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COMMENT, Professor King: Thank you very much, Gedas. I think that you have raised a lot of questions. I personally agree with you that innovation is the key to competitiveness. Basically, the frame of reference here at this conference has been very good.

QUESTION, Professor King: You mentioned information technology and information exchanges with various companies and various cross border exchanges. We have heard of local restrictions on exchanges of information across borders, a problem of personnel security problems. Also some countries such as France and Brazil have been very nationalistic in terms of how they approach this problem. Would you comment on what your experience has been in terms of those legal restrictions or practical restrictions on information exchanges across borders?

ANSWER, Mr. Sakus: I will have to address it more from the practical sense than from the legal sense. First of all, we select the areas that we choose to market in quite carefully. Part of that selection process is to look at the environment, which must include the capability of transferring information and of accessing those markets. Not all environments are equal. From a practical perspective, the laboratories that Bell-Northern Research has in Canada, the United States and the United Kingdom, have a total ability to do daily exchanges of information. We have a number of offices in some countries that have not so much legalistic inhibitions to the flow of information but rather technical ones. For example, for the last twenty years we have had a relationship with a corporation in Turkey, in partnership with the Turkish Government. Today's technology, which is digital switching telephone systems and exchanges, is built with software on computers and, therefore, is susceptible to "software bugs." These central offices can, from time to time, have difficulties in their operations as some unique parameters are called upon to be exercised. We found that as we sold digital switching exchanges to Turkey, we had to be sure we improved the data and communication links from all parts of Turkey, places which do not necessarily have the best transmission sending equipment at larger moderates or bend rates of transmission. It was absolutely necessary for us to have the capability to link back to our central laboratories in Ottawa and our Emergency Technical Assistance Services in order to hook up and diagnose a problem in an office by remote.

Therefore, one of the criteria we have to look at in selecting a market is not only the legalistic aspects of the environment, but also the technical aspects of the information flow must be considered as a necessity to

the operation of business. But I do not see from a practical sense, if one is careful where one does business and how it is done, that a desire to exchange information is an inhibitor legalistically.

QUESTION, Mr. Thibault: Yes, first of all, let me thank you for a fascinating and challenging talk. There is one term that is floating around a lot these days and it is "technology in management." It's a very important notion. Would you comment on the term and perhaps indicate in what way it is different from managing anything else. Is there anything special about managing technology or is it just applying standard management techniques to an area which has not received much attention?

ANSWER, Mr. Sakus: Ten years ago it was claimed that software was really more an art than a science and, therefore, managers could allow people to work in their little cubicles and what they created, they created. Products resulting from this management technique were prone to have far more software bugs, and more integration difficulties. People are now recognizing that the approach to the management of technology is somewhat different than the approach in the traditional manufacturing sectors, and purchasing organizations.

First of all, the workers are generally people that have had higher university education and that are driven by an intense personal desire to achieve something within their own specific fields. However, that type of person does not always work best in cross-teams and tends to be more isolated.

Businesses are recognizing that nothing can stand by itself. We used to think of products as being "discrete circuits" or "devices;" then we came into thinking in terms of "apparatus;" then from "apparatus" we spread into "systems," and now "systems" are being joined into "networks." A product must have the capability of actually transcending someone's desk in Cleveland, Ohio, and operating the way that it is intended by interlinking Tokyo and Cleveland. This means that products have to interlink in design, in development, in function and in a very integrated fashion. That does not come naturally to many people.

Second, you have got to force the concept that innovation is, indeed, a scientific approach, that it is not just pure art and, therefore, it must be managed. It must be managed for speed because, as I said, velocity is essential. Another thing that must be considered to far greater degree is what we call cross-functional teams in the roll-out of application of technology. To create technology for technology's sake, and not to be able to apply it to innovative customer solutions, is not giving the competitive edge. To do that more quickly, we have to consider different methodologies of managing people.

One of the proposals that BNR is backing is to concentrate on the management of technology. It is strategically important for research and development corporations to address not just the creation of technologi-

cal wealth but also the ability to turn it into business producing entities. How you structure these technology teams? What is the organization? Does it have to be "matrix?" I believe it must be that way.

In other words, the power of delivering something quickly to the marketplace is found in establishing clear ownership of the entire process. Ownership of a team identity may be something that transcends the existing organizational structure. In that team, you may need an expert in acoustics tied in with an expert in transmissions. If they're in their own "hierarchies" they will never share that mutual problem.

So there are some technology management issues, some which we are grappling with, some which we think we understand, but some which we have not yet found the most effective solutions on how to carry them out. The winners in the economic environment will be those that learn how to manage that. Management of technology is an issue that people have raised, and I do believe it is different, and the approach to managing a bunch of scientists and technocrats is somewhat different than managing a bunch of marketeers.

QUESTION, Mr. Stayin: What are the principal techniques in managing in an environment where you don't have as many layers of managers? What do you use to control? What do you use to motivate? How do you handle the people who are not sufficiently productive?

ANSWER, Mr. Sakus: I do not want to give you the idea that we have found a panacea in running it as an orchestra where I stand up on the podium with a baton and everyone plays in tune. We are not there yet. Peter Drucker and other visionaries say that we will gravitate to that environment. One of the possible structures is this business of matrixes. That is, while individuals may exist in teams that are of a functional nature, in order to deliver a series of products or services, you have to cohere the various teams within that series. For example, we are developing a new product in our laboratories on the outskirts of Dallas. This product is somewhat new for us and we decided that if we are going into something that is on the edge of what we used to do, product-wise, we should consider a different system of organizational structure.

Therefore, we took a vice president of Bell-Northern Research, and gave him a dual reporting line into both my organization at BNR as well as the divisional entity structure with Northern Telecom. Then, not only did we give him the scientists and the technicians needed for his project, but we also gave him the responsibility for marketing, right from the inception of the idea, so he can test the success of the process. Now, on the business of renumeration, we also created a separate type of a bonus calculation percentage formula which is a hybrid between BNR's system and Northern Telecom's system. This, in fact, put the onus on the vice president for not only the deliverance of a design but also the production of it into a revenue generating business.

Now, that is one approach. The other thing we are trying to do is

get different entities together. For instance, in the example of a telephone set, telephones evolve over time. Just as an aside, we are probably the only North American manufacturers of telephone sets still physically making them here as opposed to designing them here and producing them somewhere on the Pacific Rim. But, on the evolution of telephones, we decided we needed to get expertise together on hands-free acoustics, and transmission things: the ergonomics of accessing buttons. We pull these together into what we call a platform so that the scientists and technicians know that they are working on a team.

Now, the problem with a platform is that it is an abstract thing. To make it real, we have had to experiment with structures and the management of technology.

Finally, clear delineation of what is one's responsibility is a tremendous facilitator to motivation. People say that fear of failure drives an individual to success. If you know what it is that you will fail at, it's a clearer position.

QUESTION, Mr. Miller: Mr. Sakus, I found your comments very stimulating. You seem to put art in a different category from science, art being intuition and science being a scientific experiment. Is not this separation really at the root of a lot of the problems that we have today? Is there really a difference? Are we not creating problems for ourselves by putting science and art in different categories? How do you deal with intuition, which by definition you cannot subject to scientific verification?

ANSWER, Mr. Sakus: First of all, perhaps I overemphasized the distinction between art and science. I think you are implying something a little stronger than my point. Let me restate some of the things that I see on the art side versus the scientific side. Both are creative. I do not want to mislead on that point, and I think perhaps that is what I understood from your question.

One of the key distinctions is that in art there are very few rules. You kind of freely go about creating your thing, whether it is splattering paint or using a knife in producing a piece of canvas. The distinction that I am trying to show is that we have to recognize that there are rules by which we can, in fact, innovate.

Now, that does not mean that creativity has to follow only those rules since that would inhibit innovation in itself. You only follow the rules you set. For instance, in the area of software, you have to combine certain software tools, code reviews, code inspections, and integration and regression testing. These can help you formulate and double check to see if the intent that you had in your mind is created in the algorism of the software programs that you have developed. This is not to say you should inhibit your mind in creating it.

The other aspect is this: In order to maintain that artistic element of science, we have to be able to test. We had a past chairman who used to ask "Will the dog eat the dog food?" In other words, one of the key

elements is to bring scientists from the abstract into the real world, make them somewhat more process oriented. It is only in that aspect that I make this distinction between art and science. I do not feel we should inhibit this ingenuity in any way, but rather supplement them with a process that aids. This addresses part of the issues that we talked about in the prior couple of questions which related to motivation and to management of technology.

QUESTION, Mr. Wetston: Mr. Sakus, do you think that there is a possible danger that we can get in a situation where we have too much innovation too quickly, to the point of counterproductivity? In other words, have we become obsessed with making new products rather than actually increasing new productivity after all these products are used?

ANSWER, Mr. Sakus: The answer is yes. There are areas where technology is being pushed for technology's sake, but I think the test is going back to our ex-chairman's question: Will the dogs eat the dog food? If you have technology that nobody is willing to buy in a product, I think that it will end there.

There are all sorts of examples where technologically we could do things twenty-five years ago. Yet in a business and economic sense, perhaps the delivery path did not fit into the equation, or the product could not be utilized. You can cite a number of cases where applications of technology have either been misapplied or applied in advanced of their utility. But by and large, if you add the evolution of technology to the products that society is providing uses for that did not exist fifteen, twenty years ago, it just keeps on increasing at a more rapid pace.

The end judge is the consumer, the public, the buyer, and that is why I think it is so necessary to look for real, conspicuous customer solutions. The wise corporation will try and match technology with an innovative application to create a customer solution.

QUESTION, Mr. Epling: Would you comment on the thought that there may be significant societal differences in the ability to make technological advances? Maybe in North America there are certain advantages over Asian societies in the university system that produces freer spirited, and inherently, more innovative people.

Nobel Prizes and things like that are used as evidence. If this is true, does this have significant implications in the short-term or in the long-term in our ability to compete?

ANSWER, Mr. Sakus: There is a couple of points I would like to make. First, when you look at the Nobel Prize arena, that is generally applied to the technology aspect, where you are sparking some new technical scientific capability. Seldom is it for innovation.

Therefore, as you look at it, you are quite right. The Pacific Rim nations tend to have far fewer awards although they may have an equal or greater number of scientists on a per capita basis. Then ask yourself: Who can best apply the innovative aspect to a service or to process a

product? You will find that they are as fleet of foot, if not faster, than many in the western cultures. It is a bit of a paradox.

If you look at some of the areas that require development today, I think you generally can see it is more of an integrated problem, like the progression I cited before, from parts to apparatus to systems to networks. I think you will find that type of broader thinking is more adaptable.

So, that dimension does exist and if we couple that basic capability with talent, with speed, with vision, going for value and utility to a customer as opposed to just abstract creativity for its own sake, we have those attributes necessary for us to continue to excel economically. But innovation and application of technology will become even more important as we enter the next century, which is truly the Information Age.

QUESTION, Mr. Sherman: My question is another form of the previous question. I was thinking as I listened to you that the characteristics that you were describing that would be needed to cope with today's technological situation is almost a description of traditional American characteristics.

I am not talking now about the sciences but rather about society. Americans experience change and discontinuity more often, compared, for example, with what we think of as the very static society with traditional values in Japan. We are accustomed to operating in a world where people's careers and lives are chopped up, where people go in and out of government and in and out of academia. This kind of flux and discontinuity is very congenial to Americans. We are so attuned to it, that we seem want to flourish more than almost any other nation, culturally speaking, in the kind of situation you are describing and yet we do not seem to be able to and I wonder why.

ANSWER, Mr. Sakus: You are quite right. In other words, the enviroment appears condusive to what is needed for us to flourish and yet virtually all video cassette recorders in the world are produced elsewhere. Virtually all telephone sets are now produced elsewhere, and most TV sets are produced elsewhere. I think the answer is that Americans lack the driving focus that it takes to put the products out.

I do believe that we suffer somewhat from our attempt to do everything. Our society is so rich now in the processes and the services that we, as a mindset, look for a sort of excellence and supremacy in being capable of the variety. That means that perhaps as producers, as designers, as people that enter into a new venture, we tend to overdo it. I believe one of the key things is to roll out in a competitive environment lean, mean and quick into the marketplace and then enhance the original product with successive models.

If you look at the Japanese business approach, *Kishai*, it is, in fact, very focused. We may lack this focus, although we have all the others, because of our constant change. I do not know what others might think

on that point, but it is a very valid point. That must be the entity that we are missing since we do have an awful lot of the other attributes.

QUESTION, Mr. Harvey: I wonder if you could relate that to the notion that we somehow have an engineers gap. Japan produces as many engineers as we do with half the population. That has been referred to several times during this conference and yet I have not seen anyone focus on why. Where is the demand for engineers? Presumably in our system, if there were a demand for engineers, if they were paid adequately, if there were adequate encouragement, we would have engineers. I wonder if you have any comments in relation to that?

ANSWER, Mr. Sakus: I do not know why there is this gap. I can attest to the fact that in BNR, for example, our objectives are to grow in revenue by approximately 15% per year which is sort of a corporate growth goal.

If *X* amount of dollars is allocated for the research and development budget, continued growth will be seen there. Now there is inflation, but we experience net growth of about 8% in terms of technical staff and most of them are in the computer software or electrical engineering area. We struggle sometimes to get the amount in specific areas.

We view ourselves as manpower producing as well as product producing. We transfer about 4% of our personnel to our parent corporation. This gives, along with retirements, etc., about a 10% annual attrition rate, with an 8% annual growth rate. You are looking at a need of 18% in new people that needs to be induced into our business if we want to continue to grow. I do not think that formula is far different from most corporations.

We find that we have to work our manpower pipelines pretty strong in order to be sure we get that 18% increase. We take a number of our new personnel from the post-graduate arena, beyond the bachelor's degree level. In Canada we select maybe a dozen universities to which we are looking for post-graduate people. We are also spreading selection across the regional labs, which gives us a better marketplace for personnel.

In the end, I guess our society has always been such that it is balanced by supply and demand; if there is enough shortage, the rates go up and that area becomes a lucrative field. The problem is that this is a slow feedback cycle. By that time you have filled a need, the cycle is out of sync, and you have got a surplus.

COMMENT, Mr. Edwards: How many persons here are professionally trained in engineering? Six. Of course this is, to some extent, a lawyer and business context but it seems to illustrate that a very small number of engineers actually progress to the top of the organizations in which they participate. While there may be attractive starting salaries, there is a very small number of engineers that finally move up to the top

as compared to some other fields where there seems to be more opportunity for a more rapid rise for individuals in terms of their careers.

We seem to find very few engineers after a period of time still doing engineering work. There seems to be a tremendous movement of them into sales management and into general management.

QUESTION, Mr. Edwards: Can there be, generally, a hierarchy arrangement for engineers where they will be sufficiently motivated to remain in the area in which they have been trained in?

ANSWER, Mr. Sakus: A couple of points on the comments that you have made. There are corporations where engineers do advance. BNR's chairman is an engineer, the president is an engineer and I guess that out of about six or seven subsidiaries, about four have presidents that are engineers. But, we are a very high technology-oriented corporation.

The point that I want to make is that people who go into engineering do it for dual reasons. I know it was in my case. I tended to enjoy the technical innovative things, and the things that were being explored to make sciences broader, but I also felt I wanted to deal with people and somehow migrate to a management structure.

Engineers go in and, in the pure engineering entity of designing or facilitating a process below the managerial level, they do not stay there long. But maybe that is the greatest thing that has ever happened. If I were still designing, we would probably still be using slide rules. The key thing is that technology marches on at such a strong pace, you have to migrate through it. A firm is looking for raw talent that either wilts quickly or moves to some other areas quickly. More so than in the legal fraternity where as a rule you tend to stay affiliated in your career in law rather than tend to branch out into an administrative position. The same thing if you look at dentists or doctors. They migrate into hospital administrations, but by and large they remain practicing for forty years. An engineer tends to shift in careers and I think usually that desire is there.

COMMENT, Mr. Jutras: The answer might lie in the fact that it very much depends on the importance that technology plays in the business enterprise concerned and also the importance that technology plays in the objectives of the company. As a company teacher I can tell you that in our company we have a total of about 2,000 people. We have 450 engineers and 1 lawyer.

COMMENT, Dr. McNiven: Just to add to this, as a general rule you will find in larger organizations that the more narrow technical skills, the numbers and materials, tend to be emphasized at the bottom of the organization. By the time you get to the top of organization those technical skills are not emphasized. What is emphasized is much more mushy. "Dealing in perfect ambiguity" is probably the best way to put it. As a consequence, whether an engineer or accountant or lawyer, if you are

going to migrate upward in a hierarchy, you are going to have to have skills that are quite different from the ones with which you started out.

I cannot see a very rigorous technical engineer who is interested only in that sort of thing ever becoming a president of a corporation.

QUESTION, Mr. Epling: Is not it true that in Japan and West Germany, for example, two very successful economies, that technical presence in industry is much higher?

ANSWER, Mr. Sakus: Yes.

COMMENT, Mr. MacDonnell: It is quite important that for any firm to be creative there be technical people at high levels of the firm. This is one of the concerns in small firms; that engineering capability does not exist. You cannot say that only in certain firms technology is very important. To remain competitive or to respond to changing situations you need that technical skill. It is something we are trying to address in programs that make technologies available to small firms through some links between universities and small firms.

COMMENT, Mr. Stayin: The companies that have this high demand for engineers in our society ought to do a better public relations job on why a person ought to be an engineer. The story is not getting out as to what the career opportunities are. I represent a number of trade associations that involve small- and medium-sized machinery manufacturers. Across the board, 98% of them are owned and managed by engineers. The engineers have to create the new technology and develop the machine, but in selling it to somebody else who has a technical use for that machine you have to have engineers in the marketing of it.

It is not a backwater profession, but it is not getting out there. You just do not see in the Wall Street Journal every week something great about how wonderful it is to be an engineer and why all young people ought to hope to be there.

COMMENT, Mr. Sakus: You are right. The average perspective of someone in high school is that engineers are designers and they have to create something. This business of migration in your life span through different tiers of management or even functions such as marketing, managing, and manufacturing is not generally understood as well.

COMMENT, Mr. Tingley: In engineering we probably become obsolete much faster than lawyers because the technology is changing so much faster than the law is. It is an area we have to admit that ten years after we graduate, unless we have kept up, we are just not with it.

COMMENT, Professor King: This has just been a great session Gedas, and we thank you so much for the mind expansion here today, peering into the future. We are also grateful to Clive Allen for assisting in recruiting you for this effort. It has been great and we thank you for it.