but doesn't tell the Chief and the Chief is trampled. Then the Indian walks over to the broken, busted Chief and says, "why didn't you want me to tell you the buffalo were coming?"

There's imprecision built into our language and our communications. I've become increasingly aware of that over the last several years. I often think I know what I'm asking people to do, or what they're telling me-and I step back and ask myself, do I really know what I've said or do I understand what they have said? Often, I don't. Too frequently we don't pursue the discussion long enough to clarify ambiguity because we perceive we may hear something we don't want to hear-someone may be attempting to tell us of an impending odious future that we could prevent or minimize with more effective communications.

Thank you, you have been a delightful audience.