International Institute for
Applied Systems Analysis
IIASA www.iiasa.ac.at

Proceedings of Task Force Meeting "Human Factors in Innovation Management". Helsinki, 9-14 October, 1983

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IIASA Collaborative Paper
October 1984

PROCEEDINGS OF TASK FORCE MEETING "HUMAN FACTORS IN INNOVATION MANAGEMENT" Helsinki, 9 - 14 October, 1983

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October 1984
CP-84-46

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

ACKNOWLEDGEMENTS

This Task Force Meeting was made possible through the help of the Finnish National Member Organization and the generous financial support of the following companies:

Kymmene-Strömberg

Nokia

Valmet

Imatran Voima

Kone

Technical Research Center.

FOREWORD

These proceedings from the IIASA Task Force Meeting held in Helsinki from 9-14 October, 1983 reflect the wide spectrum of interests and experiences of the participants. The main topic—Human Factors in Innovation Management—was singled out as a potential focus early in the life of the Innovation Management Project. Preliminary meetings had already indicated how internally structured this topic could be. Intentionally, no attempts were made to limit the scope of the meeting, as the objective was to realistically reflect the interests, experiences and research results of our collaborators and constituency in this field.

The papers and studies generated for the meeting have to serve as a basis for further work in this activity. There are few, if any publications in the field which, on a working level, reflect the results of East and West research and industrial organizations. This also brings the necessity for certain caution when reading the proceedings because in spite of certain editing, we did not want to produce a "monolithic" publication eliminating some interesting particularities. This may be valid for vocabulary and semantics of a few terms. Participants from socialists countries guided by translation from Slavic languages are inclined to describe engineering and technology by "technics" and understand under "technology" the production process.

Several authors treating the subject have hinted at the vagueness of related terms such as strategic planning (Wolf, Patz), innovation and its ingredients (Benjamin, Langrish, Prakke, Riegel), or creativity (Kivikko, Langrish, Patz). In the paper by Bachvarov et al., examples are given how incentive and participative behavior are enhanced. The human factor is related to the wider problem of social impacts of new technologies, as pointed out by Langrish and Patz and hinted at by several other authors.

The interesting ideas, experiences and research results on the problems of team building and work are reported by several authors (Andersin, Bachvarov et al., Hanes, Moss, Rysina et al., Wolf). One tends to express the impression that in many companies in different countries the problems seem to be structured following similar patterns. At the first IIASA meeting on the problems of innovation the following question was posed: "To what extent is management of innovation the innovation of management?" Several authors stressed the need to educate managers to think and act creatively and in an innovative way and reported on the programs their own companies have instituted (Cervenka, Hempel, Smrcka, Virkkala). This only proves the relevance of the question posed above.

From several papers one can also feel the "in-house" practices that companies use when contemplating innovations (for example, Karttunen and Wolf).

These proceedings with selected papers, present examples of the most important problems managers face when managing innovation in the contemporary world.

Tibor Vasko
Leader
Clearinghouse Activities

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OPENING ADDRESS

Pekka Jauho
Director General,
Technical Research Centre of Finland (VTT),
Espoo, Finland

It is my pleasure and honor to open this meeting, to welcome you to the Technical Research Centre of Finland, and also to Finland. I have a double function here: I am Director General of this organization, which is hosting your meeting, and I am a member of the Finnish National Member Organization group of IIASA. When looking at the program and at the names of the people who are taking part in this meeting, we can note with satisfaction that the expert group that is meeting here in Finland is of a very high standard. We are very happy to once again welcome you to our country.

Since the beginning, Finland's position with respect to IIASA has been very positive, with a great interest in the deep-growing work at IIASA, where so many nations from all corners of the world are participating. We especially recognize the importance of the cooperation between East and West in science; and, as every scientist knows, it is often much easier to find a common language between scientists than between politicians. We also intend to continue to support the work of IIASA in the future, in spite of the present operational difficulties which are well known to this group.

I promised to open this meeting with a very informal talk. I prepared it on the airplane from Tokyo to Finland last night, so I am still a bit dizzy. I do, however, intend to illuminate some of my own views with respect to the human factor in innovation management. To start with, I thought that it might be interesting to look at some characteristics where the properties of the industrial society and the information society can be compared. As everybody knows, the Industrial Revolution started with the introduction of the steam engine; the information society is based on the computer. The basic function in the industrialization was, of course, the replacement of physical labor by machines. In the information society, it is the replacement and amplification of mental labor with the aid of microelectronics. Information society, therefore, is a natural continuation of the Industrial Revolution in the sphere of grey substance inside our brains.

The productive power in industrial societies is based on materials and products, and in information societies, on information. The difference might be expressed by saying that in industrial society materials determine the limits, in information society there are, in principle, no limits. You can produce as much information as you want, but, of course, the relevant information which can be grasped by a human being is limited.

If one starts to compare socioeconomic structures in these two cases, you see that in the information society the main product is knowledge. In and industrial society production takes place in the factories; the production of information can take place anywhere, and cover vast distances.

Market areas in industrial society have been mostly consumers, new countries and colonies. In information society, the interface is the borderline between the known and the unknown. Leading industries are manufacturing industries and information industries, respectively. Industrial structure can be divided into three, primary, secondary and tertiary, phases in the industrial society, whereas in the information society you have an integrated network. In economic structures, the transactions deal with commodities and in the information society you can speak about a synergetic economy. In the industrial society prices determine the equilibrium of supply and demand, and in the information society you have to define the goals in order to find the direction of the change. In socioeconomic terms you have the enterprise on the one hand, while in the information society, you can form lots of cooperative units which produce information. In an industrial society whether based on centralized economies or private ownership, the innovation is capital, with competition in this competitive society, and very often the profit motive is the determining factor. In the information society, perhaps the social kinetics have more weight in decision making.

The advent of the information society may mean that socioeconomic structures are changing. In the industrial society national goals are the maximization of national welfare in terms of product supply. Maybe in the future you can speak about gross national satisfaction as a goal, rather than increase of gross national product. The industrial societies are based on high consumption rates and the information society is based on high knowledge creation rates. In many countries, the form of government has been parliamentary democracy. Perhaps you can speak about participatory democracy in the information society phase. The forces producing innovations and changes in society have often been labor movements, and in the information society there are more voluntary formulations of decisions which changes continuously.

These two societies also have different value systems, as discussed in the book by Professor Masuda *The Information Society as a Post-Industrial Society*. Values in an industrial society are mostly material values. In an information society there are higher hierarchical levels of satisfaction of intellectual needs. In an industrial society the main problems are human rights as you have a system based on individuals and mostly self-discipline. You cannot impose actions on individuals in an information society if they are not in agreement with their own goals. In the information society, globalism will be a very relevant property because the whole globe will be combined in interconnected information networks. I think the most important point in the introduction of the information society will be *individual*

creativity. If it is going to work at all, and I am pretty pessimistic about that, it might be based on individuals and on the creativity of single persons, and then on the possibility of forming broader groups by using information networks, then communities, then countries, and then the whole globe. I am not quite sure whether all human beings are capable of or willing to become brain cells in a global network. In many cases, the values which must exist in the future information society are very much different from the values which we have in this concrete world of today. The acceptance of these new values will be a difficult process and it will require a long period of acclimatization.

What is certainly true is that the creativity of a man is the most tender flower of all the flowers of human activities. In the information society there are many dangers that might limit the possibility to use individual skills. Mostly I am afraid of the spread of bureaucracy which very easily follows, for example, the unwise application of computer methods. Everyone of you knows that it requires standardization; it requires many rules which must be obeyed and which very often are in conflict with the requirements of creativity in an individual person. The only way to alleviate this very serious problem is to develop managerial skills, to try to find out ways where this most important property in man can under all phases of the development of mankind be preserved and improved. In that respect your team is most up to date. If one makes a guess about a time schedule concerning the introduction of an information society, it might be ten years--which is a very short time, maybe 20 years is more realistic in most advanced countries. But just now is the right time to start thinking about these problems.

OPENING ADDRESS

Boris Segerstahl
Chairman of the Research Council, the Finnish Committee for IIASA

I am going to try in a few words to explain to you how what we are going to do this week fits into the general structure of what IIASA wants to do. I assume that I have some minimal amount of knowledge in this respect as Chairman of IIASA's Research Committee which takes care of some of the routine planning activities for short- and long-range planning of IIASA's research. Traditionally the work being done at IIASA is in several competing areas of mostly applied science. This means that we never see any one area dominating everything that is going on at the Institute. We have several really strong research areas such as, for example, energy, food and agriculture, economic structural change and so on. Innovation management fits into one area which was fairly strong for a few years, i.e., Management and Technology. This area lived a good life, but fell into the background when other research areas became more important for IIASA. Management and Technology did not completely disappear however. In different ways some people managed to keep the research going on a very small scale, mainly concerning problems directly involving production systems, industry, industrial enterprises, business and so on. Now IIASA is going to give more priority to research which has relevance for the private sector, for industry, and for producing enterprises.

You will not see the Management and Technology Area again at IIASA, but we are going to see something which is named Science and Technology. This is a small research program which will start its activities in 1984. In my opinion, work being done on creativity innovation management, and related subjects could fit very well into the Science and Technology program at IIASA.

The work which has been done under the leadership of Vadim Goncharov has been done with fairly small internal IIASA resources. It has mainly been based on very strong collaborative work with a lot of individuals and organizations in different countries operating as a network.

This seminar is not just a one-off seminar in Helsinki, it is part of a long process. Some of you have taken part in this process, some of you may only be involved in this gathering here. Unfortunately, those of you who only take part in this meeting without being part of the whole process will not get a feeling for what it is really all about. Those of you who are still here on Thursday may get an idea of the process when you take part in the planning discussions for the next two task force meetings. In any case, innovation management as a research process, as a networking activity, will be phased out when the time comes. But, if we can find the support needed and all the intellectual resources needed, and if we plan well enough for the future, these activities could continue, perhaps focused on other questions, but the main ideas will survive and could be part of the future Science and Technology Area at IIASA. One such idea, and it is only an idea, is for a project on "Computers and Children". Here at this meeting we have Evka Razvigorova from Bulgaria who is involved in trying to plan for this idea to be included in the future IIASA research plan. IIASA is very consumer oriented, and we try to avoid doing things just because it gives us a tremendous feeling of pleasure. We get our pleasure out of keeping our consumers happy.

I said earlier that we try to do work which has some relevance for industry and production systems in different countries. There are some difficulties. IIASA is traditionally an academic environment. We have a lot of scientists from universities and research institutes, which means that we very easily fall into naive academic perceptions of what is relevant, interesting and really needed by industry, and what they are prepared to support. Somehow it is very easy in an academic environment to create all kinds of nice and wonderful ideas which should be supported by industry, but when we turn to industry they are not interested.

Neverthless, in the future we will try to find out what industry needs and wants, although we can never get a complete answer because in many cases the people in industry do not know themselves. They do not know how to formulate their problems, they do not even always know where their problems are. The relationship will therefore always be complicated. IIASA has limited resources, we cannot and shall not, create big research groups. We also have to use those components of IIASA's structure that are really strong and, I would say, unique, i.e., that IIASA is multicultural and multidisciplinary. We have responded to requests for research in different areas and, as Professor Jauho mentioned earlier, one unique aspect is that we have good working relationships between research groups from East and West. This is something which we have to remember all the time and take care of the fact that we really are able to work openly and honestly together.

It is very appropriate that we have this task force meeting here at the Technical Research Center. Here in this environment, where the Technical Research Center and the Helsinki University of Technology are located, we actually have the biggest concentration of innovation potential in the whole of Finland. A lot of what is being done and created in the manufacturing environment or industry has its roots somewhere here in Otaniemi. Of course, we have some other strong centers which are quite capable of taking care of their own responsibilities, for example, we have some very strong groups in Northern Finland, however, we are all in one way or another dependent on the tremendous cluster of resources and intellectual capacity here in Otaniemi.

Therefore, in my opinion, it is essential and crucial for every organization, every country, to know that somewhere there is a concentration of intellectual power.

One other thing that we have to take care of in our networking activities is to continue good communication with so many people that we enable the group to really stay alive and create new ideas. Its very good that we see, a seminar like this in Finland with no passive participants, I suppose almost all of you are going to do some kind of work during this week, which means that we can probably achieve something. All of us are ready to do work and I hope that you will enjoy the environment around you.

This task force meeting would have been impossible without the support of the Finnish industry. The relationship between research, communication and industry is always slightly difficult. We cannot completely understand each other. We do, however, have some marvellous people here, for instance, one of the next speakers Professor Wolf, who has been working in research as a professor at the Technical University and is now working at the top management level of industry. He therefore, knows both sides. It is very unusual in Finland and some other countries, to find people who are willing and able to move back and forth between academic and industrial environments. This can be a problem in the future. This is also one reason why it is not always easy to persuade industry that we can give them anything by doing research on innovation management.

I really hope that you will enjoy your week here. We are going to spend a lot of time together here and I sincerely hope that we can have your support when we try to finish this project.

OPENING ADDRESS

Hans Andersin
Corporate Vice President, Valmet Automation Oy, Helsinki, Finland

Mr. Chairman, Ladies and Gentlemen. It was a pleasant surprise for me that I was given the honor to make the opening remarks. I was told that I have about five minutes. I am going to squeeze in a lot of my feelings and some of my thoughts into this five minutes.

It is my pleasure to talk to you as a person working in the industry as a counterpart to Professor Segerstahl who works in another environment. We in the industry consider ourselves to be very practical, again in contrast to people working in universities and research institutions. We stress practicality a lot. On the other hand, we also require an increasing amount of creativity from our people. As you know, creative people are not always the most practical, and of course, practical people are not always the most creative. Therefore, in order to achieve what we call innovation, that is, creating something new to be used for something practical, we need team work. I think that this is well understood in industry today. We have to develop teams of people who are creative with people who are practical. Of course, the third element that is needed is the management of these practical and creative resources to being order and financial organization into this work.

I think everybody in industry will share my opinion that a seminar of this kind is very important, because it is concerned with questions related to innovation. This is one of the reasons why we are happy to sponsor this seminar. We are glad that IIASA has taken up a subject like this in their program, a series of seminars concerned with innovation management. We also know very well that the human factor is the single most important thing where innovation is concerned. Innovation cannot be automated. Computers may be a good tool for the innovator, but it is human beings that have to do the creative work, more than in any other aspect of the industrial process.

This seminar in a very good way combines practical, creative and management aspects. We have people here from industry, from universities, from research institutions, from government, etc. We also have people of different cultures and ideologies. Innovation is a universal subject to talk about,

regardless of the ideologies held. This seminar therefore should be a success by definition, but its success also depends on all of the participants, how active we are, how creative and practical we are, and how much we can manage ourselves and the people sitting next to us.

As a person who works in industry I hope that this seminar will be a success and I wish this group and IIASA all good luck.

HUMAN FACTORS IN INNOVATION MANAGEMENT—THEMES, CONTRADICTIONS AND QUESTIONS FOR OUR MEETING

Thomas Moss
Case Western Reserve University, Cleveland, Ohio, USA

INTRODUCTION: RISKS AND CHALLENGES OF OUR CONFERENCE

It is a pleasure to have the opportunity to deliver this opening report. I will use the time to identify some important themes which I found in my reading of the papers submitted, to point out some questions which I saw raised or left unanswered by them, and to highlight some contradictions which struck me in the various points of view. I do this at some risk of misrepresenting the authors, or exposing my own slowness to understand, since I have only read their words and in most cases have not had the opportunity for discussion with them. I will apologize in advance to those to whom my brief synopsis does injustice.

I take the risk, however, for a simple reason. I think none of us likes a boring meeting in which reports are mechanically accepted without reaching for new synthesis and growth. If I can succeed in raising my own misunderstandings in a manner which stimulates discussion and clarification among us, and catalyzes refinement and creation of new concepts, I will have succeeded in my purpose.

Let me just point out an organizational issue which in many interesting ways raises a typical problem of management for innovation. You will note that your papers have been placed in an organizational framework which may or may not appear natural to you. We quickly found that within the core planning group there were completely different views of how the papers of this conference could be organized, and that this situation was like many others in creating a team effort for problem-solving. A group is typically brought together, apparently with a single purpose, and suddenly it appears that the diversity of assumptions and expectations is so great that synthesis and coherent purpose will be unreachable.

I imagine that in this full plenary session there is an even wider spectrum of views than in the planning group on the shape and organization of the problem

of human factors in innovation management. We are indeed a diverse group from widely varying social, economic and political backgrounds. I suggest only that we avoid retreat into discouragement and confusion, but instead take this diversity as a challenge. We can consider these next days as an actual experiment in human factors innovation management, and not simply an opportunity to sit back and analyze the issue. We are the experimental group, and our task is to overcome the gulf of different experiences, of different conceptual frameworks, and of different vocabularies to reach a higher synthesis of common principles for human factor management for innovation—a synthesis, I should add, that must be in a form which can be drawn on and applied in practical circumstances by practitioners such as those in the firms represented in this study.

The risk in the next days is that we will use the differences in viewpoints as an excuse to "talk by" each other. That is, to talk from our own frame of reference without attempting to relate it by question and exchange to those of other participants. The converse of this is an extraordinary learning opportunity: to be able, through the eyes of our meeting colleagues, to see familiar problems viewed in very new frames of reference. This new insight can bring great benefits in understanding our own weaknesses, as well as in appreciating our strengths. I trust that we are wise enough to use our precious time for the opportunity side of this dual-faceted reality of diverse viewpoints.

The challenge starts with the vocabulary itself. There are words in the program and papers such as "politics", "efficiency", and even "innovation" which are used in different ways in different languages and cultures. Trying to build a common understanding of these definitions may be an important learning process for our group.

THEMES AND QUESTIONS FROM THE REPORTS

I. INNOVATION POLICY

Let me begin now to highlight key points I saw in the papers, hopefully with enough recklessness to disturb and draw into active discussion even the most reserved of us in this assembly. In the first category, called "policy" and including the broadest concepts and goals, Professor *Lundstedt* of the U.S. brings the appropriate over-all concept that social innovation is an integral part of successful technical innovation. This is not an unfamiliar idea, but by drawing an analogy between a management structure and an ecological system he alerts us to the need for building concepts of adaptation and change into management practice. As the ecological system is based on provision of needed resources, Lundstedt proposes that management be grounded in the principle of providing for basic human psychological needs: self-esteem, affection, and other forms of emotional support. With this concept, he becomes the first of several participants to weave Maslow's idea of how to realize the full creative potential of individuals into analysis of what is at the core of effective human factor management.

Professor *Benjamin* provides an example of how such social innovations, specifically the GDR institutional and legal framework protecting workers from dislocation of technological change, can facilitate innovation by removing the threat of personal loss so often associated with it. However, confirming the Lundstedt ecological viewpoint of need for continuous adaptation, he gives us the intriguing statement that "...such strict legal obligations produce special problems..." I hope that he will enlarge on this as a clue for ideas for future paths for development once some of the original stress has been removed.

Dr. *Zacher*, from Poland, Dr. *Smrcka* from Czechoslovakia, and Prof. *Nikolov* of Bulgaria each provide papers echoing this need for adaption to new conditions. Each in a distinctive manner points out the circumstances of unbalanced supply and demand that led to strongly centralized industrial management systems in their countries, which are now giving way to experiments in decentralization. Each brings an appreciation of the fact that these experiments have enormous human factor implications. Changes of training and attitudes will be needed to create "self-management" skills able to support the new responsibilities.

Curiously, these concerns felt in the evolution of centrally planned economies are not far from very similar issues felt in large U.S. firms. Lewis *Hanes* of Westinghouse U.S. will discuss the introduction of Quality Circles into Westinghouse operations, where a clear impact and purpose is to create decentralized participation in issues of industrial management. Many other large U.S. firms, after an era in which concern for strict financial management drove tendencies to centralize all forms of decision making, are now facing the reality of lost initiative and creativity in the working and lower management level. They are experimenting with similar decentralization ideas. East and West can learn much in this area by combining the results of their diverse experimental approaches.

Gottfried *Wolf* develops a core human factors concept that can be used as a framework for discussion of many of the following papers. It is another basic Maslow notion: that of facilitating innovation by creating a management system in which there is a clear synergy between the goals of individuals, individuals and their organizational unit in the firm, and between the goals of the subunits within the larger organization. It is a simple concept and allows a straightforward and very broad definition of the task of effective innovation management: creating or adjusting the system so that the needed synergies are naturally present and detailed intervention and direction are not needed.

I myself find this synergy-building frame of mind a very helpful one, especially in avoiding managerial blind-alleys and in trying new approaches to stubborn problems. However, if life were as simple as the concept we would have no "human factor" problems and little cause to meet here. As enthusiasts for human factors management I thought we would be well-served by facing to some degree the question of why in reality we so frequently fail to create these synergies in our factories and offices. Thus my own paper is aimed at identifying the points in which we often falter, in hopes that that will be as instructive as discussing the theories for success.

As a unifying theme to this first group of papers I can certainly suggest the Maslow notion that the goal of human factor management for innovation is to build the synergy of individual and firm objectives. Viewpoints from both planned and unplanned, socialist and capitalist experience stressed bringing satisfaction, rewards and responsibility closer to the individuals from who high performance was desired.

This thought, however, leaves important questions unanswered and I list them as a challenge to those authors and the discussants:

1. The synergistic management system may *remove barriers* to innovative change—but not necessarily stimulate it. Is this passive strategy of *allowing* innovation really sufficient to bring it about? Why is it that external stress is so often linked to rapid innovation? What is the difference between simple good human factors management

and management for innovation? How do we tell when innovation is really needed, as opposed to stability? How do we choose the beneficial innovations from the unproductive ones which represent only novelty?

2. A related question triggered by the rosy picture of synergistic relationships is the true role of competition in stimulating innovation. Certainly competitive instincts have been accepted as a powerful motivating force at least since primitive human began to construct games. How can the positive aspect of competition be reconciled with the concept of building synergies as a management strategy?

3. A decentralized management system built on creating synergies and opportunities for innovation is based on an assumption that people will be constructive and creative if unrestricted. Yet many disempowering and repressive centralized management systems were created to guard against the reality of the few individuals who might abuse such a system. Can we prevent the measures needed to manage the *least* trustworthy and creative from destroying the system aimed at drawing out the best from the best?

4. Many management systems and practices of the past have justifiably bred cynicism and distrust on the part of those managed. New, more empowering and nurturing systems, will not reach their full potential until the scars of the old system are healed. Will we have the patience to understand initial cautious reactions to new approaches in the context of historical experience, and see the various experiments through to completion?

II. INNOVATION STRATEGY

Professor *Prakke* from Holland makes a broadly useful contribution in his introduction by alerting us once again to the seriousness of the problem we are examining. Rapid and nearly complete penetration of once stable markets has been made by the Japanese in Europe and the U.S. often through successful human factor management for product or process innovation. No nation, not even the Japanese, can ignore further research and experimentation in this field if it expects to remain economically successful in a competitive international arena. Prakke describes one national strategy: that of providing by government policy a strong boost to innovation skills through an "innovation consultant" program to industry. This is clearly an example of a strategy based on providing resources for innovation.

Professor *Patz* in discussing the impacts of microelectronic information systems points to a new role for general management: that of simply assembling and maintaining coalitions while decentralized units make strategy and operating decisions. Dr. *Riegel* makes a very important contribution by providing us a learning experience of a strategy in which many things went wrong: a "technology push" approach in which all the classic resistance and misunderstanding of innovation was manifest.

These three papers can be seen to represent three of the many strategies for innovation management that can be found in the literature and our collective experience. Prakke's represents resource provision, Patz "need pull", and Riegel's discusses "technology push". Though only a microcosym of a vast array, they do trigger further questions:

1. It has become fashionable to believe that "technology push" strategies can never be effective and Riegel's paper shows the risks. But are there not a few, but very important, opportunities where technology push may lead to enormous breakthroughs? I consider the sustained effort by Control Data Corporation in the U.S. to create a market for computer-based education as an example; many of you may know others.

2. Conversely, can there not be hidden risks in "need pull" approaches? Specifically, are there no innovations where the need itself is only identified by the innovation? Is it perhaps too early, for instance, to consider as is often done, that the Concorde is an example of mismanaged innovation? From a human factors point of view, will a management system oriented purely to "needs pull" miss key opportunities for breakthrough innovations?

3. A management strategy of resource provision, or "building coalitions" must answer the same question we posed about the earlier papers which saw innovation management as a question of building synergies. These allow innovation, and facilitate it—but where is the spark? Where is the driving force for risk-taking, upsetting comfortable equilibrium? Is it inherent in unencumbered management or workers? And, if not, what strategies of stress, encouragement, competition, rewards, etc., will be successful?

III. METHODS

Dr. *Ryssina* provides a well-documented paper on a crucial question in methods for human factors management: team building. The data concern the characteristics needed for effective research teams, and she raises the question as to whether the crucial roles she observes as essential can be inferred as necessary for management directed to other creative tasks. I certainly see the relevance, and those of us familiar with the language of management style, or general categories of people interacting in groups, will see clearly the generality of the role definitions she has showed.

Dr. *Hempel* describes a training approach aimed in part at building team and decision-making skills. Though he describes it generally I understand that it is a very powerful experience for Siemens managers and I hope he will provide us with concrete exemplary details to be compared with other approaches used in our participating organizations. Dr. *Andersin* provides a crucial paper which once again brings Maslow's thinking to the forefront of our discussions. He focuses on an actual case history of an innovative burst of activity in his firm, fueled by fulfillment of one of the basic Maslowian human needs: motivation. I think we must discuss this case closely because I can imagine, from the speed and pressure of competitive developments he reports, that there was little time for management to theorize and carefully construct a balanced "human factor management" system. Yet many of the goals of synergy, inventiveness, effectiveness and others seem to have come together. In earlier papers there are strong discussions of how to *allow* or *facilitate* innovative behavior, but very little on how to create it or how to "light the fire". This paper and discussion may provide some answers.

In a more comparative view, Professor John *Langrish* also provides some important insights. By looking at several case histories he notes that key elements in successfully managing for innovation may not be in nurturing invention itself, but in establishing creativity in the choice, application, and timing of development of inventions, all post-discovery functions. These ideas clearly must be linked to those discussed in the previous sections on the basic goals and strategies for innovation.

From the first three of the papers of this methods section I can once again extract a theme of using management methods to build synergistic relationships among individuals and between them and their firm. The training and team building discussed, along with the actual case history of successful project management, all point to this direction. The last paper, however, raises the question of need to search for a broader synergy: that of synergy between technical, resource, and managerial capabilities on the one hand, and the true needs of society on the other. This must include matching development of those capabilities to the timing of those needs. Without attention to creating this additional synergistic relationship we may be faced with expending scarce resources and creativity on innovation with no true utility.

My own questions on reading the papers on this section come back once more to the paradox that our methods seem oriented, as do our strategies and policies, to *allowing* innovation, not stimulating it. Only Andersin's paper really focuses on stimulation, and there the innovative behavior is triggered by an external factor of competition and survival threat—not a management activity. Hence I ask:

1. What methods do we have to stimulate risk-taking in a non-threatening environment? Is there a fixed class of natural risk-takers quite independent of external stimulation, or can and should we seek to expand this group?

2. Andersin's picture of a creative group enjoying its isolation from a larger entity brought up the role of *scale* in human factors in innovation management. Must effective methods either in reality or appearance reduce the apparent scale of an organization to stimulate innovation? Why has innovation in U.S. firms often seemed to have been coupled to a pattern of fragmentation of smaller units from larger ones, even at a loss of capital and other resources?

IV. ACTIVITIES

In this last section we have some concrete examples of innovation management activity which puts into perspective many of the more theoretical concepts we have been discussing earlier. Professor *Karttunen* discusses the practical changing needs for personnel types and management style over the course of motivation of product development projects. In this point of view he echoes from practical experience the ideas of Ryssina and Langrish which both stressed the need for different creativity roles within a working group or at different points in a decision process. Dr. *Wahlstrom* stresses the organizational needs to facilitate innovation, and also illustrates the importance of linking our work here in human factor management to that of the "organizational" group in Prague. This was brought home to me through his point on the crucial role played by informal organizations buried within large formal structures. Nurturing and using the potential of these is one of the complex demands on human factor specialists.

Mr. *Virkkala*, of Kone Corporation, provides an example of a specific training course for creativity development, and I hope we will be able to draw some useful comparisons with the training methods discussed by Dr. Hempel.

The single theme I see in this "activities" section is a dominant attitude of pragmatism. As participants have noted in our informal meal-time discussions, we understand so little about the underlying causes of human creativity that it would be foolish to base actions on any single theoretical approach. Perhaps there is one key question to ask those who bring innovation activity discussions to this meeting:

1. Of all the theoretical approaches that you have heard in this meeting and elsewhere, are there any over-all concepts that have served well in pragmatic decision making? Or do the exceptions over-run the generalities? I'm not sure I really want to hear the answer, but feel compelled to ask it in any case.

SUMMARY

As I reached the end of the papers and grasped for my own synthesis, the image of the old tale of the blind men trying to understand and describe an elephant pushed itself into my mind. Most of you remember that as each touched and experienced the part of the elephant nearest to him he reached a conclusion appropriate to the nature of the tusk, the trunk, the flank, or the tail, etc. All of the points of view were true, though very different and even in apparent conflict. When it comes to nurturing creativity and effective innovation by human factors management, we are indeed blind men and women with respect to having a complete picture. Our only hope is to follow the example of the blind men: talk to each other. Our experiences may make little sense taken individually, but with effort and truly open exchange of ideas we may be able to describe the beast. I trust that we will be wise enough to use the opportunity of this IIASA-convened assembly of blind men and women to best advantage before we go back to working blindly with our individual piece of the elephant.

SOME METHODOLOGICAL APPROACHES FOR ANALYZING THE ROLE OF HUMAN FACTORS IN INNOVATION MANAGEMENT (HFIM)

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In the 1980s we face tough and increasingly complex challenges in managing innovation projects. Many of these projects assume a size and technical complexity that is unparalleled in the history of innovation management. In recent years, several factors have had a pronounced impact on innovation management and major complications can be expected to continue in the next decade:

1. Innovation projects are more constrained by external factors such as the ecological-societal environment; new basic innovations such as biotechnics, microelectronics, etc.; state, local, and federal regulatory considerations; and the multiple needs and interests of different customers everywhere in the world.

2. Cost overruns force the need for greater assurance that innovation projects will be completed on schedule.

3. Advanced technology and unproved methods are introducing significant new unknowns and risks in many innovation projects, etc.

This overview of some trends in innovation management alone makes it clear that managing innovation projects in the 1980s is already extremely difficult, and is expected to become even more demanding. In close connection with these trends we must be able to define for each organization and company:

1. An adequate innovation policy, i.e., goal-oriented, skillful behavior as a whole, and

2. a strategic plan and methodical execution for complex innovation projects within the scope, schedule, and cost objectives. This will require broader, more advanced innovation management skills than ever before and more attention to strategic and external factors during the project life.

Innovation management is only now becoming a specific—and more and more important—management discipline. It's methods are related to the appropriateness of project-management methods in all sizes of projects and in a wide

range of situations in a variety of organizations. But these are not the same. A quick look at the definitions of innovation shows that different ones exist (see Figure 1). Therefore, I think one of the aims of this IIASA project is to also develop a new innovation definition as well as a formal set of principles and practices that can be taught in an educational format and thus be passed on as a vital element of practical innovation management theory.

Planning complex innovation projects cannot be simple and must include a strategic phase followed by a tactical base. The strategical planning of complex innovation projects—mainly based on a goal-oriented innovation policy—is analogous to the strategic planning of a corporation. The innovation project group must basically decide:

1. why, for what purpose (policy) an innovation is necessary, and

2. what strategies are necessary to achieve its goals.

Innovation time phasing in this context is shown in Figure 2.

In the new innovation environment of the 1980s, one must avoid the management approach of the 1970s of getting fancier and fancier—always looking for a control system to provide automatic management.

- Innovative corporations do not look for automatic management, they look for any tool they can use, because innovation is critical for survival.

- In innovation projects and other areas, e.g., the innovation management of software development, presents a formidable challenge. Many of the management techniques used for innovation hardware projects are inadequate, and sophisticated techniques for software innovation management have not yet evolved.

- Innovation management has to be fluid in its thinking, and not allow organization charts to rule the project. It must be able to regroup large numbers of people and define authority and responsibility to meet new situations as well as to integrate new social, political, and environmental factors into their strategic innovation planning.

I would now like to make a suggestion. As you can see from the agenda, 32 papers for the Task Force Meeting on Human Factors in Innovation Management have been prepared and 20 papers will be presented in four sessions (Figure 3):

A1,...,A10
B1,...,B6
C1,...,C6
D1,...,D6

with nine discussions denoted by

AI, AII, AIII
BI, BII
CI, CII
DI, DII

focussing on the following (see Table 1).

If possible, we should also try to find the best possible definition of "innovation" in connection with the "human factor". The expression innovation has several meanings:

J_1 A process (P = Input) that aims at bringing about a strategically and according to plan change with new qualities, where success is not yet assured.

J_2 A first accomplishment and realization of an idea for solving a problem (R = Output) (invention), i.e., changes in design, manufacture, sales and system formation for, e.g., the manufacture of a new product.

J_3 The innovation process itself as well as the realization of a problem solution in a new mode.

J_4 An absolutely successful innovation with regard to its strategically planned implementation, as well as its successful introduction onto the market.

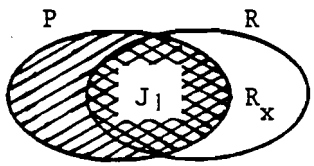
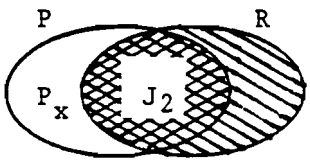
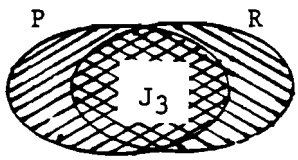
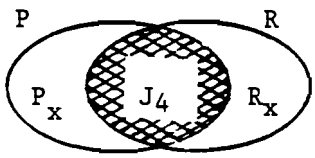
J_1 = P (Process)	J_2 = R (Realization)	J_3 = P ∪ R	J_4 = P ∩ R
			
J_1 neglects all (R_x) problem solutions that did not go through the normal process (P) channels	J_2 neglects all (P_x) endeavors and processes that did not lead to success	J_3 includes realizations (R) that occured through planned and unplanned endeavors. It also includes all (P) processes whether they were successful or not.	J_4 strictly denotes only those innovations that occured through planned (P - P_x) endeavors and which were 100% successful
That occur through proposals or activities of small groups to increase quality	Here it is very difficult to objectively define success	All inputs and outputs are summarized	Areas of effectiveness, performance standards and innovation goals are clearly identified Innova.-portfolio
E.g., continuous improvements & adjustments	E.g., original or basic innovations (mutative charac.)		New products & new production methods

Figure 1. Different definitions of the world "innovation".

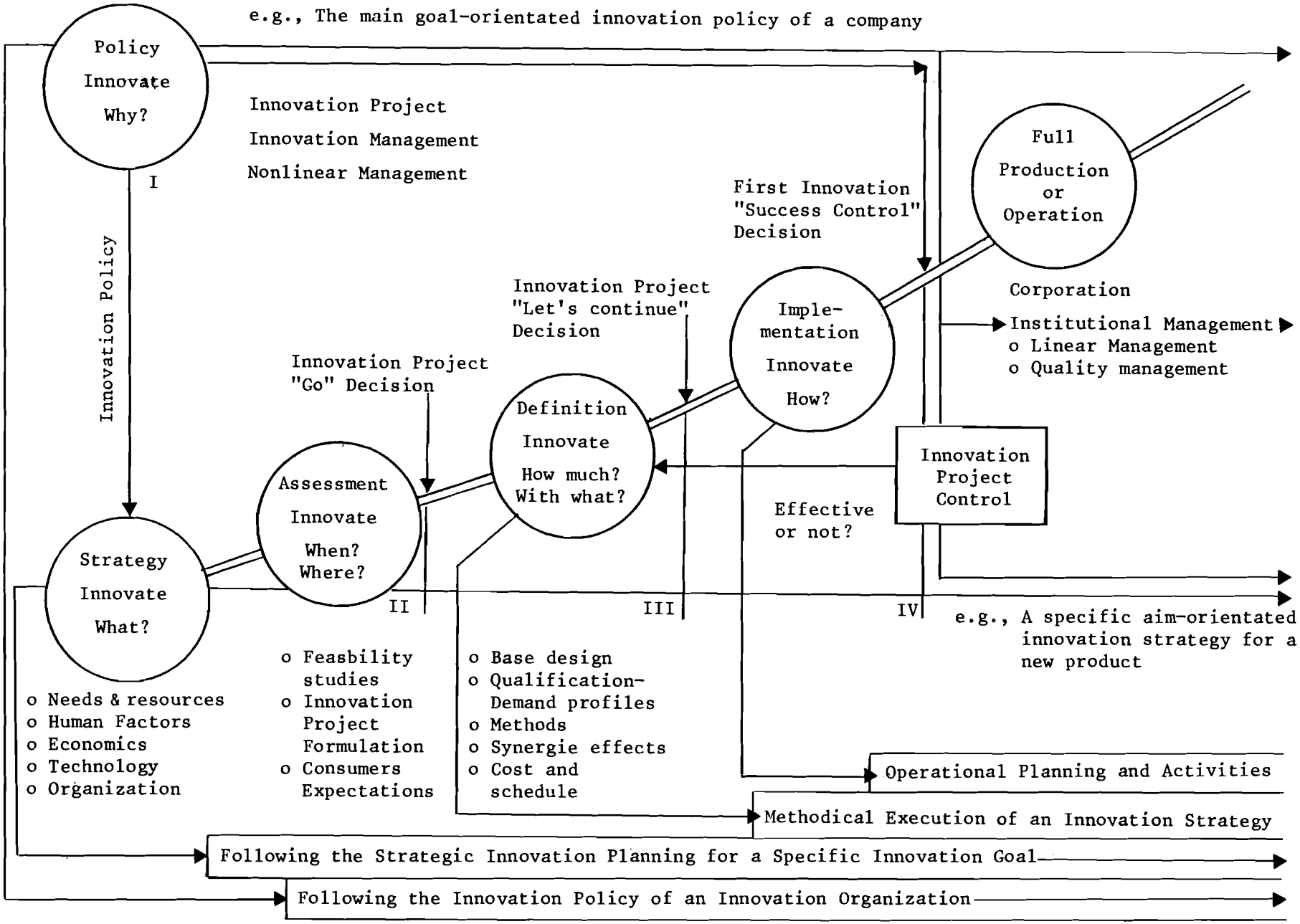
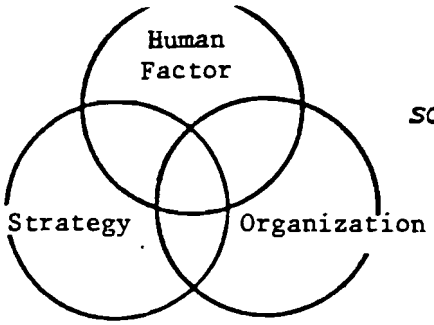
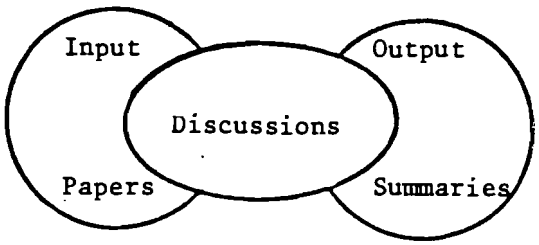

e.g., The main goal-orientated innovation policy of a company
Policy
Innovate
Why?
I
Innovation Policy
Innovation Project
Innovation Management
Nonlinear Management
First Innovation
"Success Control"
Decision
Full
Production
or
Operation
Corporation
Institutional Management
o Linear Management
o Quality management
Innovation Project
"Let's continue"
Decision
Imple-
mentation
Innovate
How?
Innovation Project
"Go" Decision
Definition
Innovate
How much?
With what?
Assessment
Innovate
When?
Where?
Innovation
Project
Control
Effective
or not?
Strategy
Innovate
What?
II
III
IV
e.g., A specific aim-orientated
innovation strategy for a
new product
o Needs & resources
o Human Factors
o Economics
o Technology
o Organization
o Feasbility
studies
o Innovation
Project
Formulation
o Consumers
Expectations
o Base design
o Qualification-
Demand profiles
o Methods
o Synergie effects
o Cost and
schedule
Operational Planning and Activities
Methodical Execution of an Innovation Strategy
Following the Strategic Innovation Planning for a Specific Innovation Goal
Following the Innovation Policy of an Innovation Organization

Figure 2.



SCHEDULE ON CONFERENCE AND RELATED EVENTS



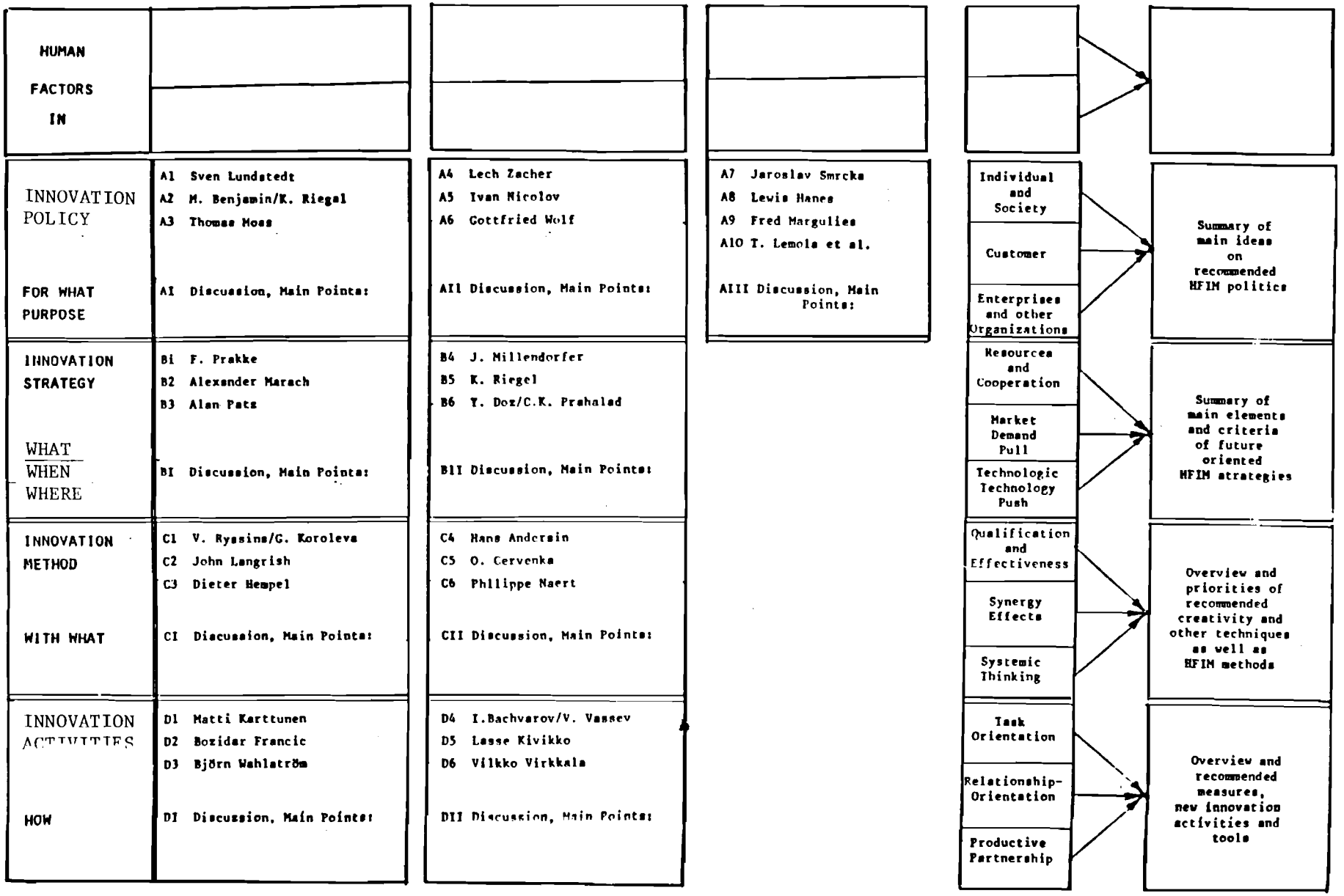
Plenary Sessions

HFIM Task Force Meeting, Helsinki	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
10-14 Oct. 1983	9 October	10 October	11 October	12 October	13 October	14 October
9:00 - 10:30			Papers A1, A2, A3 Discussion AI	Papers B4, B5, B6 Discussion BII	Papers D4, D5, D6 Discussion DII	Technical visits to Strömberg and Nokia
Coffee						
11:00 - 12:30		Registration	Papers A4, A5, A6 Discussion AII	Papers C1, C2, C3 Discussion CI	Discussion Varna TFM Vienna Conference Monograph	
Lunch			VTT	VTT	VTT	
13:30 - 15:00	Arrival	Opening Introduction	Papers A7, A8, A9 A10 Discussion AIII	Papers C4, C5, C6 Discussion CII	Afternoon free for informal discussion or sightseeing	Departure
Coffee						
15:30 - 17:30		Plenary Session	Papers B1, B2, B3 Discussion BI	Papers D1, D2, D3 Discussion DI		
Dinner		IIASA reception at Keilaniemi	Social program organized by Finnish firms			
Evening program						

MOTIVATION OF THE CONFERENCE PARTICIPANTS
INPUT
INFORMATION
COMMUNICATION
COOPERATION
RESULTS - OUTPUT

Table 3.

Table 1. Task Force Meeting on Human Factors in Innovation Management (HFIM), Helsinki, 10-14 October, 1983.



INNOVATION POLICY

Discussions AI, AII, AIII, based on papers A1,...,A10

Answers the questions: WHY INNOVATE? FOR WHAT PURPOSE?

AIM: To find main ideas on recommended innovation policies based on human factors.

INNOVATION STRATEGY

Discussions BI, BII based on papers B1,...,B6 (but also A1,...,A10 and AI, AII, and AII).

Answers the question: INNOVATE WHAT?

AIM: To find main elements and criteria of future-oriented innovation strategies based on human factors.

INNOVATION METHODS (- PROCEDURES, - TACTICS...)

Discussion CI, CII based on papers C1,...C6 (but also on all previous activities)

Answers the question: INNOVATE BY WHAT MEANS?

AIM: To find priorities of recommended analytical and creativity techniques and innovation methods based on human factors.

For example, creativity techniques (see Table 2) and synergetic use of analytical thinking in combination with an integral-thinking process (see Figure 4).

INNOVATION APPLICATIONS (- OPERATIVE MEASURES)

Discussion DI, DII based on papers D1,...,D6 (but also on all previous activities)

Answers the questions: INNOVATE HOW? (WHO-WHERE-WHEN-HOW MUCH...?)

AIM: To find measures, new innovation activities and innovation tools based on human factors.

We are already on a good path to finding new answers to the old and new questions raised in innovation management. Some of the questions in connection with this are, e.g.,

A. INNOVATION POLICIES

What demands are pulled (made) by:
a) the individual and society;
b) the customer;
c) enterprises and other organizations, etc.?

B. INNOVATION STRATEGY

What should innovation be focussed on:
a) resources and cooperation;
b) market demand pull;
c) technologic, technology push, etc.?

Table 2. Creativity techniques.

Determinants / Technique	Problem	Rules	Participants	Mode of implementation	Control	Preparation time	Implementation time	Evaluation time	Result
Brainstorming	defined	few	5-12 persons	centralized	1-2 moderators	depends on procurement of devices	maximum of 30 minutes	medium	many ideas
Method 635	defined	few	usually 6 persons	usually centralized	only initiator, "time control"	short	45 minutes	medium	great number of solution approaches
CNB-Method	problem area known	few	experts	in writing, decentralized	only initiator	1 meeting	1-10 weeks	1 session	solution concept
Morphological Analysis	defined; suitable for morphological analysis	many	5-7 persons	centralized	moderator	not required	1/2-2 hours	long	solutions
Synectics	defined	many	5-7 experienced participants	centralized	moderator	depends on procurement of devices	2-6 hours	evaluation by external parties	unconventional solution approaches

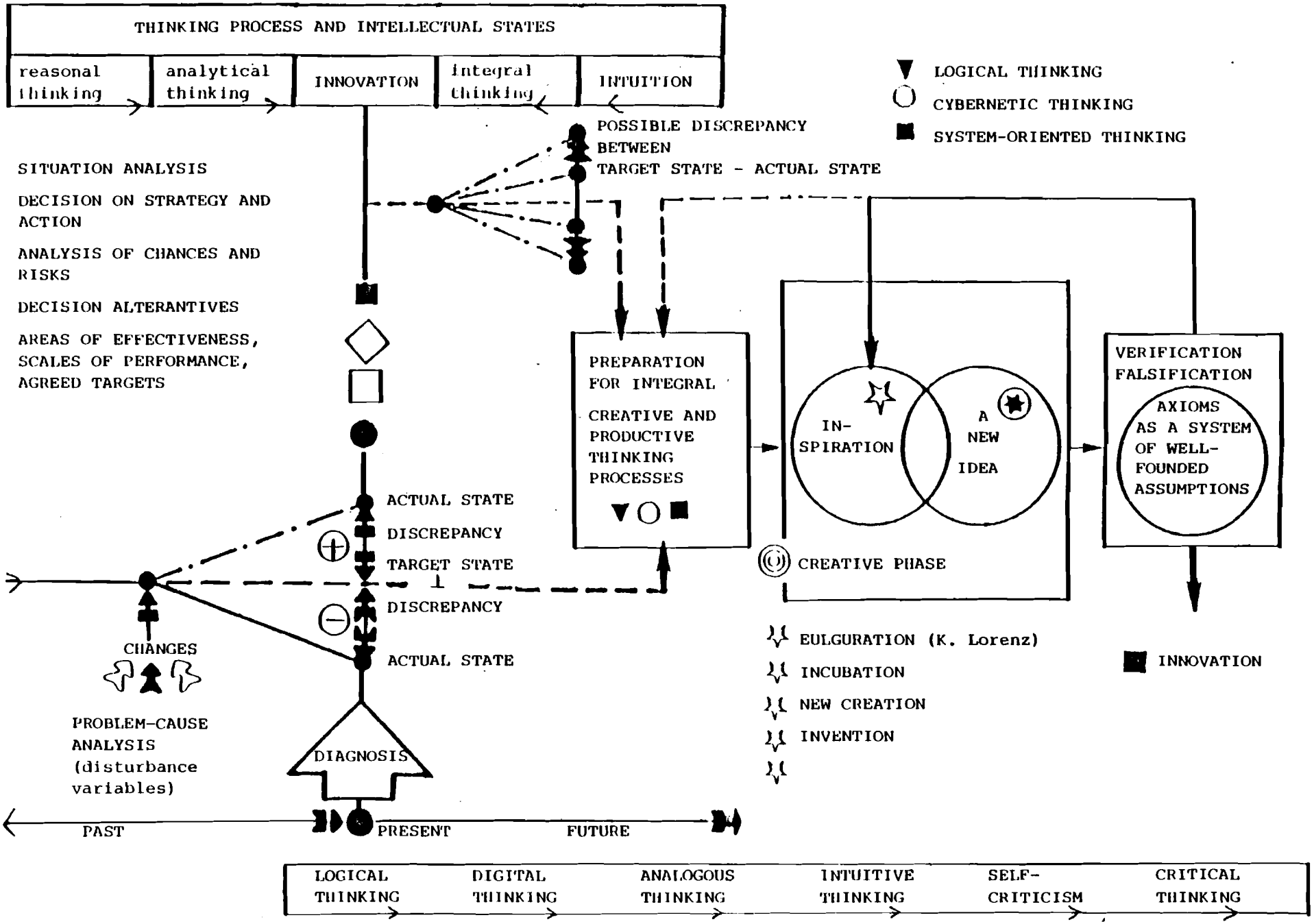


Figure 4. Integral innovative thinking!

C. INNOVATION METHODS

In an innovation process, how important are:	a) qualification and effectiveness; b) synergy effects; c) systemic thinking, etc.?

D. INNOVATION ACTIVITIES

How important are:	a) task orientation; b) relationship orientation; c) productive partnership, etc.?

INNOVATION MANAGEMENT AS A MANAGEMENT OF UNKNOWN PHENOMENA

As shown in Figure 5 there are key differences in responsibility, information, planning, estimation, integration, forecasting, etc., between innovation (project) management and institutional (corporational) management. Innovation management and institutional management can be characterized as "nonlinear management" and "linear management". There are many nonlinearities in an innovation project, whereas in an institutional setting, once the institution is established, phenomena are generally linear.

In strategic planning and management, and innovation manager is not really achieving equilibrium but disequilibrium. He is trying to plan and manage a situation that, by definition, is never in equilibrium, never settles down, and is different every day. As soon as an innovation project gets to the top of the rate curve, it has to come down again.

Because innovation managers—and their teams—are trying to do themselves out of jobs by careful innovation project planning, psychological problems are involved. The faster they get a job done, the faster they are out of a job. Thus, they do not have the same incentives as they do in longer-range, stable situations.

These few comparisons show that innovation managers must meet specific qualification requirement profiles.

Some Criteria of the Requirement Profiles in Innovation Management

Responsibility

- With more complex innovation projects, the innovation manager and his staff who have always been the key figures, acquire much more responsibility, they must be:

  — creative and innovative themselves;
  — entrepreneurial;
  — task and relationship oriented and effective;
  — situation oriented and flexible as leaders, promotors, systemizers and integrators in an effective way, etc.

Information

- Information and good communication are highly important to successful innovation. The innovation manager and his team must determine for themselves those variables that are different for innovative projects. An experienced innovation manager will probably have two or three ways of getting information, with different cross-checks. He will not

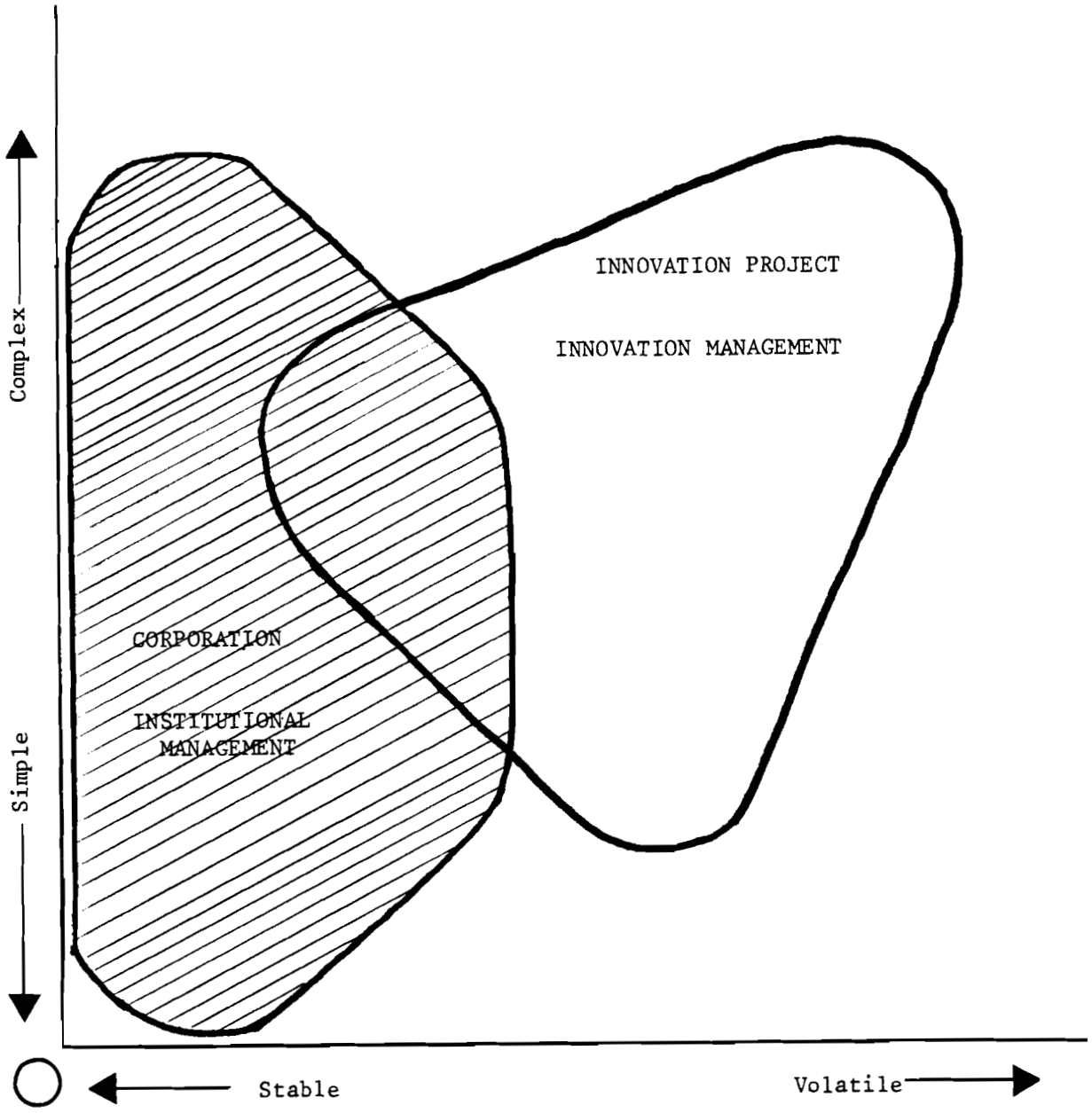


Figure 5. Complexity-volatility diagram for innovation projects and corporations.

depend entirely on a mechanized system but will have inputs from his own communication network, whether it be formal or informal.

Planning for Uncertainty

- The more complex an innovation project is, the greater the need for better planning early, when the information on which the innovation plan must be based is less certain.

  For most corporations it is difficult enough to maintain a position in existing businesses by innovation in processing and products, but even more difficult in determining what new products and businesses should be developed.

  The innovation manager who is charged with planning and implementing an innovation project will benefit from planning for such uncertainties (potential problems) and take advantage of the means available to him to deal logically and efficiently with such planning. Methods to cope with the uncertainties can be identified and characterized.

- The major objective of planning for uncertainty is to decide which

  policy (answers the question "why innovation?")
  and strategy (answers the question "what innovation?")

  This decision requires:

  1. determining which strategies are available for implementation of a specific innovation project.

  2. characterizing the uncertainties that must be considered, and

  3. projecting the implications of implementing each of the available strategies and the relevant outcomes expected.

  These analyses can (should) be undertaken at several levels of thoroughness, given the resources available to the innovation manager, the innovation manager's inclination and situation-oriented effective style, and the time available to develop the information necessary for the decision.

- The second objective of planning for uncertainty is to develop innovation contingency plans (potential changes). As the implications of implementing different innovation strategies are analyzed and studied, innovation management will obtain insights into the merits of implementing different innovation strategies.

  The objective is to identify robust innovation strategies that permit modification of the project to counter changing future conditions and give the best performance according to the organization's goals over as broad a range of future conditions as possible.

- Finally, innovation management has to select the strategy that will perform best and be to the organization's greatest advantage under the variety of conditions that may be encountered.

  The success of Japanese companies is due to a large extent to their mastery of planning methods and their steadfast pursuance of planning innovation results'

SOCIAL INVENTION AND INNOVATION

Sven B. Lundstedt
School of Public Administration, The Ohio State University, Columbus, Ohio, USA

An important lesson in technology management is provided by the recent accident at the "Three Mile Island" nuclear plant near Harrisburg, Pennsylvania in the United States. This apparent technological failure is an unusual opportunity to learn about the paractical importance of human factors in large scale electrotechnology and to advance the state of the art. The special commission appointed by the Carter Administration concluded that the technical failures at "Three Mile Island" were a result of human failure and not due alone to mechanical breakdown. The offical commission report said:

> We are convinced that if the only problems were equipment problems, this Presidential commission would never have been created. The equipment was sufficiently good that, except for human failures, the major accident at Three Mile Island would have been a minor incident. But, wherever we looked, we found problems with human beings who operate the plants, with management that runs the key operation and with the agency that is charged with assuring the safety of nuclear power plants. (Report on the President's Commission on the Accident at Three Mile Island, 1979.)

As this and previous conferences on innovation management in electrotechnology held by IIASA emphasize, special attention is being given to a better understanding of how operational technology is influenced by social systems and by people. William Fielding Ogburn's warning in 1932 seems now to be heeded more widely in the second half of the twentieth century. Ogburn said "Unless there is a speeding up of social invention or a slowing down of mechanical invention, grave maladjustments are certain to result" (Ogburn 1932).

THE SOCIO-TECHNICAL CONTINUUM*

Modern technology is usually a combination of artifacts and procedures which together form a complex system. People and machines have always been

*The term socio-technical originated with the Tavistock group in England.

interdependent. People may, however, become servants of, as well as served by, machines. By its very nature such an interdependent relationship is a socio-technical continuum of people, techniques and machines. This is hardly a new insight in the history of science and technology. Yet for some reason its practical application in this century has been slow until very recently. A common mistake is that machines, with all their seductive powers as extensions of human control over the natural environment, have often become symbolic metaphors for man in which people are viewed as extensions of machines. The term socio-technical denotes a correction of this imbalance and a reversal in priority whereby machines as tools are viewed as useful extensions of people rather than conversely. Electrotechnology is no exception to this principle.

A recent example in the automobile industry is the Volvo management system which has now become a routine policy in thier Kalmar plant in Sweden. Pehr Gyllenhammer, chief executive of Volvo, describes the socio-technical point of view this way:

> The modern working man needs a sense of purpose and satisfaction in his daily work. He feels the need of belonging to a team, of being able to feel at home in his surroundings, of being able to identify himself with the goods he produces and not least—of feeling that he is appreciated for the work he performs... Factory work must be adapted to people, and not people to machines. This calls for innovation both in the field of human relations and as regards technical aspects... I believe the humanization of work and efficiency can be compatible. Indeed, I believe that in today's society, they are inseperable. (Gyllenhammer, 1980.)

In an earlier time John Stuart Mill's statement that "It is questionable if all the mechanical inventions yet made have enlightened the day's toil of any human being" is still partly true today unfortunately (Mill, 1952). And, of course, Karl Marx was a foremost critic of the way in which work was organized in the 19th century, an example of which is his interesting critique of the relationship of people to machinery and the industry of his day. Charles Dickens in his novel *Hard Times* also draws our attention to adverse relationships between people, machines and work. As the remark by Mill shows, however, Marx and Dickens were not the first to experience this important insight.

SOCIAL INVENTION AND INNOVATION*

A realistic, and eminently practical, viewpoint is that both technical and social invention and innovation are necessary in order to create, and to operate effectively, complex technological systems including electrotechnology. My impression overall is that the American electrotechnology industry, for example, is losing its traditional engineering bias towards purely technological solutions and is becoming more socio-technical in outlook.

There is naturally more than one way to approach the subject of social invention and innovation. For example, one can see them as expressions of

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*A distinction is usually made between invention and innovation in the standard literature on the subject. Innovations are usually considered to be entire series of events including inventions and full prouduct development. The two terms are often confused and wrongly used interchangeably.

basic social phenomena and as the necessary preconditions for social change. We might call this a generic view because it involves conscious application of the social and behavioral sciences. These disciplines seek to understand people as individuals, within small groups, within organizations, within larger societies and cultures, and as creators and users of social institutions. Social invention and innovation can be found at any one or a combination of these levels of analysis (Lundstedt, 1982).

William F. Whyte, a sociologist, illustrates:

> I define a social invention as a new and apparently promising strategy designed to solve some persistent and serious human problems. It may take the form of a new organizational structure or a new set of interorganizational relations. It may involve a new set of procedures for shaping human interactions and activities and the relations of humans to the natural and human environment... The potential transferability of a social invention depends upon discovering the theoretical principles underlying its operation and the characteristics of the social and material environment into which it must be fitted in order to solve human problems. (Whyte, 1980.)

Karl Deutsch provides some generic examples in an article in *Science* in which social inventions occurring over a period of years are illustrated. They include: Max Weber's sociology of bureaucracy, culture and values; Gini and Pareto's theory and measurement of social inequalities; Freud and Jung's contributions to the understanding of human behavior; the role of innovations in socioeconomic change according to Schumpeter, Ogburn, and others; Lenin's theory of one party organization and revolution; and Gandhi's form of large scale nonviolent political action (Deutsch et al., 1980). A recent article in the *American Psychologist* examines the contributions of social science to innovation and productivity. The authors say that:

> The current debate on national productivity and innovation has largely ignored the contributions of social science. This article discusses three trends and developments: social science as a decision aid, social science as a source of social technology, and social science as a tool for understanding innovation and productivity. Despite these contributions, however, there is little utilization of social science pertaining to innovation and productivity issues. Major inhibiting factors include the nonproprietary nature of social science, the disaggregation of social science support, and the isolation of social science from decision making. The continued de-emphasis of social science research is seen as harmful for the nation's knowledge base and for its efforts to achieve economic and technological revitalization. (Tornatzky and Solomon, 1982.)

The final selection of this discussion will describe one particular kind of social invention and innovation and a contribution of empirical social and behavioral science to innovation and productivity.

Another perspective is provided by Harvey Brooks using other functional categories. They are market, managerial, political, and institutional social inventions and innovations (Brooks, 1982).

Brooks explains that market inventions and innovations are new ways of distributing products and services allowing greater market expansion for existing technologies or market penetration of a new technology. Managerial inventions and innovations include changes in work organization which improve organizational functioning. Equally important are political inventions and innovations such as new government policies or legislation. Institutional inventions and innovations are characterized by social and legal procedures and norms including legislation.

In yet another sense Peter Drucker has said that social innovation means:

> ...the creation of new value and new satisfaction for the customer. Organizations therefore measure innovations not by their scientific or technological importance, but by what they contribute to market and customer. They consider social innovation as important as technological innovation. Installment selling may have had a greater impact on economics and markets than most of the great advances in technology in this century. (Drucker, 1982.)

It has been said that periods of economic difficulty are often an occasion, and an opportunity, for creative social and technological invention and innovation. One example is the Tennessee Valley Authority in the United States which was created as a federal corporation in 1933. Among its wider efforts to develop the resources of the Tennessee Valley were electrotechnological innovations made possible by this social innovation involving both public and private cooperation. The prive sector in the United States has been equally responsive to social change over the years. For example, early managerial and organizational innovations contributed to the formation of the present electrical grid system.

ECOLOGICAL CONSIDERATIONS

Social inventiveness is a creative form of adaptation. Its underlying purpose is to alter the natural process of ecological succession which is always present. In this process access to, and control over, scarce resources and competition for them is changed by appropriate management behavior. In this sense human communities are analogous to other natural ecosystems. They contain finite resources in a limited space within which competition for such resources and space occur. Maintenance of a "resource web" to assure a constant resource supply to meet physiological and psychological needs for survival and growth is often expressed in the form of creative new modes of human cooperation, competition and individual behavior which usually include social inventions and innovations. Examples of such inventiveness are very common, one early form being the limited liability stock company, precursor of the modern corporation. Socio-technical management is another form.

But, ecological succession takes the form of constant change towards a stable state and is always a rule rather than an exception. As a population decreases or increases, and changes in its mix of individuals, more movement towards a "climax", or stable, community always occurs. Not all such climax communities that involve people are, however, conducive to human survival and prosperity as some modern bureaucracies demonstrate with their various forms of self-defeating behavior and their inability to reach their goals efficiently and effectively. Hence the need always exists in management for an assiduous amount of social inventiveness and innovativeness and this is a

necessary condition for continuing survival and growth of an organization. Otherwise the system may well run down and cease to function effectively.

The successful struggle for adequate satisfaction of human needs in earlier factories and offices has led to the present day "ecological" priorities and to new spatial boundaries and resource webs. An important example is the trend in management to eliminate the authoritarian forms of management and to increase the humane socio-technical kinds. The latter has simply proved to be more efficient and cost effective. To this extent, the traditional resource web has become enlarged in order to meet a wider variety of human physiological and psychological needs.

Modern management and organizational planning is taking the form of creative intervention in such human "ecosystems" (often called organizational development and management of change). In the conscious management of creative change that takes place to alter positively the direction of ecological succession, a much more congenial environment for human work and productivity has begun to emerge.

The virtue of an ecological perspective in management is that it recognizes the reality of constant systemic interaction between resources and people in human communities, as well with surrounding physical environments. We have spent more time in the past as a rule worrying about how machines deteriorate than we have about people deteriorating in the workplace. The conditions for optimal and successful balance in human ecological communities are being identified through research and the direction of succession can be changed in beneficial ways. There are many forms of "maintenance" not only the physical kinds. Taking good care of machinery is well understood by application of the physical sciences and their engineering derivatives. The same degree of management attention is now being given to human resources. Personal, and organizational renewal, are a constant requirement, or else organizations will deteriorate.

AN EXAMPLE OF SOCIO-TECHNICAL MANAGEMENT

There are a number of variations on the socio-technical theme and several such approaches to the management of organizations. The one with which I am most familiar and wish to describe briefly was developed by Rensis Likert with whom I have collaborated for over two decades. It is an example of applied social and behavioral science based on over three decades of empirical studies at The University of Michigan and elsewhere. This particular kind of social invention and innovation has as its basis five kinds of managerial leadership behavior.

Effectively performing managers and executives in organizations that are highly productive appear to be able to provide to subordinates 1) appropriate technical and learning support when required; 2) to encourage participation and thus personal commitment and identification with the work organization; 3) are supportive and friendly toward others in positive ways; 4) can effectively build work teams; and 5) insist upon high work standards from everyone including themselves. The gist of this kind of executive leadership is explained in the following interpretive remarks.

In my view, supportive behavior toward other people can be seen as a form of "psychological nourishment" in the ecological resource web. It recongizes basic human needs for affection and a healthy self esteem, and emphasizes the

relative positive value of reward over punishment as an incentive. There are, of course, many ways to be positive and supportive which reflect the individuality of management and executive styles. But they all have in common caring, respect, knowledge about others and a sense of responsibility toward them. Such support does not rule out challenge or even competition. If does communicate an assurance, however, that the individual who has power over one has good will and one's personal survival at heart. Supportive behavior is more than mere manipulation of behavioral reinforcement. Such behavior increases the conscious development of self esteem, one's self image and identity and is based on genuine concern for others and in a recognition of their individuality (Fromm, 1956).

Managers who know how to provide effective technical assistance and job related technological knowledge to subordinates demonstrate in a practical way how management and executive responsibility is also at times an educational responsibility. To this extent executives are teachers as well. Obviously, well informed and trained employees will make fewer errors, enjoy their work and perform more effectively overall as a rule. Lack of such continuing guidance and stimulus for self learning may alter an individual's space-time orientation sufficiently to cause personal disorientation, confusion and anxiety. Work environments are learning environments in which effective communication of technical information between people is essential. Performance appraisal, for example, should be a continuing effort and not only limited to certain days during the year. There should be a continuing emphasis upon individual self control over the work flow which can be highly motivating.

Encouraging participation on the part of subordinates serves to enlarge their overall commitment and identification with the organization's goals by deepening the sense of personal ownership of the work situation. Participation in important work-related decision making in the work place is a positive way to increase personal commitment and loyalty. Simply put, one is less likely to abuse what one owns, and toward which one has a greater sense of responsibility. Besides, participation encourages ideas and inventiveness by the very people who know the product or service the best, and thus better problem solving.

Effective team building can help to improve the cohesiveness, interpersonal communication, overall coordination and dispute resolving skills of the work group. As a rule the problem solving ability of an effective group is usually better than that of an indivudal especially where there are complex problems to be solved. The effective group is essentially a "non-zero sum game."

Finally, expectation of high standards of work is obviously important not only for quality control, but also for the enhancement of self esteem, pride in work and greater work satisfaction. However, there are upper and lower limits to human performance and standard setting has to be governed by the realistic capacities of people. It is as foolish to expect too much as too little of people.

This is the core of what is called the "participative-group" approach to leadership behavior. The five characteristics are interdependent and synergistic. Examples of publications containing both theory and applications of this approach are Likert (1966, 1977) and Lundstedt et al. (1982).

The following adapted table summarizes participative-group management (System 4) with reference to some typical management procedures while

Table 1. Some essentials of System 4.

Procedure	Systems 1,2 and 3	System 4
1. Selection	By staff and/or superior	By staff, superior and with peer involvement
2. Training	Usually to individuals	Usually to teams
3. Setting goals	Generally by orders from higher levels	With the involvement of those who are to achieve the goals
4. Job evaluation	By personnel staff	By personnel staff but with involvement of those affected
5. Incentives and profit	Reward individuals	Reward groups as well as individuals
6. Management by objectives	Person-to-person interaction between superior and subordinates	Uses group objectives set by manager and work group and with each work group member knowing what his particular objectives are
7. Positive reinforcement	By superior only	By superior and work group members
8. Problem solving	Focused on problems at subordinate's level	Focused on problems at the superior's level
9. Structure	Organization chart shows solid and dotted lines	Organization chart consists of linked multiple overlapping groups both horizontally and vertically, solid lines in both directions
10. Line-staff	Organization chart shows solid lines for line and dotted for staff	Matrix organization with horizontal and vertical linking pins and solid lines in both directions
11. Matrix form of management	Works well sometimes but more often poorly	Works well quite consistently
12. Project management	Works well sometimes but often poorly	Works well quite consistently
13. Cross-functional management	Spotty results; some managers use them successfully	Works well throughout organization and survives any change in managers

Source: Adapted from Likert (1977) pp. 70-71.

contrasting it with the less effective exploitive-authoritative, benevolent-authoritative, and consultative approaches (Systems 1, 2 and 3).

We conclude that social invention and innovation are unique human management abilities. Yet they are far from being a new means of human problem-solving or a new kind of creativity. In the last years of this century there seems to be an encouraging increase in this creative activity in the management of complex technological systems. Unless there is an untimely reversal of this trend, we may expect to continue to see improvements in the quality of working life and in the way modern organizations are designed and administered. To a great extent, the former concept of the executive role is also undergoing a change. The new executive is a decidedly different individual with different values and leadership abilities.

We also now understand better the synergistic aspects of complex human and technical systems that are functionally interdependent with one another. An ecological perspective recognizes the natural interdependence of human communities with the physical world out of which technology in general, and electrotechnology in particular, arise. That is a different perspective from an earlier one in which artificial boundaries and separations between human communities, other living systems and the physical world were a rule. We are not entirely at the mercy of all natural forces and there are reasonable grounds for optimism in the future.

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INNOVATION MANAGEMENT: SOME SOCIO-PSYCHOLOGICAL AND LEGAL ASPECTS IN SOCIALIST COUNTRIES

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1. THE PHENOMONOLOGY

The terminology related to innovation processes is not uniform and at present under rather controversal discussion; in the context of this paper, however, we understand "innovation" to mean any relatively deep-reaching process of change in technics, technology or the organization of production or management in an enterprise. Innovation, in connection with technological or scientific progress, is only one kind of innovation—possibly the most important—but not the only one. This broad understanding of innovation is justified because from the socio-psychological point of view, innovations due to scientific progress do not differ principally from innovations based on other process, e.g., structural changes in the economy.

Specific features of innovation processes include, in our understanding, the following aspects:

- — innovation processes do not involve particular, punctual changes, but more or less comprehensive changes in the production and/or management processes;
- — in a much deeper way they concern personal, individual interests rather than customary problems in the production process;
- — innovation problems concern not only the activities and development of the enterprise and changes in its structure and organization but also imply deep changes in their social environment, especially in the communities where they are located.

The fact that innovation is proceeding in socialist countries within a planned economy, based on a conception of full employment and balanced development, does not make these aspects disappear, although in some ways it alters the forms of their appearance and the methods for dealing with them.

Introducing something new (be it technics, technology, or labor organization) into the organism of an industrial enterprise generally results in a chain reaction of activities that change the quality of the system within a

certain period (the adaptation period). It is a peculiarity of organizations that man appears in them in two roles: he is the *subject* but, at the same time, he is also the *object* of the organization's activities. Generally, the members of an organization do not realize this fact and consequently do not distinguish clearly enough between the system properties and the properties of their partners on division of labor in the organization. For this reason nearly all the contradictions that emerge objectively within any organization (especially those in connection with innovation processes) are interpreted as a result of individual peculiarities or even as character faults of the people participating and cooperating in the innovation process. The case study presented by Dr. Riegel describes more detailed empirical facts from the field of innovation policy which verify this phenomenon.

2. THE SUBJECTIVE BACKGROUND

The essence of the problem seems to be the following. Under normal, stable conditions any organization (the organization as a whole as well as its members) to a certain degree performs its activities on the basis of stable anticipation and feed-back circuits. Those stereotypes, which are in deep-reaching analogy to the functioning of a computer, form the basis on which, like the top of an iceberg, the visible behavior of people appears (in our case with respect to innovation).

Innovations produce further (secondary) consequences, which appear as structural changes in the *social* subsystem of the socio-economic-technic system. Innovation eliminates automated patterns of organizational behavior and because automation is also in human behavior (generally a useful adaptation and rationalization of behavior) this means a strong increase in the imponderability of the members of the organization. The elimination of a considerable number of automated feed-backs and anticipations may destabilize the organizational system or, what in many cases means the same, make it impossible to act rationally. In a generalized way what happens to the organization can be described as the following:

- the degree of control in the system is temporarily diminished;
- memorary traces of former activities are actualized;
- the reflection of causality structures of former activity is actualized;
- new strata of anticipation are developed;
- the transparency and rigidity of system borders changes;
- contradictions in separate parts of the organization are actualized, and whereas their solution has a stabilizing effect, not solving them can have unspecified effects;
- reciprocal changes of properties, activities and operations emerge in the organizational structure, relating to *goals* and the *means* of achieving the goals, e.g.,

reliability	-	effectivity
goal	-	means
subjective	-	objective
decision making	-	problem solving

If organizational processes, adequate to the innovation processes, are blocked the system generates ficticious feed-backs and motion. The result of the individual conflict situations can be described by the following pattern of relations between the subject and its environment:

subject (properties)	environment (state)
stereotypes	not continuous
rigidity	not defined
habits	unreliable
adaptation to causal relations	instable

discontent
uneffectiveness

This somewhat sad picture reflects the subjective side of the situation, its reflection in the mind of the personnel. It is not necessarily true but it describes one very essential component of the innovation problem. In other words, innovation does not only mean the change of technics, technology, and the organization of labor; and the human aspects do not only involve the necessity of training people to enable them to use a new technology. Of course, these changes are the starting point and the well-defined goal of the innovation process; so, in a certain sense they form the axis around which the whole socio-economic and technical system moves, and which determines the direction of the movement. On the other hand, innovation processes cannot be managed, nor can they be understood and dealt with as processes of change of men and men's relations.

3. WAYS OF SOLUTION

The principal pattern for solving the contradictions described above evolves from their essence. From the socio-psychological point of view (which evidently only regards one side of the whole problem) the main question and first step to solving the problem is to become aware of the problem, to make each involved member of the organization and the organization as a whole conscious of the problem. The second step is the actual problem solving and, as a result, decision making in full awareness of the problem, its scientific and technical, as well as social and individual circumstances and properties.

The experience of socialist countries is that the general mechanism of socialist democracy in enterprises and firms (as determined by the economic and labor legislation) also proves to be effective in the case of innovation policy. This means the participation of the workers' collectives and of their organizations (first of all the trade unions) in decision making on innovative processes, including their organizational and social aspects, as well as in finding adequate and optimal technical and organizational solutions. Necessarily this participation has to be based on detailed, exact and broad information. Experience shows that even large scale innovation and restructuring process (such as the closure of a coal-mine or organization of entirely new jobs for the workers) could be performed with high efficiency and a minimum of friction by way of early, broad and exact information and discussion. This includes the use of mass media as well as detailed and exact information within the enterprise and with the trade unions, and information and discussion in the basic units with the management. From this point of view there is no difference between innovation processes and any other questions that need to be discussed in an enterprise, such as regular planning discussions. The same refers to making and carrying out decisions. Realization of the innovation process implies an awareness of its problems and conscious cooperation by all involved, including the staff of workers.

One other aspect of broadening the basis of information and decision making in innovation processes also has to be pointed out. As we have seen, organizational changes related to innovation processes also bring stress situations with them. At the same time they generate individual and group approaches to implement them and to promote, if possible, individual and group interest in the process. Public information and discussion is an effective means of elaborating a common approach, synthesising and, at the same time, limiting individual and group interests; the process itself becoming maximally transparent and convincing for the public.

The above mentioned peculiarities of the innovation process determine the specific field of information and decision making, which includes the removal and solution of any psychological discomfort caused by the innovation. *Firstly,* information about innovation processes has proved to be effective if it is given in good time (which may mean months or even years before) and if it provides the possibility for public (in various forms) discussion on the decision making process. One such method that has proved successful is for the management to organize a service to collect all ideas and propositions—positive or negative—made within the discussion. There should also be frank answers to and precise information about problems not yet solved. *Secondly,* the innovation policy should from the very beginning include solutions to the numerous personal and individual problems involved. This refers to the management staff as well as the workers.

As stated above, from our point of view innovation is mainly a process of changing and developing human relations. In this context one of the main conditions for avoiding tension and friction is to make each member aware of the fact that he will have a job, according to his knowledge and capabilities, after implementation of the innovation process. This awareness is the basis for a system of training and retraining measures based on the various characteristics and peculiarities of the particular innovation process. As is well known, many individual problems emerge from organizational changes. In many cases, innovation leads to changes in the organization of labor, such as the transition to three-shift work and changes in the structure of working groups. These questions also deserve serious discussion and, in some cases, individual solutions.

In the legislation of socialist countries there are considerably strict conditions regarding this. The GDR Labor Code states that a change in the conditions of work, as well as any training or retraining measures, are subject to special contracts being agreed between the worker and the enterprise not less than three months before such a change takes place (Labor Conditions Change Contract, No. 49). In this connection the question of wages also has to be solved. Without going into too much detail we would like to point out that the experience of socialist countries confirms that the economic effects of innovations are not based mainly on saving money on wages, but on the higher productivity of the technological process. For example, in the GDR (according to the law but also in practice) innovation processes generally mean higher wages for the worker—after training if necessary. If, in exceptional cases (about 1-2 percent of the people involved) the former wages cannot be earned by the worker within an appropriate time, he will then be paid a year's amount of the foreseeable diminuation of income. A full employment conception is also reflected in the labor legislation of the GDR. According to No. 53 of the Labor Code, any enterprise dismissing a worker is obliged to find him another adequate job if the worker demands this. Dismissal is subject to a tripartite "transition contract", which constitutes the new job legally. A transition contract caused by innovation processes also has to be concluded not less than three months before dismissal.

4. ORGANIZATIONAL FRAMEWORK

It need not be pointed out that such strict legal obligations produce special problems and complications for the management of innovation processes. On the other hand, it has been proven by experience that they create a climate of social security that helps to avoid many social tensions. Under such conditions innovations are not only not opposed by the workers but there is an increased interest in the understanding of necessities, cooperation and creativitiy in performing the necessary changes. At the same time as stressing the aspects of publicity and participation we also have to point out the organizational framework for it. It is different in different socialist countries, but the main features coincide.

First of all, the workers' collective should be mentioned; its status and competence being subject to detailed legal regulations (cf. the Law on Rights and Obligations of Workers' Collectives of the Soviet Union, also the individual Labor Codes of socialist countries). All of them provide for broad participation of the collectives in discussing principal items of work and its organization, including innovation processes. An important role is played by the trade unions, who not only organize discussion and deliberation but particularly take care that the proper solutions to all questions concerning living and working conditions during the innovation process and its results are found. Questions of this character can only be decided in accordance with the trade unions.

Another, sometimes underestimated, level of social activities in innovation processes is connected with the social environment, especially the immediate surrounding territory. There exist many deep-reaching interdependencies and interactions between them. Innovation processes induce several kinds of territorial activities. They can induce far-reaching demographic changes concerning migration, new education and training profiles and changes in the employment of women. They may require changes in the development planning of a town, long-range (and in some cases short-range) changes in the social infrastructure (education, professional training, transport, etc.). Changes in employment (e.g., employing more women, the introduction of night shifts, etc.) also means changes in the activities of kindergartens, shops, urban traffic, etc. There are examples in industrial towns in the GDR where flats were built and allocated taking into account the special requirements of night-shift workers who need peace and quiet during the day. Innovation processes therefore are in many cases not only subject to discussion and deliberation in the enterprises and firms but also in the local parliaments, their commissions and in local administration. It is especially necessary to point out the great function performed by the Communist Party organizations in the enterprises and their districts, and the territorial committees in organizing and leading discussion and decision making in innovation processes.

This therefore is the background and context within which socialist enterprise management acts in performing innovation processes. An essential conclusion therefore is that the management of innovation processes not only requires experts in technology but to no less degree also the efforts of qualified experts in social and behavioral sciences, which leads us to our next point. That is, it is not only sometimes necessary to train and retrain the staff of workers in the innovation process but also the management to enable it to perform innovation in the most effective way with respect to social relations. Personnel management should not be understood as mere "administration" but as the work of experts who should be entitled to participate (and really participate) in dealing with production problems. On the

other hand, technicians, technologists and organizers should understand that any man-machine system is an open system, the liability and effectiveness of which depends mainly on the social subsystem. The peculiar task of personnel management is to deal with the personnel as the *subject* of innovation. An additional important task appears therefore in addition to the "classical" tasks of personnel management (such as the selection of personnel), that is, the organization of direct feed-back links from the "bottom" level to the managerial level.

STRESSING "HUMAN FACTORS" IN INNOVATION MANAGEMENT— WILL IT WORK?

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This paper on human factors in innovation is not meant to be theoretical. It is based on observing or participating in the management of a variety of organizations: the International Business Machine Corporation (IBM), two universities, the U.S. Congress and federal government, and recently a start-up technology development corporation designed to create and foster new business ventures based on university technology. The ideas presented spring directly from experience in these organizations, all but the last of which have a fundamental similarity to the heavy electrical industry which is the focus of this task force meeting: they are large and "mature" organizations with relatively stable characteristics and directions.

The paper is also not intended to discuss the desirability or benefits of applying human factor thinking to innovation management. There is an enormous outburst of literature on this subject, and the achievements which can be stimulated by mobilizing the full creative potential of management and workers are well recognized. Given the current enthusiasm for the application of human factor concepts, an important priority now is to take a realistic look at the barriers which we will have to overcome as we begin to direct management strategy in this new direction. What is likely to prevent us from successful use of these ideas in our management systems? What realistic constraints of history, organization, human nature, or other influences must be confronted if we expect to plunge successfully into a management style in which human factors play a major role?

Human factors in management approaches are, of course, not new. Assumptions and hypotheses about human behavior have always been at least implicitly part of traditional management styles and methodologies. The issue is whether the implicit or explicit approaches to the human factor have been positive or negative in effect. There is a growing current consciousness that most notions of management have not been optimized for the human aspect of the innovation process. Typical management strategies, for instance, have focused on:

1. Maximizing financial control;

2. Strengthening central management information and control of all operations;

3. Providing back-up strategies and systems to minimize risk;

4. Maximizing "political" viability of a unit, e.g., visibility, conformity to fashionable trends, etc.;

5. Fostering competition between individuals or subunits to achieve goals.

All of these strategy emphases clearly have human factor assumptions and impacts, but whatever their other virtues, they often have negative implications in terms of fully mobilizing human potential for creative innovation.

To organize my remarks, I will look at a few examples of key objectives usually cited for contemporary human factor innovation management:

1. Fostering creative individuals and ideas;

2. Facilitating conversion of new ideas to practical application;

3. Building identity of individuals and subunits with the overall goals of an organization;

4. Team building;

5. Fostering goals responsibility and awareness at all levels of the organization;

6. Fostering communication along the management chain and among subunits.

The issue I would like to bring to the participants of this meeting does not concern the merits or benefits of these commonly expressed goals. Instead, I suggest that we look, in each of our experiences, at what prevents progress in achieving them. Building a realistic sense of obstacles to be encountered may be the best way for us all to see pathways to overcoming them in our respective management program.

Many of these obstacles are familiar aspects of human nature, but ones all too often forgotten in the enthusiasm for new management strategies. As a reminder, Table 1 lists some of these common stumbling blocks under the six human factor objectives where their impact is most felt. However, rather than continue with systematic lists, I think it is most important for our purpose to look at the issues in the framework of actual case histories. I will review with you some illustrative examples from my own experience and hope to hear how they compare with yours. These are real events, and provide a predictive framework for human behavior which is probably superior to most theories, if we can extract the common underlying determinants that shape both success and failure. Related case histories in any of our countries, or organizations, most certainly can also be analyzed for common themes. I will look forward to hearing the experiences of other participants, which may be more revealing than my own. We may be surprised at how universal the themes are, transcending the differences in our various economic, cultural, and political systems.

Table 1.

OBJECTIVE:	Fostering creative individual and ideas	Conversion of new ideas to applications	Building identity with organizational goals
OBSTACLES:	inertia/size	inertia/size	distrust
	disorder/equilibrium	historical practice	status/hierarchy
	status/hierarchy	disorder/ disequilibrium	rivalry/greed
	rivalry/greed	short term horizon	lack of rewards/ immobility
	lack of rewards/ immobility	disincentives	poor measures of creativity
	poor measures of creativity	fear	fear
	fear		
OBJECTIVE:	Team building	Goal responsibility and awareness	Fostering communication
OBSTACLES:	ambition/rivalry	ambition/rivalry	ambition/rivalry
	distrust	inertia/size	inertia/size
	disorder/ disequilibrium	distrust	distrust
	status/hierarchy	status/hierarchy	disorder/ disequilibrium
	short term horizon	lack of rewards/ immobility	status/hierarchy
	disincentives	poor measures of creativity	short term horizon
	fear		disincentives
			fear

The first human factor goal I would like to examine is that of nurturing an innovative idea to fruition. I will present this in the framework of an unusual "case": the creation of the U.S. Small Business Innovation Research (SBIR) program*. This is a radical new approach in U.S. government research support, in which a fraction of all government research funding will be channeled to small businesses, as opposed to the traditional university and government laboratory system. The program is based on the idea that small businesses are the source of many innovative research ideas. Moreover, these are usually ideas with practical applications in mind. Unfortunately, many of them are never developed because of inadequate research funds available to these small organizations. The SBIR program is designed to provide funds for the best of these small business research initiatives.

*The Small Business Innovation Development Act of 1982, U.S. Public Law 97-219.

I do not cite this program as an example of a success: it is much too early to tell if it will truly advance the technological competitiveness of U.S. industry. There are many American experts who feel that it will be a wasteful and undirected diversion of funds from the prime sources of our science and technology development. Nonetheless, whether evolving as a success or failure, it *is* a genuine innovation in research management in my country, and illustrates some key examples of barriers to implementing innovation management strategies.

The system in which that idea emerged is a large and complex one: the entire U.S. National research program. In some senses it is not managed at all; in another sense it is managed through a complex interplay of political, financial and historical forces which are different only in scale from similar forces in more defined organizations. The system has many subunits. It includes public and private, large and small, laboratories. These range from the U.S. national laboratories such as those run by the Space Agency, Department of Defense, or Department of Energy, to the laboratories run by private industry such as Bell Laboratories and IBM as well as many similar corporations. The management of the subunits is independent to varying degrees, though ultimately the U.S. Congress holds authority over the gross structure and budget priorities of the government laboratories, and the economic climate in which the private sector operates.

It is important to note that the idea to provide special support to small businesses in this system emerged in the unique form of a specified set-aside of all research funds due to frustration. The small business community was thoroughly frustrated and convinced that the conventional research support system would never respond to the notion that small business-sponsored research could be fruitful. The small business set-aside idea emerged because a few people who truly believed in it pushed it continuously and aggressively, despite repeated failure to get it implemented beyond token measures in conventional planning and budget processes. This energetic effort continued despite well organized opposition that initially appeared very intimidating. It was opposed on the conservative procedural grounds, for example, that the fixed percentage set-aside violated conventional management control over budget processes. It was further opposed on substantive grounds, that it would not work due to the lack of experience, small size, and short time horizon of small businesses. Last, it was opposed on constituency grounds: the universities bitterly resisted the small business set-aside as representing a loss to them of what they perceived as already very scarce federal research support.

Yet despite these obstacles, this innovative approach came to fruition for several powerful reasons. One was a survival instinct on the part of "top management" (the Congress). It was their sense that new and dramatic measures were needed to maintain U.S. technology in a prominent position against increasingly effective world competition. Another factor pushing the idea was the security of unchallenged authority in the Congress, which allowed a willingness to risk and gamble. That gambling spirit overcame the lack of a complete set of facts and reliably predicted results which are normally demanded in an institutionalized decision-making process. A third driving force was the desire for a "politically attractive" position. The groundwork for this was laid by the proponents who vigorously publicized the idea, and organized support for it, in a manner which minimized political risk in supporting it despite its unknown substantive impact.

A last and crucial element allowing the implementation of this innovative idea was the ability of the Congress and political leaders of the executive branch to maintain a dual consciousness or "split personality" concerning strategies to manage for innovation. That is, at the time of discussion of the SBIR program, there were also many systematically designed conventional innovation management approaches which moved through all the standard planning, budgeting and analysis bodies in and out of government. However, quite independently, this idea emerged, with its birth and development outside of the normal channels, never integrated into conventional strategy. "Top management", the political figures in the Congress and Executive, were able in this case to simultaneously nurture both the systematic approaches and the maverick idea.

This brief example of bringing an idea to fruition in a large structure shows the power of recurrent general obstacles to such a course: the fear, distrust, and even greed of constituencies not perceiving benefits, the general inertia and resistance to change of administrative, planning and budgetary units, and the stress and disruption of conflict among affected constituencies. It also shows some of the typical ways such barriers can be overcome. Among these were the simple persistence of idea proponents (largely because rewards to their promoting group in this case were very clearly visible), and their willingness to take full responsibility for getting the idea implemented, as opposed to expecting upper management to carry the argument for them. Important also was the survival instinct and economic stress which helped to overcome conventional inertia to new approaches, along with management's willingness and sense of security to experiment. This management security is crucial to create a climate, vital to the innovation process, in which failure or incomplete success is regarded as part of a learning process as opposed to a negative result.

Perhaps most importantly, management was able to maintain the "split personality" thinking already discussed; that is, to simultaneously maintain a portfolio of main-stream incremental strategizing at the same time as investing a fraction of policy thrust in an eccentric and untested channel. Almost by definition, the conventional, systematic planning process is unlikely to produce the truly innovative approaches. On the other hand, that systematic process is still necessary, to provide a framework for participation, communication, and action. Thus, despite the apparant contradiction of holding a set of carefully planned and developed ideas on an equal footing with a few quite eccentric notions, this "split personality" approach was essential in this case to the emergence of an idea far from main-stream thinking. Ability to integrate the conventional and the eccentric strands out from this example as a key element of innovation management.

It is interesting to compare, briefly, the "human factor" implications of this small business set-aside idea with a much more conventional national or corporate strategy for innovation management: reorganization of the appropriate organizational units. Reorganization is the most predictable way governments and other large organizations deal with changing priorities or new problems. It is also easy to see that while these steps may be necessary or have positive results, they also breed human reactions which can be very disruptive to achievement of goals. Both the former U.S. Government Administration of President Carter and the current Reagan Administration made government reorganization a major thrust of their programs. For instance, Carter labored hard and expended much political capital on the innovation of creating a "Department of Energy"; Reagan has done the same in seeking to disband this Department. Both (and many Congressmen) have also proposed

reorganization of federal agencies to deal with the issue of stimulating industrial technology and increasing the competitiveness of U.S. products. Whatever the true goals, however, all of these proposed and actual reorganizations had the effect of mobilizing powerful drives for survival or hegemony by affected subunits and individuals. The bureaucratic and political strategies to carry out these drives had little to do with the purpose of the proposed reorganizations, and drained energy from that purpose. The uncertainty of effect which were linked to these reorganizational proposals became the focal point of attention by many involved, as opposed to the original goal. In a crude political sense, the spectre of reorganization was used by the Presidents in both cases to gain the initiative and control over the bureaucracy; as long as a reorganization was pending no individual or subunit could afford to ignore top management. This is a very common human factor result, or even internally acknowledged purpose, for reorganization in government and business. To understand reactions, it is crucial to recognize how little a reorganization strategy may in reality have to do with the usually stated objective of matching organization to function. The point I want to establish in looking by comparison at this more "conventional" innovation strategy is that just as many human factor obstacles may be trigfered by a conventional approach such as reorganization, as by more novel ideas. Any new priority or strategy is loaded with human factor agenda which cannot be ignored if results are to be predicted.

Let us turn now to another set of human factor management goals and similarly ask the question, via experience and case histories, of what are the inhibiting factors often blocking or confusing implementation. For this purpose we will consider the related management objectives of nurturing the creative individual in an organization, of building identity of goals between individual and organization, and building a sense of responsibility and goal awareness at all levels of an organization. At IBM, and in most major industrial firms, these thrusts of innovation management have received enormous attention for some time, and yet problems of worker and management alienation and frustration persist. Why?

Industrial firms tend to deal with the goals of creating individual creativity and loyalty by complicated rating, reward, and educational (propaganda) approaches. As an example, the numbers of patent applications or issuances may be tabulated for each individual or department, or other types of formula rating systems established. Sometimes these are engineered in elaborately complicated fashion. In the case of one major U.S. firm, every research staff member was asked to rate every other member on a number of criteria. The results became an enormous matrix of interlocking perceptions and intentions. Equally complicated formula reward systems generally accompany the rating approaches, ranging from tickets to the movie theatre or invitations to dinner, to cash bonuses and promotion steps.

The factors that make such systems work usefully may, paradoxically, be some of the same factors which we can identify as obstacles to their effectiveness. I would characterize them, in summary, as manifestations of the acute capacity of humans to perceive accurately the dynamics of the system in which they function. That is, in a relatively small group, excellence, leadership, and creativity tend to be recognized with strong consensus despite or independently of rating systems. In general, management in such instances would probably wisely apply a formal rating system only to confirm the integrated perceptions of the individuals in the group. It would not be relied on to "discover" creativity or other qualities. The reward

system would probably be similarly biased toward confirming instinct rather than strictly following numerical ratings.

Even the obvious difficulties of this approach are clearly often factored into the integrated view. It is indeed true that personal agenda of management or colleagues, which have no relation whatsoever to the recognition of creativity, clearly can come into play in indivudal or group perception of the system. These may be fear, ambition, jealousy, sexual or racial attitudes, or many others. However, under proper conditions, the human integrating capacity can identify and discount these. No management reward and recognition system can succeed without very explicitly recognizing these realities, despite the often professed intent of "objective" rating systems to overcome them. Integrating the explicit and implicit factors of rating systems, with their visible and invisible agenda, is another aspect of the need to maintain dual or multiple channel thinking in successful innovation management.

In larger systems, where the formal results of the rating systems tend to dominate instinctive evaluations, the biggest obstacle to useful application of rating and reward systems is the same uncanny ability to perceive true system dynamics. Humans are ingenius in sensing how to manipulate the management system itself, as opposed to working toward the goals it was designed to achieve. Patent disclosure counting systems are a classic example. The greater the extent that rewards are based on such simplistic counting, the greater the extent to which work is directed to the format of patent disclosures quite independently of true needs for innovation. Even much more exquisitely designed rating/reward systems appear to have remarkably short "adaptation lives", the time in which it takes any group to see how to manipulate the rating/reward system for individual or constituency purposes.

Management strategies aimed at building identity of individual with organization goals similarly run into the obstacle of the integrating sophistication of human minds. Most significantly, human factor managers rarely appreciate the impact of historical practice, and the skepticism with which people approach claimed "new directions" and "new policies". Often, past experience where goal identity was built by survival instincts (war, impending financial collapse, etc.) is mistakenly taken by management as verification that the system succeeded in creating goal identity. The result is that techniques which were spurious to the results obtained are enshrined and applied over and over again under conditions where they will not work.

In fact, the systems that *do* work over long periods of time, in crisis and normal conditions, cluster around a simple concept: honesty. With this as the unifying principle, rating systems are led to explicitly acknowledge the need to consider many and diverse qualitative and quantitative criteria in evaluating potential and actual contributions to creativity and innovation. They will explicitly acknowledge the need to balance the biases or personal agenda of the evaluator. The reward systems, which are designed to reinforce the innovative instincts and build identity with organizational goals, will not only be substantive in an absolute sense, but will be based on conveying to the contributing individual an appreciable fraction of the benefits brought to the organization.

Similarly, management approaches keyed to developing responsibility for performance at all levels of the organization can take many forms,

but must honestly demonstrate a willingness by management to take seriously problem-solving or innovation-producing approaches generated from below. An openness to risk-taking, and trust and support for best efforts even when circumstances prevent following accustomed procedures, is the only way to truly reinforce the acceptance of responsibility at all levels of an organization. Similarly, a true commitment to open and honest communication along management chains, of both problems and opportunities, must be made despite perceived risks of early or wide dissemination of information. A history of *selective* support for initiative, or *selective* honesty about goals, problems, and intentions, and any other manifestation of incomplete honesty or commitment to trust, will frustrate the most enthusiastic management campaigns to build the innovation-producing sense of responsibility at worker and lower management levels.

A last set of human factor goals to examine in this sense of realistic experience includes those of team building and promoting communication among individuals and organizational sub-units. As a participant from the U.S., I feel confident in speaking of the obstacles faced in the area of team building. It is obviously one of our cultural weaknesses in organization management, a mirror of the fact that nurturing independent and creative individuals is one of our cultural strengths.

So many of the incentive and reward systems in the U.S. management systems are built on a foundation of competition that the obstacles to team building are deeply ingrained. Groups are often viewed as arenas for competition, in which "winners" (and losers) are to be identified. It is rare where the groups are considered as indivisible units in which success is shared by all. In the circumstances where group success is established as a norm, it is often in terms of competition with other groups, where again clear classes of winners and losers are established. Free and open communication between individuals and groups is one of the first casualties of such competitive systems. It is well known that "information" in large bureaucratic systems becomes almost a commodity, being traded and bartered, and capable of establishing position in hierarchy. In an intensely competitive system it may be closely guarded, so that the synergistic power of combining indidivual and group ideas is lost.

The impact of the breakdown in open communication is very often seen in the planning process. Organizational planning can often be a key element of internal communication, as important for that purpose as its value as a roadmap for the future. The act of forming the plan facilitates exchange of ideas concerning opportunities and constraints in the future, and catalyzes the formation of mutually reinforcing networks which might otherwise have consisted of isolated, redundant, or contradictory initiatives. When competition or rivalry restricts information flow, however, planning becomes an empty exercise, usually breeding only organizational cynicism based on the knowledge that real intentions are buried far beneath the visible planning documents.

The most extreme expressions of the American "management by competition" theme are systems in which competition for *survival* is the driving force. Indivudals and groups are put in situations where only a limited number can survive economically, or as independent units, or as permanent employees, etc. The survival drive can have great innovation-stimulating effects, of course, as we have seen in discussing conditions needed for stimulating and bringing innovative ideas to fruition. On the other hand, an enormous price is paid

in terms of the loss of the synergistic energy resulting from team building and open inter-personal and inter-group communication.

Even in cases where competition is not itself the governing management principle, systems on a large and small scale are often designed to be a tense balance of conflicting and competing interests. The federal bureaucracy in the United States is a prime example. Various agencies and subunits within them are constantly on guard against any dimunition of their authority or scope of concern; conversely they are always on alert for opportunities to probe into the territory of another. This seems to happen, paradoxically, even in a context of fatigue and frustration of over work. In many cases (e.g., regulatory agencies, the legislative-executive-judicial branch "check and balance" theory) the system was very explicitly structured with the intention of building-in these tensions of conflicting purpose.

I am far from condeming competition or "checks and balances" as management strategies. They represent perhaps the oldest techniques for managing human affairs, with clear links back to ancient tribal practices. However, they clearly have their disadvantages in terms of effects on other human factor goals, and we must be alert to these influences in planning overall strategies if we are to avoid disillusionment and frustration. The stress experienced in reorganization strategies, discussed earlier, may be the most vivid example of the "surprise" disillusionment often felt by management due to the impact of general reliance on competition management. In government and industry, like an ever-repeating morality drama, reorganization strategies are constructed to expedite new goals, and then mysteriously founder on the competitive territoriality of individuals and groups, bureaus, and departments. When we look at the human factor implications of competition-based management strategies, the reactions to reorganization ideas seem absolutely obvious and predictable. Yet over and over again, the need to deal with those implications as part of reorganization or other management strategies is constantly underestimated.

I have discussed only a relatively few of many possible "human factor" management goals, in the context of a minute set of case histories. Yet I believe that some general themes emerge as predictable obstacles to the goals of stimulating innovation through human factor management, along with clues on how to overcome them. The obstacles are simply variations and combinations of the familiar human reactions tabulated in Table 1: insecurity, ambition, rivalry, inertia, distrust, status, greed, etc.

Clearly, some conventional management strategies tend to exaccerbate these even though they may achieve some objectives in a narrow scope or limited time frame. For example, management by fear of sanctions most notedly discourages risk-taking, inhibits communication, and breaks the identity of individual and organization. Management based on competition similarly destroys communication, and weakens team building and opportunity for synergy, in addition to undermining identity with overall organizational goals. Formula rating and reward systems, especially where manipulative in even the most subtle fashion, generally are mistargeted in effect, as participants rapidly adapt to counter-manipulation of the system itself. These patterns are familiar and predictable, and yet the enthusiasm or other motivations to "sell" new management approaches, or to seek a simplistic or convenient answer to a challenging situation, repeatedly blinds individuals and organizations to these realities.

However, the examples examined, and many others, show that there are means to overcome these predictable problems. They may require flexibility, patience, investment, and risk-taking by management. Yet the rewards, of fully mobilizing individual and group potential for creativity and responsibility to achieve organizational objectives, are enormous. Moreover, the rapid emergence of a world economy based on the products of technological and organizational innovation, shows that the penalties for failing to utilize this human capacity are increasingly severe.

Among the management skills needed is the crucial ability to maintain simultaneously, and integrate, multiple patterns of thinking. Conventional planning and organizational strategies must be fostered at the same time that unexpected ideas and opportunities are nurtured. Maslow (1971) has repeatedly stressed the great benefits deriving from the ability to integrate, in the individual mind, spontaneous and subconsciously-based bursts of creativity with systematic patterns of thinking.

The same integrative capacity is essential to maximizing innovation and creativity in management or organizations. It is this integrative capacity which can enable management to benefit from the best of modern rating and incentive systems, and yet overcome the mistargeting and other disadvantages that these inevitably bring. It is the same capacity which allows an efficient and smoothly running planning system, and yet allows the full advantage to be drawn from fortuitous events and unique individuals or situations.

A second crucial element for fully mobilizing human potential is that of complete honesty in the reward structure and implementation of the management system. The same abilities that make human beings so powerful when fully mobilized enable them to sense with uncanny accuracy dishonesty in goals or expression of management approaches. The long-range benefits of a management system based on honesty and candor are often counter-intuitive, because the near-term results may be obvious complication, disequilibrium, and dissatisfaction. Yet the high-level of performance of individuals and groups operating in a climate in which suspision and disillusionment are minimized is well documented. The innovative performance of subunits in an organization, or entire corporations, can often be directly correlated with the climate of honesty and candor conveyed by the reward and management system. The need for a management commitment to openness and honesty is not based on a moral or philosophical platitude, but on practical utility in stimulating the innovation process.

A last major characteristic clearly needed to facilitate innovation management is linked to the first two. It is the maintenance of a climate to encourage risk-taking. The atmosphere of professional and personal security, management's ability to integrate and simultaneously nurture varying approaches, and the climate of reliable honesty and integrity are obviously part of nurturing risk-taking. Underlying this, however, must be the clear realization that *risk* and *conflict* are not inherently negative concepts for an organization. There is an emerging parallel to this thought in current discussion concerning public policy with respect to regulatory law and questions of siting or allocaitng the negative aspects of modern technology—dangerous power facilities, waste disposal sites, etc. Where public policy debates formerly centered on risk or conflict *avoidance*, it became clear from many examples that avoidance strategies inevitably resulted only in transferring the risk or conflict from the immediate or local sphere of attention to a broader or longer-term arena in which the threats and tensions

might turn out to be more severe. The only turly effective strategy is one of openly acknowledging the risks and conflict of any new or innovative approach, and concentrating efforts on *managing* them skillfully, not hiding, escaping, or avoiding, them. Technological or management innovation strategies must similarly face directly the fact that risks and conflicts will be generated by new or unusual ideas, and consider that these risks and conflicts are simply a normal part of creative operations. Obviously the total conflict and risk generated must be weighed against the total benefits experienced in trying a given number of new initiatives, but a pretense or vain hope of avoiding them entirely and in every case would thoroughly destroy the capacity to innovate.

I have valued the opportunity to present these ideas to the participants of this meeting, and look forward to hearing their reactions and observations from the experiences in the many diverse industrial and organizational settings represented here.

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INNOVATION MANAGEMENT AND HUMAN FACTOR INVOLVEMENT

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1. INTRODUCTION

From the very beginning the project on Innovation Management in Electrotechnology posed the crucial question: How to raise the ability of an industrial firm to more effectively manage the development and implementation of technological, organizational and social innovations? Within this question is an implicit assumption that there are two sides to the problem: supply and demand, i.e., the supply of innovations (or at least the potential for them) and, on the other side, the demand for them and the ability to implement them. What kind of balance should there be between these two sides? Are social forces and interests equal on both sides?

Several years ago Gabor (1970) pointed out that the various innovation types should be in a certain balance while Jungk (1976) announced the lack of a sufficient quantity of social innovations. These two authors thought mostly in general societal terms. I do think, however, that their reasoning is valid for the industrial firm case, especially those firms featuring intensive R&D activity and new technology application. A typical situation is the following: innovations (in abundance in leading economies) are developed and implemented with the aim of raising productivity, profits, competitiveness, etc. Until now this process was fairly effective and successful in spite of the fact that certain negative social side effects appeared. Recently we have been alarmed by diminishing productivity or, at least, by non-growth, even in countries of traditionally high productivity growth (e.g., the United States, as stated by the Center for Futures Research report). Do we have a case of some kind of general law for diminishing returns in technology as, e.g., Giarini and Louberge (1978) claim?

Perhaps we have poorly managed innovations, i.e., technological innovations that do not match the organizational ones, meaning a gap between hardware, software and orgware, to use Dobrov's (1983) terms. It is true that new technologies usually require some specific, one could even say predetermined, organization (i.e., orgware). We therefore have technology for profit making

and competitiveness and often impose its organization on people. But what about people? We learn from simple observation and research reports that working people no longer want to work as machines (Porter et al. 1980). Moreover the adverse effects of technology also have an impact on their working place and people believe less and less that "technology can be cured by more technology". They demand humanization of technology and improvement of working conditions; they demand participation, self-management and the right to be able to make a choice about new technologies (Zacher 1980).

What should immediately be learned from this, shocking for some, experience, is that traditional work ethics have gone*, and that the so called "human factor" of production becomes more and more a "subject of production" as pointed out recently by the late Czech humanist Radovan Richta (1971). This implies that the old technological rationality is no longer valid and that it ought to be combined with social and human rationality (Zacher 1981). For example, respecting the right to work as a strong political and social commitment (which is a rule in socialist countries) expresses nontechnological rationality. Some critics would say that it is also non-economic rationality. Perhaps, but only in the short run as proponents of the social and political rationality would answer.

The implication therefore is that the old, traditional style of management is no longer valid because it is technocratic and bureaucratic; it overlooks the "human subject" and neglects its liberatory ambitions. My message as a social scientist to those firm's executives and engineers in this audience is the following: it seems more and more self-evident that innovation management is not merely a "technical thing" and not only a "managerial thing". This statement is crucial for understanding the modern "changing environment" for innovation management in industry and elsewhere.

2. NEW METHODOLOGIES AND TECHNIQUES NEEDED

What are the ways out of the "managerial trap" related to technocratic types of organization and management? One way is to use "positive adjustment" strategy** in the management of innovation on a firm level and implies management initiative or response to other initiatives. Needless to say all experiments are connected with some uncertainty (which is normal when technology and technological risk are at stake). To start with some initiatives (e.g., humanization of work, job enrichment, etc.) involve having a good understanding of the processes, interests, conflicts and the various trade-offs that innovation can bring about.

To fulfill the conditions of understanding the goal sufficient methodology and techniques to assess the phenomena involved are badly needed. Some useful methodologies have already been developed and, to some extent, applied. One can mention such examples as:

- *technology assessment (TA)*; which is the anticipatory social assessment of technologies, projects, programs, etc. (also R&D processes); TA—however defined (Porter et al. 1980) comprises

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*These ethics were historically discussed from the religious angle by Max Weber and from the social point of view (e.g., in *Capital*) by Karl Marx.

**We refer to the term used in the OECD Report (1983).

a set of methods and analytical techniques that can be applied on the firm level for innovation management*.

- *social impact assessment (SIA)*; sometimes regarded as a part of TA studies, is a decade old domain of research and activity developing fairly fast. SIA is promising for innovation management evaluation, moreover it is social innovation itself. It can be added that SIA usually includes some involvement by "interested parties", i.e., citizens, workers or groups affected by the technology, etc. TA can also be accompanied by such involvement.

- *impact assessment studies in general*; some authors speak about integrated impact assessment (Porter and Rossini 1982) and cumulative impact assessment (Vlachos 1982). Studies of these types also frequently refer to environmental problems that can also be reflected on a firm level (which is important e.g., in cases of highly polluting plants such as electric power stations based on coal).

- *risk analysis*; included in TA by some authors and not by others because of its specificacy. This domain is expanding rapidly as new technologies are connected with risks of various types. The risk of losing a job or being down-graded (which, for example, is pretty typical in cases of computer automation of processes which are becoming cheaper and cheaper due to the "microprocessor revolution" (Friedricks and Schaff 1982)). The risk of less occupational safety (e.g., nuclear power plants are seen by workers and the public as being more risky than conventional work places); managers should have methods for eliciting workers' opinions regarding the risks and hazards of newly implemented technologies and, alternatively, should communicate any information about risks to the workers, foremen, technical experts and decision makers at all levels of the firm.

Risk perception research (Slovic et al. 1982) is crucial for successful innovation management. The Schumpeterian individualistic entrepreneur who is innovative anf risk-taking is not very actual anymore, the workers in the factory are the real risk takers and their risk is not only physical. Mary Douglas and Aaron Wildavsky (1982) explain that risk selection is a social process. Among methods and analytical techniques, forecasting and systems analysis ought to be especially called for. The former because the impacts of new technologies should be anticipated (however retrospective, assessment can also be useful and instructive), and the latter because systems analysis is particularly excellent for investigating relationships, interaction nets, feedback loops, etc., which is the point in case of technology and workmen.

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*For us TA is not a method of decision making but an "undertaking" providing information which can (or can not) be successfully used in the process of choice and decision making in the area of technology. Harvey Brooks (personal communication) is a strong proponent of such a stand, i.e., that TA gives additional information input for the decision maker.

3. NEW APPROACHES FOR BETTER INVOLVEMENT OF THE HUMAN FACTOR IN PRODUCTION AND INNOVATION

It is an illusory opinion that management is solely a pragmatic activity. On the contrary its nature is social and it should be sensitive to the societal and human issues that emerge when new technologies are introduced at the firm level. It is also true in the case of electrotechnology, however, this branch is relatively more capital-intensive than labor-intensive. In the last decades new experiements were conducted in many countries and their results can encompass present and future managerial philosophy and practice. These results undermined the traditional technocratic (in the prejorative sense) management approach and style.

The technocratic management approach is mechanistic (the same can be noted about Taylorism) and would be most effective in the case of robots. Now we need more humanistic and "organic" material systems. By "organic" we mean systems in which combining the requirements of innovation and production processes with aspirations, ambitions and culturally-based skills are natural and efficient from technical economic, societal and human points of view. It is essential to promote the "organic" approach in management style in all areas of activity, i.e., social planning, personnel training, designing work groups and their socio-psychological environment, conflict resoltuion, work incentives and motivations, merit rating and rotation of managerial and technical personnel with respect to innovation process management, employee involvement in management, and so forth.

Since only constant innovation assures a firm's success and competitiveness, the style of innovation management is of critical important, i.e., how to achieve the highest possible creative potential of a firm? If we assume that at the moment technology is an independent variable (i.e., it is "given" or it is available in a "given" form), we have to accept the view that human factor involvement (we can consider organizational transformation under this label too) is crucial in a firm's strategy. The question therefore is how to encourage, enhance and promote optimiazation of the human factor involvement in general, and in the innovation process in particular?

There are some general guidelines that indicate possible managerial activities which form specific "environments" (philosophical, political, social, organizationa, educational and so forth). These can be grouped as follows.

3.1. Institutional and Legal Activities

Many examples from both East and West can be quoted here and are mostly of the "condition-creating" type. Institutional forms are popular especially where the role of the state (government) is important, and a strong belief in institutional solutions seems to be in the socialist (CMEA) countries, where workers' participation is developed step by step (see, for example, Semenov 1983). Moreover, institutionalization seems to be an overwhelming process, with even trade union activities becoming more and more institutionalized as for example, the so-called "New Technology Agreements"*, which impose important

*See, for example, the TVC report on Employment and Technology, London 1979. A checklist for negotiators on New Technology Agreements comprises the following issues: the principles of these agreements, aspects of union organization and interunion relations, the provision of information, agreed plans on employment and output, retraining, hours of work, distribution of the technology benefits, control over work, health and safety, procedures for reviewing progress. This particular report was devoted to the various effects and impacts of microelectronics.

constraints on a firm's decision makers, e.g., "Employees should not be committed to introduce new technology until full agreement has been reached on the whole range of negotiating issues", meaning that full consultation is required before a decision on technology is taken. Moreover, it is postulated that "joint union/management study teams should be set up with the responsibility for monitoring the detailed effects of implementing new technology. Trade unions are definitely also creating a new environment for managerial decision making (it is demanded, for example, that research results on new technologies be redefined in terms of trade union actions, see, for example, Zacher 1981 and ILO 1982). The participation movement has also been institutionalized and legally defined, despite the fact that it begun from some grass roots activities, trade union demands and political party programs (i.e., Mitbestimmung or Sozialpartnerschaft in the GDR and Austria, respectively).

3.2. Quality of Working Life (QWL) Approach and Activities

The quality of working life seems to be an extremely promising experiment and a widening practice, although not yet institutionalized (at least not fully). It is especially designed for the plan level and has been applied in technologically advanced branches of industry (such as automobile and telecommunications, e.g., Volvo, General Motors, ATT). The experience gained by Volvo in the 1970s is significant in this respect: it was not only more effective in job design, but the new strategy on production technology and work organization (concept of flexible technology, team work and a spirit of collaboration) were diffused to all the product groups. Berth Jönsson, assistant to the President of Volvo writes:

> The base for this development must be new technology, the capability and knowledge among the employers cominbed with a managerial approach that mobilizes the potential of good working ability (Jönsson 1982).

The Volvo experience is very important as an example of successful creation, implmentation and diffusion of the organizational, social and at the same time technological innovation (or rather set of innovations). Based on the experience of the Kalmar plant six new plants have been built in Sweden and one in Holland. It is neither the Volvo experience per se nor its specific characteristics (i.e., moving toward craftmanship in assembly operations and automation and manufacturing whenever feasible) that should be recommended but the conduct proper of the whole experiment.

Two major phases of development can be identified at Volvo:

1. *The Spontaneous Trial Period* where a number of initiatives on a voluntary basis came from the shopfloor, supervision, managers, engineers, the union, doctors and others. and

2. *The Sociotechnical Strategy Period* where a new strategy was formulated and implemented.

Writes B. Jönnson:

> We are right now in an advanced stage of the second phase which includes new creative solutions to flexible hardware technology and the diffusion of ideas to Volvo subsidiaries outside Sweden. By now, change has become institutionalized, with a variety of patterns but with a common ground. Learning and diffusion of ideas are occuring continuously (Jönsson 1983).

It is worthwhile to note that the Volvo experiement was actively and explicitly supported by top management. Management philosophy can be illustrated by the statement of P.G. Gyllenhammar, president of Volvo:

> Factory work must be adapted to people, and not people to machines. This calls for innovation both in the field of human relations and as regards technical aspects. I believe that humanization of work and efficiency can be compatible (Jönnson 1982).

The top management successfully overcame the resistance of some managerial personnel. It can also be noted that the average age of the group mostly involved in and responsible for the experiment was the mid-thirties.

The quality of life approach is becoming more and more popular and shows growing institutionalization. For example, in the case of General Motors and ATT, agreements between management and trade unions were negotiated and approved*. It seems that to a great extent these agreements are designed for purposes of collective bargaining, and therefore are in some sense defensive (from the trade union point of view). In the Agreement between General Motors Corporation and the UAW can be read:

> It is recognized that advances of technology may alter, modify or otherwise change the job responsibilities of represented employees at plant location, and that a change in the means, method or process of performing a work function including the introduction of computers or other new or advanced technology will not serve to shift the work function from represented to nonrepresented employees. (Agreement between G.M. Corporation and the VAW on 14 September, 1979 Statement on Technological Progress.)

The quality of life agreements appeal for material and psychological incentives for the various categories of personnel involved in the innovation and production processes, and for socio-psychological developments of the collective as a factor for increasing the efficiency of its activity. In the CWA and ATT Statement of Principles on Quality of Work Life it is stated that:

> The essential component of a Quality of Work Life (QWL) effort is a process which increases employee participation in the decision which affect their daily work and the quality of their work life... The goals of QWL efforts are: (a) to employ people in a profitable and efficient enterprise; (b) to create working conditions which are fulfilling by providing opportunities for employees and groups at all levels to influence their working environment... Quality of Work Life is not a "program": there is no universal or one best approach. It is a process which has great potential, but it can't be the answer to all the problems of employees, the Union, or the Company.

According to M. Maccoby, the author of Gamesman, the QEL approach means a radical change in management as compared with traditional managerial approaches and practices. Maccoby's comparison between these two management approaches stresses the following domains:

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*Agreement between G.M. Corporation and the VAW on September 14, 1979, Statement on Technological Progress.

- *control*

  control based on flexible guidance (as opposed to control based on commands and rigid rules, quantitative measurement, and unquestioning loyalty), quantitiative and qualitative evaluation according to economic, social and human principles, and trust rooted in shared goals and open communications.

- *leadership*

  management as a resource—sharing power, clearing roadblocks, building strategy, developing consensus (versus management as boss, monopolizing power and prerogatives), influence based on knowledge rather than hierarchy (versus paternalistic relationships at best or policing at works), relationships of respect.

- *work roles*

  teamwork—interdependency, flexibility of roles (versus fragmentation of jobs, uniformity of turf—oriented roles), socio-technical design of technology and jobs to promote optimal decision making (versus decision making moved upward).

- *training*

  broad training, including group development of problem solving skills versus narrow training for simplified jobs.

- *motivation*

  economic and social / human shared goals (e.g., service, personal development, mutuality) versus economic interests only. Rewards to both individual and team (versus rewards to individual only), trust based on shared goals and principles (versus trust based on protection).

- *relationships*

  development of cooperative relationships among management (various levels), union and worker (versus adversarial relationship with union, overreliance on internal conflict and competition among managers, quality control as adversarial, interdepartmental rivalry), learning from each other (versus rivalry and unwillingness to learn from peers).

- *change strategy*

  centralized determination of goals and principles, decentralized participation in reaching goals (versus top-down command, one best way), respect for differences in approach, top-down (bottom-up strategy that encourages experimentation and uses volunteers; education, persuasion, and rewards to spread new ideas.*.

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*Maccoby's lecture at Salzburg Seminar.

For some, however, this comparison can seem rather idealistic. I want to recall M. Maccoby's opinion that "idealism and caring is extremely practical provided we create the structure for it." The quality of work life approach can be recommended not as an ideology but rather as a more pragmatic tool in the West and East (in the latter it can even appear to be more successful). It is applicable on the firm level, it applies to electrotechnology and to electrotechnical firms (as described by Goncharov 1982, looking to improve innovation management. It is possible also to enrich by some aspects of the QEL the structure of an approach to R&D problems in big electrotechnical firms (so-called amalgamations) as described by Levuck and Vyshinskaya (1982).

3.3. Implementation of Self-Management Principles

To implement self-management principles needs the appropriate managerial style and different activities than in the case of technocratic management, institutional approach or the QWL approach. It is more or less only fully implmeneted in Yugoslavia and to some extent in Poland (in the framework of the new ongoing economic reform). Self-management principles are derived from the long lasting socialist tradition (see, for example, the works of Engles) and is basically different from the participation concept of the West where private ownership of the means of production is the rule. There are, however, controversies whether the socialist self-managed firms could be very effective in promoting innovations. Some specialists argue that some degree of state intervention and aid is necessary. However, self-management can have important positive indirect influences (political, social, psychological) on working people and management, which can contribute to the success of innovation efforts. Anyway, more experience is needed as well as more empirical research in this respect. It should also be noted that the self-management approach becomes institutionalized too, but still it is specific enough to be presented separately.

4. CONCLUSIONS

It seems evident that successful innovation management on the firm level nowadays requires completely new approaches to human factor involvement. These approaches should be nontraditional or even counter-traditional. There are a few such approaches in operation in the West and in the East. Pragmatically taken, many of the new developments in general management and innovation management can be applied, adopted, transferred, improved in any system, under the condition that "people matter" (to quote Schumacher).

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INNOVATION—THE HUMAN SIDE

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INTRODUCTION

> *"Innovation, that is, the process of finding economic application for inventions."*

This first definition of strategically planned changes and innovation is 40 years old. As is generally known, the statement was made by Josef A. Schumpeter. He even went a step further and called competition by means of problem-solving innovation "*creative destruction.*" Figure 1 illustrates the innovation process.

In any organization the complex problem of innovation is the most important management function. Every country depends on the management of all economic, political, and scientific institutions or schools to take full responsibility in the field and in the direction of meaningful innovative activities and to contribute to the development and application of the necessary measures. Whenever innovation is neglected over a longer time period—be it in the organization, in production technology, in management or in the products themselves—this fact will not only be reflected in increasing or decreasing profits, but will also affect the viability of an organization or enterprise as such. On the one hand, the innovation process is oriented towards the future (strategic thinking), on the other hand it is oriented towards comprehensiveness. It has to be kept in mind therefore that when developing innovations comprehensive solutions have to be found. For this purpose integral thinking and acting is required. System-oriented thinking frequently draws on analogies. Being a technologist I have thus chosen the control circuit to illustrate the respective relationships (see Figure 2).

If we consider the main "control variables"—or, in the manager's language "areas of effectiveness"—of an innovation process, human skills and human behavior prove to play the central role (see Figure 3). Being the "innovator" as well as the "user", "man" decides on the success or failure of an "innovation strategy", an "innovation plan" and an "innovation process".

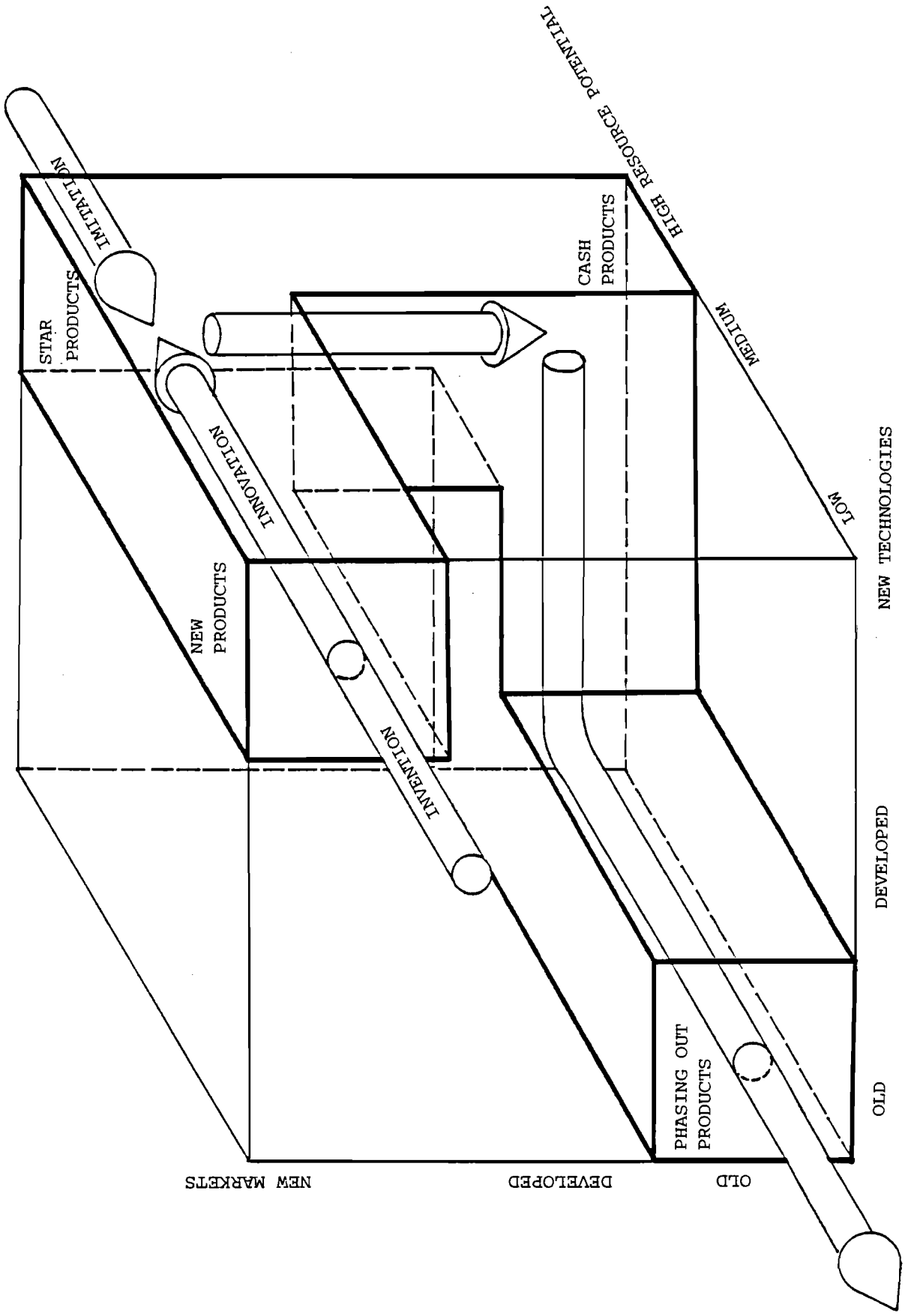


Figure 1. The life cycle of an attractive product.

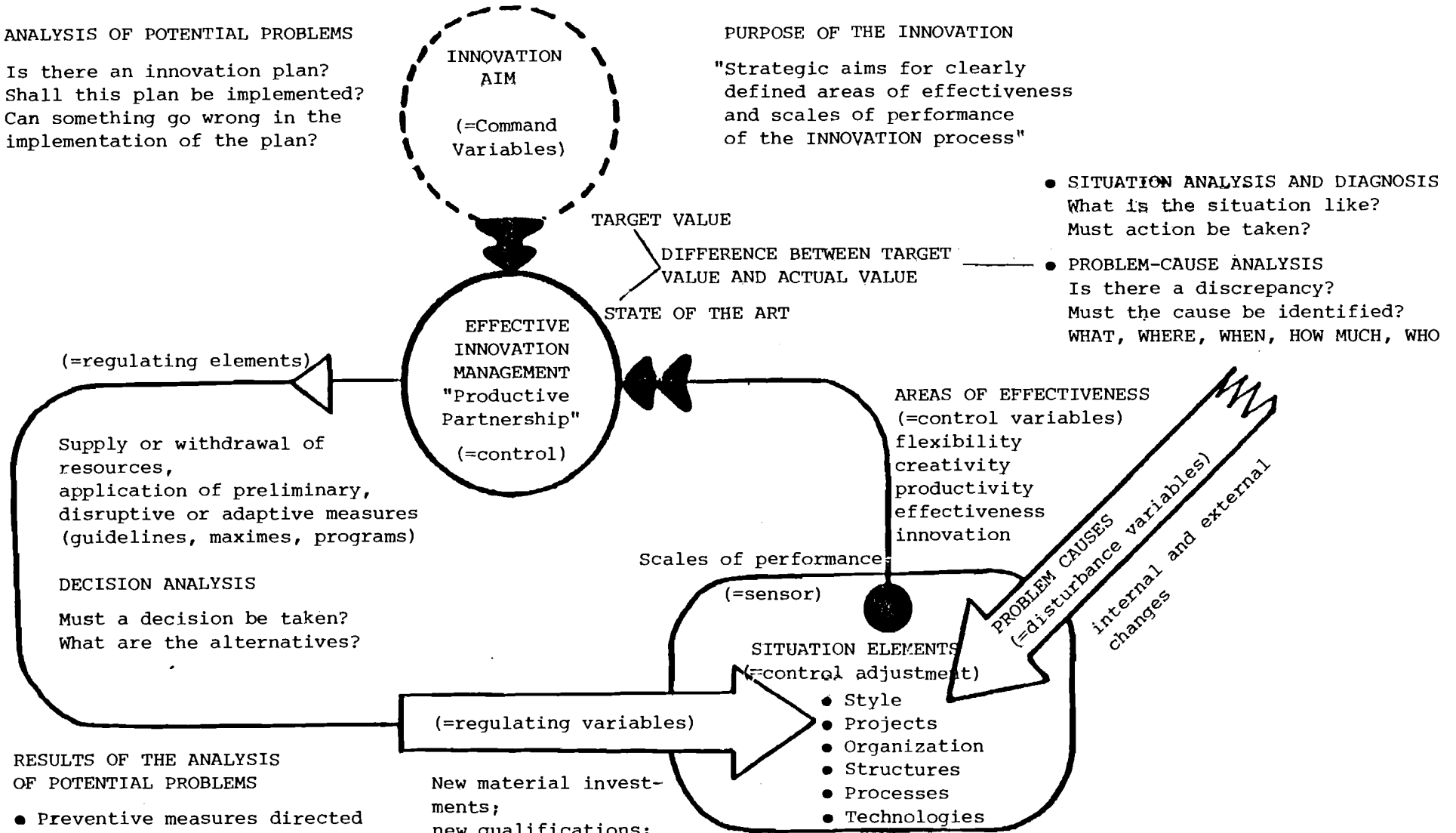


Figure 2. Control cycle of an "innovation process".

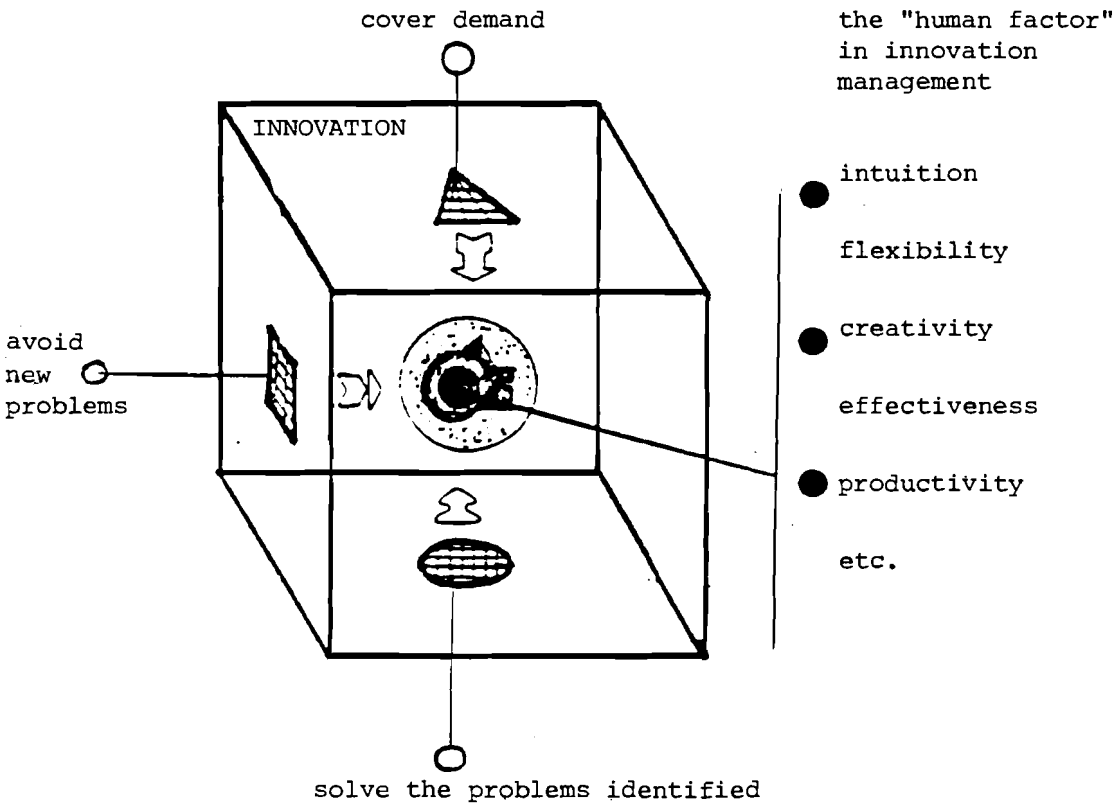


Figure 3. Some of the main "control variables = areas of effectiveness" of innovation management.

Management in general, and innovation management in particular, is faced with a production factor of a special kind, i.e., the human factor. Man has been and always will be—especially in the innovation process—a unique production factor, who requires special qualifications of those who are dealing with him. Man cannot be "processed", he can only be developed. And the direction of this development is decisive as to whether the individual, as a human being, as innovator, and as a production factor, will become more creative, i.e., more productive, or whether he will eventually stop being productive. An innovation manager will only fulfill his purpose if he is effective, i.e., if he does the right things. In this context effectiveness is the degree to which he and his team reach the innovation target, which has to be reached according to the respective agreements.

The value or the worthlessness of an innovation will be decided by the market, the customer, the user. To innovate successfully, i.e., effectively, means, above all, to understand the customer and the user of an innovation. Even if management and their team or organization have tried ever so hard to be innovative and to carry out an innovative process, *if the user or customer has been neglected in this process, their money may be efficiently, but hardly effectively invested in the innovation* (see Table 1). Certainly efficiency in the innovation process must not be neglected. But it is also important to point out that "know-why" and "know-what" range higher than "know-how".

Table 1.

An efficient innovation management prefer to:	in comparison to	an effective innovation management who are primarily concerned with
- pursue the innovation process according to schedule	instead of	making the right innovations
- solve problems according to established one-way systems	instead of	creating alternative problems
- conserve and save resources	instead of	optimizing the utilization of resources
- do its duty	instead of	obtaining results
- reduce costs	instead of	increasing gains

The "right" innovation rests on two pillars:

1. the innovation process; and
2. the feedback of the user as well as of all other "situation elements" which can influence the success of the innovation.

Thus, effective innovation management depends on the right approach to frequently changing situations. Since the term "situation" allows for an increasingly wide range of interpretations, it seems meaningful to present its main elements in Table 2. These have been developed in the last 70 years in about eight schools of thought, the first of which goes back to scientific management.

Table 2. Different interpretations of the term "situation".

Decade	School of Thought	Situation element	Behavioral approach/ relationship between
1920s	scientific management	working process and method	employer - work - worker
1930s	human relations	collaborators	employer - working atmosphere
1940s	group dynamics	colleagues	manager - team
1950s	management styles	supervisor	manager - collaborators
1960s	organization theories	organization	manager - organization
1970s	strategic planning	markets	manager - market
1980s	project management	projects	manager - project team
possibly 1990s	innovation management and productive partnership	cooperating partner	innovation manager - alternative problem solutions

Table 2, of course, only gives a very general picture; a more detailed classification is certainly possible. All schools of thought are highly active today. Different as they may be, they do, however, have one thing in common: the "human factor" as the core issue. The key element for innovations, as well as productivity and quality, are people, a fact which should not be forgotten (Figure 4). After all, technology is there for people. Any technological advances would be meaningless, unless they contributed to the well being of the people. People are in command of technology.

Change too, must be accepted to a certain degree. We cannot go too far, but we must not fail by doing too little. Such changes occur naturally. It is within this context that improving innovation, flexibility, productivity and quality must be considered.

Competition in the field of innovation, on the basis of new key technologies and products, new sources of supply, and new organizational forms, has assumed new dimensions worldwide. Any innovation process is characterized by three points of emphasis:

1. Situation and problem analysis for the identification of a new technological, economic, or social demand which has to be supplied, or of a technological, economic, or social cause of a problem which has to be eliminated.

2. The problem solution as such, i.e., an innovation which will cover the potential demand or solve the problem, must be problem-oriented and has to be developed in a creative as well as a methodical way.

3. Implementation of the problem solution, which is frequently confronted by a high degree of resistance.

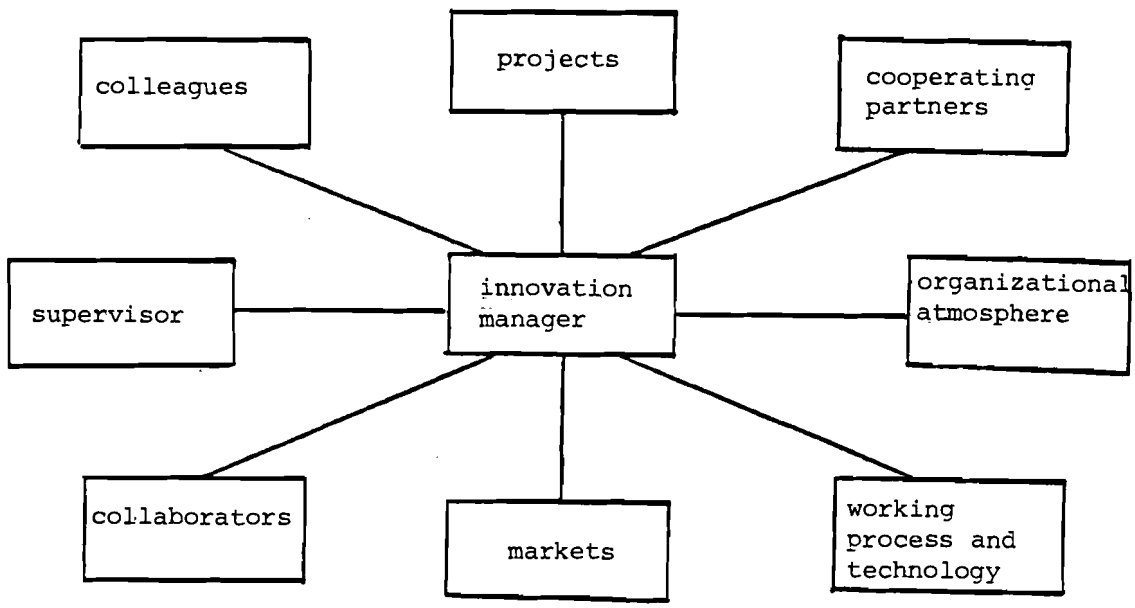


Figure 4. Situation elements of innovation management.

Innovations are above all the results of creative thinking and productive actions of individuals, groups, enterprises and whole companies. Whether we regard innovative planning of the future in terms of "global thinking and local action" or simply as a product innovation, a process innovation, or an innovated personnel and organizational development for safeguarding the future of its members, innovation invariably requires free creativity as well as problem-oriented creativity by qualified, motivated and responsible people. More than ever, human resources will have to be considered as the decisive strategic variable in mastering the future. Enterprises and companies of all countries only effectively meet the challenges of our time if they accept social innovation to range at least equal with technological and economic innovation. Since it is obvious that a successful "creative destruction" can only be effectively applied in a situation in which people constitute the demand side and the driving force as well as the balancing counterpart to these forces, I would like to develop my paper along the polarity between "creative destruction" and "productive partnership", which are the two sides of one and the same coin. I will, however, concentrate more strongly on the core issue of "productive partnership".

What does "productive partnership" mean? Productive partnership is a strategic concept. It follows the rules of a nonzero-sum game. In this case a better result is obtained for each partner—through the accumulation of forces—than one partner could have achieved by himself, as opposed to the principle of the zero-sum game, where the gain of one partner always results in the loss of the other. For the purpose of illustration I have chosen a well-known, extreme example. Let us assume that two people with highly contradictory personalities are locked in a cellar, in which the water keeps rising. Above them there is a trap door which can only be opened in a joint effort by both of them (see Figure 5). It can be assumed that everybody will prefer his life to his death. Thus two people will, regardless of their initial feelings and their prejudiced attitude towards each other, cooperate in order to open the trap door. The only possible problem they are faced with is "how" to coordinate their actions, and not "what" to do and "why". But the question of "how" is a question of creativity, i.e., of the common innovation potential available, of the productivity and of the will and the capability to form a partnership.

THE SYNERGY EFFECTS IN INNOVATION MANAGEMENT

As we all know, synergy is the combined action of various factors, organs or partners towards a jointly planned achievement, as, e.g., in an innovation process. Synergy effects are the utilization of available forces, resources, qualifications, experiences, devices, etc., for the implementation of tasks and projects. In the production process, comprising, e.g., the utilization of existing equipment, robots and procedures for manufacturing various products, in which experience can be applied, innovation synergy stands for the target-oriented use of existing human innovation potential, including motivation, creativity, productivity, etc., of the potential partners.

On the occasion of a symposium of Nobel prize winners, Eugene Wigner supported and extended this line of thinking by the following argument:

> The world is more closely interrelated than has been so far assumed. The increasing necessity of reaching aims through cooperation requires a rejection of the friend-foe paradigm, i.e., a rejection of

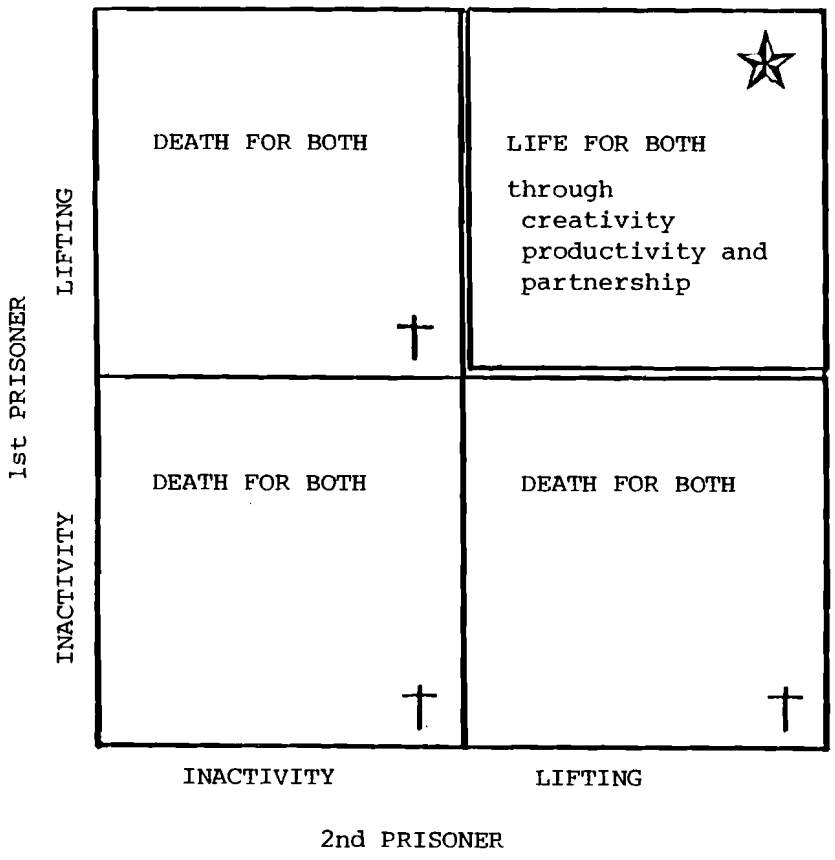
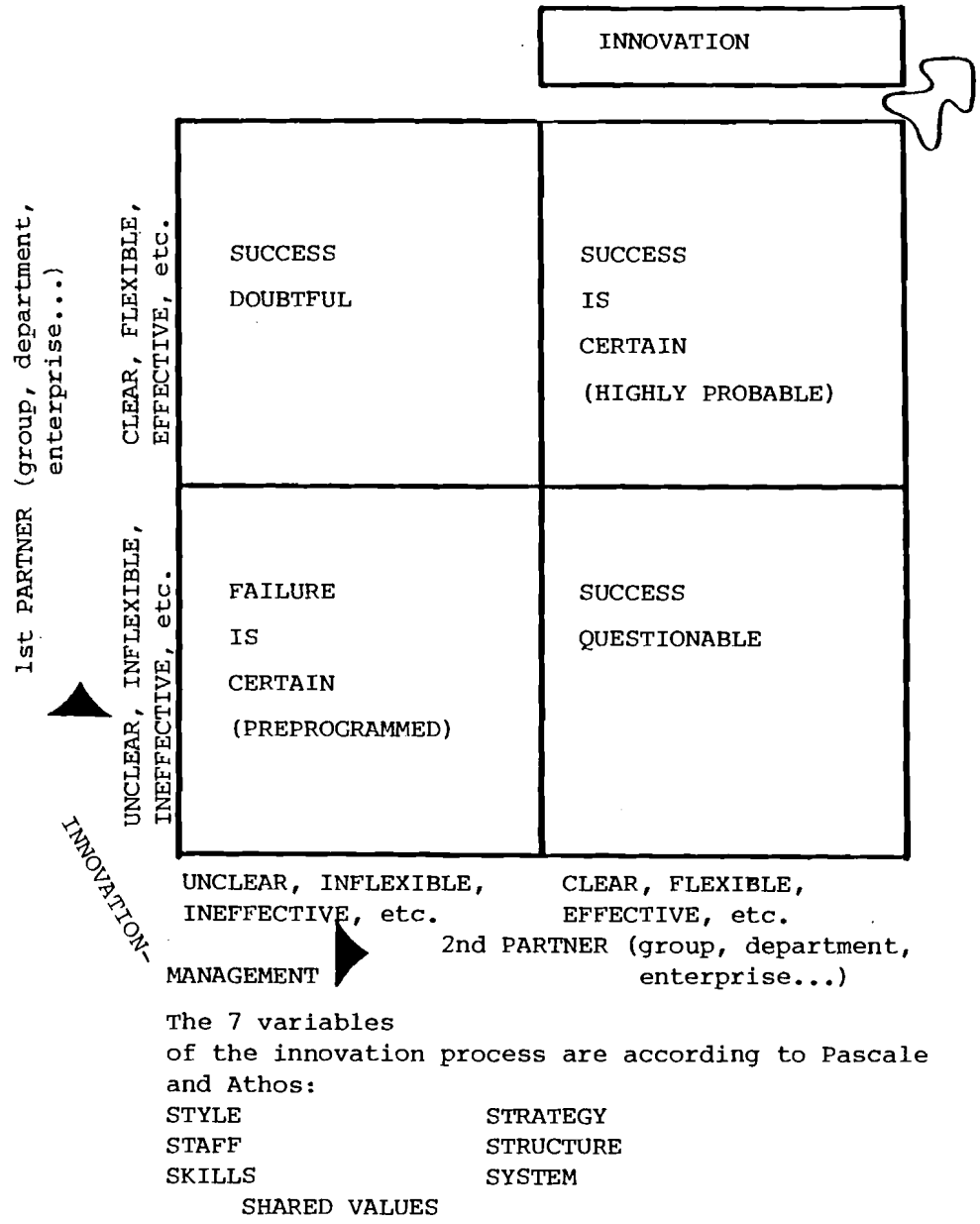


Figure 5. An innovation strategy approach.



The 7 variables
of the innovation process are according to Pascale and Athos:

STYLE	STRATEGY
STAFF	STRUCTURE
SKILLS	SYSTEM
SHARED VALUES	

> the zero-sum behavior in favor of the non-zero sum behavior. This means the acceptance of a potential partner and the realization of common interests in an organized 'productive partnership'".

One's own chances and, consequently, one's own security are primarily based on the security of the partner, so that goods may be acquired and preserved in a partnership situation.

The utilization of synergy potentials entails significant behavioral changes, a revision of the existing conditions, technological progress, joint economic activities, and last but not least, joint planning efforts towards a common aim. These behavioral changes require flexible thinking and are always connected with a learning process.

When we speak of the synergy effect we mean the supportive effect that various innovation activities exert upon each other, thus yielding better overall results than individual activities (Figure 6). An innovation strategy would, therefore, always tend to achieve a synergy effect; in this process it will, however, also be necessary to recognize possible disharmonies at an early point in time and to take preventive measures against their occurrence. Synergy effects can be best understood by way of their development. When we look at the behavior of systems, two different components can be observed: one component in which a certain behavior is retained through negative feedback; and a second one, in which a system becomes instable and tends to assume a different state; the latter is, e.g., illustrated in nature by the transition of matter from one aggregate state into another, or in economics by basic innovations, such as microelectronics.

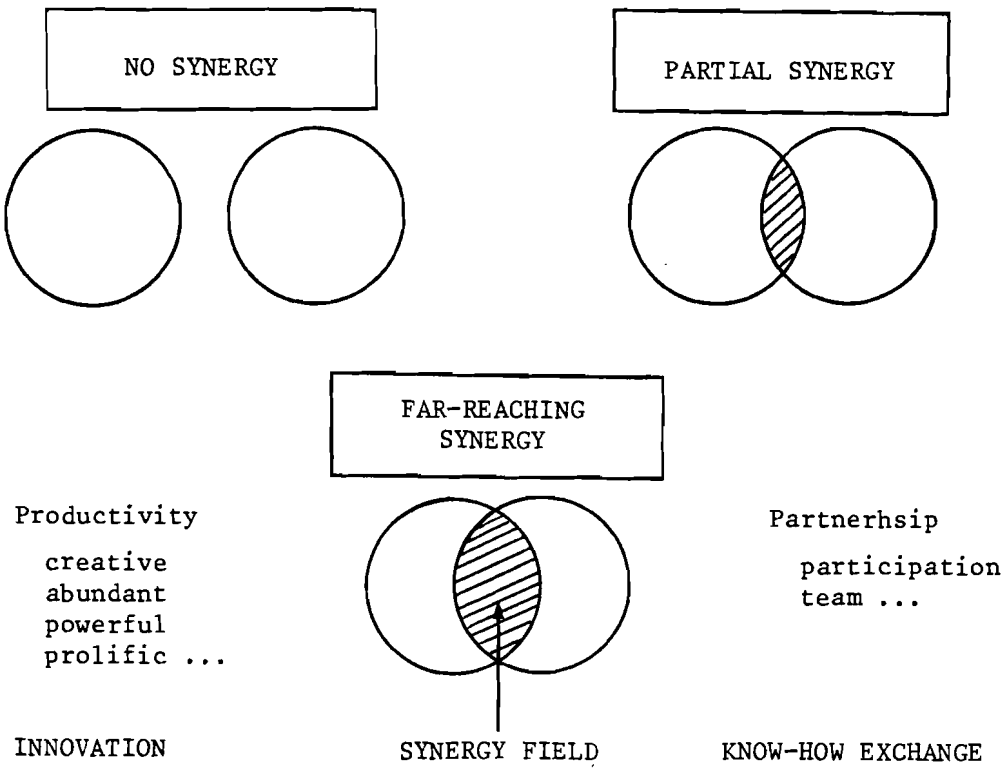


Figure 6. Synergy effects.

The basic idea of a creative partnership equally applies to project working groups, functional organizational units, whole enterprises and overlapping systems. The idea is based on the fact that all organizations are, in the first place, human communities, in which personalities of different qualifications, flexibility, motivation, and of varying innovation potential are united towards one common aim. This aim is the safeguard of long-term success (effectiveness)—a jointly accepted responsibility.

Those variables that play a decisive role in an innovation process are shown in Figure 7. They are described in more detail in, among others, the publications of McGregor (1960), Ouchi (1981), Peters and Waterman (1980) and Reddin (1970). Further coordination of these variables results from discussions with Dr. Vadim Goncharov and the participants of the past Task Force Meetings. Their juxtaposition does not present a "contrast" but a "polarity". Pascal and Athos have (possibly influenced by their Japanese experiences) subdivided the seven variables (of the scheme developed by McKinsey et al.) into:

three soft "S"	and	three hard "S"
STYLE (behavioral patterns and forms of cooperation)		STRATEGY
STAFF (collaborators and qualified managers)		STRUCTURE
SKILLS (capacities and capabilities)		SYSTEM (procedures, methods, technologies, processes)

headed by AIMS, i.e., strategic targets. This presentation is primarily intended to stimulate discussion (see Figure 8). In operational practice, three primary variables play the decisive role in innovation processes:

A	B	C
Style	Aims	Structure
Staff	Strategy	System
Skills		

In practice, success of failure of an innovation plan mainly depends on the interferences and their effective control, i.e., on the effective utilization of the synergy fields. However, organizational research has not established any proof of cause-effect chains between organizational atmosphere and productivity or between organizational atmosphere and innovation capacity. In his *Theory Z*, Ouchi ( ) writes that, among others, American managers are inferior to their Japanese colleagues with respect to the "soft S", partly because they rely more heavily on the "hard S". Pascal and Athos recommend that the American managers should learn from the Japanese to use more sublime methods than the head-on approach to the problem, i.e., to use the "digital" approach.

Certainly, "factual and analytical methods of problem solution" as well as tact and human warmth as an expression of "respect for humanity" are indispensible in any innovation process.

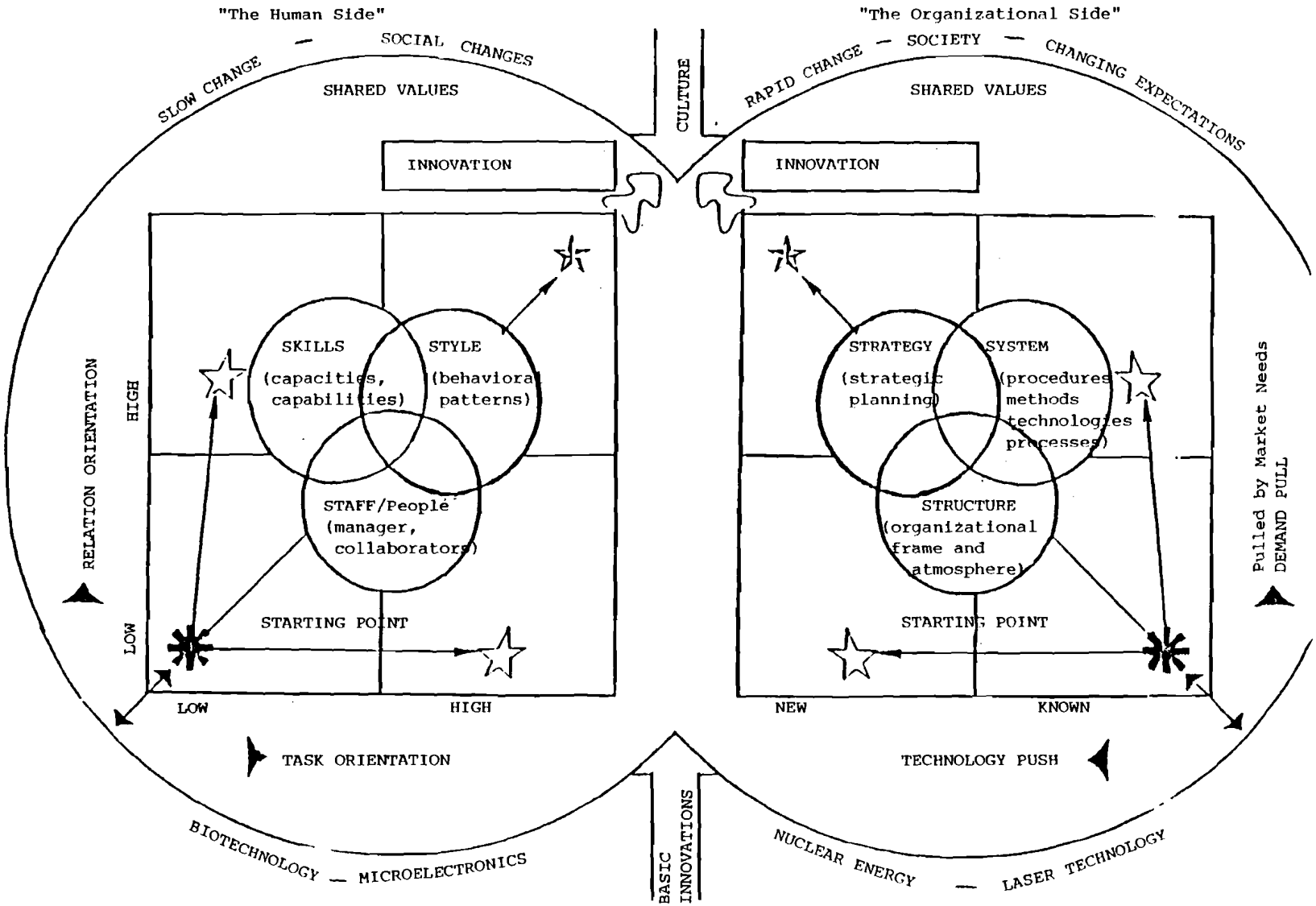
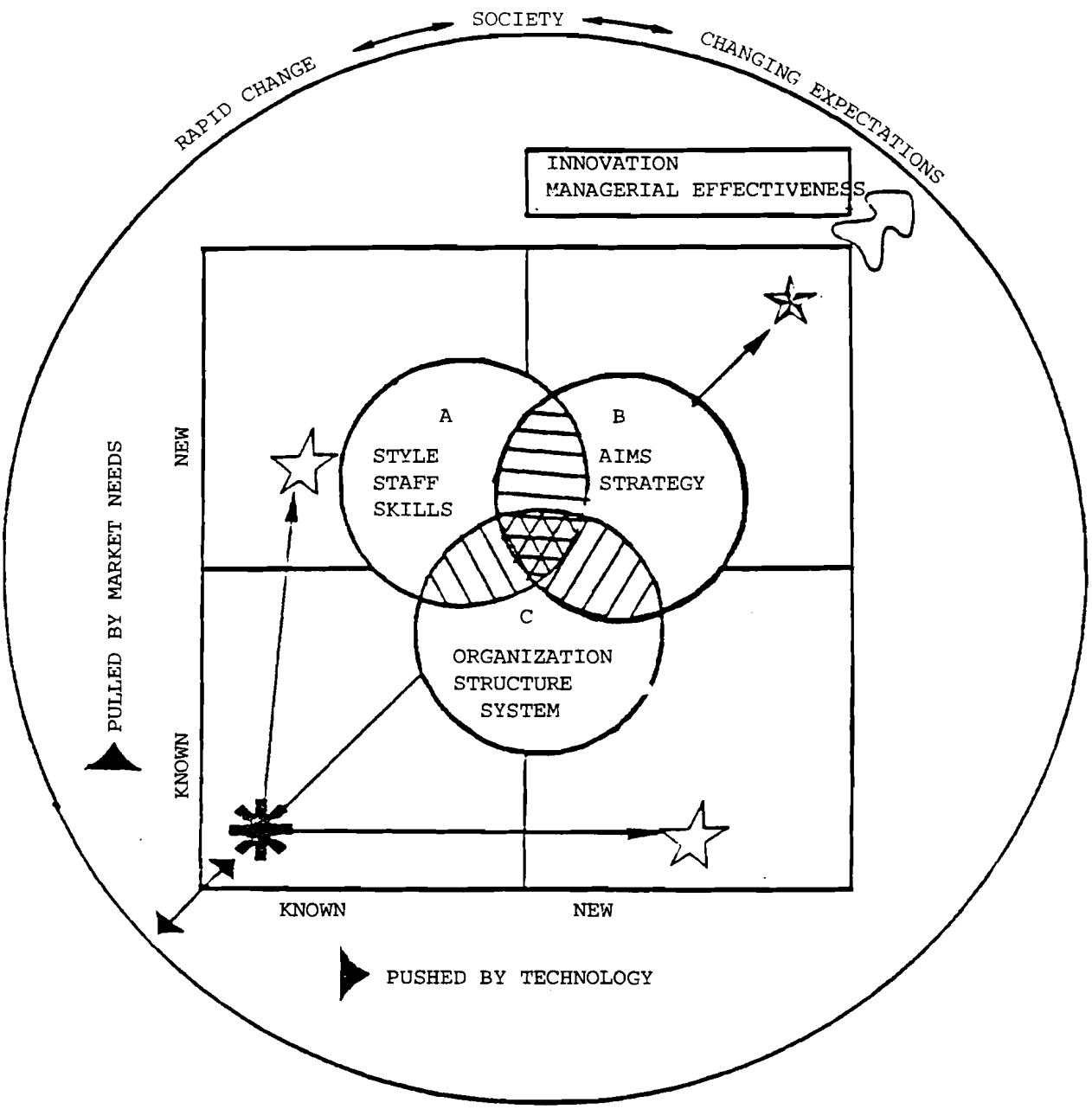


Figure 7. Reaching aims through collaboration: "productive partnership"

Reaching aims through strategic, tactic, and operational utilization of resources: "creative destruction".



A ..... HUMAN FACTORS IN INNOVATION MANAGEMENT (IM)

B ..... STRATEGY AND LONG-TERM PLANNING IN IM

C ..... ORGANIZATIONAL ISSUES IN IM

Figure 8. Primary variables of the innovation process.

STRATEGY: ACTIVATION OF HUMAN CAPITAL

In strategic innovation management, human capital plays the key role. By means of the strategic application of the intellectual potential a higher performance is achieved with the same resources, which means that, with reference to the innovative process, higher effectiveness will be obtained through a better utilization of the innovation potential (Figure 9). In a competitive situation, quality has become an increasingly decisive factor with regard to the existing innovation potential and its application. The human resources are the total intellectual capacities of the staff of an organization. Experience has shown that in an industrial production company, the unused intellectual resources are by far larger than is generally assumed, and little is yet known about their strategic significance. However, the mobilization of the total intellectual potential presents the only chance to be able to play a decisive role in international competition.

The activation of the human factor mainly consists in the development of an organizational atmosphere, in which each person is stimulated to contribute towards the human community as well as towards innovative activities and feels responsible for his role in this process. Innovative activities require the full utilization of a participant's capacities and behavioral potentials, target-oriented work within the community, and his contribution to its further development with continuous loyalty, and they also give him a feeling of satisfaction with the success of his community. A team that can cooperate in a productive partnership will experience the highest effectiveness and its members will experience a feeling of success, if they participate directly in the achievements attained, as, e.g., in the profit of the enterprise and thus show solidarity and identify with its aims. Then and only then, will they invest over and above their usual contributions, especially in terms of creativity, i.e., "human capital", into the maintenance and further development of their organization.

Motivation and a high innovation potential are the most important conditions for an effective innovation management. The innovation management will only be effective, if they produce—in agreement with all their staff—those innovations that guarantee the long-term effectiveness of their firm. The development of the human factor requires a constructive training program that deals with many aspects. In this program, the individual will not only learn new abilities and behavioral patterns, but will also get to know the spirit of the enterprise, which becomes integrated in his mind and usually acts as a creative stimulus.

Creative partnership involves working ethics that emphasize the aspect of "work" as opposed to that of "labor". Work is that part of an activity that has a meaning in itself, irrespective of the monetary compensation, and is important for a person's self-realization. Labor, on the other hand, is bought for money. Work forms a community of creative and productive partners; this does not apply to labor. While the time for work is not strictly separated from the concept of spare time, as work has a meaning, e.g., of being a jointly aspired innovation, the time for labor is clearly differentiated from spare time. Creative "organizational families" do not distinguish as strictly between working time and spare time. They also meet informally in their spare time, as the work for their own creative activities, thus developing a strong feeling of self-realization.

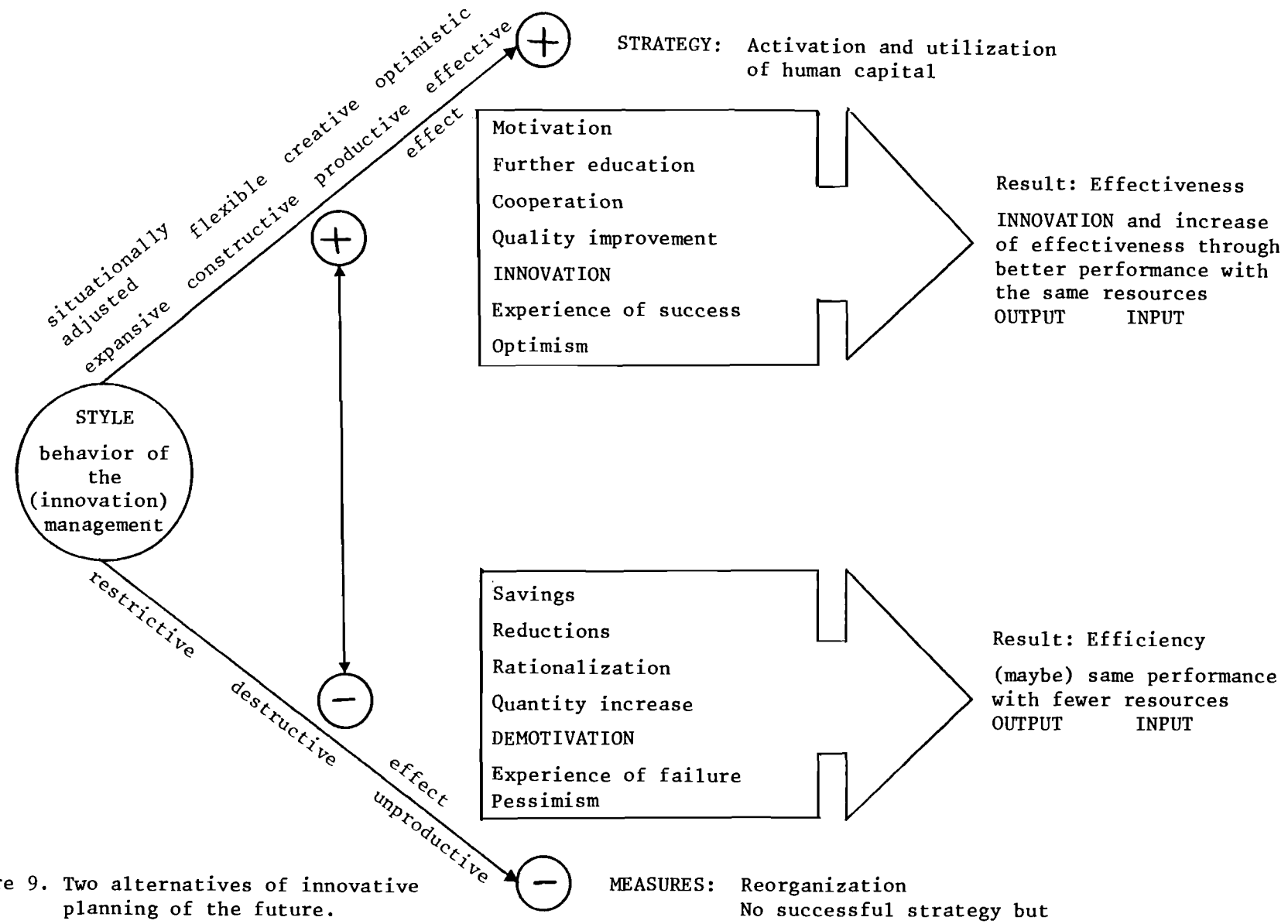


Figure 9. Two alternatives of innovative planning of the future.

Innovative enterprises differ from less innovative enterprises in that they stay relatively healthy even in difficult times and that they create more new jobs in the long run than they lose old ones (Figure 10). A disruption in the innovation process is dangerous, especially in rather traditional, centralized organizations, which are oriented towards large projects and mass production. They have to take special care to be flexible and to adjust their capacities to the varying needs of medium and small industrial enterprises. Such an effort will only be successful if all possible measures are taken towards its realization. Target oriented innovative activities lead to innovative symbioses of intelligence, if creative partners search for new problem solutions (while positively accepting technology and preserving their own tradition), if they have a thorough knowledge of the appropriate creativity techniques and apply them accordingly (see Table 3). In the following I will short recall the examples of "brain-storming", "brain-writing" and "synectics".

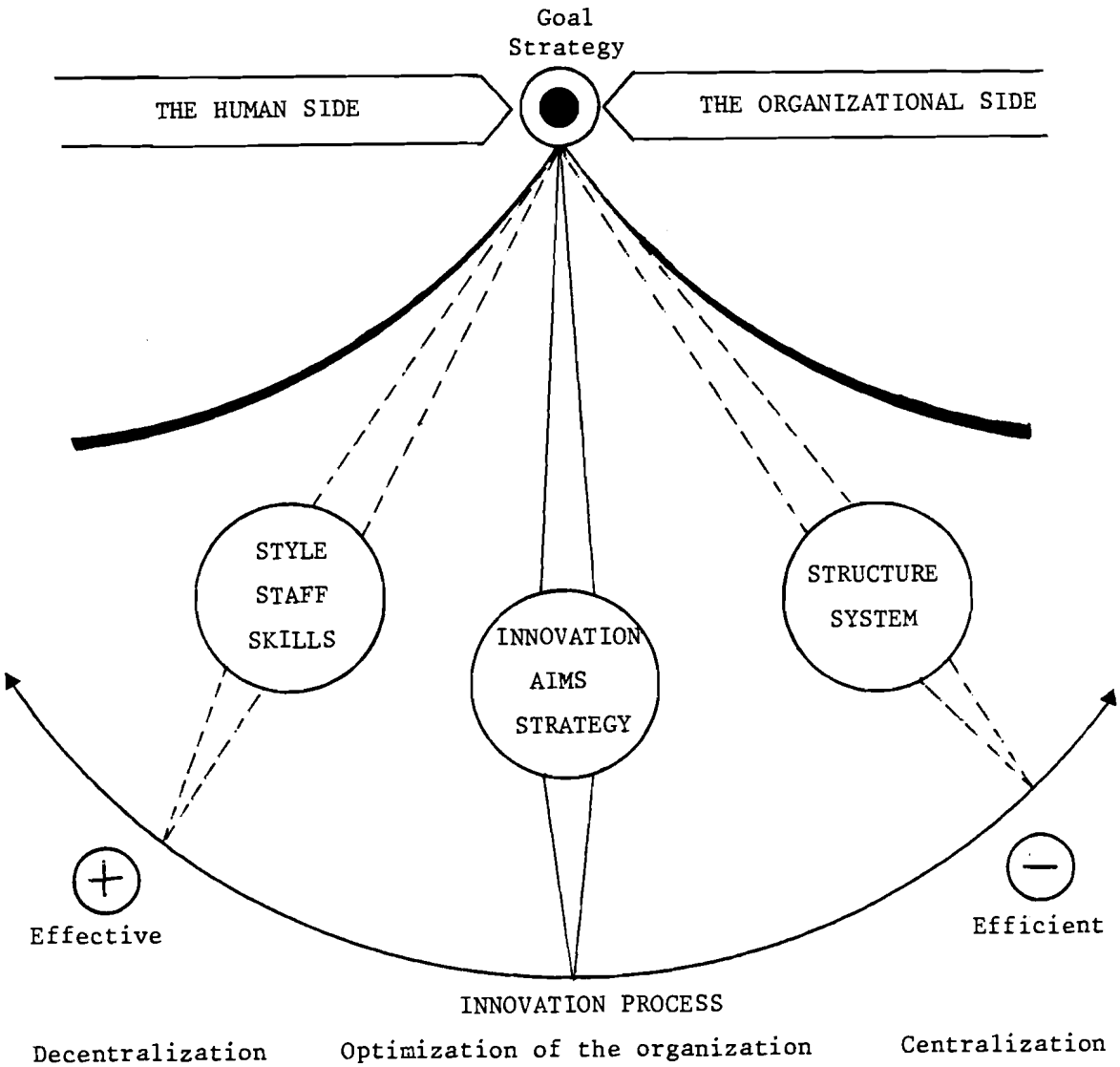


Figure 10. Optimization of the innovation process; pendulum between innovative and less innovative organizations.

Table 3.

Determinants / Technique	Problem	Rules	Participants	Mode of implementation	Control	Preparation time	Implementation time	Evaluation time	Result
Brainstorming	defined	few	5-12 persons	centralized	1-2 moderators	depends on procurement of devices	maximum of 30 minutes	medium	many ideas
Method 635	defined	few	usually 6 persons	usually centralized	only initiator, "time control"	short	45 minutes	medium	great number of solution approaches
CNB-Method	problem area known	few	experts	in writing, decentralized	only initiator	1 meeting	1-10 weeks	1 session	solution concept
Morphological Analysis	defined; suitable for morphological analysis	many	5-7 persons	centralized	moderator	not required	1/2-2 hours	long	solutions
Synectics	defined	many	5-7 experienced participants	centralized	moderator	depends on procurement of devices	2-6 hours	evaluation by external parties	unconventional solution approaches

Brainstorming

Probably the oldest and most popular of the group creativity development programs is brainstorming. Alex F. Osborn, a principal of a New York Advertizing agency, Batten, Barton, Durstine & Osborne, originated the process and it gained international prominence by virtue of his 1952 best-seller *Applied Imagination*. Utilizing a co-equal group with mixed backgrounds, large quantities of ideas are encouraged—no matter how wild, fanciful or unfeasible they may at first seem. *Quantity* of ideas is the initial goal with evaluative judgment suspended until all of the ideas have been triggered. All fear of provoking negative reactions is eliminated, and "hitch-hiking" or "piggy-backing" of ideas is supported. The idea-sparking technique continues with evaluation, development and submission of the best ideas presented.

Brainwriting

North Carolina's Center for Creative Leadership uses many of the basic techniques of brainstorming, but also utilizes other idea-stimulating methods. One interesting concept is brainwriting. In the brainwriting approach, ideas are not discussed openly by the group but are jotted down on pieces of paper. The papers are exchanged, minus the writers' names, to other individuals who build upon the ideas and pass the paper on once again until all have had an opportunity to develop each of the basic ideas.

Synectics

The synectics method was developed by Synectics Inc., of Cambridge, Massachusetts, and is described at length in Raudsepp's ( ) book *How to Create New Ideas for Corporate Profit and Personal Success*. According to Raudsepp, Synectics stresses the

> "...nonrational aspects of creativity, using analogies that provide novel contexts for approaching a problem with a fresh outlook. The two basic approaches in the Synectic's process are making the strange familiar and making the familiar strange."

Although there are many innovative elements to Synectics, a most interesting technique was inspired by George M. Prince, President of Synectics, Inc. The technique, called "goal wishes" requires that an aspiring creative person fantasize about how a particular problem could be solved if there were not any fiscal or technical restraints. After compiling a list of such fanciful solutions, the client is asked to come up with the most absurd methods of achievement—so absurd that the client would probably expect immediate dismissal had he seriously proposed them to his management. Known as the "get fired solutions", often at least one or two can eventually be refined into quite workable solutions. This is an excellent method of shaking loose repressed ideas.

I would now like to illustrate some general criteria that have a strong influence on the effectiveness of the existing innovation potential.

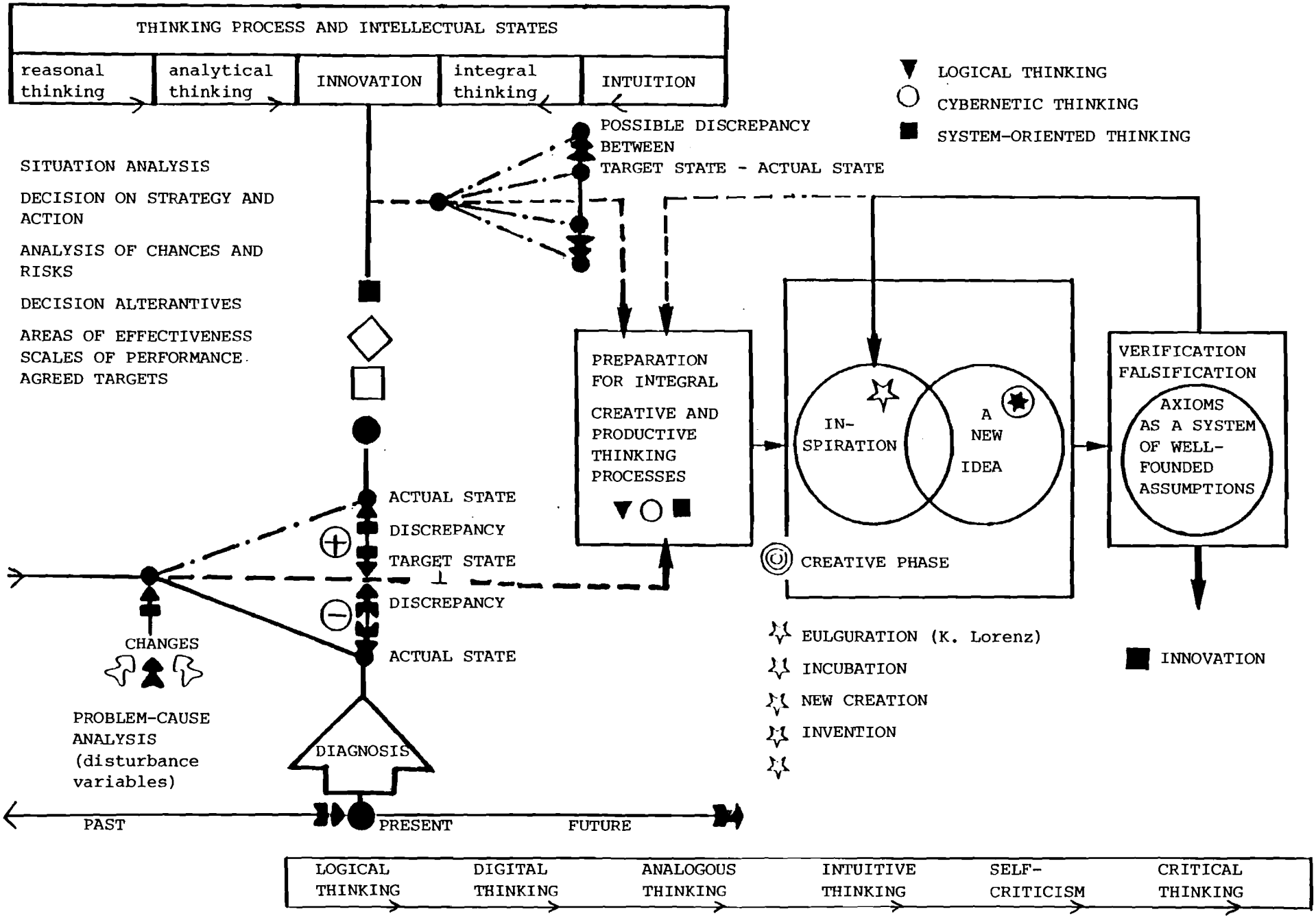


Figure 11. Integral innovative thinking.

THE ORGANIZATION AND MANAGEMENT CULTURE

In the course of their development specific organizational and management cultures have evolved in individual organizations or enterprises, but also in individual industrialized nations. These specific cultures make them capable of reacting in an appropriate way to present and future challenges by means of adaptation and innovation.

The Implementation of Organizational Changes Requires a Highly Qualified Innovation Management

In the operational practice—especially of large enterprises—there is often a discrepancy between the effort and expenditure invested in the conception, analysis, presentation and discussion of organizational structures, and the introduction, implementation and actual effectiveness of these planning processes. Frequently the organization has to pay for managerial mistakes of the past. In general it can be said that a stabilizing tendency by means of increasing bureaucracy is inversely proportional to the readiness for innovation and structural flexibility.

In an intercultural comparison the adaptation profiles of national economies are fairly similar. Significant differences are, however, observed if the cultural conditions are taken under consideration; these may facilitate or impede adaptability to a changed environmental situation and may thus promote or restrain the innovation potential. If a culture imposes restrictions on the organizational adaptation and innovation capacities, it may cause a potential weakness in the competitive position of its enterprises.

A short comparison with the Japanese cultural conditions shows that a distinctive group orientation and a highly developed consent mechanism—which are characteristic of this society in general and its organizational system in particular—promote adaptability and continuously increase the innovation potential, thus increasing conditions favorable for the survival of enterprises in the economic and social evolution process.

Organizational Culture

Many reorganization plans fail for lack of attention paid to organizational/cultural aspects. In such cases naturally grown relationships are frequently neglected, which do, however, play a central role in the occupational life of the members of an organization. According to William Osborne any enterprise forms, in the course of time, its own culture from "an organized body of conventional understandings". According to Geerd Hofstede this leads "to a collective programming of human thinking", i.e., experiences which an organizational unit (e.g., an enterprise) has gained in the past by way of successful and unsuccessful problem solutions, are automatically transferred into the present thus "anchoring the present in the past".

We have seen that apart from the environment, tradition also has an effect on the organizational culture, especially as the organizational culture establishes the link between tradition and innovation and presents the common denominator that is equally accepted by managers and staff—particularly in highly traditional enterprises. In the foundation phase of an organization only a slightly differentiated culture and thus a relatively broad orientation on new external influences can be observed; more advanced systems

show, however—again according to Geerd Hofstede—an increasing detachment from external influences. In view of the permanent confrontation with new requirements an organizational culture is constantly pushed towards adaptation and pulled towards innovation. According to Hans-Peter Thurn, organizational cultures are only viable in the long run if they prove to be good problem solvers.

In his book *Management in Foreign Cultures*, Eugen von Keller summarizes the special characteristics of a culture in the following concepts:

- Culture is man-man; it is a product of collective social thinking and acting of individual people.
- Culture is supra-individual, a social phenomenon, which outlasts the individual.
- Culture is learned by means of socialization and is passed on by means of symbols.
- Culture controls our behavior; it is expressed in rules, standards, and behavioral codes.
- Culture strives for internal consistency and integration. It is that instrument which enables society to adjust to its environment. For the individual person it provides approved methods and instruments to solve the problems of daily survival and to satisfy his basic biological and social needs.
- Cultures are adaptable, and they are at the same time subject to adaptation and innovation processes.

The special role of an organizational culture, i.e., to serve as a link between tradition and innovation, shall be illustrated in the following example. If we consider a company with a sufficiently long history we find that its so-called foundation phase will be characterized by rather informal behavioral patterns; in its more advanced stages of development, bureaucracy will, however, play an increasingly dominant role.

According to the doctrine of the Austrian Nobel prize winner Friedrich August von Hajek, an organizational culture is marked by the duality of a bureaucratically "imposed order" and a "grown, spontaneous order". The latter has been largely neglected in many Western and Eastern organizations, with the exception of the Japanese management forms. But it is the "grown, spontaneous order" that has a lasting effect on the attitude and the behavior of the management and the staff of an organization. It is usually stronger than any other order that is formally imposed by project plans, organizational handbooks, job descriptions and other organizational and management directives.

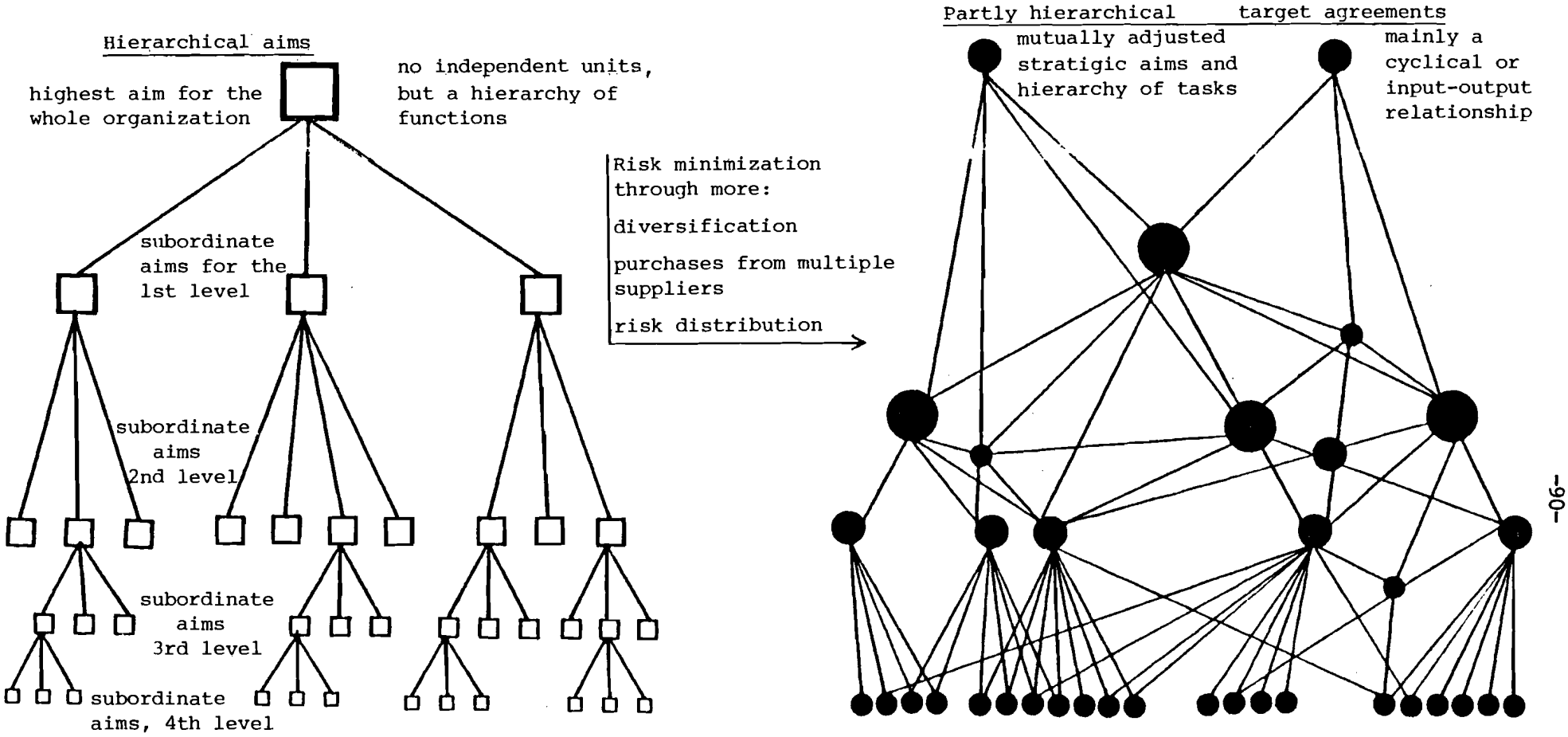
In his book *Theory Z*, William Ouchi illustrates the social background of the Japanese enterprises by the terms "collectivism - homogeneity - stability", in contrast to the cultural background of the U.S. enterprises, which he characterizes by the terms "individualistic - heterogeneous - mobile". For Ouchi the weakness of the American cultural background lies in the fact that there is only limited solidarity and confidence in the cooperation between managers and staff. What is attainable is only a loose coupling of their respective working processes. Prefabricated organizational solutions fail with respect to the development of completely new approaches to problem solutions. As the problem of harmonization becomes increasingly serious, the management will gain in terms of critical importance. A collectivisitic compensation system, as is practiced in Japan, favors organizational harmony.

Generalists are preferred to specialists, as they guarantee job flexibility; a generalist will furthermore integrate the basic values of the organizational culture in his personality and will, in any position, contribute to the success of the whole organization together with his colleagues. In Japan, this development of the qualifications of an individual person to cover various branches in an enterprise is in full progress. In Europe, and especially in the United States, such a development takes place mostly *among* enterprises and here particularly *within* a special branch.

The cultural differences thus have major consequences for the professional qualifications and position of an individual person and they are reflected in the enterprises and in the design of their management systems. The collectivisitic integration of a system is based on a general feeling of adherence to and mutual support of a group. The group forms its own cultural environment, it thus is homogeneous in itself and differentiable from other units. An "innovative" collectivism, as is at present documented by Japan, is only possible if the question of the necessary harmonization within the system is solved. Japan has managed to solve this problem by the explicit recognition of the grown, spontaneous order.

The individualistic system strategy, on the other hand, concentrates on specialization as the main criterion for the qualifications and the position of an individual person. From the system's point of view the career of a specialist follows the lines of the functional hierarchy. In this way the boundaries between functional areas are frequently unsurmountable. The individual departments form their own "sub"-cultures. Thus an integration and coordination in the direction of uniform aspirations becomes very difficult. Recourse is sought in formal organizational and management systems which are then expected to superimpose uniformity on the entire system. Now, it can certainly be maintained that individualistic structures are more apt to meet the critical challenges of a company's survival by means of innovation. It must, however, be noted that in a collectivisitic organizational atmosphere any risk behavior necessitating innovation is usually avoided from the very beginning, which is mainly due to the technical and social dependence on the group. The creativity is directed towards risk reduction. The strength of this organizational-cultural approach finally lies in the imitation of successful innovations and their optimization in every detail.

The example of Japan furthermore shows that on the basis of risk reducing organizational forms new synergy fields with a high innovation potential can be opened up and utilized. The innovation potential will clearly be suffocated by excessive bureaucracy. The tendency towards coordination and integration, caused by division of labor and specialization, usually leads to excessive bureaucracy which leaves no room for the development of the existing positive effects. The "organization man", who maneuvers himself through a large organization, may claim to be individualistically oriented, but he is programmed towards risk avoidance just as a group member of a Japanese enterprise. He can hardly be expected to give innovation stimuli. After all these considerations we shold really design the organizational culture of our enterprises in view of future challenges in such a way that they incorporate the apparently positive elements of both types of cultures, as far as they are compatible. An effective innovation management prefers an organization which is flexible and adaptible to problems and people, and not a mechanistic organization that imposes its hierarchical structures on grown-up persons.



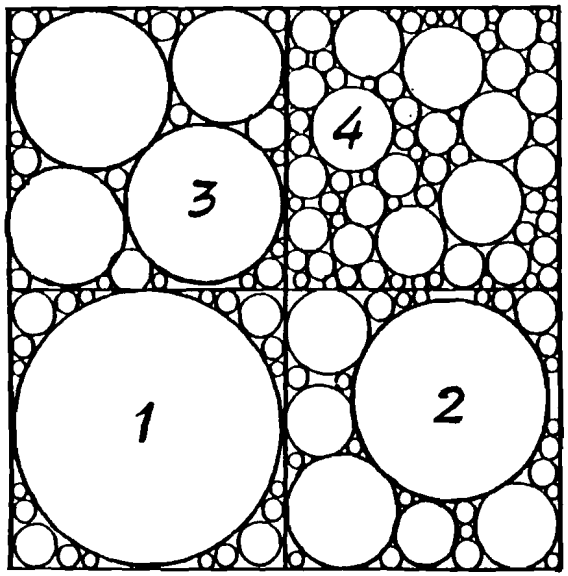
The function of the subordinate units is (mainly) derived from the aims of the higher unit.

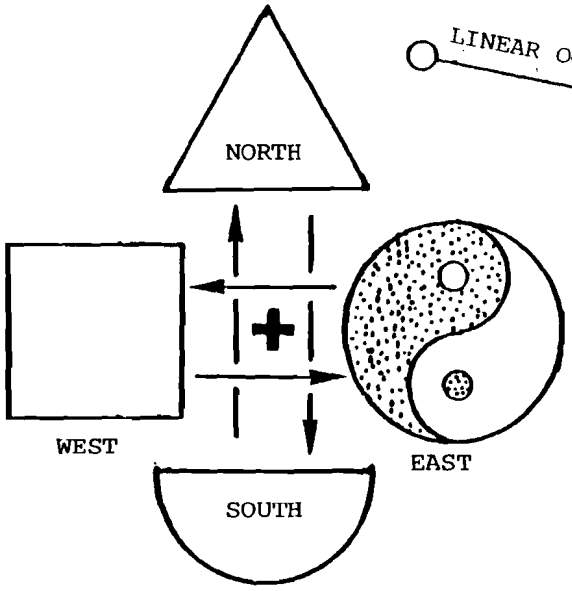
The function of the (largely independent) units is derived from mutually adjusted strategies.

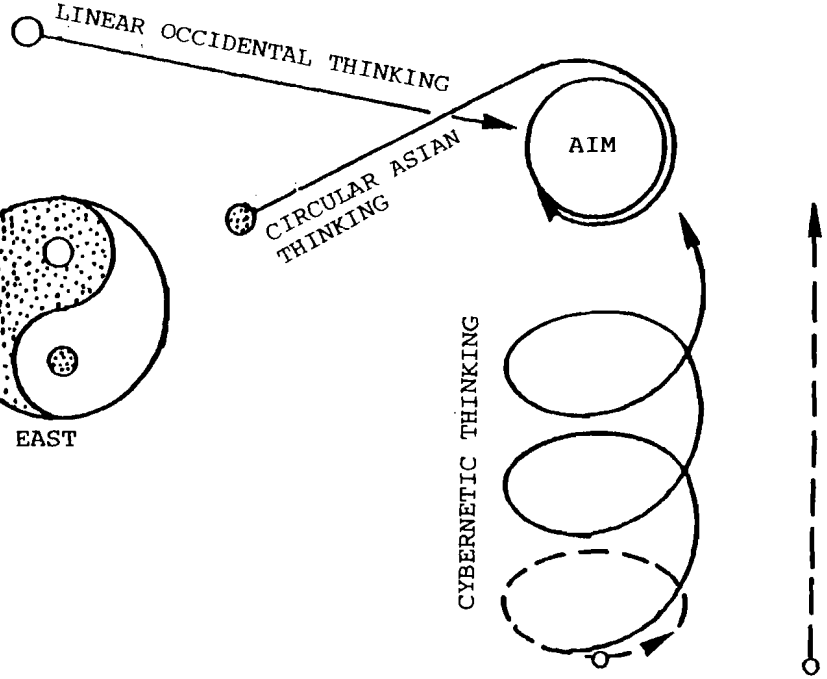
lower	equal	higher	FLEXIBILITY – INNOVATION – PRODUCTIVITY	lower	equal	higher
x			Flexibility of organization and staff			x
	x		Increase of innovation potential (job-relation...)			x
	x		Increase of productivity through synergy effects			x
		x	Individual risk in case of unforeseen changes	x		
	x		Possibility of collective risk reduction			x

Figure 12. Risk reduction and additional gain through synergy effects under change.

SYMBOL FOR VIABLE ORGANIZATIONAL UNITS
FROM SMALL GROUPS TO LARGE ORGANIZATIONS







(1) ● MAXIMUM SPACE UTILIZATION
○ SMALLEST SURFACE AND INFORMATION FLOW,
□ I.E. MINIMUM POINTS OF CONTACT
◇ AND MINIMUM COMMUNICATION

(4) ▣ OPTIMUM SPACE UTILIZATION
▣ LARGEST POSSIBLE SURFACE AND
▣ INFORATION FLOW,
▣ I.E. MAXIMUM POINTS OF CONTACT
▣ AND
MOST COMPREHENSIVE COMMUNICATION

A SYMBIOSIS IS THE CO-EXISTENCE OF HETEROGENEOUS SYSTEMS FOR THEIR MUTUAL BENEFIT:

PHOTOSYNTHESIS	- RESPIRATION
COMPETITION	- COOPERATION
PHYSICS	- PHILOSOPHY
MALE	- FEMALE
EXPANDING	- CONSERVING
YIN	- YANG
WEST	- EAST
NORTH	- SOUTH, etc.

A SYNBIOSIS OF A CIRCULAR AND A STRAIGHT MOTION IS THE SPIRAL, THE SYMBOL FOR CYBERNETIC OR SYSTEM-ORIENTED THINKING

Figure 13. Co-operation of various kinds of systems for their mutual benefit.

Two organizational principles support the development of the human factor in innovation management:

1. The establishment of a project organization for operative and strategic innovation tasks. This means that according to the respective problem a project group is put together in which the project leader, who takes the responsibility for the project, is primarily in charge of motivation and coordiantion. The thinking and working process is not carried out in organizational "boxes" but in innovative projects.

2. The consistent application of decentralization. Work is carried out in clearly defined units, together with many departments and cooperating partners. Both organizational concepts, the project organization and the work carried out in clearly defined units, are, apart from being effective, conducive to the development of the communities in the sense of "creative partnerships" (Figure 14).

WHICH GENERAL ABILITIES CHARACTERIZE AN EFFECTIVE INNOVATION MANAGER?

Management Style

- follows a clear line in his management activities
- participates in the solution of problems and decision making
- negotiates and stipulates clearly defined aims
- motivates the team to reach the aim
- delegates (tasks and responsbilities)
- makes well-founded decisions and is responsible for them
- may form teams from various disciplines
- can interest and stimulate cooperators
- knows how to settle conflicts
- communicates orally and in writing with all levels
- promots a good working atmosphere, which has a positive influence on team work
- interacts with the upper management.

Technological Know-How

- understands the technology relating to the design, development, and realization of a project
- understands the applications, market and customer demands
- knows how to manage technologies
- knows how to assess risks and make adjustments
- can predict technology trends
- contributes towards a problem solution
- communicates effectively with all project members.

Experience in Administrative Matters

- knows how to plan innovation projects
- negotiates on resources
- succeeds in obtaining promises
- sets measurable yardsticks

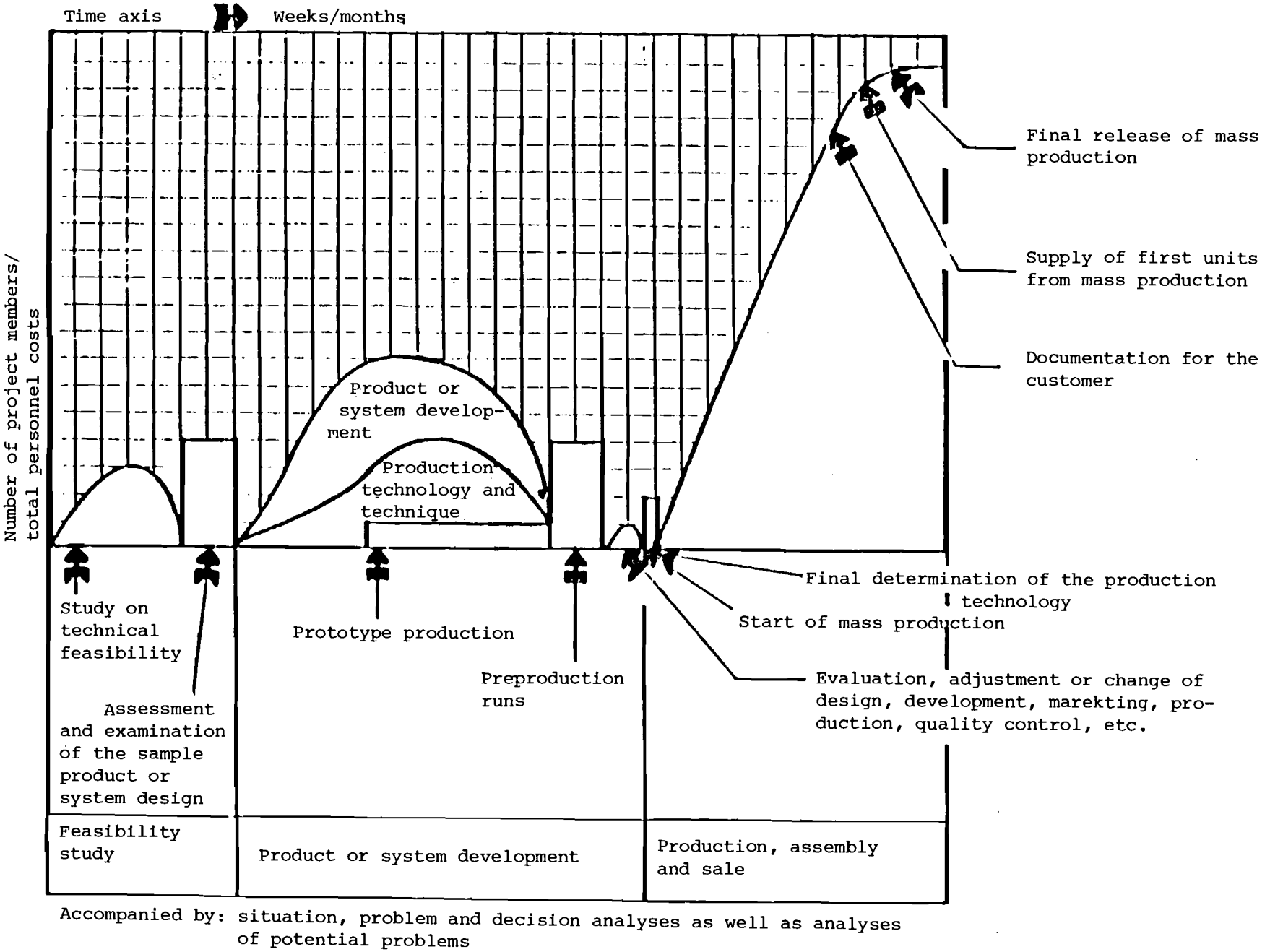


Figure 14. Critical phases in the innovation process.

- o schedules operational processes
- o establishes and maintains a reporting and checking system
- o establishes and manages a project control system
- o effectively applies program-management-instruments and techniques
- o carries out careful personnel planning.

Organizational Talent

- o knows how the organization works and how effective cooperation can be achieved
- o sets up multi-functional teams
- o cooperates effectively with experienced management
- o understands organizational points of intersection
- o knows how to arrange an effective project organization.

Entrepreneurial Functions

- o thinks/works from the perspective of the total enterprise
- o leads a project as a business
- o reaches the innovation aims.

WHICH CRITERIA ARE DECISIVE FOR AN INNOVATION MANAGER?

The usual definition of a manager stipulates that he should be a personality who effectively guides his staff and their work and who is himself effective. This is, however, according to our earlier considerations of the most important situation elements and innovation variables, a too narrow definition. An innovation manager must be able to think as well as act in an entrepreneurial way. But he must also have one more quality which cannot be learned, a qualification he cannot acquire, a quality which he just has to have. This qualification is not genius, but character.

What are the specific traits of character of an innovation manager? They cannot be generalized, as they are strongly influenced by the entire organizational culture within which innovations are made. But there are some common traits.

Individualistic innovators, whether they are artists, scientists, engineers, economists, small groups of creative partnerships, project teams or others, i.e., all people of the past, present and future who have induced and will induce positive changes by means of target-oriented efforts, have one thing in common: they consistently invest their own capabilities in an innovation process, irrespective of the majority opinion. Only a small part of this effort is made for the purpose of innovation itself, the major part results from necessity. In this way people contribute unintentionally to a necessary renewal and thus to the welfare of humanity, which goes beyond all national, racial, confessional, and ideological restrictions.

Any innovation in the form of a product or a process manifests an intention, which is the cause of its invention; its implementation will then lead to new products, processes and structures. An innovation can thus be defined as an achievement expected to be reached before the product or process has been completed.

APPENDIX: ARE JAPANESE MANAGEMENT TECHNIQUES TRANSFERABLE?

G.A. Wolf - Laudon

In today's business atmosphere companies face new problems, unique opportunities and the unexpected. Not only must corporate management cope on a reactive basis, but growth must be developed via the sheer power of new innovative ideas. New products and services, effective world marketing strategies and entirely new technologies must be developed—all requiring a creative, free management spirit. No longer can we condone Taylor's arguments that concluded, "...all possible brain work should be removed from the shop." The subsequent compartmentalization of both work and management functions has outlived its usefulness. This is the idea behind the Japanese management style and techniques.

The considerable success of the Japanese economy has attracted the world's attention to the specific strategies, methods and techniques, i.e., to the Japanese organization of work and workers. Many managers from East and West have started to study the Japanese system, which appears to the outsider as a symbiosis of "entrepreneurial capitalism and entrepreneurial socialism" or, as a new kind of "productive partnership and corporate capitalism". In this connection, the interested external parties are immediately confronted with the question of which elements (where, when, to what extent and how?) could or should be considered in their own strategical plans, i.e., which factors could or should

a) not be transferred
b) be partly transferred by utilization of synergy effects, or
c) be fully transferred

to their respective systems?

From the European point of view, the symbioses shown in Table A1 may, e.g., lead to a desirable increase in the effectiveness of the management.

Table A1. Symbiosis of Japanese and American Management Techniques.

Japanese Management Techniques JMT	Possible and desirable symbiosis of mainly Japanese and American management techniques towards a (more effective) universal management technique, e.g., for Europe	American Management Techniques AMT
Life-time employment in one company	Long-term employment of staff	Frequent change of company
Slow evaluation and step-wise	Slow evaluation and promotion of staff	Rapid evaluation and career
Development towards generalists	De-specialization in the course of the career and development towards generalists	Career through specialization
Self-regulating control	Self-imposed control combined with agreed control measures	Clearly specified controls
Joint decisions	Decisions based on general consent	Individual decisions
Joint responsibility	Personal responsibility in reasonably large units	Personal responsibility
Total integration of the staff members	Integration of the personality of the staff members including their private sphere	Interest in staff members limited to the working sphere

The effectiveness of a management is manifested in their ability to

a) change complex situations and/or
b) to adapt to these situations

to such a degree that guarantees increasing success (output) with equal resources (input). Or, in other words, the effectiveness of a management can be measured by the degree of successful substitution of energy and resources by information.

Japanese management has, since the end of World War II, demonstrated its effectiveness, among others by means of the management innovations shown in Table A2. The main interest in the Japanese management system focuses on how it can satisfy two contradictory demands:

a) Far-reaching job and income security
b) Flexible, highly qualified and adaptable staff, and
c) Flexible payroll costs depending on the company's success.

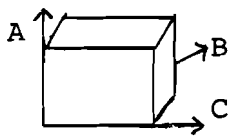
Table A2.

Tradition (Input)	Strategy and Activity (Transfer)	Innovation (Output)
Separate thinking and separate labor = higher productivity	1950 start of quality control. Increasing productivity through improving quality of each working process in every area of operation and all levels of management	Thinking workers are much more productive and creative workers
Higher quality = higher cost	After implementing "TOTAL QUALITY CONTROL" in production and service, later on constant QUALITY IMPROVEMENT also in sales, finance, administration, etc.	Higher quality = lower cost
Larger lot = lower cost	After eliminating all defects in the production process, change of the production scheduling system and step by step automatization (Fundamental idea of TOYOTA's KANBAN System)	Smaller lot = lower cost

For further orientation, the most important elements of success of an enterprise are illustrated in relation to each other and to the environment in Figure A1. Even this very simplified figure demonstrates the complexity of the subject. A further simplification is, however, required so that the presentation may be limited to the essential points.

The Japanese management techniques are thus illustrated, compared and studied with respect to their synergy effects by concentrating on three key areas of the management:

A. Human Factor - Style
B. Strategy
C. Organizational structures



Other important situation elements will, however, have to be neglected because of the limited space and time available for this discussion.

The gap between the principal impossibility and the potential possibility of fully transferring a method, a technique, etc., from one system to another is overcome by synergy. As has been pointed out before, synergy is the cooperation of various factors, organs, methods, techniques, processes, etc., or of "productive partners", towards a joint and coordinated achievement. This gives rise to an innovative learning process which may lead to joint (symbiosis) or new organs, methods, techniques, processes, etc. (see Figure A2).

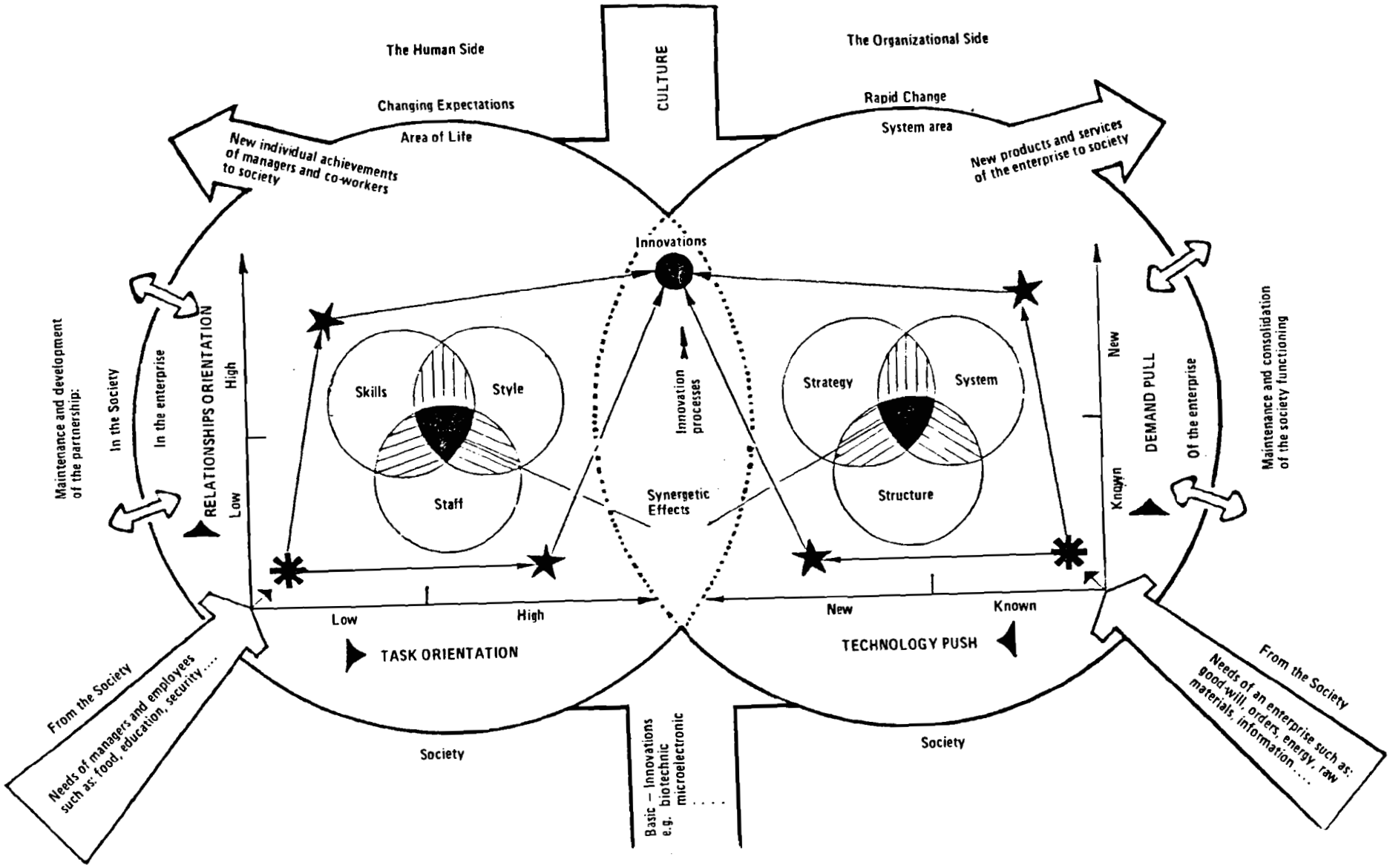


Figure 1. Elements, influencing quantities, and synergy fields of an enterprise in relation to each other and to the environment.

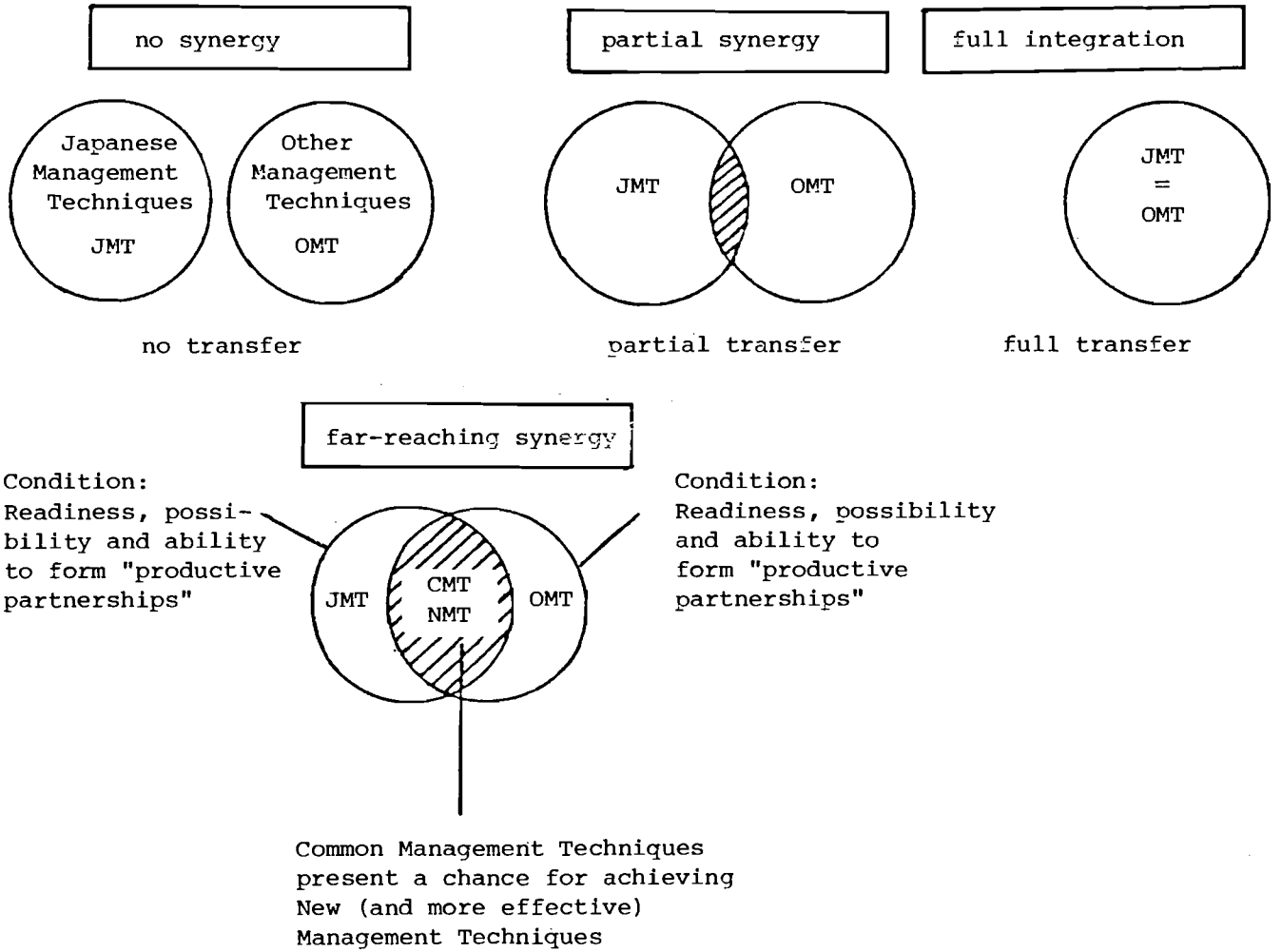


Figure A2. Synergy effects.

In the following situation analysis it is assumed that the "potential partners" are willing to accept the "Japanese Management Techniques". Thus only the possibility and ability of transferring Japanese management techniques are assessed. The following criteria are partly taken from critical American and European situation analyses of the Japanese management. They may sometimes be exaggerated or inexact. They should, however, be sufficient for outlining a certain tendency.

Japanese management techniques are:

a) not transferable
b) partly transferable by synergy effects
c) fully transferable.

A. THE HUMAN FACTOR	a	b	c
The key idea of the Japanese "Corporate Capitalism" contains in its "capital" the investment aspect of the staff. They invest over and above their normal standards in terms of "human capital".		x	
The community of managers and staff directly benefits from the achievements of the enterprise and fully identifies with its aims. The old stock of the staff (permanently employed members) call the enterprise "out enterprise" because they consider themselves co-owners.		x	
The primary common aim of the staff and the managers is to guarantee long-term success of the enterprise			x
A human community has evolved as a system of values which did not develop the kind of individualism and personal rights that emerged in the West in the 17th and 18th centuries.	x		
Frequently the role of the trade unions is compared to the role of "the mother at home" as opposed to the "father's role", which refers to the management. The fastest way to attain a top management position is often by starting as a trade union secretary.	x		
Frequently the Japanese do not distinguish as strictly between working time and spare time. Japanese working groups also meet in their spare time, actively employing their intellectural abilities for the benefit of "their own enterprise". In this way they get a strong feeling of self-realization. In other countries this is only expected from the management.		x	
Human harmony and cooperation is considered to be the most important condition for a management position. The higher his position, the more important it is for the manager to be in agreement with his staff and to promote their initiative.		x	

	a	b	c
The supervisor has to "build golden bridges" to be able to draw back without losing his face. The signals on the evaluation of his own person given by other group members, and especially by his superior, are extremely subtle, though they are constantly challenged.		x	
There is a strong operation orientation and a generalization of the management through extensive rotation.		x	
B. THE STRATEGY IN JAPANESE MANAGEMENT			
The interlinkage of trading companies, industry, banks and ministries (MITI and MOF) is one of the most important pre-requisits of the successful Japanese economy.	x		
In a—relatively small—economic elite effective voting and consent procedures are carried out which,		x	
"in plotting a strategy for economic growth (MITI)" shape "the structure of industry by using its control of investment and access to technology to nuture some industries and let others wane" (Chalmer Johnson in his new book *MITI and the Japanese Miracle*).	x		
Owing to the MITI voting system Japan has today a larger knowledge and further-reaching expereinces than any other country with respect to disencouraging out-dated industries (e.g., wharfs, petrochemical industries) and supporting new industries.		x	
Japanese enterprises dispose of a world-wide sensory system for tracing new ideas and trends, new research and development projects, and their results.		x	
The aim is highest quality of the respective product. In this way complaints and criticism are avoided and a larger scope for price-policy measures is gained.			x
Quality is the primary issue in production as well as in marketing and sales policies.			x
New production concepts are pragmatically tested on the market. This leads to a high introduction rate of new products. Products which are not accepted are rapidly withdrawn from the market. If the products are, however, successful, they will be supplied in great quantities.		x	
An essential element in Japanese management seems to be target-oriented production.		x	
Special attention is paid to the market leader, who presents a great amount of important information for a company's staff, as e.g., "What do we have to do in the development, production, and sale categories to be better than IBM?"			x x

B1. THE STRATEGY: JAPAN

for the US and Europe
it seems to be: not:
a b c

The targets stipulated by MITI for the economy are evident. Four points of emphasis can be clearly recognized:

- o Independence of energy imports through the development of alternative industries.
- o Development of the information technologies of the 5th computer generation ("artificial intelligence") and thus the elimination of the weaknesses connected with the development and the supply of software.
- o The increased living standard of the Japanese. This also involves, apart from the environmental measures already enforced in the past,
- o the development of future technologies, such as, e.g., gene technology and similar new approaches which will result in industrially exploitable developments in the 1990s.

In all these projects cooperation with other industrialized nations is intentionally and consciously aspired in order to develop a climate of international trade which would prevent any future trade restrictions.

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REQUIREMENTS FOR MANAGERS' PERFORMANCE IN THE 1980s AND POSSIBILITIES FOR THE DEVELOPMENT OF EFFECTIVE MANAGEMENT

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INTRODUCTION

In the past 10 - 15 years considerable attention was paid in Czechosovakia to the problems concerning the personality of managers, particularly in the theory of management and courses for managers. Various models for a successful manager were created and managers were tested to find out whether they possessed the required capabilities.

On the theoretical side the problems of managers were dealt with mainly by psychologists and sociologists. Certain "professional blindness" appeared in their approaches, as in the vast majority of cases they did not examine the success of managers' work in the context of concrete conditions (technical, socioeconomic, political, etc.). When we exclude a manager from the context of the above mentioned conditions we are able to obtain only a considerably abstract model, which is of little practical use.

A rather different approach consists of examining the performance*) various successful managers operating under certain conditions and comparing this performance with less successful managers, i.e., to find out those factors which differentiate successful managers from unsuccessful managers. This approach is more advantageous mainly because certain ways of performance can be more more easily modified than the features of a person, even if it is not always easy to change the accustomed working methods and to quickly overcome habits formed over a long period.

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*) Managers' performance means here the management activity performed by a manager in order to fulfil his objectives. In the following paragraphs I stress decision-making and the implementation of these decisions.

THE EXPECTED DEVELOPMENT OF CONDITIONS IN THE 80s

From a sample carried out in 1981 in 12 industrial enterprises and companies it was found that the performance of top managers was basically determined by technical, economic and socio-political conditions. (The review was carried out as a half-standardized interview.) Hence, first of all it is necessary to make an analysis of the probable development of the above mentioned conditions during the 80s and then to evaluate the corresponding managers' performance from the expected development (we are focusing here only on top managers operating in various enterprises and companies).

THE DEVELOPMENT OF TECHNICAL CONDITIONS AND THEIR IMPACT ON MANAGERS' PERFORMANCE

It is generally presumed that time is marked by fast creation and introduction of technical innovations into the production. We are speaking about the so-called scientific-technical revolution. However, closer analysis of technical innovations proves that within the last approximately 20 years, inventions in current products, materials and technologies were introduced, e.g., the electrotechnical industry is based on inventions dated from the end of the last century and the beginning of this century.

In the recent years, research and development were basically concentrated on the solution of problems which could be quickly introduced in practice; consequently, scientific-technical development has speeded up. In the years to come, a turn to more radical changes can be expected, mainly in technology. Research and development will begin the gradual orientation towards the solution of problems probably leading to radical concurrent changes in the methods of work, in organizational structure and in managerial performance.

The introduction of additional technical changes influenced the managers' performance mainly in that they saw the focus of their work on the fast solution of clearly defined objectives. The implementation of additional technical changes implies a smaller risk of failure than the orientation to radically new materials, products, and technology so far not tested. In the managers' work, routine management approaches outweighed creative activities. When implying additional changes, it was possible to make use of experience gained in the previous practice. The managers' performance was principally based on the experience gained in the past.

In the future, the focus of managers will probably be shifted to the sphere of creative management to the detriment of routine component of management. Radical innovations have certain features which influence the change of managers' performance, namely:

- a high risk of failure in the production and on the market;
- unclearly defined objectives, long-term and difficult implementation;
- difficult adaptation of personnel to the change of technical and other conditions (it is necessary to overcome the resistance of personnel).

The above mentioned features have impact on management work. It is necessary to use other methods of work in the radical innovation times than in the period of additonal innovations. Under these conditions only those managers who are able to accept high risk appear to be successful. Analyzing more closely this problem we may find out that a successful manager identifies himself with the new problem even if it is connected with high risk of failure, however, he believes in the possibility of its implementation and commercial success. The rate of innovation risk is considerably subjective. From this point of view, a successful manager estimates the risk of failure lower than the others. On the contrary, an unsuccessful manager sees the same problem as too high a risk of failure, because he does not believe in the possibility to overcome the expected obstacles. A successful manager realizes the risk, however, and believes in the possibility to overcome the obstacles. He sees his opportunity in the solution of a difficult problem and is striving to create such conditions, which would enable him to implement such an opportunity. An unsuccessful manager does not see the possibility of the problem implementation. For a successful manager it pays to undergo the solution of difficult problems, for an unsuccessful manager these problems cannot be solved.

A successful manager is able to find the resources for the solution of a difficult problem, to mobilize and use untraditional methods in order to exploit the above mentioned resources for the solution of new problems.

Successful managers are solving unclearly defined objectives of radical innovations by means of various methods, which can be summed up under the title "systems approach". Unsuccessful managers usually backlog these problems or are passing them to their subordinates. Successful managers are marked by the fact that they see their opportunity in these problems and get involved in their solution, and try to understand the problem as well as they can, they can give priority to these problems. The given problem has strategic importance for them. The personal strategy coincides to a considerable extent with the company strategy, as such problems enjoy the *priority* in the whole organization.

It is also interesting to mention how successful managers deal with long-term objectives. Usually, they divide the problem into partial stages which they check and make conclusions for further procedures. Sometimes, the solution of the problem has to be basically changed or the solution of a given problem is stopped in time and the resources are shifted to other problems. From this context, a successful manager appears to be very flexible in his ideas, in decision-making and in the implementation of his decisions. Sometimes, he often changes the objectives, organizational structure, and contacts with other organizations.

Radical innovations usually do not enable use of current knowledge, experience, and habits. They also change the status of personnel within the organization, including informal working groups.

Successful managers appear to be ready to give up current habits and organizational relations. They often re-evaluate their management practices, are self-critical, dynamic in their ideas, in decision-making and in further management activities. They often adapt themselves to changes. Besides that, they require the same features and performance from their colleagues. They are not only able to adapt themselves, they also help their colleagues to the same adaptation. The main method appears to be frequent contacts with

their colleagues, frequent discussion, evaluation of success or failures, and orientation of the personnel towards the future. They use, e.g., brainstorming, informal discussions during their rounds through the working sites, and face-to-face discussions.

Under such conditions, a successful manager uses usually democratic or liberal management methods. He tries to convince and gain the support of his personnel for new ideas. He often has long discussions which seemingly do not touch the problems of a given organization. Generally, scientific-technical development, economic problems, etc., are being discussed. The purpose is to bring about a creative atmosphere and readiness to solve further problems. In case of necessity, he is capable of quick decision-making and enforcement of his decisions, because he knows what he can expect from his personnel, which arguments to use, and where he is right or wrong.

DEVELOPMENT OF ECONOMIC CONDITIONS AND THEIR IMPACT ON THE PERFORMANCE OF MANAGERS

Our current management is based on the centralization of strategic decision-making. The five-year plan, divided into partial stages, appears to be the principal management tool. In yearly plans, concrete objectives of individual companies and enterprises are defined through the relevant ministries. Besides that, the activity of individual companies and enterprises is determined by a series of administrative regulations. Expanded administration appears to be the consequence of centralized management.

Detailed centralized planning was introduced in a time of lack of resources. Up to the mid-1960s the principal management objective was the increase of large-scale production in order to balance supply and demand. The economic growth was secured basically by extensive resources. We have realized that it was necessary to embark on the road of intensification, which required higher effectiveness. Gradually, the focus of management was shifted to effectiveness, dynamism, and quality. In 1980, the Czech Government approved "the Complex Program for the Improvement of the Management System After 1981".

In years to come, we may expect large differentiation of management, economic conditions, and the gradual creation of a larger space for the initiative of individual companies and enterprises. The extension of the decision-making authority will imply higher responsibility for the results achieved.

In the past, both the management tools and economic conditions were considerably novelized. Managers were operating in considerably similar inter-organizational and external conditions. As a consequence, it was possible, in the case of necessity, to move managers from various branches to higher managerial duties in other branches. In connection with the differentiation of management tools and economic conditions, the previously gained habits will be transferrable partly under different conditions.

The management activity in the centralized management was aimed at implementing given objectives. A successful manager was able to fulfil given objectives and mobilize resources. From the point of view of superior

authorities it was difficult to judge objective reasons for the non-fulfilment of planned objectives.

In comparison with the past, the decentralized management is marked by a certain "vacuum" in management tools (objectives, regulations, and procedures). This leads to differentiated approaches of managers. One group sees the opportunity for the development of their own initiative, the second lacks instructions. Hence, a successful manager becomes skilled in using the space for his management initiative oriented towards the effective production and increase of internal rationalization in a given organization.

Successful use of larger space for decision-making and higher responsibility for the fulfilment of objectives require numerous changes in the accustomed methods and style of management. Faster reaction to external impacts increases the importance of coordinated work. Top managers must achieve fast and effective coordination of activities in various sectors, e.g., sales, production, and technical development. The importance of economic calculations, as a basis for rational decision-making, is being increased. It is necessary to decide and act with sufficient information, while a very important role is being played by the so-called "soft information", e.g., marketing. It is not possible to hide behind the decision of a superior authority.

THE DEVELOPMENT OF SOCIOECONOMIC CONDITIONS AND THEIR IMPACT ON THE PERFORMANCE OF MANAGERS

Social stability was a part of stable productive-technical and economic conditions. Considerable personal and organizational security was achieved. In the future, faster technological and production changes will require a series of unpopular measures consisting of fast re-qualification. Under these conditions, the successful managers will be able to convince the superior authorities about the efficiency of the change and will get the support for new activities. One of the most important components in management will be to overcome the resistance of the people to change. It seems that these processes will not always be simple and without problems. Managers will have to devote more time to communicating objectives, goals, strategy of organizational development, and common efforts in order to successfully implement the above mentioned objectives.

The moral and political profile of the manager is a very important personal feature in socialism. Managers are entrusted with human, material and financial values, and they decide about their use. It must be admitted, however, that the manager is not bound to his/her organization and managerial duties by his property, nevertheless, he may be afflicted financially or removed from his post. Even in the case of his incorrect decision-making he does not always experience the full economic consequences, namely in strategic decision-making.

In decentalized management, the space for initiative decision-making and social responsibility is being enlarged. Managers with social responsibility can be characterized by the following features:

- knowledge of social priorities, objectives and personal identification with mentioned issues;

- performance in accordance with social principles, objectives, and priorities;

- division of management performance, time and energy between operational and creative activity.

In the years to come, the focus of the management activity will be shifted into the sphere of creative management, however, the routine component will not be neglected. Creative development activities will complete the existing operational activities. The importance of operational activities will drop only relatively.

With the forthcoming decentralization and enlarged framework for independent decision-making the possibility for incorrect decision-making and implementation will grow. Therefore, it will be necessary to prepare managers for demanding qualitatively new objectives. Only high qualified, morally and politically mature managers will be able to meet such requirements. In this connection, the importance of preparing cadres and the further development of qualification in the existing duties will gain greater importance.

THE IMPORTANCE OF DEVELOPING MANAGERS QUALIFICATION

Qualification can be defined as the capability to perform a particular duty. Every person must have basic prerequisites for a particular duty, which can be basically developed by practical experience required by that duty and must also absorb theoretical knowledge. Generally, it implies the relation of unique and general components. In order to acquire this qualification, both components must always be present. Practical competence can be defined as skill, theoretical competence as knowledge.*)

In the period of extensive qualitative changes, it is necessary to use other methods of qualification development than in the period of smaller changes. First of all, the development of qualification must be derived from the future objectives, not from past experience. The discontinuity of technical development is a basis for the discontinuity of qualification development.

The solution of the same category of problems, which in the past had followed from considerably stable conditions, enabled the development of management skills. A qualified manager was marked by experience which was demonstrated in his firm decision-making, solution of problems and the speed of his reaction. The educational system basically enabled gaining general knowledge about the regularity and principles of phenomena conduct. The focus of the educational process was in handing over a bulk of knowledge. Past experience was only a basis for the acquisition of skill and knowledge.

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*) Besides the two mentioned possibilities of direct acquisition of qualifications, there is a whole series of indirect components, as e.g., the impact of the particular environment in which a person is operating. Family background, hobbies, leisure, etc. also influence the development of qualification. These impacts can often have considerable importance.

The programs of educational courses for managers were considerably unified, the difference was only vertical: one type of course was usually attended by managers of the same rank, e.g., general managers and managers of large companies.

In the future, it will be necessary to adjust the educational process to new conditions. Young people acquire basic knowledge and attitudes at school. The educational system must pay more attention to the creative thoughts and dynamic approach to work. It will be necessary to teach young people not to be afraid of changes and innovation, but to see in them the opportunity for self-realization in work. It will be necessary to train a collective approach to the solution of complex problems.

The working site has an unalterable position in the development of qualification. The educational system prepares a young person only theoretically, with a greater or smaller specialization rate for a particular job. The trained adolescents may be defined as some "semi-finished article", which can be completed only by practice. Only the practice will show who has management capabilities. The working site creates basic management attitudes, approaches to decision-making, priority system in selection of working methods, etc.

It will be necessary to differentiate more between the development of the qualification of cadre reserves and managers that already have particular responsibilities. It will be necessary to prepare the cadre reserves not only for the requirements of a new duty, but at the same time to help them get rid of previously acquired habits and attitudes. The courses executive managers will have to be oriented towards future opportunities, while in the past the focus was on the solution of current problems.

The development of the qualification of managers will have to be considerably differentiated. It will be necessary to carry out the differentiation according to the responsibilities and individualization depending on the concrete needs of the managers. For example, one type of course for general managers will not be sufficient. The educational courses could become an effective tool for the qualification development, only if they are part and parcel of a systematic and differentiated plan for the personal development of individual managers. Besides the above mentioned courses it will be necessary to use other forms, such as study trips to other companies both in our country and abroad, stages with superior authorities, cooperation with scientific and educational institutions, and the participation in the solution of their problems. The basic component is self-study.

The active participation in the preparation of important central decision-making (e.g., development of branch structure, energetics, large cities, environment, relation of companies-community) can also be considered part and parcel of the development of training managers.

The dynamic and differentiated development of the qualification corresponds to the dynamic and differentiated production--technical and social conditions. The environment, in which managers are operating, including the impact of economic and moral stimulation, plays an unalterable role.

CONCLUSION

So far the management of innovations was in the majority of cases considered the domain of specialists, mainly technicians. In the future, this sphere will become an important component of management, namely top managers. It is necessary to prepare managers for these responsibilities. At present, no university trains its undergraduates for management. This is not possible, because the decision of selecting managers is taken in companies, usually several years after graduation. The environment in a company has a decisive impact on the discovery of talented managers and on the development of their qualifications.

The development of the qualification of managers in external courses can be considered as a supplementary source, which can complete, and further develop or dump certain components of the qualification. However, it cannot completely substitute the real environment of a company with all its peculiarities, possibilities and problems. Economic and moral stimulation, as a part of the performance of managers, creates an important component of the qualification development.

In the coming years, it will be necessary to create such an environment, which will motivate managers to creative orientation to the fulfilment of social objectives and at the same time will enable them to find the opportunity for self-realization. The qualification development will have to be understood in terms of self-realization of the managers' personality.

HUMAN FACTORS IN INNOVATION: EMPLOYEE INVOLVEMENT

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INTRODUCTION

Westinghouse has introduced several participative management or employee involvement programs within the corporation. The importance of such effort was addressed by Mr. Doug Danforth, Vice Chairman and Chief Operating Office of Westinghouse in remarks presented at a Quality Circle Recognition Conference. He stated that, "... I suspect that participative management will ultimately have a greater impact on the future of Westinghouse than all of the robots ... computer systems ... word processors ... and miscellaneous new technology we have on order" (Danforth 1981).

The Quality Circle (QC) program is the most widely implemented employee involvement activity within Westinghouse. It is described in detail in the next section of this report.

Examples of advanced efforts include autonomous work groups, employee task forces, and employee awareness activities. The section of the report entitled Other Prgrams contains a brief description of these approaches.

QUALITY CIRCLE PROGRAM

The Westinghouse Quality Circle program has been in operation for five years. It has grown from an initial seven circles to more than 2,000, and is still expanding.

This program is viewed by many as one of the most, if not the most, successful QC effort in the United States. Not only has the program grown in size, but tangible benefits have been recorded for both the participants and the corporation.

Lessons learned from the Westinghouse QC experience are presented in a recent book by Mr. Ralph Barra (1983), Director of Corporate Quality

Mr. Barra has provided material about the Westinghouse QC program that was helpful in preparing this section of this report. His cooperation is gratefully acknowledged.

Responsibility

The Westinghouse Productivity and Quality Center has responsibility for coordinating the QC program within the corporation, for training facilitators, and for promoting circles among workers and managers. Individual locations and/or operations make the decision about participating in the program.

Management of operations participating in the QC program have had to accept certain responsibilities (Barra 1980). First, and most important, management must welcome and accept employee participation in problem-solving and decision-making. This includes being patient through the growing pains and stresses that accompany the transition to worker participation.

The second management responsibility is to provide the infrastructure to support the QC program. This includes trained and capable facilitators, meeting rooms, training materials, and time on the job to conduct meetings. In addition, organizations within a division not involved in circle operations must be encouraged to cooperate with the circles. Collecting information and developing problem solutions may involve many parts of the total organization.

A third responsibility of management is to create a system for recognizing the achievements of circles. Barra (1980) states that self-respect and self-esteem are the energies that power the program, while recognition is the fuel.

Concept

The QC program is part of a people-oriented management policy. The objectives are to provide opportunites for workers to perform team efforts, to participate in problem-solving rather than simply following directions, and to develop a sense of belonging to the organization.

Barra (1980) has summarized the quality circle concept as it relates to Westinghouse:

> Quality circles is based on the concept that people will take more interest and pride in their work if they are allowed to influence decisions made about their work. Increased interest and pride will directly result in improved quality of work.
>
> Quality circles creates in the individual a sense of participation and contribution and recognizes the individual desire to participate in solving quality problems.
>
> Circles promotes a managerial behavior which recognizes the intellectual potential of the average human being and taps this potential by involving people in a quality consciousness.
>
> Circles restores a critical dimension to work, the opportunity to think, to commit one's mind as well as one's hands to the job.

> The growing demands and expectations of even more educated people in our work organizations must be dealt with by a cooperative approach which develops a two-way respect between worker and supervisor, or thinking "us" instead of "we" versus "they".
>
> Quality circles provide training and structured opportunities for people to become actively involved in a joint problem solving process. It is a people-owned program, not management-owned. And it is people building, not another cost reduction program.
>
> It provides employees with the opportunity for personal growth and development, self-respect, self-esteem, self-fulfillment, and achievement at work.
>
> Most important, it enables people to participate in improving their jobs. This builds more pride and a sense of belonging into the relationship between a company and the employee. It also develops a team feeling of cooperation and togetherness.

The QC identifies important problems within its organization, and determines which of these will be studied based on a consensus of circle members. The circle is under no pressure to select problems whose solutions will result in cost reductions or productivity and quality improvements.

A QC continues to operate as long as it is functioning in a problem-solving mode. Following disposition of one problem, the circle typically begins work on another issue. This method of operation differs from project-oriented task forces that usually disband after the project is completed.

Approach

Organizations within Westinghouse identify individuals to attend a four day QC facilitator training course. Upon completion a participant is capable of establishing and conducting a QC program in his or her division. Each facilitator is responsible for one to about 10 circles, depending on the size and the demands of the organization.

Each QC has a leader who usually is a first-line supervisor. Leaders receive two days of training, provided by the facilitator, on circle concepts and principles. A leader then recruits four to 12 workers within the leader's organization to form a circle. Care is taken to ensure that circle members are truly volunteers, and not forced to join the group.

During the initial six or so meetings the facilitator teaches circle members problem-solving techniques, and methods to present conclusions and recommendations to management.

Circles normally meet on company time for one hour each week. Meetings are conducted in rooms away from the participant work stations.

A circle studies problems identified by its members and agreed to by consensus. The circles are encouraged to begin by first considering simple

problems that can be solved in a short time and with a high probability of success. It usually requires about four to eight weeks to complete a problem analysis, including presentation of conclusions and recommendations to management. Management may adopt, suggest refinements, or reject the recommendations.

It has been found that management must treat the QC concept and specific circle recommendations seriously if the program is to be successful. Management must give timely and full attention to circle presentations. Good suggestions must be implemented, and explanations provided for ones that are rejected.

Circle participants normally receive no monetary rewards for recommendations that are adopted. Recognition, however, is provided at the local level for successful efforts. In addition, the Productivity and Quality Center coordinates an Annual Recognition Conference at which outstanding efforts from around the Corporation are recognized and prizes awarded.

No constraints are imposed on functions that may start a QC. Westinghouse has circles from many diverse activities, such as manufacturing, purchasing accounting, secretarial, engineering, supervision, and field services.

Results

The overall assessment of the QC program is that both employees and the corporation have benefited. Although no formal total program evaluation has been performed, indicators show positive results in many areas.

One indicator relates to the growth of the program over a five year span. It has grown from seven circles in August, 1978 to more than 2,000 in August, 1983, with more being added each month. More than 20,000 workers are QC participants. This sustained growth is impressive when contrasted with the results of the vast majority of participative management initiatives. Such programs often flourish initially but fail within a short period of time.

An attitude survey administered to circle members provides insights into employee views of the program (Barra 1983):

- Has the quality circles program made your job more enjoyable?

  Yes - 82%

- Have you spent some of your own time (lunchtime, breaks, at home, etc.) on quality circle matters?

  Yes - 88%

- Should the quality circle program be continued and extended to other groups?

  Yes - 100%

Most QC recommendations presented to management are accepted and implemented. For example, one division reports (Frick and Powell 1983) that about 90 percent of its circle recommendations have been adopted.

No attempt has been made to calculate the total economic benefit to the corporation of the QC program. However, one operation reported (Frick and Powell 1983) verified savings of more than $850,000 since 1979. In addition, some operations report less absenteeism and employee turnover since the program has been in place.

Many examples exist of successful recommendations developed by circles. A few of these recommendations that involved documented savings are as follows (Barra 1983 and, Frick and Powell 1983):

- Purchasing circle recommendation reduced the amount of overshipped material supplied by vendors for an annual cost savings estimated at $600,000.

- Supervisor circle recommendation reduced fuel consumption of vehicles by 15 percent for an estimated savings of $100,000 over a five year period.

- Manufacturing circle recommendation reduced by one week the operation cycle time of a deshrinking process resulting in a savings of about $180,000 each time the procedure is used.

- Manufacturing circle recommendation improved the way test adapters were made accessible to assembly line workers resulting in an estimated $22,000 savings.

- Engineering circle recommendation improved the design review process resulting in increased engineering productivity and lower design costs.

It is not possible to directly link recent increases in Westinghouse productivity and quality levels to the QC program. This is due to other programs occurring at the same time that involved technological changes in offices and factories. Even so, Mr. Thomas Murrin, President of one of the major groups within Westinghouse, has been quoted as saying that the circles were "a significant factor" in increasing productivity in one of his large organizations.

Challenges to Success

A successful QC program, such as at Westinghouse, faces many challenges. Initially, the shift from centralized management decision-making to sharing of power and decentralization of certain decision-making can cause major difficulties. Following implementation of a program, challenges develop due to the expectations created in workers and management. Finally, yet another set of challenges must be addressed as circle members mature and want to extend the worker involvement process to a broader set of problems.

The decision to implement the Westinghouse QC program was made by top management. It was decided to utilize the Japanese QC Circle approach as a model, but to modify it as necessary to satisfy the Westinghouse culture.

Excellent interest was expressed by employees, in participating in the program. The labor unions, middle managers, and staff personnel were most concerned about the potential shifts of power and decentralization of decision-making.

Westinghouse management worked with its unions to minimize conflict. Presentations were made about QC concepts and techniques. Some union leaders and Westinghouse managers visited Japan together to observe quality circles in action. To reduce fears that the QC program might interfere with union concerns, it was decided that circles would not be permitted to deal with areas traditionally handled by collective bargaining.

Three of the four major unions representing Westinghouse either have remained neutral or even endorsed the program. The president of one union local was quoted in a newspaper article (Singletary 1982) as saying, "As long as the employees and supervisors don't get into contractual issues, I think the program will develop a good relationship between both sides."

Some middle managers and staff personnel may be concerned that some of their responsibility, authority, and prerogatives may be lost with a QC program. It has been reported (Atwater 1981) that lack of middle management support has been a major impediment to the success of QC efforts in many American companies. Westinghouse emphasized top level management commitment, education, and patience in dealing with this challenge.

Upper level managers provided frequent and strong support for the program throughout its introduction and growth. Within some corporate groups middle managers were required to report at frequent intervals on program status and progress.

Education courses were provided to increase awareness of circle goals and methods. Middle managers attended circle meetings and management presentations of recommendations.

It was emphasized to management and workers that the QC program was a team-building activity, not a cost cutting or productivity improvement program. Therefore, all personnel directly or indirectly involved must have patience. With the passage of time tangible team building and economic results began to be visible. These positive results made it easier to influence middle managers and staff personnel about the worth of the QC program.

Many participative management programs fail after a successful introduction. There are many reasons for their demise. One important reason is that expectations develop about the program and its results. When these expectations are not met, and remedial action is not taken, the program may falter, and then fail. In Westinghouse, several strategies were followed to minimize such difficulties. Top management support of the program continued to be provided. Successful circle recommendations were given wide publicity, and circle members given recognition. A few circles that were no longer functioning in a problem-solving mode were disbanded. Training was provided circle facilitators and members in advanced problem-solving techniques to enable circles to address more difficult problems.

Two key ingredients to the Westinghouse program were the development and implementation of a consistent and standardized training program, and

a dedicated corporate staff that fosters and maintains a communications network for participants throughout the corporation (Frick and Powell 1983).

A successful QC program will create circle members who want to modify the program. A real challenge exists to satisfy such workers within the framework of management willingness to further decentralize decision-making and sharing of power.

Individuals involved with one of the most advanced and successful programs at any Westinghouse division have published thoughts on the current program and possible change (Frick and Powell 1983). "Mature" circle members have pointed out:

- The difficulty in selecting a project that is perceived as important to both management and circle members.
- The constraints of the one hour a week meeting format on the resolution of "important projects."
- Lack of opportunity for members to work with a variety of people on different projects.

The authors (Frick and Powell 1983) also report two important management concerns:

- A desire for more involvement in project selection and the overall efforts of their circles.
- Recognition of the need to align circle activities with the major objectives of the department.

The authors (Frick and Powell 1983) conclude by stating that most organizations needed a structured and visible program to stimulate a shift toward participative management. The QC program satisfies that need, and provides workers and management with a training vehicle to understand responsibilities and implications of participative management. Eventually, the QC concept of participative management should be institutionalized within the organization.

In spite of the suggestions made above, there may be real advantages in maintaining an ongoing QC program even after the entire corporation becomes "mature" in QC operations. The Japanese have maintained an active and successful QC Circle program for more than 20 years. Obviously, benefits are perceived in continuing the activity.

There are advantages to an organization for circles to operate independently in identifying workplace problems and selecting the ones to be addressed through a consensus process. Without this independence, the group may give too much emphasis to management problems.

One of the approaches being used at Westinghouse to more fully utilize capabilities of "mature" circles is to encourage them to address more difficult problems. Management that has become "comfortable" with the QC concept makes more information available about operations and difficulties. The circles are in a better position, then, to identify and select important and difficult problems.

Another thrust for quality circles is problem prevention. The current emphasis is on problem resolution.

Future Directions

The QC program as it exists will continue to grow within Westinghouse. Even though more than 20,000 workers are involved in the program, they account for fewer than 20 percent of the work force. There is a need to expand the program to involve more workers and more managers.

The experiences with the program provide a solid foundation upon which to expand worker involvement activities. Such developments will occur in organizations in which management and workers are ready for such a move.

Expansion of worker involvement will eventually lead to institutionalization of the concept as part of the normal operation of the organization.

The QC program provides an important first step in establishing worker involvement in an organization. The program will be completely successful when it and its extensions have achieved full utilization of the human resources available.

OTHER PROGRAMS

Westinghouse has implemented a variety of employee involvement programs (Springer 1983). A few of these will be discussed briefly. Mr. Jack Springer is familiar with most of these efforts. His cooperation in providing information is gratefully acknowledged.

Autonomous work groups have been started in several locations. In one plant of about 100 employees, five autonomous groups have been established. The groups have defined mutually acceptable boundaries between their respective operations. Each group develops its own objectives, and is self-managed with a group advisor rather than a supervisor.

Results with this program have been favorable. The level of production has been much higher than originally forecast. Overtime has been reduced from a high to a very low level. The employees and plant management have been very pleased with the approach.

Employee task forces have been implemented at many locations. This approach typically involves management identifying a need or a problem, although in some instances employees may bring the problem to the attention of management; establishing an employee task force; and giving the task force autonomy and resources to solve the problem and to develop a recommended course of action.

Two successful employee task forces have dealt with layout problems. One group was responsible for laying out the electrical assembly area in which group members worked. Its recommendation was adopted with good results. A significant productivity increase was measured, employees were very satisfied with the redesigned facility, and a cost savings was realized.

Another employee task force at a different location was given responsibility for laying out a new plant cafeteria. There had been many complaints about the previous cafeteria. Group recommendations were accepted and complaints have initially disappeared.

A successful employee involvement program may involve sending employees who will be responsible for operating a new piece of equipment to the supplier plant during the final fabrication and check out period. The employees become familiar with the equipment and usually "champion" its introduction into his organization.

Employees have participated in awareness programs. They visit customers, suppliers and trade shows to obtain a better understanding of the environment in which their work is performed. The results have been favorable as evidenced by improved attitudes about the corporation and their work.

CONCLUSIONS

Westinghouse experience with employee involvement programs has been very positive. The corporation has experienced tangible productivity gains and cost savings. Less tangible but very important is the improvement in program participant teamwork and attitudes about work and the corporation.

It has been found that many employees welcome the opportunity to participate in an involvement program. It is necessary, however, that the program be perceived as meaningful. Management must agree to share power and decentralize decision-making if a participative management activity is to succeed. Additionally, until employee involvement concepts have been institutionalized within an organization, it is necessary to provide a strong administrative organization to guide the effort and make the program succeed.

A successful involvement program, even if limited in scope, can produce a group of employees who want to share even more power and participate in helping making decisions that are more important to their organization. These individuals are a powerful resource. The challenge to management is to develop and implement programs that will fully utilize this resource

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EXTERNAL CONSULTANTS FOR FUNDAMENTAL PROCESS INNOVATION*

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INTRODUCTION

The most fundamental transition taking place in industry today is almost certainly the introduction of computer based automation into the manufacturing process. From a long term perspective it is easy to compare its impact with such fundamental process innovations as the first use of steam power, the replacement of driving belts by electrical motors, and the development of the assembly-line. But as Keynes has reminded us: long term analysis is easy. The really difficult problem, and at present one most uregently felt by a multitude of firms, is what the short term response to this technological challenge should be. The short term problems are illustrated by the recent estimation of a Dutch engineering consultant that 25 percent of all robot systems installed in Dutch industry are presently not operating. They stand in the corner like a new wind-up toy to which the child has no key. The cause is not technical but organizational. In this paper we will therefore pass by a discussion of the technical potential and, in the long term, undoubtedly great effects of computer based automation in favor of a discussion of the managerial and organizational issues involved in its introduction. We will conclude with some recommendations for more effective corporate and government policies in this area, based on past studies of the innovation process and Dutch experience with stimulating product innovation in small and medium sized enterprises.

THE NATURE OF THE TECHNOLOGY

It is first necessary to say a few words about the definition of the fundamental process innovation that we are discussing. A number of terms

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* This paper is in part based on the research program on "Flexible Automation" carried out by the Center for Technology and Policy Studies TNO and supported by the Dutch Ministry of Science and Education. The opinions expressed are the responsibility of the author.

have been launched to denote the new wave of micro-electronics based automation that is the subject of this paper.

Examples of such terms are Industrial Robots (IR), CAD/CAM, Flexible Automation and Flexible Manufacturing. Use is according to the author's point of view, or according to whatever product he happens to be selling. These terms generally suffer from focusing on one aspect of the automation process at the expense of others. In practice the definitions overlap, and in any case most authors do not bother to give a clear cut definition, preferring to proceed from a limited number of hardware examples. However, if we want to discuss this topic as a general industrial trend or as a problem of innovation management, it seems best to define the observed development merely as "the introduction of computer based automation in the manufacturing of discrete products". Our starting point is the computer, because whether we talk about the vacuum tube based computers that made the first NC-machines possible or the present 'computer on a chip', this piece of micro-electronic technology clearly dictates the speed of the overall development no matter what complementary technological developments such as sensors, vision, software, and handling equipment contribute. This speed causes the innovation to be fundamental rather than incremental.

The computer moreover embodies the micro-electronics that represents a foreign technology for most manufacturing firms. The example of the response of the Swiss mechanical watch industry to competition from electronic time-keeping technology demonstrates the degree to which industrial organizations resist adapting a totally foreign technology. Even within electrotechnology there is a diversity of technical cultures, some of which (for example, producers of high voltage switching equipment) regard mirco-electronics as a foreign technology. Summing up we can say that from the point of view of human factors in innovation management the two most important aspects of the new technology are its "foreignness" to the existing technical culture and its radical nature in terms of speed of development of technical opportunities.

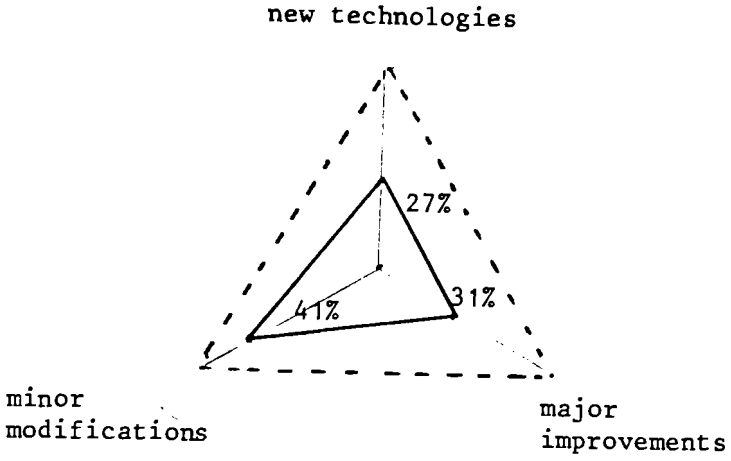
INTERNATIONAL COMPETITION AND THE NEW TECHNOLOGY

It is first necessary to discuss the economic and business strategy rationale for focusing our attention on process innovation. What is the present economic position of European industry to which innovation policy and in particular policy with regard to the introduction of computers in the manufacturing process must address itself? Traditionally Western-European weakness has been viewed with respect to US economic superiority and defined in terms of an insufficiently large market for successful commercialization of advanced technology, especially new products. Governments have attempted to improve the economies of scale by joint programs in Big Science. But lack of truly coordinated European industrial policies and the insufficiently homogenous market for high technology products have prohibited catching up with the US, despite many Euroepan scientific breakthroughs. This situation is conveniently illustrated by Gellman Research Associates Inc.'s report of 1976 which classifies 500 technical innovations made between 1953 and 1973 by provenance and degree of importance. In their ranking the US occupies a dominant position with 234 innovations. Of further significance is that, of these innovations, 27 percent were new technologies, 31 percent were classified as major improvements and 41 percent as relatively minor modifications of existing

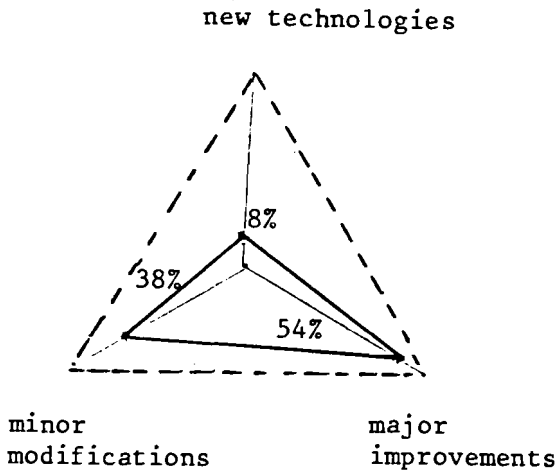
technologies. As shown in Figure 1 a well-balanced pattern of innovation is shown by the US. The UK, the largest and perhaps most typically Western European representative in the sample, claim a relatively smaller number of 45 cases of innovation, which include 56 percent new technologies, 40 percent major improvements, and only 4 percent relatively minor modifications of existing technologies. Japan had 26 innovations, but only 8 percent were rated as new technologies. Although quantifications of technological advances should always be treated with some reserve, Figure 1 may serve to illustrate the lack of balance in the European innovative record. The analysis also points up a special threat to European competitiveness in the coming years. In the fifties and sixties industrial competition was still dominated by product innovation and new technologies. Although Europe lagged behind the US in commercialization, it still excelled at creating breakthroughs. Many observers feel that, due to the maturing of many of the dominant technologies in the seventies and eighties, there has been a shift in the direction of technological change from creating new products to improving the production process of existing ones. A new emphasis on creating new products is not expected until after 1990. While such observations are necessarily speculative, they seem to fit with recent history and existing theories about technology life cycles and long waves in economic development.

Europe seems ill-prepared to meet this type of international competition, based on refinement of existing technologies and optimizing quality and productivity. At least for the coming 10 years the main competitive challe challenge will come from Japan, which is also outperforming the US under the new technological rules of the game. Some examples help to illustrate this point. By the 1970's Japanese manufacturers produced up to 350 motorcycles per man-year, compared to 11 by the US firm Harley-Davidson and 14 by Britain's NVT Group. In the Japanese automobile industry labor productivity increased 8 to 9 percent per year in the seventies compared to 3 to 4 percent in the US (Abernathy and Clark, 1981). The average assembly time per car according to the same authors is 112.5 hours for the Ford Motor Company and 47.5 hours for Tokyo Kogyo. The production of a color TV in Europe or the US requires 2 to 3 times the hours used in Japan. Of 300,000 memory chips recently tested by Hewlett-Packard the failure rate of the worst Japanese supplier was six times better than of the best US supplier. Japan now produces 90 percent of the world video tape recorder market, including 60 percent of the FRG market, 85 percent of the UK market and 100 percent of the US market. Japanese visitors to European factories are reported to be amazed at the backward methods of production.

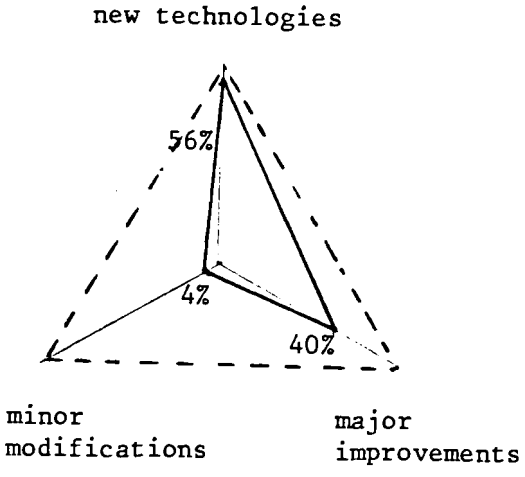
Superior productivity and quality are leading to a rapidly increasing market share for Japanese producers. Figure 2 shows the recent and expected decline of the European share of the integrated circuit markets in the total consumer goods market, based on recent research at the Delft Graduate School of Management (Van Duren, 1982). Japanese productivity and quality is now forming a direct threat not only to existing employment in mature European industries such as shipbuilding and automobiles, as has been sufficiently documented elsewhere, but also to potential new employment in new technology oriented sectors, of which our data on IC markets can give only a partial view. Some additional support is given by data gathered by Nomura Research Institute about shares of world markets of a number of leading-edge products by Japan, the US and the Federal Republic of Germany (Table 1).



U.S.: 237 cases



Japan: 26 cases



U.K.: 45 cases

Figure 1. Relative frequency of three kinds of innovations between 1953 and 1973 in the US, Japan and the UK.
Data: Gellman Research Associates (1976).

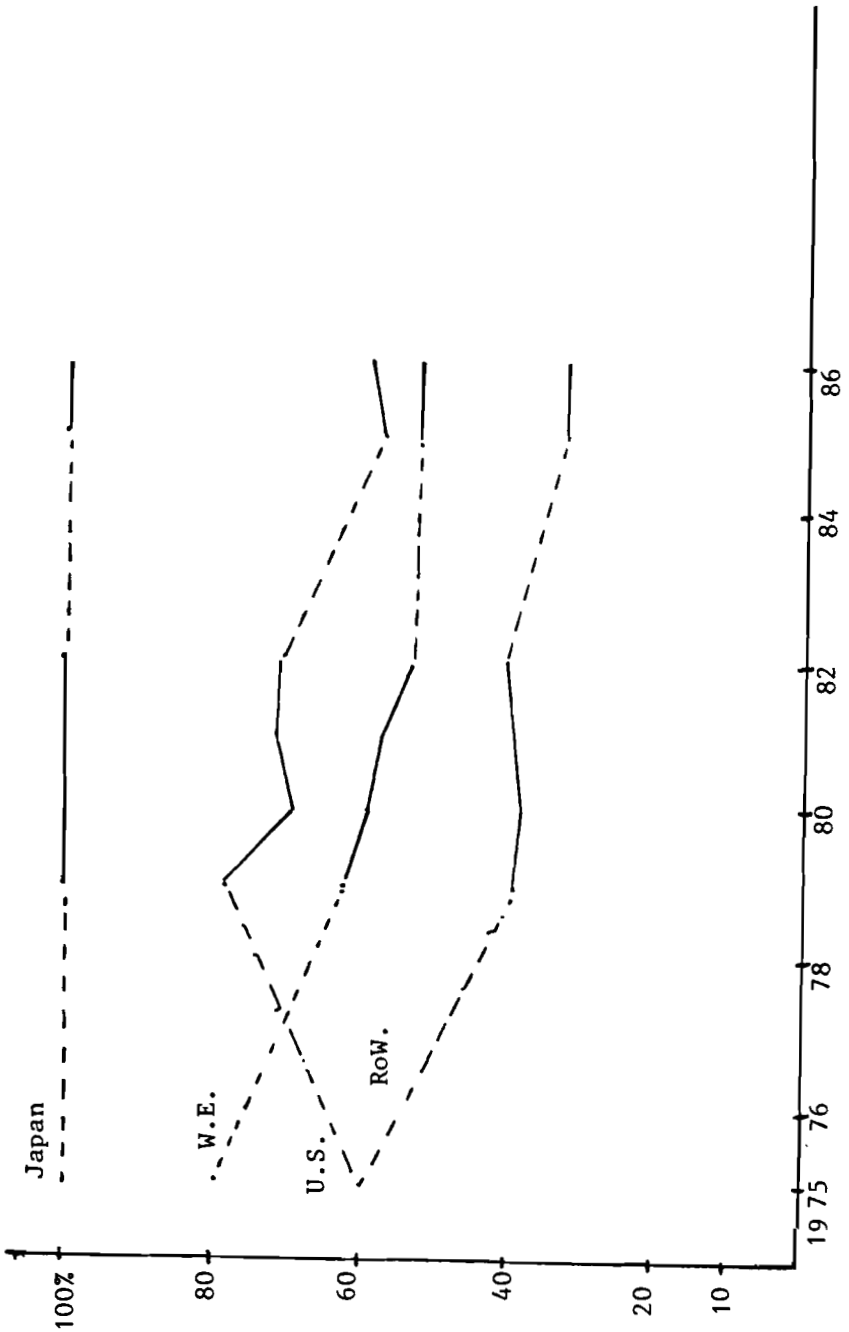


Figure 2. IC-total consumer goods markets in percentage of the largest market.
Source: Van Duren 1982, p.65.

Table 1. Share of major countries in leading-edge products.

	Japan (24%)*	U.S.A. (58%)	FRG (18%)
Semiconductor IC ('79 Y Bil.)	343.2 (24%)	1,023.6 (72%)	60.7 (4%)
Computers ('79 Y Bil.)	1,123.4 (20)	3,838.6 (70)	538.9 (10)
VTR ('79 1,000 units)	220.4 (95)	(-)	e 100 (5)
NC Equipment ('79 1,000 units)	e 17.2 (62)	e 9.1 (33)	e 1.5 (5)
NC Machine tools ('79 1,000 units)	14.3 (58)	7.1 (29)	3.3. (13)
Aircraft Engines '78 Y Bil.)	279.3 (3)	7,269.1 (88)	701.0 (8)
Plant ('76 Y Bil.)	3,125.9 (18)	6,995.0 (40)	7,441.3 (42)
Antibiotics ('79 Y Bil.)	658.0 (62)	e 324,3 (30)	e 85.5 (8)

Note: e: Estimates by Nomura Res. Institute (NRI)
Source: Zaikai Kansoku (busines reviewI Dec. 1980, NRI.

* share of combined GNP in parentheses.

At the macroeconomic level Table 2 shows the trends in productivity in manufacturing industries in selected countries between 1960 and 1980. The Japanese gains can only be termed spectacular. Observers tend to agree that Japanese performance in productivity is not merely the result of such economic factors as wage levels, restrictions on imports, high rates of savings and investments, artificially low interest etc. It seems more realistic to recognize that the Japanese are winning in an area of technological change that most firms in Europe and the US have hardly even discovered, namely modern production technology. Its key element is computer technology. The major obstacle is the integration of this technology into the production organization, or in other words: the management of process innovation. For the individual firm, finding the correct response is all too often a question of survival.

ON THE MANAGEMENT OF PROCESS INNOVATION

If we agree from the above discussion that the successful introduction of computer based process technology is crucial to the competitiveness of our industry, the next question becomes how to achieve this. For the individual firm this is a matter of improving its management of process innovation. For industrial policy this is a matter of finding and implementing appropriate stimulation measures, preferably based on a good understanding of the management problems involved. After all, we do not want a Concorde project in the area of robotics. Empirical research on and well documented experience with the process of innovation should be our guide; specific research on the introduction of computer based automation as well as the much more voluminous research on innovation in general.

The first lesson from research on technical innovation is generally that response to demand ('demand pull') rather than response to technical feasibility ('technology push') is the most effective route to innovation. This should warn us for an infatuation with hardware solutions. This is the major shortcoming of most of the studies that take the industrial robot, the 'flexible manufacutring system', or the 'unmanned factory' as a starting point. Computer based automation can be a most important tool, but not the solution. Important sources of demand pull are the market and changes in factor prices, but for process innovation certainly also signals from the firm's own production organization. Rather than buying standard automation equipment, utmost care should be taken to adapt the new technology to the specific demands of the individual firm. Existing organizational strengths and traditions should be taken into account. Full use of the firm's existing expertise at different organizational levels should be made. Involvement of the shop floor is to process innovation what market surveys are to product innovation.

This means that a great deal of attention and time should be devoted to determining the type of equipment the firm needs in terms of required functions, degree of flexibility of the new system, etc. during the phase of pre-planning. Mortimer, J. (1982) found that some 60 percent of the problems with 33 FMS case studies by Ingersoll Engineers in the US were directly attributable to poor pre-planning at the outset. Other problems according to this study were—in order of their importance—lack of a clear plan for achieving objectives, a lack of understanding of the diversity and complexity of the products to be produced, an inadequate analysis of the required flexibility, and a lack of organization champions.

Table 2. Productivity[1] growth in manufacturing industries of selected countries: 1960-1980.

(Index: 1977 = 100)

Year	United States	France	West Germany	Japan	United Kingdom
1960	60.1	40.0	40.0	21.7	58.3
1961	61.7	41.9	42.1	24.6	58.8
1962	64.4	43.8	44.7	25.7	60.3
1963	69.0	46.4	46.8	27.7	63.5
1964	72.4	48.7	50.3	31.5	67.9
1965	74.6	51.5	53.5	32.8	69.9
1966	75.4	55.2	55.4	36.1	72.5
1967	75.4	58.2	59.0	41.4	75.6
1968	78.1	64.8	63.0	46.6	81.2
1969	79.4	67.2	66.9	53.9	83.1
1970	79.2	70.6	68.5	60.7	83.2
1971	84.1	74.3	71.6	63.3	86.1
1972	88.3	78.6	75.9	69.6	92.2
1973	93.1	82.9	80.4	77.6	97.5
1974	90.9	85.8	85.2	80.8	97.2
1975	93.5	88.4	89.3	84.0	95.0
1976	97.7	95.7	95.0	91.9	98.8
1977	100.0	100.0	100.0	100.0	100.0
1978	100.9	104.9	103.8	106.8	103.2
1979	101.9	109.8	110.3	115.5	105.8
1980 (prelim.)	101.4	113.4	109.5	122.7	104.4

[1] Output per hour.

SOURCES: Department of Labor, Bureau of Labor Statistics, Office of Productivity and Technology, "International Comparisons of Manufacturing Productivity and Labor Costs. *Preliminary Measures for 1980,*" May 20, 1981, mimeograph.

From: Science Indicators (NSF, 1980).

The second lesson from studies of technical innovation is that organizations tend to resist innovation. In the area of process innovation, specifically, it can be shown that diffusion of technically and economically proven innovations beyond the first user to utilization by 50 percent of the firms in a particular branch of industry is a process of many years (see for example Mansfield, 1968, and Nasbeth and Ray, 1974). It is insufficiently recognized that technical performance within industries differ widely. Differences in productivity between firms by a factor of two or three have been found to be not uncommon. Four levels of technological performance in the area of process innovation can be identified:

1) leading edge technology;

2) state-of-the-art technology;

3) common practice technology; and

4) backward technology.

The economic potential helping firms to shift from lower levels of production technology (e.g., 'backward' or 'common practice') to higher levels is very substantial. Our analysis of Japanese industry leads to the conclusion, shared by many experts, that its competitive strength lies in the relatively large proportion of firms operating at the level of state-of-the-art technology. Visitors to Japanese factories rarely report seeing technology not familiar in Europe, but Japanese stress of modern production technology leads to an application of existing technology to the utmost of their potential.

From the point of view of government policy it should be recognized that leading edge technology is almost irrelevant in industrial practice. Much can be gained however from the process of technology transfer from higher to lower levels of technology. To promote industrial competitiveness the major thrust of government programs should be aimed at helping firms move someways from 'common practice' to 'state-of-the-art' technology. Even then it should be understood that it will probably be impossible to reach the very many firms at the level of backward technology. It should be set firmly in our minds that government programs which do not reach firms, directly or indirectly, below the level of 'leading edge' technology will have little effect on industrial competitiveness. An effective organization of the process of technology transfer, or 'diffusion and utilization of knowledge' is critical to any program aimed at industrial innovation.

A firm's palce on the continuum from leading edge technology to backward technology depends on such economic factors as degree of competition and profitability , but also on internal organizational factors as corporate culture and risk averseness. Such factors culminate, implicitly or explicitly, in the corporate strategy, which can vary strongly within an industry. Burton Klein, using examples from a.o. the US steel and automobile industries, stresses that the internal factors lead to the avoidance of innovation to the extent that only fear of corporate collapse (his concept of "the hidden foot") will cause a firm to seek fundamental change. Traditional economic forces such as profit maximization are insufficient.

Research on product innovation has pointed out that innovative firms generally distinguish themselves from others in having an explicit innovation oriented corporate strategy. (See also H. Nyström's (1979) distinction between positional and innovative firms). Having an explicit strategy with respect to production technology seems similarly to be a necessary condition for moving a firm closer to state-of-the-art or leading-edge technology in the area of process innovation.

THE STIMULATION OF FUNDAMENTAL PROCESS INNOVATION

Having sketched the nature of the new technologcial and economic challenge facing Western Europe and the management problems involved, we should now try to come to some suggestions for action. For individual firms it is clear that our analysis goes in the direction of paying more attention to the requirements of the production organization and developing, through a process of organizational development, an explicit corporate strategy in the area of process innovation. For government policy makers the situation is more difficult. If modern production technology is not in the first place a problem of developing advanced hardware, then solutions fall outside such a traditional area of government programs as R&D. More advanced robots do little to improve factories. On the other hand governments rightfully feel ill at ease in telling firms how to solve their organizational or managerial problems. This is especially true if a large number of firms need to be reached in order to have effect.

I suggest that governments can learn a lesson from a rather unique Dutch program for the stimulation of product innovation which was initiated in 1979. In that year the Dutch government started a special program to stimulate innovation in industry; not directly, but through the intervention of external consultants. The task of this "Project Industrial Innovation (Pii-b)* was to help existing small and medium sized enterprises (SME) to innovate:

- to teach 100 SME how to innovate;
- to increase the Dutch supply of consultants in the area of innovation by training and coaching 70 management consultants in aiding these 100 firms; and
- to prove the feasibility of specialized innovation consulting.

The new concept of innovation consulting had been developed at TNO by experimental projects in forms in the previous years. The concept is based on three principles:

1) Innovation is radical change.

2) The innovation process is a learning process.

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* There also was a sister project "Pii-a", designed to help new, invention based firms, which need not be discussed in this context.

3) Process consultation is more successful in implementing innovation than other types of consultation (e.g., expert consultation).

The total budget of the program was about $ 3 million. Most of it was used to subsidize the consulting fees for 70 percent. The rest was spent on the training of consultants and program costs. Of 300 firms 106 were finally selected for participation. Although the allowed fee was 30 percent lower than the usual market fee, 200 consultants applied, of which 51 were finally selected by, first, the program and, second, by a participating firm. In the majority of the firms that were at last count at or near the completion of the consulting process (48 consultant days) a definite decision had been made about what kind of innovation they should develop. Because the Pii-b interventions are designed to help a firm from the early reconnaissance of a need for innovation towards the definite choice of a well described innovation objective, it is too early to evaluate the program in terms of hard economic figures. As soon as the firm is able to proceed the process on its own, the Pii-b interventions are stopped. The program is only intended to help define the corporate strategy for innovation and to teach how to do it. In 80 percent of the cases this objective has been reached. The development stage is the task for the firm itself. Many of the 51 participating consulting firms are reported to continue to apply the innovation consulting approach outside the Pii-b program. Because of these results the Dutch minister of Economic Affairs has now extended the project for 2.5 years.

CONCLUSION

In this paper I have tried to present the case for viewing human factors in innovation management not as possible obstacles to be dealt with, but as the necessary driving force behind all conceivable successful innovation projects. This is especially true for process innovation, which is generally completely intertwined with organizational innovation. Human factors need to be mobilized at the start if the integration of new technolgoy and processes into existing production systems is to be realized. If they are only considered as obstacles to be dealt with after the hardware has been put in place, both the 'humans' and the new technology will suffer. The main conclusion of this paper is therefore that the development of a corporate strategy toward production technology is the most important tool for achieving successful introduction of the computer in the manufacturing process.

On the question of designing a policy instrument to promote process innovation I have suggested that we take a cue from a successful Dutch program, Pii-b, for the promotion of *product* innovation through the development of a system of innovation consultants. Pii-b teaches consultants how to guide firms in developing an innovation strategy. The goal is to become widely diffused in industry and self-supporting after an initial learning process. In the area of *process* innovation such an approach could be successful because so many of the innovation management principles apply. Of course the consultants will also need to be well versed in the subjects of production technology and automation.

Finally I realize that progress in IR, CAD/CAM and flexible automation also depends on creative research and development in hardware and software.

In no way am I saying that it is useless to fund these more narrowly technical activities. But it seems that efforts to improve the organizational introduction of the new technology have been relatively neglected. From the point of view of where to put your (government) money among many policy alternatives, I believe that developing the art of the management of process innovation through a system of consultants would be a very good choice.

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THE ROLE AND POSITION OF A PUBLIC RESEARCH INSTITUTION IN INNOVATION MANAGEMENT

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INTRODUCTION

After the second world war the structure of the Finnish economy changed considerably. Industrialization increased as shown by the strong shift of the work force from the agricultural and forest sectors to industry and services. However, the proportion of agriculture is still larger in Finland than in most advanced OECD-countries.

The main features in the development of the Finnish production structure during the last twenty years have been the diversification of the metal industry and the strong development of the electronics industry. However, the production structure of Finland is still rather one-sided and thus easily vulnerable. Also a rather small part of our industrial production is research intensive compared with several of our competitors, and the particularly west-oriented export of Finland still emphasizes capital-intensive and relatively little processed products. These facts have been important starting points for the discussions in our country on the acceleration of technological development and the importance of governmental technology-political measures.

According to the plans made in the early 1980s, research funding will be increased in coming years, and great efforts will be made in order to attain a more rapid growth than the average increase in expenditures, due to the nature of research and development activities as a creator of innovations. Both the public sector and business and industry must endeavour to obtain this goal.

The share of technical research and development of gross domestic expenditure on R&D (GERD) in Finland in 1981 was nearly 60%. This was divided between the three main parts of technical R&D in the following way: business enterprise sector 80%, the Technical Research Center of Finland (VTT), 15%, and technical universities 5%. The share of the business enterprise sector on GERD is about 60% which is quite close to the average for OECD countries. According to the official statistics of Finland the number of companies performing R&D in 1979 exceeded 500. R&D in the business enterprise sector is quite strongly concentrated in big companies.

VTT is a government research institute covering a diversified and wide range of research work. Its principal task is to create, maintain and develop the technical knowledge needed by the Finnish economy and the administrative bodies. Its main activities are research and development work, testing and inspection work, and information service. Priority is given to applied research related to concrete problems and needs. VTT is an exceptionally diverse research institute and its 30 laboratories cover most fields of technology. With its broad range of operations, VTT is in an excellent position to combine the expertise of several fields in resolving a single problem. The most important fields of research at VTT are building and community technology, materials and processing technology, energy and information technology. At the moment VTT's personnel number over 2,200.

VTT carries out research work on its own initiative with financing from the state budget and commissioned tasks from domestic and foreign companies. At present the commissioned tasks already comprise over one half of VTT's activities. The contractual assignments are mainly debited at cost price. VTT has quite an important role in Finland, both as a typical research institute and as a service organization. This is why the role of VTT in creating innovations has, during the last few years, been a topic of lively discussion and study. The results of this discussion can be summarized as follows: VTT develops products and processes mainly on commission from companies and, in general from the point of view of the companies, these are a smaller or bigger part of a wider innovation process. Only in some cases, at least so far, can VTT take responsibility for the whole innovation process. Development or innovation work done on VTT's own initiative is primarily to develop instruments for VTT's own use. VTT also improves the general conditions of innovation activities by performing other tasks.

From VTT's experiences the following are especially important starting points and premises for further cooperation between VTT and industry:

- o VTT has the knowledge about the latest research results;
- o VTT has the opportunity to act as a supplementary to industrial innovation capacity and as a leveller of summits;
- o VTT has the capacity to give the special experience needed by industry and the opportunity to act as a performer in wide polytechnical tasks;
- o VTT is able to work impatially and to take responsibility for the strict orders given to the time table, costs and quality of a project; and
- o VTT is able to apply the working principles familiar to industry.

In VTT innovation activities the main advantages are, first, the wide scope of VTT and, secondly, the good relationsips with industry on the one hand and on the other, technical universities. The structure and organization of VTT give rise to a very broad base of knowledge within a project using expertise from different fields. VTT is somewhere between universities and industry, and this location enables the contacts with both sides that is necessary for product development. From industry VTT can get the needs and boundaries given by practice. Good relations with the world of pure research gives knowledge of available new methods. To be able to keep the standard high enough also requires good international contacts with both industry and research institutions.

QUALIFICATION OF RESEARCHERS AND OCCUPATIONAL SOCIALIZATION

One way to study the qualification of researchers is to analyze it as a result of an occupational socialization process. This process can be defined as a "continuous personality structuring which takes place when a person responds to the demands (partly contradictory) of the production process" (Groskurth 1979:10). This approach makes it possible to analyze the special requirements caused by VTT's unique position in the national research system.

About 80% of the researchers at the Electrical Engineering Laboratory have an academic background and most of them are recruited immediately after their examinations when the socialization process of young researchers is not yet completed. The work orientation, conceptions regarding "good work" and norms of working are, therefore, greatly molded according to the demands and models offered by the organization. As a result of its position between basic research and development work, VTT has to unite traditionally contradictory requirements and ways of working to develop its own unique type of qualification and organizational character. This problem can be described as follows: how to combine such qualifications as the readiness to follow the development of basic research and methods, knowledge of different applications, basic understanding of the economical aspects of innovations and the preparedness for efficient and responsible work in strictly scheduled product development projects.

To unit such qualification requirements special values, norms and management procedures are needed. For instance, the responsibility of all team members in the project is a norm that necessarily must be transmitted by the organization. This norm, however, is not necessarily natural to researchers with academic backgrounds. In the same way, the qualification of researchers at VTT can be seen as the development of a "special type of researcher" with qualities corresponding to the demands of VTT's special position. The basis for this qualification is adequate work orientation, clear idea of special knowledge and the way of working needed at VTT. These conceptions are partly transmitted to a new researcher through the routine work activity. But, to form a conscious work orientation, explicit analysis of the necessary demands of work activity is needed.

This analysis of requirements can best be performed as part of the goal setting and planning process. The analysis of organizational goals, the "business idea" and the premises of successful innovations (the necessary know-how, forms of organizing the work) deal with the very basic qualification requirements needed in research and development work.

Because of its position VTT also has certain special motiviation sources. Among others these motivating factors are: stimulating and varying work; possibilities to influence the industry; and the opportunity for national contacts which may provide future scientific career possibilities. In the DAMATIC project case study by Dr. Andersin (1983), the quality of goals turned out to be important for the motivation of researchers. This fact could be expressed in that motivation comes from outside, from the utility and uniqueness of planned results, not from the inner needs or drives of a researcher. This unity of high motivation and challenging goals raises the importance of goal quality and goal-setting as a basic factor pushing the qualification of researchers in an organization forward.

SUCCESS AND FAILURE IN TECHNOLOGICAL INNOVATION

There is a well established tradition in innovation research to compare projects that have led to successful innovations with those that have led to failures in particular companies (see, for example, Kulvik 1977, Rothwell 1977, Rubenstein et al. 1976, and Freeman 1982). Though the studies have mainly concentrated on technological innovations in industrial firms, some of the findings provide an adequate framework for looking at human factors in innovation management also in supporting technology development institutions like VTT.

The majority of successful innovations arise in response to the *recognition of a market need* of one sort or another (need-pull) as opposed to the recognition of a new technological potential (technology-push). But as Freeman (1982) and Sahal (1981) have pointed out most innovations involve some imaginative combination of new technical and market possibilities. As both the market and technology are continually changing, innovation is a coupling process to link these two processes together. The management of this sort of process, which takes place in the minds of imaginative people, is most difficult and gets even more problematic when the knowledge of technical possibilites and market needs are brought together from different organizations. This is the case in most contract research projects in which the technological know-how is provided by the research institution and the market and production knowledge by the firm.

Successful innovation, while enjoying *good* inter-firm *communication*, must establish efficient communication links with outside scientific and technical establishments, as well as with the customers, and make deliberate efforts to survey potentially useful externally-generated ideas. VTT's personnel generally have good and close relations with the scientific community because of:

- o the convenient geographical location (VTT and the technical university are side by side);
- o VTT's recruitment practice (VTT recruits mainly from the universities);
- o VTT's substantial own basic and applied research.

But here again, communication with the other end of the innovation process, i.e., the customers, remains insufficient.

This communication problems brings with it another relevant problem, namely the different communication habits of scientists and engineers (see, for example, Rothwell and Zegweld 1981:152-153). Scientists tend to mainly look at the primary literature and form "invisible colleagues" among their peers. They appear to be little constrained by the bounds of the firm, and their rewarding system is outside their administrative organizations. Engineers, on the other hand, look more to secondary literature and draw very much on their own personal experience. They are very much bound by the firm and its rewarding system. At VTT the form of communication has traditionally been that of scientists, but along with the change in VTT's role, communication forms are also changing. So far there have been no systematic efforts to promote this change by means of, for example, splitting the personnel into those performing scientific research and those involved mainly in development. Also, the incentives have been more like those of science, and in the future

new rewarding methods have to be developed. One indication of the recognition of the new requirements is the plan to establish a marketing firm "VTT Technology" to create new channels to the markets.

An explicit and active product development or *innovation* policy as an aid to strategic planning seems to be attached to high innovation activity. This policy has to be convered into *explicit research and development objectives* (see, for example, Blake 1978, Ormala 1983) because they:

- o tie the research function closely to the objectives of the organization;
- o help to convey the strategy defined by the top management of the organization to lower levels in an operational form;
- o form the basis for decision making in different parts of the organization.

Successful innovators tend to be strongly committed to the objectives of an organization. In research institutions engineers and scientists, who are involved in industrial innovation, face the problem of dual objectives. Should they be committed to the objectives of the contractor or of their own organization? This problem may become tricky if the objectives turn out to be contradictory. At VTT the solution has been to define the objectives as broadly as possible: VTT should do everything to support the development of the Finnish economy. This formulation is definitely not very explicit!

Successful innovation tends to be associated with an *open horizontal management style* which is organic rather than mechanistic, particulary with regard to the R&D and marketing functions. The management at VTT has traditionally been relatively decentralized, and with the adoption of the matrix organization the development has been towards an even more decentralized system. In some projects it even has been possible to adopt management routines and principles from the contractor, which has eased the cooperation considerably.

There is no doubt that success is associated in particular with the presence in the firm of one or two *key individuals* (product champion, business innovator, technical innovator) who are committed to, and who enthusiastically support, the innovation (Rothwell 1977:202). To be effective, moreover, the business innovator must have sufficient power and authority to positively affect the course of the innovation, which means that he should hold a place high enough in the organization's hierarchy and have greater seniority. The most important question concerning the role of the technology development institutions is whether this product champion can be from outside the innovating firm, or whether this function can be divided into technological innovator and commercial innovator. However, as these "key individuals" are of great importance to the business firms, such persons are at least as important in technology development institutions. The recognition of this fact leads to the conclusion that among the most important management responsibilities is ensuring that the organization always has such persons available, and that everything is done to support them.

In the following sections the aspects and problems of management raised in this section will be discussed in the light of some of VTT's development projects in electrotechnology.

PRODUCT DEVELOPMENT PROJECTS CARRIED THROUGH AT VTT

A New Automation System

VTT participated in the development of a new microprocessor-based automation system for the Valmet Corporation. The system is technically described by Wahlstrom et al. (1983). Andersin (1983) discusses the project in detail and gives the customer's point of view of the project. The following are some comments about the role of VTT.

The main development phase lasted less than a year and, hence, there was considerable time pressure on the project group. The project group was highly motivated. At VTT the reasons may be the fact that the system was unique and many new techniques and ideas could be applied. Moreover, the same people at VTT had been specifying the system from the very beginning, and the feeling that the system was their own seems to have been encouraging. Also, the knowledge of the importance of the project was very motivating. When the new system was introduced there was a real market need for it. It had only one competitor which had been on the market for four years. Today there may be about 50 such notable systems available. The new, more efficient system was introduced at the beginning of an investment period in Finnish industry.

The arrangements for the project (see Andersin 1983) enabled fruitful communication within the project. About 30% of the work of VTT was also done in premises rented for the project. When people were close to each other it was easy to agree about details in the system, and due to vivid communication everyone received all the essential information without arranging special information distribution. At the beginning of the cooperation, the communication habits were very different at VTT and Valmet. During the project the researchers learned the engineer's language and communication was no longer a problem.

The customer's objectives for the project were also adopted by the VTT people and no great conflicts in this respect were noticed. However, during some extremely stressing periods some comments about the necessity of working during weekends and late in the evening were heard. It should be mentioned that VTT could not arrange for the same flexible overtime compensation as Valmet did.

The management style of the project employed weak project organization that allowed for independent work with full responsibility for the results for everyone. The total support from Valmet top management was also appreciated by the project group. Three VTT laboratories (Electrical Engineering, Telecommunications and Medical Engineering) were involved. The organization of VTT allowed for good cooperation between the laboratories, and the laboratory directors recognized the importance of the project. Although the project was real team work there were key individuals both in the management and in the project group, in the following fields:

— arrangements of resources
— adoption of end user's needs in the system
— functional approach to the system structure.

The project was successfuly brought to an end although a continuous updating is going on. However, two negative aspects of the project have to be mentioned:

- o some provisional solutions, which were made due to the time pressure, became permanant.

- o documentation was not always complete during the intensive development period. This affected the start-up procedure.

A Seeing and Learning Sorter

VTT developed a new sorting system for the Partek Corporation during 1977-1980. The system which is described by Mäenpää et al. (1982) should be able to sort different types of piece goods, and the sorting of lime-stone was chosen as the first application. The market need for this type of product was indicated by the fact that automatic classification of lime-stones allowed for utilization of about 30% more rock material than by using the hand picking method. The customer was also looking for new products and material sorting was seen to be a suitable field. The prototype was installed in a lime-stone mill in 1980 and the following year Partek came to a license agreement with a multinational company who now markets the system world-wide. Parket now has six lime-stone sorting systems in operation.

The system was mainly developed at VTT within a normal project organization and all the work, from the very first ideas to the prototype, was done at VTT. Hence motivation was very high because own solutions could be tested in reality. Moreover the problem was technically interesting, e.g., calculations showed that the problem could not be solved using a conventional approach. As the project was done mainly at VTT, normal management style was used. The main reason for the success was that a working project group could be found. Communication was quite informal within the project. The project group comprised of 4-5 people, all of whom worked in the same laboratory and came in daily contact with each other. The group also arranged special meetings to discuss different technical solutions. In order to transfer information to the customer, one person from Parket worked with the project at VTT for half a year. The objectives of the project were quite clear both for VTT and for the customer. However, there were some discussions between the two parties about what type of technical solution would give the best result. The project group had to motivate the chosen solutions very carefully, and these discussions also indicated the customer's interest for the project.

The customer was, perhaps, given better possibilities for looking into the project than is usual at VTT. This, however, facilitated cooperation and also made later phases easier to carry through. The division of the project into clearly defined parts, where some vital functions had to be demonstrated before a decision to continue could be made, gave the customer good control of the project. In the beginning the enthusiasm of some key individuals at Partek was needed to get the decision to start. This decision also depended on the first specifications of the system, which were done at VTT. Later during the project all the project members worked collectively to obtain the wanted results.

A Training Simulator For Operators of Nuclear Power Plants

From 1976 to 1980 VTT participated in the development of a training simulator for operators at the two nuclear power plants in Lovisa. The simulator which is described by Heimbürger et al. (1982) was delivered to the user (Imatran Voima Oy) by Nokia Electronics. VTT participated in the project as a consultant both for Nokia and for the user.

Several people were working in the project where a new product was developed. They had good motivation because they felt that it was important to succeed. Before the product development project, VTT had taken care of the invitation for tenders and their evaluation and participated in making functional specifications for the simulator. For Nokia there was a market need because there was no simulator available for training operators in Lovisa. The same type of nuclear power plants were going to be built in many other European countries and, hence, Nokia saw the possibility for new business. The project was done at Nokia and all the VTT people who worked as consultants for Nokia worked in the Nokia project organization with the work being done at the factory using Nokia's facilities. This arrangement again allowed for close communication. Information within the project was also distributed by arranging one day seminars at certain intervals during which the project people presented their work, at the same time receiving documentation on work already done.

In this project no differences in communication habits could be noticed. The people from VTT had, for a long time, been working with automation in nuclear power plants and had learned the language used. People at Nokia had a similar background. The objectives of the project were clear to everyone. The main objective was to get the system ready in time. The time schedule was realistic and was continuously checked and up-dated. Hence everyone in the project, from top management to the project group, knew the project status. Management was clear, with well-defined responsibility. Progress was followed by a coordination group which contained representatives of Nokia, Imatran Voima and VTT. This group made all the major decisions and was well aware of the project status. All parties (Nokia, Imatran Voima and VTT) had assigned experienced people to the project and all were in some way key individuals in the project. People from two VTT laboratories participated in the project (i.e., from Electrical Engineering and Nuclear Engineering).

CONCLUSIONS

In this paper, the role of VTT in industrial innovations has been discussed and three completed product development projects have been presented. In these projects the researchers were well motivated, and it is believed that this motivation is based on the fact that the same people worked on the project from the very beginning until the "bitter end". They could see their early drafts coming to concrete working end products. Besides motivation, the following aspects are of great importance in an organization such as VTT:

1. The incentives for making contact with VTT when there is a perceived need for research and development are important. It seems obvious that VTT should strive to develop its image and contacts to make such inquiries more likely. In this respect, the importance of personal contacts between VTT staff and potential customers should not be underestimated.

2. The initial work with the customer is important, because here VTT has to show the customer that it has the capacity to solve his problems. In two of the described cases VTT did the first rough specifications using public funds. These specifications were presented to the customer so that he could check whether the approach was appropriate.

3. Broad contacts within VTT enable the use of the right resources for every problem, and the customer can be directed to the laboratory which is most suitable to solve his problems.

4. The specifications of a new product must not be changed during the project. In the described projects no major changes were done. This fact seems to depend on the way the products are specified. The specifications were given in functional terms using the user's viewpoint and he was always represented when the system functions were discussed. In the specifications a top-down approach was used where the system was divided into smaller and smaller functionally well-defined parts.

5. The testing of a new system is critical. During this phase, everyone tries to turn the responsibility to somebody else. Testing is easier if the system is divided into functionally well-defined and well-documented parts with clear interfaces.

6. No extra pressure should be put on people who have already given their all for the project. In such cases it is better to make the time schedule more realistic.

7. The transfer of information from VTT to the customer has to be arranged in goodtime. In all the described cases the representatives of VTT and the customer worked under the same ceiling for some time. Other similar arrangements are also possible.

If a project is well planned, and both parties are aware of each other's capacities and needs, an innovation project has a good chance to succeed, although the objectives of VTT and the cusomter may sometimes differ, i.e., when the customer wants a product but VTT has to take care of all its employees, which means that the best resources cannot always be allocated to every project. Through a suitable use of both young and experienced people in the same project, the younger have a chance to learn.

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HUMAN DILEMMAS OF STRATEGIC MANAGEMENT IN AN INFORMATION SOCIETY

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INTRODUCTION

Over the past several decades, the main body of Business Policy literature has emphasized general management creativity and innovation as the keys to successful strategic planning (Christensen et al. 1982). A strategy or plan of action, according to this point of view, is supposed to define an organization's goals and objectives, the pattern of internal resource allocations, competitive risks, and plan implementation and control procedures (Patz 1981). Furthermore, when the organization under consideration is a business firm, strategic planning serves as the crossroad for innovations in product and process technologies and innovations in approaches to markets (Koch 1974).

This view of strategic planning, although heavily influenced by industrial organization economists (Porter 1981), has always been rather "human" or behavioral in its emphases (Patz 1976). Nevertheless, a new term "strategic management" has been coined as a more inclusive symbol for the strategic planning plus strategic behavior point of view (Schendel and Hofer 1979). Almost always, of course, strategic behavior refers to the actions and interactions of the general managers doing the strategic planning.

Also, much of the research on strategic behavior follows fairly typical lines. That is, the important questions focus on what kinds of people are creative and innovative in general management positions, whether or not planning behavior can be made more efficient in one sense or another, and which intervention methods are more or less useful for changing the behaviors of a planning group (Mitroff and Emshoff 1979).

These issues are important ones and need to be pursued in all kinds of societies, including those making the transition from "smokestack" to information based economies. Nevertheless, information based economies are generating an entirely new set of human issues that will profoundly affect the strategic planning process. The purpose of this paper is to discuss a few of them and their strategic planning implications.

HUMAN STRATEGIC ISSUES OF THE NEW HIGH TECHNOLOGIES

Beginning with the obvious, the phrase "high-technology" means something quite different in the 1980s than it did in the 1950s. Three decades ago, high technology products were jet liners, first generation computers, and sophisticated plastics made possible by the manipulation of molecular structures. They were admirable achievements, but they only enhanced the social and economic thrusts of the times. Today's products are artificial intelligence, automated factories, distributed data processing, international data transfers, robotics, and several others. Automated factors, for example, include CAD/CAM/CAT, that is, computer aided design, computer aided manufacturing, and computer aided testing.

The technologies of thirty years ago appear almost as distant to today's developments as the self-sufficient castles of feudalistic times did to the new factories of the industrial revolution (Durant 1944, 1950, 1975). Yet, the strategic, let alone human, implications of these more recent developments have been largely ignored in the academic and trade literatures. Hardware and software occupy center stage with only minor efforts being devoted to manufacturing strategy and human problems in an information society (Skinner 1978).

Nevertheless, the information revolution is causing another social and economic upheaval. The evidence is obvious. It ranges from high inflation and unemployment rates to the development of altogether new industries, defense systems, and social mores. In short, several symptoms of this revolution are now apparent, and as can easily be supposed, they are primarily human concerns. Briefly, key human issues of an information society are:

1. A further uncoupling of the relationship between productivity and consumption.

2. A new independence within economic units among their growing international independence.

3. A transfer of power within economic units.

4. A new sources of risk—anticipation.

Likewise, their strategic planning consequences are:

1. A wider range of self-determination.

2. A fortuitous business risk distribution.

These are not independent issues, nor are they totally interdependent. The easy distinctions of probability theory do not apply. Furthermore, because they are human issues, they have to affect individual and group aspirations and expectations. In other words, they have to affect fundamental creative and innovative process (Secord and Backman 1974).

A PROBLEM OF DEFINITION

When the first of these human issues is considered—the relationship between productivity and consumption—otherwise reasonable people lose their

perspective rather easily. One person's aspirations are another's expectations, and the scales of justice do not distinguish very well among the efforts that individuals make and the results that they achieve in the pursuit of individual rewards. Nevertheless, some crude distinctions can be made regarding human factors in the overall strategic management process.

First, few people would disagree with the argument that the rewards for an individual's contribution to an organization are at least delayed in time if not uncorrelated with the effects of the contribution. Performance measurement methods are just not that precise, and not many people responsible for deciding merit differentials would prefer a greater degree of accuracy. A substantial degree of error always aids austere as well as beneficent largesse.

Second, the coming information society is not making these difficult merit distinctions any easier. Agriculture, manufacturing, and mining are already within the province of flexible machinery and robots (Scientific American 1982), and the office of the future is not far behind (Management Technology 1983). Automated retailing is now a reality with videotex (Byte 1983), and the microcomputerization of education is already past its beginning stages (Watt 1983). In other words, the relative dominance of machines—not people—in productivity matters is becoming absolute.

Yet people—not machines—are the primary consumers of goods and services. Thus, a difficult question has been raised, and it can be asked in several different fashions. For example, what will it mean to "work" for a living in an information society? How will the concept of "income" be defined? Or, how will the results of machine productivity be distributed among people?

Strategic planners will have to face this question, in the above forms and several others, and possible answers are not very clear. Work, income, and the distribution of wealth lie at the "human" core of strategic management. Why else would people engage in such an exhausting process as strategic planning for economic competition?

This is just one dilemma, however, in the coming strategic management puzzle. It will most likely interact to some degree with the others to be discussed in the following paragraphs, but it gnaws at our very existence. Some sort of relationship between productivity and consumption seems almost sacred.

OTHER DILEMMAS

Less sacred, perhaps, are political and economic risk issues. Even without naming the issues, this territory should be familiar. But, the information (high technology) society has added some new dimensions. The most obvious one, of course, is the totally international nature of today's business environment.

Independence and Interdependence

In fact, the international interdependence among economic units is such a well-respected truism, that the absence of this recognition just a few decades ago is surprising by comparison. Markets are now worldwide, not just local, and every strategic planner has to recognize this.

But, there are more important "truisms" to be observed. Among these are the following:

1. International business alliances can be made in several directions—each one with a different marketing, production, and financial management purpose that nevertheless adds to the viability of the entire multinational enterprise. It is simply not imperative that parochial arrangements be maintained. Automobile manufacturing and assembly, oil production and distribution, and international shipping—to cite a few examples—can be negotiated in several directions. An individual firm composed of several interdependent multinational constituencies is a powerful source of economic safety (Rutenberg 1982).

2. This international range of competitive alternatives not only allows but also invites a significant increase in the number of strategic planning choices within an individual firm. As a result, the choices among alternative market behaviors have more or less equal face validity (Patz 1982).

3. Any specific strategic choice, among this class of equally reasonable ones, is difficult to verify and justify given cross cultural data differences, deficiencies, and errors. These data problems are common to regional or national strategic planning efforts. International business planning, on the other hand, not only faces the same issues on a nation by nation basis but also has to deal with the translation of findings to some common basis.

4. In short, an ambiguous international environment provides a great deal of choice independence within economic units that are otherwise internationally interdependent. That is, strategic decision making is becoming more a matter of opinion than a matter of fact.

What decision makers declare to be relevant in the determination of which goods and services to produce is at least as important as actual market forces. The inexorable machinations of these forces may be dominant in the very long run. On the other hand, predictions of market structures and dynamics are about as accurate as the performance appraisal methods mentioned earlier. Therefore, one hypothesis regarding the independence of strategic choices within economic units is that these choices are at least as effective in determining market structures and dynamics as well as vice versa.

Power Transfers

Of course, such internal independence—as it always has—leads to power struggles. Some person, or more often, some group has to decide where resources are to be allocated in the pursuit of goals that are defined more as a matter of opinion than as a matter of fact. This is not new. What is different is that the new high technologies are changing "who decides."

Distributed data processing is a prime example; and, like all information processing terminology, the term "distributed", when used with "data-processing" belies its real significance. The main issue, as far as data processing people are concerned, is how to maintain control over organizational operations. Any optimal use of information for decision making purposes is strictly coincidental (Weinberg 1983).

Most important, what is strategically important to a firm is determined by who has access to its information processing unit. Information can be manipulated, denied, and modified by anyone whose best interests are served by such procedures and has access to the necessary information channels. This is not a game; it is a matter of power. Furthermore, power interests in any organization are not best served by clear, concise, accurate, and readily verifiable information (Cyert and March 1963).

Distributed data processing enhances power transfers because it allows greater generation, modification, use and control of an organization's data base by its information processors. It is an ironic outcome of decreased information processing costs that more and more people can have access to a firm's information base with little interference. In the words of one chief executive, "We are risking our business on what those people do!"

Anticipation Risk

A greater access to and use of information, however, has more than internal organizational effects. Almost all firms can play the "information game" and, of those who can, most do. Relatively sophisticated economic and financial models, analytical tools that once were available to only a fortunate few, are now on sale at a minor cost in any microcomputer store. Furthermore, dozens of multinational information services are available without any additional computer hardware than a modem (Desktop Computing 1983).

But, due to this enhanced computing power, every firm may anticipate the range of strategic actions available to every other firm in its markets. Detailed projections can be made for each alternative taking into account product lines, markets, new ventures, and the financial conditions of the main competitors. Of course, these projections are made against each of the main strategic alternatives available to the firm doing the analysis, and several interesting results are obtained. The simplest ones, of course, are pro forma projections for all the firms included in the analysis.

Many firms are already doing this, but some analysts tend to stop at this point and argue for the strategic alternative that yields the most desirable pro forma statements. Others tend to go further and attempt to specify strategic actions that should be taken if and when:

1. Competitors' behavior is significantly different than expected.

2. Market conditions change due to factors other than competitors' behavior—including economic cycles affecting demand growth and decay, government actions (such as regulation and tax code changes), and labor negotiations.

3. Other low probability events occur—such as possible mergers, acquisitions, diversifications or research breakthroughs.

In so doing, these latter analysts are bringing competitive actions closer and closer to real time. They are making "anticipation time" to strategic actions by competitors more important than reaction time. Said in another way, a long sought after goal of strategy formulation and implementation (Business Policy) is at hand. That is, offensive and defensive strategies can be formed, in fact, before they are needed.

But, since anyone can do it, each firm's business strategies carry a higher risk. Many other firms are anticipating a given firm's strategic alternatives, and the cost of doing so is very low. More important, the probability of implementing viable competitive strategies—and successfully combating market threats—is rather high.

The US microcomputer industry is one example of the phenomenon. Many firms are surviving even though six months to one year is not an unusual life expectancy for many hardware and software items. This time span is too short for firms to survive simply by copying one another's product innovations and bringing them to market. The products and manufacturing processes are too complicated for that. In short, their strategies have to be anticipatory.

Likewise, with the advent of national and international data transfers, the banking industry has entered the world of high technology and anticipatory strategies. The bewildering array of new financial instruments is offered too closely in time from too many banks for them to be simple copies. If nothing else, the information systems and business forms take too long to develope for a bank to remain competitive simply by copying its rivals.

EXPANDED SELF-DETERMINATION

Of course, firms can and do engage in industrial espionage in order to reduce their anticipation risk. This is another human dilemma of strategic management in an information society, in spite of the fact that the success to failure ratio of such efforts is probably fairly low. In fact, such efforts may increase anticipation risk simply by forcing firms to anticipate them. Even if the net effect of industrial espionage is nil, these three basic social and economic phenoman—independence within a greater international interdependence, intraorganizational power transfers, and anticipation risks—have a combined influence on several strategic planning issues. Two are noted in this paper.

First, the range of organizational self-determination or discretion is increasing in several important dimensions. An obvious one is location. The information society does not depend upon navigable rivers and natural harbors to the extent that industrial society does. Climate and access to other desirable geographic features can dominate in the location of a firm and its various facilities. Certainly this is already the case in several areas of the world.

Equally important, if not more so, is the fact that distributed information encourages the making of key decisions at other than top management levels. Time is money, but information is power. Those who have access to it—and can manipulate it—can make strong arguments for resource allocations that favor their programs, markets, and products.

Add to this problem the difficulties associated with justification and verification of any strategy in the face of competitors' anticipation, and several power bases within an organization become contenders for discretionary prerogatives. In short, because of the new technologies, an old strategic management task is coming to the forefront. That is, it is becoming more and more difficult to maintain a coalition when independence, information and anticipation forces are pulling it apart.

Even the ruling group of the organization or coalition, the top management team, has its problems. It has to deal with conflicting demands for resource allocations from different information centers that all too often use the firm's own data base, have a reasonable face validity, and pit against each other the barely latent sympathies of the ruling group. When nonruling groups face each other however, sympathies are anything but latent.

Symptoms of these fragmenting forces at other organizationlevels are abundant. For example, compensation problems—particularly the compensation of sales people and worker participation in compensation decisions; productivity disputes; and the nonacceptance of computerized systems by those expected to use them are common examples at the operating levels of many business firms. To make matters worse, when computerization and automation occur in several places at once in a firm, and when performance measurement of those involved is difficult (the same strategic justification and vertification problem at the operating level), the relative values of individual inputs and outputs in the production process can be easily confused.

Moreover, middle management fears of being replaced by information systems at the administrative level are even more dramatic. According to one estimate, "When the factory of the future arrives, the workers on the shop floor will be the least affected, while automation will obviate entire layers of middle management" (Kindel and McDermott 1982). Of course, in several American and Japanese factories this sort of "estimate" is already a reality. In all cases, however, the coalition maintenance problems of ruling coalition or strategic managers have increased.

In other words, self-determination is a mixed blessing for the participants in modern organizations. In exchange for more numerous degrees of freedom, top managers have a much more difficult coalition maintenance task; middle managers are simply trying to survive; and everyone else is trying to deal with a nebulous performance measurement and reward system. Especially with this last problem—performance and rewards—the previously noted and mounting problem of productivity and consumption in an information society will strain the creativity and innovation of general managers.

FORTUITOUS BUSINESS RISKS

Last, but most important, anticipation risk is affected by expanded self-determination and power transfers. The computational power referred to earlier, and the flexible strategies that can result, are not immune to the power struggles of fairly independent organization participants. Rightly or wrongly, in any particular circumstance, individuals and groups will view their self-determination rights as paramount—more important, that is, than the execution of the ruling coalition's intended strategy. Perceived and actual productivity/consumption discrepancies will enchance these difficulties; and, with increased access to important information, the bases of such difficulties will be easy to justify.

In short, anticipation risks—with a fairly well-defined probability distribution—can and sometimes will become fortuitous business risks. That is, the possible outcomes of a particular strategic choice, given the strategic choices of all main competitors, will be impossible to define. In program management terms, the costs, time required, and ultimate profitability of implementing a particular strategy will become "unknown-unknowns".

This sort of condition can result from technology alone. For example, the development of a new weapons system is oftentimes begun when it is well-known that its successful deployment will depend upon technologies that have not yet been developed. Likewise, commercial projects such as the Alaskan pipeline (Patz 1981) and Kodak's SX-70 camera (Steiner and Miner 1977) have begun under the same conditions.

But, the purpose of the above argument is to suggest that human factors are and will be more important than technical ones. A wider distribution of independence and decision making power is the key. It allows more people to participate in strategic decision making; thus, it allows these same people to bend the process to their own interests. It is again ironic that another outcome of decreased information costs is a simultaneous increase in the probability of individual freedom and organizational chaos.

The net result, of course, is that strategic outcomes cannot be very well defined in advance, and the ability to predict them is severly attenuated. In fact, prediction becomes far less important than maintaining a coalition and pursuing some sort of flexible strategy.

In traditional terms, a flexible strategy is one based upon the anticipation of change. In periods of great technological change, however, fortuitous or accidental futures reinforce and amplify change, and planning becomes a real time issue. Real time planning, in short, will be concerned with market dynamics of at least shorter durations than in the recent past and possibly with wider fluctuations.

Taking multiproduct firms as an example of such dynamics, market share battles will take less time but occur more often as industry product-market structures undergo continuous rather than discrete changes. Product life cycles will diminish as the rate of technological (product and process) innovations increases. And there may be some increase in mergers and acquisitions that attempt to reduce risks through integration and diversification.

Again, the microcomputer industry is a leading example of these phenomena, but other industries are demonstrating the same characteristics. Banking has already been mentioned; and others include the machine tool, photographic equipment, office equipment, and aerospace industries—to name a few. Even the US automobile industry is beginning to reassert itself and cause a few dynamics in at least its domestic markets.

CONCLUSIONS

Of course, more turbulent market dynamics pose another human dilemma in the information society. People may tolerate high levels of uncertainty for a long time, especially in these beginning and novel stages of the revolution. However, as the years pass and the novelty begins to wear, it is not unreasonable to assume that general human tolerance levels for such conditions will diminish. Humans do search for certainty and definition in their lives (Secord and Backman 1974), and there is no reason to suppose that an information society will profoundly affect basic human motivations.

The new so-called "cottage-industries" that have developed, especially around software design, are a case in point. The archetypical scene is one of several individuals working alone in front of their CRT's, communicating with each other via their modems only when absolutely necessary. There may

be an occasional group meeting for coordination or sales purposes, but most of the time people work in their homes.

This sort of existence may suffice for some people and, in fact, it does. Most people, however, develop and validate their self-images and world views through interactions with other people on a regular basis (Mead 1934). These interaction regularities govern not only our thoughts, feelings, and perceptions, but they also teach us how to anticipate other people and respond to their actions. It seems highly unlikely that a fairly isolated existence in front of a CRT will become very much of a substitute for regular human exchange.

Likewise, large performance/reward imbalances within an organization usually become known when information is exchanged as part of normal human interactions. This phenomenon is not new; it is as old as human existence. What probably will be new is that people will tolerate only narrower and narrower income distributions, thus, more and more identical consumption possibilities. The reason, in short, is the uncoupling of productivity and consumption made possible in an information society. If individual contributions to productivity are difficult to trace, why should consumption patterns have a large variance?

In other words, market thus organizational turbulence and reward inequities will become matters of even greater concern for general managers in an information society than they are in an industrial society. Evidence for this statement already exists and is reported regularly in business newspapers and magazines. That is, chief executives and other top managers regularly report that they spend more than half of their time on government, labor and public relations problems. In fact, one recent article suggests that public relations experts will be tomorrow's chief executives (Cannon 1983). Clearly, someone else will have to attend to the technical and financial details of business.

Indeed—as the preceding discussion of anticipation risks, power transfers, and independence/interdependence suggests—managing innovation on the general management level will be concerned to a large extent with the maintenance of viable coalitions. A wider range of self-determination and fortuitous business risks appear to be focusing general management attention in that direction. In fact, the final irony of the information society may be that general managers will "run-the-organization" and someone else will "run-the business." Only a few years ago, one of the main reasons for buying a computer was to help general managers run the business.

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THE FUTURE GENERATION—A GENERATION OF INNOVATORS

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Modern society depends very strongly on science and technology and, in the future, these two main factors will become more determining. The growth of science and technology to satisfy the growing and emerging needs of society is the main objective of modern production in all areas. Therefore, innovations, both in industry and in all other areas, are vital and inherent for modern society. Innovations change working conditions, educational environments, the way and conditions of life. The easier and more imperceptibly these changes are made and the less social contradictions they cause, the easier it is to implement each innovation, and the easier and quicker it is to pave the way for technical progress.

While in the 1950s and 1960s many industrial firms ignored the importance of the human factor in the management of innovation processes, today a glance is much more frequently cast at the methods used for the effective use of human potential in progress and productivity. But the fact that we are here today to talk about the role of the human factor in innovation processes makes our conviction deeper that, in these conditions, it is difficult to find the labor force (potential) that is ready and capable to adapt to the new requirements of technical progress*.

The motivation, the stimulus to creativity, to cooperation and readiness to accept innovation, is one of the main tendencies in the modern management of innovation processes. How do we solve this problem?

1. MICROCOMPUTERS - A BASIS OF INNOVATIONS IN THE 1980s

Since 1950 the computer has played an important role in the field of technological development. Today, large computer systems, and small personal

*Dr. Thomas Moss, Human Factors in Innovation and Productivity, Task Force Meeting, Leningrad, May 1982.

computers are common in big organizations, for individuals and for specialists. Gradually, data processing, by means of highly efficient computers, has turned into a need not only in industry but in the social sphere and in everyday life, especially in education. It has been determined that microcomputers, as a primary innovation, have entered electrical engineering and electronics and have become a basis for the increase in productivity and effectiveness in all spheres of human activity. It has been predicted that, so far, microcomputers have revealed only about 20% of their technological possibilities and that in the following twenty years will reveal the remaining 80%. The period from 1984 to 2000 is expected to be an epoch of important main innovations in the field of microcomputers, and around the years 2000 to 2025 new inventions can be expected in the domain of energy sources*. At present, innovation activities require more interdisciplinary studies which will result in workable innovations, satisfying the increasing needs of people. The strategy now is to unify and promote the innovation activities of all key areas, including data processing, communications, etc. The next "boom" in microcomputers will entail wide interdisciplinary studies and will bring many secondary innovations in all fields of human activity, including social activity. The next 20 years will be the years of the microcomputer, but it will cause many changes in science and technology and in study methods as well.

2. TRAINING OR EDUCATION

What are we doing today to prepare the personnel potential for the big change of tomorrow? The serious changes in the technique and technology of tomorrow will lead to important changes in everyday life, in the social sphere and in education. This in turn will impact human relations in all (small and big) other spheres -- the family, the team, society as a whole. Are people ready to accept this technical revolution easily?

Today we develop, train and retrain employees to meet the requirements of the organization, of their job, of life. First, we look for and evaluate the conditions and requirements and then we organize training and retraining. Very often it happens tomorrow. It delays the process of adoption of new techniques and technology; and the tempo of learning new knowledge is lost and at best it makes the man a party (if not a well-intended observer) of technical progress and not an initiator of the new.

Today the idea of "training for innovation"** is attractive and may be the appropriate answer to some problems. But what we need tomorrow is not "training for innovation" but eventually "training and education for innovation". We need a generation of innovators, who accept the technical revolution as their natural environment, and as a natural course of development. Innovators, promoters, implementors -- these are the people needed by industry. If a generation grows in a natural environment of technique and technology and more precisely of microcomputers and computers, it will continue refering to its assistance and will try to develop this natural companion in everyday life. This approach to the training and education of the younger generation will create the possibility for eliminating the negative effects

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*Cesare Marchetti, Society as a Learning System: Discovery, Invention and Innovation Cycles Revisted; Technological Forecasting and Social Change, 18:267-282 (1980).

**Gottfried Wolf, Training for Innovative Activity, IIASA CP-82-00 (1982).

of innovations, and of new informational technology in particular. It will also provide the possibility of avoiding undesired social traumas in communications as a result of the informational "boom" and the fast advent of the computer in everyday life.

3. APPROACH TO PROBLEM SOLVING

Solving this problem is a difficult and complex task which can only be solved by systems analysis. This set of tools is still not used for solving the problem of the behavior or relation of children and the younger generation with the computer, or, on a wider basis, with the modern technical revolution.

The problem, as already noted, is complex and covers nearly all spheres of human activity: training, education, industry, science. Therefore, interdisciplinary studies in this field will give faster and more important results. The efforts of many specialists and wide international cooperation are needed to achieve success in this complex, but very perspective field of study. Maybe it is not incidential that we are approaching the International Youth's Year, declared by the United Nations as 1985. Maybe on the eve of 1985 scientists and specialists will really face a problem, related to the future generation and the whole development of society.

4. IMPACT ON INDUSTRY

As already mentioned, the method of training and educating the future generation with regard to technical progress is a complex issue which will have an effect on all spheres of human activity. However we here are mainly interested in the impact of these decisions on industry and their use for managers.

A new approach to training and education or the creation of "training and education for innovation" will give industry the possibility of having an "able and knowing" personnel potential; people who are not afraid to encounter unknown techniques that are complex and require new knowledge and new skills. So there will be people who have accepted new techniques and technology as a natural process in their everyday life; people who can work with microcomputers, who have the microcomputer as a natural companion in their environment and know that its perfection can be only of use both for man and society. This personnel potential is a natural environment for new ideas; as it produces an inner potential and drive for creativity and initiative, and it does not need additional promotion, still less training and retraining. The presence of such personnel will ease innovation processes in the organization and will naturally lead to the solution of some new problems with regard to cooperation in idea development, choice of the best idea, etc.

It can be maintained that innovation is born under pressure of a new idea, but for this the personality needs some creative features, initiative and creativity. The education of the young generation in this line will provide the possibility for each member of society and of the organization to become an innovator.

5. STATE OF THE PROBLEM

For the time being the problem regarding education and training of the new generation in such a way that it will decrease the deformities arising from the co-existence with computers, and which will make computers part of man's natural environment so as not to cause psychic traumas and deformities, is considered and studied unilaterally by different sciences with different purposes. Such main problems as future computerization and changes in the social mileu, the adaptation of young people to science and technological progress in general, and to microcomputers in particular, and the use of the creative activity of the young people in the field of science and technique, are left out of the scope of many studies.

The use of computers in education is studied, but it is mainly done to ease the education process and to increase the volume of presented information, it is done less to achieve social, universal or industrial oriented goals.

The People's Republic of Bulgaria has a continued and lasting interest in the problems of affording opportunities for the young generation to develop as harmonious and creative personalities with great possibilities for manifestation and deployment of their talents in science, technology and the arts. Therefore, the problem is of considerable interest for us and we would welcome and support the formation of interdisciplinary and international groups to study these problems. Seminars are being held in Bulgaria on the problems of computer use in education, with children's meetings on technical and scientific arts, and a regulated movement among the youth, i.e., "technical and scientific work of youth" is seriously developed. These types of activities are developed on a larger scale and the People's Republic of Bulgaria will hail all steps for the organization of research programs which will create opportunities for accumulating new ideas, decisions, proposals and studies in this field.

ROLE STRUCTURES AND CREATIVE POTENTIAL OF WORKING TEAMS

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In the process of creation and introduction of any innovation--new technology, process, product or service, etc.--there arise new, hitherto unknown problems to be solved practically at all stages. At an early stage these would be largely R&D problems. Later problems of an organizational and managerial nature such as industrial engineering related to a product (service) or assimilation of new technology (process), elimination of organizational or psychological barriers to innovation introduction, and the training of the user (customer) for consumption of a new product (service), etc.

Each of the above-mentioned problems gives birth to completely new tasks and requires innovative ideas and their verification and implementation. The newer the problem, the greater should be the degree of creativity employed for its solution. Those tasks related to the innovation introduction stage, e.g., connected with restructuring the organizational system, may be similar in their novelty and complexity to those arising at the birth of the innovation (formulation of the first hypothesis and their logics) as far as the level of the required creativity is concerned.

It follows from the above that one of the decisive factors for successful innovation creation and introduction is the creative potential of the individuals and teams called upon to solve the innovation related problems. Nowadays, since labor has acquired a collective character, the creative potential of teams working on new, non-trivial problems seems most important for a shorter lead time, and a higher effectiveness of innovation introduction.

In this connection one of the most promising ideas would be the improvement of the socio-psychological structure of the teams engaged in creative work. This idea is based on the "program and role" approach to the analysis of the research teams' activity

Studies show that the activity of research teams is greatly dependent on its role structure characteristics. The role structure of a team is the totality of scientific roles and the relationships existing between them. The role structure is formed in the process of various components of research activity distribution between individual members of the research team. It is expressed in the stable specialization of its members in the performance of specific homogeneous functions (if they perform these functions with intensity and sufficient regularity) and the intensity characteristic for this role is above the average for the team as a whole.

It is obvious that the creative activity itself is the main determinant of a role structure in a research team. Distribution of scientific roles among the team's members is also influenced by a number of objective and subjective factors. The former include primarily the necessity for division of labor, differentiation of functions in any joint activity, and the team's formal structure.

The subjective factors include:

a) level of special training of the team members (more creative roles require, as a rule, a higher level of specialization);

b) the personal and psychologically distinctive features of team members: mentality, temperament, character, inclinations;

c) interpersonal relations in a team; and

d) creative potential of the associates.

One can distinguish the following roles in a research team:

1. *Leader-organizer.* The person playing this role is oriented towards the team's activity. He skillfully coordinates the efforts of the team members, organizes activity to accomplish the assigned task, motivates members to perform their functions, and provides for fruitful scientific interaction. This role is usually played by the formal head of the team who thereby acquires the status of an informal leader.

2. *Generator of ideas.* The person who plays this role should be able to grasp the problems better than others, constantly supply new ideas and non-trivial solutions, find unsought-for analogies revealing the problem from a new angle, etc.

3. *Critic.* This is an essential role for any successful creative activity in science. The critic finds weak and strong points, formulates the pros and cons of ideas, methods, approaches; doubts everything, and urges the team to debate the existing or suggested solution.

4. *Erudite.* This role is characterized by broad scientific erudition. The person playing it reads a lot, knows a lot, and willingly shares his knowledge, and is always capable of giving scientific reference.

5. *Performer.* This person should have one main pre-requisite--the ability and willingness to work under the guidance of others. The performer in a team is largely engaged in executing activity: he can make experiments as per assigned program very well, make calculations, the required documentation, drawings, accounts (reports) and perform minor jobs assigned him by the leader.

6. *Practitioner.* This role consists in establishing contacts with process engineers, those engaged in the production process, the clients and consumers. The practitioner is essential for the practical development stage of research findings. He looks upon each issue with respect to its practical effect and is capable of persuading people to see the usefulness of a new development.

All the above roles are essential for an effective process in a research team. The best number of roles in a team is a difficult question since one can identify very subtle nuances of the role structure and thereby increase the quantity of possible roles. In any case the number and assortment of roles in a research team should correspond with the research activity structure and completely provide for its entire process.

We have made an empirical study of role structures in research teams in a series of research institutions in the field of engineering. Before summarizing the study, let us point out the three basic variables used for the study:

1. effectiveness of a research team's activity and its management;

2. the degree (level) of creativity of a research program; and

3. the role profile of the leader and team members.

Effectiveness of the research team's activity and its management. So far there has been no single criteria for evaluating this variable. In our study expert judgment served as a basis for performance evaluation. This technique is sufficiently reliable to determine relative (if not absolute) productivity of some or other research team. Directors of institutions, their deputies for science, and heads of major scientific units (divisions, laboratories) acted as experts.

The degree (level) of creativity of a research program was determined by expert judgment with respect to novelty, utility and originality of the program.

The role profile of the leader and members of the research team was determined by means of *cross evaluations (including self-evaluation) by the leader of the team* on:

1. actual performance (regularly, as a rule) of some or other scientific functions;

2. quality of their performance (evaluation made by the leader and members of the team).

In the course of the study the following stages or research activity were identified: pre-program, problem selection and its solution, research program elaboration, implementation, application (publication of results), and acceptance of the results by the clients (users, industry, etc.).

The study has shown that in each step of the research program implementation of certain scientific roles or their configurations were identified as characteristic of that step only and essential for its successful accomplishment.

At the pre-program stage the problem is not yet explicitly defined, only broad problem areas are identified. The final objective of this stage is to define feasible problems. Of primary importance here are the roles of "generator of ideas" and "erudite".

At the problem selection stage a dialogue from among a certain set of problems occurs between the "generator of ideas" and the "critic". These roles become dominant in the role structure of the research team. A significant part is played here by the leader who often makes the final problem formulation. Problem selection is an important component of creative activity.

At the elaboration stage the heaviest burdens are shouldered by the "organizer", "generator of ideas" and "critic" as this stage requires not only theoretical work in formulating hypotheses, searching for adequate solutions, etc., but also job distribution among the team members.

The implementation stage is characterized in that the leader and performer roles come to the foreground. The leader coordinates the efforts of the team members and controls their performance.

At the application stage the leader, practitioner and performer roles are the most important.

Analysis of the empirical material has revealed only minor discrepancies in the role structures of research teams working on research programs that require different creativity levels. In teams with different research programs the specific weight of each role is practically the same. The only thing that is not the same is the representation of functions concentrated in the role of "practitioner". Research problems that require teams with a higher level of creativity are less oriented towards immediate practical application of the results of their work.

Analyzing the quantitative indicators, one notices that they are different in effective and non-effective teams. This difference is characterized by two factors:

1. in effective teams a larger number of members have an active role profile, i.e., at least in one role their performance is higher than the standard;

2. the presence of a distinct leader in each role is more characteristic for effective teams than for non-effective teams, i.e., there is a more rigid role differentiation that leads to closer scientific contacts, and a greater need for cooperation.

Of great significance is the composition of the role ensemble established in a research team. Teams containing "generator of ideas", "critic" and "erudite" work most effectively, while teams composed just of "generators", "critics" or "erudites" are less effective and often fail to accomplish the assigned task.

One of the powerful factors influencing the performance of research teams is how the role is perceived by the leader. The better he perceives the roles of the team members, the more effectively the research team he heads works.

Of no less importance for the intra-group effectiveness is the role profile of the leader, i.e., the assortment of scientific roles he plays in his own team. The leader as a rule plays the roles of "generator of ideas" and "erudite". This outlay is confirmed by the objective facts and the opinions of the leaders themselves as to how the role functions are performed by them. From our viewpoint, these roles are optimal for the leader of a research team, as he should possess broad knowledge in his own and related fields of science, ability to generate new ideas, find non-trivial approaches to the problem resolution, etc.

We turn now to the role of "organizer". The literature on the subject always emphasizes that the leader of a research team should also perform organizing functions but in reality the formal leader is not always the organizer of the team's relevant activity aimed at the research program implementation. It is remarkable that in nearly half the cases of our study these functions are assumed by another member of the team. However, the performance of the roles of "critic" and "performer" by the leader have a negative effect on the team's activity.

It should be pointed out that the role profile of the leader is influenced by the role profiles of the team members, and vice versa. For instance, in highly qualified research teams where the leader has no intellectual superiority his excellence as "generator of ideas" will be lower in comparison with other members of the team.

The results of the study permit a number of interesting and constructive conclusions concerning improvement of research team management through selection of optimal role structures and effective utilization of the team's potential.

Knowledge of the research team's role structures may be helpful to the leader at a very early stage of the team's formation. In recruitment of scientific personnel the leader (after basic acquaintance with the work of the candidates and personal interviews) may form a preliminary opinion of the abilities of some or other person, decide what functions will be performed by him, and whether he or she will fit into the team's role ensemble.

Shaping a research team, the leader should provide for a "generator of ideas", "erudite" and "critic" who will make the team's core. The team that does not possess people corresponding with the above roles cannot hope for effective research activity.

It is assumed that the leader can actively influence shaping the role structures in his team, not only by recruiting the appropriate brain but also by developing the required qualities (abilities) in the team members. He can do this by assigning them with ever more sophisticated functions, thereby raising their professional level.

Regular evaluation of team members' performance of their roles will considerably help the leader in the distribution of responsibilities, formation of forces for some specific tasks and organization of scientific discussions. Knowledge of role structure dynamics will contribute to a more effective distribution of effort at various stages of research program implementation.

There is another conclusion that the leader must make after acquaintance with the role structure theory: he himself should avoid assuming the roles of "critic" or "performer" but find other people capable of performing these functions.

All the above conclusions stem from the study mentioned earlier in this paper.

Our next hypothesis consists in that the conclusions shaped in the course of the study of research teams can be applied to teams engaged in other types of creative activity. It is based on the understanding that the level of creativity required for resolution of the problem depends on its novelty and not on the character of the task (theoretical, technological, organizational, etc.). Handling new problems that are not prone to trivial approaches and techniques, there arises a need for new hypotheses, their verification, critical examination and organization of effort toward their solution. Consequently, there emerges a need for performance of the same functions and application of the same abilities of people who participate in the solution of these problems as in research teams. It is quite natural to expect that as a result of interactions inside the group and differentiation of labor there will appear distinct bearers of some or other roles similar to those in a research team, as well as a certain role structure whose nature will substantially influence the team's performance.

These conclusions may be applicable to teams engaged in all stages of innovation processes to solve various tasks. It is confirmed by the above-said independence of the role structure configuration from the creativity level required by the tasks to be solved.

This hypothesis, undoubtedly, requires experimental testing.

INNOVATION MANAGEMENT: THE ROLE OF CREATIVITY

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1. INTRODUCTION

Most technological change involves organizations; most new ideas come from individuals or the interaction between two or three individuals. The management of organizations is often concerned with preserving the present rather than creating the future but creative individuals usually need access to the resources of organizations in order to turn their ideas into reality. There is often a problem—how to harness the creativity of individuals to the resources of organizations.

One solution to this problem is for an individual to gain control of an organization and there are many examples of technological change resulting from the activities of a creative individual either owning or managing an appropriate organization. The early history of the uses of electricity is full of such people. Werner Siemens, for example, founded the firm Siemens and Halske as a vehicle for his ideas on electromagnetic telegraphy.

This approach of replying on individual entrepreneurs is favored by believers in the virtue of free-market competition and is reflected in Government action to encourage the setting up of small firms. Nonetheless, large organizations do exist and are sometimes responsible for technological change. Even Governmental organizations (normally thought of as bureaucracies) can be responsible for technological change. Thus the revolutionary Republic of France was responsible for installing the first semaphore-type telegraph followed by the British Government and the Prussian State Government. Similarly, the manufacture of synthetic rubber was the result of government action in the USSR followed by Germany and then the United States (the British did not bother because prior to 1941, they controlled the supply of natural rubber).

Organizations have to have a management system and one responsibility of management is the management of innovation. This paper poses the question of how can management make use of the creativity that resides in individuals. The question is tackled in four parts. What is the nature of technological

change? Can this process be managed? Where do creative individuals fit into the process? Can individual creativity be "managed"?

2. THE NATURE OF TECHNOLOGICAL CHANGE

Many observers of the phenomenon of technological change have suggested that there are two different driving forces, the first being creativity which produces new products to manufacture, new ways of producing old products (including new ways of organizing production), new ways of storing, distributing and financing products and also new ways of obtaining and transmitting information about all of the above activities. The second driving force is contained in the expression, "necessity is the mother of invention", which suggests that when the need for a solution to a problem is great enough, even the most conservative of organizations will initiate change (the ultimate need being the need to survive).

Various versions of this dichotomy exist. The Manchester study of Award-wining innovations in the UK (Langrish, et al., 1972), suggested the terms "discovery push" and "need pull" to describe the two forces and further sub-divided discovery push into science push and technological push whilst need was divided into customer need and management need to demonstrate that "need" is a wider phenomenon than the concept of market demand.

In the USA, Utterback (1974) expressed the two forces as technical opportunities and need with need being sub-divided into market need, mission need (which in the USA means a stated government requirement) and production need which is an internal need of an organization to improve its productive efficiency. Utterback lists eight different studies of technological innovation and interprets their results as showing that between 66% and 90% of examples of technological innovation arise from "needs".

The Sussex comparison of successful and failed attempts at technological change in the UK (Science Policy Research Unit, 1972) seemed to support the Utterback conclusion in that out of over 100 variables the one that most distinguished success from failure was attention to the needs of potential customers.

The Manchester study mentioned above has been misquoted by several authors as lending support to the view that "need pull" predominates. What the study actually said on this issue was three things: (i) very few of the 84 cases fitted either the need pull or the discovery push models in that both forces had to be present, (ii) if instead of looking at the overall process of technological change, one confined the question to what stimulated an Award winning firm into taking action that led to technological change then need pull predominates numerically, but, (iii) in the small number of cases involving a large degree of technological change (such as the Hovercraft and the Pilkington Float Glass Process), discovery push is more important.

Whilst assertions about need have to be treated with care, one thing is quite clear from the above studies namely that simple views of the process of innovation as "discovery" followed by application, prototype production, etc., are not adequate to describe the complexities of the ways in which technological change takes place.

This has important practical implications for the management of creativity. For example, it used to be believed that creative individuals like

scientists should be left on their own to make discoveries which could then be assessed to see if an "application" could be found. By the late 1960s and early 1970s, policy makers both in industry and government were realizing that this approach was not working.

The American "Hindsight" study (Isenson, 1969), was prompted by politicians asking why should the US Navy be spending money on theoretical research by scientists in universities. The Navy's claim that advances in military technology were "applications" of scientific advances were not supported by the study which instead leant support to the view that technological advances rested on other technological activities directed towards stated aims (the study used "mission-oriented" to describe such activities which were found to be numerically much more predominant than "curiosity-oriented" activites).

The above studies can be interpreted as saying that organizations often seem to initiate change because there is a need for change. Such change, however, often seems to depend on the presence of individuals who might be called "creative" but not necessarily creative in the sense of technical or scientific creativity.

As long as innovation is thought of as a process started by discovery or invention, the person responsible for the discovery or invention will receive considerable acclaim. Thus in the UK most people believe that we have penicillin because Flemming discovered it and we have TV because Baird invented it (in other countries the names may be different but it is still believed that innovation is the end result of a processes started by a named individual). A careful examination of the history of penicillin and TV shows that the named individuals were NOT particularly crucial to subsequent events (the "breakthrough" that led to penicillin being used was the concept of chemotherapy which was NOT developed by Flemming. Modern TV depends on cathode-ray tubes; Baird's system was based on an older technology).

The displacement of the "discovery-push" model of innovation should involve a displacement of the importance of the individual "discoverer". This is not to say that individuals cease to be important. Rather, it means that other kinds of creativity must be recognized.

If the most important step in the process of innovation is not "discovery" but something else, say "x", then the role of individual creativity in "x" needs identifying. To do this we need a new model for innovation. Before describing this new approach it is necessary to discuss further the claim that a certain kind of creativity has been over-emphasized as this goes against many popular assumptions.

One reason for claiming that some attribute which might be called inventiveness (in the sense of a propensity to produce technical inventions) is not as important as previously thought is derivable from considerations of the probability of improving something.

Patents are awarded to individuals who invent something having novelty, a different way of doing something. However, different is not the same as better. Given a hand of playing cards at Poker, a different hand can easily be obtained but the better the original hand the less likely is a new hand to offer an improvement.

Technology might have some similarities with card playing. In the very early days, of say aeroplanes or steam locomotives (band hand), almost anything

new would also be better but with a developed technology (good hand) such as electrical power generation almost anything different would not be better.

This is why most patented inventions are never used and this is a reason why the type of creativity associated with inventions may not be as crucial as some other type of creativity. In the case of a well developed technology, the most important creative activity could be associated with problem recognition and definition, i.e., identifying where there is scope for improvement rather than problem solving, i.e., inventing the improved technology.

Another reason for stressing the importance of problem recognition and definition is again probabilistic in that there can be ten different technical possibilities for solving a problem. Only one needs to work but if the problem definition is wrong no solution however technically brilliant will result in an overall improvement. The Hovercraft, for example, can be seen as a technically brilliant solution to the wrong problem. So can the Concorde (which is a solution to the problem of how to make an aircraft fly faster instead of solving the problems of cost and noise).

Any discussion of creativity and innovation must therefore extend beyond the type of creativity associated with discovery and invention. To do this we need a better frameowrk for discussing innovation.

3. TECHNOLOGICAL INNOVATION AS THE INTERACTION OF THREE SYSTEMS

It is suggested that the process of technological innovation can be viewed as having necessary inputs from three systems. These are the technical system which consists of existing and imagined hardware, the advantage system which determines whether a new addition to the technical system is actually better or not and the resource system which determines whether a particular organization has the capability to develop a better technical concept.

This view of inputs from three systems can be seen as a statement that the success of a technological change requires three necessary conditions to be present:

1) A technical concept capable of being developed to the stage of achieving:-

2) an advantage over alternative technical concepts; and

3) the capability of developing (1) to the stage of achieving (2).

The technical concept may be a brand-new idea or discovery, a new combination of ideas (old and new) or an old concept not previously developed because of lack of (2) or (3).

The advantage can take a variety of forms. The capability also has different aspects including money, skills or the availability of some particular form of organization necessary to achieve the development of the technical concept.

The three conditions can be illustrated by reference to examples in which one of the conditions is missing. A cure for cancer is an example of condition (1) being missing. There is lots of advantage awaiting such a cure and no shortage of money or skills for development. What is missing is the concept of what to develop.

It can be argued that the hovercraft is an example of condition (2) being missing. Here we have a new technical concept, government money for development through NRDC, some very skilled design effort; and yet firms have gone bankrupt attempting to manufacture Hovercraft (Johnson 1974). The problem with the hovercraft is the absence of any real advantage over alternative ways of traveling from A to B. The helicopter can also travel over land and water and the hydrofoil is increasingly being used for short-distance water transport. The Concorde might also fit into this category of having no advantage. Examples of the third condition being absent are frequent in developing countries, where technical concepts may be prevented from providing an advantage through lack of money and technical skills.

The three conditions have to co-exist in the same place and time. For example, when the US army was in Vietnam, many soldiers contracted malaria and several pharmaceutical firms started programs aimed at the development of new improved antimalarial compounds. Although some potentially important discoveries were made, the American withdrawal from Vietnam led to the dropping of development work on antimalarials. So we now have the situation where conditions (3) and possibly (1) exist in one place and condition (2) somewhere else. This is not to say that the pharmaceutical firms are deliberately withholding some new wonder drug from those parts of the world where malaria is common. It means that the pharmaceutical firms do not see any net advantage to themselves in spending a lot of money on testing new compounds in the hope of finding a better drug which even if it existed would not produce enough financial return to pay for the development costs.

This situation also illustrates the point that whether a new technical concept possesses an advantage or not is usually a matter of speculation until it has been tested. Finding out if an advantage exists or not can be very expensive so it is necessary to state that innovation is attempted when there exists a "perceived net advantage" to be gained from the use of a "capability" in developing a "technical concept" that is considered capable of development to the stage of obtaining the advantage.

If the attempt fails, it could be that the perception of the advantage was incorrect, the technical concept was in fact not capable of development to the advantage stage or the capability of carrying out the development did not exist. (An example of the latter is the case of an electronics firm that attempted to develop the concept of numerically-controlled machine tools to the stage where it would make a profit from selling them. The attempt failed because the firm lacked capability in the design of machine tools.)

The three systems which contributed the three necessary conditions are not static but continually changing and interacting with each other and also with other systems of society. For example, the technical system interacts with an independent scientific system, the perceived advantage system with political, economic and marketing systems and the resource system interacts with financial and educational systems.

4. CAN INNOVATION BE MANAGED?

To what extent is a complex process involving the interaction of several systems capable of being controlled? The concept of Technological Determinism has been discussed elsewhere by this author (Langrish 1977) and it sometimes seems that technological change can be viewed as a Darwinian struggle for survival. Most discussion is confined to two of the three systems mentioned

above—the technical and the resource systems. However, the addition of an advantage system makes clear one difference between biological evolution and technical evolution that the "climate" for competition can be controlled.

An example may help to illustrate the importance of control of the advantage system. Synthetic rubber was first produced in a small factory in 1912 by a group of Manchester chemists who developed the so-called Buna rubber. However, this development did not survive because it had no advantage over natural rubber obtained from plantations. In particular, the price of the synthetic material was about fifteen shillings per pound when the price of the natural product, although fluctuating, remained below two shillings per pound and the technical properties at that time were slightly inferior to those of the natural product. There was no advantage therefore, to any company in developing synthetic rubber; nor was there any advantage to the British nation. As the majority of the rubber plantations were owned by Britain there was no national advantage to be gained from developing a rival product.

The situation in Germany, however, was different. Under the Nazi government of the late 1930s, it was realized that Germany at war would need considerable supplies of rubber. There was therefore an advantage to be gained from the development of synthetic rubber and the capability existed in the German chemical industry. The main problem was solved by manipulating the advantage system as perceived by private industry. The German government imposed an import tax on natural rubber so as to make it more expensive than synthetic rubber, which then had an advantage in the eyes of German industrialists. It was not until the Japanese took over the natural rubber plantations that the rest of the world saw an advantage in synthetic rubber. A massive investment program, involving government-owned factories in the USA, Canada and Russia was able to supply the wartime needs of the Allied nations.

This example illustrates the fact that in a conflict between national interests and the interests (perceived advantages) of individual firms in a private-enterprise system, there exist two alternative ways of government to control the introduction of new technology. The first can be seen as direct control of the capability system (e.g., government-owned factories) and the second as manipulation of the advantage system (e.g., differential taxation). As the first alternative is not very popular in some countries more attention needs to be given to the possibilities of the second.

Control of the advantage system offers a possibility for nation states to indulge in competition and also produce more beneficial effects from technology at the same time.

For example, the British Government is worried about the imports of foreign cars. It does not wish to impose controls of a conventional nature as it fears retaliation against our own exports. It could however use the desire to obtain beneficial effects as a way of controling imports. It could say, for example, that all cars sold in Britain must conform to some standard of safety where this standard involved some new British technology which otherwise would have no competitive advantage. (It might even say that in order to protect the quality of working life, all cars sold in Britain must be manufactured under working conditions approved of by British unions.)

This technique is being used by the USA to restrict Concorde through anti-noise regulations. A whole new vista of international technological competition could emerge. Individual firms could see an advantage in developing "nice" technology if they thought that their government would bring in

regulations insisting that new standards of "niceness" were obligatory or at least carried some tax advantage.

Because the present structure of the advantage system is economic, countries and firms are forced to become more efficient, which in the long run means that people must be either subjected to greater stress or be unemployed. The way out is to change the rules of the game in such a way that technology capable of improving the quality of human life is given some advantage.

The above discussion illustrates that a fresh approach to thinking about innovation can give a fresh insight into the types of creativity required. It is possible for a person to be creative in thinking about the advantage system. Under some circumstances, such creativity could be more important than the creativity of invention.

5. THE ROLE OF CREATIVE INDIVIDUALS IN INNOVATION

Some of the evidence for claiming that creativity within the innovation process is not just discovery and invention, comes from case studies of technological change which aimed to find out how things happen at the level of the firm.

The Manchester study of innovation (Langrish et al., 1972) attempted to identify factors which enabled firms to succeed. Partly to the surprise of the authors of that study, the factor which occurred more frequently than any other was what they called the "top person phenomenon", the presence of an outstanding person in a position of authority, a manager or director who made a special contribution to the innovation. Considerable care was taken in forming this conclusion; supporting evidence was looked for and the uncorroborated testimony of the person concerned was not accepted as evidence for the importance of a "top person". The top person phenomenon was the most frequently occurring factor in all of four technological subdivisions (the case studies were divided into chemical, electrical, mechanical and craft) and was also the most frequently occurring factor in the small sample involving large degrees of change in technology.

The roles performed by these top people were any one or any combination of the following three:

1. The Technical Entrepreneur. A small number of the cases studied involved an unusual individual of high technical creativity who had solved the problem of the interaction between organizational structure and the creative individual by creating his own organization as a vehicle for his technical skills.

Thus, Sir James Martin combined the roles of Managing Director and Chief Designer of Martin-Baker Aircraft. He worked from about 7.30 in the morning until 20.30 at night during the week and until 16.30 on Saturdays. He personally approved each drawing and modification before it went to the production department and was responsible for creating a firm employing about 2,000 people having started with two men and a boy. Similar, Martin Wood started Oxford Instruments by making magnets in his own home. Such individuals undoubedly exist but are comparatively rare. Most of the cases involved top people in the following two categories.

2. *The Problem Definer.* Many of the firms in the study produced their successful innovations because a senior person was in a position to define new areas of activity for the company. Such activity often involves creative insight into opportunities that can be taken or constraints that can be removed. Thus Lazell of Beechams who was trained as an accountant was responsible for directing Beechams research efforts towards semi-synthetic penicillin. He did this as a result of studying American sales figures and buying the best scientific advice that was available to work towards a commercially identified market. The Beecham scientists working in a country house would not have done this on their own. Nor would the marketing department have known about semi-synthetic penicillins which did not then exist. In a functionally organized firm, it seems to require someone at the top of the pyramid to put together commercial and technical information in a creative manner.

3. *The Resource Provider.* The third role of the top person is to ensure sufficient resources to guide an innovation through its development stage. (This can, of course, be a recipe for disaster if the idea is a bad one.) A certain type of creativity is involved in selecting which ideas to back and in obtaining resources either from inside an organization or from other sources, such as Government.

The development of Procion Dyes by ICI illustrates this role. Procion Dyes are an example of "discovery push" in that they were discovered by two ICI employees Stephen and Ratee who were following their own ideas. However, two Directors spotted the importance of the discovery and put the large resources of ICI into development. In the words of one of the Directors, "the two of us were able to ginger the whole development machinery into an unusual activity". These three top roles can be interpreted in terms of the three system view of innovation with each role being directed towards one of the systems.

The study also identified other key individuals in the process of innovation. Such individuals who were not top people were mainly of the technically creative kind. In terms of the breakdown between technologies, these other individuals occurred most frequently in the electrical area. Several of the technically creative people whose presence was vital to the success of an innovation were not university graduates but older people, educated at evening classes. Ransom of Short Brothers, for example, had no formal engineering qualifications but as design draughtsman contributed no less than eight out of 18 patents taken out on the Seacat missile system.

It is possible for people outside the technical area to play an important role in innovation. Staff of a marketing department, for example, may spot some change in the advantage system which offered scope for technical change. However, in the 84 case studies, we found only one example of a sales employee making a successful suggestion to a research department without the intervention of a top person. This probably says more about the nature of hierarchical organizations than about individuals.

6. CAN INDIVIDUAL CREATIVITY BE MANAGED?

This question is usually posed in terms of providing suitable environment and incentives to encourage individual creativity where creativity is seen as technical creativity. However, this paper has attempted to show that such a view of the question is inadequate.

The creativity of management itself needs to be recognized. The Swedish engineer, Dr. Erik Haeffner, who as a Vice President of the Swedish Inventors Association might be thought to favor the old view, has stressed the importance of creative management. He claims:

> "All evidence points to the decision-making process itself being a creative function. The person concerned must have knowledge and experience, partly the same ingredients that are needed for the creation of an idea, in order to make the correct decision and to dare invest in a new product. It is therefore important, if innovation activity is to produce a return, that great attention should be paid to creative ability when selecting leaders for development work, and that creativity should be regarded as a desirable qualification" (Haeffner 1972).

Even if we can find creative managers who will interact with the advantage system, define problems, etc., large organizations require organizational structures capable of encouraging all types of creativity.

The first step towards better organizational structures is the realization that in some circumstances, groups can be more creative than individuals. Much creativity consists of a new combination of existing ideas. Where the existing ideas are present in different people, it requires some kind of interaction to produce the combination.

In the area of technical creativity, it has long been recognized that the lone inventor or discoverer can be bettered by teams of people. The German Dyestuffs Industry in the last century was the first to employ a team of scientists in their search for new and better dyes and there are many examples of discoveries being made as a result of interactions within a team environment.

Can the team approach be used in other areas of creativity? The role of the "top person" as problem definer as discussed above can certainly be made the task of a team. Several organizations have benefitted from a "think tank" or a new ventures group where interdisciplinary teams are given the task of thinking about the future.

Such groups should not be confused with coordinating committees where people are concerned with protecting their own power structures and status quo rather than creativity. Creative groups normally involve people outside the power system of large organizations.

Another way of encouraging creativity is to free people from concern with daily problems through a revision of existing functional boundaries. Many organizations are structured into research, production, marketing, etc., in ways which prevent creative thinking for the future.

It is possible however to structure an organization in terms of its time span of concern. Production, sales and quality control are all concerned with the present and could be structured together. New product research and design, experimental manufacture and long term marketing are all concerned with the future and could be given an organizational unity. Between these two extremes there could be another group concerned with existing problems of manufacture, quality, distribution, etc., but given the time to tackle such problems in a creative manner, free from interfunctional disputes.

Another function of the creative individual that is often lost in large organizations is that of what might be called "resource reallocation". In private enterprise societies it is possible for an individual to spot waste resources and turn them into useful resources. The waste solvents of the pharmaceutical industry, for example, are waste because pharmaceuticals require very pure solvents. Such solvents, however, are purchased by entrepreneurs with small companies who turn them into raw materials for the paint industry and other industries that do not require such pure solvents.

Could large organizations recruit creative "resource reallocators" with the specific task of having a creative look at waste? Such an activity could also lead to new products and processes.

It is hoped that this discussion has demonstrated that creativity in innovation is much more than invention and that the management of innovation is much more than creating incentives for invention. Management itself should be a highly creative activity, that not only encourages new ideas but makes sure that the right problems are selected.

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NOTE

Some earlier research by J. Langrish has been translated:

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MANAGERIAL EFFECTIVENESS: IMPLEMENTATION OF A SEMINAR FOR THE UPPER MANAGEMENT OF SIEMENS AG

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SOME BASIC ASSUMPTIONS

This paper is based on the assumption that the success of any large industrial organization depends to a very large extent on how its human resources are utilized and that there are two basic approaches in mobilizing these human resources. One is to try to influence people as individuals. The other approach is to use systems as a means of steering the behavior of people.

Budgeting would be an example of the systems' approach. Introducing seminars on managerial effectiveness for upper management provides an example of the people-oriented approach.

Within SIEMENS AG we believe that generally speaking both aspects are equally important. Of course it depends on a given situation whether one puts more emphasis on the one or the other.

This is one of the reasons why we feel a manager should strengthen his abilities to diagnose the rapidly changing situations correctly and to improve his ability to act flexibly according to the different demands of various situations.

So while reading this paper on the implementation of a seminar on managerial effectiveness for upper management of SIEMENS AG one should keep in mind that it is just one measure within a very complex set of efforts to mobilize human resources.

SIEMENS AG: SOME KEY FIGURES

SIEMENS is one of the world's leading companies in the electrical and electronics industry; in terms of sales in this sector it ranks among the five largest in the world. The broad spectrum of products, focusing on

power engineering and communications, extends from the electric motor to the power plant, from the telephone to the large computer, and from electronic components to X-ray departments. The intensive research and development work draws primarily on the innovative potential of electronics. Products and systems based on electronic technology account for almost 50 percent of our sales. Through a world-wide sales and manufacturing organization established in well over 100 countries we make more than half of our sales outside the Federal Republic of Germany.

In September 30, 1982 SIEMENS employed a total of 324,000 people throughout the world; of this number roughly one-third were working abroad. The work force includes scientists, engineers and technicians, as well as commercial staff, professional workers, skilled and semiskilled labor trainees, and temporary student labor.

Its size and variety of projects enable the company to offer its employees job opportunities suited to different talents and capabilities. Size and variety of job demands also create considerable challenges to management and call for a personnel policy and organizational structure which allow for extensive delegation and a good match of responsibility and authority.

SIEMENS AG: OFF-THE-JOB TRAINING PROGRAM FOR MANAGERS

In order to help managers to cope with problems deriving from these challenges SIEMENS has established various measures for management development which include both on- and off-the-job training.

The off-the-job program starts with a set of three seminars which build upon each other.

Starting with first-line managers (not foremen for whom there is a separate program), each seminar draws participants from different rank levels. Roughly speaking the aims of these seminars are:

- to acquaint participants with company goals;
- to make responsibilities, aims, and problems of both groups and central divisions transparent; and
- to develop an understanding for each other's problems through personal contact among participants and top level managers.

Following these seminars, which all managers should attend during their career development, there is a set of problem-oriented seminars which are more or less optional and which draw their participants mainly from upper- and top-level management. Contents of these seminars are general management, political issues, problem-solving-techniques and languages. This is where the Managerial Effectiveness Seminar fits in.

THE 3-D MANAGERIAL EFFECTIVENESS SEMINAR

For better understanding of the implementation process a short description of the seminar itself may be of some help.

It has been developed by Professor W.J. Reddin and forms an integral part of his organization development programs. Its functions within these programs is to start the unfreezing process. He describes the seminar as follows:

What is Managerial Effectiveness?

Managerial effectiveness is "the extent to which a manager achieves the output requirements of his position". This concept of effectiveness is the central issue in management. It is realistic and unambiguous—concerned with output rather than input, with what a manager achieves, rather than does. Managerial effectiveness is measurable in output terms. The 3-D Managerial Effectiveness Seminar teaches the manager how to do this.

The 3-D Learning Process

The 3-D Managerial Effectiveness Seminar is a residential learning experience. Hours are long. About eighty percent of the learning takes place in teams of from five to eight managers—which corresponds roughly to the span of control.

The 3-D Managerial Effectiveness Seminar confronts the teams with a wide variety of problems generally related to methods of achieving effectiveness through an accurate recognition of the reality of a situation, and the best approach to managing it. The seminar begins at 5.30 p.m. on Sunday, and ends at 12.30 p.m. on the sixth day, Friday.

Prework

Each participant receives a participant kit before coming to the seminar. This consists of three texts, wall charts and a Seminar Workbook. The basic text is Managerial Effectiveness. This explains the 3-D Theory and shows how it is applied to improve effectiveness. Effective Situational Diagnosis is a self-instruction book which teaches the manager how to diagnose situations accurately—so that he may make more effective decisions. Effectiveness Areas shows the manager how to describe his job in effectiveness terms. Well defined "effectiveness areas" are a prerequisite to setting accurate objectives. The Seminar Worksbook contains questionnaires, style tests, effectiveness inventories, seminar tasks, case studies, team diagnosis instruments and other learning aids.

Depending on the participants' prior knowledge and individual capacity and dedication, seminar prework generally takes from fifteen to twenty-five hours to complete.

Day 1 and 2--Concept Mastery

Participants work in teams to deepen their understanding of the basic concepts relating to effectiveness, objectives, situation management and managerial behavior. Teamwork skills are also learned during this period, and regular reviews of individual and team effectiveness are carried out.

Day 3--Case Study Application

Effectiveness concepts are applied to written case studies, so their practical application is demonstrated and learned. This day transfers theoretical learning into practical application. Team building skills are also practiced and reviewed.

Day 4, 5 and 6--Application to Self

The entire second half of the 3-D Managerial Effectiveness Seminar applies effectiveness concepts to the participant's actual work situation. Day 4 is spent on effectiveness, day 5 on managerial behavior, and day 6 on situation management. The last three days demand a high degree of involvement from all participants.

Post Seminar--On-the-Job Application

The manager uses the conceptual and printed tools the 3-D Managerial Effectiveness Seminar has provided. He may use them to redefine his position in output terms, to work with subordinates, coworkers and his superior on objectives, to change his less-effective behavior, or he may decide to change his work situation.

THE PROCESS OF IMPLEMENTATION

It is difficult to answer the question as to how the process got started. There were many discussions in seminars, during projects of organizational change, both formal and informal which finally led to an overall consensus that we would need some kind of training in leadership behavior for upper management. So the next question was, what should this seminar look like and how could we get the commitment of the Managing Board.

One first step in solving these problems was to make the topic of "Leadership Style and Effectiveness" part of a "Workshop" or "Information Forum" for upper management. This information forum was set up to discuss problems the company would have to cope with in the future. The method used was mainly group discussions and poster sessions.

One outcome of these discussions was that, as seen by upper managers themselves, there was a need for more training in leadership. As a further step the Central Personnel Department was commissioned to conduct some research into what the needs for training were in some more detail.

From the results of this research we developed the basic criteria for the design of the seminar. Some of these criteria were as follows:

- the seminar should go hand in hand with the principle of delegating and matching responsibility and authority;
- it should help the individual manager to analyze his situation by himself;
- it should not sell some kind of ideology but rather help towards more clarity in setting objectives and measuring results;

- it should help towards better cooperation within teams and between teams;

- it should help to develop human resources; and

- it should match with international standards.

It would have been quite a challenge for the specialists of Central Personnel Department to develop such a seminar themselves. But for reasons which need not be explained to the practician they decided to answer the question "make or buy?" in favor of "buy".

After some "market research" we came to the conclusion that we should take a closer look at the 3-D Managerial Effectiveness Seminar. We sent a group of managers from different functions, e.g., production, research and development, sales, administration and personnel to an open seminar in England.

These managers reported to the respective committee of the Managing Board and it was decided to have two seminars in company and ask the participants for further evaluation.

According to this decision we asked Reddin Associates to conduct these two seminars with their staff in English at our management institute in Germany. Evaluation of the seminar by the participants at the end is part of the seminar design and it turned out to be very positive. In addition to each seminar we had a follow-up meeting half a year later. The evaluation of the seminar at that point showed an even more positive attitude toward it and there was quite an amount of evidence that the participants had started working with some of the seminar concepts in their own area of responsibility.

This finally led to the decision of the Managing Board to continue with these seminars, to have our own staff trained as trainers and to cooperate on the translation of the materials into German.

RESULTS AND FURTHER DEVELOPMENTS

It took us, as a company, about 2½ years to decide on the implementation of these seminars. It took us 5 years to have some 750 upper managers as participants. We introduced the follow-up meetings as a part of the seminars because the participants wanted to share their experiences in transferring what they had learned at the seminar into practice.

The process of implementation is still going on. At this moment one can say that the seminar has been broadly accepted as a means of individual development. There is quite an amount of transfer as far as the personal area of responsibility of the individual participant is concerned. There are difficulties in communicating some good ideas where participants meet partners who haven't been to the seminar, and thus there is still some hesitation as to how some of the seminar concepts are in harmony with company regulations and cultural environment. But the decision to continue has been taken, and to make participation mandatory for managers who are to be promoted to certain functions and levels of hierarchy. We finally hope

that more and more participants will send their own subordinates to the seminar and then start working to design the organization of their own unit in a more effective way.

Maybe we could have been more effective outselves in managing this implementation process. But there is one thing we have learnt: It takes time and needs a continuous effort to spread new ideas in a large organization.

MOTIVATIONAL FACTORS IN A PRODUCT DEVELOPMENT PROJECT

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INTRODUCTION

Motivation is one of the most important aspects of the everyday practice of management and one of the central themes for much of the literature and research in the field of management psychology. A well founded gross theory of motivation has been established in the form of the Maslow hierarchy of needs, but the fine structure within the different need levels still lacks generality.

This study is confined to motivation within the highest need level, i.e., the need for self-actualization. It is in the form of a case study of a specific product development project concerning a complex process automation system which was successfully developed by a group of highly motivated people. Being a case study the findings cannot be generalized, although in the experience of the author many of the findings are consistent with those in similar projects. The final conclusions are presented as a list of statements.

A somewhat similar case study describing a highly motivated project aiming at developing a new computer has been published by Tracy Kidder (1981).

In the present study a series of unstructured informal interviews were conducted with seven persons representing various tasks within the project. Although the total number of persons participating in the project during the period of observation (1978 - 1980) was 36, the interviews gave such a consistent picture of the motivational aspects that they can with reasonable assurance be regarded as representing the entire group.

The author of this paper was not directly involved in the development project although he followed it closely from his position at headquarters.

In this paper we shall first present the result of the project--the DAMATIC process automation system--and the project organization. This will

be followed by a narrative account of the interviews. The conclusion takes the form of a list of statements reflecting the motivational factors and a discussion of the general validity of the findings.

THE DAMATIC PROCESS AUTOMATION SYSTEM

In the mid-1970s the Valmet Instrument Works lost a number of prestige orders to Honeywell, who had recently put on the market an entirely new digital process control system intended to replace conventional pheumatic and electronic analog process control systems. To stop this undesirable course of events the Instrument Works decided to develop a similar system.

The system, called DAMATIC, turned out to be much more than merely a copy of the Honeywell system. DAMATIC, a distributed communications-oriented microprocessor-based automation system, incorporates a large number of innovations which were not present in any competitive system, for example:

- Integration of both continuous and logic control functions in one single system. Even today there are still only a couple of successful installations of competitive systems of this kind.

- Extremely high systems reliability. Approval given by such rigorous testing institutions as the International Instruments Users Association WIB, and Det Norske Veritas.

- Open-ended and flexible systems architecture and communications structure permitting unprecedented application orientation and adaptation to each customer's special needs.

- A high level problem oriented programming language that can be used by process instrumentation engineers with no computer background.

The success of the system has been demonstrated by the fact that to date about 200 DAMATIC systems have been sold all over the world without any instances of customer dissatisfaction. This is an impressive record taking into account the size of the Instrument Works, which is only about one tenth that of its largest competitors. The cost of the smallest installation sold to date is about US$ 30,000 and the largest about US$ 6 million.

DAMATIC is described in more detail by Wahlström et al (1983).

THE PROJECT

The project can be divided into the following parts:

- A feasibility study and project planning carried out by the Technical Research Centre of Finland with Instrument Works' participation during part of 1976 - 1977.

- Development of specifications by the Instrument Works and the Technical Research Centre starting in early 1978.

- The development of the hardware by the Instrument Works starting mid-1978.

- The development of the system software by the Instrument Works with the Technical Research Centre and others as subcontractors starting in late 1978.

- The development of the applications software by the Instrument Works starting in late 1978.

- Delivery of the first DAMATIC in the summer and fall 1979. The order for this system had been received one year earlier.

- Continued development after the first installations. This phase was started in fall 1979 and is still going on. It is beyond the scope of this paper.

The feasibility study was carried out independently by the Technical Research Centre as the Instrument Works did not have enough knowledge of digital systems at that time. This phase, too, is not covered by this paper.

The hardware and both of the software projects were carried out under Instrument Works' project management although some of the project personnel were from the Technical Research Centre and other subcontractors. Most of the Instrument Works' software personnel were newly employed from outside. Throughout the project a customer advisory board consisting of key persons in the Finnish process industry actively followed the progress of the project, providing fresh ideas, encouragement and criticism.

When the first order had been received in summer 1978 customer key personnel got very actively involved in directing the project according to their special needs.

Much of the work was done outside the Instrument Works in separate premises rented especially for this purpose; a small part was done at the Instrument Works and at the Technical Research Centre. When the system had been shipped to the first customer the project group moved to work at the customer's premises for a time.

The total effort spent on the project between 1976 and 1980 is Valmet's trade secret. Nevertheless, it is generally considered to be less than that spent by large competitors on developing similar systems. Three persons were initially employed on the project. At the peak 36 persons were directly involved, of whom 16 were from the Technical Research Centre and other subcontractors.

MOTIVATION ACCORDING TO THE PERSONS INTERVIEWED

All the interviewees agreed that motivation was exceptionally high among participants up to and including the first installation. This high level of motivation was demonstrated by the fact that the people on the project worked literally day and night, sacrificing family and other personal interests, and becoming emotionally involved in the outcome of the project.

Various demotivating effects were experienced after the first customer installation. These were mainly caused by sheer fatigue and by some

antagonism between the software and the hardware groups. It was also considered demotivating not to know "what to do next"; it was felt that everything had already been made and delivered to the customer. This period following the first installation phase is not covered by this study.

When asked what they thought was the foremost reason for their exceptionally high motivation, most interviewees gave the uniqueness of the the system to be developed. "We had the feeling we were making something absolutely new and unprecedented in the history of process automation."

Interviewees qualified this statement by mentioning new technical features not present in competitive systems. Others mentioned that the advanced technology employed was new to them. "I was working with something new that I knew was important for me to know about."

The fact that the success of the project was of vital importance to the survival of the Instrument Works in competitive markets was a highly motivating factor, especially to the executives involved. The Technical Research Centre employees also mentioned the attraction of being confronted for the first time with an important real-life problem of large proportions.

The importance of the project was accentuated by top management support. "When we asked for resources we got them." "Top management was interested and showed it."

Next to the uniqueness and importance of the end product, people seemed to appreciate the considerable freedom of action given to them. This ranged from executives having the right to decide on product structure, the technology to be used, and division of work and resources, to the people building the system having the right to decide on technical details and their own working times and habits. It was also stressed that the people involved did not have any duties outside the project.

Top management style was described as soft (in a positive and motivating way) and democratic. "The top man always listened to us before he made a decision about matters of concern to us." "There was a complete absence of competition among the team members."

The high quality of the project personnel was mentioned in several interviews. Most of them were very young, which was considered a positive factor. "Young people have to make a career, and they have the necessary stamina and endurance." Even if most of them were young and relatively inexperienced, they included people with "the highest level of know-how available in Finland." Such were some of the experts from the Technical Research Centre and some of the employees of the Instrument Works who had earlier taken part in developing ELMATIC 100, a successful electronic analog control system, and a microprocessor-based x-ray generator (the first in the world).

Most of the participants felt that working conditions were excellent and had a positive influence on their motivation. They mentioned that they enjoyed working in peace and isolation (the premises rented for the project were some distance from the main plant). "We were not disturbed by visitors and undue management attention." "The isolation created excellent team spirit."

The positive factors included several referring to project management and leadership. "Objectives were clear from the outset for all participants on the project." Abundant resources and top management support were also mentioned as were good organization, division of work and responsibilities, and flow of information. Such important factors as division of the system into subsystems with a clear definition of the boundaries between the subsystems seemed to have been well understood. Such leadership "gimmicks" as kick-off meetings, celebrations, informal get-togethers and sauna evenings were abundantly used and greatly appreciated.

The software people were motivated by working with and having the responsibility for all the different phases of developing the subsystem assigned to them: defining the subsystem, planning its implementation, and programming, testing, and documenting it. They obviously preferred this holistic approach to the usual assembly-line method of software work.

Without exception everybody agreed on the importance of working closely together with the customers:

- The customer orders put tremendous, motivating pressure on the project schedule in a positive sense. An expensive plant would have been standing idle if DAMATIC had not been operational by the first days of July 1979. It was emphasized that the pressure came directly from the customer to the project members and not along the usual organizational channels which perhaps would have been considered demotivating.

- The keen interest of customer personnel in the success of the project was experienced as highly motivating, especially because some of the principal innovations emanated from the first customer to buy the system.

- Working physically close to a customer, even in the customer's plant, gives a feeling of working with something tangible and important in contrast to academic work.

- The interest of the special customer advisory board in the development work was also seen as a positive factor.

One of the persons interviewed mentioned a rather curious factor which may be true nevertheless: "We did not really know in advance what a tremendous risk of failure there was in the project and how difficult and complicated it really was. Had we known, our motivation might have been lower and the results correspondingly less favorable." Several of the interviewees thought that "good luck" was an important success factor in this project.

The project was a good demonstration of the applicability of some theoretical concepts, e.g., the theory of reliability, and some advanced computer science subjects, e.g., in communications and high level languages. This was felt by the young and highly qualified group to be worthwhile *per se*.

Some strictly personal factors were also mentioned. These included the opportunity of doing as much paid overtime as one wanted.

CONCLUSIONS

This section takes the form of a set of motivators that the author believes are true as much for this project as for similar complex development projects being implemented for the first time, using new technology. No order of importance is given although some of the motivators received wider support than others.

- Working on projects staffed with brilliant young people alongside older, more experienced people.

- Creating something that is believed by the team members to be new, advanced, and unique. This applies to the methods used as well as to the end result.

- Outside pressure in the form of a fixed delivery time or fear of losing the market to competition especially when this pressure is directed straight to the project group.

- Working close to tangible problems and situations.

- Working on a well-managed project. "Well-managed" means all the usual qualities such as effective delegation of authority and responsibility to a low organizational level, clearly understood objectives, top management support and attention, and democratic leadership.

- First class resources, premises and other working conditions.

A glance at the above list suggests that it is almost trivial. The only mildly surprising statement is the one indicating that "outside pressure" is beneficial for motivation. Project members are usually shielded from such pressure, which tend to be the concern of the management. The importance of providing first-class working conditions is not surprising but is often overlooked by management.

ACKNOWLEDGEMENTS

The author thanks the persons interviewed for this study: B. Wahlström of the Technical Research Centre, J. Hanhinen, M. Hannila, I. Karaila, T. Kuusisto, J. Salmi, and T. Talvinen of the Valmet Instrument Works.

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TRAINING OF HUMAN RESOURCES FOR INNOVATION

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One of the factors that more or less influences an innovation from the origin of an idea to its realization is the human factor. In my brief presentation I would like to mention some of the methods and experiences concerning training and development of human resources in innovation creation and realization in the concern CKD Praha.

Staff education in the scientific, engineering, marketing, management and production fields essentially concerns two major groups of people: the staff already employed by the concern, and students of universities and secondary schools and apprentices who have either been preparing themselves for the work within the concern or who are interested in future employment in the concern.

The main goal of education is to create prerequisites for the creative management of changes occuring through scientific knowledge and aimed at the rapid realization of these changes in the form of product or technology innovation. The ways leading to this goal consist in:

- o increased specialization, facilitating learning, understanding and employing new scientific knolwedge and thus being in a position to adapt qualifications to prospective needs;
- o developing the capability to manage, organize and cooperate in teams as an inevitable precondition for solving new tasks;
- o developing the capability to tackle problems in a new creative manner.

To ensure thse goals, CKD Praha employs partly its own forces and partly the possibilities, following from long-term contracts concluded more than 10 years ago with

- — the Charles University of Prague
- — the Czech Technical University in Prague

— The Czechoslovak Academy of Sciences
— the School of Economics in Prague.

CKD Praha's own forces are concentrated in the so-called "Works Institute", the aim of which is to train and increase the qualifications of the technical staff and workers of the concern. This is achieved by organizing:

- o courses and seminars on special topics, e.g., computer technology, automation of technological processes, realiability of machines and quipment, rationalization, management, etc.;
- o preparatory courses for study at secondary schools and universities;
- o adaptation courses for new employees with secondary and university education who, during the first year of employment go through so-called entrance practice in accordance with the concern's pre-set and quarterly evaluated program;
- o re-qualification courses;
- o courses for increasing the qualifications of workers.

Approximatrey 200 people, of which 90% are CKD employees, take part in ensuring the special contents of these courses. All costs connected with the training are covered by CKD.

In 1982, for example, more than 7,000 technicians and 12,000 workers took part in courses and seminars for increasing qualifications. 1,310 employees attended study courses, 273 of which were at university level, and 82 attended special studies to achieve a higher academic degree -- "Candidate of Science"*. Employees attending courses and qualifying for university-level or higher academic degrees receive certain exemptions from their work for study and examinations with no loss of earnings.

On the basis of the experience of the CKD Works Institute, results from these courses and seminars are better when there is a higher share of lecturers directly from CKD, and a necessary prerequisite is, of course, to use the best CKD specialists for these lectures. This is usually very difficult with respect to their busy timetables, etc., and, of course, in finding suitable substitutes for the times they are away from their work place. It is difficult to convince managers that they are also an object as well as a subject of the training: they usually understand well why they have to further educate themselves, but they usually consider that the education of others should be the duty of specialised departments only.

From the viewpoint of utilizing external sources for the education of CKD staff, i.e., cooperation with universities and the Czechoslovak Academy of Sciences, I would like to mention several principles on which this long-term cooperation is based. It is developed in:

- o basic and applied research in the form of a mutual exchange of results; cooperation of departments in solving and realizing approved research tasks; mutual assistance in the field of

*Equivalent to Doctor of Technology (editor's note).

measurement and instrument technology in selected experimental work; and assistance in instrument and equipment production.

- o educating students, post-graduates and scientific personnel so that organizations can mutually facilitate organizing educational stays of their employees in external departments.

- o creating joing research centers or laboratories.

- o mutual utilization of specialists in the special and educational bodies of both organizations.

General agreements on cooperation, as a rule for five-year periods, are filled with concrete contracts between the individual faculties or research departments of the Czechoslovak Academy of Sciences and the research and development departments of individual CKD enterprises or the central CKD Research Institute, which are then in direct working contact.

The experience of the last ten years has shown that in spite of the large CKD scientific and research base, it would not be possible to solve all the necessary and technically demanding tasks without this cooperation. Moreover, the direct contact between the research and development staff of CKD and the departments of basic research at the institutes of the Czechoslovak Academy of Sciences and universities enables CKD employees to further increase their special qualification and to become acquainted with the latest research results. Also, the direct contact between these research departments and production departments provides the opportunity for direct confrontation of the achieved results with industry needs and opens the door for their rapid realization.

This close cooperation with industry also facilitates solving tasks which go far beyond their own possibilities with regard to investment, material and personnel demands.

Last but not least, creating joint teams for solving concrete scientific and technical tasks is, in our experience, one of the best ways to develop the cooperation, organization and management skills of workers towards rapid realization of innovation.

The institutes of the Czechoslovak Academy of Sciences and universities enables CKD employees to attain higher academic degrees. On the other hand, a number of leading specialists take part in teaching students in the form of external professorships, assistant professorships and membership in examination boards, scientific councils, etc. Also the material assistance of industry facilitates building specialized departments for educating students aimed at prospective future needs. The faculty of electrical engineering at the Czech Technical University in Prague, for example, established a special center for the education of design engineers employing CAD in the department of electrical machines, and a center for students specialized in designing microelectronic parts, making full use of computer technology, was established in the department of microelectronics.

Building these centers at the university enables students to become acquainted with the chosen topics during their study and, through participation in solving actual tasks set by industry, become acquainted with the work they will do in practice. This speeds up their adaptation and, in manufacturing plants, can also speed up the introduction of new technology, which is sometimes met with a conservative attitude on the part of the staff.

In 1982, for example, almost 100 tasks concerning CKD Praha innovations were solved in cooperation with the Czech Technical University in Prague. In the electrical engineering branches they concerned the further development of power semi-conductor devices, automated management systems, drives fed from semi-conductor converters, special measurement technology, use of opto-electronics, automation of design engineering, automation of testing, etc.

The task of educating new CKD employees, who are graduates of technical, economic, management or other schools, is undertaken by state vocational schools and universities. The education of production workers is undertaken by CKD in its so-called "Apprentice Training Center". Study at secondary vocational schools lasts four years, and, depending on the branch, four or five years at technical universities. Branches at the faculty of electrical engineering have five-year study periods.

The possibility also exists for part-time study (for employed persons) which lasts six years. The main bulk of this part-time study consists of studying the literature on one's own, with students attending consultations 10 to 15 times a year. At the end of each term they are put through practical exercises and sit for examinations. Altogether in 1983, 273 CKD employees attended the university level courses for employed persons.

Post-graduate work enables university graduates to widen thier knowledge of the latest developments in a particular field. This is organized in the form of external study and has an innovation, specialization or re-qualification character. In 1983-1984, for example, the following courses were organized at the faculty of electrical engineering:

— computing methods of dynamic systems - innovation.
— automated management systems - re-qualification.
— microprocessors and microcomputers - innovation.
— technology of hybrid integrated circuits - specialization.
— computer software - specialization.
— communication systems with program control - specialization.
— increasing quality and reliability of electronic products - specialization.
— economical utilization of energy in industry - innovation.
— microelectronics and opto-electronics - specialization.
— transmission technology - innovation.

Study at Czechoslovak schools, including medical care, is free of charge. Any student whose parents' income per member of the family falls below a certain minimum is also awarded a state scholarship. Where good results are achieved, another second type of scholarship is granted. Apart from these two types of state scholarships, students can also be awarded scholarships from enterprises or from the central bodies of state administration. Scholarships from enterprises, in the amount of 30-35% of an average monthly wage in the CSSR, are provided for five years to students who agree to work in a given organization for five years after finishing their studies. In 1982, CKD granted such scholarships to 194 students. On the whole CKD annualy engages almost 200 university graduates and 300 graduates from secondary vocational schools.

The long-term cooperation between CKD and universities, based on contracts, the participation of CKD specialists in the education process at the universities and in their management bodies, and the transition of a number of leading CKD specialists into the roles of assistant professors, professors

and deans has facilitated in formulating future industry requirements as far as the education of new scientific workers and engineers is concerned, and in realizing them in the form of introducing new study subjects, even whole branches of study, and building laboratories and other facilities.

In 1982, for example, the School of Economics in Prague introduced a new branch of study, i.e., "Scientific and Technical Information" -- the aim of which is to educate specialists in this particular field. Requalification post-graduate study is also organized in this branch as well. For the further education of the production category of employees, CKD has its own so-called Apprentice Training Center, which annually accepts almost 1,500 pupils at the end of their basic nine-year school education. Here study is organized in three-year cycles during which the apprentice acquires basic theoretical and practical knowledge in a special training center. During the last year they obtain the necessary production training directly in the factory where they will later work. Select branches of electrical engineering training were introduced several years ago with respect to the development of new electronic branches and new technologies (NC machines, automation, etc.). Here an extended theoretical study and five-year period of apprenticeship training is necessary. Training is finished by taking school-leaving exams and is of the same level as secondary vocational education.

The aim of these measures was to better prepare production workers for the complicated tasks involved in electronic equipment production and its application, and in making full use of NC technology in production techniques. Existing experience shows that the theoretical part of the study is rather good, there are, however, certain comments concerning the practical training, Experience has shown that innovation processes are more demanding with regard to management activity and its intensity and specialization. The dependence of innovation results on the qualification of managers and workers in research, development, production and marketing is obvious. Education is one of the tools for developing organization and human resources management. Therefore, we consider paying due attention to education goals as one of our main tasks and we make every effort to ensure that education is not an aim in itself, but rather a source and stimulator for the further development of human resources.

IMPLEMENTATION OF MARKETING DECISION SUPPORT SYSTEMS

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In the innovation literature one often distinguishes product innovation from process innovation. The latter almost invariably deals with process innovation in the production area. In this paper I will touch upon another type of process innovation, namely with respect to management decision making, through the use of decision support systems (hereafter DSS). My examples will in fact relate to marketing problems, and I will therefore more specifically discuss marketing decision support systems.

Many models are built, few are used is a "dictum" that has almost become a common place in the Operations/Management Science literature. There has been much concern with this state of affairs in the Management Science profession, and over the last 15 years or so a very substantial effort was made to remedy the situation. Partly as a result of that effort, labels such as Decision Support Systems, Interactive Systems, Decision Calculus Models and the like are also becoming household words. Although these different labels may refer to somewhat different things, they have in common that they are blending data, statistical methods, mathematical models and techniques and easily manipulable and interactive input-output devices.[1] The system is typically intended to help management in monitoring, analyzing and acting upon its environment. Figure 1--based on Little (1979)--shows a graphical representation.

My main objective here will be to discuss a set of factors that determine the likelihood of acceptance, and therefore of usage of such DSS. Here we will primarily deal with the human aspects. We will also use DSS and models interchangeably.

The likelihood of model acceptance depends on three main categories of factors:[2]

1. Model-related factors.

2. Organization-related factors.

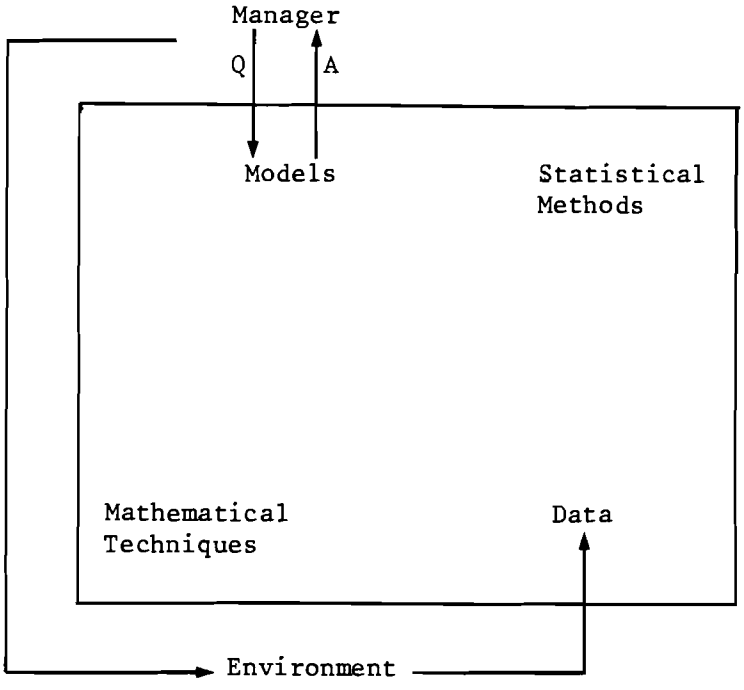

Figure 1. Main components of a marketing decision support system.

3. Implementation strategy factors.

We will discuss each of these three categories in turn.

MODEL RELATED FACTORS

Likelihood of implementation of decision support systems will in the first place depend on the underlying models, and more in particular on characteristics that relate to (i) model structure; (ii) parameterization; (iii) validation; and (iv) cost-versus-benefit considerations. These factors and subfactors are listed in Table 1. Most of these have been discussed at length elsewhere.[3] In this paper we will restrict ourselves to making some comments on parameterization.

Parameterization of models is often a difficult task. In many cases historical data are insufficient in quantity, quality or variability to permit reliable estimation by, for example, econometric techniques. More important, however, is the fact that even when such estimation is feasible, the users of DSS typically resent it on the ground that the past cannot serve as an adequate basis for future decision making in a changing and dynamic environment. Marketing DSS therefore become much more acceptable when a provision is made for supplying subjective inputs and subjective estimation. The basic idea being that the manager's experience is used for parameterization rather than the historical facts. Managers typically favor this approach for two main reasons: (i) They believe that their day-to-day experience with the market envrionment gives them a much more

Table 1. Model related factors.

Model Structure:	o Simple
	o Complete
	o Adaptive
	o Robust
Parameterization:	o On the basis of objective data
	o On the basis of experience
Validation:	o "Face" validity
	o Statistical validity
	o Predictive validity
	o Validity in use
Cost and Benefits:	o Cost
	o Direct benefits
	o Indirect benefits

up-to-date view of the different forces at work in the market place than do historical data; (ii) It actively involves them in the development of the DSS, and as such contributes to team building between developers and users of the system, and to giving the user a feeling of control over the DSS.

A warning may be in order here. In some cases managers will exploit subjective estimation to construct self-fulfilling prophecies. Let us illustrate this with an example from a company that wanted to apply a DSS to improve the process of allocating marketing resources to its different product lines. One of the inputs into the system was the subjectively measured responsiveness of the market to these resources (relative to competitive effort) and to a change in quality of the product (relative to quality of competing products). The curve labeled "first" in Figure 2 shows the estimated response curve for one of the product groups originally provided by company management. In fact, it turned out that the company wanted to abandon the product line. Given the initial response curves the DSS indicated that the product group was profitable. Management therefore re-estimated the response curves until in a third iteration (see curves labeled "third" in Figure 2) the DSS was conform to their a priori thinking since it indicated that any dollar invested in the marketing of this product group would have a negative return.

We should add that the danger of misusing subjective estimation is much smaller for recurrent decisions where people can be easily made accountable for their judgments by later confrontation between estimates and reality. In single decision situations asking people to carefully justify their judgments may also reduce the danger.

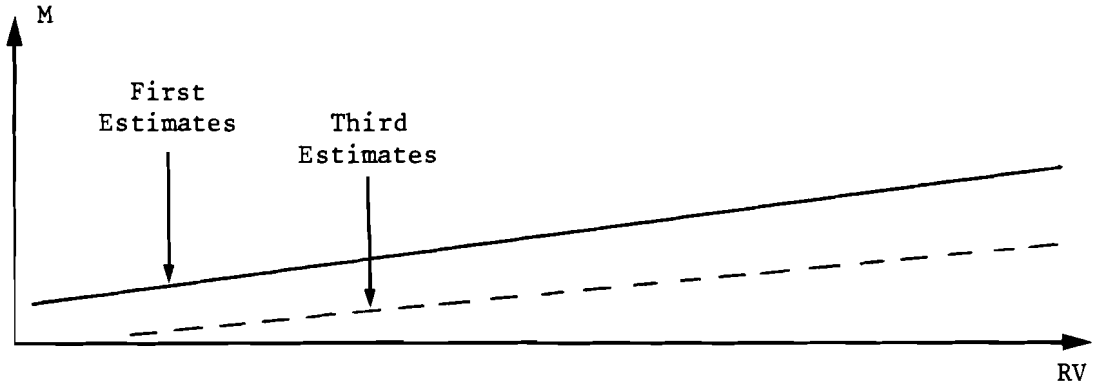

Figure 2a. Market share as a function of relative personal selling.

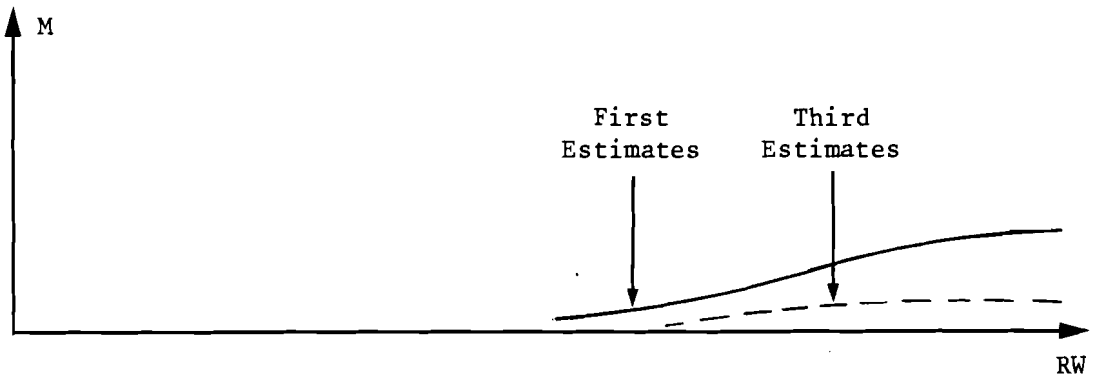

Figure 2b. Market share as a function of relative value.

In any event, it is fair to say that the introduction of experience based parameterization has been the single most important factor in improving the degree of acceptance of DSS in marketing, and in reducing the resistance to change associated with the introduction of a DSS.

ORGANIZATION RELATED FACTORS

Decision support systems are developed in collaboration with, and used by, people who work in organizations. The probability of model acceptance will therefore not just be dependent on model related factors, but will also be influenced by human components. We can study these at three levels: at the personal level; at the level of the relation between model builder and user; and at the level of the organization.

Personal Level

Different individuals have different capacities for processing information. Some are capable of processing substantial amounts of very complex and intricate information, whereas others already experience difficulties in trying to integrate information at much lower levels of complexity. In other words--and

to use the terminology of Schroder, Driver and Streufert (1967)--integrative complexity varies across individuals. Or if we translate that in terms of models: The optimal degree of model detail varies across users. As a consequence it is desirable to build models in an interactive and modular way. As such the user can through answering a series of questions in an interactive mode, select the model complexity most suitable to him.

Interpersonal Level

A crucial factor in determining the implementation chances is the interaction between model builder (MB) and model user (MU). Churchman and Schainblatt (1965) have proposed a simple typology describing four basic patterns of interaction between managers and researchers. If we substitute manager by model user (MU) and researcher by model builder (MB) we obtain the typology described in Table 2.

Table 2. Model builder (MB) - model user (MU) interface.

	MB understands MU	MB does not understand MU
MU understands MB	Mutual understanding	Communication
MU does not understand MB	Persuasion	Separate functions

Roughly speaking the entries can be described as follows:

Separate function. The function of MU and MB are seen as essentially separate. It is a situation where little or no interaction takes place.

Communication. Here it is assumed that the MU does not need to have deep insight into the problems facing the MB. It is then the MU who must penetrate the way of thinking of the MB, such that he can more carefully communicate his problem to the latter.

Persuasion. In this pattern, the MB must put sufficient effort into getting a grasp of the problems and the way of thinking of the MU. The underlying assumption is that the MU is too busy to familiarize himself with the methodology and the jargon of the MB.

Mutual understanding. This cell combines the positive aspects of communication and persuasion.

It should be clear that this typology represents the extremes of a continuum, and that refinements are possible.[4] The simple representation, however, suffices for our purpose. It is instructive to examine what MBs and MUs themselves consider the appropriate pattern of interaction. We first refer to two American studies, one by Dyckman (1967) and another by Duncan (1974). Some elements of the study are shown in Table 3. Again we use MBs and MUs rather than researchers and managers. The figures in the table are to be interpreted as follows: In the Dyckman study, for example, 16 percent of the MBs agree that separate function is an appropriate pattern of interaction. In the category of MUs 42 percent agree. The sum of each column is larger than 100 because respondents may find more than one pattern appropriate. This seems to have been very much the case in the Dyckman study.

Table 3. Appropriate pattern of interaction as seen by model builders (MB) and model users (MU).

	MBs Agree		MUs Agree	
	Dyckman (1967)	Duncan (1974)	Dyckman (1967)	Duncan (1974)
Separate function	.16	.03	.42	.01
Communication	.56	.11	.64	.07
Persuasion	.69	.37	.53	.35
Mutual understanding	.62	.77	.58	.83

From the Dyckman study we retain that MBs and MUs have substantially different opinions, more in particular concerning the appropriateness of "separate function". This figure is especially high for MUs. "Persuasion" dominates "communication" for MBs, and the reverse is true for MUs.

The results of the Duncan study, published seven years later, are quite different from those obtained by Dyckman. Almost nobody agrees with "separate function". "Persuasion" dominates "communication" for both categories of respondents, and "mutual understanding" is seen as appropriate by almost 80 percent. On average MBs and MUs roughly share the same opinions. Thus it appears that in the United States much has changed between 1967 and 1974.

It is therefore interesting to make a comparison with a study carried out by Vandenbroucke in 1979. In Table 4 we have taken the average of the results for MBs and MUs from Table 3. It is striking how close the findings of Vandenbroucke correspond to those of Dyckman. It is an indication that in Europe (or at least in Belgium) the development and use of management science in practice runs 10 to 15 years behind the United States.

Returning to Table 3, we notice a trend towards "mutual understanding", with yet a strong position for "persuasion". We should, however, also ask ourselves the question as to whether "mutual understanding" is realistic or realizable. Hammond (1974) has observed that managers and model builders

Table 4. Comparison American and Belgian study.

	MBs and MUs agree with		
	Dyckman (1967)	Duncan (1974)	Vandenbroucke (1979
	United States		Belgium
Separate function	.29	.02	.21
Communication	.60	.09	.61
Persuasion	.61	.36	.74
Mutual understanding	.60	.80	.64

differ from each other on many dimensions, such as, goal orientation, time horizon, comparative expertise, style of interpersonal relations, problem definition, desired degree of structuredness, etc. Without further exploring these points, we can nevertheless conclude that the profiles of MBs will strongly differ from these of MUs. In that sense "mutual understanding" may to a certain extent be utopian. We cannot expect both MB and MU to be specialists in marketing, and statistics, and mathematics, and econometrics, and mathematical programming, and informatics, etc. It will be more realistic to bring distinctive competences together and to develop systems that make it easier on them to work together. Looking at modern DSSs we observe that their users do not have to get training in the areas of specialization of those who develop them. In that sense we can position the evolution of the last 10 years near the category "persuasion", on the continuum "persuasion", "mutual understanding."

Level of the Organization

There are many characteristics of the organization itself that should have an influence on DSSs. I will single out one of them, namely hierarchical structure.

Much of the earlier work on building models or decision support systems did not explicitly take the existing organizational structure into account. Yet if we want these systems to be used in practice, they must (at a minimum in the early stages of development) accept the organizational structure as given.

Secondly, many of the existing DSSs deal with partial aspects without hierarchical linking of, and feedback between, the parts.

For example, there are DSSs for allocating marketing resources to product groups or strategic business units (an aggregate problem); others to allocate resources to products within a group (a more disaggregate problem); still others to allocate a marketing budget to different marketing instruments for a given product (a detailed problem). Until recently these

various problems were treated by separate DSSs. Only now are DSSs being developed that enable hierarchical linking and feedback through a sequence of aggregations (see Figure 3). These systems borrow heavily from the work on linking aggregate and detailed scheduling in production, and on hierarchical approaches to solving large scale problems. The closer correspondences of such integrated DSSs to existing hierarchical structures in organization is a factor that again favors acceptance. For a detailed application in marketing, see Naert, Gijsbrechts and Weverbergh (1983).

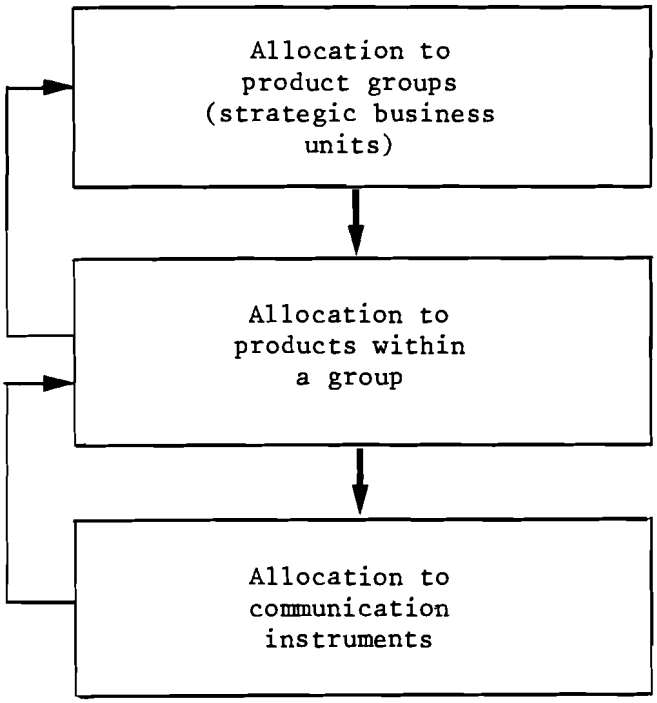

Figure 3. Hierarchical linking of aggregate and detailed decisions.

IMPLEMENTATION STRATEGY

The traditional approach to model building starts with the specification of the relevant variables and the mathematical relation between them. This is followed by estimation of the parameters, validation and implementation. These are steps that were already listed in Table 1 and therefore are model related.

However, we also pointed out that decision support systems are not developed in a vacuum, but in organizations, and that we should therefore take these organizations and their members into consideration. It then follows that a process approach is to be preferred. In practice that boils down to the fact that specification, estimation and validation are preceded by a number of other steps. We will briefly describe them:

1. *The model builder as change agent.*

   Introducing decision support systems is a form of organization development. The model builder should therefore be considered

as a--in most cases external--change agent. As a result it is worthwhile to exploit the findings from research on organization development when studying the implementation of DSSs.

2. *MB-MU interface.*

   To be effective the change agent must develop good contacts with the users, and the change must come about through close cooperation.

3. *Problem definition.*

   The change agent will take sufficient time to get a thorough understanding of the problems for which his intervention is requested. Only then should he start tackling them.

4. *Model structure as a function of intended use.*

   A number of the model structure characteristics should depend on what one intends to do with the model. A model may, for example, be suitable for forecasting, but not for deriving normative conclusions.

   The desired degree of robustness therefore also depends on the intended use. Models should not be more complicated than necessary and useful.

5. *Starting from existing procedures.*

   Models will be more easily accepted if one takes existing procedures into account. There will indeed in most cases be good reasons for using these procedures. Building from and on what currently exists, rather than starting from scratch, should therefore be recommended. For an example we refer to Naert, Gijsbrechts and Weverbergh (1983), where a planning procedure is proposed for allocating marketing resources to product groups and to products within each group. As a basis they took the planning procedure currently applied by the firm, and the new system was as much as possible translated in terms of the old one. As such, the transition to the new system was much easier to follow by product management, and one also realized more quickly that the system results in a very substantial improvement.

Evolutionary Model Building

Models should not be built in all their ramifications right from the start. A typical scenario proceeds as follows: Managers and model builders begin by defining the most important elements of the problem, and their interrelationships. After a few meetings a first simple model is developed. The managers are completely involved, and it is therefore more likely that they will understand the model and be interested in its potential. On the basis of experience-in-use, they will gradually add new elements and refine others. The model therefore becomes more complex, but management nevertheless maintains understanding, because the extensions were made on their demand. It is through this process that the criterium "simple" and "complete" can be reconciled.

To maintain this evolutionary character, and yet be able to realize economies of scale in model construction, we again plead for modularity. In essence that implies that a model is built as a set of components or submodels. The ultimate model that will be suitable for the user and adapted to his experience then comes about by simple linking of a number of these components and submodels.

User Friendliness

Models have a better probability of being used if they are easy to work with, that is if they are made user friendly. In the first place that requires easy communication with the model, i.e., one that is adapted to the work and communication habits of the user. That is the reason for programming models in an interactive mode.

It must also be possible for the user to intervene. In other words he must, for example, be allowed to adjust some of the parameters. That will particularly be the case when parameterization is data based. Parameters estimated on the basis of historical data indeed measure a more or less average effect. It should be possible to correct them on the basis of more specific and up-to-date information of the management.

CONCLUSIONS

In conclusion we can say that success in implementing decision support systems--apart from the intrinsic qualities of the system--depends on the ability to obtain strong personal involvement of the various affected parties, team building, and efforts to overcome resistance to change. The relevant human factors are therefore very closely related to those one finds in implementing innovations in general.

FOOTNOTES

1) Little (1979, p. 11) defines a marketing decision support system as "a coordinated collection of data, systems, tools and techniques with supporting software and hardware by which an organization gathers and interprets relevant information from business and environment and turns it into a basis for marketing action".

2) This is roughly the same structure as used in Leeflang and Naert (1978). The discussion here however emphasizes the human factors and also contains new elements accumulated since the publication of that 1978 paper. See also Naert (1984) on which much of this paper is based.

3) For the model structure criteria see Little (1970) and Naert and Leeflang (1978, Chapter 6). The other factors listed in Table 1 are treated at various places in Naert and Leeflang (1978) and more in particular in Chapters 3, 11, 12 and 14.

4) See, for example, De Brabander and Edström (1979).

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PRACTICAL ASPECTS OF HUMAN FACTORS IN PRODUCT DEVELOPMENT

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INTRODUCTION

This report deals with practical experiences obtained during actual research and development work in the company Oy Strömberg. The company itself is presented in two earlier IIASA reports (Potila 1982 and Karttunen 1983). Many of the thoughts presented in this report were introduced during discussions in the company's Research Centre, which mainly concentrates on research and development work related to heavy electric apparatus and transformers. The Management theories used in the R&D work are presented in modern literature, one source being the Harvard Business Review. In the conclusions based on observations of practical work, some statements of a theoretical nature are also given.

Although reporting on actual cases gives reliable material, it should be remembered that these refer to special circumstances. Under other circumstances other factors may lead to different conclusions. For example, the different size and history of an enterprise, different types of products and the different social background of the people may produce diverse results.

WHAT ARE HUMAN FACTORS?

Human factors may be divided into two classes, both of which are equally important. The first class relates to personal characteristics and human abilities such as creativity, determination, activity, intelligence, and expert knowledge. Some of these characteristics may be improved by training, some are of a basic nature and cannot be changed. One of the problems of a manager is to choose those people among new personnel whose basic characteristics are suitable and not to make his decision based only on those characteristics which may be improved by training.

The second important class of human factors relates to interpersonal relations. The ability to cooperate and work in a team, and the ability to inspire and lead others are some examples of this category. Motivation also belongs more to this category than to the first one. Many organizational problems also have a component which should be handled when speaking about human factors. Some forms of organization prevent individual activity, some encourage it. It is not possible therefore, to exclude organizational problems when speaking about human factors.

A very important human factor of the second class is the behavior of superiors towards people working in R&D. Even a bad organization may work well if there is a leader with the right attitudes and behavior, alternatively a good organization may totally fail in the opposite case. Most of the human factors of the second class may be improved by training and changing the organization. Sometimes the best solution can be found by transferring a person to another position not belonging to R&D.

In the following, human factors are not treated separately according to the above classification, but are handled together from different points of view.

THE IMPORTANCE OF R&D RESULTS

It is an accepted fact in all industrial enterprises that one of the most important principles for the life of the enterprise is an effective, continuing development of products. In fact, this work is needed for survival, not just for success. It is also stated many times today that it is not R&D itself but the results, whcih are needed.

After the Second World War a belief often found in industry was that if you give enough manpower, financial resources and a free hand to R&D, new products would come out. Today, R&D departments are considered more like other departments requiring exact plans and useful results during a reasonable time. If there is no planning and control of work, especially in big R&D departments, there is a danger of losing the objectives and using the time in useless efforts, or for people to further their own scientific career rather than to work for the best of the enterprise. Of course, some freedom of choice should be left, the question is how to find an optimum.

The basic human factors are that all R&D personnel realize the importance of the development work results and accept the necessity of planning and reasonable control. If both of these basic conditions are accepted, it is easy to continue by training and developing the organization, and improving the general premises for effective working. If, on the other hand, one of those is not accepted, hardly any measure can help the R&D activity from being ineffective.

DIFFERENT TYPES OF TASKS IN R&D

When discussing the human factor in innovation management it is necessary to realize that there are many types of R&D and that in each type there are many different kinds of jobs. R&D is not some kind of continuing innovation process, not is it a process where all steps are carefully calculated and

planned beforehand. In fact, the big moments of great ideas are very exceptional. When an idea is born the work which follows to realize it is usually very hard and various difficulties and disappointments are very common. Only a small amount of original ideas which seem to be very promising at first, survive to the stage where they are also successful on the market.

The development of a product as a whole can be divided in two phases: the first phase is the starting period, and the second phase realization of the idea. Usually the second phase requires much more time, money and work than the first even if the first includes some preliminary tests in order to see something about the possibilities of the new idea. Depending on the product, both phases may require very different tasks and also people for their realization. The following list gives some examples arranged in pairs, and each pair gives two examples which are opposite to each other.

Pair 1.

- Keeping a good product able to compete on the market.
- Developing a completely new product using a new technology.

Pair 2.

- Developing a product starting from raw materials.
- A product composed of parts made by other manufacturers.

Pair 3.

- Developing a product which requires many experiments.
- A product which can be designed completely on the drawingboard.

Different development methods are better for the various cases shown on the list. The organization of the work may also be different as well as the answers to various problems relating to human factors.

The following steps are needed in nearly all cases of the first phase of development work:

- a problem or a market need is observed;
- facts about the problem are gathered;
- ideas for solving the problem are sought;
- one or a few ideas are chosen for further evaluation;
- a final choice is presented for approval.

It is clear, that no one person could be optimal for all steps, and one of the manager's main tasks is to find the best possible choice.

REQUIREMENTS FOR R&D PERSONNEL

Research and product development includes many different tasks and jobs, therefore different types of people are also required. In this chapter, a survey of the different requirements needed is given without going into details. Many of the requirements mentioned here relate not only to single persons but also to the organization. It should be arranged not as an obstacle, but to give possibilities and to encourage the right actions.

In spite of the different tasks, it is seldom possible or even useful to find a new person for every task in the chain of events included in the development of a product. Normally the same person or persons compose a group that takes care of the whole process. Sometimes they may need help from different kinds of technical experts, but in principle the overall responsibility for the project is theirs. The requirements for managers concentrate on the following points:

- decision to start development work;
- decision to stop the work;
- following the progress of the work.

A manager is not usually in a position to decide to start or stop development work by himself. Large projects usually need to include more decision levels. However, the R&D manager should be active and able to give well-argumented proposals concerning the decisions.

Following the progress of work means not only taking part in formal meetings, where the progress is discussed and compared to timetables. It is also necessary that the manager visits the people engaged in the actual R&D work frequently enough in order to get a real picture of the situation. Motivation of the personnel will also be improved when the superiors show active interest in the work.

Stopping a project because of bad results is one of the manager's difficult jobs. Even if it is difficult, it is very important and bad projects should be stopped as soon as the result becomes evident. On the one hand, a manager requires courage and, on the other, good personal behavior in order to win understanding for the decision and to keep the people involved motivated for new jobs.

During the starting period of a project, the essential characteristics for persons involved are the following:

- the ability to understand clearly what the market need or the problem is for which the product should be developed;
- the potential for high innovation and creativity;
- a good knowledge of technological and manufacturing possibilities;
- good connections to information sources about the changes of technology;

- the ability to present one's own view and proposal clearly and honestly.

In the fast changing field of technology special means are often needed to speed up and promote the flow of knowledge from the outside world to the company. Gatekeeper ability is often mentioned in the literature, and these people are well-suited to follow progress and report any new happenings to the right people. It is the duty of all people involved to use their possibilities and follow progress, but some people are more successful at this and they could be called gatekeepers.

The realization period starts after the first decisions are made and some product ideas are chosen for development. It is in this period of R&D that the major part of man hours, money and other resources are used. Typical tasks in this phase are e.g., designing prototypes, testing them, evaluating results and making conclusions. Good characteristics for people engaged in these kind of tasks are:

- a good knowledge of the manufacturing possibilities;
- the ability to easily adapt to new methods;
- the ability to work together with people in other organizations (i.e., production, marketing, testing);
- the ability to work to long-range plans and timetables;
- an honest, hard-working character;
- an independent, sometimes headstrong character.

A special difficulty in realizing new product-ideas is the fact that only a small percentage of new ideas are a success. Development work often produces results which necessitates stopping the work. From the motivation point of view such situations are very difficult but cannot be avoided, and this leads to a special requirement for R&D people:

- that in spite of a failure work should go on with other subjects effectively and motivated.

A good knowledge of manufacturing possibilities was mentioned in the preceding list. In practical life this requirement can be fulfilled in a good way, when product development is performed very near the manufacturing place. When R&D people daily see the production, its changes and difficulties, they may take them better into account in new products.

The period of new product realization sets requirements on the leader of the development group which are combined under the title "product champion" in the literature. It is often stressed that one of the most difficult jobs of a product champion may be to solve the conflicts inside the company that arise because of the new product and the different opinions about it.

MOTIVATION

The main conditions for a high motivation to do the right things may be listed in many ways. The following list gives a subjective choice of some of the important points:

- What the right things are should be well known. The company strategy and objectives should be clearly seen.
- One's own responsibility for the work is high.
- There should be a trusting atmosphere regarding the evaluation of proposals and estimation of the results of the work. The individual person should have the feeling that his work is rated justly.
- Each person should regard his own job important for the company and be socially rated.
- Also necessary, especially for younger people, job rotation to improve motivation.

The above factors may be mostly influenced by the manager-level. The manager's own behavior is the most important factor influencing motivation in his department.

There are of course always people who do not get on well in R&D work or who after a few years of R&D work would like to do something else. The best way to solve this is to arrange for a transfer to another department. It is difficult to define a list of personal characteristics which would guarantee beforehand that a person would have a high motivation in R&D tasks. On the one hand, very different people seem to get on well, and on the other a "typical research-man" may ask for a transfer to the marketing department. High-level R&D people are often independent people with good professional skills and would also be high-level people in many other tasks other than R&D.

To answer the question what is more important for motivation, management behavior and the company's organization characteristics, or one's inner properties to find motivation in one's work is not easy. Inner properties also seem to be very important and here there may also be differences caused by different cultural and social backgrounds.

TRAINING POSSIBILITIES AND LIMITATIONS

In addition to basic education at different levels, continuous training is needed for several reasons:

- to keep up-to-date with changing technology;
- to train people for new jobs for the time when the old ones have become obsolete;
- to train people for teamwork, development of creativity and in problem saving techniques;

- to train the managerial level in modern management methods;
- to train technical people to see the economic side of things;
- to show new possibilities, open new contacts and learn new ways of thinking.

Training has many important objectives. Its efficiency, however, is often very difficult to estimate. If no consideration is given to the efficiency of training, it may be really low. The training events may be used more for recreation and meeting old friends, which although also could prove useful and good for motivation, may lead to a neglect of the purpose behind the training. The most important and perhaps also the most fruitful sort of training after basic studies, is that performed during normal working. The company's specialities are usually learned during the first two years and its products and methods familiar. For R&D people this should not mean, however, that they go into details, because their main task should be to work with new products and old ways of of thinking could be a hindrance here. Training in the working place also continues after the first few years. It is then not usually called training, but gathering experience. When new tasks require new knowledge to be found in the literature or from experts, the direct need and use make the "training" very effective.

Another useful way of learning is to visit exhibitions, clients, conferences and other companies working in the same field. Especially in big companies R&D people may feel themselves too isolated from the outside world and these kinds of visits are therefore important. In discussion with customers many good ideas for products may arise, which would not be found in the laboratory or textbooks. Also the validity of one's own ideas can be better tested when thinking how they could operate in the actual conditions described by possible users of the product. For advanced R&D people another fruitful occasion for learning are discussions with colleagues outside formal conference meetings. The newest happenings and trends are often first mentioned in small circles, whereas they may be heard a year or two later in the conference hall.

In improving efficiency the first thing to make sure of is that the person to be sent to a training event really is motivated to that training and needs the abilities to be taught. He should also be on such a level that the event is neither too difficult nor too easy for him. The interest of a foreman in the results of the training also improves efficiency. If it is known that he is going to ask about the impressions received and maybe arrange an internal meeting where the person involved should give a summary the results of the training will be more effective.

Too many training events may also lower efficiency. The right number of training days/year depends very much on the situation. It may be several months/year if a new technology is to be adapted. Such transient periods excluded, the range may be some days/year or some weeks/year depending on the subject, person and what is included in the training. In principle, everybody working actively in R&D tasks should have yearly possibilities to improve his abilities.

The evaluation of training results is easier for technical matters than for courses on e.g., problem solving or innovation technqiues, project-leading

methods or managing by objectives. People are often very enthusiastic after returning from training events of the latter character. It may occur, that very little from the new information is in use after several months. One possible reason is often that these kinds of new methods require that a great part of the personnel start to use the new method. A single person can hardly use them alone and efficiency is improved, when several active persons participate in the training. Even then the manager should also push actively and show himself that the new way of handling things is really being used. Another reason for small, long-time changes may also be that the new methods are perhaps not always so good as advertised. Some caution should therefore be exercised, and they should not be put in use by force. This may lead to harmful confusion and disturbances in the good working atmosphere.

DANGER OF COMMITTEES

Developing a product is always a case of both cooperation and individual responsibility. Practical experiences seem to show that the results of R&D work are better when the person in charge of the project has a high degree of independency and responsibility regarding the project. However, the project leader's superior cannot delegate all responsibility to him, the superior has to make decisions regarding starting and stopping the project as well as to follow its progress.

In some project organizations a big formal status is given to committees who in their meetings handle the reports of the project leader and make decisions on how to continue. The author's opinion is that if it really is the committee that makes decisions, then the project may seriously be in danger. The lack of the committee's responsibility causes low motivation and their decisions may be inconsequent. Committees are a very useful instrument for discussing results and presenting different views, however, decisions should be left to one responsible person.

Nearly as bad, or maybe worse, than deciding committees is the situation where the project leader has to wait for tactical decisions regarding the project from many managerial levels above him. When decisions are made physically and organizationally far from the actual work by people who do not know the real situation the presumable result is bad mistakes and slow progress.

The individual responsibility of the project leader does not mean that he does not need contact and help from his superiors. In a good working atmosphere, the project should get the support it needs from managerial levels and should also keep them informed of what happens. When the project leader or people working in the project ask for opinions or advice it is also very important for motivation purposes that they get fast feedback from the managerial level and others who are interested in the work. A good designer or research worker is not always a good project leader. He may have difficulties in delegating and supervising the other tasks, and may try to do too much himself. Management should be aware of this and give him advice in the early stages of the work. When choosing a project leader this part of the task should be carefully taken into account. Sometimes it is better to choose for a leader a person whose ability as a leader is known and not necessarily the best designer.

JOB ROTATION

Job rotation is a very useful way to introduce new people to the enterprise and often R&D departments are the first places for a newcomer. Usually its atmosphere is nearer to that of universities than in production or marketing departments. This may however sometimes cause problems for the R&D department. Even though it is good for R&D to get young people, it also needs qualified, experienced personnel. The problem is how to give the people remaining in R&D a wide enough knowledge of the company without losing them into other departments. Another problem is that senior people working for R&D should also realize the value of their work for the company, even if they see a constant stream of young people coming in and out to other jobs. There are several ways the managerial level should motivate people to stay in R&D, as presented in the chapter on motivation.

THE NEED FOR FEEDBACK

It is a common human characteristic that the results of one's own work should be evaluated. In R&D this should be specially stressed because there is perhaps a greater danger than elsewhere, that work remains unnoticed. The work of R&D is often busy work, revolutionary results come very seldom.

The receiver of proposals, research reports and other documents should always give some clear comment. Even a negative answer is better than no answer or too general an answer. It can be said that a good answer is the new jobs, which show that the level of results from previous ones has been good. It would however be better if the feedback, at least for bigger jobs, comes soon after the work is ready. One of the most important feedbacks is the proper salary development. A manager should also give incentives for improvement to any points in the activities which are not satisfactory, and should also express his thanks for good performances. Feedback should also go in the other direction. In a good working atmosphere the manager should get information about feelings and hopes during normal daily discussions without any special arrangements.

SUMMARY

The first important human factor to be considered in R&D is the choice of people for R&D tasks. Because there are many types of work starting with the first idea to the ready product, not only one type of character is needed. Many people, fulfilling normal qualifications, can find a suitable place in R&D. The question is more one of motivation than other human factors.

The second important task relating to human factors is to make the company's main lines of activity, objectives of the R&D and the normal working rules related to time-tables and so on clear. The third important activity is taking care of motivation. This requires activity from the manager at all times. The fourth task is continuous training. The lines of the training program always require updating and efficiency needs supervising.

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THE HUMAN FACTOR IN ORGANIZATIONS; SOME IMPLICATIONS OF INNOVATION MANAGEMENT

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INTRODUCTION

The importance of the human factor in the execution of different tasks has slowly become more apparent. The influence of human errors could be dramatic, as in the case of the Three Mile Island incident, but humans could also grow in their duties and perform far better than ever expected. Understanding the human as a part of the system is still in its infancy, although some means for describing and predicting human behavior are emerging from sciences such as psychology and sociology. In spite of the results available it is, however, discouraging to observe that very few of the results have been applied in practice in organizations dependent on the human factor.

During recent years there has been a growing interest in the implications of the human factor on the safety of nuclear power. There has also been a strive for including a quantitative prediction of human behavior in risk assessments. At the present level of understanding the description of human behavior in complicated decision making situations has, however, to rely on qualitative rather than quantitative methods.

In considering case histories where the human factor has played a part in an accident or near accident, one of the contributing factors that could be seen is different organizational deficiencies, with the implication that individuals do not have the proper support in their decision making situations. This observation led to the initiation of a subproject as a part of the Nordic cooperation on "Human Reliability in Complicated Energy Systems" (Wahlström and Rasmussen 1983). The subjproject "Safety Oriented Organizations and Human Reliability" (Wahlström 1983) considered the safety implications of organizational deficiencies and has been divided into the following main phases:

- establishment of a theoretical model of the organization;

- collection of case histories;
- categorization of organizational deficiencies;
- establishment of a normative model for a safety oriented organization;
- development of checklists and other measuring methods.

The purpose of this paper is to give a brief account of the most important concepts identified in the Nordic cooperation project and to extend the discussion also to organizations with other types of goals. The discussion is then amended by some observations made from development projects in which the author has participated. As a conclusion some requirements on the organization of a company, which is dependent on its innovative capacity, are stated.

THE ORGANIZATION

A collection of individuals working together for some common goal according to a set of accepted rules could be called an organization. The organization of the work gives a gain due to the rationalization by the specialization between the different individuals in the organization. The following functions could be found in each organization:

- leadership function;
- production function;
- different support functions.

The leadership function is executed by one individual or a group of individuals, which have been assigned the task of leading the organization. The production function is associated with the execution of the main goal of the organization and consists of the largest portion of individuals. In addition to the two main functions of the organization, there are different support functions such as research and development, marketing, accounting, etc.

An organization is characterized by the existence of both sub-organizations and super-organizations. A company could for instance be subdivided into departments and could also be part of a larger concern. Organizations could then be seen as a hierarchy of organizations where the individual represents the lowest level. The concept of an organizational unit could therefore be used as a model of the organization at an arbitrary level. The organizational unit contains its own leadership, production and supporting functions and is responsible for its own resources. The organizational unit could also be seen as an independent decision making unit collecting its own information and making control decisions on the basis of the collected information. The coordination of the organizational units in a larger organization is then exercised from above, with the organizational units also supplying information to the higher levels (see Figure 1).

The resources of an organization are its individuals and the rules by which the organization is defined. The rules of the organization could be subdivided into the following resources:

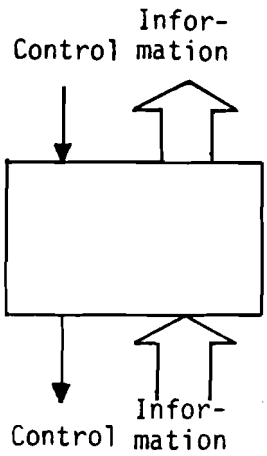

Figure 1. The organizational unit.

- value system;
- decision making and executive system;
- information system.

The value system is determined by the primary and secondary organization goals, and is used to define values and deduced objectives for the different tasks performed. The decision making and executive system is used by the leadership function as a means of controlling the organization to achieve the goals defined. The information system is used to collect, judge, store and retrieve information to support decision making in the organization.

A typical characteristic of organizations is also the existence of formal and informal organizations. The formal organization is usually the result of a conscious design process which is documented in organizational charts and has defined tasks and responsibilities. The informal organization is again the result of a more random development, where informal value systems, decision making and executive systems and information systems are built up. The information organization has both pros and cons, e.g., when patches in the organization are developing to correct deficiencies in the formal organization, and, e.g., when different shadow values could be more important than the goals of the organization.

THE HUMAN FACTOR

Any organization will, however, rely on its individuals and it is therefore important that it is able both to develop and utilize its human resources. In this connection the interaction between the individuals and the organization could be seen as a complicated interplay between the organizational rules and the resources of the individuals. In this connection the resources of the individual could be divided into the following systems:

- motivational system;

- decision making system;

- acquired attitudes, skills, experience and knowledge.

The different systems are thus very similar to the systems defined for the organization, and have been discussed using similar definitions in the field of psychology and management science.

Decision making in organizations is always performed by humans who, however, could be using different computerized decision making support systems. Decision making could be divided into the following phases:

- identifying the need for a decision;

- obtaining the necessary information for the decision;

- generating and assessing decision alternatives;

- selecting and implementing the decision;

- obtaining feedback from the decision.

The decision making phases could also be seen as data processing activities which are separated by states of knowledge of the human decision maker (Rasmussen 1976). The decision making process is also characterized by the existence of two types of reasoning, one slow and deductive that could be called knowledge-based, and one fast and inductive which could be called rule-based (Rasmussen 1981).

The performance of the organization is now dependent on the performance of all its single decision makers, and it is therefore important to consider errors in the decision making process. Considering, the human as a rational being, the blame for errors should not be put on the person but rather on the organization for not providing the necessary support for the decisions. A model of the decision making procedure can now be used to suggest a classification of different errors and their underlying causes (Rasmussen et al 1981). One such classification in the form of a so-called Murphy diagram (Pew, Miller, and Fehrer 1981) is shown in Figure 2.

The human errors could then be attributed to deficiencies in the organization with respect to the following broad categories:

- goal conflicts;

- lack of decision capacity;

- deficiencies in the information system;

- lack of training.

Any goal conflict, e.g., between individual and organizational goals, or between formal and informal goals, should be sought and resolved as a part of maintaining activies in the organization. The possibility of overloading the individuals in their decision making is large especially for key persons in the organization, and the organization should thus provide necessary mechanisms for the delegation of decisions. Deficiencies

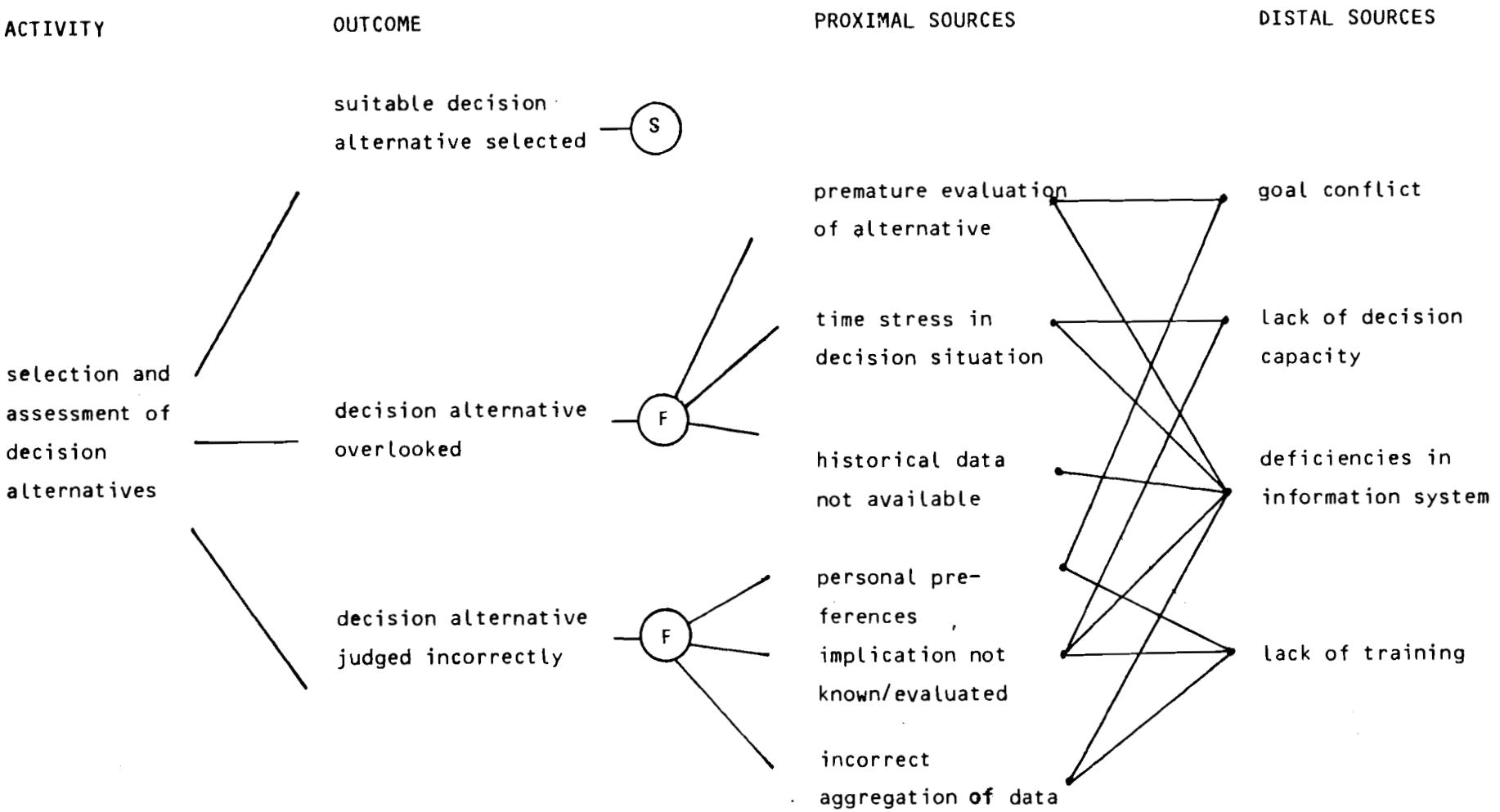

Figure 2. A Murphy diagram for the underlying causes for errors in activity "selection and assessment of decision alternatives" (S = success, F = failure).

in information are the largest cause for human errors, and this category could be divided into several subcategories. The need for training should also be identified continuously and additional training should be given, when necessary.

THE INNOVATION PROCESS

The word innovation is usually assigned a slightly different meaning than the word invention. The term innovation is used then more to characterize a new combination of known facts than something really new. Innovation is also typically initiated in a cooperation between different individuals who have their own specialization. Innovation is usually triggered either by a perceived need for development or by a possibility to use a known method in a new way. Innovation usually goes through several stages of refinement before its final implementation.

The capacity for innovations is an important asset in any company, and the different factors underlying the innovative process have therefore been studied. Different courses aiming at the improvement of individual creativity and thereby increasing the innovative capacity of the company have also been developed. In identifying factors underlying creativity the following division could be made:

- personality-associated factors;
- attitudes, skill, experience and knowledge;
- situation-dependent factors.

The personality factors are, for example, interest in other people and willingness to take responsibility. Education and acquired experience will also have influence on the ability of a person to come up with usable innovations. The situation-dependent factors are then, for example, the organizational atmosphere and opportunities to work in a creative group.

Innovations can occur spontaneously or be consciously initiated as a means for the improvement of a company. In the case of a conscious effort, the innovative process could ideally be divided into the following non-overlapping phases:

- collection of background material;
- definition of the problem;
- generation of ideas;
- design of a solution;
- information and marketing of the solution.

The different phases also suggest reasons for ideas not to succeed in working themselves through to a successful application. If there are deficiencies in the background material collected, there is a great risk that good ideas will be generated for the wrong problem. In the definition of the problem it is important to both define the goals for the solution and to define

the possible restrictions in the implementation in as concrete terms as possible. If a solution is not even considered, it is clear that it will not be implemented. The design of the solution contains both the further refinement of the ideas generated and the final evaluation of different solutions possible. The description and marketing of the solution is also an important phase in the application of an idea, and could, if not appropriately managed, even introduce conscious sabotage from the members of the organization.

The initial evaluation of an idea is a very sensible stage in the innovation process because it will determine if the idea gets a chance. In organizations one could often see a negative attitude to new ideas, which could be illustrated with some common excuses given for not taking up an idea, Figure 3. The underlying causes could, however, often be found among the following:

- laziness with respect to
  - o making extra efforts
  - o taking responsibility;
- being afraid of
  - o risk-taking
  - o stepping on someone's toes
  - o ridicule;
- limitations in knowledge and experience
  - o idea not understood
  - o possibilities not seen
  - o implications not judged.

The old way is working fine.

It will never work.

It has not been tried before.

It has been tried before.

There is not enough time.

This is not the correct time.

It will be too expensive.

It is not my job.

People will never accept it.

It is not within our business idea.

Figure 10. Ten Common Excuses for Not Taking Up an Idea for Development.

MANAGING INNOVATIONS

A company interested in enhancing its innovative capacity could try to influence the different underlying factors. The personality factors of the people working in an organization are difficult to influence directly, but could be influenced indirectly in the hiring policy of the company. The attitudes, skills, experience and knowledge could be influenced by different training courses. The most important influencing factors are, however, the situational factors, because the control of these factors will show the shortest time constants. The control of the situational factors will naturally also involve training, but the training will be directed towards the key persons which have a large influence on the innovative process.

Considering the flow of ideas through an organization, the following preconditions have to be fulfilled in order to trigger the innovative process:

- the idea should be good;
- the idea should be accepted for realization.

For the idea to be good it has to be realizable in the right context, have the markets, etc. In order to be accepted for realization it has to be presented in the right way for the right person and funding should be available. These preconditions imply that only a few ideas of all generated ideas are good, and that there is always the risk that a good idea is not identified. The identification of good ideas is very important for the innovation process, and it is also very likely that good ideas are screened out if the ideas have to go through very many decision levels in the organizational hierarchy before they can get the necessary acceptance for realization. On the other hand, it is necessary that bad ideas are screened out as soon as possible and do not use the financial resources of the organization.

In trying to look for obstacles to the innovation process the following two are the most important:

- an idea is not presented for judgment;
- an idea is judged incorrectly.

The presentation of ideas for further consideration is very important and requires a favorable motivational climate. The climate could be influenced by showing, in words and deeds, that the presentation of ideas is appreciated. The persons judging the ideas have also a strong influence on the motivational climate in giving feedback to the person presenting the idea. The judges of the ideas could perhaps be given training in social skills and creativity in order to improve their performance in giving the feedback and in seeing other possible applications of the idea, but it seems clear that their performance to a large extent is dependent on personality factors.

The development of an original idea into useful innovation has to go through several phases. The application field perhaps has to be changed, the final realization should be given to another department, or the production process will be in need of refinement. During that development it is important that all the possible influences from markets, production

processes, labor resources, etc., are considered and resolved in an optimal way. In the adaption of the idea to its final realization the use of creative disagreement could be seen as an important factor; there are experts in different fields trying to find and resolve different obstacles which hinder the successful application of an idea. In this phase it is especially important that all the tacit arguments against the idea are brought into the open and are discussed in a constructive way. The discussion should thus be considering technical and quantifiable matters where the assumptions are clearly stated.

CONCLUSIONS

The human factor in innovation management is very important. The human factor influences both the individual level and through it the organization. In order to achieve the goals defined for an organization it is also necessary to reflect them in the organization. Using a model of both individuals and organization we could construct some requirements which should be imposed on the organization. The requirements could also serve as a checklist to be used in improving the performance of the organization.

Although it is comparatively straightforward to compile some of the requirements it is rather astonishing to note that in many cases they have not been considered. The existence of organizational deficiencies is one of the major obstacles to many organizations in their effort to attain their primary and secondary goals. With respect to innovation management it is in some cases rather astonishing that any idea gets through in the organizational systems used.

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MOBILIZING THE WORKING TEAMS FOR THE IMPLEMENTATION OF INNOVATIONS AT THE STATE ECONOMIC ASSOCIATION ELPROM

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The role of the human factor in the implementation of innovations in the electrical industry, and possibly other industries too, has two divergent apsects:

- On the one hand, it can be conservative, with workers unwilling to introduce any changes into well-established production routines characterized by good technological and economic indicators; this unwillingness may well be justified and objective from a very short-term perspect.

- On the other hand, when those participating in the innovation process at all levels are convinced that innovation is needed, they find ways to overcome any negative aspects of the implementation process or the period immediately thereafter; in such circumstances the human factor plays a very positive and in many cases decisive role in the rapid and widespread implementation of the innovation concerned.

Of course, these are two very extreme situations: in practice, we encounter many intermediate variants where one or the other factor predominates to a greater or less extent. If we consider the development of the innovation process over time, the conservative aspect usually prevails at the beginning, after which the constructive implementation attitude gradually asserts itself. Of course, waiting for the natural development of the process very often confronts us with the bitter truth that the innovation is already too late (in particular, when new products are to be introduced); favorable market and other conditions may have ceased to exist, and the overall level of efficiency that might have been reached with earlier implementation is now unattainable, resulting in losses in the shape of increased costs for finished development activity and in losses of lower sales.

For this reason, it is very natural that each firm should attempt to speed up the process of "ripening" of the human factor until a sufficient level of understanding is reached about the need to promptly implement a given

innovation. As a rule, the need for basic innovations, which will determine the firm's development and very existence, is assessed and decided by the responsible management of the firm. However, in many cases and particularly under the conditions of a planned economy, some innovation implementation tasks are assigned by the corresponding higher-level authorities, which are mainly guided by the interests of the national economy. On the other hand, individual innovations are frequently initiated on the shop floor and in particular, by the research and development divisions of the firm.

All these features may be observed in the activities of the State Economic Association "Elprom" in the area of innovation implementation. As a first step in overcoming the inertia of employees involved in implementation, optimum and real plans both for the current year and for a longer period of time (five or more than five years ahead), are prepared and approved. By examining tasks proposed by individual divisions and discussing these tasks beforehand, the Association management takes a decisive step toward their eventual successful fulfillment.

The approval of a real and resource-supported plan that has been the subject of preliminary discussion and development by corresponding sections of the Association and devisional managements does not mean, however, that all divisional or Association resources have been taken into account. One of the most important "resources" in this sense is the maximum mobilization of those employees who participate directly in the development and production processes.

The criticial period during which to achieve this mobilization is that corresponding to the development of the so-called counter plan, a device that we have utilized for over ten years. Under this system the approved plan for the forthcoming calendar period (one year, for example) for each division is sent to those who directly participate in the production process. The members of every first-level production team are assigned direct responsibilities, as specified in the divisional plan. Within the production enterprises these teams consider, first of all, ways of fulfilling the production tasks assigned. During the discussions, individual members of the team and the first-level team as a whole make counter-proposals on how best to fulfill both the plan itself and additional tasks, according to the specific situation, which increase the possibility of wage increases and improvements in social and everyday living conditions. Among the proposals from the first-level teams are suggestions connected with innovations, though mainly directed at the improvement of the production process, related to working practices. Proposals concerning the adoption of new products, with improved technological and economic specifications, are comparatively rate at this level.

Discussion of the counter plan continues at a higher level in each of the divisions of the Association (in individual shops, for instance). Evaluations are made at this level as to which of the proposals of the first-level teams can be dealt with within the framework of the structural unit concerned and which of them must be handed over to the next higher level.

Thus, step-by-step, the discussion moves up to enterprise management level, where it includes not only the direct administrative management that took part in the compilation of the approved plan, but all the managements of the various social organizations involved, the economic council of the enterprise, and the delegates meeting. At this level it is finally decided which of the proposals made during all the stages of the discussion will be accepted, and which cannot be implemented within the division and must therefore be discussed when coordinating the counter plan of the Association as a whole. The

latter group generally covers the adoption of new products and the implementation of new technological and organizational assignments for particular divisions.

One of the main reasons for the counter planning procedure is to encourage the disclosure of additional, inner reserves within the planned financial and labor resources. Only when highly efficient proposals are made to serve the needs of the Association, are possibilities considered for the additional provision of the necessary resources from available reserves, and sometimes from a redistribution of resources between divisions.

The divisional counter plans, after discussion with Association management, provide a basis for the Association itself to work out its own counter plan, based on the changes made by the divisions, reflecting changes in individual specifications, and underlining the most important tasks to be solved at the level of the Association. The counter plan of the Association is approved by its higher collective management body, the economic council.

In contrast to the shop floor production divisions, the institutes and other research and development units in the State Economic Association Elprom develop their own counter plans, where tasks connected with the development of new products and technological processes (including equipment for their implementation) predominate. To coordinate these development and implementation activities, the representatives of the institutes and other engineering organizations of the Association directly participate in the preparation of counterplans for the production units. On the one hand this approach makes it possible to keep development units informed of the needs of the production units for new products, technological tasks and equipment, as well as the organizational problems faced by the productions units; on the other hand it ensures that new projects from the engineering departments are implemented in the production process at the appropriate time.

The fact that the development of the counter plan begins with the first-level teams within the divisions, and that division and Association employees at all levels take part in the discussion of the plan means that each person has the opportunity to voice his or her personal opinion and to assume further responsibility; in turn, upon successful fulifllment of the counter plan, this may lead to extra payments, improvement of working conditions, better social and living conditions, etc. From what has been said, it can be seen that the constructive involvement of the human factor in tasks connected with the implementation of innovations essentially involves speeding-up the implementation itself and overcoming the innate human conservatism regarding new techniques or practices.

Unfortunately, in practice the making and approving of counter plans (including those parts that cover the innovation process) frequently does not exactly follow the idealized scheme described above. Organizational shortcomings due to a variety of factors, distort the way in which the counter plan process operates; this is sometimes manifested either in superficial discussion of the tasks of the approved plan in the first-level working team or in this stage being completely ignored and replaced by discussion of the problems at divisional management level. It is clear that isolating a large and even predominant part of the divisional team in this way from creative discussion of the counter plan destroys the opportunity to use the capacities of the working teams for speeding up the implementation of innovations throughout the Association.

Measures taken to avoid a purely formal attitude to the development of counter plans fall into two groups: administrative and social. The first of these concerns the Association management whose representatives directly participate in the making of counter plans in the divisions. The second group covers the social and political organizations involved, including the working teams of the divisions. The interests of the trade union organizations are directed toward the improvement of the standard of living of its members, to increasing their social incentives within the division, to improving working conditions, etc. Since the active and creative discussion of both the approved plan and the "bottom-up" counter plan at all divisional levels results in the more complete satisfaction of these interests, these organizations also exert pressure on the administrative management of the division to prevent an excessively formal attitude to the making of the counter plan.

Motivating those who participate directly in the production process through the construction of counter plans is one of the ways for overcoming human conservatism utilized in the State Economic Association Elprom, although as we have seen, the counter plan is also directed toward the improvement of production and overall economic activity.

Another approach, specifically aimed at the accelerated implementation of innovations in the production divisions and the activation of the "human factor" is related to the working contacts between the Association's development centers—the two research institutes and the "Balkan" scientific and production enterprise* on the one hand, and the production divisions serviced by them, on the other. This type of activity is characterized by the conclusion of bilateral (usually one- or two-year) contracts between the development organization and the production unit it services. In practice these contracts are drawn up between the working teams of the two divisions taking part in the fulfillment of the common taks, with their directors (or deputies) and the leaders of the social and political organizations as their representatives. The contracts are based upon cooperation in the fulfillment of their mutually planned tasks, i.e., those tasks that are developed in the project development unit for subsequent implementation in production units. The state and indepartmental norms specify to a great extent the relations between designer and implementor, particularly concerning the volume of work as well as the completion and documentation of various stages of the project up to the handover of results by the implementating enterprise. Unfortunately, strict observation of all the prescriptions of these norms is very time-consuming and slows down the research/implementation cycle; in practice this leads to delays in the arrival of new products in the marketplace or in the adoption of a new technological process. It is not difficult to see that all of these delays mean losses for the enterprise and the Association as a whole, and a decrease in the effectiveness of development activity.

The objective of these contracts, which mainly cover important projects from the strategic viewpoint of the Association's future development, is that teams of specialists and workers from each organization identify productive and organizational possibilities in order to carry out in parallel some proportion of the otherwise consecutive operations at each individual stage. Mainly this involves the launching of new products, starting equipment design and devising the necessary tools even before work on final tests, and the

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*I. Bachvarov, V. Vassev, V. Vassilev, "Management Structures of Innovation Systems in the State Economic Association Elprom". Proceedings of the IIASA Task Force Meeting on Organizational Structures in Innovation Management Prague 30 May-4 June, 1984. IIASA, Laxenburg: CP-83-50.

modification and documentation of experimental product samples. Certainly, there is some (perhaps considerable) risk if changes need to be made in the already designed and manufactured tools, and this not only makes the project more costly but can also delay implementation. To decrease this risk, the two parties assume responsibilities within the contract for close cooperation during the process of product design and the development of the required tools for regular production. In practice, this cooperation means additional involvement of team members and stimulates them to speed up implementation of the new product.

A specific example of cooperation involving this type of contract is given by the cooperation between the "Nikola Belopitov" Institute of Electric Industry in Sofia and two plants producing complex electric drives for metal-cutting machines in the towns of Sliven and Troyan, with regard to their introduction of a range of DC servo drives in 1980-1981. At the beginning of 1980, the customers for Elprom three-pulse DC servo drives required improvements in some of their technical specifications. This could have been achieved quickly through the improvement of individual units of the drives but within the existing three-pulse concept. At the same time, this course of action would have delayed the development of a new range of DC servo drives based on the six-pulse concept, which potentially allows considerable improvement in all the main technical economic specifications of the drives to cater for a wider range of consumers. Through discussions of the most appropriate method to attain the technical levels requested by customers, the Association management, the managements and working teams of the "Nikola Belopitov" institute, and the implementing plants decided to speed up the development of the new range of six-pulse drives by applying the form of cooperation already established through contracts between the institute and the plants. The correctness of this decision was confirmed in practice by the appearance and acceptance after less than a year of the first version of the six-pulse DC servo drives, followed by the introduction of practically all the remaining model sizes (with a few specific exceptions) in the subsequent year. During the period that would have been required to introduce the necessary changes in the existing drives, corresponding models from the new long-term series were adopted, quickly followed by model sizes produced for the first time. Meanwhile, on the basis of these decisions, improvements were made in the manufactured three-pulse drives, thus more fully satisfying the specific needs of consumers. These positive results were achieved thanks to the maximum mobilization of the specialists and workers who implemented and realized the project, and their initiative and creativity which were reflected in the award of the Dimitrov prize in 1982 to the leading specialists and authors of the project.

Naturally, the results of institute-plant contracts can be unsatisfactory if an excessively formal or nonspecific approach is followed when the mutual obligations of both parties are determined. In such situations, the Association management, the administrative management, the social organizations, and the managements of the agreeing parties must work particularly hard to control and improve the cooperation, to mobilize the human factor in order to speed up the implementation of innovations, and to prevent a formal, superficial attitude that can have negative effects instead of stimulating the initiative and creativity of workers and specialists.

Other methods are also utilized within Elprom to encourage initiative and creativity in the implmentation of innovations, but we shall not discuss these here.

In conclusion, we would like to point out once again that one of the ways to activate the "human factor" in the process of innovation implementation according to our experience with the State Economic Association Elprom, is to put into effect administrative forms and methods of management that involve the participation of teams of specialists and workers, represented either by themselves, by their direct managers, or by the social and political organizations.

HOW TO CONTROL THE INNOVATIVENESS OF AN ORGANIZATION

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We need creativity if we are in search of innovations.

Creativity is not a blind power that is in a bottle, and the only question to solve is not: Where is the corkscrew?

Therefore, the right question is not: How to stimulate creativity in one's organization? This way of putting the question is not specific enough.

Systematic research and empirical work in numerous Scandinavian industrial and service organizations gives support to much more sophisticated starting-points in creativity and innovation management. It can be said that one has to control the innovativeness of one's organization.

We therefore have to ask our questions like this:

1. What kind of creativity is needed?
   (Profile?)

2. What kind of creativity is not needed?
   (Frustrations!)

3. To what kind of problems do we focus the creative power of our organization?
   (Priorities!)

4. Which are the main obstacles to the needed creativity?
   (At organizational level.)

5. What kind of creative capacity do we have in our organization?
   (Strengths and weaknesses at individual level.)

In a systematic evaluation that was carried out in 25 Finnish industrial organizations (with 1,000 to 5,000 employees) emphasis on (actual) difficulties are given in the following way:

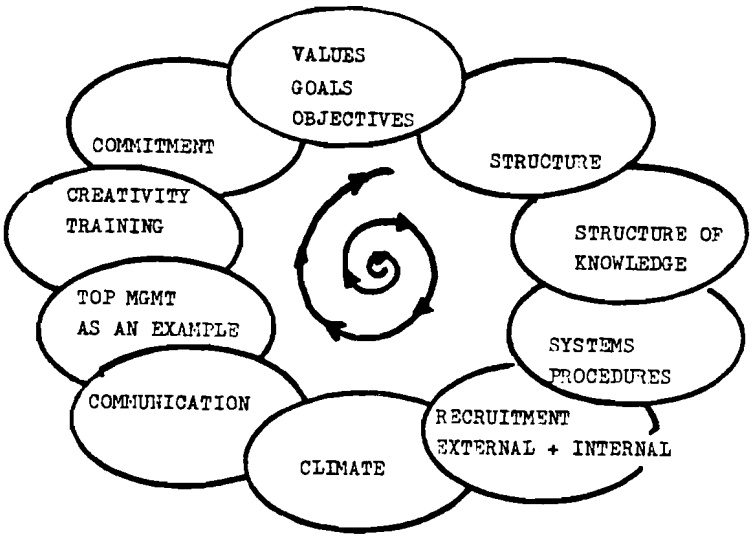
- Ability to find new problems and challenges.	20 - 26%
- Ability to reformulate and to restructurize open-ended problems.	4 - 6%
- The knowledge-factor.	4 - 9%
- Ability to produce ideas (variations).	7 - 11%
- Ability to make use of problem-solving methods.	14 - 22%
- Evaluation of ideas produced.	5 - 15%
- Implementation of selected ideas.	18 - 30%
- "Listening."	7 - 11%
TOTAL	100%

In one Scandinavian company (heavy industry) a lot of time and money was invested in creativity training, to restructuring the organization, etc., without any results. The real problem was (and still is!) that the upper management are afraid of the company executive officer (CEO). They would not take any risks and would not do any experiments.

In another Scandinavian company (process industry) the main problem was in focusing the creativity. They obtained some help when they began to apply MBO.

It seems there is not much worth in investing too much in increasing activity at the individual level if other factors are too far behind.

There must be a kind of balance among all relevant factors and we must go step by step along a positive spiral:



There are two books which show many practical paths to innovative and creative organization:

- The Art of Japanese Management (R.T. Pascale and A.G. Athos); and

- In Search of Excellence; lessons from America's best-run companies (T.J. Peters and R.H. Waterman);

that bring forward the same conditions for innovation which apparently form the base of innovativeness in many Scandinavian organizations.

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DEVELOPMENT OF CREATIVITY IN MANAGERS, TECHNOLOGISTS AND MARKETERS ENGAGED IN PRODUCT INNOVATION ACTIVITIES

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BACKGROUND

The following experiences and impressions are based mainly on observations gathered from two training programs developed and used in Finland. The *Creativity Development (CD) Course* was originally developed at KONE Corporation in 1974. The course material was also given to INSKO, the Engineering Organizations' Training Center and has undergone several refinement cycles since its introduction. The study group under INSKO, which only started in the Spring of 1983, number 400. As one study group consists typically of between seven and nine people, and as the program has been in continuous use at its originator corporation, some 3,000 to 4,000 people have by now worked through the course, or have at least started it. Some 50 to 60 percent of the participants have been product development engineers, the rest consisting of other engineers or technicians but also non-technical people.

The *Management Creativity Development (MCD) Program* was also developed in cooperation between KONE Corporation and INSKO. This program is closely related to the CD course but contains more material needed by managers. In a way, the MCD program is intended to be a combination of an Organization Development (OD) program and the CD course. The MCD program is only about two years old and so far only six groups have completed it.

Both these courses are based on the group self-study principle. A group of six to nine people work through material sent in suitable installments by the training organization. The core of both programs consists of exercises on real problems selected from the participant's work, home or hobby environments. There is no teacher (partly because good teachers in this area hardly exist) but a "Godfather" (forget the movie), namely, a person who has already worked through the course and has received some additional training, and who visits the group two or three times to provide help. The CD course requires between 100 to 150 hours of work during about one year, the MCD program somewhat more. A considerable part of the work (perhaps up to 60 percent) can be directly productive if the exercises are suitably selected from problems that ought to be solved anyway.

EXPERIENCES AND IMPRESSIONS FROM THE ABOVE DESCRIBED ACTIVITIES

What Type of Creativity Should be Developed?

Creativity is now a very popular subject, but different people use the word to mean very different things. The following three meanings, at least, seem to exist:

- Artistic creativity; protagonists of this group would typically like to reserve the word "creativity" for themselves and would prefer that some other word be used in practical life.
- Practical creativity; consisting just of the ability to generate unusual ideas.
- Practical creativity; seen as a complete process beginning with the initial vague feeling that an opportunity for improvement might exist and ending when a new idea is in fully-accepted use by the appropriate people.

My opinion is that the last one is by far the most fruitful approach. The well known creativity research pioneers at the New York State University College at Buffalo divide this process into the following five phases:

- Fact finding
- Problem finding
- Idea finding
- Solution finding
- Acceptance finding

This five phase formula is used in two ways: as a rough guide on how to proceed when solving a problem and as a code on how to sort out the problem-solving methods and other information concerning the process. Both uses of the five phase process are very useful. Basically the same process, with a slight modification, is used in the Finnish training programs as a general structure to hold the material together.

How Much Training is a Suitable Amount?

Quite a lot, but actually very little. One needs a long activity involvement in the creative problem-solving area to fully understand how terribly bad the behavioral models we have been taught—mostly indirectly—in school are, and which are still being taught continually by, e.g., TV plays. Here are just a few examples:

- That it is important to immediately know the right answer.
- That the right answer is faultless.
- That more educated people—pupils in a higher class—know everything better.
- That the hero always knows what to do and does not have to search or ask for ideas.
- That it is fine to give snappy, quick-witted answers.
- That if there are different opinions then naturally a quarrel begins and the hero wins.

Now, most people are quite interested in creative problem-solving and would like to learn how to do it. However, the studying habits of typical adults are such that they consider anything above a one week seminar to be almost unthinkable. The Finnish CD course requires about three times that amount of studying time during one year, and many people have remarked that only towards the end of the year do they begin to understand what it was all about. Still, 120 hours represents only about 0.4 percent of the time they spent in regular schools, homework included. Trying to neutralize the ill-effects of standard schooling, TV, etc., with this small amount of antidote is already quite a brave effort. I would not like to recommend a smaller dose. The English consultant Vincent Nolan speaks about a "vaccination phenomenon": a small dose of bacteria or creativity development results in no infection but immunity against larger doses. People who receive such doses of creativity training are happy to believe that now they know most about it.

I posed the following question to about 20 managers who had just finished the MCD program: If you had to develop an ideal education program for future managers, beginning from earliest grade school, what percent of the time would be devoted to the types of questions and methods included in the MCD program? The answers spread from between one to 65 percent, an average of 18 percent. This 18 percent would mean some 5,000 to 6,000 hours.

Wouldn't This Belong to Elementary, Basic Education?

Yes, but can you wait for some 100 years?

People typically start our type of creativity training by thinking that creativity is something quite fine, belonging only to some elated situations in distinguished professions. During the year they find that what they learn is astonishingly useful in everyday life. Afterwards, one often hears that this should be taught in elementary school to everybody. I quite agree, but if we had this fine, creativity-promoting elementary school system ready this year, it would take nearly 60 years for all people in working life to be graduates from the new school. It will also probably be quite a time before we could have this school with teachers who can do the job.

What Effects Does This Type of Training Have?

One would perhaps expect success stories about fine technical inventions. To a certain degree such stories are being told, but more often what people relate are general improvements in the working atmosphere. These are, of course, more noticeable in organizations where a high percentage of employees have participated in these courses. They are even more noticeable if the original atmosphere of the organization was traditionally authoritarian. One often hears remarks that the atmosphere after the CD courses is much more open and positive than before, and that all kinds of ideas can be presented and discussed freely. There seems to be a general belief that many of the hundreds and thousands of little daily problems find better solutions, although success stories of single, very valuable ideas are not so common. I remember, however, the case of one fairly large company where the people claimed that one of the very first exercises produced such a valuable idea that it certainly paid for the whole program in the company.

In this context, it might be useful to remark that when I tried to analyse some unsuccessful designs made in my corporation it was typical that the basic idea of the designs was not wrong. The designs failed because of a large number of detail problems: the general competence of the group was just not sufficient enough to handle the large mass of details well enough.

Some fairly typical comments heard from participants of the CD course are:

- "The greatest difference I see in our working style is that in situations which previously would have led to a prestige conflict, people now ask 'How do we handle this type of problem?'. Then they take a formal problem-solving method and by using it they proceed in a constructive way."

- "The best part of the CD course is the section devoted to listening skills."

- "First we tried to run through the course in half the recommended one year. Then we found that it was not a good idea. There is enough stuff to digest for a year."

- "My most successful exercise was on a quite delicate non-technical problem. I do not like to tell what it was."

- "One of the most valuable things learned was that if I do not succeed the first time, I know how to try again. Thus I now often succeed in cases that I would have abandoned with my previous style."

In discussions one often gathers the impression that the course has been a quite profound learning experience to the participant. The benefits are not at all limited to the working environment, and stories about considerably improved family life are also fairly common.

CONTENTS OF THE COURSE PACKAGE

The main contents of both the packages, as far as the creative problem-solving process is concerned, consists of the following three parts.

1. The five-phase process.

   Described above.

2. A collection of problem-solving methods.

These could be understood to be tools, sorted into a toolbox with five compartments formed by the phases of the process. In the idea-finding compartment there are half a dozen idea finding methods. In the solution-finding compartment there are tools for evaluating and refining ideas. The selected evaluating methods could be called *personalized decision analysis tools* (Ulvila-Brown 1982). Mechanistic methods that try directly to point to the optimum solution are not recommended.

It seems that heavy, mathematics-intensive decision analysis methods have little use in everyday industrial life, product development included. They may even be harmful as compared with simple methods complemented with human intuition and judgment. Real-life decision making situations are normally very complicated and full of uncertainties, and it is absolutely impossible to include all important factors in a mathematical model. If the model is simple, it is easy to remember that the model must be used only as a very rough guide. If, however, the designer or other person made a great effort

to build a comprehensive model, he or she may be tempted to believe too much in the model and neglect an important factor that was not included.

The main method presented in the acceptance-finding part is participation in the process as early as possible, but at least in the evaluation phase.

3. Attitudes, skills and habits.

As to these, the above mentioned problem-solving methods are also used as a kind of mental gymnastics: their use is understood to develop "creative fitness" that consists of attitudes, skills and habits, such as:

- o The ability to vary one's way of thinking between widely imaginative and practical.
- o The ability to prolong the idea-finding phase beyond finding the first feasible idea.
- o The ability to listen to others in a positive, constructive way.
- o The ability to see solution ideas from many viewpoints in a balanced way.
- o The ability to see a difference of opinions as a situation requiring constructive problem-solving, not arguing.
- o The ability to see opportunities, an attitude of constructive discontent.
- o The belief that ideas can be generated as needed.

ADDITIONAL COMMENTS

The CD course was not started in its present group self-study form. The first attempt was individual self-study because in the originator company people travel a lot. It was thought that individual self-study offered the best possibility to adjust the pace to travel and other busy periods. The very beginning looked good: when we wanted to find about 30 people to try out the first edition of the material package, 70 appeared. After a couple of months, however, almost everyone had stopped progressing. The fairly demanding exercises were just being postponed indefinitely. If we had not reorganized the course into the group self-study form probably only two or three percent of the participants would have finished. Now in courses started via INSKO about 90 percent of starters finish the course. In the originator company the corresponding figure is only about 60 percent. The fact that the course is free there may have something to do with this.

Because the courses are fairly difficult, they are voluntary in all organizations. The spread of participation in an organization is quite interesting. If the managing director or top management in general are interested and participate, fully or even partly, quite a high percentage of employees may participate. The highest figure, about 80 percent of the salaried staff and a remarkable percentage of workers too, has been achieved in one such company (Vaisala Oy), that manufactures advanced meteorological instruments.

If the use of these courses starts at lower levels it does not, in general, spread to the higher levels and, typically, not very widely horizontally either. In quite a number of discussions I have tried to find cases where participation in the CD course has spread one step directly upwards in an orgagization: i.e., where the boss started it after one of his subordinates. So far I have found only one such case.

REFERENCE

Ulvila-Brown (1982) Decision analysis comes of age. Harvard Business Review, September-October.

CONFERENCE ANNOUNCEMENT

IIASA STUDY ON INNOVATION MANAGEMENT IN ELECTROTECHNOLOGY

TASK FORCE MEETING ON

HUMAN FACTORS IN INNOVATION MANAGEMENT

HELSINKI, 9-14 OCTOBER, 1983

(AS APPROVED AT THE MOSCOW PLANNING MEETING 12-14 JANUARY, 1983)

Human Factors in Innovation Management

Helsinki, 9-14 October, 1983

Many theorists and practioners of innovation management are realizing that strategies involving organization, financial, or technical measures to promote innovation cannot be fully effective without attention to the special creative and productive potential of the human behavior involved. Human behavior is indeed a commonality of innovation problems and opportunities around the world, molded by the interesting diversity of cultural and historical backgrounds. Thus,comparative analysis of ideas and experience in addressing the human factor in innovation will be an important aspect of the over-all IIASA study of Innovation Management in Electrotechnology.

The Task Force Meeting will be organized around the following major issues:

1. Training and Development of Human Resources.
2. Strengthening Worker Motivation for Innovation and Quality.
3. Incentives for Innovation Leadership and Management.
4. Easing the Transaction of Innovation Change.

Four major sessions on these topics will be held, along with a general session for presentations by industrial managers with experience in all aspects. A synthesis session will present the most important common themes and conclusions from the individual presentations. A detailed outline of issues under each of the four major categories is attached.

FORMAT AND PROCEDURE

The meeting will be focused on the unique strength of an IIASA-convened group: the ability to learn by drawing on the comparative experience and theory of the varying social and economic systems represented. To accomplish this we will:

1) Take special steps to promote real discussion, probing questions, and idea exchange among participants.

2) encourage participants to stress real experience with ideas in actual application, including constructive discussion of problems encountered and failed ideas as well as successful ones. Learning from failure will be emphasized as an important part of the general learning process.

3) encourage participants to bring to the meeting the broadest possible view of their countries' innovation experiences, theories, and current debates on the significance of human factors in innovation.

Specific steps to meet these goals will include a schedule for receipt of speakers' papers which will allow them to be distributed to all in advance. Speakers will be asked to orally summarize only the highlights of their papers, to maximize the time available for discussion. In addition, discussants will be designated for each paper. They will have a special formal responsibility to study specific papers, and lend discussion of them. Speakers will also be asked to put together packets of recent important literature from their countries or firms on innovation management. These will be duplicated and distributed to all participants, to provide uniquely broad insights on comparative global innovation thinking.

Participants will be drawn from countries represented at IIASA and a few others. Active executives and managers from electrotechnology and other firms will be involved, along with experts from research institutes and universities. Heavy emphasis will be placed on relating management theory closely to actual management practice and needs. A detailed outline of issues to be covered under the major headings follows.

Major Issues for the Task Force Meeting Agenda

Human Factors in Innovation Management

I. TRAINING AND DEVELOPMENT OF HUMAN RESOURCES FOR INNOVATION

A. New skills needed for promoting innovation among various groups of employees: scientific, engineering, managerial, and production personnel.

1. Training for versatility and adaptability to change in addition to specialization.

2. Training for capability to integrate ideas and scientific, engineering, and design capabilities.

3. Training for innovative problem solving.

B. New approaches and methods of training of important groups of employees: scientific, engineering, managerial and production personnel.

1. Workshops and seminars on innovation and innovation management.

2. Experiential training for personal development, creativity, and communication skills.

3. Training for teamwork and group creativity.

C. Issues and approaches to mid-career training and re-training.

1. Estimating value and allocation of resources to mid-career training.

2. Methods of mid-career training and re-training.

D. Issues faced in establishing training and human resource development as a societal responsibility.

1. Anticipating skill needs; keeping training programs in line with workplace needs and technological change.

2. Financing for training investment, from government and employer sources.

3. Incentives for employer and individual investment in human resource development.

II. STRENGHTENING WORKER MOTIVATION FOR INNOVATION AND QUALITY

A. Participation in goal setting, system planning, and design.

B. Incentives for innovation and creativity for individuals and groups.

C. Removing barriers, systems flaws, or conflicts that inhibit innovation and creativity.

D. Encouraging new and unconventional approaches to improvement of products and production.

E. Building worker identification with organizational goals:

   1. Worker participation in setting long-term goals and sharing long-term benefits.

   2. Using planning systems as communication devices to build participation, understanding, and support of long-term goals.

III. INCENTIVES FOR INNOVATION LEADERSHIP AND MANAGEMENT

A. Building incentives, removing disincentives for long-range thinking.

B. Encouraging creative risk-taking.

   1. Blending traditional fiscal planning with intelligent gambling.

C. Building the ability to nurture and utilize the strengths of unconventional but creative inventors, entrepreneurs, and groups.

D. Building teamwork and habits of cooperation for productivity and innovation; reducing individual and group conflict.

E. Providing incentives to allow overall organizational goals to dominate "territorial" subgroup goals.

F. Creating innovative group norms and personal attitudes.

G. Building subgroup self reliance, responsibility, and creativity, while also encouraging communication and cooperation among subunits.

H. Recognizing special management needs at the varying stages of the innovation process.

IV. EASING THE TRANSITIONS OF INNOVATIVE CHANGE

A. Resolution of group and individual conflicts arising from innovation introduction.

B. Building institutions and traditions to provide creative new pathways for individuals and groups displaced by innovative change.

C. Retraining systems for displaced managerial or production personnel.

D. Integration of new technology and processes into existing production and marketing systems.

E. Implications of microelectronics on management and production, e.g., robotics, computerized management and communication systems.

Task Force meeting on Human Factors in Innovation Management

Helsinki, 9-14 october 1983

The Finnish Committee for IIASA

IMATRAN VOIMA OY

TECHNICAL RESEARCH CENTRE OF FINLAND

IIASA International Institute for Applied Systems Analysis

NOKIA

VALMET

STRÖMBERG

KONE

International Institute for Applied Systems Analysis

Task Force Meeting on

Human Factors in Innovation Management

10 - 14 October, 1983

at

Technical Research Center of Finland (VTT), Espoo, Finland

AGENDA

MONDAY 10 OCTOBER

11:30	Registration (VTT Conference Hall)
12:00	Lunch (VTT)
14:00-17:30	WELCOME ADDRESS *P. Jauho* (Finland)
	INTRODUCTORY SESSION Chairman: *V. Goncharov* (IIASA)
	OPENING ADDRESS *B. Segerståhl* (Finland) *H. Andersin* (Finland)
	IIASA Plans of Electrotechnology Case Study Development and Main Goals of the Helsinki Task Force Meeting *V. Goncharov* (IIASA)
15:00	PLENARY SESSION Chairman: *B. Segerstahl* (Finland)
	Human Factors in Innovation Management—Themes, Contradictions, and Questions for Our Meeting *T. Moss* (USA)
	Some Methodological Approaches to Analyzing Human Factors in Innovation Management *G. Wolf* (Austria)
16:00	Coffee
	DISCUSSANTS *L. Hanes* (USA) *M. Karttunen* (Finland) *L. Zacher* (Poland)
19:00	Sauna and reception hosted by the International Institute for Applied Systems Analysis at Keilaniemi (a short walk from the hotel).

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TUESDAY 11 OCTOBER

9:00-12:30 PLENARY SESSION
Chairman: *E. Razvigorova* (Bulgaria)
Co-chairman: *B. Wahlström* (Finland)

Social Invention and Innovation *S. Lundstedt* (USA)

Innovation Management: Some Socio-Psychological and Legal Aspects in Socialist Countries *M. Benjamin* (IRIMS)

Stressing Human Factors in Innovation Management—Will it Work? *T. Moss* (USA)

DISCUSSANTS
O. Červenka (CSSR)
G. Wolf (Austria)

10:30-11:00 Coffee

Innovation Management and Quality of Working Life
L. Zacher (Poland)

Innovation—The Human Side *G. Wolf* (Austria)

DISCUSSANTS
M. Benjamin (IRIMS)
S. Lundstedt (USA)

12:30-13:00 Lunch

13:30-17:30 PLENARY SESSION
Chairman: *T. Moss* (USA)
Co-chairman: *J. Honko* (Finland)

Requirements for the Performance of Managers in the 1980s and Possibilities for the Development of Effective Management *J. Smrčka* (CSSR)

Human Factors in Innovation: Employee Involvement
L. Hanes (USA)

DISCUSSANTS
V. Ryssina (USSR)
B. Wahlström (Finland)

15:00-15:30 Coffee

External Consultants for Fundamental Process Innovation
F. Prakke (The Netherlands)

The Role and Position of a Public Research Institution in Innovation Management *E. Ormala* (Finland)

DISCUSSANTS
V. Virkkala (Finland)
P. Naert (EIASM)

19:00 Bus departs for reception hosted by Valmet and Strömberg at Kaivohuone restaurant in Helsinki. The bus will return to the hotel at 10:30.

WEDNESDAY 12 OCTOBER

9:00-12:30 PLENARY SESSION
Chairman: *O. Červenka* (CSSR)
Co-chairman: *H. Andersin* (Finland)

Strategic Management Implications of New High Technologies *A. Patz* (USA)

The Future Generation—A Generation of Innovations *E. Razvigorova* (Bulgaria)

DISCUSSANTS
F. Prakke (The Netherlands)
J. Smrčka (CSSR)

10:30-11:00 Coffee

Role Structures and Creative Potential of Working Teams *V. Ryssina* (USSR)

Innovation Management and the Role of Creativity *J. Langrish* (UK)

Managerial Effectiveness: Implementation of a Seminar for the Upper Management of Siemens AG *D. Hempel* (FRG)

DISCUSSANTS
T. Moss (USA)
A. Patz (USA)

12:30-13:30 Lunch

13:30-17:30 PLENARY SESSION
Chairman: *G. Wolf* (Austria)
Co-chairman *V. Virkkala* (Finland)

Motivational Factors in a Product Development Project *H. Andersin* (Finland)

Training Human Resources for Innovation *O. Červenka* (CSSR)

Implementation of Decision Support Systems *P. Naert* (EIASM)

DISCUSSANTS:
D. Hempel (FRG)
L. Kivikko (Finland)

15:00-15:30 Coffee

Practical Aspects of Human Factors in Product Development *M. Karttunen* (Finland)

WEDNESDAY 12 OCTOBER CONT.

The Human Factors in Organizations: Some Implications on Innovation Management *B. Wahlström* (Finland)

DISCUSSANTS
J. Langrish (UK)
E. Rzzvigorova (Bulgaria).

19:00 Bus departs for reception hosted by Nokia. The bus will return to the hotel at 10:30.

THURSDAY 13 OCTOBER

9:00-12:30 PLENARY SESSION
Chairman: *M. Karttunen* (Finland)
Co-chairman: *J. Smrcka* (CSSR)

Features of Mobilization of the Working Treams for Innovations Implementation in the State Economic Association "ELPROM" *V. Vassev* (Bulgaria)

How to Control the Innovativeness of an Organization *L. Kivikko* (Finland)

Development of Creativity in Managers, Technologists and Marketers Engaged in Product Innovation Activities *V. Virkkala* (Finland)

10:30-11:00 Coffee

Discussion on the program of the forthcoming IIASA Task Force Meeting to be held in Albena (Bulgaria) 7-11 May 1984. *T. Moss* (USA)

Discussion on the program of the forthcoming IIASA Conference on "Innovation, Flexibility and Productivity Improvement" to be held in Vienna, 17-21 September, 1984 *G. Wolf* (Austria)

Discussion on Contents of the IIASA Monograph on Innovation Management *J. Smrcka* (CSSR)

General Discussion

12:30-13:30 Lunch

Afternoon free for informal discussion or sightseeing.

FRIDAY 14 OCTOBER

8:30 Bus departs for technical visits to Nokia and Strömberg

12:30 Lunch hosted by Strömberg

13:30 Bus returns to hotel

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Task Force Meeting on
Human Factors in Innovation Management
Helsinki, 10-14 October, 1983

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